Food and Water Security in the Arab World

Proceedings of the First Arab Development Symposium

Atif Kubursi
Editor
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LIST OF ACRONYMS

AAAID—Arab Authority for Agricultural Investment and Development
ACSAD—the Arab Center for the Study of Arid Zones and Dry Lands
ADB—Asian Development Bank
ADF—African Development Fund
AfDB—the African Development Bank
AFFM—Africa Fertilizer Finance Mechanism
AFSED—Arab Fund for Social and Economic Development
AGFUND—Aga Khan Foundation
AGU—Arabian Gulf University
ALAD—Arid Land Agricultural Development
AOAD—Arab Organization of Agricultural Development
BGRI—Borlaug Global Rust Initiative
CAADP—Comprehensive Africa Agricultural Development Program
CIAT—International Center for Tropical Agriculture
CIMMYT—International Maize and Wheat Improvement Center
CFR—Cost and Freight
CGIAR—Consultative Group on International Agricultural Research
COV—Coefficient of Variation
CWANA—Central and West Asia, North Africa
ENSAE—École Nationale de la Statistique et de l'Administration Économique
FAO—Food and Agriculture Organization
FIFO—First In First Out
FY—Fiscal Year
GAFSP—The Global Agriculture and Food Security Program
GCC—Gulf Cooperation Council
GCM—General Circulation Models
GDP—Gross Domestic Product
GFRP—The Global Food Crisis Response Program
GIS—Geographic Information System
GBPC—Global Business Policy Council
IBRD—International Bank for Reconstruction and Development (World Bank)
ICARDA—the International Centre for Agricultural Research in Dry Areas
ICBA—the International Center for Biosaline Agriculture
ICBS—Israel's Central Bureau of Statistics
ICRC—International Committee of the Red Cross
IDA—International Development Association
IDB—Inter-American Development Bank
IFAD—International Fund for Agricultural Development
IFC—International Finance Corporation
IFPRI—International Food Policy Research Institute
IMF—International Monetary Fund
IPM—Integrated Pest Management
IPPC—Intergovernmental Panel on Climate Change
KFAED—the Kuwait Fund for Arab Economic Development
MDG—Millennium Development Goals
MENA—Middle East and North Africa
MI—Masdar Institute
NGO—Non Governmental Organization
NTF—Nigeria Trust Fund
ODA—Official Development Assistance
OECD—Organization of Economic Cooperation and Development
OFID—OPEC Fund for International Development
PDBAC—Principal Bank for Development and Agricultural Credit
RAI—Responsible Agricultural Investment
SINEAU—Tunisian National Water Information System
SPI—Standardized Precipitation Index
UNCTAD—United Nations Conference on Trade and Development
UNDP—United Nations Development Program
UNEP—United Nations Environment Program
UNESCWA—United Nations Economic and Social Commission for Western Asia
UNIDO—United Nations Industrial Development Organization
USDA—United States Department of Agriculture
WFP—World Food Program
WISP—Wheat Import Supply Chains
WP—Water Productivity
WTO—World Trade Organization
Recognizing the importance of policy debate and knowledge sharing in the field of development, the Arab Fund for Economic and Social Development and the World Bank (Middle East and North Africa Region) agreed in March 2010 to hold a joint development symposium around issues pertaining to the Arab World annually. The Arab Development Symposium was conceived to provide an opportunity for policymakers to share ideas on topics which are high on their agenda. As such, it complements other fora for training and research papers’ discussion.

Food security was selected to be the topic of the first Symposium, which took place in March 2011 at the Arab Fund premises in Kuwait. This topic is high on the agenda of the Arab countries as stated during the Arab economic summit of Heads of States, which took place in January 2009 in Kuwait. It is also high on the global agenda as the spike in food prices worldwide, which peaked in the second half of 2007 and again in the second half of 2011, pushed over 40 million people into poverty.

This Symposium highlighted the critical issues facing the Arab region in the area of food security. These include concerns about agricultural production and productivity, land use, water demand management, efficiency of the supply chain, storage capacity, price volatility, nutritional composition of food consumption, and climate resiliency. Some of these issues are outside the control of policymakers; others are squarely within their responsibilities. In coming years, Arab countries’ vulnerability is likely to be exacerbated by structural factors such as population growth and scarcity of water and land resources. Projections of the region’s food balance indicate that dependence on cereal imports will increase by almost 64 percent over the next twenty years.

The Arab Development Symposium could not have been timelier, given its potential contribution to the development agenda being shaped by the “Arab Spring”. Given the paramount importance of the issue of job creation, the next topic of the Symposium will be on Small and Medium-Scale Enterprises (SMEs)—their potential for accelerating growth and creating much-needed jobs in the Arab World.

Abdlatif Al-Hamad
Director General and Chairman of the Board of Directors
Arab Fund for Economic and Social Development

Inger Andersen
Vice President
Middle East and North Africa
The World Bank
ACKNOWLEDGEMENTS

This volume has its origins in the First Arab Symposium on Food and Water Security in the Arab World which was held in Kuwait on March 14-15, 2011. The Symposium is part of a series of workshops that the Arab Fund for Economic and Social Development and the World Bank would organize jointly on an annual basis. The coordinators of this event are Imed Limam (Arab Fund) and Mustapha Rouis (World Bank) who worked tirelessly to ensure the success of the symposium from the inception stage to the actual event itself and beyond. I wish to thank them both for their superb efforts and tireless support.

I wish to thank a number of people for their help and support in completing this volume. In particular, I am grateful to Ahmed Osman, Director of the Technical Department of the Arab Fund for Economic and Social Development, for all his expeditious support and incisive corrections and to all the contributors for their readiness with which they have accepted my suggestions for the many patient revisions and for the promptness with which they submitted their essays and comments.

I am also grateful to Steve Spencer, Norman Kearney and Velma Grovers for their meticulous work in translating my laborious specifications for preparing a camera ready final product. My greatest gratitude goes to Abdlatif Al-Hamad for all his support and the confidence he has put in me, without which this volume would not have been completed.
KEYNOTE ADDRESS I

Abdlatif Al-Hamad
Director General and Chairman of the Board of Directors AFESD

Ms. Shamshad Akhtar, World Bank Vice President for the Middle East and North Africa, Prof. Atif Kubursi, Economic Advisor and Professor of Economics at the University of McMaster, Canada, and the Rapporteur of this symposium.

Ladies and gentlemen,

I am pleased to welcome you at the headquarters of the Arab Fund for Economic and Social Development in the State of Kuwait, and thank you all for accepting our invitation to participate in this symposium. Let me take this opportunity to extend my thanks to the World Bank for joining the Arab Fund as partner in the preparation and organization of this symposium, and to express our appreciation for their fruitful cooperation, in a number of activities in areas of great importance to the development of the whole Arab region. We have agreed to hold together annual symposiums to address development issues in the Arab World. This is the first in a series of symposiums that will tackle strategic subjects such as “Food and Water Security in the Arab World”, which is the theme of today’s meeting.

This theme was chosen for a number of pertinent reasons. First and foremost, the clear devastating impact of the recent world food crisis has had on Arab countries that has compromised their food security and stands as a major challenge to contend with. The second reason is the need to shed light on the neglect of the water problem in the Arab countries and its link with the issue of food security.

The interest of the Arab region in the issue of food security is not new. Many countries in the region have developed programs to achieve self-sufficiency in staple food commodities. Food security in the sense of self-sufficiency has, however, encountered many constraints and obstacles, the most important of which are water scarcity, poor management of natural resources, low interest in agricultural research and poor applications of modern technologies in the agricultural sector.

The greatest failure in the management of the agricultural sector in a region, characterized by its scarce water resources, is, however, the persistent wasteful consumption of this scarce resource. In fact, the low-productivity of the agricultural sector stands in stark contrast to the high rate of water consumption, which amounts to about 90 percent of all the water usage in the region. In addition, agricultural policies’ effectiveness in the region is severely hindered by its disregard of the concept of comparative advantage.

Despite the fact that the Arab countries have made considerable progress in developing agricultural production, the results are still modest, particularly with regard to their impacts on the growing demand for food. The high rates of population growth especially in low-income
Arab countries such as Yemen, Mauritania, Palestine, Somalia, Sudan, Djibouti, and Comoros create a major challenge to their ability to secure their needs for food in a sustainable manner.

The global food crisis has already caused severe social unrest in a number of Arab countries as a result of the substantial increase in food prices and declining purchasing power of citizens. The crisis and its aftermath should be perceived as an alarm bell of what might happen if food prices continue to rise in international markets without appropriate actions taken to halt their increase.

The Arab countries must follow a realistic approach to ensure their food security. They must make arrangements to secure continued supply, and support the purchasing power of consumers. They also need to increase agricultural production by improving land use and water management.

Ladies and gentlemen,

I do not need to give you a detailed overview of all of the Arab Funds’ activities. I will limit myself to the efforts made by the Arab Fund since 1974 in the agricultural and water sectors. Since the commencement of its operations in 1974 and until the end of 2010, the Arab Fund extended 568 loans to finance 480 projects in 17 Arab countries, for a total amount of about $24 billion U.S., of which about $6.3 billion U.S. was earmarked for agriculture and rural development, and $2.5 billion U.S. for water and sewerage projects. A great many of the Arab Fund-financed projects, in addition to those in the agriculture and water sectors, were targeted directly or indirectly towards supporting and improving the ability of Arab countries to realize their food security objectives.

So far success is limited in meeting the targets of food security, which require radical changes in agricultural policies. In this symposium we should try to discuss various aspects of food security in the Arab countries. However, we must focus on the six themes, addressed by the six main papers. We are sure that this esteemed gathering will enrich the debate and contribute to enhancing Arab capacities in these areas.

The first theme deals with the strategic framework to improve food security in the Arab region in the light of price volatility of food commodities in international markets.

The second theme deals with the role of water in meeting the challenge of Arab food security. The paper proposes ways to improve the management of scarce water resources reduce waste and improve irrigation efficiency.

The third theme is devoted to the role of infrastructure, logistical facilities, and the management of post-harvest period. The paper on this theme will focus on the role of modernization of transport and storage of grain and the importance of alleviating bottlenecks surrounding the supply of food to local markets.

The paper on harnessing scientific research and innovations to achieve food security in the Arab region, deals with the role of investment in infrastructure, education and agricultural research, in addition to the role of farmers’ participation in the selection and adoption of modern technology and its dissemination.
The fifth theme deals with the effects of the expected climate change on water resources and the agricultural sector in the Arab region. The paper under this theme highlights the negative impact and consequences of the expected decline in rainfall during the coming years, and the volatility of the performance of the agricultural sector due to the rising frequency of drought cycles.

The sixth and final theme of the symposium deals with the role of investment and finance in food agriculture. The paper analyzes the funding needed for the agriculture sector to adequately play a greater role in food security, and assesses the role of financial institutions.

Ladies and gentlemen,

In conclusion, I would like to thank the international and regional institutions that took part in this symposium either by contributing papers or providing comments. In particular, I would like to extend my gratitude to the Food and Agriculture Organization (FAO), the International Fund for Agricultural Development (IFAD), the International Centre for Agricultural Research in Dry Areas (ICARDA), the Arab Center for the Study of Arid Zones and Dry Lands (ACSAD), the International Center for Biosaline Agriculture (ICBA), the Kuwait Fund for Arab Economic Development (KFAED), and the African Development Bank (ADB). I would like also to thank the authors of the papers and commentators for their efforts, and to extend special thanks to Dr. Atif Kubursi for accepting to be the rapporteur for the symposium and editor of its proceedings volumes. I would also like again to thank and pay tribute to the World Bank for accepting to co-sponsor this symposium. Finally, I thank you all for honoring us with your attendance and your participation.
KEYNOTE ADDRESS II

Shamshad Akhtar
Vice President Middle East and North Africa Region, World Bank

Introduction

Excellencies let me welcome you all to the launching of the First Arab Development Symposium. This Symposium is a collaborative effort between the World Bank and the Arab Fund led by Abdlatif Yousef Al-Hamad, Director General and Chairman of the Board of Directors of the Arab Fund. Today’s session has been dedicated to the topic of food and water security—a top priority for the region.

We are meeting amidst historic and momentous events in the Region, witnessing an awakening and movement that bears tremendous hope and opportunity for the future development of the Region. However, the political transition and transformation could be complicated if some attendant risks are not effectively addressed. Besides the need to address concerns of governance, youth unemployment and level of exclusion of women and other vulnerable groups from the benefits of growth, the Region has to tackle the twin deficits of food and water and their serious social consequences. This Symposium, along with other initiatives discussed later, should help the Arab World to develop strategic thinking to shape effective responses.

In my remarks today, I plan to (i) discuss the recurrent rise and high volatility in international food prices; (ii) highlight the key factors contributing to these trends; (iii) share concerns regarding the growing vulnerabilities among the poor and at the country level; and (iv) offer some insights into World Bank initiatives to address the challenges of food insecurity.

Food Price Increases and Volatility

The recent recurrence of a sharp rise in food prices after the episode of 2008 has again triggered grave concerns about food security, malnutrition and increased poverty in the Arab World. This round is of more concern as it is occurring at a time when the Region is undergoing political turmoil. This in turn is adversely affecting regional growth prospects and macro-economic imbalances that are coming under pressure as governments attempt to offer a range of wage and subsidy increases and other benefits to settle the public agitation and mitigate consequences of the rising food prices.

Food price rises and volatility, though not new phenomena, appear to have increased markedly over the last six years. In this round, international food prices are not only higher (almost reaching their 2008 peak at the end of January 2011) but also appear to be more volatile. Large and unpredictable variations in international prices are particularly problematic as they increase economic risks for both producers and importers, and pose fundamental food security risks for consumers and governments, while discouraging needed investment in agriculture for development.
The ratio of stocks for major grains (wheat, maize, and rice) to use is also an important driver of change in international commodity prices and one where the countries in the region can actually play a significant role because MENA consumes 30 percent of the world's wheat. When stock-to-use ratios are low, prices rise. Good public management of stocks and involvement of the private sector should be a major emphasis going forward. If the Arab World, as the largest single importer, has high reserve stocks then they put less pressure on thin food markets. Two important caveats are in order: (i) it would be counterproductive to try and increase stocks in lean times because this will drive prices up; and (ii) this is about ensuring access to food rather than minimizing cost (because storage does cost much money).

Factors Contributing to Agriculture Commodity Price Trends

A number of factors behind the current high agricultural prices are similar to those observed in 2007/2008 such as high energy prices, depreciation of US$ against most currencies, and high level of financial investment in agricultural commodities. At the same time, there are some additional factors worth highlighting relative to trends observed for 2008. These include (i) more broad-based rise in agriculture commodity prices; (ii) adversities prompted by inclement weather; and (iii) trade policy responses such as Russia’s ban on exports in late 2010 that further raised the amplitude of the grain price spikes in 2011.

Aside from this, there are more penetrating factors that have and will continue to impact the food security situation in the Arab World:

(i) Growing population and income growth and urbanization driving food demand: the Arab population growth rate is 1.9 percent, which is higher than the average world rate of 1.2 percent and urbanization, which is correlated with increased caloric intake, is also on the rise.

(ii) Limited water resources in the Arab World limits potential for domestic food production. Water stress has been rising and per-capita renewable water resources fell by 75 percent since 1950. Some 60 percent of the region’s water flows across international borders, further complicating the water resource management challenge. Rainfall patterns are predicted to shift as a result of climate change. Estimates show that per capita water availability will be cut in half by 2050. This calls for a number of policy measures to be adopted by countries in the region to increase agricultural water productivity through the shifting of water management strategy from supply-side to demand-side.

(iii) Opportunities for expansion of arable land are limited. Excluding Sudan, the amount of permanent and arable cropland increased at an annual growth rate of 1.7 percent from 1995–2005 relative to 6.7 percent growth in Sudan and 2.3 percent worldwide.

(iv) A rapidly growing population may combine to create a troubling future: by 2050, arable land per capita is projected to reach 0.12 ha, a fall of 63 percent from its 1990s level.

Over the longer term, energy prices and total factor productivity are additional key drivers likely to shape world food price levels. Crude oil prices will not only exert upward pressure due to
increased costs of agricultural inputs, production and transport, but also through increased demand for bio-fuel feedstock.

Regarding self-sufficiency in the Arab World it is best addressed in terms of trade-offs between food availability in the market and access to it. The trade-off for food security has to do with spending valuable water, land, and capital to grow crops that are typically low value (wheat) versus using these resources to produce higher value crops and/or invest in much needed social sectors such as education, health and jobs. Furthermore, most MENA governments are subsidizing wheat production in most years in order to encourage farmers to produce wheat for food security reasons. This is obviously not the most efficient use of resources.

**Vulnerabilities from Surging Food Commodity Prices**

In view of the issues and constraints highlighted above, the Arab World is the largest net importer of cereals and sugar. Surging international prices and sharp swings induce upward pressure on the national and household budgets, depending on the level of domestic consumption, subsidies and the pass-through from international prices. Prices of two principal commodities, cereal and sugar, that account for roughly 61 percent of per capita caloric consumption face high degree of volatility. This is largely because 58 percent of consumed cereal and 75 percent of sugar is imported in the Arab World and the price index of these two commodities rose by 40 percent and 77 percent, respectively. A sustained surge in international prices of food will likely hit the poor significantly as they spend as much as 65 percent of their income on food.

The most vulnerable countries (defined as those with high exposure to food price and quantity risk that are a function of fiscal balances and dependence on food imports) are Yemen, Jordan, Djibouti, Lebanon, Iraq, and Tunisia with low grain reserve stocks and less fiscal room to bear the costs of imports and its subsidization. The Kingdom of Saudi Arabia, Kuwait and few other oil surplus economies would be able to mitigate vulnerabilities. They have large fiscal surpluses that benefit from oil price increases which allow them to build high reserve stocks and offer subsidies to avoid pass through of international prices. Egypt, Syria, and Morocco face high price risk, but their quantity risk is lower due to higher domestic production levels. However, over the medium to long-run water scarcity and climate change will stress domestic production, thereby increasing price and quantity risks.

Over the short-run, despite the political distraction, policy makers and development agencies need to be vigilant to ensure food availability and affordability for the vulnerable groups and ensure that proper humanitarian assistance is provided to those drifting across the borders between Libya-Tunisia and Libya-Egypt. Evidence emerging from the Region; however, is that food vulnerability is highest in countries around or below 3 months of grain stocks. Irrespective of stocks, most countries maintain food subsidies and/or maintain broad based food distribution systems—both quite inefficient in targeting the poor besides being fiscally unsustainable. What is more surprising that MENA has steeper fuel subsidy than food subsidies — though both

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1 In MENA countries, the cost of importing grain sometimes does not fall upon the consumer because governments often regulate prices. Thus, part of the food-price risk is absorbed at the country-level as fiscal risk.
commodities are victims of price volatility but the latter is absolute necessity and constitute the bulk of poor households' consumption basket.

The World Bank Group’s Response to the Food Crisis

The World Bank Group is responding with an expanded menu of options for both short-term rapid response and a longer-term scale-up of investment in agricultural public goods, tailored to differing client needs and circumstances. The short-term rapid responses focus on fiscal support, safety nets for the most vulnerable, and stimulating short-term food production to avoid further problems in the next harvest cycle. The longer-term scale up focuses on raising agricultural productivity and improving future resilience of supply chains. The instruments include:

- Grant funding for rapid response in the poorest and most vulnerable countries and expedited use of IDA and IBRD funds under programs such as the Global Food Crisis Response Program (GFRP)—a $1.5 billion U.S. program—and the new IDA Crisis Response Window;
- Facilitation of long-term aid effectiveness programs in agriculture and food security in IDA countries through the establishment of the Global Agriculture and Food Security Program (GAFSP) in 2010, with total pledges amounting to $925 million U.S.;
- A scaled-up regular program of IBRD and IDA lending, policy advice and technical assistance for long-term results. 71 percent of World Bank agriculture program goes to raise productivity; and
- IFC further closes the loop through its various programs for lending to the private sector, including the set up of a private sector window for GAFSP and a planned Global Agriculture Price Risk Management Facility.

While these instruments are largely geared towards low-income countries, the challenge ahead for all of us is to start working on specific solutions for the Arab World. Most of the Arab World countries are middle- and high-income, with the exception of Djibouti and Yemen which are IDA recipients. On one hand, we can work with the Arab World to increase food production at home, even with the constraints imposed by the limited availability of water and land. Since 2008, the World Bank has provided assistance of close to $450 million U.S. for enhancing agriculture productivity and irrigation efficiency in Morocco, Egypt, Yemen, Tunisia, and Djibouti for investments in technology, research and development, and improved agricultural water management. This can be complemented with additional sector specific interventions as well as support for increased public access to information on the quantity and quality of grain stocks; improving weather forecasting and monitoring; improving food security risk management options; providing countries access to fast-disbursing food-oriented support as an alternative to food export bans or price fixing; ensuring effective social safety nets that include a focus on nutritional outcomes; and help smallholder farmers become a bigger part of the global solution to food security.

On the other hand, recognizing that the Arab World will remain net cereal importer and around 75 percent of the retail price of food is attributable to production, transportation, and marketing, the World Bank has an ongoing regional study of 10 countries to examine the efficiency of wheat
import supply chains and how these can be improved to increase food security. Drawing from this evidence, the World Bank is exploring options to develop facility to support potential investments—\textit{in} transportation, logistics, and storage—\textit{that} can reduce the time and cost of importing food and ultimately serve as a buffer against international price spikes. In supporting this facility, the World Bank can offer IBRD funding and seek options of buy down of interest charges by grant funding from other development agencies.

Finally, the World Bank is also helping countries with analytical work such as analysis of country specific bread distribution system and poverty targeting in Egypt, and launching technical work and studies to better understand various dimension of food and water security. In this context, World Bank staff has contributed to a special issue of the Journal of Food Security entitled \textit{Food Security in the Arab World--Partnerships for a Sustainable Future}.

The World Bank’s dominant focus for the Arab World going forward is on strengthening safety nets, increasing agricultural and water productivity, and reducing vulnerability to international food price shocks through improved grain logistics, storage and handling.

- For countries highly dependent on cereal imports with fiscal deficits (Egypt, Djibouti, Jordan, Algeria, Lebanon, Tunisia, Yemen, Iraq & Bahrain) priority is given to strategies for improving safety nets and better managing exposure to market volatility, then to investments in agricultural research and development and rural livelihoods.

- For countries that are not highly dependent on cereal imports, but have fiscal deficits (e.g. Morocco, Iran and Syria), the priorities are: better manage agricultural and water to raise productivity; invest in agricultural research and development and rural livelihoods; and better manage exposure to market volatility.

- For countries with a higher dependence on cereal imports, but with fiscal surpluses (Kuwait, Libya, Oman, Qatar, Saudi Arabia and United Arab Emirates), emphasis is on better management of grain imports through reduction of bottlenecks in critical infrastructure, strategic grain reserves, port facilities and roads.

- Further efforts will also be made to diversify incomes through creating opportunities for high value fruit and vegetable exports and through improved skills development, especially for rural youth.

The idea of buying land overseas and matching Arab capital with land and labor in other countries to produce food is in principle a good one, but will only help address global food supply (a positive spill over) as opposed to directly helping the region’s own food security situation. The global demand for farmland has increased significantly since the 2008 food crisis. More than 70 percent of such demand has been in Africa. There are a wide range of risks associated with the rising of commercial pressure on productive resources that should not be overlooked. These are highlighted in the recent World Bank study \textit{“Rising Global Interest in Farmland.”} They include, inter alia, issues of land rights, transparency, good governance, environmental sustainability, and food security.
Conclusion

The sharp rise in food prices has triggered grave concerns about food security, malnutrition and increased poverty throughout the world. And it is increasingly being recognized that, due to a confluence of factors, international food commodity prices are likely to exhibit a rising and more volatile medium-term trend. This trend is of particular concern for Arab countries because of their rapidly growing populations, limited water and arable land resources, and significant dependence on international food commodity markets.

Arab countries want and need to act urgently to improve food security. Projections of the region’s food balance indicate that dependence on imports will increase by almost 64 percent over the next twenty years. Going forward we need to deploy together our efforts to help offset vulnerability to future food price shocks in the region by focusing on investment in three key areas: (i) strengthening safety nets; (ii) enhancing food supply; and (iii) reducing exposure to international commodity market volatility.
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INTRODUCTION

Atif Kubursi
McMaster University and Econometric Research Limited

Background

Food and Water Security in the Arab World was the focus of the First Arab Development Symposium planned jointly by The Arab Fund for Economic and Social Development and the World Bank. The Symposium was held in Kuwait on March 14-15, 2011 and brought together a select group of experts and policy makers to discuss the critical, challenging and vital twin problems of food and water security that afflict many parts of the world in general and the developing world in particular, but nowhere more specifically and more devastatingly than in the Arab World.

The experts at the symposium focused their attention on the many ramifications and implications of food and water security in the Arab region against the backdrop of rising world food prices, declining Arab agricultural productivity, increased water scarcity, rapid population growth and urbanization in the region, and heightened concerns about global warming and climate change impacts on rainfall, evapotranspiration, length of the growing season and variability of weather.

The richness of the symposium and its findings captured in this volume derives from the diverse expertise and experiences of the participants that brought together economists, agronomists, hydrological and agricultural engineers, practitioners and policy makers.

Naturally the diversity of the participants’ expertise and their intimate familiarity with the region and its food and water issues gave rise to multiple perspectives, some unique and profound analyses and a host of rich policy recommendations.

It is impossible to summarize the findings of the many papers that comprise this volume in a short introduction and, worse yet, to do justice to the elaborate and profound presentations, comments and discussions; there is no alternative to reading and digesting in full each and every paper in this volume including the comments made by the discussants. This will be a worthwhile and rewarding exercise. I cannot think of a similar compendium on the subject that matches its extensive and intensive coverage of the issues, the up-to-date data, the cogent arguments or the relevant and innovative recommendations.

The presentations covered a number of core issues that I will briefly summarize below. It is not expected that there will be general agreement on all issues and there was not, but the points below seem to represent the general consensus.
The MENA region, but particularly the Arab World is home to the largest set of water poor and water stressed countries of the world where water poverty is defined as less than 1000 m^3 per person per year. Actually, 15 countries of some 22 countries considered by the World Bank to be water poor are in the MENA region. This scarcity of water and food has been on the rise. It is impossible to capture the many manifestations of the twin deficits covered by the participants in this introduction; below only a small subset of the salient features is presented:

- The Arab World represents about 10 percent of the world's area and about 5 percent of the total population; it has, however, less than 0.5 percent of the world's renewable fresh water resources. The region ranks as the world’s lowest rated water availability per capita (approximately 800 m^3) per year compared to the global average of more than 7000 m^3.

- Renewable water resources in the Arab countries have shrunk by about 75 percent since 1950, and are expected to decrease by an additional 40 percent by 2050. Average water availability per capita in the MENA region stood at 4,000 m^3 in 1950, declined to 1,000 m^3 in 2000 and is expected to fall by another 50 percent by the year 2050.

- The rate of population growth is currently 1.9 percent (compared to 1.2 percent globally), while the rate of urbanization rose at 3 percent per year during 1990–2006 (compared to 2.2 percent worldwide). These relatively high rates of population growth and urbanization do not augur well for the future water demand in the region.

- Climate change will make water shortages even more acute. Global warming is expected to reduce precipitation further notwithstanding the fact that this rate in the region is already one of the lowest in the world (about 67 percent of the total area of the Arab World receives less than 100 mm/year of rainfall, and is classified as desert and semi-desert, not suitable for rainfed agriculture). It is also expected to increase evapotranspiration, reduce the length of the growing season, and unleash pests and serious diseases.

- Water (ground or surface water) in the region is typically shared with other riparian countries. Over 60 percent of this water is shared with others and in some cases (Tigris and Euphrates, the Nile and the Jordan rivers) this proportion exceeds 85 percent.

- The non-Arab riparian countries (Israel, Turkey and Iran) whether downstream or upstream have in the past showed no hesitation to use their asymmetrical power to claim more than their fair share of this water. The asymmetrical balance of power has, on a number of occasions, conflicted with the balance of water interests in the region.

- Water reliability defined as the average secure amount available 9 out of 10 years is less than 5 percent in the Arab region; in Canada this amount is over 30 percent.

- Quantity shortages are accompanied by quality scarcity. Pollution, salinity, intrusion and depletion are compromising the available clean water supply in the region.

- Physical scarcity is joined by economic scarcity. The water tariffs (prices) in all of the countries of the region are below the true scarcity value of water (shadow price) and in
many countries fall short of the marginal product in agriculture or what is needed to recover the full cost of operation and maintenance. There exists no single case in the region where the water tariff per one m$^3$ of water reflects the full supply price let alone the opportunity cost of this water.

- The agriculture sector claims the lion’s share of available water exceeding 87 percent of the total available supply.

**Difficult Choices**

Most Arab countries must choose between using scarce water resources to grow grain, and thereby enhance domestic food supplies, or to grow high-value fruits and vegetables for export, which delivers much higher value per drop of water but which can put food security at risk. They must also choose to store and stockpile food supplies or produce them at higher costs at home. These are not simple choices and there are no simple answers. The increased uncertainty about availability and new restrictions imposed by suppliers raise questions about the functioning of international food markets and increase the costs of being caught short of supplies and provisions.

The criticality of the situation for Arab States is becoming more intense and the expanding gap between their growing needs and dwindling supplies for food commodities is exacerbated by their inability to increase agricultural production to a level that is sufficient to meet the increasing food demands.

Arab countries, with minimum variation, tend to import about half of their food requirements, and are considered to be the major importers of grain in the world. Three countries (Egypt, Algeria and Morocco), although among the most important producers of grain in the region, are also among the top ten importers of wheat in the world. The Arab countries, as a group, import more than half of their grain, about 72 percent of sugar demand, 68 percent of vegetable oil, 31 percent of dairy products, and 14 percent of meat needs. As a result, the food gap has increased, and so has the net value of food imports; the latter increased from $10.2 billion U.S. in 1980 to $28 billion U.S. in 2009, and out of the $16.3 billion U.S. of Arab grain imports, more than half was wheat. It is expected that the value of this gap will reach $80 billion U.S. by the year 2030.

Recent recurrence of sharp increases in food prices after the episode of 2008 has again triggered grave concerns about food security, malnutrition and increased poverty in the Arab World. The current round of price escalation is cause for more concern as it is occurring at a time when the Region is undergoing political turmoil. In this round, international food prices are not only higher; they have already reached the 2008 peak at the end of January 2011 and also appear to be more volatile.

Surging international prices and sharp swings have had direct and severe effects on the region’s governments and public as they have induced upward pressures on national and household budgets exacerbating deficits and declines in purchasing power. The extent to which these budgets are compromised varies with the level of domestic consumption, subsidies and the pass-through from international prices. Prices of two principal commodities, cereal and sugar, that account for roughly 61 percent of Arab per capita caloric consumption have already experienced
high degree of volatility. This is largely because 58 percent of consumed cereal and 75 percent of sugar is imported in the Arab World and the price index of these two commodities rose by 40 percent and 77 percent between 2008 and 2010, respectively. A sustained surge in international prices of food tend to hit the poor of the region more significantly than other segments of the population as the poor spend as much as 65 percent of their income on food.

A number of drivers of the current high agricultural prices are similar to those observed in 2007/08 including high energy prices, depreciation of the US$ against most currencies, and high levels of financial investment in agricultural commodities. There are, however, a number of additional factors this time around; these include (i) broader based increases in agriculture commodity prices, (ii) adversities prompted by inclement weather and greater climate variation, and (iii) recent trade policy responses such as Russia’s ban on exports in late 2010 that further raised the amplitude of the grain price spikes in 2011. Add to this the increased use of agricultural commodities in the production of bio-fuels which placed an additional demand on these goods and contributed to a significant rise in their prices.

These effects could have been mitigated had there been opportunities for expansion of arable land in the Arab World. Excluding Sudan, the amount of permanent and arable cropland increased at an annual growth rate of 1.7 percent from 1995–2005 relative to 6.7 percent growth in Sudan and 2.3 percent worldwide. A rapidly growing population creates a troubling future: by 2050, Arab arable land per capita is projected to reach 0.12 ha, a fall of 63 percent from its 1990s level.

Saudi Arabia, Kuwait and few other oil surplus economies have been able to mitigate price and quantity vulnerabilities given their large fiscal surpluses which allow them to build high reserve stocks and offer subsidies to avoid pass through of international prices. Egypt, Syria, and Morocco face high price risks, but their quantity risk is lower due to higher domestic production levels. The most vulnerable countries include Yemen, Jordan, Djibouti, Lebanon, and Tunisia. These are the countries that have low grain reserve stocks and less fiscal room to bear the costs of imports and its subsidization.

Land constraints despite the limited availability of arable land in the region are less binding than water constraints. Every drop of water counts in the Arab region as shadow prices (scarcity prices) of water are relatively high. Water productivity defined as value added after subtracting farming costs has been estimated in the Arab region as follows:

- An average of $0.1 U.S. /m³ from flood-irrigated cereals, $0.5 U.S./m³ from flood-irrigated cash crops and $0.75 U.S./m³ from modern-irrigated cash crops.

- These estimates are higher in Lebanon where water productivity from modern-irrigated cash crops can reach $1 to $2 U.S./m³. It is also estimated that the irrigation net diversions/year is around 150 billion m³/year. If the same volume of water is used in exporting cash crops rather than grain, the net value added to the Arab World will be at least $75 billion U.S./year². There is a cost to pursuing self sufficiency and higher food security. These estimates show that the region will forgo high value added if it uses its

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² 150 billion m³/year multiplied by an inter-sectoral shadow value of water of at least $0.5 U.S./m³.
scarce water to grow more cereals at $0.1 \text{ U.S.}/m^3$. But there are costs and significant risks for the Arabs to expose themselves to quantity shortages given the recent experience of export controls exercised by some large producers of grain. It pays to balance higher value added returns against food shortages risks.

It is to be expected that more water will be diverted from agriculture to meet the growing demand from priority sectors such as households and the industrial sector. As a result, agriculture’s share of water in the region will drop from the current 87 to about 50 percent in 2050. This reduction will seriously threaten food security and the already fragile environment. With declining water for agriculture the only solution to enhance food security or even to maintain current production levels is to sustainably and substantially increase the productivity of water.

**Improving Efficiency of Water Use**

Water productivity (WP) is not restricted to higher output levels per unit of water. The return or the benefits derived from each cubic meter of water consumed has many dimensions. This return may be biophysical (grain, meat, milk, fish etc.), socio-economic (employment, income), environmental (carbon sequestration, ecosystem services) or nutritional (protein, calories etc.). Most of the water is consumed through evapotranspiration and is therefore “unrecoverable.” Recycled water is not considered to be consumed or depleted.

Improving WP depends on the objective of the user and on the scale of operations. At the field level it is desirable to maximize the biophysical WP of a specific crop or product. At the farm level, the farmer would seek to maximize the economic returns from the whole farm which could involve multiple crops or products. At the country level the drivers for improved WP are food security and exports. At the basin level, competition between sectors, equity issues and conflicts may drive WP issues. Research has shown that it is within reach to, at least, double the current productivity of water used in agriculture in the region. This is equivalent to doubling the amount of water available at the current productivity level.

WP can be improved in many different ways but particularly through implementing modern technologies, adopting more efficient water management methods such as supplemental irrigation and water harvesting, improved cropping patterns and agribusiness practices, and using improved germplasm. Rainfed agriculture still has the highest potential for increases in water productivity and food production in the region’s agro-ecosystem given its extensive use.

Oweis (Comments on Chapter 3) argues that a trade-off needs to be made in the region in order to optimize the use of both water and land resources. This, in his opinion, will require substantial changes in the way we think and undertake agricultural development. These changes include adopting new irrigation guidelines using deficit irrigation, changing cropping patterns, reforming water policies to value water appropriately to encourage conservation and rational use, increasing the support for agricultural research and development, encouraging people’s participation and promoting regional cooperation.

Modern irrigation systems, such as drip and sprinklers, generally deliver higher water application efficiency than traditional surface irrigation. The lower efficiency of surface systems is due to
higher deep percolation and runoff losses. These losses occur at the field level but may be fully or partially recovered at the scheme or basin levels by recycling drainage and runoff losses or by pumping deep percolation losses from groundwater aquifers. This encourages countries to convert from traditional systems to modern ones. Irrigation losses in Egypt, for example, are recycled through the drainage systems several times before becoming too saline for agricultural use. These modern systems such as sprinkler and drip irrigation can only be efficient if they are managed properly. In many areas the efficiency of modern systems is as low as that of surface systems because of poor management. Modern systems do not guarantee high efficiency; surface systems may be better under certain circumstances especially as farmers know them well. The selection of the appropriate system depends on the physical, managerial and socioeconomic conditions at the site.

Drip and Sprinklers and other modern irrigation systems increase productivity not because they reduce system losses in deep percolation and runoff, but due to better control, higher irrigation uniformity and frequency, better fertilization and other factors. The benefits, however, come at a cost: capital, energy and maintenance. Successful conversion requires developed industry, skilled engineers, technicians and farmers, and effective maintenance. They are most successful in areas where water is scarce and expensive, so that farmers can recover the system cost by reducing irrigation losses and increasing productivity. When water is ample and low in cost, farmers have little incentive to convert to modern systems. In fact improving surface irrigation systems through land leveling and better control may be more appropriate for most of the farmers in developing countries. The vast majority of irrigation systems in the world are surface and assuming that this will change in the near future is unrealistic. A wise strategy is to invest more in improving surface irrigation but opt for modern systems when conditions are favorable.

In many Arab countries, investment is directed to conversion to modern irrigation systems. But the increased efficiency, according to Oweis, is obtained from the improved performance of the system—not the performance of the water. It is possible to have very high irrigation efficiency but low agricultural productivity. Irrigation efficiency and productivity are not synonymous. Investment should, therefore, also be directed to increase water productivity.

Food security depends on consistent availability of sufficient food supplies, and also on stable access to resources to acquire food, and the proper use of food to achieve nutritional well-being. Countries achieve food security at the national level when each citizen is food secure.

**Logistics and Infrastructure**

Poor logistics and deficient supply and storage management may result in spillage and spoilage of food imports, exacerbating supply risks. While improving logistics will not reduce exposure to volatility or structural increases in international food prices, it can smooth some volatility in domestic food prices as well as reduce the base cost of importing food and thus the severity of future price shocks. This is all the more so in the case of Arab wheat imports.

With net wheat imports of approximately 36 million metric tons in 2009 and 2010, Arab countries are the largest net importers of wheat in the world. On average, Arab countries spent about 1.3 percent of GDP on wheat imports in 2009, ranging from less than 0.1 percent in Qatar to 3.1 percent in Yemen.
Battat et al. (Chapter 4) assessed the Wheat Imports Supply Chain (WISC) performance in 10 Arab countries, identified possible bottlenecks, and provided recommendations to help manage exposure to import supply and price risks. They argued that Arab countries’ price risk and supply risk can increase significantly if supply chains fail to perform. They examined ways in which countries can reduce WISC logistics costs (measured in US$/mt) and transit times (measured in days) to ensure a reliable and efficient WISC. Performance was assessed at each segment of the WISC from the unloading port to bulk storage at the flour mill.

Based on the selected corridors for each participating Arab country, they found that the average WISC transit time in 2009 was 78 days. Dwell time of wheat was the major driver of overall WISC transit time, accounting for 87 percent of total transit time. Both operational and strategic storage were included in this figure, reflecting throughput volumes and logistics as well as policy decisions. The other main driver of transit time was vessel turnaround time, accounting for 12 percent of total transit time. Although transport networks in many Arab countries are frequently inefficient, inland transportation accounted for less than 1 percent of transit time and did not appear to be a main bottleneck in terms of the overall transit time for an average metric ton of wheat. For comparison’s sake, WISC transit time in the Netherlands was approximately 18 days while it is around 47 days in South Korea. Both South Korea and the Netherlands are large importers of wheat.

In the WISC benchmarking exercise in Chapter 4, Battat et. al. found that supply disruptions can first occur at the port, threatening food and overall national security, especially in times of crisis. The first transit segment is vessel turnaround time; they found that on average, wheat vessels arriving at ports in Arab countries had a turnaround time of 9.5 days, including both waiting time in the harbor and discharge time. While discharge time is a function of unloading capacity and the cargo volume, waiting time is largely independent of vessel size and could be minimized. On average, vessels arriving at ports in Arab countries in 2009 waited about three days before they began discharging wheat.

Among Arab countries there was quite a range of waiting times. Relative to vessels unloading in the Netherlands, vessels waited up to eleven times longer, significantly impacting overall vessel turnaround time. The waiting times in Arab countries can be compared to waiting times of less than one day in the Netherlands and nearly six days in South Korea. Such long waiting times in Arab countries have significantly impeded the timely delivery of wheat to people in need. Not only was there a range in the average waiting time across countries, but within a single country waiting times varied from vessel to vessel. These long waiting times cause major disruptions to the WISC and could have severe consequences for food security. While the source of these bottlenecks can vary from country to country, reducing waiting time in the harbor for some countries could help quickly deliver supplies during emergencies.

Ghanem (Comments on Chapter 4) feels that the authors of the infrastructure paper have focused on bringing the wheat from the boat to the consumer, which is important in itself but there is a critical point before that, which is getting the wheat on the boat. The orderly functioning of international food markets are now in question. There is an issue as to whether countries, who face chronic food deficits, as is the case for most of the Arab countries, can safely depend on trade to ensure their food and nutritional security. We have seen over the past four years countries imposing export restrictions, and changing their trade policies. That obviously has an
effect on the world prices: it pushes world prices up, but it also poses quantity risks for those who are dependent on them for imports. Ghanem believes this is an issue that needs to be brought up, and Arab countries should be heard in international forums. They have hitherto been conspicuously silent in the international arena on this matter.

Ghanem also argued for having not necessarily common food reserves but, at least, coordination amongst countries of those reserves. Arab countries need to look at Asia’s lessons who have agreed to put together joint reserves for rice and building joint rice stocks. The argument here is for security reserves or emergency reserves, and not buffer stocks which manipulate the market. The experience around the world in buffer stocks has been disastrous, except in a few cases. These reserves have to have clear objectives and there is a need to have important rules on how to use them, when to use them, and rules on how to move and protect those reserves. Ghanem points out examples of countries with emergency reserves but he notes that the quality of these reserves seemed to deteriorate very quickly because these countries did not know how to manage them. India is an example of a country with huge losses from their reserves due to poor management. Food stocks are not only held by governments; actually, most food stocks throughout the world are held by the private sectors. This calls for putting in place policies that encourage farmers and the private sector to hold adequate levels of inventories. In a general sense we need Arab countries to finance big warehouses, encourage their use, and provide warehouse receipts which farmers can use to obtain credit, and so on.

While it is important to reduce costs of transport, there is another important area in need of reform and that is procurement reform. The Arabs need to put in place procurement laws and systems that ensure the attainment of the best prices. Transport costs are important but they are only a fraction of the total cost of food purchases.

**Financing Food and Water Security**

The food crisis of 2008 created a surge in cereal prices that left many developing countries reeling. According to FAO estimates, 105 million people were thrown into poverty by the price shocks of 2008, and over 1 billion were left without enough food to eat. The global community responded with a flurry of measures designed to ease the crisis. The World Bank in cooperation with the G20 nations and the United Nations High-Level Task Force on the Global Food Security Crisis set up the Global Food Crisis Response Program (GFRP) to provide short-term, rapid help to people in the direst need, and subsequently the Global Agriculture and Food Security Program (GAFSP) to address longer-term issues. While these programs helped mitigate the immediate impact of the 2008 food crisis, reducing world hunger by close to 10 percent by 2010, there were still more people without enough food in 2010 than there had ever been before.

Cackler (Chapter 7) argued that while there are multiple pathways out of poverty, improving support to agriculture has proven to be among the most effective. The World Bank has estimated that GDP growth in agriculture benefits the income of the poor two to four times more than GDP growth in other sectors. The most important impact on agricultural GDP will come from increases to productivity. This is particularly so in most Arab countries where arable land and water are stretched to their limit, making it virtually impossible to expand the area under cultivation. Spending on agricultural research and development to increase productivity has been shown by the World Bank to have rates of return of up to 36 percent in Arab countries.
Development assistance in agriculture declined dramatically between 1988 and 2000—falling by more than half from $9 billion U.S. to about $4 billion U.S. Over the past decade, Official Development Assistance (ODA) has gradually climbed back up—to $6.3 billion U.S. in 2008. However, growth in agricultural assistance has not kept pace with overall aid, dropping from a high of 25 percent of total ODA in the 1980s to only 4.5 percent in 2008, in spite of the fact that 75 percent of the world’s poor live in rural areas. The Middle East (Mashreq) region, however, has seen the highest rates of growth in agricultural aid of any region in the past decade, outstripping overall aid growth in the region by almost 50 percent. In North Africa, ODA to agriculture has focused on water resources. In 2008, investments in water represented 46 percent of all agricultural spending in the region. Investment in agricultural finance has dropped by almost half from 2000–2003 levels. This reduction; however, reflects in part a number of policy shifts which have moved away from commodity-targeted credit in favor of broadening and deepening general financial services, and this aid is therefore no longer identified as specifically agriculture-related.

In the Middle East and North Africa (MENA Region), where no investments had been made earlier in the decade, the World Bank committed $350 million U.S. to agricultural aid in 2011. Its support will focus on three elements to reduce future vulnerability to food insecurity:

- (i) strengthen safety nets, provide people with access to family planning services, and promote (nutrition) education;
- (ii) enhance the food supply provided by domestic agriculture and improve rural livelihoods by addressing lagging productivity growth through increased investment in research and development; and
- (iii) reduce exposure to market volatility by improving supply chain efficiency and by more effectively using financial instruments to hedge risk.

Investment in agricultural research and development pays large dividends. Yet Arab countries invest only about 0.7 percent of agricultural GDP in research and development. This is slightly higher than the average of 0.53 percent for developing countries, but far below the recommended investment level of 2 percent of agricultural GDP. On the other hand, developed countries invest 2.36 percent of agricultural GDP on research and development.

Cackler presents a set of characteristics that has proven its merits in financing agriculture, particularly smallholder farmers. These include:

- Loans to finance agriculture needs to be provided as part of a broader set of financial services (savings, payments, insurance) and also include loans for consumption smoothening so that loans to finance agriculture are not diverted for consumption smoothening.
- Loans must be large enough to be adequate to help farmers make productivity enhancing investments (high quality seed, fertilizer, equipment) that will make farms more productive.
• Loans duration needs to match that of the duration of the crop being financed, and therefore, typically a longer duration than typical microfinance loans.

• Repayment schedules must also be based on the production cycle of the crop in question, and therefore typically involving most of the loan amount being repaid at the end of the loan term, unlike microfinance loans that are repaid on a weekly or monthly basis.

• Interest rates must be high enough to be sustainable for the financing institution.

A new support program is now funded by the World Bank and Gates Foundation. The Agriculture Finance Support Facility (AgriFin) has significantly increased access to financial services for smallholder farmers and other enterprises in rural areas. The goal of AgriFin is to demonstrate that providing financial services to smallholder farmers and other enterprises in rural areas can be a profitable business for financial institutions. The major activity of AgriFin is to provide grants to regulated retail financial institutions to support the expansion of their agriculture and rural finance business. The grants will finance up to 50 percent of the business development costs, structured on a case-by-case basis. The grants can be used for a broad range of activities and related costs, including technical advice, rural outreach infrastructure, such as smart cards and card-reading devices, training expenses for staff and clients, consultancy expenses, and staff salaries. AgriFin may be able to provide support to financial institutions in Arab countries to extend the critical financing that will allow smallholder farmers to thrive. Making Arab farmers aware of this facility can help increasing the access of smallholder farmers in the region access finance that is typically not available to them.

**Conflict and Food and Water Security**

Political instability in the Arab World is one of its most defining characteristics. The effects of conflict further exacerbate the food and water deficits in a number of countries by weakening public institutions, creating parallel or extra-legal economies, and rampant violence and forced displacement. The effects of conflict, both at the national and at the household level put many people at risk of poverty and food insecurity, especially in rural areas where people are highly dependent on agriculture, for both food and livelihoods.

Losacco and Khouri (Chapter 2) argue that given the vulnerability of the poor to food insecurity and their exposure to the negative effects of conflicts, rural development interventions - which are specifically directed towards rural poor and marginalized groups – could help reduce the vulnerability of communities to conflict.

This is possible through a wide range of actions, which include: microfinance and credit, creation of off-farm job opportunities for rural youth, land and water resources’ management and strategies to reduce vulnerability to climate change.

Losacco and Khouri draw on two recent studies to confirm the sensitivity of the poor and vulnerable to conflict and its consequences. The first study was conducted by FAO on 38 countries which experienced conflict between 1961 and 2000; it demonstrates that agricultural and food production per capita and GDP per capita decline significantly during conflict and
remain low during the subsequent 5 years (a decline on average of about 1.5 percent for agricultural production and of 2.2 percent for GDP per capita for each year of conflict). The second study was conducted by IFPRI and it shows how consistent the impact of conflict is on food security. The rate of food insecurity in most conflict/post conflict countries exceeds 20 percent and, more importantly, usually exceeds the rate of the population in need of humanitarian assistance.

There are, however, several international agencies that have developed delivery mechanisms, involving a considerable number of NGOs and international/national organizations with an extensive presence in the field, with the scope to promote development in rural areas. Their interventions, beyond contributing to decreased food insecurity and improved living standards, are helping to prepare rural communities to deal with the effects of conflict. They do so by providing smallholders and the rural poor with more options, assets and resources, thus increasing their chances of survival in situations of conflict.

**Case Study of Tunisia—A Success Story of a Country with Food and Water Security**

The Arab Fund for Economic and Social Development (Chapter 3) has tendered the experience of Tunisia as a model for other Arab countries to consider as a leading example of rational strategies to deal with Food and Water security issues. The choice of Tunisia for the case study is instructive as meaningful given that Tunisia is one of the most "water-poor" countries in the MENA region and suffers from most of the binding constraints governing agriculture and water. Yet, Tunisia was able to implement a long-term water and agricultural strategy that has achieved some impressive results. The Tunisian success story can be summed up as follows:

1. Integrated and coordinated planning of both agriculture and water sectors: the fact that a single ministry is responsible for the two sectors has ensured effective integration and coordination. It is still an issue whether having the two departments within one ministry would bias water usage in favor of agriculture.

2. Implementation of a sophisticated information system for the management of water and natural resources. This of course takes for granted the existence of technical and info-structure in place to support this system.

3. The recognition that close monitoring and evaluation of surface and ground water resources is critical.

4. Optimizing the use of occasional flood waters for artificial aquifer recharge.

5. Implementation of a comprehensive program for soil and water conservation, including major investments in water harvesting infrastructure and soil erosion control.

6. Promotion of exports of crops (e.g. olives, dates, citrus) that have the highest economic returns per unit of water and using export earnings to cover the costs of imports of staple grains.
Tunisia provides a serious example of the right mix of incentives (water tariffs and subsidies for modern irrigation) encouraging farmers to rapidly adopt improved irrigation techniques. Tunisia has reached one of the highest rates of adoption of modern irrigation techniques in the Arab region. In other Arab countries governments have focused on providing subsidies for irrigation equipment without increasing water tariffs, which has led to some very low levels of adoption. Optimal intervention and subsidies must target end-results and not intermediate inputs.

The Tunisian experience is clearly a useful success story, and may be replicable in a number of small and highly water stressed countries such as Jordan, Lebanon and Yemen.

One very important factor for the success of the Tunisian food security strategy is the highly effective and efficient Tunisian’s population control policies that managed to achieve one of the lowest rates of population growth in the Arab World. This has probably contributed to a very moderate increase in the demand for food and allowed the country to maintain a reasonable balance between the value of food imports and agricultural exports. Other Arab countries, particularly in the Mashreq continue to have relatively high population growth rates that are contributing to undermining their overall food security and greater water deficits.

The pre-requisites for the implementation of this strategy include: (1) building institutional and organizational frameworks for the water and agricultural sectors; (2) the need to increase irrigation efficiency; (3) increasing crop yields; (4) maximizing net economic returns to water; and (5) development of non-traditional water resources and their utilization. The Arab Fund’s arguments in favor of the program particularly stress the need to improve irrigation efficiency through the adoption of improved irrigation methods. It also stresses the critical importance of implementing reasonable water charges to provide the necessary incentives for farmers to use water more efficiently, including the incentive to invest in modern irrigation. In stressing the importance of maximizing net returns to irrigation water, the Fund has implicitly supported the broader concept of food security rather than the unsustainable concept of food self-sufficiency.

Recommendations

Every paper and the entire discussions in the book and the symposium have advanced a rich mix of policy recommendations to address the challenges of food and water security in the Arab World. The main recommendations are presented below under thematic headings:

Integrated Water Demand Management

- A strong and comprehensive demand management program with structured tariffs is a necessity. Besides programs to encourage conservation and protection of agricultural land and water are also required.

- Change the way water is valued to truly reflect its scarcity. Water is extremely valuable in water scarce areas and should be used as such. Farmer support can be better designed to avoid inefficient use of water. Graduated S-Shaped prices for blocks are
recommended. The low usage cohorts will pay a very low price whereas high volume users will pay a much higher tariff. This way both efficiency and equity consideration can be met.

- Change trade policies to import food where there is no comparative advantage in local production. Large amounts of water cross borders as virtual water. This needs to be adjusted to reduce water demand, support existing farming communities and rationalize socioeconomic decisions.

- Generalized food subsidies are widely used in Arab countries, for example in Egypt, Jordan, Morocco and Syria. These subsidies have substantial drawbacks. First, they distort consumer decisions and lead to an over-consumption of the subsidized commodity, usually cereals. The result is a great deal of waste and demand that is increasing at very high rates. With current policies, cereal imports in the region will increase by 55 percent over the next two decades. Egypt’s imports will increase by more than 100 percent. Increasing food self-sufficiency is not a matter of just producing more locally. It is also a matter of rationalizing demand, which can be achieved by avoiding generalized subsidies. A shift from subsidizing prices to subsidizing incomes is necessary for efficiency and effectiveness of interventions.

**Enhancing Efficiency/Productivity of Water and Agricultural Land**

- A major investment plan is needed to modernize the irrigation and drainage sector. In addition large investments are urgently required in supplementary irrigation for the rainfed land. This should be part of a major regional investment program in ground and surface water management.

- The main focus of the region should be on increasing the yield of crops per unit of water. The Chinese in particular have very carefully monitored these rates and have been very successful at using the data to increase the agricultural productivity per unit of water. The region may benefit from the Chinese approach to maximize production by integrating the engineering aspects with the agronomic and institutional aspects that cause water savings and productivity increase.

- Special programs to encourage farmers to adopt modern irrigation systems; there should be a government program (supported by regional and international funding agencies) which supports the farming communities in the introduction of water-efficient systems. The introduction of such systems should be based on a cost-sharing arrangement whereby beneficiaries contribute (depending on the country and region) between 30 percent to 70 percent of the cost of investments and whereby small pilot/demonstration farms would be established on beneficiary land to train farmers in the region on best practices. Such systems have been ongoing in Yemen over the last two decades with Bank/IDA financing and support.

- Change the emphasis from land to water when water is more limiting than land. Maximizing water productivity can alleviate water shortages and improve food security.

- Change current land use and cropping patterns to more water-efficient crops and cropping systems based on comparative advantages among agro-ecologies, especially in rainfed systems.
• Change from disciplinary to integrated approaches. Maximum productivity will never be reached unless all production elements are optimized.

• The Arab countries could and should at least double the research and development budgets in agriculture. There are major advances available at the region with gene banks, special varieties and techniques that can contribute handsomely to Arab agricultural productivity.

**Effective Regional Cooperation Systems and Initiatives**

• The countries in the region should also benefit from each other’s experiences in water savings, from the increases in productivity, and from the promotion of agricultural exports. The Tunisian experience and success story should be studied and implemented where applicable.

• Change the attitude towards regional cooperation, encourage and improve Arab coordination, harmonization of policies and management. Water productivity can be enhanced if food is grown in Arab countries with comparative advantages in water, climate, soils and socioeconomics.

• Arab countries need to form a position and make it known in World forums and institutions whether in the G20 meetings, FAO, World Bank or WTO. In the context of the WTO, there is also an opportunity to raise this issue. Short of obtaining an agreement prohibiting countries from imposing export restrictions, some mechanism to minimize impact on trading partners should be found.

**Institution Building and Effective Governance**

• The region should move from securing staple crops towards a more diversified basket that includes growing cash crops with the aim to increase exports by using their comparative advantage and then use some of the money generated from the exports to import staple food.

• Climate change and its impact on agriculture and water should be studied and adaptation measures should be mainstreamed in agriculture and water development.

• There should be more focus on building institutions in the water and agricultural fields, including R&D.

This book contributes to the debate on the complex issues of food and water security; it opens a necessary debate about two critical and existential deficits. Time is running out on indifference and hesitation, and in the balance is the future of the Arab World.
CHAPTER 1—ACHIEVING ARAB FOOD AND NUTRITION SECURITY IN TIMES OF INCREASED FOOD PRICE VOLATILITY

Hafez Ghanem
Assistant Director General, FAO

Introduction

This note updates the working paper on ‘Improving Food Security in Arab Countries’ published in January 2009 by the World Bank, FAO and IFAD. It starts by presenting an outlook for food markets till 2020 based on joint work by FAO and OECD. It argues that over the medium term food prices are likely to remain high and volatile. It presents some explanations for increased volatility. Arab countries import about half of all the food calories they consume. Hence, they are particularly affected by international food price volatility. The policy recommendations in the 2009 working paper remain valid. In particular, action is needed by Arab countries in four areas: (1) replacing generalized food subsidies that encourage waste and over-consumption by targeted safety net programs; (2) increasing public investment in agricultural research and development with the objective of at least doubling it in the short run; (3) putting in place an import strategy which includes maintaining adequate emergency reserves and using financial tools for hedging risk; and (4) encouraging a new type of Arab investment in other countries’ agricultural sectors that does not rely on large land acquisitions and respects the seven principles of Responsible Agricultural Investment (RAI).

The period since 2006 has been one of extraordinary food price volatility, and most observers expect that the trend of higher and more volatile food prices will continue over the medium term. This poses a global challenge of ensuring food and nutrition security for a growing world population when about one billion people are already undernourished today. As major food importers, highly dependent on world markets for their food and nutrition security, the challenge facing Arab countries is particularly severe. This note seeks to highlight some of the policy options raised in previous work by the World Bank, FAO and IFAD on food security in the Arab World, showing how they may be particularly appropriate for dealing with food price volatility.

Global Developments and Regional Implications

Ensuring food and nutrition security in the 21st century is an important global challenge, and a particular concern for Arab countries. At the global level, FAO estimates that there are about 925 million undernourished people in the world today. This represents 16 percent of the world population, down from 18 percent last year but still well above the 10 percent target set by the first Millennium Development Goals (MDG). In sub-Saharan Africa 30 percent of the population is undernourished. This is clearly a humanitarian and development disaster. It is also a challenge for world peace and security. We all remember the food riots of 2007-2008 that rocked more than 20 countries. In an increasingly interdependent world, political instability in one part of the globe affects everybody else. While the numbers of undernourished people in the
Arab World remain low (except for Yemen and Sudan where 30 percent and 22 percent of the population respectively is undernourished), many are around or below the poverty line and are deeply affected by changes in food prices.

The task of ensuring food and nutrition security is not likely to get any easier, for the world at large and particularly for the Arab region. World population is expected to grow by over a third (or 2.3 billion people) between now and 2050 when it will reach 9.1 billion. Nearly all of this increase is forecast to take place in developing countries. Urbanization is foreseen to rise at a rapid pace with urban areas are expected to account for 70 percent of world population in 2050, up from 49 percent at present. If global economic growth continues at about 2.9 percent annually, per capita incomes in 2050 will be a multiple of today’s levels. These trends imply a rise in the overall demand for food by about 70 percent, as well as a change in its composition. For example, while the world demand for cereals (for food consumption) is expected to rise from 2.1 to 3 billion tones, the demand for meat would nearly double to reach 470 million tons in 2050. The task will be even more difficult for the Arab countries because population growth is projected at 1.9 percent compared to a global average of 1.1 percent, income is expected to grow at 3.4 percent rather than the global average of 2.9 percent and the urban population is increasing at 3 percent a year.

Food prices are expected to remain high and volatile over the medium term. The 2010 “OECD-FAO Agricultural Outlook” predicted that average nominal prices of food products for the decade ahead would be the same as their levels in 2007-2008 (which was a peak price period) or exceed them by some 10-20 percent. In February 2011, the FAO food price index rose by 2.2 percent from January 2011 to reach the highest ever level since its inception (1990) in both real and nominal terms (Figure 1). Food prices have fluctuated wildly over the last four years. The index rose from 122 in 2006 to 214 in June 2008 as the 2007—2008 food price crisis unfolded. The index then fell rapidly in the second half of 2008, reaching 140 in March 2009. In the latter half of 2010, it increased markedly, especially after a severe drought hit Russia, and reached 215 in December, surpassing its 2007-2008 crisis peak.

Figure 1. FAO Food Price Index

High and volatile food prices are a result of the neglect of agriculture over the last three decades which led to a slowdown in yield growth while demand for food continued growing. Low food prices during the 1980s and 1990s appear to have convinced governments and the private sector that food and nutrition security is not a major problem. They allowed investment in agriculture to decline sharply. 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 during the period 1991-2007. 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. FAO estimates that in order to

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meet growing food demand, annual investment in agriculture needs to increase by at least 50 percent.

In addition to long run developments in supply and demand, FAO consistently finds that volatility in four variables—petroleum prices, crop yields, food stock levels and exchange rates—significantly increases food price fluctuations. First, petroleum price volatility—which tends to be high—translates into food price volatility through transportation costs and fertilizer prices. The link has become even stronger with the advent of biofuels, which require food crops as inputs and can therefore change food prices. Between 2000 and 2009 global output of bioethanol quadrupled and production of biodiesel increased tenfold. Second, because the demand for food is inelastic, small changes in supply can lead to large changes in prices, meaning that even limited crop yield volatility can have large effects on food price fluctuations. The role of crop yield variability is only expected to rise as extreme weather events become more common and as the Black Sea Region (where yields are more volatile than the rest of the world) increases in importance as a major exporter. Third, food price volatility is inversely related to the level of food stocks—as stocks fall, price volatility rises. Both public and private actors have lowered stocks in recent years. Finally, changes in exchange rates, especially of major exporting countries, translate to changes in international food prices. Thus, as macroeconomic factors lead to more volatile exchange rates, food price volatility also rises.

In an extraordinary meeting that followed the drought in Russia, the Intergovernmental Group (IGG) on Grains and Rice pointed to an additional cause of price volatility: the lack of reliable, up-to-date information on crop supply and demand, stocks, and export availability. The role of speculators in increasing food price volatility remains controversial. Market liberalization and financial deregulation have led to a rapid increase in the volume of transactions in commodity exchanges. Ninety billion bushels of wheat worldwide were traded on the Chicago Board of Trade in 2009—the equivalent of trading the entire U.S. Soft Red Wheat crop every business day. Most of those transactions must have been speculative. As a result, it is possible to argue that increased speculation contributed to higher food price volatility. However, real factors such as production shortfalls in key exporting countries—and not speculation—triggered the two recent bouts of volatility (in 2007-2008 and 2010). Moreover, the futures' markets, where speculators tend to operate play important societal roles by discovering (please explain) prices and providing liquidity, suggesting that over-regulation could further hurt the food market.

Policy measures put in place by a number of governments (such as export restrictions or hoarding) increase international price volatility. For example, according to analysis carried out in 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.

Arab countries are particularly affected by those international developments. They are the largest cereals importer in the world and depend on world markets for 50 percent of their caloric intake, and this import dependence is likely to increase so that by 2030 nearly two-thirds of the calories consumed in Arab countries will be imported. Thus international food price volatility has an immediate impact on Arab countries’ macro-economic balances, poverty levels and food and nutrition security. In the remainder of this note I propose that in order to deal with increasing food price volatility, Arab countries need to adopt a four-pronged action plan: (1)
replacing generalized subsidies by targeted safety nets; (2) increase investment in agricultural research; (3) develop new strategies for imports and food reserves; and (4) encourage responsible international investment in agriculture. This action plan is based on the work done in a 2009 joint paper by the World Bank, FAO and IFAD on ‘Improving Food Security in Arab Countries.

**Food Subsidies and Safety Nets**

Generalized food subsidies are widely used in Arab countries, for example in Egypt, Jordan, Morocco and Syria. These subsidies have substantial drawbacks. First they distort consumer decisions and lead to an over-consumption of the subsidized commodity, usually cereals. The result is a great deal of waste and demand that is increasing at very high rates. With current policies, cereal imports in the region will increase by 55 percent over the next two decades. Egypt’s imports will increase by more than 100 percent. Increasing food self-sufficiency is not a matter of just producing more locally. It is also a matter of rationalizing demand, which can be achieved by avoiding generalized subsidies.

Second, over-consumption of subsidized cereals also implies under-consumption of other foods that are important for balanced nutrition. This leads to poor nutrition and undesirable health outcomes. Subsidies on unhealthy foods like bread, sugar and cooking oil make a balanced diet less attractive. Obesity, high intake of animal fat, and low intake of dietary fiber are risk factors for chronic non-communicable diseases such as coronary disease, diabetes and breast cancer. 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 avoiding generalized subsidies to unhealthy foods.

Third, generalized subsidies are too expensive and mostly go to the non-poor, usually in urban areas. Being non-targeted they are unnecessarily costly and wasteful. Moreover, food distribution systems entail heavy administrative overhead and substantial wastes due to storage losses, and they encourage corruption and leakage of food to non-human uses. Food subsidies cost about 2 percent of GDP in Jordan and Syria, 1.3 percent in Egypt and 0.7 percent in Morocco. These are resources that could have been used to more directly help the poor or to invest in education so that young people are better equipped to enter the labor market.

Most countries around the world are replacing generalized subsidies by targeted safety nets for the poor. But many safety net programs in Arab countries do not serve the poor well. They mostly use categorical targeting approaches—for example, single mothers, widows, unemployed, elderly or disabled. These categories include people who are not poor. Egypt’s social assistance program covers less than 12 percent of the poor and has a benefit leakage rate to the non-poor of more than 50 percent. In Yemen, the Social Welfare Fund reaches only 13 percent of the poor, and about 70 percent of the people who receive transfers from the Fund are not poor. The National Aid Fund in Jordan covers less than 20 percent of the eligible population and some 85 percent of those who receive aid are actually not eligible.

Arab countries need to improve the design of their safety net programs to ensure that all the poor are protected and that resources are not leaked to people who do not need them. In doing so they could benefit from the experiences of Latin American countries that use conditional cash transfers to provide targeted assistance while fostering human capital development and helping
break the vicious cycle of poverty. For example, transfers could be made conditional on a child attending school, or receiving necessary immunizations. Brazil’s Bolsa Familia and Mexico’s Progresa/Oportunidades are examples of successful large scale conditional cash-transfer programs.

The argument against reducing generalized food subsidies and replacing them by well-targeted safety net programs has mostly been political. Generalized subsidies are widely popular, especially in densely populated urban centers. Therefore, it could be useful to start broad national dialogues on the subject so that Arab populations are better informed of the drawbacks of generalized subsidies and alternative policies and programs that could provide better protection for the poor and contribute positively to food and nutrition security as well as overall economic development.

**Investment in Research**

Food production in Arab countries is limited by scarce land and scarcer 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 ha, 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 ha. 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 (when exactly), water per capita in the Middle East and North Africa Region is about 1,100 cubic meters compared to a world average of 6,300 cubic meters.

The above implies that future increases in food output, required to reduce import dependency, will have to be based on enhanced productivity and a more efficient use of scarce land and water resources. Productivity in Arab countries lags behind other developing countries. Cereal yields are currently at half the world average and the gap is growing. In the mid-1980s productivity in Arab countries started catching up due to the widespread adoption of improved wheat and rice varieties in Syria and Egypt. Recently, however, productivity growth in the Region started falling again. Water scarcity makes it difficult to raise productivity without greater investment in research and development as well as in extension services to support farmers.

Investment in research and development has many social benefits, including enhanced food and nutrition security and improved rural livelihoods. It benefits farmers as well as food consumers. The rate of return on investment in research and development in Arab countries is estimated at 36 percent. Hence, it is surprising that Arab governments appear not to assign a high priority to research. Arab countries invest about $1.4 billion U.S. annually, or 0.7 percent of agricultural GDP, in research and development. This is far below the internationally recommended level of 2 percent of agricultural GDP as well as the level of investment in OECD countries which averages 2.4 percent of agricultural GDP or an emerging economy like Brazil that invests 1.7 percent of agricultural GDP. Research and development is an area where additional public spending is urgently needed.
Agriculture researchers need to be given greater incentives. The number of researchers in Arab countries is high but they are underfunded and ill-equipped. There are about 14 agricultural researchers for every 100,000 rural dwellers; which compares well with countries like Brazil (11) and Mexico (12). However, funding per researcher in Arab countries is much lower, so researchers have lower salaries and fewer resources, making them less productive than their counterparts in developed and emerging economies.

Governments will need to cover most of the cost of agricultural research since it produces mainly public goods. However, several countries have developed innovative strategies that encourage private sector investment in research and development. In many Latin American countries competitive funding for research and development has become common. Private firms are allowed to compete for public funds, which they can use to conduct research with private co-financing. Governments can also offer rewards for certain innovations, such as drought-resistant wheat varieties that are developed by the private sector. Yet another approach is to encourage innovation by letting farmers apply for grants to implement new technologies and techniques.

Arab countries need to finance and support an ambitious multilateral research agenda. Because many Arab countries share the same goal of food and nutrition security and face the same challenge of water scarcity, a multi-nation initiative could increase the number of beneficiaries from a common research agenda. The International Center for Agricultural Research in Dry Areas (ICARDA) has a mandate that covers most Arab countries. The Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD) has a mandate similar to ICARDA’s and covers all Arab countries. A multi-country research initiative could work with ICARDA and ACSAD and other research organizations to achieve the goal of increased productivity.

Investments in research and development need to be coupled with improvements in extension which must reach large and small farmers alike. Extension’s major failure has been its inability not to provide smallholders with basic information. Extension is necessary to help smallholders produce and market crops with more value added, which will generate more economic opportunity for both the farmers and their communities. Support to smallholders is essential for fighting poverty and ensuring food and nutrition security in Arab countries.

Women represent about 40 percent of farmers in Arab countries. A recent FAO study shows that because women have less access to technology, inputs, credit and land their productivity is 20-30 percent lower than that of men. The study argues that closing this gender gap could lead to an increase in agricultural GDP by 2.5-4 percent. That is why a renewed extension in Arab countries should pay special attention to the needs of women farmers.

Import Strategies and Food Reserves

As major food importers, Arab countries need to develop strategies to protect their food security in a world of high and volatile food prices. One area that deserves special attention 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 recently used these instruments to fix the price of its corn imports and avoid another ‘tortilla crisis’. Future contracts 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 $5 million U.S.

Holding physical food reserves is another strategic decision. We usually distinguish between two types of stockpiling strategies: buffer stocks that aim at market interventions to stabilize prices and emergency stocks that aim at avoiding crises and supporting the most vulnerable. Experiences around the world with buffer stocks have generally been negative. They are very costly to manage, and are usually not very successful in protecting against price spikes because of their vulnerability to speculative attacks.

On the other hand, 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. Emergency food reserves are usually integrated in national food security strategies. The effectiveness of such reserves could be improved if national food reserves agencies operate independently of political processes, with well defined and clear triggering mechanisms supported by effective early warning systems. In many countries emergency reserves are integrated with social and food security safety nets and food assistance programs, in order to increase their effectiveness in benefitting the vulnerable. Finally, well-functioning emergency reserves need to be adequately resourced and financed by governments.

**International Investment**

Investing in the agriculture sectors of other developing countries is a possible option for Arab countries to enhance their food and nutrition security. Foreign investments can be a “win-win” arrangement but they need to be done right. Large-scale land acquisitions are controversial and raise complex economic, political, institutional, legal and ethical issues in relation to food and nutrition security, poverty reduction, rural development, technology and access to land and water. While much land in Sub-Saharan Africa may currently not be utilized to its full potential, its exploitation under new investments may involve potentially negative effects on livelihoods and food and nutrition security. Investments involving large-scale land acquisition are problematic in situations where local land rights are not clearly defined and governance is weak. Case studies catalogue a lack of transparency in land transfers, no consultation with local stakeholders and no recognition of their rights, displacement of local smallholders and loss of grazing land for pastoralists with consequent negative impacts on livelihoods and no compensation. There are also instances of environmental damage arising from additional demands on local water resources caused by large-scale production of crops such as oil palm and sugar.
The risks are real, but so are the potential benefits in terms of capital inflows, technology transfer leading to innovation and productivity increase, quality improvement, employment creation, backward and forward linkages and multiplier effects through local sourcing of labor and other inputs and processing of outputs and an increase in food supplies for the domestic market and for export. The fact that many developing countries are seeking to attract inward investment suggests that they see these benefits as desirable and real.

Real partnerships need to consider what form investments should take. Land investments are arguably least likely to deliver significant developmental benefits to the host country. Looser business arrangements may be more conducive to the interests of the host country, offering more accessible benefits to smallholders and their associations. Joint ventures between foreign investors and local producers or their associations as partners might offer more benefits for the host country. Under contract farming or out grower schemes, smallholders can be offered inputs including credit, technical advice and a guaranteed market at a fixed price.

International investment must bring development benefits to the receiving country in a true partnership and provide greater food security for both investors and the host country. The investment objectives of investors needs to be reconciled with the investment needs of developing countries to ensure investments meet the development priorities of the host countries too. Investment priorities need to be identified in a comprehensive and coherent investment strategy and efforts should be directed toward identifying the most effective measures to promote the matching-up of capital to opportunities and needs.

Arab countries may consider developing a more coordinated approach to foreign investment through regional economic communities and related ongoing regional and sub-regional programs. Such an approach would help reduce transaction costs, decrease pressure on often limited human resource capacity at country level, broaden the application of lessons learned through Arab development support and open opportunities to integrate private investment with regional and sub-regional agriculture, transport and trade, as well as food safety and quality initiatives, with a consequent catalytic economic effect. In Africa, such an approach is strongly supported by the Comprehensive Africa Agricultural Development Program (CAADP), which promotes moving from a national to a regional approach in dealing with regional food and nutrition security issues.

FAO, the World Bank, UNCTAD and IFAD have developed a set of principles for responsible agricultural investment that respects rights, livelihoods and resources. These principles highlight host country interests but are also a guide for investors to socially responsible investment. They highlight the need for transparency, sustainability, involvement of local stakeholders and recognition of their interests and emphasize concerns for domestic food security and rural development. They are based on detailed research concerning the nature, extent and impacts of foreign investment and best practices in law and policy and are intended to distil and encapsulate the lessons learned and provide a framework to which national regulations, international investment agreements, global corporate social responsibility initiatives and individual investment contracts might refer.
References


COMMENTS ON CHAPTER 1

Fawzi Hamad Al-Sultan
Chairman, International Food Policy Research Institute (IFPRI)

The paper provides a good framework for discussion of policy and action for improving Arab food security but in light of the recent youth uprisings in several Arab countries some actions would now need to be taken with a greater sense of urgency.

- How to target social protection programs to food insecure people, women and children instead of universal subsidies which are not sustainable: An example was the Bolsa Familia Program evaluation by International Food Policy Research Institute (IFPRI) based on education and health outcomes, designing protection policies and analyzing political feasibility. Such a program, however, needs strong management capabilities.

- Rationalize consumption, focus on healthy living: consumer education for health and nutrition, linking agriculture to health and nutrition. Food bio-fortification: Harvest Plus Consultative Group on International Agricultural Research (CGIAR) Challenge Program managed by International Center for Tropical Agriculture (CIAT) and IFPRI. Science is only part of the program which works with farmers and consumers through effective communication.

- Job creation for the youth and the unemployed, rural and urban, generating income and improving access to food. Short term: increase spending for improving rural infrastructure projects. Increase rural incomes including nonfarm activities and high value crops, International Fund for Agricultural Development (IFAD).

- Improving smallholder farmers’ productivity by improving access to inputs, technology and markets. Needs more government focus on productivity gaps, extension and gender.

- Water policy and investment: Food production, industrial and urban, International Center for Biosaline Agriculture (ICBA) water master plan for Abu Dhabi which looks at supply, demand and policy issues.

- Non conventional water use and policy: biosaline agriculture to save fresh water, land and soil salinity (Iraq), diversification of forage/ livestock systems (Arab Fund, IFAD, Inter-American Development Bank (IDB)).

- How to build national strategic reserves at the optimal level and financial risk hedging: policy and institutions. Can the present institutions importing grain handle it? Do we have the right regulatory frameworks?

- International investment: Agree with the Responsible Agricultural Investment Principals, add intra-regional trade agreements as a tool to encourage private investors reduce food price volatility, and add address private investor problems. Recent "land grabs" by a
number of governments in developing countries need to focus on pro poor development focusing on smallholders and generating local employment.

- Finally, support more resources needed for research from regional and international institutions, bilateral donors and private contributions.

For those interested in food security please look at food security portal facilitated by IFPRI for news, commodity prices, country profiles and policy analysis tools.

Also, Yemen digital food security atlas for data and tools for analysis: includes food security assessment and an action plan for pro food secure growth and programs for child nutrition.
CHAPTER 2—SUSTAINABLE ASSISTANCE TO THE MOST VULNERABLE: CONFLICTS AND FOOD SECURITY IN THE ARAB COUNTRIES

Maria Losacco and Nadim Khouri
IFAD Deputy Executive Secretary, UNESCWA

Introduction

The Middle East is already facing a number of constraints which hinder increases in food production and long-lasting conditions to improve food security. The effects of conflict further exacerbate the situation in a number of countries; weakening public institutions, creating parallel or extra-legal economies, and leading to violence and forced displacement. The effects of conflict, both at the national and at the household level, put many people at risk of poverty and food insecurity, especially in rural areas where people are highly “dependent on agriculture, for both food and livelihoods.”

Given the vulnerability of the poor to food insecurity and their exposure to the negative effects of conflicts, rural development interventions—which are specifically directed towards rural poor and marginalized groups—help reduce the vulnerability of communities to conflict.

This is possible through a wide range of actions, which include: microfinance and credit, creation of off-farm job opportunities for rural youth, land and water resources management and strategies to reduce vulnerability to climate change. The aim of the present paper is to explore rural development’s contribution to the reduction of vulnerability to conflict, and the ways in which these interventions could be improved.

Effects of Conflict on Food Security at the National Level

Economically, the dramatically negative impact of conflict on food security results in:

- decreases in agricultural and food production
- decrease of GDP per capita

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Table 1. Level and Growth of Agriculture and Food Production Indices Before, During and After Conflict

<table>
<thead>
<tr>
<th>Variable</th>
<th>5 Years Before Conflict</th>
<th>During Conflict</th>
<th>5 Years After Conflict</th>
<th>During Peace**</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGRICULTURE Per Capita Production Level Index</td>
<td>117.5 (YYY)</td>
<td>107.2 (YN)</td>
<td>101.7 (Y)</td>
<td>--</td>
</tr>
<tr>
<td>FOOD Per Capita Production Index Level</td>
<td>113.4 (YYY)</td>
<td>103.8 (NY)</td>
<td>101.3 (Y)</td>
<td>--</td>
</tr>
<tr>
<td>AGRICULTURE Production Index Growth Rate</td>
<td>3.29 % (YNN)</td>
<td>0.64 % (YY)</td>
<td>3.85 % (N)</td>
<td>2.90 %</td>
</tr>
<tr>
<td>AGRICULTURE Per Capita Production Index Growth Rate</td>
<td>0.42 % (YNN)</td>
<td>-1.53 % (YY)</td>
<td>1.23 % (N)</td>
<td>-0.07 %</td>
</tr>
<tr>
<td>FOOD Production Index Growth Rate</td>
<td>3.56 % (YNN)</td>
<td>0.84 % (YY)</td>
<td>4.06 % (N)</td>
<td>2.81 %</td>
</tr>
<tr>
<td>FOOD Per Capita Production Index Growth Rate</td>
<td>0.64 % (YNN)</td>
<td>-1.32 % (YY)</td>
<td>1.44 % (Y)*</td>
<td>-0.17 %</td>
</tr>
</tbody>
</table>


Notes: Production indices are production valued in 1989-91 prices and are net of seed and feed. Y(N) indicates statistically significant (insignificant) at least at the 10 percent level with regard to corresponding cell to the right (using either pooled or separate variance).

* Statistically significantly different from -0.0017 at the 10 percent level when variances are pooled, not otherwise.

** Peace time averages for per-capita levels of agricultural and food production are not meaningfully comparable to the other periods. Source: Own calculations based on FAO and SIPRI (for conflict classification) data.

A study conducted by FAO on 38 countries which experienced conflict between 1961 and 2000 demonstrates that agricultural and food production per capita and GDP per capita declined significantly during conflict and remain low during the subsequent 5 years (a decline on average of about 1.5 percent for agricultural production and of 2.2 percent for GDP per capita for each year of conflict). As a consequence, the daily energy supply falls by about 7 percent.

Similarly, a study conducted by IFPRI shows how consistent the impact of conflict is on food security. The rate of food insecurity in most conflict/post conflict countries exceeds 20 percent and, more importantly, usually exceeds the rate of the population in need of humanitarian assistance.

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7 Ibid.
Table 2. Arab Countries in Conflict and Food Insecurity in 2002—2003⁹

<table>
<thead>
<tr>
<th>Region/Country</th>
<th>Percent food insecure FAO</th>
<th>Population in need of humanitarian assistance (percentage of total population)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>Somalia</td>
<td>71</td>
<td>750,000 (9.4 %)</td>
</tr>
<tr>
<td>Sudan</td>
<td>25</td>
<td>2,800,000 (7.3 %)</td>
</tr>
<tr>
<td>Iraq</td>
<td>27</td>
<td>27,000,000 (100 %)</td>
</tr>
<tr>
<td>Palestine</td>
<td>40*</td>
<td>1,500,000 (10 % **)</td>
</tr>
</tbody>
</table>

* Not present in the original table, integrated with the data reported in the Comprehensive Food Security and Vulnerability Analysis (CFSVA) West Bank and Gaza Strip, FAO, 2007.
** Percentage calculated on the basis of total population as from Israel's Central Bureau of Statistics (ICBS).

Effects of Conflict on Food Security at the Household Level

Chronic conflict has a direct impact on livelihoods and food security through:

a. The destruction, looting and theft of key assets—as "both a means of warfare and a consequence of common banditry and obliteration in the absence of the rule of law."¹⁰ Loss of assets such as houses, land, utensils, cattle, livestock and other productive assets hit the poor very hard and impact significantly on the ability of affected households to cope with conflict.¹¹

b. Changes in the household composition—Killings during war time and forced displacement are among the main causes of the increase in the number of female-headed households which, especially in rural areas, are found to be more exposed than male-headed households to the risk of poverty and food insecurity.¹² In the Arab countries, a combination of social and cultural factors, such as, the gender differentials in accessing land and resources, the difficulties in conciliating productive and reproductive responsibilities and the lack of an adequate educational background all limit women’s chances of finding a job. Furthermore, they are believed to exacerbate the effects of conflict, thus leading to higher rates of poverty, especially in rural areas.¹³

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⁹ For the complete table see IFPRI, Conflict, Food Security, and Globalization, 2006, pp. 6-8.
c. **Serious damage to water, land and biological resources for food production**—Conflict puts additional stress on water resources, arable land, forests, and other means of sustenance. Both direct effects (e.g., landmines, destroyed target-related impacts, defensive works and targeted natural resource destruction) and indirect effects (e.g., environmental impacts related to population displacement, natural resource looting and war economy resource extraction, lax environmental governance, information vacuum, funding crises, arrested development and conservation programs) deeply impact communities living in conflict situations.¹⁴

d. **Limited coping strategies**—Rural poor, who can only rely on a limited number of strategies in peace time,¹⁵ see their possibilities further reduced by the effects of conflict. In general, coping mechanisms during times of conflict comprise: diversification of land holdings and crop cultivation, storage of grain from one year to the next, sale of assets such as cattle and land to release capital, borrowing from village lenders or other moneylenders, and gifts and transfers from informal mutual support networks.¹⁶

e. **Migrations**—both from rural to urban areas and vice versa. While in Iraq, a number of small farmers decided to migrate to cities in search of job opportunities,¹⁷ in Somalia migration went in the opposite direction, when, due to the worsening of the security situation, many people abandoned the cities and sought shelter from their respective clans in the rural areas.¹⁸ In Darfur agricultural production dwindled and markets collapsed as a consequence of displacement, thus affecting the food security of the entire population.¹⁹

f. **Economic sanctions** – When economic sanctions were imposed on Iraq, the country became largely dependent on food aid. Consequently, due to the diminished total availability of essential food, the poor had less access to food and medicines and were more exposed to food insecurity.²⁰

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In addition, off-site effects include:

a. **The loss of basic services** and access to employment, markets, farms or pastures due to the limitation of movement;\(^{21}\) and

b. **Changes in the surrounding institutions** (local and national) and in social networks\(^{22}\)—Conflicts reduce state capacity, both across and within countries, directly affecting its “ability to collect taxes—which is a prerequisite for the provision of public goods—and to enforce contracts and protect property rights, which is fundamental for the functioning of a market economy”.\(^{23}\)

Although less severe, the effects of non-chronic conflicts deserve attention, as they entail:

a. **Disruption of public services**—(i.e., closure of offices, schools and banks)

b. **Limitation of movements**—of both people and goods, which can potentially impact both livelihood and food security. In Egypt, for example, as a consequence of the unrest in February, both exports from and imports to Egypt decreased due to the risks, increased insurance costs and contractual uncertainties, causing some companies in Egypt to stop exporting their food products.\(^{24}\)

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**Rural Development’s Contribution to Reducing the Poor’s Vulnerability to the Effects of Conflict**

Several international agencies have developed solid delivery mechanisms, involving a considerable number of NGOs and international/national organizations with an extensive presence in the field, with the scope to promote development in rural areas. Their interventions, beyond contributing to decreased food insecurity and improved living standards, are helping to prepare rural communities to deal with the effects of conflict. They are providing smallholders and the rural poor with more options, assets and resources, thus increasing their chances of survival in situations of conflict. Hereafter, we present some of the existing evidence of the positive impact of rural development interventions in improving the coping strategies of poor rural communities. While some of the examples are not from conflict situations per se, they all illustrate the proven impact of rural development interventions on reinforcing various elements that make communities less vulnerable to conflict.


\(^{24}\) See Jamil Khan, *As Egyptian fruits go off market shelves, prices soar*, The Gulf Today, February 4, 2011, at: [http://gulftoday.ae/portal/b33ddeb-9810-40ee-bac8-a7c33e80d009.aspx](http://gulftoday.ae/portal/b33ddeb-9810-40ee-bac8-a7c33e80d009.aspx);


a. **Encouraging income diversification**—Households in risky environments tend to undertake low-risk, low-return activities in the attempt to reduce the risk of income shortfall, e.g., subsistence farming and the production of traditional crops. People able to diversify their income are more prepared to face the negative economic effects of conflict, but in rural areas this strategy is usually hindered by the limited number of economic opportunities accessible to the poor. In the governorate of Irbid, in Jordan, rural poor were provided with a number of new income sources as a result of a rural development project. Thanks to the adoption of a wide range of high value fruit trees, an increase in farm-income contribution to total household income has been registered: from a 25 percent average (corresponding to $1,260 U.S. per year) before the project, to a 57 percent average (corresponding to $3,780 U.S. per year) after the project; an increase of 32 percent for total household income. Poverty was also reduced. Considering a poverty line of $2 U.S. it has been calculated that annual per capita income increased from $625 U.S. ($1.7 U.S. per day) before the project, to $825 U.S. (or 2.3 U.S. per day) after the project. These positive achievements played an important role in improving food security and reducing malnutrition.  

b. **Favoring surplus and savings**—Due to the disruption of markets and other negative effects usually associated with conflict, the ability to rely on savings and on stored food is essential, especially when the movements of the population are limited and access to other markets is unsafe. In the Awdal and Woqooyi-Galbeed regions of North Western Somalia (Somaliland) a number of communities became self-sufficient in their food requirement thanks to the introduction of sustainable use of soil and water resources and the reestablishment of abandoned farmlands. The communities also experienced an increase in production, for example, sorghum production increased from 1,400 to 17,600 tons. More than 85 percent of the communities participating in the project were food secure and able to store surplus grain (an average of 900 kg/household), compared with 50 percent before the project. As a result incomes increased from about $167 U.S. to $1,960 U.S.  

   Similarly in Sudan, due to the introduction of an improved quality of sorghum, almost 60,000 farmers (67 percent of total farmers) in the region of South Kordofan benefited from an increase in the productivity of sorghum from 0.25 to 2.86 tons per hectare. Not only did they become food secure, but they were able to produce a surplus to sell to markets.  

c. **Increasing the number of assets**—providing people with more assets to rely on effectively contributes to enhancing their coping capabilities in times of conflict. Land reclamation/improvement contributes to the increase/improvement of the assets of the rural poor. In West Bank and Gaza 32 villages in the districts of Ramallah, Nablus, Jenin and Tulkarem benefited from rural intervention: a total of 11,034 dunums of land were improved; 38.3 dunums of home gardens for households were established;  

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241,275 m² of retaining walls and 27,214 m³ of water cisterns were constructed; and 52,132 olive and other fruit-tree seedlings were planted on reclaimed lands. Similarly in Syria, where a high proportion of surface rocks has both limited the cultivatable area and affected cultivation, agricultural interventions have contributed to de-rocking 180,000 ha of land, doubling the arable land in project areas and directly benefiting 70,652 households.

d. **Improving natural resource management**—Water scarcity is a major problem for the whole region, especially in rural areas where it is essential for agriculture. In Somalia, thanks to a rural intervention, it has been possible to detect likely underground water sources in different areas. After the initial exploratory phase, a borehole was dug in the area of Dilla and groundwater actually found and tapped. The success in Dilla led to a reassessment of underground water availability in Somaliland, resulting in seven more boreholes drilled in different sites.

e. **Creating job opportunities**—In Tunisia, an intervention in the village of Guermassa created job opportunities for young women who were able to revive a traditional Berber handicraft called *Al margoum* (embroidery). Thirty-nine women had the opportunity to start their own business, twenty young women were employed in a needlework center, other young people opened a rest house, a restaurant for tourists and a shop to sell the products.

f. **Favoring self-insurance mechanisms**—since most rural poor do not have access to credit, their chances of developing their own business are particularly limited—a situation that is even more severe during conflicts. In Sudan, the establishment of 173 Sanduq, traditional credit associations, has benefited 173 villages in Bara and Um Ruwaba (North Kordofan), with an outreach of about 69,290 households. The borrowers used the capital obtained through the Sanduq for a wide range of activities (for example: specialized crop production, home gardens, livestock rearing and trading, hashab replanting, petty trading of freshly prepared foods, cheese processing and selling, handicrafts, artisanal occupations such as, village carpentry, metal work, building and service provision, transport and agricultural contracting).

g. **Supporting women**—In the West Bank and Gaza, because of the death, detention or unemployment of the men, women have had to assume the responsibility of sustaining the family. But the border closure policy and the restricted access to infrastructure and water supply have had a negative impact on both their living conditions and their livelihood opportunities, resulting in a higher rate of poverty among female-headed

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31 Ibid.
households (30 percent) compared to male-headed households (22 percent). The establishment of 12 women’s Saving and Credit Associations in the West Bank and Gaza, reaching out to over 6,721 members distributed geographically throughout Palestine, has provided women with access to credit and other services. This access to credit has enabled them to start and expand their own businesses, thus actively contributing to sustaining their families.

**Possible Actions in the Region**

Both chronic and non-chronic conflicts add strain to a region which is already particularly vulnerable to food insecurity. Rural interventions not only create new economic opportunities for the rural poor but also assist in reducing their vulnerability to the effects of conflict.

Even if, thanks to rural interventions, the poor can now count on a wider number of livelihood opportunities to sustain their coping strategies during conflict, their safety might continue to be at risk for a number of reasons, depending on the specific nature of the conflict, i.e., having a certain identity, owning a certain type of asset or living in a particular area.

The distinction between delivering emergency interventions and eradicating poverty in the long-term is not a clear-cut (or useful) one. For rural communities threatened by conflict, protection and livelihood are two sides of the same coin: very often their livelihoods are threatened by conflict-related effects, while at the same time the “loss of livelihoods inevitably makes them more vulnerable to the threats in their environment.”

In order to bridge the gap between short and long term interventions, we should first gain an increased awareness of the role that rural development is already playing in reducing vulnerability and then consider the risk of conflict from the very beginning—at the planning phase.

Actions explicitly aiming at protecting the population from the effects of conflict (food insecurity included) are as follows:

- **Advocacy**—engaging with state or other armed actors to prevent or stop violations or abuse.

- **Providing emergency relief and livelihood support**—for example, providing water, health and educational services.

- **Providing access to information programs**—for example: providing information on food aid entitlements to reduce the exclusion of vulnerable groups; and providing displaced people with information on their places of origin to facilitate and make safer their return home.

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34 Ibid.


- **Capacity building**—for example, strengthening community-based organizations in order to help communities to become self-reliant.

- **Substitution**—providing assistance or services in areas where governmental authorities are unable or unwilling to protect people, for example, by providing medical support.

- **Reducing the number of displaced people**—for example, by expanding food distribution to rural areas to help people remain in their place of origin.

- **Reducing the need to engage in risky activities**—for example: providing/protecting assets, tolls, seed, cash and increasing production from the limited areas people can safely access (e.g., home gardens) to reduce the need to travel in unsafe areas.

Given the role that poverty plays in increasing the risk of conflict, and the problems that rural development seeks to address, rural interventions could be used to decrease the probabilities of conflict by addressing some of the factors behind it.

Non-chronic conflict in the Middle East is a reality, and the fact that it needs to be addressed is nothing new, as can be seen from the advice expressed in an article written back in 1996: “if we are to face the issue of conflict effectively, we need to learn new skills, cover new literatures, and talk to new kinds of specialists, to enable us to do our own work with new perspectives.”

Rural interventions are already achieving very positive results, but their full potential is still yet to be realized. It is now time to consolidate our knowledge and skills and transform theory into action.

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CHAPTER 3—MEETING WATER AND FOOD SECURITY CHALLENGES IN THE ARAB COUNTRIES: INSIGHTS FROM THE TUNISIAN EXPERIENCE

Arab Fund for Economic and Social Development

Introduction

Most parts of the Arab World are located in arid and semi-arid climatic zones, with low rainfalls, contain the largest area of desert in the world, and are characterized by high rates of evaporation throughout the year, which reduces the use of rain water and adversely affects the groundwater. The Arab World suffers from severe strains on its scarce water resources. As it represents about 10 percent of the world's surface and about 5 percent of the total population, it has only less than 0.5 percent of the world's renewable fresh water resources, which ranks it as the world lowest rated water per capita (approximately 800 m$^3$) per person per year compared to the global average of more than 7000 m$^3$. It is expected that this limited availability of water would decline to reach about 550 m$^3$/year by year 2030, which will approximately be dangerously close to the water poverty level of (500 m$^3$/year).39

About 67 percent of the total area of the Arab World receives less than 100 mm/year of rainfall, and is classified as desert and semi-desert, not suitable for rainfed agriculture. The average rainfall in about 15 percent of the Arab World is between 100-300 mm/year, and large parts of these areas are considered natural pastures with possibility of producing field crops such as barley. These parts are also suitable for establishing projects based on supplementary irrigation on condition that water is available. Only 18 percent of the Arab World receives more than 300 mm/year of rainfall suitable for the cultivation of strategic crops, such as grain and fruit trees, and is a major source of surface water and groundwater recharge. This rain zone covers the coastal and highland areas in Syria, Lebanon, Morocco and Sudan.

The total renewable water resources in the Arab World is estimated at about 280 billion m$^3$/year, not all utilizable; as part of these resources are considered marginal and far away from areas of consumption. It should be noted that more than half of the water resources come from outside the Arab region. This is a very important issue for Arab water security, in view of the vulnerability of these resources quantity, volatility and expected deterioration in quality, especially in the absence of international agreements guaranteeing the rights of Arab states, with the exception of Senegal River in Mauritania. The total water consumption is around 215 billion m$^3$, of which about 87 percent is devoted for agricultural use, about 10 percent for domestic purposes and the remaining 3 percent for industrial purposes.

39 The water poverty level of 500 m$^3$/year is defined according to the international classification as the level below which economic and social development becomes severely affected.
The harsh climatic conditions and scarcity of water have clearly affected the food security situation in the Arab states, where it shifted the Arab World, from nearly self-sufficient region in the early seventies, to the most food imports dependent region of the world. The Arab World imports half of its food despite the large investments made in the past decades to develop agricultural and major irrigation projects. The population growth rates of the Arab states are the highest in the world (about 2.3 percent per year). The global food crisis and its repercussions have shown the fragility of food security in Arab countries, as they are most affected by this crisis, being one of the major food importers in the world. This has forced a number of Arab countries to take urgent action such as raising wages and increasing subsidies for food commodities.

Achieving food security relies on several factors, such as land, climate, water and production inputs, plus indirect factors such as water policy, agricultural research, regulations to manage water and agriculture and infrastructure necessary for transport and marketing of products. This paper will mainly address water and its role in meeting the challenge of food security in Arab countries, and will also address Tunisia's strategy in water management and its policies to meet the challenge of food security, in an attempt to highlight some useful lessons that other Arab countries may find helpful.

The problem associated with the role of water in achieving food security in agriculture is that, despite its scarcity, water is excessively wasted. The efficiency of surface irrigation in most Arab countries ranges between 40 percent and 60 percent only, and the pricing of irrigation water does not encourage farmers to conserve water. The Arab countries have used up most of their water resources, and agriculture currently consumes about 87 percent of the total water available. The most important priorities are to address irrigation inefficiencies, promote water conservation programs and incentives, and develop policies and organizational structural systems and appropriate regulation for the efficient management of water systems in collaboration with the farmers. However, before addressing the role of water management in addressing the food security challenge, we should address the prevailing conditions of food and agriculture in the Arab countries, in order to identify the size and magnitude of the food security problem.

The Challenge of Food Security in the Arab Countries

Food Security Concept

The Arab Organization for Agricultural Development defines Food Security as continuously providing all members of the society with food in quantity and quality necessary for their activity and good health, depending first on local food production, second on the basis of comparative advantage for the production of food commodities in each country and third on the availability of food to the citizens at prices that are suitable to their incomes. On the other hand, the Food and Agriculture Organization asserts that, food security is achieved when all the individuals, at all times, possess the necessary economic and social capacity to have access to adequate and safe food components to meet their food needs and preferences, in order to enjoy an active and healthy life.  

40 Known as the FAO definition, which was adopted during the World Food Summit in 1996.
between the two definitions in that the first stresses the use of locally available resources as a first option and then resorts to food imports as a second option, while the second focuses on the availability of sustainable food, in adequate quantity and quality, regardless of whether its source is local or external.

There is a firm belief in the Arab countries that food security is one of the essential elements of national security, and self-sufficiency in major food commodities, especially grain, is its most concrete form. On this basis, Arab countries, particularly those with large agricultural capabilities, have worked on achieving the goal of self-sufficiency, reducing the food gap, and have implemented many national plans and programs to increase production and productivity within the agricultural sector. At the regional level, many strategic plans were launched, such as the Agricultural Development Strategy 2005-2025, and the Emergency Program of Food Security, which was declared during the Economic and Social Development Summit held in Kuwait in 2009. The aim of all these endeavors was to develop agricultural production, increase the ability of Arab countries for self-reliance to meet the needs for major food commodities, and achieve the sustainability of Arab agricultural resources.

Despite these national and regional efforts, and the relative abundance of land, human and financial resources, food security has not been achieved. The Arab World has shifted from the semi-sufficient region in the early seventies, to the most deficient region of the world. Although some Arab countries were successful, to varying degrees, in achieving self-sufficiency in some agricultural products, this was not cost-effective and in some cases led to depletion of renewable and non-renewable groundwater resources.

**The Food Security Situation**

The Arab States are experiencing growing deficits in their needs for food commodities, due to their inability to achieve an increase in agricultural production to meet the increasing food demands. This is in part the result of high rates of population growth. The average annual growth rate of population increase during the last decade is about 2.3 percent, which is of the highest rate compared with other regions of the world. Consequently, the average income (per capita) has increased, in the same period, from $2,540 U.S. to $5,159 U.S. (double). The Arab countries import about half of their food requirements, and are considered the major importers of grain in the world. Three countries (Egypt, Algeria and Morocco), although among the most important producers of grain, are also among the top ten importers of wheat in the world. The Arab countries import more than half of their grain, about 72 percent of sugar, 68 percent of vegetable oil, 31 percent of dairy products, and 14 percent of meat needs. As a result, the food gap has increased, as the net value of food imports increased from $10.2 billion U.S. in 1980 to $28 billion U.S. in 2009, and out of the $16.3 billion U.S. of grain imports, more than half was wheat. It is expected that the value of this gap will reach $80 billion U.S. by the year 2030.

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43 Data from Arab Monetary Fund et al. (2010), Arab Unified Economic Report.
44 Calculations made by authors based on projections of actual trends for production, consumption and prices.
Figure 1 shows the average value of the food gap for the major commodities during the period 2005-2008 for Saudi Arabia, Algeria, Egypt, Jordan, Iraq, Syria, Sudan, Tunisia and Morocco, which together account for 60 percent of the total value of the Arab food gap. The gap in Saudi Arabia, Egypt and Algeria, makes about 80 percent of the total gap of the nine countries mentioned. Also, some countries such as Morocco, Tunisia, Jordan and Syria have been able, through diversification of exports and a surplus of some commodities (such as vegetables, fruit and fish) to reduce the gap and offset a portion of the exports of other commodities, especially cereals.

Annex (1) shows the development of the production, consumption, food gap and self-sufficiency of the major food commodity groups in the Arab countries, during the period 2000-2008. The data shows that the Arab countries managed to achieve self-sufficiency in fish, vegetables and fruits, while the degree of sufficiency is about 50 percent for cereals and about 30 percent for sugar and vegetable oils. The rates of self-sufficiency declined steadily for cereals, legumes and vegetable oils. Figure 2 summarizes the development of self-sufficiency ratios for the most important groups of food commodities in the Arab countries between 1980 and 2009.

With regard to consumption, the percentage of food expenditure reaches, in some of the Arab countries, more than 75 percent of the poor people’s income. The consumption pattern of a representative Arab citizen shows that wheat represents 35 percent on average of his total food consumption. As a result, and due to the inability of local production to meet domestic demand for grain, the Arab countries have been affected, more than others, by the global food crisis in 2008 and its aftermath. The crisis has led to great pressure on the purchasing power of large segments of the population in a number of Arab countries with low incomes, who already suffer from high rates of malnutrition and poverty. In some Arab countries like Yemen, Mauritania, Palestine, Somalia, Sudan, and Djibouti, poverty levels have exceeded 40 percent of the population, which makes these...
populations very vulnerable to food prices fluctuations, especially in wheat.\textsuperscript{45} This confirms that the achievement of food security in some Arab countries is more linked to the inability of poor people's access to food than to availability of food. Thus, the success in raising incomes, reducing poverty and achieving economic growth is an important element in achieving food security. The development of the agricultural sector is an important factor in alleviating poverty, especially in the rural areas, which include about 75 percent of poor population and more than 25 percent of the workforce in the Arab countries.\textsuperscript{46}

**The Challenges and Prospects for Agricultural Production Development**

Agricultural production depends on several factors, such as natural resources (land, water and climate), manpower, machinery, equipment, seeds and fertilizers, in addition to the factors that affect the productivity and efficiency of these resources, such as scientific research, use of advanced techniques, policies, incentives, guidance services, infrastructure, marketing, storage facilities, and management of post-harvest, plus the institutional arrangements that improve the efficiency of markets and ensure a continuous food supply.

The main potential factors in the development of agricultural production in Arab countries are: increasing of the land area (horizontal expansion), intensification of crop, increasing of the productivity per unit area of agricultural land, and per unit of water of irrigated land (vertical expansion). Horizontal expansion faces a number of limitations including scarcity of water resources, poor infrastructure, high investment costs needed for preparing the land, and deterioration of soil quality. All these factors make vertical expansion in cultivated land (i.e. focusing on increasing the productivity per unit area and crop intensification) more realistic than horizontal expansion. This is particularly true since land productivity, levels of crop intensification and efficient use of water resources in Arab countries, is still low in the rainfed agriculture and irrigated farming, and is very low in comparison with the rest of the world.

Given the scarcity of water and limited possibilities of mobilizing additional water resources in Arab countries, water conservation and improving the use of water resources are the most important priorities for increasing agricultural production, reducing the food gap and improving the food security situation in these countries. On this basis, the rest of this paper will focus on the role of water resources management to enhance food security in the Arab countries, by proposing some insights and suggestions that could contribute to the improvement of water management and food security in the Arab countries.

**Water and Food Security Challenges in the Arab Countries**

The total area of arable land in the Arab Countries is 197 million ha, of which currently about 71 million ha are under cultivation (about 36 percent). The cultivated area in 2008 has reached about 54 million ha. Rainfed agriculture makes around 75 percent of the total cultivated land and the balance of 25 percent is for irrigated agriculture. The distribution of crops is: 60 percent

\textsuperscript{45} World Bank, Food and Agriculture Organization (FAO) and International Fund for Agricultural Development (IFAD), 2009, Improving Food Security in Arab Countries.

\textsuperscript{46} Arab Unified Economic Report 2009.
grains, 5 percent vegetables, 8 percent fruit, 13 percent oilseeds, and the balance of 14 percent are for other crops. It is clear that the structure focuses on grains more than on other products.

**Conditions of Irrigated Agriculture**

The irrigation sector is the largest consumer of available water, as it uses about 187 billion m$^3$ of water annually to irrigate about 14 million ha. Irrigated agriculture is mainly in Egypt, Sudan, Iraq, Syria, Morocco, Algeria, and Saudi Arabia, with a total irrigated area of about 12 million ha, or approximately 85 percent of the total irrigated area in the Arab World. Confronted with worsening conditions of expanding food gap during the seventies, the Arab countries, especially those with high agricultural potential, accelerated the process of surface and groundwater mobilization mostly for the purpose of expanding irrigation. The past three decades witnessed intensive exploitation of groundwater, including, non-renewable water, and construction of large number of dams, especially in Iraq, Syria, Morocco, Algeria, Sudan and Tunisia. This was accompanied by an expansion in irrigated areas, where the total of such areas increased from about 9.5 million ha in 1980 to approximately 14.2 million ha in 2008. Figure 3 shows the development and distribution of irrigation areas in the Arab countries with an indication of the area cultivated with seasonal sustainable crops.

**Figure 3: Distribution of irrigated areas and their development in the Arab countries during the period 1980-2008**

In spite of the fact that irrigated area in the Arab World constitutes approximately 25 percent of the total cultivated area, it contributes on average about 60 percent of the value of agricultural production. Water has contributed significantly to the reduction of the food gap, and helped achieve self-sufficiency in vegetables and fruits.

**Water Management and Food Security Challenges**

Arab countries use about 215 billion m$^3$ of water per year for agriculture, drinking and industry, which constitutes about 77 percent of renewable available water. This is a high percentage, and indicates that cost-effective water mobilization is close to its maximum. Indeed, the potential for
further mobilization of water resources in most Arab countries is limited, as they have mobilized most of the water resources available at acceptable cost. Most of the remainder is either marginal or expensive in terms of mobilization and transport. Limited possibility for mobilizing new water resources is still possible in countries like Algeria, Somalia, Morocco and Mauritania, though in modest quantities compared to what has been used so far.

Although Arab countries use about 87 percent of water in agriculture, the Arab World is still far from achieving self-sufficiency in food, particularly cereals, with a cereals gap estimated in 2010 at about 60 million tons. Figure 4 shows projections of the trend of that gap until 2030, where it is expected to reach about 120 million tons.\textsuperscript{47} In order for the Arab countries to achieve sufficiency in grains, vegetables and fruit, it is estimated that there will be a need for additional quantities of water of not less than 220 billion m\textsuperscript{3}. The above quantity does not include the future needs for drinking water and livestock production. The above mentioned volume shows the limited water resources in the Arab World and its inability to achieve self-sufficiency in major crops. The volume also gives a realistic idea about the size and dimension of the water constraint that impedes the ability of the Arab region in meeting its food security challenge.

Agriculture in the Arab countries faces, in addition to the great waste in irrigation water, bad planning and poor coordination between water and agriculture sectors, poor organization of major irrigation facilities, and limited participation of farmers in the operation of irrigation systems. These factors negatively affect the performance of water and agriculture management.

Although the limited water resources in the Arab countries hinder achieving self-sufficiency in major crops, there is a way to reduce that gap significantly and to achieve acceptable food security. This may be achieved by raising irrigation efficiency and increasing the productivity of many agricultural crops, thereby increasing production by using the same quantities of water. However, this solution requires good organizational and institutional arrangements that enable water and agriculture sectors to work in an integrated manner, develop plans and programs, and have clear water policies and directions aiming at optimizing the use of water. This paper touches on the most important of these institutional and organizational arrangements and

\textsuperscript{47} Water requirement of cereals were estimated based on actual production levels and projection of demand underlined by a constant per capita consumption and a population growth rate of 2.3 percent. It was assumed that 1 ton of cereals would require about 1500 m\textsuperscript{3} of water, and that closing the cereals gap by 2030 would require about 180 billion m\textsuperscript{3} of water, assuming that Arab countries will maintain self-sufficiency in fruits and vegetables during the period 2010-2030, which requires about 40 billion m\textsuperscript{3} of water per year.
approaches that can contribute to meet the challenge of food security in light of the scarcity of water resources in the Arab countries.

**Institutional and Organizational Framework for Water and Agriculture Sectors Development**

**Organization and Coordination between Water and Agriculture Sectors**

The absence of comprehensive and integrated vision for water and agriculture, and the absence of strategies and specific programs to manage both sectors have adversely affected their performance in many Arab countries. In fact, the functions of several institutions and various government bodies overlap in the management of water without adequate coordination. This results in fragmentation of the regulatory framework and laws relating to water and agriculture sectors, and leads to poor and improper planning and management of water. There is a need for coordination of water and agriculture policies in a context of clear strategies and targets, which should be directed towards improving allocation of water resources and efficiency of their use.

**Institutional Arrangements Relating to Irrigation Water**

The institutional arrangements relating to irrigation water mainly refer to the management of irrigation facilities and systems. Government agencies, and sometimes central departments, in many Arab countries manage irrigation networks. Such networks suffer from poor maintenance and mismanagement due to lack of proper staff. International experiments have shown relative success of irrigation management programs in partnership with farmers to support the implementation of those programs. This arrangement is usually carried out by "water user associations", which are financially independent and responsible for the operation and maintenance of irrigation networks, water distribution and collection of the proceeds of the sale of water. Such arrangements are used in some Arab countries like Egypt, Jordan, Libya, Morocco, Oman, Tunisia, and Yemen. Given the relative success of these arrangements, they should be extended to include other aspects of infrastructure for irrigation.

**Pricing Irrigation Water**

Water pricing is intended to recover part of the cost of water provided, which would contribute to the sustainability of facilities and irrigation systems. It can play an important role in allocating resources to the best use of water and the most economic return. The current situation of water pricing in the Arab states is not reaching this goal, as these states often provide water for irrigation without charge or at subsidized prices, which leads to waste and misuse. Annex (2) summarizes prices of irrigation water in some Arab countries. In Syria, for example tariffs are applied annually per hectare, and there is no fixed price for water in Egypt. In Algeria, the price per cubic meter is about $0.14 U.S., and in Morocco it ranges between $0.020 U.S. and $0.053 U.S. There is a need to use the water tariffs as a means of rationalizing water use, through the application of marginal cost pricing according to the quantities actually consumed (volumetric pricing). This volumetric tariff system could be combined with other incentives to encourage the

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use of modern irrigation methods or cultivation of water-saving or strategic crops. Equity issues can be handled through escalating steps (block prices) that rise with use. Poorer farmers use less water than others and the lower blocks can be charged much lower prices than more profligate users that pay more per unit of water in order to compensate for the lower charges on small quantities used by poorer farmers and users.

**Legislation and Control**

Most Arab countries suffer from the absence of clear and consistent legislation for water, plus firm control mechanisms to ensure the sustainable use of water resources and environmental conservation. For example, digging groundwater wells, in many cases, without prior permission from the authorities, and use of groundwater without charge, lead to abuse of water and sharp drops in aquifer levels plus saltwater intrusion in the aquifers. In many Arab countries large amounts of water are lost due to pollution by wastewater of communities and industries without any treatment. The use of wastewater in some cases without addressing the dangers of irrigation of agricultural crops poses a threat to public health. The agricultural drainage water contains significant quantities of pesticides, salts and compost waste which, if disposed of in the rivers or seeped into the groundwater, can be highly contaminated. Therefore, the existence of strict laws is essential to ensure the sustainable exploitation of water and maintain the quality of water, soil and environment.

**Policy Coordination and Incentives**

Water management in the Arab countries consists of several policies and incentives which for the most part are not conducive to water conservation and restriction of wasteful behavior. Water is provided in most cases at cheap prices and the energy used in pumping groundwater is subsidized. Moreover, although fertilizers, pesticides and seeds are highly subsidized, no sufficient investment is extended to agricultural infrastructure, and no adequate support is provided to agricultural research facilities. Restrictions or high taxes are in some cases imposed on some water-saving agricultural products, in addition to setting prices for commodities that do not reflect their cost of production.\(^49\) This shows the importance of adjusting the subsidy policies and incentive structure in order to achieve the desired results in terms of improved water management, particularly in the long run.

**Integrated Planning of Natural Resources**

Despite the scarcity of water, the Arab countries do not conduct enough studies and surveys regarding their water resources, nor do they employ monitoring systems for the quantity and quality of rivers including seasonal ones. The groundwater resources continue to be inadequately measured and their characteristics poorly monitored. Data and information on water uses are still inaccurate, and typically fail to achieve the objectives of national strategies. These represent the most important constraints to plan and manage water efficiently in most Arab countries.

The foregoing also applies to the agriculture sector in terms of knowledge of the soil properties, relation of agricultural production to actual use of water, and the productivity and economic

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profitability of water. The Arab countries do not follow the world steps in adopting new technologies in many fields such as remote sensing using satellites to monitor water resources, the nature of the soil, the percentage of moisture, and uses of the cultivated area as a tool for planning and follow-up. There is a need to improve the methods and information systems for planning and management of natural resources more effectively.

**Raising the Efficiency of Irrigation Water**

The water use in agriculture in the Arab World is generally characterized by low efficiency, where conventional surface irrigation (about 80 percent of the irrigated area) is the dominant system, particularly in countries of major agricultural production, and almost the only system used in Sudan and Iraq. Some agricultural practices and the use of traditional irrigation systems have resulted in water wastage. The average percentage of the total losses in surface irrigation is not less than 50 percent, thus leading to salinization of important parts of the Arab lands, and deterioration in the quality of the soil. Some Arab countries, during the past three decades, have introduced modern systems for irrigation, but the percentage of irrigated areas equipped with modern irrigation systems are still limited in most of the Arab World with the exception of Gulf countries, Jordan and Tunisia. Figure 5 shows irrigation methods used in some Arab countries.

Arab countries lack integrated and accurate statistics, which include for each crop or group of crops; the irrigated area, the production of major crops, and the amount of water used. What is available is usually the yields (production per hectare for rainfed and irrigated agriculture). Therefore, it is difficult to conduct a serious evaluation of the irrigation efficiency. Annex (3) shows the Arab countries (i.e. Egypt, Sudan, Syria, Morocco, Jordan) which have data on the use of irrigation water and water consumption per hectare. The reality of irrigation in the above mentioned countries mirrors the situation in the whole Arab World, since the total irrigated area in the latter countries is about 7.5 million ha. This represents about 53 percent of the Arab World total irrigated area, and its water consumption of 95 billion m³/year represents about 51 percent of the total irrigation water.

Annex (3) shows that the average water consumption in the above mentioned countries is about 9,600 m³/hectare, ranging between 5,400 m³ in Tunisia, to about 16,500 m³ in Sudan. Figure 6 also shows cropping pattern of irrigated areas in these countries.  

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50 For Sudan, it covers only the Al-Jazeera Irrigation Project.
It is clear that the consumption per hectare of water is relatively low in Tunisia and Jordan (between 5,500 and 6,200 m³). This is the result of, among other things, the widespread use of techniques of modern irrigation, where the rate of the use of these techniques is about 81 percent in Jordan and about 88 percent in Tunisia, while the per hectare consumption rises to about 10,000 hectares in both Syria and Egypt, where the ratio was about 19 percent and 11 percent, respectively. In Sudan, where surface irrigation is dominant, the consumption is about 16,500 m³/hectare which shows, in addition to poor efficiency of surface irrigation, poor water transport facilities and irrigation systems. The cropping pattern is also an important determining factor in the consumption function of water, but in light of the lack of data on the quantities of water used for each crop, it is difficult to assess its role. However, it seems very clear that, in both Tunisia and Jordan, the focus is on vegetables and fruit crop which consume limited amounts of drip irrigation, compared with consumption of surface or surface irrigation of grains in Egypt and Sudan.

The use of modern irrigation systems is not the only factor contributing to water conservation. Indeed, some studies in Tunisia and Morocco show that the use of advanced surface irrigation techniques, like the use of plastic to isolate the channels inside the farm to prevent leakage of water or the use of concrete channels or plastic pipes in the case of pressured water, is economically feasible compared to using drip irrigation.

Using modern irrigation techniques can help avoid use of excess water over the crops' requirements, which is not less than 20-25 percent of the amount of water used in surface irrigation. It is noteworthy that irrigation efficiency does not depend on the use of modern technologies within the farm, where water transport lines and main irrigation lines are inadequate due to poor maintenance. Such networks should be rehabilitated and, if necessary, replaced, in order that water loss, which in some cases reaches up to 30 percent of the quantities used, may be reduced.

Despite the belief of most Arab countries in the usefulness of mainstream modern irrigation, the application is still limited for reasons that must be addressed and resolved. Among the most important reasons is that it requires, in addition to government investment for the rehabilitation of existing facilities and networks, investments to be made by farmers relating to the irrigation system, drip or sprinkler, inside the farm. The farmers may not be encouraged to do so due to lack of financial ability and ignorance of the economy behind it. Furthermore, the installations of drip and sprinkler irrigation require competence and experience for their operation, and also

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51 Known as “Sawaki” in the North-African countries.
require development of programs of awareness and guidance for farmers, particularly in the early years of introducing these new systems to them. Therefore, there is a need to develop integrated institutional programs in which farmers should be included. But above all, incentives should be established in order to encourage farmers and attract them to use the new technologies. Such incentives may take the form of tax exemptions on modern irrigation equipment, or the farmers contributing a certain percentage of purchase cost. Introduction of modern technologies also requires punctual follow-up and extension of assistance to farmers by qualified professionals who are trained in modern irrigation techniques.

In general, it has become certain that new technologies, including surface irrigation, can raise the efficiency of irrigation between 60 percent and 65 percent for enhanced surface irrigation, and between 70 percent and 75 percent for sprinkler irrigation, and between 80 percent and 85 percent for drip irrigation. There is considerable economy in these techniques estimated at about 20 percent of the total amount of water used (about 37 billion m$^3$), which represents a large amount that can be used to raise the intensity of irrigated agriculture with limited costs of water transfer and use.

**Increasing Crop Productivity**

Studies by some regional organizations have shown that the use of drip irrigation plus economic use of water can increase the productivity of several crops, particularly vegetables and fruit trees, with an estimated increase of up to 35 percent.\(^{52}\) Figure 7 shows the rate of productivity of both rainfed and irrigated grains, and the rate of productivity for the total grains, during the period 2006-2008, for six countries: Egypt, Syria, Morocco, Sudan and Saudi Arabia and Tunisia. The rate of total production of irrigated grains for the said six countries is about 64 percent of the total grains production of the Arab countries. It is clear that the productivity of rainfed cereal is significantly low, ranging between 0.5 tons/hectare in Sudan to about 0.9 tons/hectare in Tunisia. In spite of some climatic and environmental factors constraining rainfed agriculture in the Arab countries, there is a wide gap between the current actual and potential productivity in large areas of agricultural land. Where available, data indicates a significant difference between the productivity of wheat and barley in rainfed areas where traditional techniques are dominant such as in Algeria, Tunisia and Syria (700 to 1,500 kg/hectare) and that observed in experimental stations of rainfed agriculture in the same areas (4,000 to 5,000 kg/hectare). Considering the advantageous conditions, which are usually available in the experimental stations, the aspiration to raise productivity from its actual current rate to the equivalent of 60 percent of the productivity in these stations is technically

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reasonable and possible. High levels of productivity require protection of land resources and use of modern technology and inputs, and the development of agricultural research to produce varieties of crops resistant to drought and salinity, and dissemination of research findings among farmers. High levels of productivity also require the development of basic agricultural and technical knowledge of the agricultural product, development of agricultural tenure system, in addition to the restructuring and rehabilitation of agricultural research institutions. The areas of arable and unused land, which are estimated at about 143 million ha, can also be used for horizontal expansion of rainfed agriculture, if the necessary investments are made available.

With regard to irrigated grain production, Figure 7 shows that productivity in Egypt has reached about 7.5 tons/hectare, which is one of the highest in the world, followed by Saudi Arabia (about 5 tons/hectare) where, in contrast to Egypt, grain is produced by pivot spray irrigation. Productivity ranges between 3.6 and 4.0 tons/hectare in Syria, Tunisia and Morocco, while remaining low in Sudan. According to some field studies in Egypt, Syria, Jordan, and Iraq, the index of on the farm water efficiency for the production of wheat is ranging between 40 percent and 80 percent, which means that the rate of water loss is ranging between 20 percent and 60 percent. A study by the World Bank indicates that; although the productivity of agricultural land in Egypt is considered high by global standards, there is still a potential to raise the productivity of self-pollinated crops (such as rice and wheat) at a rate of 20-25 percent, and that of mixed pollination crop (such as maize) by more than 35 percent.

Supplementary irrigation is the most dominant technique in Syria, Tunisia and Morocco. Supplementary irrigation means the addition of small amounts of water to rainfed crops during insufficient rainfalls times for normal growth of the plant. It can improve crop yield and provide it with stability. ICARDA has conducted field studies to determine quantities of water for supplementary irrigation necessary to get the best productivity by rainfall. Figure 8 shows the results of increasing the productivity of wheat under low, medium and high conditions of rain-fall, using quantities of supplementary irrigation of about 183 mm and 120 mm and 75 mm, respectively.

The appropriate seed varieties vary depending on the type of irrigation: rainfed or supplementary irrigation. The suitable variety for supplementary irrigation is the one which responds well in situations of limited quantities of irrigation water while maintaining an appropriate level of

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drought resistance. The good management of supplementary irrigation is crucial to obtain the highest productivity for grain with the lowest possible amount of water. The difficulties lie in setting the proper date for irrigation and responding to water needs according to soil moisture. Farmers, however, largely rely on personal experience in terms of rainfall and the appearance of the crop, and tend to start supplementary irrigation at an early date and use the largest possible quantity of water in order to increase production, which leads to an over-use of water, thus transforming supplementary irrigation into a normal one. This may explain the differences observed between the rate of consumption of water for supplementary irrigation in Syria, where the rate ranges between 4,500 and 5,000 m³/hectare, and in Tunisia, where the average rate is about 2,500 m³/hectare. The difference in water consumption may also partly be explained by differences in irrigation techniques used. While in Syria, mainly surface irrigation is used; in Tunisia spray irrigation is more common. Based on the foregoing, it seems clear that there is a considerable scope for improving the productivity of agricultural crops as well as the productivity of water used through the adoption of supplementary irrigation.

Most of the vegetables and fruit trees, in the Arab countries, are surface irrigated, which also leads to consumption of large amounts of water that could have otherwise been used for irrigating other crops or for raising agricultural intensification. Moreover, use of drip irrigation can, at the same time, increase crop productivity and improve its quality. According to some studies, drip irrigation application in about 60 percent of the Jordan Valley area has led to the doubling of revenues from vegetables and fruits.56

Figure 9 shows that there is a potential of increasing production using drip irrigation, especially for vegetables and some fruits. By comparing the productivity of some surface-irrigated crops, tomatoes are the most important crops that show increase in productivity using drip irrigation, where the percentage increase ranges between 40 percent and 70 percent. On the other hand, apples, plums, pomegranates are the most important fruit products where gains in productivity are feasible, while citrus is not much affected by drip irrigation.

It should be noted that the management approach consisting of maximizing productivity of unit area under cultivation may be inappropriate in a context of water shortage such as is the case in the Arab region. Hence, the importance of the concepts of water productivity and economic value of water.

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Maximizing the Economic Value of Water

The estimated total economic return per cubic meter of water for irrigation, for the six countries referred to in Figure 9, is shown in Figure 10. As shown, value-added varies greatly between the latter countries, ranging from about $0.32 U.S. for every cubic meter in Egypt, Sudan and Syria, to about $ 0.59 U.S. in Tunisia.

The low economic rates of return for irrigation water in Egypt, Syria and Sudan, are mainly due to the inefficient use of irrigation water, and the allocation of water in low-value crops. It is clear, from the crop mix pattern of irrigated agriculture, that grains dominate the latter pattern at the expense of vegetables and fruits, whose returns are generally higher than those for grains. Therefore, there is room to reallocate water resources in a manner conducive to higher economic value for water, and thus higher production and higher revenues for the country. This does not mean, of course, that the Arab countries should abandon grain production, but they can provide a minimum level of local grain and commodity production depending on the resources and the consumption pattern of each country, and import the rest of the needs of these commodities. Consequently, the adoption of the principle of maximizing the economic return on water in the allocation of water resources requires improving water productivity by raising the efficiency of its use and using modern irrigation techniques, in addition to deciding appropriate policies and incentives, especially water pricing policies.

Water Resources Development and the Use of Non-Conventional Water

In parallel with working on irrigation facilities rehabilitation and development of the use of modern techniques, it is necessary to continue efforts in the development of the remaining part of water resources that have not been mobilized yet. Special attention should be directed towards water harvesting, which includes—in particular—the establishment of small dams and excavation of mountains' lakes to collect all possible rainwater to be used in rural areas, so that agriculture becomes a source of income, thus contributing to the improvement of the living conditions of populations in those areas. The experience of Mauritania in the areas of oases and Ashram, in particular, is a good example of water harvesting in remote areas with an effective farmers' contribution under cooperative societies.

Sewage treatment represents an additional source of water in the Arab countries, which can be used for agricultural purposes. Despite the scarcity of water in the Arab countries and the increasing amounts of sewage due to population increase, Arab countries do not make sufficient use of treated water. In fact treated water is not used directly for irrigation of crops and green
spaces, but is mostly used indirectly, and occasionally discharged in rivers or valleys that flow into the dams, and thus mixed with fresh water and used for agricultural purposes, and often for drinking purposes as well. The estimated sewage that is collected annually in the Arab countries is approximately 10 billion m$^3$ and only about 5.7 billion m$^3$ of that amount is processed. The total amount of treated wastewater that is reused in the Arab countries is about 2.7 billion m$^3$/year, of which about 1.3 billion m$^3$/year is in Egypt, and about 0.5 billion m$^3$ in Syria, and the rest in other Arab countries.

In general, the environmental problems and poor legislation represent the most important obstacles that limit the use of treated wastewater in the Arab countries. Moreover, some social and even psychological beliefs play an important role in the farmers’ reluctance to use treated water; especially if the use of ground water or irrigation system is made available in the same area. The locations of treatment stations in major cities are usually far from agricultural areas, which make it difficult to utilize these stations for agricultural purposes.

On the other hand, water desalination remains too expensive and therefore unlikely to be used in agriculture. Yet, it is important to encourage the reuse of agricultural drainage water, although its use is quite limited, especially when the salinity is high.

Having covered some general directions for improving water management which are pertinent to the food security issue, the rest of the paper will address the lessons that can be gleaned from Tunisia’s strategy in water management and its policy in addressing the food security challenge.

**Tunisia’s Strategy in Water Management and Policy for Food Security Challenges**

Tunisia is one among the many Arab countries suffering most from scarcity of water, with a rate of water per capita not exceeding 450 m$^3$/year, and expected to decrease to about 350 m$^3$/year by 2030. In addition, water resources availability varies greatly between the different regions of the country, as 82 percent of the surface water is concentrated in the north, and about 53 percent of water that can be mobilized has salinity of 1.5 gram/liter, which limits the separate use of each water source, requiring mixing waters from different sources. Tunisia, like the rest of the western Arab countries, suffers from drought periods, and floods resulting in significant damage to infrastructure and agricultural lands, which requires good management to control surface and groundwater resources in order to take advantage of the flood water on the one hand, and reduce the destructive effects of droughts on the other.

To face these challenges Tunisia has made, during the last three decades, significant investments for the mobilization of water resources, through the establishment of dams and water transfer systems covering great distances towards the Greater Tunis and the coastal region of Sfax (the main demand for drinking water), and to the northern lands suitable for irrigation in Majradah basin, the north-eastern region of “Alwatan-Alkibli” and the center. Efforts of mobilizing water resources involved drilling wells with depths exceeding 2500 m in the south and transferring water to the palm tree oases, in order to achieve advanced agricultural development. The total mobilized water in 2010 was about 83 percent of available water resources (about 4.0 billion m$^3$/year), and is expected to increase to about 91 percent in 2016 after the completion of several
dams under development and the construction of some new dams. Tunisia has already established and developed a large plan to control surface water including the construction of 30 large dams with an estimated storage capacity of 2.7 billion m$^3$. These dams, channels and conveyance pipes are connected for carrying water to the Greater Tunis area and the country's central and southern regions ("northern water system"). The system, in its current advanced form, is able to meet the demand for drinking water in Greater Tunis, the region of Alwatan-Alkibli, the coastal strip and Sfax, and also for irrigation in the north, Alwatan-Alkibli’s region and the center of the country, and will serve the demands, under all climatic conditions, up to 2030. The system made it possible to transport water over long distances of about 500 km, and to realize equitable distribution of water resources between the various consumers in Tunisia.

In parallel with the security of water resources, Tunisia adopted a clear policy for water management on the basis of achieving the highest economic "value of each cubic meter of water." This was mainly achieved through an integrated approach based on demand management, rational use of water, including the setting of a tariff for drinking and irrigation water to be as close as possible to the economic cost of water, and the adoption of incentives to encourage farmers to use modern means of irrigation, which made it possible to raise the proportion of modern irrigation to about 88 percent of the total irrigated area. This, in addition to improving water conservation, has resulted in raising crop yields significantly. Therefore, Tunisia has had a successful experience in raising the efficiency of irrigation. Moreover, Tunisia has a pioneering experiment in water harvesting through the construction of dams and mountain lakes and the conservation of water and soil. Tunisia also has a good record in the artificial recharge of groundwater basin by benefiting from surface water during floods to replenish some basins that have been depleted by heavy pumping, and the reuse of sewage water directly for the purposes of agriculture, and recharging certain groundwater basins not used for drinking water. Tunisia has also developed systems for measuring and monitoring surface and groundwater, and has adopted a developed Geographic Information System (GIS) for agricultural land, known as farming map, and is currently finalizing an integrated system for the management of natural resources, i.e. water and land, including the sources of environmental pollution. This project, known as SINEAU, will be available to all institutions and departments concerned with water, agriculture and the environment and its data will be updated on a continuous basis.

Recharged and restored water has played a key role in enhancing food security in Tunisia through the expansion of irrigated area, in addition to the traditional rainfed agriculture, where the annual use of water is about 2.1 billion m$^3$ (80 percent of the total water use) used to irrigate about 400 thousand ha, of which 100 thousand ha use supplementary irrigation of cereals. Recharged and restored water also played an important role in reducing the food gap in Tunisia, especially in drought periods. The production value of irrigated agriculture represents about 37 percent of the total agricultural production, and 20 percent of agricultural exports. It contributes to the production of about 95 percent of vegetables, 70 percent of fruits, 30 percent of dairy products and 16 percent of cereal production in the country. To meet the challenge of food security, Tunisia has directed the agricultural sector in general and the irrigated agriculture in particular, towards the production of agricultural crops that have the highest economic value for exports. These exports cover the deficit in the trade balance resulting from the high import of

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57 This policy is clearly stated in the 1975 water code, and served as a basic reference for the water and agricultural policies in Tunisia.
food crops that are not produced locally in sufficient quantity due to weak economic feasibility. Tunisia has also used water management to raise the productivity of irrigated agriculture in products which give the largest value-added per cubic meter of water used. Thanks to this policy, Tunisia was able to reach, in the normal rainy seasons, an acceptable balance in the food trade, where exports of olive oil, dates and fish products, exceed imports of cereals, vegetable oils and other products, while the country is actually achieving self-sufficiency in fruit and vegetables, red meat, poultry products and milk.

To accomplish these achievements, it was necessary for Tunisia to have a clear strategy for water management aiming at adopting efficient and effective water policies, resulting in the highest economic value per cubic meter of the water used. Tunisia was able to pursue effective agricultural policies, cognizant of water scarcity, and within an appropriate institutional framework for both water and agriculture sectors. We now turn to the institutional framework that is behind the relative success of the Tunisian experience in order to make proper inferences regarding water management and the ability to meet the challenge of food security.

The Institutional Framework and Mechanisms for Managing Water and Agriculture Sectors

The Ministry of Agriculture and Water Resources and Fisheries ("the Ministry of Agriculture") is responsible for the management of water and agriculture sectors, and the setting up of strategies, policies and programs needed to develop these sectors.

The Organization and Functions of the Ministry of Agriculture

Figure 11 shows the Ministry's structure, which includes the Minister, a Secretary of State in charge of water resources, a Secretary of State in charge of marine fishing and a number of public administrations at the central level. In addition, there are 24 regional delegations for agricultural development ("Regional Delegations of Agriculture"), located in each governorate, reporting to the Minister and are directly engaged in the scope of decentralization and coordination with others in the field of water, agriculture and the environment. Figure 11 shows the relationship between the structures of the Ministry, and water users (farmers associations, who are responsible for the maintenance and operation of irrigation systems, plus associations of drinking water who are running and maintaining drinking water infrastructure in the scattered rural villages) both central and regional, as well as the relationship with the most important public institutions that operate in the water sector who are also subject to the guardianship of the Minister. The most important central technical departments who work in the field of water and report to the Secretary of State for water resources are: (1) Public Administration of Water Resources which is responsible for measurements of the flow of the valleys and the water level of groundwater basins, laying down plans for the mobilization of groundwater and surface water resources, preparing studies of major groundwater basins, approving licenses for drilling wells, and controlling the exploitation of groundwater; and (2) General Directorate of Dams and Major Works, which is responsible for preparing studies of dams and the larger establishments for water transportation and supervising their implementation, and operating dams after completion.
A number of specialized central technical departments follow the Minister directly: (1) General Directorate of Rural Engineering and Water Management, which holds the control over operation of irrigation systems, and the overall supervision of the councils of water, as well as being responsible for providing small rural villages with water; (2) General Directorate of Studies and Agricultural Development; (3) General Directorate for the Development and Maintenance of Agricultural Land; (4) General Directorate of Agricultural Production; (5) Public Administration for Protecting and Monitoring the Quality of Agricultural Products; (6) General Department of Forestry; and (7) General Directorate of Veterinary Services.

The National Company for the Exploitation and Distribution of Water ("Water Company"), a public company under the guardianship of the Minister of Agriculture, is responsible for the planning, implementation and operation of production facilities, transmission and distribution of drinking water in cities and villages that have populations of more than 500 people, over the entire country. Moreover, the Exploitation of Canal and Pipes of North Water Company ("Canal Company"), which is subject to the guardianship of the Minister, operates and maintains the facilities to transfer water from north dams, which include the north open water channel, and pipes to transport water and pumping stations. The Canal Company is in charge of selling water for irrigation purposes to each of the Regional Delegations of Agriculture and sometimes to the water pools or directly to some of the farmers, and to the Water Company for drinking purposes.

The Regional Delegation for Agricultural Development in each state ("Delegation of Agriculture") is responsible for land preparation, within the scope of the region, for sustainable irrigation. It also operates and maintains irrigation facilities, distributes irrigation water, either directly or through the watershed, which it supervises and provides technical support and guidance services. Besides, the Delegation of Agriculture is responsible for the implementation of agricultural projects that are planned at the central level, the establishment of new irrigation
networks and the rural areas drinking water, the preservation of agricultural lands, the implementation of awareness programs, the extension of agricultural and livestock services, and forest protection.

**General View of the Integrated Water and Agriculture Sectors**

The most important feature of the institutional framework for water and agriculture sectors in Tunisia (the Ministry of Agriculture) is that; it can allow various departments and institutions working in the agricultural and water sectors to easily carry out consultation, coordination and exchange of information, thereby enabling careful planning of the work of each sector, and contributing to an integrated approach to the water and agriculture sectors. The foregoing can be seen clearly by reviewing the components of the ten-year plans developed by the Ministry of Agriculture, which include interrelated and integrated objectives for the various components of the plan. Perhaps the planning for water harvesting and water and soil conservation gives the best example of this overlap and integration, which serves most areas with respect to water and agriculture. The organization of these sectors within one Ministry, greatly contributes to the speeding up of the decision-making process, including the distribution of water to different sectors (drinking and irrigation, and distribution to entities or types of crops), especially in emergency situations such as during drought periods.

**Decentralization of Irrigation Systems Management**

Among the special features of the institutional framework for water and agriculture sectors in Tunisia, is its decentralized feature. In 1980 the offices, which controlled the irrigation systems (13 offices), were dissolved and a Regional Delegation, directly reporting to the Minister of Agriculture, was established in each governorate. Among the functions of the Regional Delegations is the operation of the irrigation systems in public irrigated areas, which are the spaces that are constantly supplied with water from major and medium government installations, such as deep wells and the northern water system. The total of these areas is about 226 thousand ha representing about 56 percent of the total irrigated area, while the rest of the private spaces of about 174 thousand ha are generally supplied through direct pumping from private shallow or deep wells. Figure 12 shows the distribution of these areas based on the water source.

In the context of institutional reform of the Ministry of Agriculture and under Act No. 35-87 / 1987, the direct management of irrigation systems was discontinued, and part of the system was assigned to some of the groups with common interests, while others were retained for the management of the Regional Delegations, in accordance with the importance and level of complexity of the system. Furthermore, the maintenance and operation responsibilities of drinking
water facilities in rural villages have been abandoned for the benefit of the drinking water Groups. The Common Interest Groups Law was amended as to allow the Groups, according to law No. 28-01 for the year 2001 to exercise their activities in the governorate as soon as depositing within the latter a file which includes the name of the Group, the area of its activity (drinking water, irrigation, land protection, etc.), a copy of the its constituent regulations and the names of its directors.  

The Groups with Common Interest are non-profit societies, financially independent and monitored by a consultative assembly under the chairmanship of the Governor. The Groups working in the field of irrigation support the farmers in the maintenance and operation of the irrigation systems, and water distribution among farmers. The expenses of such Groups are covered by the participants' contributions. The Groups collect water charges; represent the farmers at the Regional Delegation as regards their share in the water, payment of the water charges, receiving technical support and agricultural guidance, and enjoying benefits and incentives extended by the governorate for the irrigation sector. By the end of 2009 the total number of agricultural Groups was approximately 1104, covering about 200 thousand ha (90 percent of public areas for irrigation), and including about 1.45 million farmers and beneficiary peasants. The number of the Groups active in providing rural communities with drinking water, during the same period, was about 1380.

**Reliance on a Developed Information System**

The Ministry of Agriculture monitors surface and groundwater resources of the entire country. The Public Administration of Water Resources have accurate information and data about groundwater levels, gathered from approximately 3700 monitored wells of which about 500 are under permanent and constant level recording, about 60 monitored stations with automatic measurement of valley flow, and 60 stations under manual measurement. This collected data enables update of the studies of groundwater basins and control of their exploitation, and improves the degree of knowledge about the surface water and its control. The Dams Management Department, on the other hand, closely monitors the water levels of dams and controls the water supply system in the northern water, on demand and according to the requirements of the beneficiaries regarding the salinity of the water. During the period 1990-1995 the Ministry has developed an integrated mathematical model for the use of the system in the management of water demand at the national level until 2030. The model is also used for simulating the operation of the system according to hypotheses of controlled demands. It is therefore a tool for preparing water budgets and providing assistance in the control of the system, including dams. A comprehensive and accurate information base was set up for all of groundwater and surface water sources, the quantities available, the quality of water, and the water demand data for drinking and irrigation in all areas. All of the above have been added to the Geographical Information System (GIS) discussed earlier, in a context involving water and its uses.

In 2004, the Ministry of Agriculture completed a map for agricultural regions, as a pilot project intended to determine the productive properties of the various governorates in the country, to be

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58 Licenses were previously granted by the Ministry of Agriculture.

59 Optimal Water Resource Management Model, known also under the French abbreviation: GEORE.
used as a reference in guiding agricultural activities according to their feasibility and efficiency and a tool to rationalize investments and control the exploitation of available resources. The map contains about 50 digital geographic information systems in the form of a collection of farming maps as follows:

- **Main map** (including administrative boundaries, road and rail network, water facilities, topographical and climatic characteristics, soil classification, irrigated areas, storage units, etc).

- **Agricultural land uses map** that has been developed based on satellite images to determine the geographical distribution of various productive activities in the states, including major crops, fruit trees, vegetables, forest and pasture. This map shows the specialization in production at the regional and local levels and highlights the importance of some activities and the effectiveness of the production system. In addition to the statistical data provided by this map, several tests can be done, based on the map, to determine compatibility of the current distribution with the agricultural potential of land and the proper utilization of available resources.

- **Agricultural potential maps**, depending on the data of natural resources (soil quality, water availability and the elements of climate and terrain) that characterizes each governorate to identify the characteristics of production and select plants for various agricultural activities. This map is important in directing investment and farmers towards activities consistent with the natural characteristics of each region.

- **Product competitiveness maps** for the most important agricultural products traded, depending on the state index of economic feasibility and patterns of cultivation areas to determine the capacity of each product to cope with competition, especially in light of openness of the country's economy to global competition.

To sum up, the agricultural maps can be considered as a farmer dashboard giving the vision and facilitating the task of decision-making, on the basis of data from each map type or, a combination of data from different maps, according to user needs, with a view to setting several scenarios to help in the following:

- General knowledge of physical, climatic and agricultural factors of various regions;
- Development of investment in agriculture in accordance with priorities and strategies;
- Facilitate the work of the Delegations and the Agency for Agricultural Investment Promotion in the adoption of incentives; and
- Guide the interested investors towards activities that are in line with available natural resources of each region in order to provide the proposed projects with a greater chance of success.

The use of the agricultural map was encouraged in all the regions, and a unit to continuously update their contents was set up. The said results were also placed on the internet at: [http://www.carteagricole.agrinet.tn](http://www.carteagricole.agrinet.tn). The Ministry of Agriculture has recently integrated the geographical information system, relating to water resources and their uses, with the
geographical map, and a further digital map related to environmental matters, in particular sources of pollution of various kinds, has been added. As a result, an integrated geographical information system is expected to be available soon to all sectors of water, agriculture and the environment (known by the French name SINAU). This will be a comprehensive system for all information with programs that allow data analysis and processing to facilitate the integrated management of natural resources.

Planning and Integrated Management of Water Resources

The sectors of water and agriculture in Tunisia depend on consistent integrated strategies and policies which were developed during the past decades in the framework of an integrated water resources management and use. Since the seventies Tunisia has developed legislations to preserve the water resources and rationalize their use.

Legislation and Policies

The water laws in Tunisia are traced back to the colonial period. Such laws and orders determined most of the different aspects relating to water uses (the Order dated 5/8/1933), and the establishment and regulation of the Water Groups (the Order dated 30/7/1936). Some of those laws were modified after independence, and the National Company for the Exploitation and Distribution of Water was established (The Order 22-68 dated 2/7/68). In 1975, however, the laws were unified in a single law called the Water Law. This law has been used in the formulation of water policies for the optimal utilization of available water resources and needs in line with the scarcity of water.

Water Law

The Water Law number 16-75 dated 31/3/1975 was adopted by the Ministry of Agriculture with a view to drawing the water policies of the subsequent decades. The law includes basic principles which are considered as developed, e.g.: (1) that the resources of surface water and groundwater (more than 50 meters deep) are public property; (2) the Ministry of Agriculture is responsible for the planning and mobilization of water resources, monitoring and controlling their use and conservation; (3) where water mobilization is conducted, priority should be given to drinking water, and to meeting the needs of the concerned region of the water basin; (4) giving top priority to water conservation; (5) water users may organize themselves into associations licensed to carry out water and agricultural projects, and run such facilities as a collection of groups of common interest; and (6) the possibility of using treated wastewater for agriculture. The Water Law is properly comprehensive; as it has defined the role of the Ministry of Agriculture in the distribution of water, highlighted the importance of taking into account the economic value of used water, the protection of water against pollution and the protection of groundwater against bad use. Furthermore, the Law prohibited drilling of wells in the depleted basin. In 2001, the water law was amended to the effect that water has been treated as a "national treasure", which should be protected and preserved and not to be owned by any single party, but in return the private sector has been empowered to invest in non-conventional water such as

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60 Established water rights for some water users such as farmers in oases located in the southern part of the country but were charged for water use within predefined limits.
desalinated water or treated wastewater in accordance with the conditions and the provisions laid down by the Ministry of Agriculture.

**Water Policies**

Based on the Water Law provisions, and in parallel with the mobilization of the available water resources, the Ministry of Agriculture has established water policies, developed over the past three decades, which can be summarized as follows:

- Achieving a fair distribution of water wealth among the various organizations, and enabling the majority of the population to benefit from it.

- Applying integrated management of surface and groundwater, managing the water demand and encouraging anything that might contribute to the economic use of water, in order to minimize wasting water. The main procedures adopted are: the setting of tariff on drinking water capable of compensating the expenses, removing the subsidies extended to the Water Company (from 1990), and recovering the cost of maintenance and operation from the tariff on irrigation water.

- Establishing a national program for water conservation, including adoption of financial incentives to encourage farmers to use modern technologies for irrigation, working on the rehabilitation of water facilities and transmission lines, and improving surface irrigation when it becomes difficult to use modern irrigation technologies.

- Adopting decentralization in the organization of the Ministry of Agriculture, gradually abandoning the operation of irrigation networks, and endeavoring to encourage farmers to organize in water users' associations to carry out tasks of operation and maintenance of irrigation systems, in addition to providing services to farmers. In the same context, drinking water groups in rural areas would manage the water facilities.

- Using treated wastewater for agricultural purposes in accordance with environmental, health and safety procedures set by the World Health Organization, considering it an important source of water, in addition to the development of desalinated water for drinking purposes if economically feasible.

- Developing a program to manage and reduce the severity of drought periods. The Minister would act as an arbitrator among the beneficiaries in respect of the distribution of available water, giving priority to drinking water.

- Developing water harvesting by establishing dams and mountain lakes, and water and soil conservation.

- Controlling groundwater basins from depletion and pollution, applying the Water Law to prohibit drilling of wells in the depleted basins, identifying and protecting basins under threat, and utilizing flood waters to recharge the aquifers of depleted basins.


**Water Policy Mechanisms**

Water policy mechanisms include drinking water tariffs, irrigation water tariffs intended to recover the costs of maintenance and operation of irrigation systems, incentives to encourage farmers to use modern irrigation techniques and to reduce wastage in water use.

**Drinking Water Tariff:** Since 1974 the water company has adopted a progressive tariff for potable water, few years later a drainage fee was added to participants' bills who enjoyed the services of the National Wastewater Treatment Company, in order to recover part of the costs of those services. The tariff was increased gradually. So, since the nineties, the tariff managed to recover all the costs of water, including investment costs. Current tariff includes lower category consumers (1-20 m$^3$ in three months), dedicated to needs of residents of low-income, at the price of 0.130 dinars ($0.095$ U.S.) per cubic meter, while the price for the upper category consumers (more than 150 m$^3$ in three months) is 0.830 dinars (about $0.620$ U.S.). The upper category consumers are set for major consumers, industry and tourism. The tariff has played a key role in the rationalization of water consumption in Tunisia and in the management of the drinking water demand.

**Irrigation Water Tariff:** Water tariff represents a prominent element in the mechanisms of implementation of the water policy in Tunisia. In 1970 the irrigation tariff was, on average, $0.01$ U.S. per cubic meter, and increased based on many studies to recover all costs of maintenance and operation of irrigation facilities. The rate of irrigation tariffs continued to rise by an annual rate of about 9 percent, until 2002, when the rate remained the same up to the present. The current average is $0.08$ U.S. per cubic meter, ranging between a maximum of about $0.12$ U.S. per cubic meter, and a minimum of about $0.02$ U.S. per cubic meter. Figure 13 shows the development of tariff during the period 1990-2008. Water meters' program was applied to water associations, which in turn collect water charges from farmers. Irrigation water tariffs vary according to the governorate, source of water (dams, wells etc.), ownership of farm (private or cooperative), type of crop and type of irrigation. There are two tariff systems: the first the price of water is volumetric and depends on the amount of consumption, and the second a fixed cost is added for payment even in the absence of water use. The second system aims at encouraging the farmer to make use of the amount of water allocated to them and increasing the coverage for maintaining the facilities regardless of the amount of water used. The Ministry of Agriculture reviews the tariffs on a continuing basis, according to studies and accurate statistics which monitor the response of the farmers to the amendments made to the tariffs. The rate of tariff for irrigation water covers the average cost of operation and maintenance of facilities, delivery of irrigation water to irrigated areas, but not the investment

**Figure 13. Evolution of Irrigation Water Tariff (1990-2008)**

Source: Ministry of Agriculture, 2010
costs of mobilization, transport and delivery of water. Such costs are borne by the Government. The current tariffs allow the North Canal Company, in addition to the amount of water it receives from the Water Company, to cover the cost of transporting water and its operating expenses, thus achieving an acceptable balance.

Farmers pay the price of water to the common interest groups, in addition to the costs of maintenance and operation of the irrigation network. The groups in turn pass the collected amounts to the Delegation or to the Canal Company. In 2009, the average collection rate for irrigation groups, compared to the total costs, was estimated at about 84 percent, and about 67 percent of the groups were estimated to have covered more than 80 percent of those costs.

Incentives and the Control of Waste of Water: The second component of the implementation of water policies is a set of incentives, mainly consisting of actions taken by the Government in 1995 to encourage farmers, in the framework of the national program for the economy in water, to abandon traditional irrigation and use modern irrigation techniques instead. These incentives are summarized as follows:

- Raising the rate of subsidies of the costs of modern irrigation equipment from 25 percent to between 40 percent and 60 percent, depending on the size of agricultural holdings and location, and quality of crops grown.
- Reduction in customs duties on modern irrigation equipment to a level of 10 percent in case of foreign import, and exempting equipment and supplies manufactured locally from the value-added tax.61
- Facilitating lending for the acquisition of modern irrigation equipment. Providing incentive grants for the renewal of equipment and modern irrigation system amounting to 20 percent to 30 percent of the cost (as of 2001).

The Government subsidizes water tariffs for the cultivation of some strategic crops, and due to the large increase in food prices in 2008, the Government decided, in particular, to subsidize supplementary irrigation of cereals.

In 1995, the Government adopted a number of measures to reduce the wasteful use of water, by forcing major consumers of water for irrigation (more than 5 million m³ per year), and major consumers of drinking water (more than 1,000 m³ per year for private consumption and more than 5000 m³ per year for industry, tourism, and public consumption), to carry out periodic checks, to be conducted by specialists, for any loss of water. In the case of a need to rehabilitate or replace the internal networks, the consumers benefit from government subsidies allocated for this purpose, otherwise water supply will be cut.

The Government also provides financial support for each particular process of producing non-conventional water from desalination of saline water or wastewater treatment, and for the costs incurred in establishing water treatment plants for the industry, or for the treatment of hazardous substances harmful to the environment prior to disposal in sewage systems.

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61 Plastic pipes and polyethylene for drip irrigation are produced locally.
Integrated Planning for the Mobilization of Water Resources and their Uses

The average rainfall in Tunisia is around 36 billion m$^3$/year, ranging between about 11 billion m$^3$/year in drought periods, and about 90 billion m$^3$ in wet years. It also ranges between 100 mm in the extreme south to over 1500 mm in the far north, reaching between 400 and 600 mm in most areas of the north and between 250 and 400 mm in the central regions, while the southern regions are considered dry.

Available Water Resources

The amount of conventional water available in Tunisia is estimated at about 4.84 billion m$^3$/year, of which about 2.7 billion m$^3$/year is surface water (56 percent), and about 2.14 billion m$^3$/year is underground water (44 percent). The surface water is located as follows: about 82 percent in the north, about 10 percent in the center and about 8 percent in the south.

The groundwater consists of about 0.745 billion m$^3$/year (15 percent), as shallow groundwater (less than 50 meters), and about 1.42 billion m$^3$/year (30 percent) as deep underground water. Most of the deep underground water is located as follows: (about 58 percent) in the south, (about 23 percent) in the north and (about 19 percent) in the centre. Figure 14 shows the amount of conventional water available and its distribution within the regions of the country.

One of the main problems facing the use of water in Tunisia is its high salinity, where more than 53 percent of the water contains 1.5 grams/liter of salt. This limits the use of each water source, and requires in many cases the mixing of different water salinities prior to their use. The deep groundwater is the most important part of the saline water (only 20 percent less than 1.5 grams/liter), including non-renewable water in the south.

Table 1. Salinity of the Water by Sources

<table>
<thead>
<tr>
<th>Source of Water</th>
<th>Less Than 1.5 g/L</th>
<th>Between 1.5 and 3.0 g/L</th>
<th>More Than 3.0 g/L</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface water</td>
<td>72%</td>
<td>22%</td>
<td>6%</td>
<td>100%</td>
</tr>
<tr>
<td>Shallow groundwater</td>
<td>8%</td>
<td>32%</td>
<td>60%</td>
<td>100%</td>
</tr>
<tr>
<td>Deep groundwater</td>
<td>20%</td>
<td>57%</td>
<td>23%</td>
<td>100%</td>
</tr>
<tr>
<td>Total amount of water</td>
<td>47%</td>
<td>34%</td>
<td>19%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Planning and Mobilization of Water Resources

The Ministry of Agriculture prepared, during the seventies, programs for each of the northern, central and southern regions, in order to determine the necessary actions needed for the mobilization of the available water resources to meet the demand for water for different purposes. This was based on the study of the most important groundwater basins, and the feasibility and technical studies of large dams, the transport system of water from these dams to consumption centers. Based on that, Tunisia has, over the past three decades, allocated substantial investments to secure its water resources, through construction of dams and transport of water over long distances towards the Greater Tunis area, the Sahel region and Sfax (where drinking water is mostly demanded), and towards the irrigation lands in the north, Mujrada basin, the north eastern part and the center, as well as drilling of deep wells over 2500 meters in the south and transporting of water to the date palms' oases. By the end of 2010 Tunisia completed the establishment and development of a large water system, which included about 30 large dams to mobilize about 1.76 billion m$^3$/year, connected to channels and lines of pipes carrying water to the Greater Tunis area, the center and the south. Moreover, about 224 mountain dams and 837 mountain lakes were constructed to mobilize yearly about 0.225 billion m$^3$ and 0.113 billion m$^3$, respectively. Therefore, the mobilization of surface water and groundwater of the total available water increased from about 29 percent in 1980 to about 83 percent in 2009, which is a huge improvement. Figure 15 shows the evolution of the development of the ground and surface water during the period 1980-2010.

Tunisia is planning to reach the mobilization of around 4.4 billion m$^3$/year by 2016, which is equivalent to about 91 percent of the available water. The average volume of the annual water available from dams and mountain lakes is estimated at approximately 1.6 billion m$^3$/year, equivalent to 76 percent of the mobilized water resources.

Water Use

The total water use in 2009 was about 2.6 billion m$^3$ of which about 0.8 billion m$^3$ depended on shallow groundwater (29 percent), about 1.14 billion m$^3$ depended on deep groundwater (41 percent), and about 0.74 billion m$^3$ depended on surface water (27 percent). Besides, about 20 million m$^3$/year from desalination plants is used for drinking purposes, and about 67 million m$^3$ of treated wastewater is used for agriculture. The use of non-traditional water in Tunisia, thus, represents only about 3 percent of total use of water.

Agriculture is the largest consumer of water resources, where the total consumption in 2009 reached 2.14 billion m$^3$, equivalent to around 80 percent of the total use, followed by drinking purposes (14 percent), industry (5 percent), and tourism (1 percent). The use of water for
agriculture has increased from about 1.575 billion m$^3$ in 1990 to about 2.14 billion m$^3$ in 2009, irrigating about 405 thousand ha (equivalent to 88 percent of arable land for irrigation). As a long-term water strategy for the Ministry of Agriculture, the water allocated for irrigated agriculture is expected to be reduced in 2030 to about 2.035 billion m$^3$/year, as a result of the continued efforts towards water conservation. Figure 16 shows the development of water use for different purposes during the period 1990-2010, and the expectations for the year 2030.

**Integrated Management of Northern Water System**

Northern water system is a main link in the water management system in Tunisia. It is, indeed, the main system providing surface water for drinking and irrigation purposes demanded at different areas of the country. The system is a tool for planning and programming the construction of dams and transport lines by the Ministry of Agriculture that develops and maintains the system continuously, taking into account the actual development of the water demand in different regions. During the years 1990-1995 the Ministry developed an integrated mathematical model to be used by the system for the management of water demand at the national level until 2030, Figure 17. For this purpose, the Government prepared a comprehensive information base with precise locations for all ground and surface sources, and the quantities and qualities of available water, in addition to the data concerning the demand for drinking and irrigation water in all areas. All this was included in a geographic information system to work with the mathematical model for simulating the operation of the system according to different controllable hypotheses. The aforesaid mathematical model is used to carry out water budgets in each region, in order to determine the appropriate time for the construction of large dams and transport lines. The model is also used to determine water quality (salinity) in each region according to the conditions in which the system operates, and for the management of drought periods; by relying on surface water in wet years. Furthermore, the model is used in arbitrations between water users, especially in periods of

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62 GEORE introduced in footnote 19.
severe drought, in respect of the quantities of water to be provided to them. The system is shared by the main users of water, which are the Water Company and the Regional Delegates. Two factors have assisted in the success of the above efforts: First, all the aforesaid organizations report to the Ministry of Agriculture, and second, the planning for all the projects is made at the national level and, at the same time, for all of the Government organs.

**Drinking Water Services**

The percentage of population with access to drinking water in Tunisia is about 98 percent, as the entire urban population and about 47 percent of the rural population are provided with drinking water by the National Company for the Distribution of Water. On the other hand, the General Directorate of Rural Engineering at the Ministry of Agriculture covers approximately 45 percent of the dispersed rural population. The Company covers the entire country, and provides about 81 percent of the population with drinking water through public networks, and has about 2.1 million subscribers. The total quantities of water produced and distributed is about 460 million m$^3$/year. The average per capita consumption of potable water in Tunisia for all purposes is about 112 liters/day. The average for domestic purposes is about 87 liters/day in cities, and about 63 liters/day in the countryside. This may seem low compared to consumption per capita rates in other Arab countries, but is in fact the result of the rationalization of water use that has been adopted in Tunisia since the eighties, notably by applying appropriate water tariffs that are as close as possible to the economic cost of producing and delivering water.

The Water Company provides potable water services in all parts of the country. This company is a public institution working under the Ministry of Agriculture. Since the mid-eighties the Government has stopped all financial support to the Company. The latter Company covers the full cost of water from subscribers, and funds new projects and expands networks out of its own resources or through loans, with the exception of projects financed by the Government in the rural areas. This model for the management of drinking water is unique in the Arab countries, since many similar institutions are incurring heavy financial losses and suffering from multiplicity of actors and overlapping prerogatives. It should be noted that the service provided by the Water Company in Tunisia is one of highest quality in the region, as water is very well monitored and distributed to all sectors seamlessly with no interruptions or rationing of quantities, even in periods of severe drought. In 1995, the Company has developed an integrated strategy for water conservation including rehabilitation of water networks, replacement of water meters for participants, and educating customers, in particular, the Government administrations and the tourism and industrial sectors, to control their consumption of water. This has increased the efficiency of drinking water systems from 70 percent in 1996, to 77 percent in 2007.

**Development of Water Resources**

The Tunisian Government is working continuously on mobilizing water resources by benefiting from the floods in years of rainfall for the artificial recharge of underground basins, and the re-use of treated wastewater, water harvesting and the establishment of dams and mountain lakes. Tunisia has also collaboration programs with neighboring countries for the optimal usage of non-renewable groundwater.
Artificial Recharge of Groundwater Basins

The artificial recharge of groundwater basins is an important factor in controlling water resources, where excess quantities of surface water, especially in wet periods are stored. The process of artificial recharge of the groundwater basins mainly consists of injecting large quantities of surface water to shallow aquifers of water, or through water accumulation areas, wells or river streams where it is possible to slow down the speed of water through barriers. Artificial groundwater basins recharging is also used to restore the balance of water in basins with low water level, or to counter the risk of saltwater intrusion in coastal basins. Tunisia has considerable experience in the artificial recharge of groundwater basins. Government attention has begun at the end of the sixties by the programs of the Ministry of Agriculture to protect water and soil. In the nineties, artificial recharge has become part of a strategy to restore water resources. Figure 18 shows the development of the volume of artificial recharge in the different groundwater basins during the period 1992-2007. In 2007 the artificial recharge was performed in 57 locations distributed over 23 groundwater basins. It is clear from Figure 18 that the quantities of water that are injected annually vary depending on the availability of water in the dams, and that the total quantities that were injected during the period 1992-2007 amounted to about 600 million m$^3$ at an average annual rate of about 37 million m$^3$.

The Public Administration of Water Resources follows up the results of artificial recharge of groundwater basins through the help of some research institutions. Reports indicated that many of the groundwater basins had regained their water balance, including the water layers in each of the Alkhalidia, Wadi Guenich, Ras Al-Jabal, Shaqafiah and Wadi Khairat. Yet a number of other groundwater basins require additional efforts to intensify the artificial recharge, especially the layers of Grombalia, the coastal strip of Alwatan Alkibli, Kairouan valley and Fosana, Nathoor and Sawaf.

Reuse of Treated Wastewater

Tunisia has accumulated a long term experience in the use of treated wastewater, which can be traced back to the seventies, where part of the sewage treatment plant in Shotrana was used for irrigating some of the citrus and fruit trees within the Soukra irrigation project, with an area of 600 ha. The use of this system was developed over the years, until Tunisia has become able to use about 67 million m$^3$ of wastewater (approximately 30 percent of the total amount of treated water), to irrigate around...
1450 ha of golf courses and green areas (26 million m³/year), and to irrigate about 8000 ha of agricultural land (29 million m³/year), and uses about 2 million m³/year for artificial recharge of some aquifers. Figure 19 shows the development of quantities of treated wastewater and their reuse.

The areas irrigated by wastewater treatment are about 1200 ha of grain, about 2900 ha of fodder, about 3600 ha of fruit trees and about 300 ha of industrial plantations. The use of treated water is subject to strict control in accordance with the laws of Tunisia (the Water Law 1975 and Order No. 1047-89) which meets the World Health Organization for the use of treated wastewater.

The main obstacles that limit the expansion in the use of treated wastewater are the psychological attitude of farmers toward the use of waste water in addition to the presence of most of the high-capacity sewage plants in large cities, far away from the areas which can be irrigated. It is also difficult to encourage farmers to use treated sewage water in many areas where well developed networks of irrigation or wells are available. For these reasons, the expansion in using treated water requires relocation to areas where there is no water, and which are close to the treatment plants.

Since 1988 the Ministry of Agriculture has had successful experiments in recharging groundwater by treated sewage water in the regions of Nabeul and Mornag. These successful experiments led the Ministry of Agriculture to expand that process. During the last three years groundwater basins have been annually recharged by about 2 million m³ of treated water.

In the context of the expansion of the reuse of treated wastewater, the Ministry of Agriculture has developed a plan to increase the quantities by the year 2021 to about 200 million m³ (about 3 times the current usage). A preliminary study was conducted for the transfer of water from the treatment plant in the Greater Tunis area to the regions of Zaghouan and Al-Fahs in the first phase (2011-2014), and to the region of Kairouan in the second phase (2016-2021). It is expected that the water will be used to irrigate 26000 ha of agricultural land, and about 30 million m³ for recharging the groundwater basin.

Cooperation with Neighboring Countries over Shared Water

Algeria and Tunisia share some surface water sources in the eastern part of the country. The two countries officially agreed on how to utilize and share these resources, and have developed a mechanism for coordination and follow-up of the shared water of the Majradah River. Tunisia also shares with Libya and Algeria, in its southern part, the northern desert basin, which includes the two underground basins containing large amounts of non-renewable water. The three countries agreed to prepare detailed studies designed to evaluate, conserve and explore the optimal safe use of the basin. The studies provided an information bank and a simulation system that can be run up to year 2050 to analyze the effects of future exploitation of the basin. The main points agreed upon by the three countries were the limitation of exploitation in the coastal areas to avoid salinization of basin water, and the adoption of water conservation techniques used in agriculture in the three countries. Based on this study a safe level of groundwater use in the deep basins in the south of Tunisia was determined at approximately 650 million m³ per year.
Sustainable Management of Natural Resources

The main challenges to achieve sustainable management of natural resources is soil degradation, erosion of agricultural land, and over pumping of groundwater basins leading to low levels of water, and infiltration of sea water, pollution of river streams and groundwater basins by sewage water, and the threat to environmental systems by the network of constructed dams.

Water Conservation and Soil Protection

The percentage of the land located in a dry and semi-dry climate is estimated at about 75 percent of the area of the country (16.4 million ha). This land is affected by the Mediterranean and the Sahara climates, making the top soil vulnerable to erosion due to drought or heavy rains which occur in short periods and leading to soil degradation and production capacity loss. Studies made in 1989, estimated the area of land prone to erosion at about 4 million ha. In 1990, however, the Ministry of Agriculture prepared a national plan for the protection of sloping lands through terracing, and adopted a number of techniques to stabilize the soil, including the construction of mountain lakes to reduce the negative impacts of erosion on the natural resources. The plan also included the improvement of drainage basins and protection of areas planted with grains, and the periodic maintenance of water facilities. This work was carried out within the first two ten-year plans. During the period 1990-2009, terraces were built, grain crops on an area of approximately 1.5 million ha were protected, and water brushes for artificial recharge were installed. In addition, river drainage of around 7,500 units were modified, about 755 mountain lakes were established, and water and soil conservation facilities in an area of 580 thousand hectares were maintained. These achievements reduced the threatened area from 4 million hectares to about 2.4 million hectares (15 percent instead of 24 percent of the total land in 1990). It enabled the establishment of mountain lakes to increase the size of the surface water storage by approximately 80 million m$^3$/year, and to reduce sediment loads in the major dams from 28 million m$^3$/year before 1990, to about 17 million m$^3$/year in 2009, thus contributing to the increase in operational life of those dams. Lakes have enabled the development of irrigated agricultural areas of 7,590 hectares cultivated with cereals and fruit trees, vegetables and forage. This provided job opportunities for about 4,224 farmers.

Monitoring and Protection of the Groundwater Basins

Exploitation of deep underground water basins is estimated at about 1140 million m$^3$, equivalent to 82 percent of the safe exploitation of these basins. According to the Water Law these reservoirs cannot be exploited at depths exceeding 50 meters except after prior authorization. This restriction helped protecting deep basins from depletion. The shallow underground water basins (less than 50 meters) have been subjected to several years of over exploitation amounting to about 806 million m$^3$/year, about 108 percent of the total safe yield. This average hides considerable differences in the exploitation of groundwater basins, where the exploitation of some of them reached 150 percent, and led to a continuous decline of water levels and increase in salinity of reservoirs, especially in the coastal zones. Since 1945, 16 districts and 10 maintenance zones were established to reduce the exploitation of underground water reservoirs in order to protect groundwater basins from continuous deterioration. Drilling of wells and changing the equipment to increase exploitation in the restricted areas were banned. Any rehabilitation of wells and drillings are subject to prior license from the Minister of Agriculture.
Artificial recharge has contributed to the recovery of the water balance and led to the replenishment of approximately 39 million m$^3$ of water annually in aquifers that are suffering from intensive exploitation. Work is still ongoing to pursue threatened reservoirs and restore their water balance.

**Sewage Water**

The National Bureau for Sanitation provides services in all urban areas for a fee which is recovered within the water tariff. These fees are set to penalize industrial polluters of water that is discharged into the sewerage network collection system. The estimated number of beneficiaries is approximately 6 million, about 87 percent of the population. The total number of sewage plants is 100 stations, treating about 230 million m$^3$/year (2nd treatment), 29 percent of it is allocated for the purposes of agriculture, and the balance is discharged into the sea. The Public Administration of Water of the Ministry of Agriculture and the Ministry of Environment monitor the quality of groundwater that can be exposed to environmental pollution by sewage and industrial discharges. A map of environmental pollution is circulated and will be used in the context of integrated information system (SINEAU).

**Ecosystem Protection**

The largest ecosystems that are threatened by the construction of dams is the northern Lake of Ichkeul which is supplied by a number of rivers (Joumine, Sajnane and Ghazala), where dams were constructed, and currently 6 dams are under construction on the other rivers which still flow into the Lake. Ichkeul Lake is connected to Lake Benzert, which is connected to the Mediterranean Sea. During winter, Ichkeul Lake is supplied with fresh water from the surrounding rivers thus raising water levels in the Lake and reducing salinity. The said Lake is internationally classified as a natural reservation used by many kinds of rare birds that migrate from Europe at different periods of the year. An environmental study of the Lake prepared by the Ministry of Agriculture has identified the necessary discharge of at least 20 million m$^3$/year from dams to maintain the ecological balance of the Lake. Some negative signs of the Lake’s ecosystem have been noticed, especially the declining level of the Lake and the rise of its salinity due to lower water flows during the period 1990-2000. The Ministry of Agriculture has solved the problem through feeding the lake with 470 million m$^3$ of water during the period 2003-2005, as shown in Figure 20. The Ministry of Agriculture and Environment has also followed up the ecological conditions of the Lake.

![Figure 20. Evolution of Water Flows into Ichkeul Lake from Northern Wadis](image-url)
Drought and Floods Issues

Tunisia, like the rest of the north western Arab countries, faces severe and continuous drought periods stretching sometimes to three consecutive years, as well as high rainfall rates during short periods, causing significant flood damage. In recent decades, as an example during 1969-1970, the recorded average annual rainfall was about 11 billion m$^3$/year, while during 1993-1994 this average did not exceed 780 million m$^3$/year. During the past three decades dams played a major role in stabilizing the water supply. The Ministry of Agriculture monitors the water inflows and outflows for dams on a regular basis to cope with variations of monthly water demand especially in periods of drought, in the best manners.

Among other measures to cope with drought periods are the integrated management of surface and groundwater to rely more on surface water in wet years, and groundwater in drought periods, and inter-connection of the dams in order to improve the control of water resources and give greater flexibility to the system to meet the required demand for water both in the quantity and quality (salinity) required. Managing drought is part of the work programs of water and agriculture sectors, where rainfall and the storage level in the dams during autumn and early winter are carefully followed up and addressed. In 1999 the Ministry published a manual for drought management, setting out the practical steps that must be taken with the institutions and departments concerned to maintain the water, agricultural crops and forests and to provide drinking water to the population. The manual contains instructions based on lessons learned in responding to previous periods of drought. Tunisia has also considerable experience in dealing with flood damage on people and infrastructure, including using of the early warning system, which played an important role in that regard.

Water Management and the Food Security Challenge

Water mobilization in addition to traditional rainfed agriculture, play a key role in enhancing food security in Tunisia. About 2.1 billion m$^3$ (80 percent of the total water use) is used annually to irrigate about 400 thousand hectares, of which 100 thousand hectares of cereals are under supplementary irrigation. This has played an important role in reducing food deficit, especially in periods of drought. The production value of irrigated agriculture constitutes about 37 percent of the total agricultural production, provides 20 percent of agricultural exports, and contributes about 95 percent of the country's production of vegetables, 70 percent of fruits, 30 percent of milk and about 16 percent of cereals. To understand the policy of

![Figure 21. The Crop Structure for Each of the Rainfed and Irrigated Agriculture](image-url)
Tunisia to achieve food security it is important to know the characteristics of the agricultural system especially with respect to the climate prevailing in different regions of the country.

The total arable area in Tunisia is about 5 million hectares, and pastoral and forest area is estimated at about 5 million hectares. The distribution of agricultural area of the country is as follows: 37 percent in the north, where the prevailing climate is rainy and used for the production of fodder and grains, 47 percent in the center where the rainfall ranges between 200 and 400 mm, and mainly used for fruit trees, and 16 percent in the south, where rainfall does not exceed 200 mm, and used for the production of olives in the coastal areas and dates in the oases. The usable area for irrigation is about 460 thousand ha, out of which 400 thousand ha are effectively used for agriculture, and distributed among the various regions of the country.

Figure 21 shows the crop structure in each of the irrigated areas and rainfed agriculture areas. Unlike the situation in most of the Arab countries with great agricultural potential, the percentage of the total area planted with grains in Tunisia is limited and do not exceed 30 percent of the total cultivated area (1.5 million ha). The area planted with grains represents 39 percent of the total areas of rainfed agriculture, and about 13 percent of the total areas of irrigated agriculture, where supplementary irrigation is used. The cultivation of fruit trees prevails over the rainfed agriculture, occupying half the entire size (mostly olives). The cultivation of fruit trees also prevails over irrigated agriculture (dates, citrus) and vegetables, whose sizes are about 39 percent and 33 percent, respectively.

**Water Use Efficiency**

The Government has given priority to improving the efficiency of irrigation, where water consumption in agriculture constitutes about 80 percent of the total water use. The conventional surface irrigation was dominant in Tunisia until 1995, and known for its low efficiency which does not exceed 60 percent. In 1995, the Government developed a program that aims at promoting the use of modern irrigation techniques such as drip and sprinkler irrigation to improve surface irrigation (especially in the oases areas). To achieve this goal, a number of measures were taken to encourage farmers to abandon their traditional irrigation methods and shift to new modern irrigation equipment.

In preparation to adopt the water conservation program, the National Institute of Agronomy of Tunis has established a specialized division for the engineers specialized in the modern irrigation techniques, and sections specialized in water conservation, in order to guide farmers to use modern techniques and especially on matters of operation and maintenance. The Ministry of Agriculture has published a technical guide about the use of equipment for modern irrigation, particularly drip irrigation, and the optimal use of such techniques under different salinity, soil quality and climatic conditions. The Ministry also published specific technical handbook to ensure acquisition of good quality equipment. In addition to encouraging farmers to use modern irrigation, the Ministry of Agriculture has also completed a number of projects to rehabilitate the facilities for water transport and distribution to the most important projects in the southern oases, and projects in the mid-west, totaling about 30 thousand ha. Some of these projects have been completed while others are still under construction.
Using Modern Irrigation Techniques

During the period 1995-2010 a significant development in the use of modern irrigation technologies and improved surface irrigation was achieved (about 88 percent of the total irrigated area), which left only 50 thousand ha to be equipped with modern irrigation facilities or to be improved before the end of 2011. This confirms that the program has received wide acceptance by farmers. Figure 22 shows the development of irrigated areas, based on irrigation methods.

Impact of the Use of Modern Irrigation Techniques

In 2001 the Ministry of Agriculture, prepared an interim Phase I assessment on the water conservation program, based on a comprehensive evaluation of the areas that have been applying the techniques using the production and productivity of different crops, consumption of water, as well as evaluating the response of farmers to the program. The results were very encouraging for future implementation of the program.

The most direct and positive result recorded using modern techniques was the improvement in the efficiency of irrigation at the farm level, which is estimated to have increased by 25 percent, shortening the water cycle, reducing manpower, and the amount of water needed to irrigate crops (thus avoiding water logging), and increasing the productivity of most crops, with significant improvement in the quality, resulting in more competitive advantages when crops are exported. Annex (4) shows the most important results that have been attained by raising the efficiency of irrigation using modern techniques. The said results may be summarized as follows:

Increasing the Productivity of Crops

The use of modern irrigation techniques has resulted in a remarkable increase in the productivity of crops, especially when using fertilized irrigation. Figure 23 shows the development of productivity for some crops using modern irrigation compared to traditional irrigation. The increase in productivity of modern irrigation is about 75 percent for tomatoes, about 69 percent for pepper and 35 percent for potato. It is also noted that grain production has tripled when using supplementary sprinkler irrigation.
Decline in Consumption of Water per Hectare

Up to the year 2000 the average consumption per hectare of water has decreased by about 7 percent, (5 percent for vegetables and 9 percent for fruit trees) as a result of using drip irrigation. The decline varies greatly depending on the crop. For example, consumption of tomato has decreased from 7275 m³/hectare to 6100 m³/hectare (-16 percent), for potato from 4736 m³/hectare to 4075 m³/hectare (-14 percent), and is considered limited for the rest of vegetables. As for fruit trees, the consumption of peaches has decreased from 5800 m³/hectare to 4250 m³/hectare (-27 percent), and for pomegranate from 7000 m³/hectare to 5700 m³/hectare (-19 percent), but has risen for apples. Figure 24 shows the development of the average consumption of water per hectare, where it is estimated to have declined from about 6000 m³/hectare in 1996 to about 4800 m³/hectare in 2009.

The above rates are acceptable when taking into consideration the fact that about half the water resources used have high salinity (more than 1.5 grams per liter) and require the use of additional quantities of water (from 10 percent to 30 percent) to wash the accumulated salts in the soil which have a negative effect on the total production. Figure 25 shows the average amount of water consumed and the amount of water used per hectare for each of the vegetables and fruit trees in 2009.

Increase of the Value-Added per Cubic Meter of Water

Figure 26 shows the value added per cubic meter of irrigation water in 1990, and water prices for the period (1990-2009). It is clear that the value was relatively stable during the period (1990-1994), and has declined slightly in 1995 because of the drought period at that time, but started rising continuously during the period (1996-2009). The increase in value added per m³ between 1996 and 2009 is about 43 percent. This increase is mainly due to the increase in water productivity.
Increasing Cost-Effectiveness of Water

Based on the study mentioned above, Figure 27 compares return per cubic meter of water between the traditional irrigation and drip irrigation for the main vegetables and fruit trees in 2000. It shows the following:

- The average return of water for vegetables has increased from about $0.42 U.S./m³ for surface irrigation, to about $0.80 U.S./m³ for drip irrigation, an increase of approximately 90 percent.

- The average return of water for fruit trees has increased from about $0.58 U.S./m³ for surface irrigation, to about $0.83 U.S./m³ for drip irrigation, an increase of approximately 42 percent. The increase in return for fruit trees has been limited, in comparison with that of vegetables, by the large areas reserved for palms and citrus trees, whose productivities are insensitive to drip irrigation.

Tunisia’s Policy in Achieving Food Security

Tunisia has followed a well-balanced and realistic policy in dealing with food security. This is due to the prevailing good economic situation and the lack of available water resources to achieve complete self-sufficiency in the main food groups. In addition to subscribing to the UN (FAO) definition of food security, Tunisia has appended two important principles in their strive to achieve this goal: (1) food must be made available by relying on national production in as much as possible and as long as its economic viability is proved; and (2) achieving a sustainable food trade balance.

Accordingly, the agricultural sector was directed towards the development of products and agricultural crops that have the highest export value and whose exports can cover the deficit in the trade balance resulting from the import of products not produced locally. To achieve this, Tunisia has worked on the development of competitive advantages in both rainfed and irrigated agriculture in products such as olives, dates and citrus. Also, according to the Water law, Tunisia has provided incentives in irrigated agriculture crops which give the largest value-added per cubic meter of water used. Therefore, Tunisia avoided the intensification of irrigation to achieve self-sufficiency in grain. In return, it has tried to achieve an acceptable degree of self-sufficiency by using supplementary irrigation of cereals on an area of about 100 thousand ha (20 percent of the total irrigated area), consuming a limited amount of water, which does not exceed 2500 m³/hectare per.
Tunisia’s Accomplishments in Achieving Food Security

The following are the most important accomplishments achieved by Tunisia with regard to food security.

Covering the Cost of Food Imports by Exports

Figure 28 shows the development of food trade balance during the period 1990-2009. It is clear that Tunisia has achieved during that period acceptable results in food security, enabling the value of exports to cover imports up to about 85 percent. The low coverage ratios (between 50 percent and 60 percent) recorded during 1995-1996 and in 2002, are due to the drought that swept the country during these periods. With the exception of those periods, exports have generally covered the entire import value and a surplus was achieved during the periods 2004-2006 and in 2009.

Figure 28. Food Trade Balance, and the Ratio of Exports-to-Imports of Food Products During the Period 1990-2008.

The trade balance shows that Tunisia has achieved self-sufficiency in fruit and vegetables, red meat, poultry, and milk products, but it imports annually about 25 percent of its durum (hard) wheat, and 75 percent of its bread (soft) wheat. Moreover, Tunisia imports all of its needs of vegetable oils, rice, maize, tea, coffee, and about 500 thousand tons of barley for animal feed. Tunisia also covers its imports from cereals and vegetable oils, tea, coffee and sugar from exports of olive oil, fruits (especially dates) and fish, as shown in Figure 29.

Figure 29. Average Gap in Main Food Groups (2005-2007)

Source: Statistics of the Arab Organization for Agriculture Development 2010
Figure 30 shows also the percentage distribution of both imports and exports regarding the main food products during the period 2007-2009.

**Increasing the Value of Agricultural Exports**

Increasing food products' exports is an important element in achieving food security. In this context, Tunisia has set up an integrated policy to encourage exports, by relying on comparative advantage of some of its products, and utilizing good timing to market the products, especially taking advantage of early harvest season relative to Europe, its main export market. It has also relied on research, field experiments and developed storage capacity to expand its export potential throughout the year. Tunisia has, on the other hand, improved export laws and regulations to meet European standards in terms of packaging, quality control prior to export. The Government also established a special institution “The Export House” to guide exporters, and provide many incentives for the establishment of export companies, including sharing 50 percent of the cost of air freight for agricultural products.

Among other encouraging steps to raise the exports of agricultural products is the support of biological products by allocating more lands for biological agriculture which have increased from 17 thousand ha in 2001 to about 285 ha in 2008. As a result, production has increased during the same period from 4 thousand to 170 thousand tons. The export revenues from biological products in 2008 were about 64 million Tunisian dinars. The most important products are olive oil, aromatic and medicinal plants and some vegetables.

Tunisia has accorded a special emphasis in food industry on obtaining the highest value added in agricultural product exports. This is evident particularly in the production and export of food like couscous and pasta made of durum wheat, in addition to a number of vegetables and fruits, respectively, representing about 6 percent and 4 percent of total exports.
Grain Production and the Role of Supplementary Irrigation

The average planted area of grains during the period 2000-2010 is 1.5 million ha, of which about 53 percent is planted with durum wheat, 10 percent with bread wheat, and 37 percent with barley. Figure 31 below shows cereal production during the period 1988-2009. It has increased from about 1.6 million tons during the period 1991-1995 to about 1.85 million tons in the period 2006-2009. The production of durum wheat represents about 65 percent of the total cereal production.

Figure 31 also highlights the effects of climatic changes on the production of cereal crops, where production is shown to dramatically decline during drought periods (1988-1994-1995-2002-2008). In 1988, grain production record was at its lowest level since 1961 (200 tons) as a result of drought and locust attack, and in each of 1994-1995 and 2002 the grain production did not exceed 750 thousand tons (about 40 percent of the production).

In the eighties Tunisia has used supplementary irrigation in only 30 thousand ha. However, this area has increased from about 40 thousand ha in 1990 to about 100 thousand ha in 2010. Currently around 50 percent of the area is planted with durum wheat, about 10 percent with bread wheat and about 10 percent with barley. Figure 32 shows the evolution of productivity of both supplementary irrigation and rainfed grain during the period 1988-2009. It is clear that the productivity of cereals under supplementary irrigation had risen significantly after 1996. This was due to the

Government support for sprinkler irrigation facilities, the reduction of water tariff in supplementary irrigation by 50 percent and granting water free of charge for the first irrigation in the season. The highest productivity recorded in 2009 for cereals, was for supplementary irrigation with a yield of 4.3 tons/hectare. The rainfed cereal yield, which is greatly affected by climate changes, ranges between 0.5 tons/hectare in drought periods and about 1.8 tons/hectare in wet years, with an average of 1.3 tons/hectare during the period 2003-2009.

Although the area of supplementary irrigation accounts for less than 7 percent of the total area planted with grains, they have contributed, in recent years, around 20 percent of the total production of grain. Supplementary irrigation plays a key role in achieving food security. It can
provide a minimum quantity of grain in times of drought, particularly durum wheat. Also supplementary irrigation is used in providing quality seed for future years.

**Self-Sufficiency Program of Durum Wheat**

Durum wheat is the most important strategic crop and widely used in the daily diet of Tunisians (mainly couscous and pasta). Figure 33 shows the development of production of durum wheat, the imported quantities, and the percentage of self-sufficiency during the period 2003-2009. It is clear that the self-sufficiency rate is about 75 percent, and it has ranged between about 53 percent in 2008 (a dry year) and 94 percent in 2004.

During the international food crisis that led to record high prices of foodstuffs in 2008, especially grains, Tunisia faced difficulties in providing the needed quantities of durum wheat, due to the lack of internationally traded quantities and speculative behavior prevailing in the market at the time. That experience has forced Tunisia to set a plan to achieve self-sufficiency in durum wheat by 2014 through the following plan:

- Focusing on supplementary irrigation and productivity by increasing the area of durum wheat from about 50 thousand ha to about 80 thousand ha, and raising productivity to 5.5 tons/hectare.
- Directing the cultivation of durum wheat to the most suitable lands in terms of climate (humid and semi-humid), over an area of 150 thousand ha, and increasing its productivity to about 4 tons/hectare.
- Raising productivity in the remaining areas of rainfed agriculture to about 0.9 tons/hectare.

Specific work programs have been developed to achieve the plan, such as activating the role of the National Institute for Large-scale Farming, the development of agricultural services (storage capacity, quality seed air conditioning, land and water preparation), improving the financial system, determining the prices of grain before the planting season, and rehabilitation and completion of the restructuring of land tenure.

**Conclusion and Most Important Lessons Learnt from Water Strategy Management in Tunisia**

The main problem inhibiting the role of water in achieving food security is that, despite its scarcity, there is a huge waste of water in agriculture, as surface irrigation is dominant in most of the Arab countries. Besides, the low pricing of irrigation water does not encourage farmers to conserve on water and optimize its use. Since the Arab countries have used up most of their
water resources and agriculture currently consumes about 87 percent of these resources, the most important priority is to address the food security challenge by raising the efficiency of irrigation. This paper shows that there is a considerable potential for water conservation by saving at least 37 billion m³/year through the use of modern irrigation methods and improved surface irrigation in the Arab World. The implementation of modern irrigation would also have a significant impact on productivity, quality of crops and the economic yield per cubic meter of water.

Despite conviction of most of the Arab countries about the merits of modern irrigation, its use is still limited representing only about 20 percent of the total irrigated areas. One of the main reasons that hinder the use of modern technologies for irrigation is the large investments needed for the rehabilitation of existing main irrigation facilities and networks, and the difficulty faced by farmers in providing for the investments necessary for the introduction of modern technologies. Indeed, drip and sprinkler irrigation systems require skills and expertise in operating and maintaining the equipment. There is an urgent need to overcome all these obstacles in order to achieve concrete results in terms of water conservation and increased crop productivity.

The Tunisian Government underwrote many of the equipment and infrastructural costs and provided financial and other incentives for farmers to make the shift from traditional to modern technologies. Arab governments can adopt this strategy.

Through its national program to save water, launched in 1995, Tunisia was able to increase the use modern irrigation techniques and improved surface irrigation by almost 82 percent. Furthermore, Tunisia’s experience shows the importance of taking advantage of the arrangements that preceded the implementation of the national water conservation program, which includes the formation of engineers and technicians working groups, the development of important incentives to encourage farmers to use modern irrigation and providing them with training and assistance, especially in the early stages of using such techniques. The experience of Tunisia in using modern irrigation techniques has led to a significant increase in the productivity of crops, an increase between 35 percent and 75 percent for vegetables, and 58 percent for fruits. It has also shown significant gains in the cost-effectiveness of water. Given these results, it may be appropriate to undertake a comprehensive assessment of the Tunisian national program for water conservation as many useful insights and lessons could be gleaned by the rest of the Arab countries.

This paper shows that the productivity of rainfed grain in the Arab countries is low, and there is room to improve it drastically, as it has been confirmed by field experiments. However, this requires the protection of resources, the use of technology and modern production inputs, the development of agricultural research and land tenure, and the restructuring and rehabilitation of agricultural research institutions. The good management of supplementary irrigation is crucial to obtain the highest productivity of grain with the least amount of water. Farmers in some Arab countries tend to, in light of low water prices, to over-use water. This waste is often exacerbated by the use of traditional surface irrigation. The use of sprinkle irrigation, as the Tunisian experience shows, leads to substantial reductions of water consumption.
In addition to water wastage, Agriculture in the Arab countries suffers from lack of planning, poor coordination between water and agriculture sectors, and poor participation of farmers in the operation of irrigation systems. The public irrigation systems are often centrally managed, which led in most cases to poor maintenance and mismanagement. Decentralization and involvement of farmers in the context of cooperative societies in the management of irrigation networks proved successful in Tunisia as well as in some other Arab countries. Also water pricing has been found to be an effective means of rationalizing water use. The more efficient volumetric pricing system may be combined with other incentives in order to encourage the use of modern techniques of irrigation. The Arab countries are in urgent need of clear and consistent water legislations, and firm rules regarding for instance, groundwater use and disposal of agricultural drainage water and liquid industrial waste, in order to achieve sustainable use of water resources and environmental conservation.

The presentation of Tunisia's strategy of water management and its policies to meet the challenge of food security in spite of water scarcity shows prudence and farsighted planning. Since the seventies the development of water legislation (Water Law) was established and aimed to achieve the highest possible economic value per cubic meter of water. This Law considered water as a "public property" and "national treasure" and must, therefore, be preserved. In parallel, with the careful planning of mobilization of water resources, the Ministry of Agriculture strategies and water policies were formulated with the aim of achieving a fair distribution of water between the various sectors, managing water supply and demand, rationalizing water use, achieving the greatest possible economic value to water use, increasing access to potable water, and preparing for the drought periods. Tunisia is currently working within a framework of a strategy up to 2030, and has an integrated system of dams and pipelines transporting water capable of meeting the demand for drinking water and agriculture until 2030. Moreover, the Ministry of Agriculture is currently planning for yet a longer term strategy up to 2050. It is perhaps useful to add, to what has been addressed regarding the results achieved by the National Program to Save Water, a summary of the mechanisms and practical programs that have been implemented, and institutional arrangements that have contributed to the achievement of the strategic objectives of Tunisia for water management and food security by way of providing a framework for others to consider, evaluate and adopt:

1. **Integrated and coordinated planning for agriculture and water** is an important factor for the success of water management and development of irrigated agriculture. The experience of Tunisia of full decentralization (Regional Delegations) and the organization of water users association that operate irrigation systems and drinking water facilities under the supervision of the Regional Delegations can be considered and benefited from. The same also applies to the mechanisms used to implement the policies of rationalization of water use such as tariff incentives and measures to stop water wastage.

2. **The advanced information system for the management of water and natural resources** is an important tool for easy and proper assessment and decision making. Of much benefit, also, is the mathematical model simulating the northern water system in Tunisia. The model can be employed for budgeting and saving water in different regions of the country, as well as for managing periods of drought. Being a very useful and advanced management tool, the model should be generalized and adopted in other countries.
3. **Regularly and accurately monitoring and following-up of water resources**, including surface groundwater through a network of wells and measurements of water in the rivers, in order to update studies of groundwater basins, control consumption, and improve the degree of knowledge about water resources.

4. **Artificial recharge of the groundwater basin under the integrated management of surface and groundwater**, notably through the use of flood water is paramount in restoring water balance of drained basins. The Tunisian experience is quite unique, and therefore may be useful to know its details, the difficulties it encountered, and the solutions adopted to escape these difficulties.

5. **The planning and implementation of water conservation and soil protection** through the construction of mountain lakes and dams, protecting sloping land from erosion, and planting water brushes etc. These activities are important not only from a water management perspective but also in terms of development of agriculture around the mountain dams and lakes.

6. **The development of food products and agricultural crops that have the highest economic value.** By focusing on the development of such products it will be possible for the proceeds of the exports to cover the deficit in the trade balance resulting from the large imports of food crops that are not sufficiently produced locally. This turns out to be crucial in increasing water productivity in irrigated agriculture and improving food security.

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Source: Agricultural Development Organization Arabia


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Source: Agricultural Development Organization Arabia
Annex 2. Water Price in Some Arab Countries

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<th>Country</th>
<th>Minimum</th>
<th>Average</th>
<th>Maximum</th>
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<td>Egypt</td>
<td>There is no specific price for irrigation water but the law can retain basic expenditure</td>
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<td>0.049</td>
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<td>Morocco</td>
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<td>0.053</td>
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<tr>
<td>Syria</td>
<td>Tariff of $12.5/ha./yr. winter crops and $73/ha./yr. for summer crops</td>
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<td>Tunisia</td>
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Annex 3. Water Consumption per hectare in Some Arab Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Irrigation Area 1000/ha</th>
<th>Planted Area 1000/ha</th>
<th>Crop Intensity %</th>
<th>Irrigation Water million m³</th>
<th>Water Consumption Million m³/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syria</td>
<td>2006 - 2008</td>
<td>1356</td>
<td>1524</td>
<td>112%</td>
<td>15695</td>
<td>10.229</td>
</tr>
<tr>
<td>Egypt</td>
<td>2002</td>
<td>3422</td>
<td>6027</td>
<td>176%</td>
<td>59000</td>
<td>9.789</td>
</tr>
<tr>
<td>Morocco</td>
<td>2000</td>
<td>1407</td>
<td>1520</td>
<td>108%</td>
<td>11000</td>
<td>7.237</td>
</tr>
<tr>
<td>Jordan</td>
<td>2004</td>
<td>72.0</td>
<td>99.0</td>
<td>138%</td>
<td>611</td>
<td>6.17</td>
</tr>
<tr>
<td>Tunisia</td>
<td>2006 - 2008</td>
<td>406</td>
<td>390</td>
<td>96%</td>
<td>2100</td>
<td>5.385</td>
</tr>
<tr>
<td>Sudan/AC Jazira</td>
<td>AC Manager Projects</td>
<td>864</td>
<td>425</td>
<td>49%</td>
<td>7000</td>
<td>16.486</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7,527</td>
<td>9,985</td>
<td>133%</td>
<td>95,406</td>
<td>9.555</td>
</tr>
</tbody>
</table>

Calculated based on statistics from different sources and from Syria, Tunisia and Arab Fund records from project evaluations.

Annex 4. Comparison between Productivity, Consumption and Added Value of Traditional and Modern Irrigation on some Vegetables and Fruit Trees in Tunisia

<table>
<thead>
<tr>
<th>Irrigated Crop</th>
<th>Modern Irrigation</th>
<th>Traditional Irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomato</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potato</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peppers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Artichoke</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean for Vegetables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pomegranate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Citrus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean for Fruit Trees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hard Wheat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft Wheat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean for Major Crops</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Annex 4. Cont’d Comparison between Productivity, Consumption and Added Value of Traditional and Modern Irrigation on some Vegetables and Fruit Trees in Tunisia

<table>
<thead>
<tr>
<th>Irrigated Crop</th>
<th>Productivity</th>
<th>Production</th>
<th>Cost</th>
<th>Price</th>
<th>Revenues</th>
<th>Net Profit</th>
<th>Water Consumption</th>
<th>Added Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tons/Ha</td>
<td>Tons/Ton</td>
<td>T.D/Ha</td>
<td>T.D/ton</td>
<td>T.D/Ton</td>
<td>T.D/ha</td>
<td>M³/ha</td>
<td>T.D/m³</td>
</tr>
<tr>
<td>Tomato</td>
<td>70.5</td>
<td>54.6</td>
<td>3.850</td>
<td>120</td>
<td>8.460</td>
<td>4.610</td>
<td>6.100</td>
<td>0.756</td>
</tr>
<tr>
<td>Potato</td>
<td>27.0</td>
<td>136.1</td>
<td>3.675</td>
<td>300</td>
<td>8.100</td>
<td>4.425</td>
<td>4.075</td>
<td>1.086</td>
</tr>
<tr>
<td>Peppers</td>
<td>22.0</td>
<td>131.6</td>
<td>2.895</td>
<td>500</td>
<td>11.000</td>
<td>8.105</td>
<td>4.500</td>
<td>1.801</td>
</tr>
<tr>
<td>Artichoke</td>
<td>12.0</td>
<td>258.3</td>
<td>3.100</td>
<td>600</td>
<td>7.200</td>
<td>4.100</td>
<td>6.300</td>
<td>0.651</td>
</tr>
<tr>
<td>Mean for Vegetables</td>
<td>32.88</td>
<td>102.8</td>
<td>3.380</td>
<td>380</td>
<td>8.690</td>
<td>5.310</td>
<td>5.244</td>
<td>1.073</td>
</tr>
<tr>
<td>Palms</td>
<td>6.0</td>
<td>231.7</td>
<td>1.390</td>
<td>1.600</td>
<td>9.600</td>
<td>8.210</td>
<td>7.300</td>
<td>1.125</td>
</tr>
<tr>
<td>Pomegranate</td>
<td>17.5</td>
<td>53.4</td>
<td>935</td>
<td>400</td>
<td>7.000</td>
<td>6.065</td>
<td>5.700</td>
<td>1.064</td>
</tr>
<tr>
<td>Peach</td>
<td>12.0</td>
<td>91.7</td>
<td>1.100</td>
<td>500</td>
<td>6.000</td>
<td>4.900</td>
<td>4.250</td>
<td>1.153</td>
</tr>
<tr>
<td>Citrus</td>
<td>25.0</td>
<td>160.0</td>
<td>4.000</td>
<td>450</td>
<td>11.250</td>
<td>7.250</td>
<td>6.500</td>
<td>1.115</td>
</tr>
<tr>
<td>Mean for Fruit Trees</td>
<td>15.13</td>
<td>122.7</td>
<td>1.856</td>
<td>738</td>
<td>8.463</td>
<td>6.606</td>
<td>5.938</td>
<td>1.114</td>
</tr>
<tr>
<td>Hard Wheat</td>
<td>4.0</td>
<td>150.9</td>
<td>608</td>
<td>295</td>
<td>1.187</td>
<td>579</td>
<td>2.300</td>
<td>0.252</td>
</tr>
<tr>
<td>Soft Wheat</td>
<td>4.1</td>
<td>131.5</td>
<td>539</td>
<td>295</td>
<td>1.210</td>
<td>671</td>
<td>1.925</td>
<td>0.349</td>
</tr>
<tr>
<td>Mean for Major Crops</td>
<td>4.1</td>
<td>141.1</td>
<td>573</td>
<td>295</td>
<td>1.198</td>
<td>625</td>
<td>0.296</td>
<td></td>
</tr>
</tbody>
</table>
COMMENTS ON CHAPTER 3

Theib Oweis
Director, Integrated Water & Land Management Program
International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria

Water for Agriculture

Water is the most important—and the scarcest—natural resource in the Arab World. Annual per capita water availability is less than 800 cubic meters for the region as a whole, and less than 200 m$^3$ in some countries; quantities that are insufficient to meet basic needs. New fresh water supplies are limited by physical, economic and political constraints. There is little new water that is not already tapped and this is mostly of low quality (e.g. treated sewage) or involves high processing cost (e.g. desalination).

Increasingly more water is being diverted from agriculture to meet the growing demand from priority sectors such as domestic and industrial. As a result, agriculture’s share of water in the region will drop from the current 80 percent to about 50 percent in 2050 (Figure 1). This reduction will seriously threaten food security and the already fragile environment. With declining water for agriculture the only solution to enhance food security or even to maintain current production levels is to sustainably and substantially increase the productivity of water.

Agricultural Water Productivity

Water productivity (WP) is the return or the benefits derived from each cubic meter of water consumed. This return may be biophysical (grain, meat, milk, fish etc), socio-economic (employment, income), environmental (Carbon sequestration, ecosystem services) or nutritional (protein, calories etc.). Most of the water is consumed through evapotranspiration and is therefore “unrecoverable”. Recycled water is not considered to be consumed or depleted. Figure 2, presents average values of various types of water productivity for some products.

Drivers to improve WP vary with scale. At the field scale it is desirable to maximize the biophysical WP of a specific crop or product. At the farm level, the farmer would like to
maximize the economic return from the whole farm, involving multiple crops or products. At the country level the drivers for improved WP are food security and exports. At the basin level, competition between sectors, equity issues and conflicts may drive WP issues. It is important to note that the WP concept provides a standardized way of comparing crops and production areas, and for determining what to grow and where. Determination of cropping patterns should take into consideration drivers at all scales and all types of WP relevant to the population.

**Figure 2. Average Water Productivity (Biophysical, Economic, Nutritional and Energy) Values of Selected Food Products. Calculated by Averaging High and Low Values**

Research has shown that it is within reach to, at least, double the current productivity of water used in agriculture in the region. This is equivalent to doubling the amount of water available. WP can be improved by implementing modern technologies, adopting more efficient water management methods such as supplemental irrigation and water harvesting, improved cropping patterns and agribusiness practices, using improved germplasm; all combined and supported by sound socioeconomics and policies. Rainfed agriculture has the highest potential for increases in water productivity and food production and investment in this agro-ecosystem may be the most feasible (Rockström et al. 2010).

**Water Vs. Land Productivity**

In water-scarce areas, like the Arab countries, water, not land, is the most limiting resource to agricultural development. Accordingly, in water scarce areas, the strategy to maximize agricultural production per unit of land (land productivity) may not hold everywhere. New irrigation management strategy based on maximizing the production per unit of water is more relevant. Fortunately practices for increasing water productivity also improve land productivity but within limits (Figure 3). A tradeoff needs to be made to optimize the use of both water and land resources (Oweis and Hachum, 2009). This will require substantial changes in the way we think and conduct agricultural development. These changes can be achieved though adopting new irrigation guidelines using deficit irrigation, changing cropping patterns, reforming water
policies to value water, increasing the support for research, encouraging people’s participation and promoting regional cooperation.

**Modernizing Irrigation Systems**

It is well known that modern irrigation systems, such as drip and sprinklers, deliver higher water application efficiency than traditional surface irrigation. This encourages countries to convert from traditional systems to modern ones. The lower efficiency of surface systems is due to higher deep percolation and runoff losses. These losses occur at the field level but may be fully or partially recovered at the scheme or basin levels by recycling drainage and runoff losses or by pumping deep percolation losses from groundwater aquifers. Of course these are important losses to the farmer and recovering this water has a cost—but these are not total losses at the larger scale. It should not be understood that reduced losses by increasing irrigation efficiency, through converting to modern systems, will make the saved amounts of water available for expansions or use by others. Irrigation losses in Egypt for example are recycled through the drainage systems several times before becoming too saline for agricultural use.

Modern systems such as sprinkler and drip irrigation can be efficient only if they are managed properly. In many areas the efficiency of modern systems is as low as that of surface systems because of poor management. Modern systems do not guarantee high efficiency; surface systems may be better under certain circumstances especially as farmers know them well. The selection of the appropriate system depends on the physical and socioeconomic conditions at the site.

Modern systems increase productivity not because it reduces system losses in deep percolation and runoff, rather due to better control, higher irrigation uniformity and frequency, better fertilization and other factors. The benefits, however, come at a cost: capital, energy and maintenance. Successful conversion requires developed industry, skilled engineers, technicians and farmers, and effective maintenance. They are most successful in areas where water is scarce and expensive, so that farmers can recover the system cost by reducing irrigation losses and increasing productivity. When water is ample and low in cost, farmers have little incentive to convert to modern systems. In fact improving surface irrigation systems through land leveling and better control may be more appropriate for most of the farmers in developing countries. The vast majority of irrigation systems in the world are surface and assuming that this will change in the near future is unrealistic. A wise strategy is to invest more in improving surface irrigation but encourage modern systems when conditions are favorable.
In many Arab countries, investment is directed to conversion to modern irrigation systems. The increased efficiency obtained reflects the performance of the system – not the performance of the water. So we can have very high irrigation efficiency but low agricultural productivity. Irrigation efficiency does not tell us anything about productivity. Investment should also be directed to increase water productivity.

**The Necessity of Change**

“Business as usual” is no longer an option for water management in the Arab World. Unless strategic changes are made, the region will face increasing water and food insecurity. New thinking on managing water in agriculture should drive new strategies and approaches. Important changes should include:

- Change the emphasis from land to water when water is more limiting than land. Maximizing water productivity can alleviate water shortages and improve food security.
- Change current land use and cropping patterns to more water-efficient crops and cropping systems based on comparative advantages among agro-ecologies, especially in rainfed systems.
- Change the way water is valued to truly reflect its scarcity. Water is extremely valuable in water scarce areas and should be used as such. Farmer support can be better designed to avoid inefficient use of water.
- Change trade policies to import food where there is no comparative advantage in local production. Large amounts of water cross borders as virtual water. This needs to be adjusted to reduce water demand, support existing farming communities and rationalize socioeconomic decisions.
- Change the attitude towards regional cooperation. Water productivity can be enhanced if food is grown in Arab countries with comparative advantages in water, climate, soils and socioeconomics.
- Change from disciplinary to integrated approaches. Maximum productivity will never be reached unless all production elements are optimized.
References


COMMENTS ON CHAPTER 3

M. Abdulhamid Azad
Irrigation Engineer, World Bank

Water and the Challenge for Food Security in the Arab Countries is a comprehensive document written with growing water scarcity in mind and therefore particularly relevant to irrigation-related agricultural water management in the Middle East and North Africa Region. The paper advocates and pledges support for a comprehensive approach to agriculture water management and incentives for good water management at the farm level.

1. The paper starts with an introductory section on "Food Security Challenges in the Arab Countries". This section has clear difficulties in distinguishing between the concepts of "Food Security" and "Food Self-sufficiency."

The authors provide two alternative definitions of the concept of Food Security: the first one is based on the definition of the Arab Organization of Agricultural Development (AOAD), whereas the second one is based on FAO's definition. The AOAD definition stresses the need for reliance on domestic food production first and imports second, while at the same time promoting the need for relying on comparative advantage to guide domestic food production. This definition is contradictory, given that the concept of comparative advantage is based on growing only that crop that you can grow most efficiently, while importing other crops from other countries. It would be advisable if the authors would stick with the FAO definition which was accepted globally during the World Food Summit in 1996. This internationally accepted definition is even more appropriate for the Arab countries since most of these countries do not have the necessary natural resources to reach self-sufficiency in food while, at the same time, many Arab countries have the necessary revenues to import a good deal of their food needs. In fact, even after introducing the two definitions of food security, the rest of this section is focused exclusively on analysis of self-sufficiency ratios in various Arab countries rather than on actual food security. It would have been useful if the authors could have used some background statistics on malnutrition levels as one indicator of food security rather than self-sufficiency ratios.

2. Following the introductory section, the authors present a general section on issues related to the problems facing water management in the Arab countries. This section provides a very good overview of the critical issues affecting the water sector in Arab countries. It also provides some very useful comparisons between different countries about which reliable data are available. The main constraints highlighted include: (1) building institutional and organizational frameworks for the water and agricultural sectors; (2) the need to increase irrigation efficiency; (3) increasing crop yields; (4) maximizing net economic returns to water; and (5) development of non-traditional water resources and their utilization. The analysis particularly stresses the need to improve irrigation efficiency through the adoption of improved irrigation methods. It also stresses the critical importance of implementing reasonable water charges to provide the necessary incentives for farmers to use water more efficiently, including the incentive to invest
in modern irrigation. In stressing the importance of maximizing net returns to irrigation water, the authors are implicitly supporting the broader concept of food security rather than the unsustainable concept of food self-sufficiency.

3. The water productivity (added value after subtracting farming costs) is as follows:

- Average of $0.1 U.S./m³ from flood-irrigated cereals, $0.5 U.S./m³ from flood-irrigated cash crops, and $0.75 U.S./m³ from modern-irrigated cash crops (source: Table 4 in the paper's annex).
- Figures from Lebanon show that the water productivity from modern-irrigated cash crops can reach $1 to $2 U.S./m³.

4. The irrigation net diversions/year is around 150 billion m³/year. Thus, if the same water is used in exporting cash crops (rather than in increasing food self-sufficiency), the added value to the Arab World will be at least $75 billion U.S./year (150 billion m³/year multiplied by an intersectoral shadow value of water of at least $0.5 U.S./m³). These figures tell us that the region will forgo lots of wealth if it uses its scarce water to grow more cereals at $0.1 U.S./m³. It seems more sensible that the region redirect its water policies to support agribusiness growth and exports.

5. The paper emphasizes irrigation water pricing. Few countries recover the full costs of irrigation and drainage services through user charges. In irrigation and drainage, cost recovery targets have often been too ambitious and unrealistic. Increasing the involvement of irrigators in managing the services is one way that can lead to significant improvements in cost recovery. The World Bank’s position on cost recovery in the water sector is presented in the 2004 Water Resources Sector Strategy. It emphasizes that cost recovery needs to be a core element of reform, in particular with regard to projects providing sanitation services as well as irrigation and drainage. The Strategy acknowledges that, in both developed and developing countries, there is a large gap between the economic principle of full cost recovery and the on-the-ground reality of water users paying only a fraction of the costs. In response, the Strategy calls for “pragmatic, but principled” interventions, and recommends “developing a realistic, sequenced approach to cost recovery.”

Many WB supported projects in water supply and sanitation and in irrigation and drainage include substantial efforts to improving cost recovery along the lines of the 2004 Strategy. The approach that the Bank takes is to work gradually towards cost recovery by a variety of measures and focused on incremental improvements to at least achieve the coverage of operation and maintenance costs, and to make irrigation projects more financially sustainable.

In order to further improve cost recovery and also address the question of who will pay for the uncovered costs, it is important to keep in mind a few basic principles. First, the full cost of services will need to be paid to ensure that the services can sustainably be provided in the short- and medium-term. Recovering costs from users thus helps provide the funds for adequate current financing of the services, for retirement of the loans that funded the investment, and/or for future public needs. But cost recovery and water charges may also be used with the aim of managing demand, and providing an incentive for improving the allocation of scarce water resources.
Second, if there is a financing gap between current charges and full cost recovery, it would often require substantial increases in user fees to close the gap. Such increases may be politically difficult to implement, not least because they may conflict with the need for the affordability of services and for ensuring access of the poor. Thus it is important to consider a number of measures that can be taken to close the gap besides charging higher fees, including improving fee collection; and reducing the cost of the service (mainly by improving the efficiency with which water services are provided).

Overall, closing the financing gap in the irrigation and drainage sector requires a range of instruments including higher user charges, higher collection rates, and most importantly more efficient irrigation service provision resulting in lower costs.

**Recommendations**

- A major investment plan to modernize the irrigation and drainage sector. In addition to investments in supplementary irrigation for the rainfed land.

- A strong shift towards demand management, conservation, and protection of agricultural water.

- Major regional investment in groundwater management.

- The region should move from securing staple crops towards more diversification and growing cash crops with the aim to increase exports by using their comparative advantage and then use some of the money generated from the exports to import staple food.

- The main focus of the region should not be on saving irrigation water, but on increasing the yield of crops per unit of water. The Chinese in particular have very carefully monitored these rates and have been very successful at using the data to increase the agricultural productivity per unit of water. The region may benefit from the Chinese approach to maximize production by integrating the engineering aspects with the agronomic and institutional aspects that cause water savings and productivity increase.

- Climate change and its impact on agriculture and water should be studied and adaptation measures should be mainstreamed in agriculture and water development.

- The countries in the region should also benefit from each other’s experiences in water savings, from the increases in productivity, and from the promotion of agricultural exports.

- There should be more focus on building institutions in the water and agricultural fields, including R&D (the Arab Water Academy based in Abu Dhabi).

- To encourage farmers to take up modern irrigation systems, there should be a government program (supported by regional and international funding agencies) which supports the
farming communities in the introduction of water-efficient systems. The introduction of such systems should be based on a cost-sharing arrangement whereby beneficiaries contribute (depending on the country and region) between 30 percent to 70 percent of the cost of investments and whereby small pilot/demonstration farms would be established on beneficiary land to train farmers in the region on best practices. Such systems have been ongoing in Yemen over the last two decades with Bank/IDA financing and support.

- There should be a clear strategy and action plan to implement the paper’s recommendation.

**The Key Issues Addressed During the Discussions**

1- To what extent would management of the existing irrigation systems and improvements in both field-level and basin-wide water-use efficiencies help to address the future water demand?

2- To what extent would the use of a demand-based approach (e.g. full pricing of irrigation water) help to close the gaps between water supply and water demand?

3- How would inter-sectoral demand for water and the impacts of pricing policies on other sectors of water use affect the supply and demand of irrigation water?

4- How would the development and management of trans-boundary water resources and the trading of water within and among the different uses and regions help resolve the national water requirements on a sustainable basis and in a cost-effective way?

5- How much additional reservoir storage is needed to build up the large dams for augmenting freshwater to meet the growing water demand, and to what extent would it be financially, economically, socially, and environmentally feasible in the next 25 years? To what extent have the costs been estimated and the feasibility of solving the associated financing aspects studied?

6- We are dealing and have been dealing for a long time with a lack of monitoring and a lack of data collection on ground and surface water quantity and quality. At the same time, there is a lack of incentive to adequately and consistently measure irrigation water use. This makes it extremely difficult to arrive at good management of agricultural water. You really cannot manage without measurement. During the recent droughts in Australia, it became very clear that the procedures and irrigation infrastructure that are firmly in place in that country for measuring and controlling water, and which include tradable water rights, were extremely useful, because ultimately the agriculture GDP was relatively little affected by the drought, which could otherwise have been economically catastrophic.
Case Study of Tunisia

- The choice of the Tunisia for the case study is excellent. Tunisia is one of the most "water-poor" countries in MENA and suffers from most of the constraints (identified above) prevailing in other Arab countries. Yet, Tunisia was able to implement a long-term water and agricultural strategy that has achieved very impressive results. The paper provides a very detailed analysis of the background of Tunisia's water and agricultural sectors as well as an assessment of the various elements of this successful strategy. The Tunisian success story can be summed up as follows:

1. Integrated and coordinated planning of both agriculture and water sectors: the fact that a single Ministry is responsible for the two sectors has ensured effective integration and coordination.

2. Implementation of a sophisticated information system for the management of water and natural resources.

3. The recognition that close monitoring and evaluation of surface and ground water resources is critical.

4. Optimizing the use of occasional flood waters for artificial aquifer recharge.

5. Implementation of a comprehensive program for soil and water conservation, including major investments in water harvesting infrastructure and soil erosion control.

6. Promotion of exports of crops (e.g. olives, dates, citrus) that have the highest economic returns to water and using export earnings to cover the costs of imports of staple grains. This is the essence of Tunisia's food security strategy.

- As highlighted earlier, Tunisia provides an excellent example of the right mix of incentives (water tariffs and subsidies for modern irrigation) encouraging farmers to rapidly adopt improved irrigation techniques. Tunisia has reached one of the highest rates of adoption of modern irrigation techniques in the Arab region. In other Arab countries governments have focused on providing subsidies for irrigation equipment without increasing water tariffs, which has lead to some very low levels of adoption.

- The Tunisian experience is clearly a very useful success story that several other Arab countries, with similar agro-climatic conditions, could replicate.

- The paper does not mention one very important factor for the success of the Tunisian food security strategy: Tunisia's population control policies have resulted in the lowest rate of population growth in the Arab World. This has probably contributed to a very moderate increase in the demand for food and allowed the country to maintain a reasonable balance between the value of food imports and agricultural exports. Other Arab countries, particularly in the Mashreq continue to have relatively high population growth rates that are contributing to undermining their overall food security.
One question in relation to having one Ministry responsible for both water and agriculture sectors that was not addressed in the paper: how was this single Ministry able to avoid bias towards agriculture in the allocation of water resources among the various economic sectors in Tunisia?
CHAPTER 4—ROLE OF INFRASTRUCTURE AND LOGISTICS IN FOOD SECURITY: IMPROVING WHEAT IMPORT SUPPLY CHAINS (WISC) IN ARAB COUNTRIES

Michelle Battat (FAO), Sean Michaels (World Bank), Julian Lampietti (World Bank), Arnold de Hartog (World Bank), and Dana Erekat (World Bank)

Introduction

Food security depends on consistent availability of sufficient food supplies, stable access to resources to acquire food, and proper use of food to achieve nutritional well-being. Countries achieve food security at the national level when each citizen is food secure (World Bank 2009). Wheat is a staple food in Arab countries and citizens must have access to a sufficient wheat supply. Therefore, governments have a vested interest in facilitating the financing and procurement, through public and private sector avenues, of domestic and imported wheat supplies.

With net wheat imports of approximately 36 million metric tons in 2009 and 2010, Arab countries are the largest net importers of wheat in the world. On average, Arab countries spent about 1.3 percent of GDP on wheat imports in 2009, ranging from less than 0.1 percent in Qatar to 3.1 percent in Yemen. Underlying this pattern are a number of structural factors, including rising population and income growth as well as binding production constraints such as scarce water and land resources. For these reasons, import dependency is expected to continue increasing, which means Arab countries will remain vulnerable to risks associated with a high dependence on wheat imports.

Given the recent volatility in international wheat markets, Arab countries are concerned about both the import supply and price risks they face. The thin world wheat market, uncertain harvest forecasts, and possible export bans from major wheat producing countries—such as the one imposed by Russia in August 2010—raise concerns about the availability of wheat and the risk of shortfalls in wheat supplies. Poor logistics may result in spillage and spoilage of wheat imports, exacerbating these supply risks. Meanwhile the international wheat market is experiencing increased price volatility and price shocks, which can have a significant impact on food-price inflation in Arab countries. While improving logistics will not reduce exposure to volatility or structural increases in international wheat prices, it can smooth some volatility in domestic wheat prices as well as reduce the base cost of importing wheat and thus the severity of future price shocks.

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63 The amount spent on wheat imports was calculated by adding Cost and Freight (CFR) to wheat-import supply chain (WISC) logistics costs. These figures may be underestimated as demurrage costs are not factored in the total amount spent on wheat imports.

64 Price risk is the risk that food prices will be prohibitively high, making purchase difficult even though supply is available on world markets. Supply risk is the risk of food not being available, even if there are sufficient funds for purchase.
This paper assesses WISC performance in 10 Arab countries, identifies possible bottlenecks, and provides recommendations to help manage exposure to import supply and price risks. Arab countries’ price risk and supply risk can increase significantly if supply chains fail to perform. This paper examines ways in which countries can reduce WISC logistics costs (measured in US$/mt) and transit times (measured in days) to ensure a reliable and efficient WISC. Performance is assessed at each segment of the WISC from the unloading port to bulk storage at the flour mill (Figure 1).

![Figure 1. The Analysis Covers the Supply Chain from the Unloading Port to Bulk Storage at the Flour Mill](source)

To help assess relative performance, Arab countries’ WISCs are compared to one another and to those of the Netherlands and South Korea. Based on discussions with representatives from Arab countries, the Netherlands and South Korea were selected to serve as reference points of WISC performance outside the region. The Netherlands was selected as a benchmark because it is a major wheat importing country with outstanding logistics performance. However, the structure of the Netherlands’ WISC is different from that in many Arab countries, since much of the inland transport is conducted along waterways. South Korea was selected as an Asian benchmark because, like Arab countries, it is highly dependent on wheat imports, and its WISC is somewhat comparable to that of some Arab countries in terms of volume handled and inland distribution.

**Why is Having an Efficient WISC Important?**

A well-performing WISC should ensure delivery of supplies in a timely and cost-effective manner. Regardless of the amount of wheat a country imports, the timeliness of its WISC is one key measure of efficiency. Bottlenecks in the supply chain may cause longer transit times from port to consumer, which can lead to more spoilage and to delays in the delivery of supplies to people in need. A country’s food security depends not only on the ability to purchase wheat, but also on the ability to move the wheat through the supply chain to the consumers; bottlenecks in transit may increase risks to food security. A second measure of WISC efficiency, cost

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65 Ten countries participated in the study including Bahrain, Egypt, Jordan, Lebanon, Morocco, Oman, Qatar, Saudi Arabia, Tunisia, and Yemen. WISC data was collected from public and private sector representatives in each country.

66 Figure 1 displays the general WISC structure for Arab countries. Of course, each country has a unique WISC. For example, some countries store wheat at the port and transport it directly to the flour mill; other countries have a consolidated WISC with the flour mill at the port.

67 The Netherlands is the world’s fourth largest importer of wheat by volume (FAOSTAT, 2010) and ranks fourth in the World Bank’s 2010 Logistics Performance Index.

68 South Korea’s wheat import dependency ratio (net imports divided by consumption) is 93 percent.
effectiveness, affects a country’s exposure to price risks. The cost of wheat entering the WISC is the CFR (Cost and Freight) price,\textsuperscript{69} while the cost of wheat when it arrives at the flour mill is the CFR price plus WISC logistics costs. These costs should be minimized, yet inefficiencies such as vessel demurrage costs or assets that remain idle while waiting for delivery of wheat (e.g., trucks waiting or mills not operating at full capacity) result in increased costs. Transit time and cost are inextricably linked, and thus an efficient and reliable WISC will help mitigate both supply and price risks.

All segments of the WISC are interconnected and efficiency throughout the supply chain is critical. Bottlenecks in one segment or node of the chain can have repercussions in other segments and nodes, both upstream and downstream. For example, one cause of vessel waiting times may be slow vessel discharging/unloading rates: vessel discharging rates depend on the effective capacity of the vessel unloading system, the effective capacity of the conveying system to the silo, and the available capacity in the silo. At the same time, the available capacity in the silo depends on outtake capacity by trucks (a low outtake capacity increases the risk of a full silo). A bottleneck at any one point in this chain can result in a delay upstream at the port. Conversely, if a port becomes congested by an import surge, long vessel turnaround times (waiting time in the harbor plus discharge time) might prevent a smooth flow of wheat to flour mills. In this second example, a bottleneck located upstream in the supply chain may cause insufficient supply of flour and bread downstream. For a country’s WISC to be robust, the entire chain must be free of bottlenecks that prevent a constant flow of wheat to the flour mills.

**How Do WISC Logistics in Arab Countries Perform in Terms of Addressing Supply Risk?**

Based on the selected corridors for each participating Arab country, the average WISC transit time in 2009 was 78 days (Figure 2).\textsuperscript{70} Dwell time of wheat is the major driver of overall WISC transit time, accounting for 87 percent of total transit time.\textsuperscript{71} Both operational and strategic storage are included in this figure, reflecting throughput volumes and logistics as well as policy decisions. The other main driver of transit time is vessel turnaround time, accounting for 12 percent of total transit time. Although transport networks in many Arab countries are frequently inefficient, inland transportation, accounts for less than 1 percent of transit time and does not appear to be a main bottleneck in terms of the overall transit time for an average metric ton of wheat. For comparison’s sake, WISC transit time in the Netherlands is approximately 18 days while it is around 47 days in South Korea.

\textsuperscript{69} Incoterms CFR (Cost and Freight) is specified in contracts where the delivery of goods to a named port of destination/discharge is at the seller’s expense. The buyer is responsible for the cargo insurance and other costs and risks. The term CFR was formerly written as C&F.

\textsuperscript{70} For each country the authors considered the corridor with the largest throughput volumes.

\textsuperscript{71} Dwell time was combined for all points of storage throughout the chain. This could include storage of wheat at the port, inland, or at the flour mill.
In this benchmarking analysis, supply disruptions can first occur at the port, threatening food and overall national security, especially in times of crisis. The first transit segment is vessel turnaround time. On average, wheat vessels arriving at ports in Arab countries had a turnaround time of 9.5 days, including both waiting time in the harbor and discharge time. While discharge time is a function of unloading capacity and the cargo volume, waiting time is largely independent of vessel size and could be minimized. \footnote{The waiting time includes any time required for customs procedures, inspections and analysis, as well as any delays due to limited berthing space, priority for other vessels (container, cruise, export), inadequate handling capacity, silos being full, or poor scheduling.} On average, vessels arriving at ports in Arab countries in 2009 waited about three days before they began discharging wheat. \footnote{This figure is based on the mean waiting time for the ten selected corridors. If vessel wait times are weighted based on volume of imports for each country, average waiting time in Arab countries is nearly 5.7 days.}

However, among Arab countries there was quite a range of waiting times. Relative to vessels unloading in the Netherlands, vessels waited up to eleven times longer, significantly impacting overall vessel turnaround times (Figure 3). The waiting times in Arab countries can be compared to waiting times of less than one day in the Netherlands and nearly six days in South Korea. Such long waiting times in Arab countries could significantly impede the timely delivery of wheat to people in need. Not only was there a range in the average waiting time across countries, but within a single country waiting times varied from vessel to vessel. Figure 3 demonstrates that while the majority of vessels in 2009 spent less than two days waiting in the harbor, there were a number of ships that waited significantly longer. Such long waiting times cause major disruptions to the WISC and could have severe consequences for food security. While the source of these bottlenecks can vary from country to country, reducing waiting time in the harbor for some countries could help quickly deliver supplies during emergencies and improve food security (Figure 4).
Bottlenecks can also occur during inland transport. Inland transit time is dependent on a number of factors including the number of segments in the WISC, the geography of the country, the quality of the inland transportation infrastructure, and transportation regulations. While the networks could comprise different modes of transportation including road, rail, and waterways, the majority of wheat in Arab countries is transported by truck. This analysis considers only a
single corridor for each country and may not fully reflect the state of inland transportation in each country. For a single metric ton of wheat, inland transit time can vary from less than one hour, in countries whose WISC is fully consolidated at the port (requiring no inland transportation), up to a day and a half in countries that must transport the wheat first to a silo near the port, then to an inland silo, and then to the flour mill. Yet across different Arab countries, the range in transit times is relatively small, amounting to a difference of only one day. Even significant improvements, in percentage terms, for countries with relatively long transit times such as Jordan, may result in only marginal reductions in supply risk. Nevertheless, access to safe roadways in good condition will not only help reduce transit times, but it will also minimize spillage losses from uncovered trucks and allow the use of larger trucks, thereby reducing the amount of grain handling.

Lastly, WISC transit time is largely dependent on dwell time of wheat, which is driven by two types of storage: operational and strategic. Strategic storage aims to mitigate supply risks by providing wheat supplies ready for immediate consumption in emergency situations and by providing critical lead time to secure alternative wheat supplies or supply routes during times of crisis. While strategic storage is driven by public policy, operational storage is driven by logistics. Here, we focus on operational storage, which is needed to create smooth logistics, regulating flow of incoming and outgoing wheat in the supply chain. Operational storage is meant to prevent excessive turnaround times of vessels and trucks and can be minimized so that the wheat is only stored for long enough to ensure a smooth inflow and outflow. At the port, for example, wheat imports arrive in batches on vessels, while flour mills operate more or less at a constant rate. Thus, operational storage at the port allows for unloading the vessel as quickly as possible (inflow), while releasing wheat at a constant rate from the silo (outflow) into the downstream segments of the chain.

Operational and strategic storage could be combined, particularly at a country’s point of entry, and therefore it is important to understand what is driving dwell times at a given storage facility. Storage of wheat should always be temporary as wheat is a perishable product. Yet, dwell times can be long and may be the result of inefficient logistics or storing for emergency situations. Distinction therefore has to be made between operational and strategic storage. For example, depending on the incoming volume, a dwell time of 30 days could be considered inefficient if there is no strategic storage. If, however, the facility is meant to regulate throughput and simultaneously maintain strategic reserves, 30 days may be reasonable, assuming first-in-first-out (FIFO) rotation and a policy stipulating the need to maintain approximately one month’s worth of strategic wheat reserves. However, since, in practice, operational and strategic storage are often combined, analyzing the dwell times alone makes it difficult to assess the efficiency of storage logistics. Nevertheless, efficient use of operational storage will help reduce bottlenecks throughout the chain and will thereby reduce supply risks.

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74 Storage effectively is transportation with a speed of zero. Therefore dwell time is the amount of time an average metric ton of wheat stays in storage.
75 Operational storage is a “necessary evil” to create smooth logistics in normal situations, where predictable issues are present at the transfer points including: incidental and temporary interruptions in supply, change of transport mode, variations in arrival times of transport units, and local constraints (physical, operational, natural, etc.).
How Do WISC Logistics in Arab Countries Perform in Terms of Addressing Price Risk?

Maintaining a reliable and efficient WISC will also mitigate wheat import price risks. Regardless of throughput volumes, an inefficient WISC will increase the cost of food regardless of the amount of wheat imported. Egypt, for example, has a road network with limited connectivity in some parts of the country, and the quality of the roads used to transport food, particularly those to Upper Egypt, are not in the best condition. This leads to longer transit times and an increased need for truck maintenance, all of which contribute to higher WISC costs. Meanwhile, limited storage capacity in Tunisia appears to cause bottlenecks at the port as vessels cannot unload the wheat immediately due to full silos; this causes longer vessel waiting times and increases logistics costs. Deficiencies in port infrastructure can also add to costs; a port that has not been designed to handle larger vessels will be forced to import wheat on smaller vessels, and thus will not be able to take advantage of the lower unit costs of large vessels. The higher WISC costs caused by inefficient logistics increase the final price of wheat that consumers face. If the Government subsidizes wheat, flour, or bread, these additional costs are absorbed by the Government in the form of fiscal burdens, caused by the difference between the price fixed by the Government and the economic cost of wheat.\(^{76}\)

While this analysis is based on reported costs, hidden costs, in the form of a quasi-fiscal subsidy, must also be accounted for. Just as the domestic consumer price of wheat might not reflect the full economic cost of importing wheat due to Government safety nets in the form of subsidized bread, flour, or wheat, the WISC costs discussed in this benchmarking analysis also might not be an accurate reflection of the full economic cost of logistics. Many Arab countries subsidize the cost of fuel, which effectively lowers reported WISC costs, including transportation costs and the operation costs of equipment and storage facilities. In 2009, total fuel subsidies in the Middle East and North Africa were $150 billion U.S. (The Economist 2011), which is approximately 7 percent of the region’s 2009 gross domestic product (GDP).\(^{77}\) Some countries, such as Lebanon, Jordan, and Tunisia have implemented reforms, and their energy costs are more reflective of real prices, but other countries such as Saudi Arabia and Egypt have significant fuel subsidies. Transportation and electricity costs are likely to be understated for Gulf Cooperation Council (GCC) countries (Bahrain, Oman, Qatar, and Saudi Arabia) and other oil producing countries (Egypt, Morocco, and Yemen).

\(^{76}\) When the Government subsidizes wheat, flour, or bread, the price consumers pay will be lower than what they would pay if the subsidy did not exist.

\(^{77}\) According to the World Bank’s World Development Indicators, GDP in 2009 for Middle East and North Africa as a region was $2.2 trillion.
Reported WISC costs in Arab countries added an average of $40 U.S. per metric ton to the final cost of imported wheat in 2009, which is equivalent to 17 percent of the average CFR price. Due to the quasi-fiscal subsidies that are imbedded in reported WISC costs, these figures represent a lower bound of the full economic cost. WISC costs are broken down into four main categories (Figure 5): port logistics (29 percent), storage (12 percent), transportation to inland silos and mills (22 percent), and WISC management (36 percent).78 WISC management includes such costs as product loss, cost of capital, and overhead, which on average total about $15 U.S. per metric ton. Given the different WISC structures throughout the region, total WISC costs in Arab countries range from being similar to that of the Netherlands to being more than four times as much (Figure 6).79 Total WISC costs were approximately $11 U.S. per metric ton in the Netherlands and $16 U.S. per metric ton in South Korea.

Of total WISC costs, 29 percent were incurred at the port,80 65 percent of which were driven by vessel turnaround time. This means that vessel turnaround time, one of the largest driving factors of a country’s total WISC costs accounted for about 20 percent of total WISC costs in Arab countries. Generally speaking, the shorter the WISC, the greater the share cost of vessel turnaround time will be of total WISC costs. For example, cost of vessel turnaround time accounts for 37 percent of total WISC costs in Qatar, which has a short WISC that is consolidated at the port.

Figure 6 is not intended to reflect a ranking of countries, but rather to offer a starting point for the sake of comparison.

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78 WISC management includes loading port costs, bank costs, insurance for the WISC, commissions, security costs, cost of working capital, overhead & administration costs, risk & profit margins, and product loss. WISC management is not directly addressed in this paper as the focus is primarily on logistics. For a more in depth discussion on WISC management see forthcoming World Bank publication on Improving Wheat Import Supply Chains in Arab Countries.

79 Figure 6 displays the reported WISC costs, which do not reflect the full economic cost. Some segments, particularly storage and transport to inland silos and mills, may be heavily subsidized in some countries. Thus,

80 Port logistics costs include vessel wait time in harbor, inspection/sampling/analysis, agent fees, fumigation prior to discharge, unloading/handling at the berth, and transport to port silo (if applicable).
The second category, total transport costs for a country’s WISC, ranges widely within the Arab World. Inland transport costs are driven by a number of factors including a country’s size, the quality of transport infrastructure, the level of fuel subsidies, the number of actors throughout the WISC, and the relative level of stakeholder power at each segment of the WISC. But the primary driver of a country’s cost of inland transportation as a share of total WISC costs is the structure of the WISC. Countries that have the mill at or near the port, or have minimal transport segments, will have lower overall transport costs both in absolute terms as a share of total WISC costs. This is more common in smaller countries such as Bahrain and Qatar, but some larger countries also have consolidated WISCs. However, one must remember that this paper focuses on the supply chain up to bulk storage at the mill. In the context of this paper, while countries with flour mills located at or near the port have lower inland transportation costs than those with inland flour mills, one must still take into account downstream transportation costs that could be incurred in order to bring flour from the mill to population centers and to rural areas.

Increasing the efficiency and reliability of the WISC’s inland transportation may reduce some price risk. In Arab countries, inland transportation is dominated by the trucking sector and on average accounts for about 22 percent of WISC costs. While transport costs represent a small share of total WISC costs for most Arab countries, inland transportation makes up a significant share of total WISC costs in some of the larger countries. For example, these costs could account for up to 51 percent of total WISC costs in countries such as Egypt, Jordan, and Yemen (Figure 7), adding an additional $10 U.S. to $18 U.S. to the cost of importing one metric ton of wheat. The higher transportation costs in these countries are partly due to geography, which clearly cannot be changed, but they are exacerbated by inadequate infrastructure such as poor
road conditions. With improved inland transportation systems, these countries might be able to reduce a portion of their transport costs.

Figure 7. Inland Transport Costs May Account for up to 42 percent of Total WISC Costs

The third category, cost of storage, is a significant driver of total WISC costs. While this paper advocates the reduction of costs in other WISC segments, when it comes to storage segments it is critical that countries consider the tradeoff between minimizing operational storage costs and financing the cost of maintaining strategic reserves. Storage costs are largely dependent on dwell time, and in Arab countries these costs represent 12 percent of total WISC costs and can add up to an additional 2 percent of the CFR price to total wheat costs. Dwell times associated with operational storage, to regulate inflows and outflows of wheat, can be minimized to reduce costs. However, total storage costs should not necessarily be minimized as there are additional costs associated with maintaining strategic reserves which may result in both financial and non-financial future benefits. Each country must decide how much they are willing to spend in exchange for the physical, financial, and psychological security that comes with maintaining strategic wheat stocks. For example, on average, increasing storage by three months would increase the cost of storage by $6.52 U.S. per metric ton of wheat. If a country that imports 3 million metric tons per year adds three months of strategic storage over the course of one year, this country would increase its annual imports from 3 million to 3.75 million metric tons. Supposing that the average CFR price in 2009 was $210 U.S. per metric ton, this would increase the import bill that year by around $158 million U.S., plus an additional $24 million U.S. to store this wheat, resulting in additional costs of $182 million U.S. But if the average CFR price in 2010 rose to $280 U.S. per metric ton, adding these storage costs in 2009 would still be less expensive than the $210 million U.S. it would cost to import three months worth of wheat consumption in 2010. Thus, for a country that imports and consumes approximately 3 million

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81 The cost of storage includes handling, fumigation, and the storage itself.
82 These figures account for costs associated with both operational and strategic storage.
83 For a more in depth explanation of the benefits of strategic wheat reserves see forthcoming World Bank publication on Improving Wheat Import Supply Chains in Arab Countries.
metric tons of wheat per year, adding three months of storage could save the country over $28 million U.S. in a year of a price shock similar to the one from 2009 to 2010.

Product loss due to inefficient WISC logistics is a significant contributing factor to WISC management costs, the fourth category of WISC costs. Reported estimates of product loss suggest that there is wide variation across Arab countries, ranging from 0.5 percent to 5 percent of imported wheat. Based on communications with public and private sector representatives from Arab countries, product losses in 2009 were up to $15 U.S. per metric ton in some countries. This is equivalent, at current wheat prices, to over $480 million U.S. annually for imported wheat to Arab countries. Product loss can occur for a number of reasons. For example, inefficient WISC logistics may result in substantial shrinkage and spoilage. These could be due to poor grain handling systems, outdated storage facilities, inadequate transportation networks, unnecessarily long dwell times, and insufficient fumigation or protection from pests. Product loss could also be due to pilferage and smuggling, which tend to be more frequent when international wheat prices are high. While governments may be able to reduce pilferage and smuggling rates through regulation and policy decisions, shrinkage and spoilage could be minimized with an efficient WISC.

How Can Improvements to the WISC Help to Address Both Supply and Price Risks?

Bottlenecks at the port are a significant source of increased costs, but they are driven by a number of factors including port capacity, customs and inspection procedures, and vessel unloading rates. Countries must explore various opportunities for future cost and time savings, particularly in terms of how to reduce vessel waiting times, the largest contribution to total port logistics costs. If vessel waiting times could be reduced to one day, the 10 Arab countries studied in this analysis could save over $60 million U.S. per year or $2.94 U.S. per metric ton. While some factors, such as freight rates, are out of the Government’s direct control, there are actions that could be taken to improve waiting times, and thereby vessel turnaround times. Arab countries could reduce waiting times by expanding port handling and silo capacities, adding more berths that can handle grains, changing priority rules, dredging the harbor to allow for larger vessels, and reducing bureaucracy in customs procedures. The variability in waiting times, and thus in vessel turnaround times, that are observed in Arab countries also suggests a need for more effective scheduling of arriving and departing vessels. It will be important for Arab countries to undertake further analysis of the specific causes of, and potential solutions to, bottlenecks at individual ports to help mitigate supply risks and to ease pressures on wheat prices.

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84 Product losses are estimated based on the difference between the amount of wheat unloaded from the vessel and the amount of wheat delivered to flour mills.
85 Average price of wheat in July 2011 is $264/mt (USDA 2011). It is possible that these figures are underreported and that product losses are even more significant.
86 Shrinkage refers to wheat that is lost in the WISC due to spills or an inability to unload every last grain of wheat. Spoilage refers to wheat that is no longer of a consumable quality.
87 Wheat subsidies reportedly encourage smuggling across borders, from subsidizing countries to nearby non-subsidizing countries.
The benchmarking analysis also suggests that consolidating WISC at the port might help reduce costs for small countries. Countries that have longer WISCs tend to have increased total WISC costs, while countries with a greater share of their WISC costs at the port tend to have overall lower average costs per metric ton. This is because close proximity between facilities enables countries to make use of more cost-effective handling and transport solutions such as conveyors, and because product loss is minimized due to a reduction in total transit times. In small countries such as Bahrain and Qatar, a consolidated WISC is sensible. While larger countries might want to consider consolidating their WISC at or near the port of entry, they may also want to evaluate subsequent tradeoffs. If a large country such as Jordan or Egypt were to consolidate its WISC at the port, the current costs of transporting flour and bread are likely to increase due to longer transport distances for those downstream products.

Regarding transportation, improving national road and rail systems can reduce WISC transit times and costs while promoting inter-regional connectivity. This paper finds that inland transport can represent a significant share of total WISC costs. If these countries were to reduce their transportation costs by 20 percent, each country could save up to $12 million U.S. annually. These cost savings could be generated in a number of ways. Some countries may benefit from strengthening competition in the trucking sector. Others might want to assess if they are making the most of their inland transportation networks. Currently, most Arab countries rely on roadways to transport wheat, while railways and waterways are frequently overlooked. Investing in and expanding wheat transportation to railways and waterways may create spillover benefits throughout the transport network, including freeing up capacity on roadways for additional transport needs. Egypt, for example, does not use the Nile for the bulk of its wheat transportation, but river transport may offer a lower cost and more reliable method of transporting wheat from the ports along the Mediterranean to Upper Egypt.

In terms of storage, increasing efficient management of operational grain silos may reduce transit times and WISC costs. Any silo that connects two segments of the import chain must regulate incoming and outgoing flows of wheat. Regulating flows depends on having the right equipment to take in wheat without causing bottlenecks upstream (e.g., at the berth) or downstream (e.g., discharging to trucks). In addition, operational grain silos must maintain appropriate occupancy rates to ease bottlenecks. If silos are too full, then they cannot receive new wheat shipments and will cause bottlenecks. Analysis must be conducted for each storage location to determine what the appropriate occupancy rate should be. Governments may also consider the location of silos and flour mills to help further reduce WISC costs and transit times.

In addition to improving individual segments of the WISC, countries may want to consider improvements throughout the chain, such as investing in multi-purpose solutions to enhance throughput and promote savings. Using multi-purpose solutions could allow for horizontal spillovers to other sectors. A one-time investment to improve logistics infrastructure will not only reduce WISC costs, but will also benefit other industries using the same transport corridors, storage facilities, and equipment. For example, a multi-user transport network would entail having infrastructure for inland transportation (trucks, railcars, and vessels) that can be used to move multiple commodities, not just wheat, through the same corridors. Similarly, multi-grain storage facilities can be constructed to hold several types of grains, although these may be more expensive to manage. Lastly, whereas pneumatic unloaders are primarily used for grains, ports
could be equipped with multi-purpose unloading equipment such as grab unloaders that can be used to unload multiple types of cargo including grains, coal, iron ore, and fertilizer. As Arab countries dependence on imported wheat is expected to grow, expansion of WISC infrastructure may allow for increased economies of scale both in terms of cost per unit and of total throughput volume. Combining imports with domestic production within the supply chain to increase throughput volumes might further help increase economies of scale.

Arab countries will want to identify WISC segments in which they can achieve the greatest improvements for the lowest investment costs. This paper provides an initial assessment across different Arab countries, yet each country could conduct an in depth WISC analysis. Conducting a more comprehensive and detailed analysis would allow each country to identify specific bottlenecks in each corridor within its borders. Not only does the type of bottleneck vary from country to country, but it could also vary from corridor to corridor within the same country. And alternative solutions may be more cost-effective in some situations: dredging a harbor to increase water depths and constructing new storage facilities can be significantly more costly than purchasing new unloading equipment with increased unloading capacities and streamlining customs procedures. In-depth analyses will help Arab countries identify the investments that offer the greatest returns.

References


I argued that we need to double our investment in research and development and that we should use the existing institutions that we have in the region. This is essential for ensuring food and nutrition security in the Arab World. We cannot continue with the under-investment levels that we have here in the Arab World compared to the rest of the world. We need to catch up in this area.

I am going to comment on the paper focusing on managing exposure to import supply and to price risk. There are two types of risks, and I would like to make six points.

The first is that the authors focused on bringing the wheat, in this case, from the boat to the consumer, which is important. But there is a point before that, which is getting the wheat on the boat. There is an issue today about the functioning of international food markets. There is an issue as to whether countries who face chronically food deficits can safely depend on trade to ensure their food and nutritional security. We have seen over the past four years countries imposing export restrictions, and changing their trade policies. That obviously has an effect on the world prices, it pushes world prices up, but it also affects those who are dependent on them for imports. I believe this is an issue that needs to be brought up, and Arab countries should be heard in international forums.

Examples: in FAO, we organized a meeting of an inter-governmental group on grains in September, right after the Russian drought and export restrictions, to discuss the situation and the types of policies needed. There was a big debate between countries; Russia and Argentina said we need to be able to restrict as we wish for our own security, while others said we need discipline in this area to think also as a community of nations on overall security of the world. In this debate I did not hear a single Arab voice. On one side there was Russia, Argentina, and some others, arguing for freedom to restrict exports as they wish, on the other side was the US, Australia, Canada, and the EU, but not a single Arab. In the end, nothing happened because the largest importers of grain in the world did not express an opinion. The country most hurt by export restrictions from Russia was Egypt. An Egyptian representative was there but he said nothing.

We, as Arab countries, need to form a position and make it known. There are, today, discussions. We are working with the World Bank and others to provide advice to the G20, where Saudi Arabia is a member, on issues of global food security and we are raising this issue of export restrictions. In the context of the WTO, there is also an opportunity to raise this issue. Maybe we cannot obtain agreement that countries can never impose export restrictions, but we should achieve some mechanism to minimize impact on trading partners.
Yes, we worry about moving wheat from ship to consumer, but I worry also about whether there will be wheat on that ship.

The second point I want to make on the concept of strategic reserves. It is important for Arab countries to look at having strategic reserves, three sub-points: 1) it is important to have strategic, security reserves or emergency reserves, and not what we call buffer stocks which manipulate the market (our experience around the world in buffer stocks has been disastrous, except in a few cases)—those reserves have to be very clear and you need to have important rules on how to use them, when to use them, and rules on how to move and protect those reserves (we also have examples in countries with emergency reserves but the quality deteriorates very quickly because they don’t know how to manage it, India is an example of huge losses from poor management); 2) food stocks are not only held by governments, actually most food stocks throughout the world are held by the private sector (in addition to official emergency reserves, we need policies that encourage farmers and the private sector to hold adequate levels of inventories, and that in a sense we see countries use many different systems to finance big warehouses, encourage their use, and provide warehouse receipts which farmers can use to obtain credit, and so on); and 3) the paper mentioned cooperation between countries, Arab countries need to look at Asia’s lessons who have agreed to put together joint reserves for rice, joint rice stocks. The paper showed us in one of its figures how you can move wheat from one place to another. Is there room for having not necessarily common reserves but at least coordination amongst countries of those reserves?

Third point: if you want to go that route, reserves well-managed and structured, you need a regional early warning system and monitoring. It becomes important for decision makers to have at their fingertips the information on supply and demand around the region and stock levels and the risks to food security. In FAO, we do this at a global level. I was surprised six months ago when I got a visit by the Chinese Ministry of Agriculture who asked for our support to develop this kind of system in China. And they’re actually sending some of their Chinese experts to spend six months in Rome so that the system we have at the global level—the early warning system at the global level—is used in China.

Fourth point: Yes, it is important to reduce costs of transport but there is also the area of procurement reform. Procurement laws and systems must ensure attainment of the best prices. The logistics system needs to be improved, and I was quite struck by a slide in the presentation: the cost of moving the wheat from the ship to the final destination was more or less equivalent to the cost of bringing the wheat over here. If I understood correctly, the cost to put it on the ship in US to Jeddah was equal to emptying the ship and moving it around Saudi Arabia. That is obviously very important, but we need to look also at our procurement systems and the price we are paying for that wheat is the right price. In this joint paper I talked about this morning you can see that there are some examples of countries, e.g. Yemen, where the procurement system does not ensure you get the right price—it probably ensures the wrong price.

Last point: financial markets. When we talk about managing exposure to price risk, we have to talk about financial markets. Dr. Fawzi raised the question: who will do that? It is actually a very important and legitimate question, and it is essential when we are talking about managing exposure to price risk. Two types of financial instruments can be used: 1) buying forwards, and
2) buying an option. They have different implications. In our experience around the world, in determining who is using what and why, there are two problems: a political problem and a technical/institutional problem. Political, if you are a minister of supply and you want to reduce your risk of importing wheat you buy wheat six months forward at a fixed price, but in the meantime if the price comes down then the minister will probably get fired or go to jail. Some countries have tried to avoid this problem by not using forward contracts and instead using options: you have a right to buy wheat, but you are not forced to buy it. It is like buying an insurance policy, basically. You put an option, if the price increases you use your option, and if it is lower, you don’t use it and you only lose your insurance. That tends to help deal with the political problem. Then institutional and technical problem remains: people who have the capacity to use options tend to be in central bank or treasury/ministry of finance, not the people responsible for buying the food supplies. That is where there is a need to do some capacity building and also for those people in the ministries of supply/food to work more closely with the central banks and the ministries of finance.

Those are my comments on this paper. For everything they said, international markets have to actually work. Our stock of reserves policy must be adequate. We must be procuring correctly. And we must use all available financial instruments to cover our risk.
CHAPTER 5—HARNESSING RESEARCH AND INNOVATION FOR ARAB FOOD SECURITY

Mahmoud El-Solh, Director General
International Center for Agricultural Research in the Dry Areas (ICARDA)

Introduction

More than two-fifths of the world’s land surface is classified as “dry”. The largest contiguous zone of dry areas is the West Asia and North Africa region, comprising the Arab countries. Worldwide, dry areas (Figure 1) cover 41 percent of the earth’s surface, and are home to over 2 billion people—and the majority of the world’s poor. About 16 percent of the population lives in chronic poverty, particularly in marginal rainfed areas.

Arab countries must overcome a number of biophysical challenges in their efforts to ensure food security. These challenges include:

- Fragile dryland ecosystems, vulnerable to over-use and decline;
- Severe water scarcity: low and erratic rainfall, frequent drought, groundwater depletion;
- Rapid natural resource degradation and desertification (Figure 2); and
- Salinity.

In addition, dry areas, more so than other eco-regions, are highly vulnerable to climate change. Climate change models clearly highlight the Arab region as among the most vulnerable to climate change and climate change will exacerbate many of the challenges mentioned above.

This chapter describes the challenges to future food and water security in the Arab region, including the potential impacts of climate change. It describes technologies that have been used successfully to overcome these challenges, and reflects on how best to harness science and technology to help Arab farmers improve output and productivity while ensuring sustainable use of water and other natural resources.

The Global Food Crisis and its Implications

Food security is a complex issue, encompassing not only the availability of food, but also access to food, stability of the availability of food, and the utilization of that food in ways that are healthy and nutritious. Not only the Arab region, but much of the developing world is concerned about ensuring food security, in the context of rapid population growth, declining natural resources, and the additional impacts (mostly negative) of climate change. The recent food crisis focused governments’ attention on food security and the vulnerabilities in the global, and national, food supply systems. Figure 3 shows changes in price indices of major food crops over the past two decades. In the past five years, prices of most commodities have increased sharply.
Figure 1. Dryland Regions, Classified Following Standard Nomenclature

Source: Map developed by ICARDA, based on World Distribution of Arid Zones. UNESCO 1979.

Figure 2. Dry Areas – Notably the Arab Region – are Highly Vulnerable to Desertification

Source: Millennium Ecosystems Assessment.
The global food-price crisis of 2008 may have passed, but it has highlighted vulnerabilities in the system—discussed below—particularly for countries, in the Arab region and elsewhere, that rely on food imports.

Arab countries are the world’s largest cereal importers: in 2010 net imports were 65.8 million tons and imports are expected to continue to rise. Figure 4 shows region-wise imports of cereal grains, with current data and projections up to year 2030. Taking cereals as a proxy for overall food consumption, it is clear that the Arab region—represented in Figure 4 as the Near East and North Africa—currently is, and in the future will remain, the world’s largest cereals importer.

The food-price crisis was caused by a combination of factors including: slow down in productivity growth, use of food crops for bio-fuel production, reduction in world food stocks, trader speculation, drought and floods in major wheat producing countries, changes in diet and consumer preferences, high economic growth in China and India, and an imbalance between world production and consumption.

The food crisis has led to considerable debate about self-reliance versus self-sufficiency. Earlier, countries sought self-reliance through domestic production combined with imports financed from other domestic economic enterprises. Instead, policy makers are now gradually shifting focus, aiming at self-sufficiency through a combination of domestic and regional production.

This debate has highlighted several issues:

- Current agricultural policies in the region are inadequate in general, and particularly ineffective in protecting the fragile natural resource base, while aiming to increase production.
- Land degradation is occurring rapidly, both in marginal environments and in irrigated areas.
- It is extremely hard to protect and conserve communally owned natural resources such as rangeland and water; technology alone is not sufficient but must be supported by policy, community-led action and constant monitoring.

**Water Security**

The Arab region, and the non-tropical dry areas (ICARDA’s mandate region) in general, face severe water scarcity. Per capita annual water availability averaged across the region is less than 2000 m³, with some areas experiencing per capita water availability of less than 500 m³ per year. Large areas have annual rainfall below 100 mm per year and even water extraction rates are mostly unsustainable leading to continuous fall in groundwater levels. Most countries in the region will drop below the internationally defined “water scarcity” level in the near future. There are concerns about quantity as well as quality of water resources. Since the majority of water is used in agriculture, shortages have direct implications for food security.

Figure 5 shows expected changes in precipitation, averaged from a large number of general circulation models (GCMs). Clearly, West Asia and North Africa will be severely affected by climate change, with a large part of the region experiencing up to a 30-50 percent decrease in rainfall. Climate change will also increase the frequency and severity of drought in the region.

**Figure 5. Relative Change of Mean Annual Precipitation 1980/1999 to 2080/2099**

Source: ICARDA, based on Fourth Assessment Report of the Intergovernmental Panel on Climate Change.
* Scenario A1b, average of 21 GCMs (compiled by GIS Unit ICARDA, based on partial maps in Christensen et al., 2007).
**Implications of Climate Change**

The likely impacts of climate change on temperature, precipitation and crop productivity have been widely discussed, and are increasingly being factored into policy considerations. In summary, based on reports from the Intergovernmental Panel on Climate Change (IPCC), climate change in the region is expected to lead to:

- Reduced precipitation and more frequent drought
- Extreme temperatures
- Changes in agro-climatic zones
- Shorter growing seasons
- New diseases and insect pest threats.

Climate change affects not only food production, but all four dimensions of food security, as follows:

*Availability*: though direct loss in food production due to shorter growing season, lower rainfall, and higher temperatures; degradation of the natural resources on which food production depends; and increasing biotic stresses;

*Access*: Infrastructure damage, asset losses, loss of income and employment opportunities;

*Stability*: increased livelihood risks, pressure on food prices, higher dependency on food imports and/or food aid, increased environmental variability leading to larger fluctuations in food supply; and

*Utilization*: human health risks, nutrition issues.

**Food Security: Challenges and Opportunities**

We can summarize the key challenges to food production in the region:

- Biotic stresses such as diseases, insect pests and parasitic weeds;
- Abiotic stresses, particularly drought and salinity;
- Loss of biodiversity, affecting not only current ecosystem balance but also hampering future efforts in crop and livestock improvement; and
- Other challenges such as inadequate policy support, lack of an enabling environment for sustainable agricultural development, and insufficient investment in agricultural research and development.
Science and technology, if properly harnessed, can help overcome these challenges. Research centers must play the key role in developing new technologies; and must work with a range of different partners (national research and extension agencies, NGOs, donor agencies). Crucially, all stakeholders must work with policy makers to help understand the driving factors, create an enabling policy environment to support technology development and dissemination, and enable small-scale farmers across the region to grow their way out of poverty.

Opportunities for horizontal expansion are limited. Increase in cultivated area is likely to contribute at most 7 percent higher food production. This contribution could well be smaller, because unsustainable land and water use, and climate change, have the potential to “desertify” millions of ha of arable land. Increases in food production can therefore come only by intensifying cropping systems (e.g. double cropping with irrigation) and by increasing productivity per unit of land and water.

However, agricultural intensification could affect the environment and natural resources (water, land, soil and biodiversity) unless it is practiced in a sustainable manner. Increasing production through irrigation, double cropping and other intensive practices can lead to large increases in output and profitability—but only in the short term. Such practices can result in depletion of limited water resources and exhaust soil fertility. Thus, the emphasis must be on sustainable intensification.

**ICARDA’s Approach: Integrated Research-for-Development**

ICARDA’s research is structured under four programs:

1. **Biodiversity and Integrated Crop Genetic Improvement**: including the conservation, evaluation agro-biodiversity (wild relatives and landraces of food crops), and the use of those genetic resources in breeding improved varieties; as well as research on seed production and seed delivery systems.

2. **Integrated Water and Land Management**: which develops technologies to improve water productivity and sustainably manage water resources in both rainfed and irrigated production systems, and investigates the sustainable management of natural resources to combat land degradation and strengthen climate change mitigation/adaptation.

3. **Diversification and Sustainable Intensification of Production Systems**: investigating options for the sustainable intensification and greater market orientation of crop-livestock-rangeland production systems, and the diversification of agricultural incomes from alternative crops, livestock systems and adding value to crop and livestock products.

4. **Social, Economic and Policy Research**: analyzing the drivers of rural poverty, and alternative livelihood strategies, to improve research targeting and impact. The Program studies these issues to identify pathways out of poverty, develop policy and institutional options to improve livelihoods, and identify constraints to technology adoption and ways to overcome them.
ICARDA’s approach is to work with partners at every stage of the research-development continuum, from strategic research through adaptive research and dissemination. In this approach, we seek to integrate the three pillars of sustainable agricultural development—Natural resource management and inputs, Crop and livestock genetic improvement, and Socio-economics, policy and institutions—at field or national agricultural research systems levels. Research outputs, once tested and validated, are out-scaled through partnerships with national or donor-funded development projects.

**Harnessing Science and Technology: Some Examples**

**Conservation and Utilization of Crop Genetic Resources**

The genebank at ICARDA’s headquarters in Tel Hadya, Syria, holds over 135,000 accessions (Table 1). Most of these accessions are safely duplicated in other reliable gene-banks around the world. For example, more than 90,000 accessions are being stored in Svalbard Global Seed Vault in Norway, under an agreement involving multiple international centers.

About two-thirds of ICARDA’s gene-bank holdings comprise unique sets of landraces and wild relatives, collected mostly from dryland areas in the CWANA region (Central and West Asia, North Africa). This region encompasses four major Vavilovian Centers of Diversity; and the origin of many of the world’s most important crops. For these crops, and many others, the CWANA region contains tremendous diversity, both in cultivated landraces and wild species. Efforts to conserve and freely share these genetic resources will continue. Previous collection efforts focused on landraces and wild relatives—from diverse eco-geographic origins. Future collections will be based on gap analysis, using modern GIS tools, and targeting of valuable traits.

<table>
<thead>
<tr>
<th>Crop</th>
<th>No. of Accessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>24,975</td>
</tr>
<tr>
<td>Wheat</td>
<td>34,227</td>
</tr>
<tr>
<td>Wild cereals</td>
<td>7,671</td>
</tr>
<tr>
<td>Forage legumes</td>
<td>28469</td>
</tr>
<tr>
<td>Food legumes</td>
<td>33,313</td>
</tr>
<tr>
<td>Wild food legumes</td>
<td>857</td>
</tr>
<tr>
<td>Forage and range</td>
<td>5,744</td>
</tr>
<tr>
<td>Total</td>
<td>135,256</td>
</tr>
</tbody>
</table>

Source: ICARDS’s internal genebank records

**Biotechnology Tools**

Biotechnology applications can supplement traditional plant breeding methods, and considerably increase the speed and effectiveness of plant breeding programs. This effort has been enhanced by the construction of a new state-of-the-art bio-safety facility at ICARDA’s headquarters, with generous support from the Arab Fund for Economic and Social Development (AFESD).

In collaboration with national research programs in the CWANA region and advanced research institutes in Australia, Europe and the Americas, a range of biotechnology tools—genomics, marker-assisted selection (MAS), double haploids, embryo rescue, tissue culture, DNA fingerprinting—are being used to develop improved cultivars or breeding lines, that are higher
yielding and more resistant to the pests, diseases and the environmental constraints in dry areas. For example, 600 barley genotypes have been screened, using diagnostic molecular markers, to identify sources of resistance to major barley diseases. Successes include resistance to:

- Scald—Rrs1
- Cereal cyst nematode—Ha2, Ha4
- Powdery mildew—mla, mlo
- BYDV—yd2, yd3

Biotechnology tools are also being used to identify the genes that confer specific traits such as early maturity to avoid drought, or improved nutritional quality of food crops.

**Improved Crop Varieties**

A large number of improved crop varieties have been developed from ICARDA-supplied germplasm, either directly through collaborative projects or by national programs using ICARDA germplasm. The new varieties offer a range of valuable traits that are directly relevant under the environmental conditions in the Arab region, offering higher and more stable yields, ability to survive harsh conditions, and with climate change adaptation traits:

- High yield potential and yield stability;
- Agronomic traits such as earliness, improved canopy architecture;
- Tolerance to abiotic stresses such as drought, heat, cold and salinity; and
- Resistance/tolerance to biotic stresses (diseases, insect pests, parasitic weeds).

**Table 2. Improved Crop Varieties Developed from ICARDA Germplasm and Released by National Programs**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Developing countries</th>
<th>Industrialized countries</th>
<th>All countries, last 2 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>175</td>
<td>31</td>
<td>6</td>
</tr>
<tr>
<td>Durum wheat</td>
<td>102</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Bread wheat</td>
<td>224</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Chickpea</td>
<td>108</td>
<td>31</td>
<td>9</td>
</tr>
<tr>
<td>Faba Bean</td>
<td>51</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Lentil</td>
<td>96</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>Forages</td>
<td>30</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Peas</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sub-Total</td>
<td>795</td>
<td>106</td>
<td>37</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>901</td>
<td>37</td>
<td></td>
</tr>
</tbody>
</table>

*Source: ICARDA internal records*

More than 880 crop varieties, developed from ICARDA germplasm, have been released to date (Table 2). The new varieties have generated net benefits worth an estimated $850 million U.S. per year.

Several high-yielding wheat cultivars with resistance to heat stress (common in most production zones across the region, increasingly so) have already been developed in Sudan. This has made wheat an attractive crop south of Khartoum, where heat stress once prevented its cultivation.
An innovative program is developing synthetic wheat lines, based on crosses with wheat’s wild relatives, with tolerance to severe drought (Table 3). This approach could hold the key to maintaining yields of the main food staple, despite changes in precipitation and temperature.

A number of legume varieties have been developed and widely adopted, contributing to higher farm incomes and better nutrition. These include kabuli chickpea variety Gokce, developed by ICARDA and Turkish national scientists, which is now grown on about 70 percent of the country’s chickpea area (over 550,000 ha). It offers a yield advantage of 300 kg/ha over other varieties. High-yielding lentil varieties are making similar impacts. In faba bean, as many as 20 improved varieties, developed jointly with the national program, have been released in Egypt. The most recent is Sakha 4, to be released this year. It is an early-maturing variety developed specifically for post-rice cultivation in the Nile Delta. These efforts have not been limited to the Arab region. In China for example, faba bean variety Yandou 147, developed from ICARDA material, covers almost one-third of faba bean area in Yunnan province.

Crop improvement research combines traditional methods (conventional plant breeding) with modern biotechnology tools. ICARDA has also pioneered the use of participatory breeding methods – which are being institutionalized by national programs in several CWANA countries.

**Analyzing Yield Gaps**

Collaborative studies with National Agricultural Research Systems (NARS) have provided valuable information on the gaps between potential and actual yields (Figure 6). Studies in several countries including Egypt, Morocco and Turkey have helped identify the causes for yield gaps, and focus research and development efforts. The key factors include:

- Increasing the efficiency of technology transfer;
- Use of recommended practices: sowing date, seed rate, fertilizer amount, rotation, use of proper farm machinery, disease and pest management practices;
- Proper targeting of varieties to production zones;

### Table 3. Synthetic Wheat Lines Offer Substantial Yield Advantages Under Drought Conditions. Data from Tel Hadya Research Station, 2008, Rainfall 211 mm

<table>
<thead>
<tr>
<th>Line/parent/variety</th>
<th>Yield, t/ha</th>
<th>% recurrent parent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charm 6*2/SW2</td>
<td>1.6</td>
<td>147</td>
</tr>
<tr>
<td>Charm 6*2/SW2</td>
<td>1.5</td>
<td>138</td>
</tr>
<tr>
<td>Charm 6 (backcross parent)</td>
<td>1.1</td>
<td>100</td>
</tr>
<tr>
<td>Attila7 (check variety)</td>
<td>1.3</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: ICARDA internal records
• Timely availability of inputs: quality seed, water and fertilizers; and
• Government intervention and policies to strengthen input availability and crop marketing.

![Figure 6. Yield Gap Analysis in Syria, Identifying Potential Gains.](image)

Source: ICARDA unpublished research

**Trans-Boundary Diseases**

ICARDA and its partners are playing a key role in combating pests and diseases that cross national boundaries or emerge in areas where they have not been experienced before; such phenomena are expected to increase with changes in climate. An example is a new race of stem rust disease of wheat, named Ug99, which could threaten global food security. The new race has spread from East Africa, across the Red Sea into West Asia, and now threatens South Asia and other regions. Ug99 attacks both wheat and barley, and has a wide host range including bread and durum wheat, barley and wild grasses. About 80 percent of the world’s commercial wheat varieties in the world are susceptible to this race.

To combat this threat, ICARDA, the International Maize and Wheat Improvement Center (CIMMYT), FAO and Cornell University launched the Borlaug Global Rust Initiative (BGRI) in September 2005. The BGRI is a consortium involving over 30 countries, for developing and deploying wheat varieties with stable resistance to Ug99 and other races. Partnerships under the BGR framework have led to major advances. ICARDA has distributed biological trap nurseries to 32 countries. Working with the national programs of Egypt, Ethiopia, Sudan and Yemen,
possible routes of spread of the pathogen have been mapped. Disease surveillance and monitoring networks have been established, and race analysis studies are providing new insights into the evolution and spread of Ug99 and similar pathogens.

Resistance screening programs have been established in Ethiopia, Kenya and Yemen, and more than 10,000 lines have been screened. Two Ug99-resistant durum lines (Bakalcha and Malefia) were released in Ethiopia. For bread wheat, several resistant lines have been developed, and seed is now being multiplied in Egypt, Ethiopia, Iran and Pakistan.

**Integrated Pest Management**

Insect pests cause widespread damage to crops in many parts of the region. ICARDA’s approach focuses on integrated pest management, which combines the use of resistant varieties with improved crop management practices, as well as bio-control methods to achieve effective control while reducing the use of chemical pesticides. One example is with the Sunn pest complex, which affects more than 15 million ha of wheat in West Asia, Central Asia and East Europe. Severe infestations have been known to reduce wheat yield by 50-90 percent in some areas. In the highly successful Integrated Pest Management (IPM) program, researchers focus on several components:

- Hand collection of Sunn pest in overwintering sites
- Use of insect-killing fungi in overwintering sites
- Conservation and enhancement of egg parasitoids
- Genetic resistance at the vegetative stage.

The IPM package combined improved varieties, better crop management, judicious use of chemicals, with a major bio-control component. The use of natural enemies (parasitoids which attack Sunn pest eggs) reduces pest populations without the need for excessive doses of pesticide—thus reducing farmers’ costs as well as protecting the environment. This research has helped change national policies in West Asia: government-supported aerial sprays have been replaced with targeted ground applications, on over 3 million hectares (Figure 7). In addition, revised ‘economic thresholds’ have been implemented, significantly reducing pesticide use.
**Enhancing Water Productivity**

Given the critical scarcity of water in the Arab region, ICARDA’s research with partners focuses on increasing water productivity (the amount of crop or biomass produced per unit of water used) both at the farm and basin levels. The Center’s flagship project, involving ten countries in West Asia and North Africa, entered its second phase, with generous support from the Arab Fund for Economic and Social Development (AFESD). The CWANA Benchmarks Project aims to promote community participation, efficient use of resources, and adoption of new technologies that increase water productivity. These technologies can be considered under three groups: supplemental irrigation, rainwater harvesting, and deficit irrigation. Results from field trials in different countries have demonstrated that water productivity is significantly higher under supplemental irrigation (small amounts of water, optimally timed) compared to fully rainfed or fully irrigated crops. Figure 8 illustrates the huge efficiency gains possible with small amounts of water. Figure 9 presents results from a field experiment on wheat. The project has tested and is promoting the use of the Vallerani plough, a specially designed tractor-drawn plough that can mechanize the construction of micro-catchments on marginal lands, at up to 40 ha per day.

**Figure 8. Potential Gains in Water-Use Efficiency (WUE), Comparing Supplemental Irrigation (SI), Fully Irrigated Crops (FI) and Solely Rainfed Crops**

![Figure 8: Potential Gains in Water-Use Efficiency (WUE)](image)

Source: ICARDA research results

The project covers three major agro-ecosystems: marginal rangelands or *badia*, rainfed systems, and irrigated systems. In rainfed systems, the package combines optimal supplemental irrigation, and/or the use of deficit irrigation (irrigating only when soil moisture falls below a critical level), and early sowing to avoid end of season drought. In irrigated systems, the focus is on increasing water productivity and economic returns on water investment; deficit irrigation, management of saline water and soils; policies and institutions; and modifying cropping patterns in light of resource availability and market opportunities. In *badia* areas, the focus is on rangeland rehabilitation and through water harvesting; and integrating micro-catchments with fodder production.
This research has helped understand the drivers to increase water productivity at different scales:

- At the basin level: competition among uses (environment, agriculture, domestic), conflicts between countries, and equity issues;
- At the national level: food security, availability of hard currency, and socio-political factors;
- At the farm level: maximizing economic return, and nutrition in subsistence farming; and
- At the field level: maximizing biological/economic output.

ICARDA has also been studying the use of alternative water resources. For example, marginal-quality water and treated wastewater have been found useful for growing cotton, forages and trees. In Uzbekistan, studies have shown that conjunctive or blended use of drainage water with regular irrigation can optimize yield while conserving fresh water.

**Other Initiatives on Water and Land Management**

Several collaborative research programs seek to introduce, test and disseminate integrated methods to improve land and water productivity in different countries across the region. For example, Egypt-ICARDA collaboration in salt-affected areas has demonstrated huge benefits from a relatively simple change of practice. The use of wide furrows for wheat cultivation leads to 20 percent saving of irrigation water, 38 percent increase in crop water productivity, and an increase of 640 kg/ha in wheat grain yield, compared to traditional farmer practice.
A new project on salinity management in Iraq involves five Iraqi Government ministries, two international organizations, and two Australian institutions. The project focus is in central and southern Iraq—formerly the country’s bread-basket, but now facing extensive salinity-related degradation of land and irrigation water. The project will be implemented at river basin, irrigation district, and farm scales. It aims to increase water productivity, improve salinity management, and arrest the loss of productive farmland. Initially, the project will assess the drivers of salt distribution and soil and irrigation water salinity at different scales, and develop methodologies for salinity control and agricultural productivity enhancement.

**Diversification and Intensification of Production Systems**

In most Arab countries, agricultural growth is limited by biophysical constraints. Yet, harnessing science and technology can allow small-scale farmers to better use of the limited opportunities available. The key is to diversify the farming systems, in order to improve agro-ecosystem resilience, reduce risk and simultaneously create new income opportunities. Innovations in systems diversification include; dryland fruit trees, protected agriculture and herbal, medicinal and aromatic plants. For example, indigenous fruits, such as olives, date palm, almonds, figs and pomegranate, are a potential source of cash income. ICARDA works with partners – the World Vegetable Center, Taiwan; l'Institut des Régions Arides, Médenine, Tunisia; and other national institutions – to identify fruit and vegetable crops and varieties to specific dryland cropping systems. Protected agriculture technologies enable farmers to cultivate within simple, cheap greenhouses small plots and marginal lands, with very high land and water productivities. Protected agriculture research focuses on different aspects: low-cost, locally fabricated greenhouses for resource-poor communities (e.g. Afghanistan, Yemen); intensive integrated management packages for greenhouses (Arabian Peninsula); and hydroponics or soil-less culture for relatively advanced growers in the Arabian Peninsula.

**Conservation Agriculture**

Conservation agriculture methods are widely used in many countries (more than 100 million ha globally), but not so far in West Asia. ICARDA and its partners are helping to promote these technologies in the region. Conservation agriculture combines minimum soil disturbance (zero tillage), stubble retention, crop rotations (legumes, oilseeds) and early sowing of crops. It offers multiple benefits: savings in time, fuel and machinery costs for land preparation; better soil structure; better soil moisture infiltration and conservation; improved trafficability, meaning the land is more easily traversed by field machinery, preventing further degradation of the soil by mechanization; higher yield potential; and less soil erosion. Current efforts build on highly successful examples from Central Asia, where conservation agriculture has now spread to about 1.2 million ha. In the Arab region, the bottleneck has been the lack of affordable planting equipment. This has now been resolved with the development of locally fabricated, low-cost zero-till seeders developed through an Australia-ICARDA project. The first seeders were fabricated in 2008, and are now being promoted, with support from government agencies and NGOs, to farmers in Syria and Iraq. In the 2010/11 season they were used by more than 400 farmers to plant about 25,000 ha of zero-till crops.
Livestock-Based Production Systems

Small ruminants (sheep and goats) are a key source of livelihood and income throughout the region, where rangelands are the single largest land use category. ICARDA’s work focuses on integrating crop and livestock production and maximizing crop-livestock synergies to increase the supply of livestock fodder, while maintaining production of food crops. Another key area is conservation, management and genetic utilization of indigenous livestock breeds, which are well adapted to hot, dry conditions.

Research also covers animal nutrition and adding value to livestock products. Fodder production in the region has been significantly improved through the development of improved fodder varieties, introduction of new fodder sources (Atriplex and spineless cactus) into rainfed crop systems, and promotion of low-cost ‘feed blocks’ made from farm residues and agro-industrial products. The concept of ‘strategic feeding’—supplementation at critical periods has been successfully introduced as a solution to the common problem of high feed prices in dry years. In trials, strategic supplementation using balanced but low-cost diets resulted in a net gain of $18.70 U.S. per ewe. In a typical flock of 50 ewes, farmers using this technology would earn an additional $935 U.S. Other related aspects include flock management (practices targeted at market sales), promotion of indigenous fodder species, rather than exotics such as alfalfa or Rhodes grass, and rangeland management and rehabilitation through community-led grazing calendars with adequate ‘rest’ periods for sections of rangeland.

“Value added” research aims to increase income opportunities for the poor, by producing dairy and other livestock products for sale. These include yogurt, cheese, mohair, etc. Research is complemented by training programs to empower farm communities—especially women—to make the best use of the new technologies.

Socio-Economic and Policy Research

Socio-economic, institutional and policy research is an integral part of any research-for-development portfolio. ICARDA’s socio-economists help to target biophysical research to the most vulnerable groups or regions, inform policy development, monitor and measure the impact of new technologies, and understand the factors determining the adoption of these technologies. Research components include:

- Socio-economic characterization at household and community levels;
- Analysis—poverty, livelihood strategies, gender dimension;
- Adoption and impact assessments;
- Identifying policy options that will stimulate agricultural development;
- Studies of markets;
- Institutional frameworks; and
- Natural resource economics.
Geographic Information Systems

Geographic Information Systems (GIS) are a powerful tool in analyzing spatial as well as temporal factors, and for improving the targeting of research or development interventions. GIS maps have helped identify areas with high vulnerability to climate change, or with high poverty levels (Figure 10), in order to target investment by government agencies as well as other organizations.

Other examples of GIS applications include

- Land use mapping to promote diversification of production systems;
- Maps for potential areas for water harvesting; and
- Maps for potential areas for removal of rocks to expose high-potential arable land.

**Figure 10. Poverty Mapping in Sudan, Using a Composite Index of Life Expectancy, Knowledge Deprivation, Lack of Access to Public and Private Services.**

Based on data from two national surveys. A high index (red) shows a high degree of poverty, as defined by the above indicators.

Source: ICARDA GIS Unit
Regional Project: Enhancing Food Security in Arab Countries

Building on three decades of successful research in the region, a new initiative seeks to integrate technologies, policies, institutions through regional partnerships, to stimulate agricultural growth in the Arab region. It is supported by the Arab Fund for Economic and Social Development (AFESD), the Kuwait Fund for Arab Economic Development, and the Islamic Development Bank. The first of a planned three phases will be for three years, 2011-2013.

The project has two broad objectives:

- To increase the productivity and production of wheat-based systems through an integrated approach: development and dissemination of improved wheat and food legume varieties; transfer of improved agronomic practices and conservation agriculture; improving water productivity; diversification of production systems; and an enabling policy environment for agricultural development.

- To help create a new generation of agricultural scientists; and enhance research and development capacity in Arab countries through a Young Scientist Program.

The project will use a multi-institution, multi-disciplinary approach, pooling skills and resources among a wide range of organizations. All activities will be participatory and inclusive, aiming to strengthen linkages between researchers, extension staff, farmers, policy makers and other stakeholders.

Implementation has already begun. The project will progressively cover seven countries in the first phase: Egypt, Jordan, Morocco, Sudan, Syria, Tunisia and Yemen. To date, initial project sites have been selected in the different agro-ecologies in five countries (Table 4).

Table 4. Implementation Sites for the Regional Project to Enhance Food Security in Arab Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Site</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egypt</td>
<td>El-Sharkia</td>
<td>Irrigated</td>
</tr>
<tr>
<td>Morocco</td>
<td>Chaouia-Ouardigha</td>
<td>Rainfed</td>
</tr>
<tr>
<td>Morocco</td>
<td>Tadla perimeter</td>
<td>Rainfed with supplemental irrigation</td>
</tr>
<tr>
<td>Sudan</td>
<td>Northern State</td>
<td>Irrigated</td>
</tr>
<tr>
<td>Sudan</td>
<td>Gezira</td>
<td>Irrigated</td>
</tr>
<tr>
<td>Syria</td>
<td>El Bab Area</td>
<td>Rainfed with supplemental irrigation</td>
</tr>
<tr>
<td>Tunisia</td>
<td>Fernana (Jendouba)</td>
<td>Rainfed</td>
</tr>
<tr>
<td>Tunisia</td>
<td>Chebika (Kairouan)</td>
<td>Irrigated</td>
</tr>
</tbody>
</table>

Source: ICARDA
Capacity Development

Capacity development is central to ICARDA’s work. The Center works with partners to increase national capacity to conduct research, disseminate new technologies, and create the policy and institutional framework essential for sustainable agricultural growth and assured food security. These efforts have been supported by many partners, including crucially, the Arab Fund for Economic and Social Development (AFESD).

Capacity development programs include a variety of options: internships, support for graduate research, participation in collaborative research projects, technical meetings and conferences, specialized training courses, and others. Farmer field schools and hands-on practical training targets farm communities as well as extension staff. Over 650 postgraduate students, interns and research fellows have done theses research at ICARDA. Advanced institutions have co-supervised M.Sc. and Ph.D. students. To date, about 17,000 researchers, students and development workers have benefited from various types of training programs (Table 5). The curricula for training courses are tailored to NARS requests. The emphasis is on hands-on training that can be put to immediate use. In addition to agricultural sciences, training programs also covered information technology, database management, website administration and science publishing.

Table 5. Capacity Development Programs

<table>
<thead>
<tr>
<th>Type of training</th>
<th>1978-2010 (all countries)</th>
<th>1978-2010 (Arab countries)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-graduate (M.Sc. and Ph.D.)</td>
<td>651</td>
<td>419</td>
</tr>
<tr>
<td>Individual non-degree</td>
<td>2,091</td>
<td>1,654</td>
</tr>
<tr>
<td>Internship</td>
<td>105</td>
<td>34</td>
</tr>
<tr>
<td>Training courses</td>
<td>14,150</td>
<td>8,991</td>
</tr>
<tr>
<td>Total</td>
<td>16,997</td>
<td>11,098</td>
</tr>
</tbody>
</table>

Source: ICARDA

Linking Research with Development

ICARDA has a comparative advantage in research. Other organizations have a comparative advantage in development. Our focus, therefore, is to conduct research-for-development: to generate outputs and international public goods that can feed into development programs, implemented by our partners, for rapid, large-scale dissemination.

ICARDA’s unique approach also includes the use of integrated research sites that strengthen research-development linkages. Such sites have been established throughout the region. They serve two purposes: to tackle location-specific problems (particularly in natural resource management) in specific agro-ecologies; and as platforms for up-scaling proven technologies to similar agro-ecologies elsewhere. This is part of ICARDA’s emphasis on active participation at all stages of the research-for-development continuum discussed in section 6.

The Center’s primary aim is to develop relevant, effective technologies to improve agricultural productivity, as well as policy and institutional options to support this growth. To accelerate the
transfer of new technologies and ideas, ICARDA uses an integrated approach with various components:

- Poverty mapping and livelihoods analysis to target research;
- Integrated research sites as platforms for technology transfer and development;
- Technology transfer through researcher-extension agent-farmer linkages;
- Adoption of technologies and impact assessment; and
- Community-led, farmer-participatory methods.

It is important to note that these activities are not mutually exclusive. Indeed, they must be undertaken together, in an integrated manner, if we are to ensuring food security in the region, in the medium and long term.

**Partnerships**

Many successes have been achieved with other partners since the Center was established in 1977. None of this would have been achieved without our partners. All ICARDA’s work is planned, implemented and monitored in close collaboration with a range of partners. These include national agricultural research and extension systems, other international agricultural research centers, regional and international organizations, donor agencies such as AFESD, OFID and others, UN development agencies such as IFAD and FAO, advanced research institutes, NGOs, the private sector—and most important, farm communities.

**Conclusions: Research, Innovation and Modernization**

In conclusion, we could identify the factors driving food security in the Arab region:

- Enabling policy environment and political support for agriculture;
- Investment in research, to harness science to sustainably increase food production;
- Investment in agricultural infrastructure and development;
- Sustainable intensification of production systems;
- Extension and effective technology transfer mechanisms;
- Capacity development and institutional support; and
- Innovative partnerships and networking.

Modernization of agricultural production is essential. This requires greater investment in research, basic infrastructure, education, research and extension. Farmer education and involvement in the development and dissemination of new technologies is critical. Equally important are an enabling policy environment, capable institutions, and modern legal and political frameworks to underpin these efforts. Unless each of these components is in place, the
region will continue to be challenged in its efforts to provide food to its rapidly growing populations and ensure sustainable livelihoods of the poor.

Given the region’s current strengths and weaknesses, what needs to be done to ensure food and water security? We offer some suggestions, based on lessons learnt from three decades of research-for-development:

Each country must design and implement a comprehensive national strategy for agricultural development taking into consideration the available land and water resources and proven currently available technologies. An example would be the "Green Morocco Plan", Morocco’s strategy for modernizing its agricultural sector on a sustainable basis by incorporating the conservation of natural resources and expected climatic changes (Agency for Agricultural Development. 2009).

National agricultural research strategies must be clearly articulated, with activities and targets designed to meet the objectives of agricultural development strategy.

Both strategies must be implemented through well-financed five-year action plans, with well defined milestones and mechanisms to monitor technology development and dissemination.

A comprehensive regional program must be established to enhance food security. This would include regional and/or sub-regional components, building on complementarities and comparative advantages of each country.

This would require close collaboration among a very wide range of partners, and strong political will to make the necessary policy changes, for example to encourage rational and sustainable use of natural resources. The benefits would be substantial—while failure to address the region’s food security challenges could be extremely costly.

References


Introduction

Importance of Food Security in Arab Region

The Arab region is one of the most arid regions in the world and consequently faces enormous food security and food sovereignty challenges. Limited cultivated land and water resources are major constraints on agricultural development and food production. As a consequence, Arab countries are highly dependent on imported foods, particularly basic foods such as cereals that are the regular diet of the poor. With the projected increase in population, the demand for food—for human consumption as well as animal feed—is expected to grow substantially. The challenge for the future is to find the best ways to improve food security while recognizing that there will be continued and increasing dependence on imports. Adding to the complexity, climate change projections for the region indicate considerable negative impact on farm-level productivity due to the high dependency on climate-sensitive agriculture in the region.

Importance of Research and Innovation in Contributing to Food Security

Meeting future demand needs a two or three pronged approach. Given the constraints in many countries, to produce more food locally, they need to rely on international markets as well as on regional co-operation so as to create a regional food reserve, especially for staples. At the same time, the Arab World needs to increase agricultural productivity by investing in agricultural research and technological innovation. Applied research can directly contribute to food security not only by the introduction of more stress tolerant crops, crop varieties and better cropping practices but also through improved food storage, processing, packaging and marketing technologies.

Despite the fact that agricultural R & D yields very high returns (estimated to be 45 percent worldwide), there is gross underinvestment in the Arab countries. A substantial number of agricultural technologies available ‘on the shelf’ are those developed during the Green Revolution for well-endowed environments and may work poorly in marginal environments which is prevalent in the Arab region. Therefore, much more innovative research is needed to identify viable productivity-enhancing options in marginal lands. For instance, better protection and management of the limited water resources, coupled with the more efficient use of water—i.e. more crops for the drop will be the key conditions to increase production in both irrigated and rainfed agriculture.

In conjunction with water conservation, innovative strategies such as crop and system’s diversification, integrated farming systems through livestock raising, forestry and fisheries, land
use changes to take advantage of modified agro-climatic conditions, contribute to socio-economic sustainability of the production systems in fragile environments. From the biological viewpoint, research and innovations in plant breeding and biotechnology to develop varieties with increased resistance to heat shock, salinity and drought, together with the agronomic measures to improve soil fertility and better dissemination of improved technologies are important considerations towards achieving food security in the Arab World.

**Highlights of Dr. Mohamoud Solh’s Paper**

**Major Issues Raised and Comments**

Dr. Mahmoud Solh has articulated comprehensively the global drivers affecting food security ranging from climate change, changes in consumption from vegetarian to carnivorous diets, productivity decline and increasing populations. Dr. Solh has then outlined the impact of these drivers on the Arab World and the resultant challenges this poses—in particular for the Arab region: biotic stresses, inadequate agricultural policies, insufficient investment in agricultural research and development, and political volatility.

In summary, Dr. Solh proposes that the underlying principles for food security solutions in the Arab World will be based on the following:

- **Sustainable intensification of agricultural production systems** with emphasis on the word Sustainability, which Dr. Solh envisions to rest on 3 pillars:
  - natural resource management and inputs;
  - innovation and integration at farm and field levels; and
  - crop and livestock genetic improvement.

- **Promotion of technologies** such as improved varieties of winter cereals and food legumes, water practices, integrated pest management, conservation agriculture, diversification of production systems; integrated crop/rangeland/livestock production systems; and empowerment of rural women.

- **Modernization of agriculture**.

- **Farmers’ education and involvement in innovation development and dissemination of technologies**.

- **Enabling policy, institutions and governance**.

Dr. Solh continues his comprehensive presentation with four examples of the scientific endeavors of ICARDA designed to meet the food security challenges: 1) germplasm conservation and crop genetic improvement; 2) plant protection and integrated pest management; 3) global research partnership to cope with trans-boundary diseases; 4) enhancing sustainable water productivity to contribute to food security in different agro-ecologies; and 5) integrated crop/rangelands livestock production systems.
In looking at solutions beyond research, Dr. Solh identifies: capacity development of human resources; technology transfer; integrated research which is linked with development and partnerships and institutional linkages.

In conclusion, Dr. Solh recommends a comprehensive national strategy for agricultural development and a national agricultural research strategy to support implementation within a 5 years’ time frame supported by action plans; i.e., comprehensive regional cooperation programs to enhance food security at the regional or sub-regional programs.

**Issues that Need More Attention**

Below are some of the research issues and innovations that were touched upon in Dr. Solh’s presentation, but need more elaboration:

1. **Alternative Sources of Water for Irrigation**: Use of alternative sources of water will be an important aspect of improving production in the Arab region. This includes: non-conventional water sources such as desalinated and brackish ground water, other marginal quality waters such as agricultural drainage water and treated wastewater. A study by ICBA/IFAD showed that brackish ground water can be used to irrigate 332,000 ha with a potential saving of 2,185 million m$^3$/year of fresh water in seven MENA countries. However, the use of saline and brackish water for agriculture required specially adapted germplasm and modification of existing soil, irrigation and crop management practices and ICBA has been leading the international R&D efforts in this regard.

2. **Studies on Saline Water**: Within the region, in Oman, ICBA scientists continued to collaborate with colleagues to formulate a National Strategy to combat salinity. As a result of water depletion and environmental deterioration, agricultural areas in the Batinah coastal plains have suffered from decreasing productivity, increased salinity of groundwater and intrusion by sea water. The combination of these factors has led to dramatic deterioration and depletion of natural resources impacting severely the livelihood of farmers dependent on agriculture in the region. The Omani Ministry of Agriculture and ICBA are collaborating on the development of two national plans—strategic and action plan to combat salinity, protect water resources from pollution and salinity, ensure the sustainable development of the agricultural systems and the livelihood of farmers.

Also in Oman, ICBA has applied its technical expertise to contribute to improved irrigation planning and irrigation scheduling through precise assessment of all components of the water balance equation, thus ensuring that the goal of irrigation-to supply the correct amount of water required is achieved. Barely was the crop used in the weighing lysimeter to contribute to ICBA’s research program into the crop water use of different crops/forages and developing crop efficient values.

3. **Salt-tolerant Plant Genetic Resources**: Critical to ICBA’s research are its plant genetic resources programs as genetic diversity contained in the germplasm assembled at ICBA is the basis to improve the productivity of salt-affected areas. Initially ICBA’s focus had
been on assembling the germplasm of salt-tolerant forages. However, recently the program has started to acquire and conserve germplasm of high value crops such as vegetables and ornamentals. The purpose of such endeavors is to study their adaptation to marginal environments and disseminate the germplasm to the national programs for research and other uses. At present, ICBA has accessions representing 220 species from 134 countries. This represents one of the largest and specialized global collections of salt-tolerant plants.

4. **Forage Production in Marginal Areas:** Forage crops are known to play an important role in improving the environmental and socio-economic sustainability of smallholder production systems in fragile environments. Pertinent to this, meat consumption in the region is expected to increase by 104 percent and milk by 82 percent by 2030 and thereby the demand for feed will nearly double. Also related are the increase in salinity from unsustainable irrigation practices which is making the production of traditional crops uneconomical and has resulted in the dislocation of poor farmers. It is clear that alternative production and management systems appropriate to the socioeconomic and environmental conditions to sustain livelihoods in the region are critically needed. Hence, ICBA has been focusing on integrated forage-livestock feeding systems based on salt-tolerant forages and marginal quality irrigation water.

5. **Salt-tolerant Grass:** ICBA has studied *Cenchrus ciliaris* (Buffel grass) extensively. An important forage grass native to the Arabian Peninsula, it is salt-tolerant and can be grown in poor soil and water conditions. Seeds have been collected and kept for distribution among NARS and other collaborators. Genetic material will be propagated by vegetative means for multiplication and distribution.

The response to salinity of two other grasses, *Lasirus Scindicus* (indigenous Dhai) and an introduced African variety of *Cencherus ciliaris*, is being investigated by ICBA scientists as part of its collaboration with the UAE Ministry of Environment and Water. With the increasing pressure on all types of water resources in the UAE, high water consuming plants for forage/fodder and other uses need to be replaced by water-efficient plants. *Lasirus, scindicus* and *cencherus ciliaris* show better adaptability, growth and biomass under saline conditions than other introduced plant species.

6. **Use of Seawater to Irrigate Grass:** ICBA expanded research on several fronts to improve agricultural and water productivity. Ongoing research into NyPa forage has concluded that NyPa grass has the potential to be grown as forage crops and landscaping grass in the coastal regions, where sea water can be used for irrigation. With proper management of soil and water, ICBA researchers have demonstrated that long term irrigation with sea water does not increase the soil salinity in the coastal area, as the salts are flushed with each irrigation activity. The use of marginal water such as sea water for growing some halophytic crops that have either economic value or for certain kinds of landscaping, diverts water usage from freshwater to marginal water for agriculture.

In another project within the UAE, researchers at the Masdar Institute (MI), along with several companies like Boeing, Etihad Airways and UOP Honeywell are keen to evaluate
the potential of growing *Salicornia* with sea water for use as a biofuel and maintenance of CO$_2$ equilibrium. A halophyte that grows in salty water, the seeds of *Salicornia* are an abundant source of biofuel. Given ICBA’s rich experience in the evaluation of genetic material and optimizing different types of production systems, MI has agreed on a collaboration to evaluate different germplasms of *S. bigelovii* in seawater salinities, in addition to testing different agronomic characteristics.

7. **Climate Change and Salt-tolerant Plants:** Climate change predictions for the Arabian Peninsula project increased temperatures and higher rates of evaporation, which are likely to aggravate land and water resources degradation with adverse effects on food and feed production. Thus, identification of germplasm, which could produce good economic yields under the harsh climatic conditions with saline water and soil resources, will be crucial to sustain agricultural productivity in the region. ICBA is presently developing resilient production systems based on salt-tolerant plants to cope with the climate change.

8. **Soil Microbes (Mycorrhiza and Rhizobia):** Desert sandy soils are infertile due to low levels of clay and organic matter and have low water holding capacity. Mycorrhizal symbiosis is known to confer numerous benefits to host plants including improved plant growth and mineral nutrition, tolerance to stresses such as drought, temperature and salinity. A study at ICBA showed that Mycorrhized date palm plants had better growth under high salinity conditions compared to non-Mycorrhized plants and established clear rationale for using Mycorrhizae fungi biotechnology to improve productivity under marginal conditions. Several fronts to improve agricultural and water productivity.

**Way Forward:** Arab countries need to act urgently to improve food security. Better protection and management of the water resources, coupled with the more efficient use of water are key conditions to increase production. Greater regional cooperation and increased investment in agricultural research and technological innovation are also vital to improve food security in the region. The following are suggested to achieve these:

- A comprehensive regional strategy for food security, including creation of regional food reserves and national research strategy for agricultural development from individual countries for implementation within a 5 years’ time frame, supported by action plans.
- Comprehensive regional cooperation programs to enhance food security at the regional or sub-regional level.
CHAPTER 6—CLIMATE CHANGE IMPACT ON WATER RESOURCES AND THE AGRICULTURE SECTOR IN THE ARAB REGION

Droubi, A., Jnad, I., Sibai, M., Ashkar, H., Mawed, K., Hassoun, I.
Water Resources Department, ACSAD

Introduction

Climate change phenomena has already become a reality after it was considered for a long time as a sporadic climatic cycle event affecting different areas of the world. The Arab region was one of those areas subject to such events, including high frequency of drought and peak floods which was difficult to link to PRECIS Regional Climate Modeling System. At present, it is believed that the climate change is caused by global gas emissions resulting from human activities.

According to the Intergovernmental Panel on Climate Change Report (IPCC, 2007), the Arab region will be very vulnerable to expected climate change impacts, due to its wide geographic extends, the high variance of its socioeconomic conditions in addition to its limited natural resources. Extreme weather events due to climate change are expected to increase in frequency and variability which will pose a threat to the region's socio-economic development. It may even prevent the achievement of the Millennium Development Goals (MDG’s), particularly Goal one related to poverty alleviation, even when the region's contribution to gas emissions is less than 3 percent of the global gas emissions. The IPCC global climate change modeling has projected that during the next decades a decrease in precipitation in the Arab region, mainly in Mashreq countries, by 20 percent during the next 50 years (IPCC 2007). At the same time water demand will increase due to the increase in evapotranspiration resulting from the increase of air temperature and the increase in the frequency of drought events. This will have a direct negative impact on the water resources available in the region for agriculture production, and could result in land degradation, desertification, loss of valuable biodiversity and finally to a reduction in the food and water security of the region. As is well known, about 75 percent of the cultivated areas in the Arab region are rainfed and about 60 percent of the population depends for its livelihood on these areas (FAO 2008). Climate change, through its negative impacts on agriculture and water resources could damage strategic economic sectors and constitute a major threat to food and water security in the Arab region.

In addition, it is expected to pose a security threat given that about 34 percent of the Arab rural population, or 52 million, are poor and depend on agriculture for their main source of income exacerbating political crises and provoking human immigration from drought-prone areas towards less affected areas within the same country or neighboring countries (IFAD 2010). Rising of sea level could lead to inundation of the lengthy coastal areas of the Arab region where most of the urban and socioeconomic activities are concentrated causing a huge damages in the affected countries.
Since the expected climate change impacts on the Arab region are the result of the Global Circulation Model, and in the absence of a regional climate model for the Arab region, ACSAD has conducted a study of the variability of precipitation and temperature for a selected set of Arab countries, mainly in Mashreq region (Syria, Lebanon, Jordan, Iraq, Palestine) since they belong to the same climatic zone (Figure 1). The objective of this study is to show the extent of such variability and its impact on agriculture production of particularly wheat, as a case study. The paper will also describe the vulnerability of the West Asia region to environmental changes including climate change.

**Figure 1. Location of the Study Area**

Data Collection and Analysis

Climate data is considered as the main base for climatic and hydrological studies. ACSAD has tries to assess all the available historical data regarding temperature and precipitation, either from national or international sources. Figure 2 shows the location of different climate stations covered by the present study. The selection of climate stations has been based on predefined criteria including continuity of historical data and homogeneous geographical distribution of stations all over the four countries. About 16 stations were selected for Syria having historical data for about 42 to 60 years (1946-2006). For Jordan, 6 stations with historical data of about 35 years (1971-2010). For Iraq, 4 stations with historical data of 30 years (1971-2001). For Saudi Arabia, 4 stations having historical data for 30-39 years (1971-2010), and finally, for Lebanon, one station with 47 years of data (1963-2010).
Defining Coefficient of Variation

Based on the collected data, the coefficient of variation (the standard deviation divided by the average) has been calculated for the stations concerning each country. A high coefficient value has been found for all the stations and generally increased from humid to arid areas (Figure 3). High values are found in the South of Jordan and Northeast Saudi Arabia which are more arid areas. It is well known that the arid and semi-arid regions are usually characterized by high variability in precipitation compared to humid and semi-humid areas and consequently they are highly vulnerable to any variability of precipitation. Agriculture production in these areas, mainly of wheat and barley which are almost rainfed crops, as well as livestock will be affected by these variations primarily due to land degradation and desertification that will result from the decline in precipitation. Determining to which extent these variations will affect the different agriculture zones within each country will permit us to evaluate the expected threat climate change will pose for these areas and should help us in developing adaptation and mitigation plans.

Standardized Precipitation Index (SPI)

Drought is considered as one of the general consequences of climate change. It is considered also as one of the threats to the Arab region given its impact on the renewability of water resources and agriculture sector. For examining the variation of precipitation in the study area, the standardized precipitation index which was developed by Edwards and Mckee (1997) and Mckee
et al. (1993) for Colorado State in USA has been calculated. This index can help in defining the dry and wet period during a period which extends from 1 to 72 months. It was used to estimate the variation of precipitation from the average (Median). Negative values of the index signal drought periods as shown in Figure 3 (Hosseini et al. 2009).

**Figure 3. Distribution of Coefficient of Variation in the Study Area**

<table>
<thead>
<tr>
<th>SPI values</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0 and above</td>
<td>Extremely wet</td>
</tr>
<tr>
<td>1.5 to 1.99</td>
<td>Very wet</td>
</tr>
<tr>
<td>1.0 to 1.49</td>
<td>Moderately wet</td>
</tr>
<tr>
<td>-0.99 to 0.99</td>
<td>Near normal</td>
</tr>
<tr>
<td>-1.0 to -1.49</td>
<td>Moderately dry</td>
</tr>
<tr>
<td>-1.5 to -1.99</td>
<td>Severely dry</td>
</tr>
<tr>
<td>-2.0 and less</td>
<td>Extremely dry</td>
</tr>
</tbody>
</table>

This index is calculated from the relation;

$$SPI = \frac{Xi - \bar{X}}{S}$$

Where:

Xi is seasonal precipitation the average precipitation for each station.
S standard deviation
SPI index has been calculated for studying the variation of precipitation for Syria (Figure 4).
As we can see from Figure 4 most of the stations have high drought frequencies during the period 1975-2006, even in the semi humid area such as Bouka station near the Syrian coast where the precipitation average is more than 600mm. Figure 5 shows the SPI variation for selected climatic stations in Syria for different climate zones. As we can easily see there is a trend towards a negative value for different stations with high frequency of drought.
The seasonal variation in precipitation and temperature has also been covered in the study area using Mann Kendall trend analysis (Figures 6 and 7). Significant increase in temperature has been recorded in almost all the climatic stations in the study area. For precipitation, the variations show no clear trends. This means that for precipitation the variation is most probably mean frequent drought events rather than a trend. This result is confirmed also by the variation of the SPI in Figure 5 where we have an increase in frequent drought events rather a clear trend.

**Figure 6. Seasonal and Annual Precipitation Trends for the Period 1955-2006**

![Seasonal and Annual Precipitation Trends](image)

- ● no trend denoted
- ▲ significant increase
- ▲ insignificant increase
- ▼ significant decrease
- ▼ insignificant decrease
- ● insignificant increase or decrease

**Figure 7. Mann-Kendall Trend Analysis Applied to Seasonally Average Annual Temperature Series Between 1955-2006**

![Mann-Kendall Trend Analysis](image)

- ● no trend denoted
- ▲ significant increase
- ▲ insignificant increase
Climate Modeling Scenarios

Different climate models were developed for studying the past climate changes as a mean to predict the future climate. Such models have been tested at the global level in order to develop future climate scenarios for different regions of the globe. The grid of such models was 250x250 km. Within this study, we tried to apply one of these models on the study area using a grid of 25x25 km. PRECIS model which was developed by HADLI center in UK (Hadley Center for Climate Change, Met Office, Exeter, UK) has been used in this simulation exercise. A basic scenario for precipitation (reference period 1961-1990) was developed using the model for a grid of 25x25 km for the Mashrik region. Four numerical models have been tested to see which one fit better the observation data for calibration. Figures 8 and 9 show the standard mean yearly precipitation and temperature respectively for the selected period of reference (1961-1990). This approach is typically used for calibration of the model before developing future scenarios.

Figure 8. Standard Mean Yearly Precipitations 1961 -1990
A predictive scenario was developed using the different models. As a first step many climatic models have been tested for comparison and calibration purposes before producing a future climate scenario for the study region. The models are HadAM3P, NCEP—R2, ECMWF (ERA40), ECMWF (ERA15). In a second step, the scenario A1B, developed by IPCC was tested using HadRM3Q0 model for both precipitation and temperature. Figures 10 and 11 show the results of the future scenario for the year 2025 presented as a percentage of the referenced period 1961 -1990.

We can see from Figure 10 that there will be a decrease in precipitation by 0.005 to 0.001 up to year 2025 in the eastern part of the region with an increase by 0.02 percent in coastal zones. The temperature will experience an increase in all over the region by about 1 percent. These results need to be confirmed more precisely in further work in the future.

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88 HadAM3P; a 150km-resolution version of the Hadley Centre’s global atmosphere only model.
89 NCEP—R2; NCEP R2 (1979–2004) has been derived from the CEP/DOE (National Centers for Environmental Prediction) reanalysis, available for the years 1979–2004 inclusive.
90 ECMWF (ERA40); ERA40 (1957–2001) A quasi-observed set of boundary data has been derived from ERA402, an ECMWF (European Centre for Medium-Range Weather Forecasting) reanalysis dataset available for the years 1957–2001 inclusive.
91 ECMWF (ERA15); Assimilated ERA15 (1979–1993) A quasi-observed set of boundary data has been derived from ERA15, an ECMWF (European Centre for Medium-Range Weather Forecasting) reanalysis dataset available for the years 1979–1993 inclusive.
By way of conclusion, most of the region will experience within the coming 15 years a decrease in precipitation and an increase in temperature compared to the reference period. This result is still need to be validated by adding more climate stations in different countries.

**Figure 10. Winter and Spring Total Precipitation Difference in % (2025 –1961-1990)**
Evaluation of Climate Change Impact on Agriculture Production

Agriculture production and food security are closely linked to availability of water. Climate change is expected to affect food security in the Arab region through its impact on water and in turn on agriculture and food production systems.

A case study has been undertaken to evaluate the impact of climatic conditions variation (precipitation and temperature) on wheat which is considered as one of the main strategic crops in Syria (Jnad, 2010). Wheat is considered as the most important strategic crop in Syrian agriculture given the Syrian population dietary preferences. It occupies 34 percent of the cropping area of the country with 55 percent of this production is coming from irrigated farming and the remaining areas are rainfed. Furthermore, wheat occupies 70 percent of the irrigated land that is devoted to strategic crops. It is not surprising that wheat is considered as the pillar of the food security policy in Syria.

It is expected that climate change will have a high impact on wheat production in Syria and subsequently on the Syrian economy. Figure 12 shows the production of wheat in Syria during...
Hasakeh governorate, located in Northeast part of Syria has been chosen for this study, since wheat cultivation covers about 45 percent of the total wheat cropped area in Syria. Climate data regarding max. and min. temperature, solar radiation, relative humidity, wind speed has been obtained from the global climate data base, CLIMWAT (FAO 2003). The average annual precipitation in the region is 279mm.

The Global circulation model predicted median change in annual temperature and precipitation as generated from the MMD-A1B models for the 2080 to 2099 period as shown in Table 1.

Table 1. Predicted Median Change in Annual Temperature and Precipitation

<table>
<thead>
<tr>
<th>Season</th>
<th>DJF</th>
<th>MAM</th>
<th>JJA</th>
<th>SON</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature response (°C)</td>
<td>2.6</td>
<td>3.2</td>
<td>4.1</td>
<td>3.3</td>
<td>3.5</td>
</tr>
<tr>
<td>Precipitation response (%)</td>
<td>-6</td>
<td>-16</td>
<td>-24</td>
<td>-12</td>
<td>-12</td>
</tr>
</tbody>
</table>

Where; DJF: December, January February; MAM: March, April, May; JJA: June, July, August; SON: September, October, November.

CROPWAT model developed by FAO Land and Water Management Division (Smith 1992), has been chosen and used for predicting the impact of climate variation on wheat production. CROPWAT is an irrigation management model used to evaluate crop water requirements and irrigation needs. The model was utilized to assess the effects of climate change on wheat water use and yield (irrigated and rainfed). Meanwhile, the results should be used as indicators of the effect of climate change on agricultural crops only due to inherent deficiencies in the model itself and other external parameters such as the effects of warming on the length of the growing season.

The data required for the model includes, date of cultivation, crop coefficient (Kc), and climate data. The model determines the water crop requirement based on the referenced crop requirement, ET0 and Kc, using the formula;

\[ ETc = Kc \times ET0 \]  

Where:  
ETc ; Crop evapotranspiration (mm)  
ET0; Reference evapotranspiration (mm)  
Kc ; Crop coefficient  

ET0 can be calculated using Penman Mentith (Allen and als.1998)
It was possible to evaluate the crop productivity using CROPWAT model based on the formula developed by (Doorenbos and Kassam, 1979)

\[
1 - \frac{Y_a}{Y_m} = K_y \left[ 1 - \frac{E T_a}{E T_m} \right]
\]

Where,  
\[E T_a = \text{CROP evapotranspiration (mm)}\]  
\[E T_m = \text{ETc evapotranspiration maximal}\]

Tables 2 and 3 below summarize the results:

<table>
<thead>
<tr>
<th>Table 2. Impact of Climate Change on Irrigated Wheat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crop water requirement (mm)</strong></td>
</tr>
<tr>
<td>Under current climate conditions</td>
</tr>
<tr>
<td>Under climate change conditions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3. Impact of Climate Change on Rainfed Wheat Production</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crop water requirement (mm)</strong></td>
</tr>
<tr>
<td>Under current climate conditions</td>
</tr>
<tr>
<td>Under climate change conditions</td>
</tr>
</tbody>
</table>

As we can see from the Tables 2 and 3, under climate change the irrigated wheat production by hectare will decrease by 16 percent with an increase in water requirement by 10 percent. For wheat rainfed, the production by hectare will decrease by 21.4 percent and water requirement will increase by 10 percent.

**Fresh Water Vulnerability to Environmental Change of the West Asia Region**

This study is a result of a project initiated and funded by UNEP-ROWA and implemented in cooperation between The Arab Centre for the Studies of Arid Zones and Dry Lands ACSAD (covering Levant countries, and Yemen) and Arabian Gulf University AGU (covering the Arabian peninsula). The objective of this study was to carry out a national and regional vulnerability assessment of freshwater resources to better understand the existing status of the
water sector performance under prevailing water developments and management practices, as well as the delineation of the most dominant factors that influence vulnerability in west Asia countries.

The approach used for this vulnerability assessment is based on the methodological guidelines prepared by UNEP and Peking University (UNEP 2009). The vulnerability of freshwater resources was explored by isolating strategically-important issues related to different functions (uses) of freshwater systems in a drainage basin, marking a considerable departure from the preconceived notion of “water crisis” being synonymously linked to vulnerability in general.

Thus, this analysis is based on the premise that the vulnerability assessment must have a precise understanding of four components of the water resources system, including their states and relationships, these are:

- Total water resources
- Water resources development and use
- Ecological health
- Management

The methodology is based on the Driver, Pressure, State, Impact and Response (DPSIR) principles to estimate a vulnerability index influenced by the four indicators defined as resources stress (RS), development pressure (DP), ecological security (ES) and management capacity (MC). The extent of stresses that are being placed on the water sector by water scarcity, increasing water demand and the requirements of socio-economic activities and ecological conditions will be evaluated by the vulnerability assessment.

- Drivers: such as the population growth and the associated urbanization.
- Pressure: water pollution, water development pressure, desertification, conflict over shared water resources.
- State: the state of water resources availability and deficit due to natural and man-made activities and pollution from different sources especially wastewater.
- Impacts: could be the change in the state of water sector performance and adaptability resulting from climate change and other socioeconomic activities.
- Response: is estimated by the adaptive capacity of the ecosystem and human beings to potential threats.

The vulnerability index can be evaluated from the application of a number of governing equations explained in the above mentioned report (ACSAD; AGU; UNEP 2011).

To estimate the four following parameters;

- Water Stress Parameter (RS)
- Water Development Pressure (DP)
- Ecological Health Parameter (EH)
• Management Capacity Parameter (MC)

The data used to calculate these parameters was extracted from a collection of extensive published papers and reports. Values of parameters range between 0 to 1, low values represent low vulnerability and high values represent high vulnerability.

The Freshwater Vulnerability Index is then calculated using the following parameters;

**i- Resources stress (quantity and quality)**

The vulnerability of fresh water resources to external threats either natural or man-made or both may impact the water quantity and quality, thus contributing to stress on water availability and distribution variation in time and place.

**RSs -Water Stress Parameter:**

The renewable water stress for each country was estimated based on per capita water resources and the population growth. The water availability stress was calculated for three different years (1985, 1995 and 2005).

**RSv -Water Variation:**

The water availability variation can be estimated by the coefficient of variation (COV) of the long-term average precipitation over a long period of observation preferably covering 50 years. It is well known that the higher the rainfall coefficient of variation is, the less the dependability of water availability. Consequently, the higher is its vulnerable to climate change due to changes in the rainfall regimes.

**DP- Water development pressure:**

The exploitation of the renewable water sources result from the utilization of water in excess of the amount of replenishment from rainfall and snow melt. Over-exploitation will result in a decrease in surface water flow and spring discharge and a decline in groundwater table levels. The other variable related to the aspect of water development pressure is the availability and the provision of adequate drinking water supply to meet the basic needs for the social well being of society. It represents the social adaptation to the freshwater shortage in regard of how the development facilities address the population needs (UNEP 2009). The water development pressure can be estimated from the available renewable freshwater sources, total water requirement, water supply coverage and the total population.

**EH- Ecological health parameter:**

The ecological health of the water sector can be impacted from natural phenomena and man-made activities.

The ecological health can be measured with two parameters; namely, the water quality/water pollution parameter and the ecosystem deterioration parameter.
Water pollution from domestic and industrial wastes will diminish its utilization and reduce the available amount of freshwater. The estimation of the ecological health can be estimated from calculation of the pollution level and ecosystem deterioration. The ecosystem may be degraded from a variety of socio-economic development activities such as urbanization expansion, land use, removal of vegetation, over grazing and desertification.

**MC- Management capacity parameter:**

The capacity of the water sector to manage its freshwater resources can be accessed from three aspects: efficiency in water utilization, human health in relation to accessibility to adequate and safe sanitation services, and competition over the shared surface and groundwater sources. Water utilization inefficiency results in waste of freshwater water resources, especially in the irrigation sector. The efficiency is estimated in terms of the financial contribution per one cubic meter of water in any of the water consuming sectors. It can be estimated by the GDP value of one cubic meter compared to a world average for a selected country (UNEP 2009). The health aspect is estimated by the inaccessibility to sanitation facilities and services. The conflict management of shared water sources is estimated through the evaluation of the institutional arrangements, policy formulation, communication mechanisms and effective implementation of agreements. UNEP assessment guidelines contain a matrix that relates these issues into a weighted value to be used in the calculation. The information used in the estimation of the management capacity MC consists of GDP value produced from the use of one cubic meter of water, mean value established for a given comparator country, population without access to sanitation services, total population, and a weighted conflict management value.

![Figure 13. Trends of Water Stress Parameters for Different Countries and Different Years](image)

Figure 13 shows the calculation of one of the parameters used in evaluating the vulnerability which is the water stress parameter. This parameter is calculated by comparing Per capita water resources of a country to the generally-agreed minimum level of per capita water resources (1700m³/person). Each of the calculated parameters varies between 0 to 1. Lower values mean low vulnerability and high values mean high vulnerability of each country to environmental change.

**VI- Vulnerability Index**

Based on the estimated values and following consultations with experts for assigning equal weights to parameters in the same category and also to different categories, the vulnerability index is calculated and presented in Figure 14.
To identify the most important factor for each country, the previous figure was re-plotted as a stacked bar showing all the component factors (Figure 15).

The most dominant factor by far is the Water Variation Parameter (RSv), which is a natural factor and could be used as an indicator to highlight how vulnerable the region is to climate change.
The second most important factor is the Water Exploitation Pressures (DPs), which reflects the efforts of the countries to satisfy their water needs from their limited water resources.

**Conclusion**

The results of this study confirm the extent to which the Arab region is vulnerable to climate change. Changes in the climate are expected to affect food security through their impact on agriculture production and water resources. Climate change is also expected to adversely affect the three main pillars of sustainable development: environmental, economic and social aspects. Moreover, climate change threatens the region’s ability to achieve the MDGs.

In view of the projected negative and severe impacts of climate change on the Arab region, adaptation is a priority for ensuring the long term effectiveness of national and regional efforts to achieve sustainable development. This requires that immediate action should be taken to strengthen the coping capacity of the Arab countries to reduce the vulnerability of sensitive sectors and systems changes in the climate. To this regard a regional project adopted by the Arab Water Ministerial Council has been launched as part of the Global project on Integrated Water Resources Management project which was adopted by the Arab Economic Summit held in Kuwait in 2009.

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قيد النشر.
I would like first to express my appreciation to the Arab Center for Studies in Arid zones and Dry Lands (ACSAD) and to the contributors of the Paper on “Impact of Environmental Change on Water Resources and the Agricultural Sector in the Arab Countries” for their commendable efforts in preparing the paper.

The Paper indicated that the Arab region will be most affected by expected climate change and its various impacts, thereby exposing the Arab countries to further challenges. Under these circumstances, efforts are underway in search of the most effective ways for addressing the challenges imposed by climate change in various economic, social and environmental activities, and putting into place a framework with suitable guidelines for adaptation and mitigation of climate change impacts.

In line with the title of the study, one aspect of the paper focused on rainfall and temperature changes, with an evaluation of the impact of climate variations on wheat crop in Al-Hasakah Governorate in Syria, where most of the crop is produced in an area covering about 45 percent of the total area under wheat cultivation. Based on a mathematical model and a scenario extending over the period 2070—2100, as mentioned in the paper, it is expected that temperature would rise by 3.7°C, and rainfall would drop by 62 mm in the Northeast region in Syria, giving rise to an increase in water consumption and a decline in productivity of both irrigated and rainfed wheat.

In this regard, the paper concludes that the combined effect of a rise in temperature and a drop in rainfall reduce productivity of irrigated wheat from 3.5 tons per hectare to 3.15 tons per hectare (that is about 10 percent), and productivity of rainfed wheat from 1.4 tons per hectare to 1.2 tons per hectare (that is about 14 percent).

The paper also dealt with another issue concerning the vulnerability of fresh water resources to environmental change in the Arab Mashreq countries based on an assessment of the vulnerability index of each country over periods of 10 years each between 1985, 1995 and 2005, with the objective of arriving at expected changes in 2020 and 2040. This approach depended on the assumption of the variability index of fresh water resources taking into consideration the relationship between the four elements of the water resources system, namely: total water resources, development and uses of water resources, ecological health, and management of water resources. Each of these elements is affected by specific parameters for which required country data was obtained from government ministries, from reliable scientific sources and pertinent organizations and research centers.

In this respect, the paper concludes that climate change is the main reason for changes in water resources, and it is not easy to fully capture its impact because of lack of a reliable climate...
database and regional climatic models. This fact points to the need for further efforts, studies, and research to collect the required data and design suitable climatic models to form the basis for formulating appropriate strategies for adaptation to expected changes, especially regarding water resources in the Arab region where the per capita share is declining over time.

The paper demonstrates a decline in wheat productivity resulting from climate change. This has implications on Arab food security, particularly concerning a principal food commodity like cereals. The latter is at the top of Arab countries’ priorities, especially following the outbreak of the global food crisis characterized by the sharp rise in the prices of food commodities, particularly those of cereals. As was already pointed out, the decline in the productivity of rainfed wheat is expected to exceed that of irrigated wheat. The paper emphasizes that "unless the increase in water consumption is compensated through additional amounts of irrigation water, irrigated wheat in the Al-Hasakah governorate will drop down from 3.5 tons per hectare to 2.95 tons per hectare (about 15.7 percent) as a result of an increase in water stress".

According to World Bank data cereal productivity in Arab countries amounted to about 417 kilograms per hectare in Somalia and about 567 kg/hectare in Sudan, and ranged in other Arab countries between 939 kg/hectare in Yemen and about 7,506 kg/hectare in Egypt, with an average of about 1,686 kg/hectare in the Arab World in 2008, which is less than half the world average at about 3,400 kg/hectare over the period 2006-2008. An increase in cereal productivity is therefore a key to making progress towards narrowing the regional food gap in this principal food commodity. This depends, among other things, on the potential for expanding irrigated cereal crops, but prospects for this are limited by water scarcity and growing demand on water for domestic and industrial uses.

Additional challenges imposed by climate change on water resources and agricultural productivity bring to the forefront the utmost importance for using water resources with the highest efficiency possible, and the urgency to take steps necessary to improve productivity and water consumption in the Arab region. A share of over 85 percent of renewable water resources for irrigation, with an efficiency not exceeding 50 percent, requires first identifying the reasons behind this in order to adopt policies and implement measures capable of restricting water losses.

Increasing water availability in the region necessitates raising the low irrigation efficiency level in the Arab region. This can be accomplished in a number of ways that include: reducing water losses in water canals, using modern irrigation techniques at the farm level, in addition to other sources such as waste water treatment with suitable specifications for irrigation, and water harvesting. Agriculture in the Arab region uses more than 200 billion cm of water annually. If for example, irrigation efficiency is raised from 50 percent to 70 percent only, this would result in saving about 40 billion cm of water. If this amount of water is used as per water requirements for cereals (about 1,500 cm/ton) it would be sufficient to increase production by about 27 million tons, equivalent to more than half the current production of cereals in the Arab region.

In its 2009 report, the Arab Forum for Environment and Development considered the impact of climate change on water resources in Arab countries. It underscored the urgency of improving water use efficiency, especially in agriculture, in addition to developing new water resources, including innovative technologies for water desalination. The report also indicates that food
production faces challenges posed by an increase in drought and changes in seasons' variation which could reduce agricultural productivity by half unless adaptation alternatives are put into place. Rise in temperature, drop in rainfall, and season variation require development of new crop varieties to cope with adaptation to new situations, such as crops requiring less water, ones that can endure higher levels of salinity and could be used at a larger scale.

New challenges posed by climate change call for further efforts to augment water resources for irrigation, and build up the agricultural knowledge base to improve productivity, especially those related to quantity and quality of agricultural inputs, and adopting sound agricultural practices that are not harmful to the environment.

In view of the limited potential of irrigated agriculture, rainfed agriculture which is dominant in the Arab region remains a significant source of food security. As this is the case, unveiling agricultural knowledge is critical to increasing productivity. Progress on this front demands intensifying research efforts on agriculture in dry areas and introducing new improved seed varieties. In addition it is necessary to undertake studies and research, and building mathematical models on the basis of specific local and regional data and information for assessing the impact of expected climate change on water and agricultural resources in the Arab region with a view to design resilience and adaptation strategies.

Another aspect relates to post harvest operations. The Unified Arab Economic Report 2009, refers to loss in production of plant crops, and indicates for example, that loss in cereals is about 15 percent of total Arab production. To the extent that this percentage loss can be reduced, it will reflect positively on quantities available for consumption.
CHAPTER 7—FINANCING AGRICULTURE IN ARAB COUNTRIES

Mark Cackler
Manager, Agriculture and Rural Development Department
World Bank

Introduction

It is an ongoing paradox that most of the world’s hungry people grow food. Three quarters of the world’s poor live in rural areas, and most are farmers, but inadequate support for agricultural technology and barriers to financing agricultural improvements have meant that many of these farmers are unable to feed their families. Growing population and urbanization combined with recent food price shocks and decreases in development aid to agriculture have led to a dramatic increase in the number of people without enough to eat over the past decade. The amount of food must increase by 70 percent globally and by 100 percent for staples in developing countries in order to feed the world in 2050. Arab countries will face even higher demands for food than the global average: the rate of population growth is currently 1.9 percent (compared to 1.2 percent globally). The rate of urbanization rose by 3 percent from 1990—2006 (compared to 2.2. percent worldwide) (Lampietti et al. 2011). The global community must find more effective ways to finance agriculture in developing countries.

As a result of low productivity and constraints to land and water, Arab countries are the largest importers of cereals in the world. Most import at least 50 percent of the food calories they consume (FAO 2008b). Roughly 24 percent of the total value of regional food consumption comes from imports (AOAD 2007). It is projected that this figure could increase by almost 64 percent over the next 20 years. This dependence on food imports makes Arab countries acutely vulnerable to fluctuations in global commodity prices. The food price shocks of 2008 for example caused overall food prices to rise by more than 20 percent in Egypt and Jordan, with the price of staples leading the increase.

The price shocks of 2008 and the recent price increases of 2011 were felt disproportionately by the region’s poorest people and were particularly damaging in rural areas. Farmers make up about 60 percent of the poor in Egypt and Morocco, but instead of being able to take advantage of higher prices for the food they grow, smallholder farmers spend most of their income on food. When food prices rise, many people who live in rural areas are at risk of slipping into poverty. Despite almost universal food subsidies, poverty in Egypt increased from 19.6 percent in 2004/05 to 22 percent in 2008/09 (World Bank 2011b).

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The food crisis of 2008 was a wake-up call that forced policymakers around the world to acknowledge the vulnerability of communities to global pressures that are beyond the control of any single government. Poor harvests in major grain exporting countries led a number of them to impose export restrictions. These, coupled with high oil and bio-fuel prices, created a surge in cereal prices that left many developing countries reeling. According to some estimates, 105 million people were thrown into poverty by the price shocks of 2008, and over 1 billion were left without enough food to eat (FAO 2010). The global community responded with a flurry of measures designed to ease the crisis. The World Bank in cooperation with the G20 nations and the United Nations High-Level Task Force on the Global Food Security Crisis set up the Global Food Crisis Response Program (GFRP) to provide short-term, rapid help to people in the direst need, and subsequently the Global Agriculture and Food Security Program (GAFSP) to address longer-term issues. While these programs helped mitigate the immediate impact of the 2008 food crisis, reducing world hunger by close to 10 percent by 2010, there were still more people without enough food in 2010 than there had ever been before (FAO 2010). And then, in 2011, food prices began to rise again (Figure 1). It has become clear that the price volatility that caused the crisis of 2008 was part of a cyclical pattern that stemmed from increased pressure on oil reserves and bio-fuel production, against a backdrop of rising population, low yield growth, and climate change driven extreme weather events (Ali 2011). Reducing short-term price volatility will require long-term solutions to all these issues.

While there are multiple pathways out of poverty, improving support to agriculture has proven to be among the most effective. GDP growth from agriculture benefits the income of the poor two to four times more than GDP growth in other sectors (Figure 2) (World Bank 2009a). The most important impact on agricultural GDP will come from increases to productivity. This is particularly so in most Arab countries where arable land and water are stretched to their limit, making it virtually impossible to expand the area under cultivation. Spending on agricultural research and development to increase productivity has been shown to have rates of return of up to 36 percent in Arab countries (World Bank 2011b). But global annual growth rates in yields of major grains have slowed, from about 3 percent in 1980 to only about 1 percent in recent years (World Bank 2009a). In Arab countries, agricultural productivity in cereals lags behind even other developing countries, although high-value vegetable cultivation has fared better, and productivity growth for fruit is above the global average (World Bank 2009c).
The global priorities for reducing poverty and hunger are well known and attainable. The world must:

- accelerate smallholder productivity increases for agricultural growth and food security;
- follow a comprehensive approach to reduce rural-urban disparities and poverty in transforming countries;
- enhance sustainability and environmental services from agriculture;
- pursue multiple pathways out of poverty: smallholder farming, labor market, rural non-farm employment, migration; and
- improve the quality of governance in both developing and developed countries in agriculture at local, national, and global levels.

But financing these imperatives will require a mix of public support and private investment that may prove challenging.

Arab countries face the dual challenge of increasing smallholder productivity without exhausting already overstretched water resources. Renewable water resources in Arab countries have shrunk by about 75 percent since 1950 (Figure 3), and are expected to decrease an additional 40 percent by 2050 (World Bank 2009c). Climate change will probably make water shortages even more acute. Most Arab countries must choose between using scarce water resources to grow grain, and thereby enhance domestic food supplies, or to grow high-value fruits and vegetables for export, which delivers much higher value per drop of water but which can put food security at risk. In countries such as Iraq, Jordan, Lebanon, and Syria, and the Gulf States, in which many crops are irrigated, making irrigation systems more efficient and developing alternative water sources for irrigation through desalinization and wastewater re-use will be important. In countries such as Morocco, Algeria, Libya, Tunisia, Mauritania and Sudan, in which most agriculture is rainfed, increasing productivity through the development of drought resistant crop varieties and improved farming techniques such as conservation tillage will be key components to ensuring food security and reducing poverty (World Bank 2009c).
How Can These Priorities be Financed?

It will require an estimated $14 billion U.S. to $28 billion U.S. in investment to meet the Millennium Development Goal of halving hunger and poverty by 2015 (World Bank 2009b). It will entail a combination of development assistance, wise country financial management, and investment by the farmers themselves. The establishment of sustainable access to financial services for smallholder farmers—savings, credit, payments, and insurance—will be critical.

The Proportion of Official Development Assistance to Agriculture has Declined

Development assistance in agriculture declined dramatically between 1988 and 2000—falling by more than half from $9 billion U.S. to about $4 billion U.S. Over the past decade ODA has gradually climbed back up—to $6.3 billion U.S. in 2008. However, growth in agricultural assistance has not kept pace with overall aid, dropping from a high of 25 percent of total ODA in the 1980s to only 4.5 percent in 2008, in spite of the fact that 75 percent of the world’s poor live in rural areas. The Middle East, however, has seen the highest rates of growth in agricultural aid of any region in the past decade, outstripping overall aid growth in the region by almost 50 percent. In North Africa, ODA to agriculture has focused on water resources in particular. In 2008 investments in water represented 46 percent of all agricultural spending in the region. Investment in agricultural finance has dropped by almost half from 2000–2003 levels. This reduction; however, reflects in part a number of policy shifts which have moved away from commodity-targeted credit in favor of broadening and deepening general financial services, and this aid is therefore no longer identified as specifically agriculture-related (ONE 2010).

World Bank Support has Increased

The new World Bank Group Agriculture Action Plan (FY2010–2012) projects an increase in support (from IDA, IBRD, and IFC) to agriculture and related sectors from an average of $4.1 billion U.S. per year in FY2006–2008 to between $6.2 and $8.3 billion U.S. annually over the next three years. This would be between 13 percent and 17 percent of total projected World Bank commitments (World Bank 2009a). But even using conservative estimates, the increase in lending by the World Bank would represent only about 14 percent of the total incremental annual investment of $14 billion U.S. needed to meet the MDG for food security and poverty reduction. The World Bank has assigned high priority to agricultural productivity, with more than 70 percent of its agricultural portfolio going to increase agricultural productivity for smallholder farmers.

In the Middle East and North Africa Region, where no investments had been made earlier in the decade, the World Bank committed $350 million U.S. to agricultural aid in 2011. Its support will focus on three elements to reduce future vulnerability to food insecurity:

- strengthen safety nets, provide people with access to family planning services, and promote (nutrition) education;
- enhance the food supply provided by domestic agriculture and improve rural livelihoods by addressing lagging productivity growth through increased investment in research and development; and
• reduce exposure to market volatility by improving supply chain efficiency and by more effectively using financial instruments to hedge risk.

The ongoing IDA/IBRD program in the MENA region is dominated by irrigation and drainage, which accounts for 77 percent of its investment. The focus over the next three years will be to do more on agricultural research and extension, agricultural markets and trade, and rural non-farm incomes. The analytical program will focus on public expenditures and rural livelihoods. Arab countries are however very diverse in terms of their food security needs, and support to agriculture will be aimed at the needs of client countries. For those countries highly dependent on cereal imports, but with fiscal deficits (Djibouti, Jordan, Morocco, Lebanon, Tunisia, and Yemen), priority will be given to advice and improved access to financial instruments to hedge risk, then to investments in agricultural research and development and rural livelihoods. Some Arab countries (Egypt, Syria) have fiscal deficits but are not highly dependent on cereal imports. For these countries the first priority is to invest in agricultural research and development and rural livelihoods, and then to provide advice on the use of financial hedging instruments. Finally, some wealthier countries with fiscal surpluses but that are heavily dependent on cereal imports (Algeria, Bahrain, Iraq, Kuwait, Libya, Oman, Qatar, Saudi Arabia, and the United Arab Emirates), have requested advice on issues related to longer term sourcing requirements from developing countries, and on the use of financial hedging instruments (World Bank 2009a).

**Agriculture-Based Countries Spend too Little on Agriculture and Agricultural R&D**

In many developing countries domestic public expenditure on agriculture has declined precipitously over the past two decades. A study of 44 countries found the agricultural share of total government expenditure fell from 11 percent in 1980 to 7 percent in 2002 (ONE 2010). The proportion of these expenditures that was spent on subsidies (which tend not to effectively target the poor) increased. The proportion invested in agricultural research and infrastructure has declined. (See, for example, Figure 4 for what happened in one large developing country).

Investment in agricultural research and development pays large dividends. Worldwide returns to agricultural research are estimated at 45 percent, although in Arab countries the benefits have been found to be somewhat lower at 36 percent. Yet Arab countries invest only about 0.7 percent of agricultural GDP in research and development (World Bank 2009c). This is slightly higher than the developing country average of 0.53 percent, but far below the recommended investment level of 2 percent of agricultural GDP (Gana et al. 2008). Developed countries on average invest 2.36 percent of agricultural GDP on research and development.
New Initiatives in the Public Sector Will Help

In response to the 2008 food price shocks, a concerted effort was made by the global development community to focus on food security as a global issue.

The Global Food Crisis Response Program (GFRP) Provided Rapid Support

The GFRP was launched by the World Bank in May 2008 as a direct response to soaring food prices and their effect on the world’s poorest people—it is estimated that there were 830 million hungry people before the 2008 crisis and up to 1 billion afterwards. The goal of the GFRP was to expedite processing of aid to help countries adapt to higher and more volatile prices quickly before more people suffered the effects of not having enough to eat. The program focused on three objectives:

- **Reduce the negative impact of high and volatile food prices** on the lives of the poor in a timely manner.
- **Support governments in the design of sustainable policies** that mitigate the adverse impacts of high and volatile food prices on poverty.
- **Support broad-based growth in productivity and market participation in agriculture** to ensure an adequate supply response as part of a sustained improvement in food supply.

The program was initially funded with $1.2 billion U.S. from reprogrammed World Bank funds and a new multi-donor trust fund, but the funding limit was subsequently raised to $2 billion U.S., and the time period for expedited processing extended to June 2011 (World Bank 2010). The GFRP was instrumental in reducing the impact of the food crisis in lower-income Arab countries. In Djibouti budget support from the GFRP provided critical assistance by allowing the Government to reduce tariffs on food, and thereby reduce domestic food prices, without jeopardizing the funds necessary for social assistance programs. In Yemen and Sudan, targeted cash transfers mitigated the effect of the crisis on the poorest and most vulnerable communities. In Yemen, cash for work programs—designed specifically to include women—also enabled a large number of low-income workers to feed their families through projects that responded to emergency needs while providing skills training and building essential infrastructure for the longer term. One problem identified by the GFRP in its 2010 progress report was that the hasty implementation of these programs prevented the establishment of community committees to maintain this infrastructure after the projects were completed (World Bank 2010).

The Global Agriculture and Food Security Program (GAFSP) Provides Ongoing Support for Longer-Term Agriculture Development Projects

At the G20 summit in Pittsburgh in September 2009, participants called on all stakeholders to coordinate their efforts to improve global nutrition and build sustainable agricultural systems. The Global Agriculture and Food Security Program (GAFSP) were established by the World Bank in response to the call for a multilateral trust fund to implement the pledges made by governments, private foundations, and NGOs. To date seven donors have pledged a total of $925
The purpose of GAFSP is to scale-up support to poor countries to help alleviate poverty, improve rural livelihoods, and increase food security. GAFSP was designed to address the underfunding of country and regional agriculture and food security strategic investment plans already being developed by countries in consultation with donors and other stakeholders. GAFSP identifies four components that will help to meet these goals: raising agricultural productivity, linking farmers to markets, reducing risk and vulnerability, and improving non-farm rural livelihoods. GAFSP comprises two windows for funding: a public sector window that is intended to provide additional funding for agriculture to countries eligible for IDA financing; and a private sector window that is available to private sector firms and financial institutions operating in IDA eligible countries.

The second GAFSP component, linking farmers to markets, includes a sub-component that specifically addresses rural financing. This sub-component will promote a financial systems approach to developing rural finance, based on the principle that only commercially viable institutions can reach large numbers of clients over the long term. Support will be provided to all three levels of the financial system: promoting an enabling environment at the macro level; developing effective associations, credit bureaus, industry standards, and monitoring mechanisms at the meso level; and developing sound financial institutions that offer a range of financial products at the micro level (World Bank 2009b).

Arab countries have not yet benefitted from the GAFSP initiative, but for those Arab countries that are IDA eligible (Sudan, Djibouti, Yemen, and Mauritania) GAFSP may provide valuable support to improve agricultural productivity and increase the availability of financing for smallholder farmers.

A Revamped CGIAR Will Contribute to Better Agricultural Research

In 2010, the Consultative Group on International Agricultural Research (CGIAR) finalized a reform plan that pledged to do a more efficient, focused, and accountable job of leading global research on agricultural productivity. The CGIAR Consortium was established to unite the work of the 15 previously existing CGIAR Centers on the principle that collectively they can do better research than they can individually. An independent Science and Partnership Council was created to support the consortium by providing sound advice on scientific issues, and the CGIAR committed to building stronger partnerships with the external research community and other stakeholders in improvements to agricultural productivity. System wider "CGIAR Research Programs", or CRPs (and sometimes called "Mega Programs") were introduced to allow CGIAR researchers to draw better on the CGIAR’s collective strengths—improving major food crops for added resilience and nutritional value and enhancing the management of crops, livestock, trees, water, soil and fish. Funding for this new research strategy was streamlined by the creation of the CGIAR Fund which aims to harmonize the contributions of donors to agricultural research for development, improve the quantity and quality of funding available, and engender greater financial stability (CGIAR 2009b). In the Middle East and North Africa, the International Research for Agricultural Research in the Dry Areas (ICARDA) is leading the research agenda
in developing more resilient, diversified, and productive crop/livestock systems for water-scarce countries.

**The Private Sector Will Play a Major Role in Financing Agriculture**

While the public sector has traditionally taken the lead in designing programs to support agriculture, over the past decade an emerging vision of *agriculture for development* has redefined the roles of producers, the private sector, and the state (World Bank 2008). While the state should strive to correct market failures, regulate competition, and engage in public-private partnerships to support the greater inclusion of smallholders, it is the private sector that drives the organization of value chains that bring the market to smallholders and commercial farms. The International Finance Corporation (IFC) already provides 30 percent of World Bank financing to agriculture, and the private financing window in GAFSP will increase World Bank support to the private sector further still. Private sector financing for agriculture comes from a large array of sources including large scale private financing (land purchases and leasing), as well as private financing from banks, financial cooperatives, microfinance, and leasing. Each of these has the potential to increase agricultural productivity, strengthen value chains, and improve food security in Arab countries. Each however also presents risks and challenges.

**Large Scale Private Financing: Land Grab or Driver of Prosperity?**

Approximately 56 million ha worth of large-scale farmland deals were announced in 2009, compared to an average annual expansion of global agricultural land of less than 4 million ha before 2008. And Arab countries were involved in both sides of these transactions. Gulf States (Saudi Arabia, Qatar, and United Arab Emirates) have been key sources of the announced farmland deals, and a number of Sub-Saharan African countries, most notably Sudan, have agreed to sell or lease their land. Saudi Arabia and the United Arab Emirates hold more than 2.8 million ha, mostly in Indonesia, Pakistan, and Sudan. Several other countries have also either acquired or attempted to acquire foreign agricultural land: Egypt in Uganda and Sudan; Bahrain in the Philippines; Kuwait in Cambodia, Laos, and Myanmar; Libya in Ukraine and Zimbabwe; and Qatar in Cambodia (Cotula et al. 2009). The announced investments are undertaken by governments (UAE), multi-national financial institutions (Arab Authority for Agricultural Investment and Development, or AAAID), and private companies (Saudi Arabia’s Al-Qudra). In 2009, The Director-General of the Arab Organization for Agricultural Development (AOAD), based in Khartoum, called on Arab countries and the Arab private sector to band together to create joint agricultural projects in the region, saying “I am convinced that if there is a real interest and seriousness by investors in the farming sector, then the whole Arab World needs of cereal, sugar, fodder and other essential foodstuffs could be met by Sudan alone” (Kawach 2009). Between 2004 and 2009, about half a million ha of land was transferred to foreign interests in Sudan (Cotula et al. 2009), a large proportion of which was from purchases within the Arab World.

Although investing in foreign land could be an attractive investment strategy, it is fraught with risk for both buyers and sellers. And the risk is a threat to food security goals. There are significant political risks to investing in agriculture in countries like Sudan that do not grow
enough food to feed their own people. Nor do they have reliable land administration systems that ensure tenure security for either current or prospective landholders. It may prove politically difficult to export food from a country where a sizable portion of the population is hungry. By purchasing or leasing foreign land a government or private investor also assumes all the risks that come with agriculture such as extreme weather, pests, and drought. The risks are especially high in new and ‘greenfield’ farming investments, and are magnified by the size of the land holding. Although if done properly, foreign land purchases may increase the available food supply of the investor country while benefitting the recipient country by an infusion of much-needed capital, it is not clear that they are the best hedge for Arab countries against food-price rises (World Bank 2009c). Less risky alternatives include improving import logistics, stockpiling, and futures and options contracts.

On the seller’s side, the political and social risks of transferring large parcels of land to foreign investors are even more daunting. There has been considerable debate about the wisdom of large land sales to foreign investors. Possible threats include the lack of consultation, trampling of local rights—especially informal land rights, dispossession of lands, diversion of farmland away from food crops, environmental damage, opportunities for corruption, lack of transparency, absence of dispute resolution mechanisms and the undue exertion of outside influence and interests on a country’s food policies.

In response to these concerns, a number of organizations, including FAO, IFAD, UNCTAD and the World Bank, have formulated seven principles of responsible agro-investment for large-scale agricultural investment:

- **Land and Resource Rights:** Existing rights to land and natural resources are recognized and respected.
- **Food Security:** Investments do not jeopardize food security, but rather strengthen it.
- **Transparency, Good Governance and Enabling Environment:** Processes for accessing land and making associated investments are transparent, monitored, and ensure accountability by all stakeholders.
- **Consultation and Participation:** All those materially affected are consulted and agreements from consultations are recorded and enforced.
- **Economic viability and responsible agro-enterprise investing:** Projects are viable economically, respect the rule of law, reflect industry best practice, and result in durable shared value.
- **Social Sustainability:** Investments generate desirable social and distributional impacts and do not increase vulnerability.
- **Environmental Sustainability:** Environmental impacts are quantified and measures taken to encourage sustainable resource use, while minimizing and mitigating their negative impact.

The 2011 World Bank report on the rising global interest in farmland concludes that: “When done right, larger-scale farming can provide opportunities for poor countries with large agricultural sectors and ample endowments of land. To make the most of these opportunities,
however, countries will need to better secure local land rights and improve land governance. Adopting an open and proactive approach to dealing with investors is also needed to ensure that investment contributes to broader development objectives” (Deininger and Byerlee 2011, xv).

**The Best Route Toward Agricultural Growth is to Help Smallholder Farmers Finance Themselves**

It has been shown again and again that when farmers can take charge of their own financial decisions, they make much better use of resources. One study of smallholder farmers in West Africa found that irrigation pumps purchased with the farmers’ own funds were used regularly 95 percent of the time, whereas if the pumps were donated by a development project or NGO they were only used regularly by half the farmers who owned them (World Bank 2011d). But farmers need access to financial services—savings, credit, payments, and insurance—if they are to manage their own resources optimally, and such access is scarce in the rural areas of most developing countries. Most smallholder farmers worldwide have almost no opportunity to borrow or save toward their future. The lack of financial services limits farmers’ capacity to make productivity-enhancing investments in new technology and services, and it increases their vulnerability to financial and weather-related shocks (AgriFin 2010). The MENA Region performs relatively poorly in terms of providing credit to a substantial proportion of its population, although financing does tend to reach relatively more poor people than in other regions (Pearce 2011).

In the past agricultural credit tended to be provided through subsidized direct credit programs. These programs often had very low repayment rates that created a poor credit culture in which limited funds were available intermittently. Neither the lenders nor the borrowers could rely on an ongoing, sustained flow of credit. Agricultural credit was not only expensive for governments, but it was also often subject to elite capture, and funds did not reach the poor effectively. Today, most analysts support a financial systems approach to agricultural credit, with market-based interest rates and a focus on sustainable financial institutions and deposit mobilization.

**There are a Number of Potential Providers of Rural Finance**

Since the early 2000s many different types of organizations have developed innovative approaches to financing agriculture. These new approaches show great promise, but no single approach works for all situations (Kloeppling-Todd 2010).

**Agriculture Development Banks** have been the mainstay of agricultural finance in developing countries for the past three decades. The absence of financial institutions in rural areas of developing countries spurred governments to step in with state-owned or state-controlled banks focused on agriculture. In the long term, these banks have had only limited success at establishing a solid credit system. In general, these banks tended to be too bureaucratic, and, by focusing on agriculture, their risk was concentrated in only one sector. A few years of poor harvests could therefore decimate a country’s agricultural banking system. In Sudan, the Government restructured the Agricultural Bank of Sudan and other state-owned specialty banks, but they have continued to experience difficulties. In addition, reforms resulted in increased exclusion of poor farmers rather than increased access to credit (UNDP 2009).
State-run agriculture development banks can be a positive force in the banking system because they are able to establish pro-poor policies and ensure equitable financing. But to make them work efficiently, they will need to be run on sound commercial principles and have transparency and good governance. Their modernization will be particularly critical for Arab countries, where state banks are the leading provider of loans to microenterprise. In Egypt the state agricultural bank (PDBAC) has more than 1,200 branches throughout the country outside of Cairo, which provide loans for agriculture and other small rural enterprises (Pearce 2011).

**Commercial Banks** will play an increasingly important role in financing smallholder agriculture. Given a good understanding of rural markets and a sound strategy to diversify their business, commercial banks can successfully manage the risks inherent in providing financial services in rural areas. Some have already developed the necessary business models to profitably provide financial services. Their experience proves that with the appropriate management, knowledge, and support, financial institutions can significantly scale up financial services for smallholder farmers (AgriFin 2010). But commercial banks still play only a very limited role in providing small-scale loans to farmers in Arab countries. They generally prefer to work through microcredit institutions. In Lebanon, several commercial banks partner with Ameen, one of the largest microfinance providers in the country. In Egypt commercial banks similarly work in cooperation with microfinance service companies. Moroccan banks have set up microcredit associations or foundations rather than providing small loans directly (Pearce 2011).

**Microfinance Banks or Specialized Microfinance Institutions** are an alternative model for providing loans to small enterprises like smallholder farms. In the past 30 years microfinance has boomed. As of December 31, 2007, 3,552 microcredit institutions had reached 154 million clients worldwide, about 106.6 million of whom were among the poorest when they took their first loan (Liu and Deininger 2010). The microcredit sector has grown more slowly in the MENA Region, reaching only 1.78 percent of the adult population—half the percentage reached in South Asia or Latin America. Egypt and Morocco lead the field in microfinance in Arab countries, accounting for more than 70 percent of loans made in these two countries. In Jordan however, microcredit reaches a higher proportion of the poor (Pearce 2011). Recent campaigns to promote microfinance by the Arab Gulf Program for United Nations Development Organizations and the Aga Khan Foundation (AGFUND) have seen microfinance spread to Yemen, Syria, and Jordan (Pearce 2011, AGFUND 2011). Although microfinance organizations have served an important role in many developing countries by widening access to financial services for the poor, particularly women, they have proved more successful in funding microenterprises than in financing agriculture, which requires a higher tolerance to risk than most microfinance institutions can support (AgriFin 2010).

**Financial Cooperatives and Other Community and Member-Based Institutions** are an important source of financing for smallholder farmers in some developing countries, but they have not yet become a significant factor in Arab countries (Pearce 2011). These locally owned and operated groups provide saving and lending services to their members and, by virtue of their local identity, can be a significant avenue for saving and borrowing for the poorest farmers in remote areas who are not otherwise served by banks or microfinance institutions (Ritchie 2010).
Leasing Companies offer several advantages for asset financing because they do not require the collateral that is typically required by credit agencies, and that forms an insurmountable barrier to many poor farmers. Leases also often require lower down payments than the equity required for loans, making them more affordable for rural enterprises that have limited funds (Nair 2010). Leasing also offers a particular advantage in Arab countries since it is a financing instrument that is compatible to financial principles that are accepted by Islam. Leasing has not been widely used in Arab countries to date, but new financial legislation promises to open the field for microfinance organizations to develop leasing as another source of microcredit (Pearce 2011).

Some General Principles for Effective Agricultural Financing are Clear

Financing smallholder farmers requires all the fundamental good principles of finance, but agriculture also presents specific demands:

- Loans to finance agriculture needs to be provided as part of a broader set of financial services (savings, payments, insurance) and also include loans for consumption smoothening so that loans to finance agriculture are not diverted for consumption smoothening.
- Loans must be large enough to be adequate to help farmers make productivity enhancing investments (high quality seed, fertilizer, equipment) that will make farms more productive.
- Loans duration needs to match that of the duration of the crop being financed, and therefore, typically a longer duration than typical microfinance loans
- Repayment schedules must also be based on the production cycle of the crop in question, and therefore typically involving most of the loan amount being repaid at the end of the loan term, unlike microfinance loans that are repaid on a weekly or monthly basis.
- Interest rates must be high enough to be sustainable for the financing institution.

In order to build a sound system with which to finance agriculture, countries need to establish foundations across sectors. These can be grouped into three pillars:

- Pillar 1: Build strong financial institutions that are transparent, fiscally sustainable, and economically justified.
- Pillar 2: Strengthen financial sector infrastructure by creating capacity within regulatory bodies and supporting industry and trade associations, training institutes, and credit information agencies.
- Pillar 3: Support economic and social infrastructure by facilitating income-generating activities by local communities with smart subsidies that decline over time, and include a match from beneficiaries.

Agricultural Financing Presents Unique Challenges, Although Solutions are Available

Smallholder farms in Arab countries tend to be much less productive than large commercial farms. While a substantial portion of smallholder farming produces for the market, and while it
can be profitable, low productivity weakens farmers’ ability to obtain and successfully repay loans. The productivity of agriculture is linked to several factors including access to good-quality inputs, and basic infrastructure, such as roads and power, as well as dissemination of knowledge about more productive techniques.

For smallholder agriculture to be profitable, farmers must be able to gain access to markets. It is easier for financial institutions to finance smallholder agriculture that is part of a structured value chain because assured market linkages reduce the likelihood that a farmer will default. Direct contacts in the produce distribution sector also make it possible for the financial institution to ensure that loans are paid off before the farmer or cooperative is compensated for his produce. It is possible to finance smallholder farmers who are not part of structured value chains, but it requires farmers who are educated in risk management and financial institutions that have policies and systems to assess and mitigate the risks involved (AgriFin 2010).

Providers of agricultural finance must have a firm understanding of the range of risks that small farmers face. These include weather risks, production risks, and market risks (Dellien and Lynch 2007). In general, financial institutions can reduce risk by diversifying their agricultural portfolios across crops, regions and size of operations, as well as their rural portfolios across farming and non-agricultural enterprises (AgriFin 2010). The field officers of financial institutions must be able to assess risks for different crops and farming systems, and senior management should have the ability to develop specific risk-evaluation procedures.

Both the quantity and quality of crops are subject to fluctuations in temperature and precipitation, making farming highly vulnerable to weather risk (Dellien and Lynch 2007). Irrigated agriculture is less susceptible to variations in precipitation, although irrigation that relies on groundwater faces serious longer-term risk as groundwater tables are depleted. In many Arab countries (Morocco, Algeria, Libya, Tunisia and Mauritania) smallholder farming is dominated by rainfed agriculture. The risks facing rainfed farming and groundwater-irrigated farming are both likely to increase with climate change. Weather risk is difficult for lenders to absorb because weather-related disasters such as drought will affect all farmers in a region at the same time. This can cause widespread defaults.

Crop and draught insurance can mitigate weather risks for financial institutions, but in order to spread the correlated risk of weather disasters it is generally necessary to employ global reinsurers, which can be difficult in developing countries. A pilot project in India sponsored by the World Bank has been successful in providing weather insurance to a microfinance institution that provides loans to smallholder farmers by using a rainfall index that measures the rainfall at a local weather station. If rainfall does not surpass a given threshold the insurance secures repayment of loans to farmers. Since the index system is fully transparent, global reinsurers are more able to assess the risk (Skees and Collier 2010).

Production risks are often closely related to the technical and managerial skills of farmers and their ability to move produce from the field to the market. Inadequate inputs, substandard farming practices, and flawed handling and storage systems can all create reduced quantity and quality of produce. But even the most skilled farmers with good yields can face default if excess market supply causes a sudden drop in price for a given product (Dellien and Lynch 2007).
Dealing with production and market risks requires financial institutions to be able to conduct detailed assessment of farmers’ production capacity with specific crops in specific markets (AgriFin 2010).

One reason traditional commercial banking has been reluctant to finance agriculture is a lack of knowledge about the sector among financial professionals. Most banks are based in cities, and do not have staff who are trained to evaluate the specific problems involved in agricultural lending (Kloeppinger-Todd and Sharma 2010). To successfully finance agriculture, financial institutions must build a deep base of knowledge about the risks and potential rewards of agricultural finance. From field officers to senior managers, this knowledge is needed to develop credit policies and procedures which are expressly designed for agricultural lending, including lending to small rural enterprises. These financial institutions also have to be able to monitor risks at the portfolio-wide level and at the sub-sector levels. Relatively small financial institutions such as financial cooperatives or rural banks may be able to reach out to federations or apex institutions for the necessary specialized skills (AgriFin 2010).

It can be costly for financial institutions to service farmers because they are physically difficult to reach. Rural clients are usually scattered across wide geographic areas, posing significant logistical challenges for urban-based banks. The development of flexible distribution channels to deliver and monitor loans is critical for sustainable agricultural finance (Dellien and Lynch 2007). In Egypt, the state agricultural bank, the Principal Bank for Development and Agricultural Credit (PDBAC), with the help of technical assistance from Rabobank, has revamped its network of rural branches by improving inter-branch connectivity (Pearce 2011).

In the past few years, a number of financial organizations in developing countries have successfully applied new technologies to this old problem. In Kenya, the use of mobile phones to access all types of bank services including repayment of loans has been a huge success, with tens of millions of transactions performed every month using this system. With cell phone service able to reach most rural communities, this service has revolutionized the money transfer system in Kenya, bringing access to millions in rural areas who were previously not served by banks (Lowie 2010). Mobile phone banking services have started to emerge in Arab countries as well, with some limited services now available in Morocco, Yemen, Tunisia, and Iraq. In some Arab countries mobile phone banking has the potential to transform rural banking. In Yemen, where 70 percent of the population lives in rural areas without banking infrastructure, there are close to 8 million mobile phone subscribers and fewer than 1 million bank accounts (Pearce 2011).

The isolation of rural farmers not only makes it difficult for them to access financial services, but it is also more difficult for lenders to establish client identity to assess credit worthiness and thus reduce risk. Identity fraud has been a nagging problem to lenders in developing countries with limited identification systems. Biometrics, including fingerprinting and retina scanning, may help to securely identify clients and reduce fraud. A pilot project using fingerprinting to obtain loans in Malawi found that biometrics improved repayment rates for farmers with previous defaults by up to 40 percent. A cost-benefit analysis of the project suggests that the benefits from improved repayment greatly outweighed the cost of fingerprint collection (Giné 2010). “Know your customer” identity requirements are relatively exacting in Arab countries, and some may not be appropriate for low income and semi-formal customers (Pearce 2011). The use of biometrics may help to extend credit safely to a larger segment of the rural poor.

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One of the most persistent and structurally difficult challenges to agricultural finance is the inability of many smallholder farmers to provide the collateral that traditional banking requires for obtaining loans. Insecure property rights and the lack of land titles leave many farmers with no collateral with which to secure loans. Improving land titles will be a necessary long-term step to broadening agricultural credit for smallholder farmers. Where financial legislation allows, it is also sometimes possible to use movable collateral such as warehouse receipts, accounts receivable, equipment, and standing crops or livestock as alternatives to land for securing loans (Wenner 2010). In April 2011, the IFC and the Arab Monetary Fund launched the Arab Secured Transactions Initiative, a program to boost business lending by encouraging the region’s financial institutions to accept movable assets as collateral. This initiative hopes to achieve progress in the use of alternative collateral by assessing secured lending laws across the region, by raising awareness about positive changes that could be made, and ultimately by partnering with governments to pilot reform programs (IFC 2011).

Government policies and the actions of donors and development banks have sometimes caused distortions in the agricultural lending sector by treating agriculture as a social problem rather than an economic activity. By providing subsidized funding to farmers or cooperatives, these agencies have made it difficult for private financial institutions to charge the necessary fees and interest rates to create a financially viable and sustainable agricultural financing system. The risk assessments required for agricultural lending are complex and costly, and higher interest rates are necessary to compensate for these costs (Wenner 2010). Government-imposed interest rate caps, currently in place in several Arab countries, force microfinance lenders to either charge interest rates that are above the caps, risking a court challenge, or to limit the credit they provide to reduce the risk of defaults (Pearce 2011).

**AgriFin – A New Initiative that Supports Solutions for Agricultural Financing**

The vision of the Agriculture Finance Support Facility (AgriFin) is significantly increased access to financial services for smallholder farmers and other enterprises in rural areas (AgriFin 2010). With funding by the World Bank and the Gates Foundation, the goal of AgriFin is to demonstrate that providing financial services to smallholder farmers and other enterprises in rural areas can be a profitable business for financial institutions. AgriFin seeks to build on the lessons learned from financial organizations worldwide that have succeeded in establishing viable and sustainable rural operations. Many of the challenges and solutions discussed above can be addressed through this kind of support to both private and public financial institutions.

The AgriFin website describes the goals of this new initiative: “The major activity of AgriFin is to provide grants to regulated retail financial institutions to support the expansion of their agriculture and rural finance business. The grants will finance up to 50 percent of the business development costs, structured on a case-by-case basis. The grants can be used for a broad range of activities and related costs, including technical advice, rural outreach infrastructure, such as smart cards and card-reading devices, training expenses for staff and clients, consultancy expenses, and staff salaries. The grants are expected to assist financial institutions to substantially increase their agriculture finance business, ultimately benefiting the smallholder farmer (AgriFin 2010).” AgriFin may be able to provide support to financial institutions in Arab countries to extend the critical financing that will allow smallholder farmers to thrive.
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COMMENTS ON CHAPTER 7

Hesham Kandil
Chief Water Resources Engineer, Agriculture and Agro-Industry Department, AFDP

Introduction

Colleague from World Bank extensive review of AgriFin and possibility to support smallholders. We know what to do if finance is available and priorities are known, what we can do at different levels. Those are true, but we need to do some upstream work before we can get finance working.

In Africa, the challenge is different than Arab World. Low prod, low margin, broken value chain, market inefficiency, and high risk and low perception for access to finance. With all these challenges, investing in a culture in water is not yet a priority for most countries. We are convinced that investment agriculture will pay, will have an impact on reduction of poverty and economy, but we were not until this point very successful in convincing decision makers, i.e. Minister of Finance, that this is a priority for the country and that a good part of investment should go to agriculture.

What we are doing at African Development Bank (ADB) in support of agriculture? Our strategy from 2008 to 2012, we want to be preferred partner, impact and well-focused development.
Priority areas: infrastructure, governance, private sector, and higher education. Those areas will serve investment support. Our focus is on infrastructure.

The challenges are huge. We cannot do everything. In line of Paris declaration, we want to focus on areas of comparative advantage, i.e. provision of infrastructure: rural community roads, improvement of water storage multipurpose, and infra for fisheries and livestock. As our second pillar, renewable natural resources and climate change mitigation and adaptation.
African countries are classified into two categories according to GDP: eligible for commercial loans, eligible for concessional loans.

Contrary to my colleague, we are saying that we have more investment in agriculture in absolute value but not in ratio terms. Historically, agriculture in North Africa and rural development support amount to 10.6 percent of Official Development Assistance (ODA). Now this share is down to 2.4 percent with the lion's share going to transportation and communication and power supply.
The country decides on the country priority, donors ensure country ownership on their assistance.

If we want to support agriculture, where do we intervene? Country Strategy Paper, programming stage, followed by identification, preparation, appraisal, approval and negotiation, implementation, and post-evaluation.

We all realize the impact agricultural investment would have on poverty, but unless we put agricultural investment clearly as a priority you will not see an increase. At this stage we are presenting economic and sector works, but it needs to be translated to concrete arguments that would convince decision makers to translate into Country Strategy Paper.

- ADF provides concessionary loans and grants to the lower income countries
  Lending limit based on Performance Based Allocation System

- ADB raise funds from capital subscriptions by Member Countries and capital market bond issues
  Lending limit for each country based on a number of key factors including Country Risk Assessment and ADB financial resources
As I mentioned, there are two types of lending: lending for concessional lending, and huge 
competition for that, the terms are favorable—not only in the country, but amongst different 
sector departments within institutions. ADB is like the WB, we are convinced but we really need 
to make the case against people from infrastructure, health, education. For ADB countries, the 
role for what they want to do fall to the country. They are not concessional.

**Public Sector Window**

Many of us want to finance projects in water, we do not find bankable projects. Michael League 
mentioned the GASP, regardless of the economy, good or bad, it’s a good way of financing 
agriculture and food security, but it’s based on competition and the ability of the country to 
prepare a good proposal. We saw some countries with great needs and were unable to prepare 
good proposals who did not win and did not get what they needed.

This technical, distinguished group is tasked with preparing their own respective countries to 
prepare bankable operations.

Multi-development bank work in terms of financing: a commercial window for ADB, and 
concessional loans/terms/windows, African Development Fund (ADF) and Nigeria Trust Fund 
(NTF).

In support of agriculture in Africa, and the Arab region in Africa, we have four programs that we 
can use to support agriculture water development and agriculture:
1) Agriculture Water Development and Water Storage Enhancement Business Plan, we have set targets to improve agriculture water development in Africa in half a million hectare, provide institutional support for project preparations.

2) Post Harvest Loss Reduction Program, policy formation, rural infrastructure, technologies for post harvest reduction, and market development

3) Africa Fertilizer Finance Mechanism (AFFM), average use of fertilizer is five kilograms per hectare. We need to assist regional member countries to increase their productivity and to facilitate use of fertilizer. The keyword is regional integration: the need of the country for a year will not fill up one ship, so the country who procures the fertilizer pays the transportation costs for the whole ship yet uses only say 30 percent of it. Transportation costs could come up to 250 percent of fertilizer. One of the main themes therefore is infrastructure, including roads. We support research and a five-year project, Comprehensive Africa Development Program (CAADP)—cassava, maize, rice, and wheat. And ensure that North Africa will benefit from this.

We are beginning to see more and more professionally managed operations in the private sector, willing to invest on the value chain and to attract institutional investors with acceptable albeit lower return but sizeable social return. At the bank we are trying to provide an enabling environment.

In summary, we need to ensure that agriculture and water management and development come as priorities in country national strategic and investment plans. In addition to public investments and despite the challenges, there is increasing support and number of private sector initiatives focused in Agribusiness and Agriculture. This will ease access to investors and donors funding and help transform the challenges of financing agriculture in Africa into sustainable opportunities.
One last word about investment in large-scale agriculture: it's happening, whether we like it or not, so those principles of good practice are important. In some cases, when the ADB intervenes it helps to provide a balanced deal that will not be skewed to commercial company but will balance smallholders and country and will ensure that environmental and social dimensions are considered, and land tenure and mitigation measures are addressed. I would support that investment in large infrastructure will be co-financed with institutions with experience in the region to ensure impacts are resolved.
CONTRIBUTORS

Dr. Abdlatif Y. Al-Hamad

Dr. Abdlatif Y. Al-Hamad is the Founding Director General of the Kuwait Fund for Arab Economic Development. He currently serves as Chairman and Director General of the Arab Fund for Economic and Social Development (AFESD). He is a member of the Group of Thirty.

He served as a member of Boards of Trustees of universities and higher educational institutions in the Arab World and abroad.

He served as a Member of advisory committees boards of international financial institutions such as the World Bank and in different parts of the World.

Dr. Shamshad Akhtar

Prior to becoming a Vice President in the World Bank, Dr. Shamshad Akhtar served as Governor of the State Bank of Pakistan (2006-2009), a Federal Ministerial level ranking. During this period she was also a Governor of the International Monetary Fund (IMF). In 2006 and 2007 she was nominated Asia’s Best Central Bank Governor by Emerging Markets and the Banker’s Trust. Prior to her leadership of the Pakistan Central Bank, she worked as Director General of the South East Asia Region of the Asian Development Bank. From 1998-2002 she was Director of the Asian Development Bank’s (ADB) Governance, Finance and Trade Division. She also served as ADB’s Coordinator of the APEC Finance Ministers Process. Between 1980 -1990 she worked as a Country Economist at the World Bank’s Resident Office in Islamabad. She is the recipient of a Post Doctoral Fellowship from Harvard University and holds an MA in Development Economics from the University of Sussex and a M.Sc. in Economics from the Quaid-e-Azam University, Islamabad, Pakistan.

Dr. Hafez Ghanem

Dr. Hafez Ghanem holds a Ph.D. in Economics from the University of California, Davis – is a development expert with extensive experience in policy analysis, project formulation and supervision and management of multinational institutions. He has worked in over 21 countries in Africa, Europe and Central Asia, Middle East and North Africa and South East Asia.

He joined the Food and Agriculture Organization of the United Nations (FAO) in 2007 as the Assistant Director-General responsible for the Economic and Social Development Department. This Department, with more than 200 employees from all over the world, is responsible for FAO’s analytical work on food security, agriculture development, trade and markets, gender and equity, and statistics. It produces three FAO flagship publications: The State of Food and Agriculture, The State of Food Insecurity and The State of Agricultural Commodity Markets.
Prior to joining FAO, he spent twenty-four years on the staff of the World Bank where he started as a research economist and then senior economist in West Africa and later South Asia. In 1995, he moved to Europe and Central Asia where he was Sector Leader for Public Economics and Trade Policy. In 2000, he returned to Africa as Country Director for Madagascar, Comoros, Mauritius and Seychelles. In 2004, he became Country Director for Nigeria where he led a multinational team of more than 100 professionals, managing the Bank’s loan portfolio of some $1.5 billion U.S.

Dr. Ghanem has many publications in professional journals and was a member of the core team that produced the 1995 World Development Report. He is fluent in Arabic, English and French.

**Dr. Nadim Khouri**

Dr. Nadim Khouri was Director of Near East, North Africa and Europe at the International Fund for Agricultural Development (IFAD) from 2008 to 2011. In this capacity, he led IFAD’s activities in the tripartite World Bank-FAO-IFAD operational initiative on Food Security in the Arab Region.

Prior to joining IFAD, Mr. Khouri had a 20-year career at the World Bank in Washington DC, where he held various policy and operational positions on rural investments in development in the Middle-East, North Africa, South Asia, Latin America and the Caribbean. Between 1979 and 1988 he held positions of Researcher at the American University and the University of Massachusetts at Amherst as well as a 5-year Soils and Irrigation Specialist position at Dar Al-Handassah, an international consultancy firm.

Dr. Khouri has a Ph.D. in Agronomy from the University of Massachusetts at Amherst (USA), an M.Sc. of Agricultural Development from the University of London (UK) and a B.Sc. and M.Sc. in Agronomy from the American University of Beirut (Lebanon). Currently Dr. Khouri is the Deputy Executive Secretary of UNESCWA.

**Ms. Maria Losacco**

Ms. Losacco is a Junior Consultant in the Near East, North Africa and Europe Division at the International Fund for Agricultural Development (IFAD). She has helped the Division develop a concept note on the role of rural development interventions in reducing the vulnerability of rural communities to conflict. She is currently coordinating a research program on that topic.

Maria holds a Bachelor’s degree in Foreign Languages and Literatures and a Masters Degree in International Relations and Strategic Military Studies, with a specialization in linking development with security.

Prior to joining IFAD, Maria worked as researcher and project officer for the Center for High Defense Studies (Italian Ministry of Defense) both in the “Didactic Department” and in the “Military Centre for Strategic Studies."
**Ms. Michelle Battat**

Michelle Battat is a Consultant for the Food and Agriculture Organization of the United Nations (FAO), as part of the FAO/World Bank Cooperative Program, specializing in food security and agricultural supply chains in the Middle East and North Africa. Prior to her work with FAO and the World Bank, Michelle worked as a Senior Business Analyst in the Global Business Policy Council (GBPC) of A.T. Kearney, a leading management consulting firm. At the GBPC she developed an expertise in country competitiveness in the services industry, consulting for both corporate and public clients. In addition, Michelle worked as an Associate Analyst at NERA Economic Consulting in their Antitrust practice area. Michelle graduated with a B.A. in both Economics and French from Brandeis University, and a M.A. in International Economics and Policy from the Johns Hopkins School of Advanced International Studies (SAIS).

**Dr. Mahmoud El Solh**

Dr. Mahmoud El Solh assumed the office of the Director General of ICARDA on 8 May 2006. He has been associated with international agricultural research and development in the dry areas since 1972 when he became a staff member of the Arid Land Agricultural Development (ALAD) Program of the Ford Foundation in the Near East, the predecessor of ICARDA.

Dr. El Solh returns to ICARDA after serving for four years as Director of Plant Production and Protection Division at the Food and Agriculture Organization of the United Nations (FAO) for four years. Prior to that he had served ICARDA with distinction for nearly 16 years in various capacities—as Lentil Breeder, Regional Food Legume Breeder in North Africa, Regional Coordinator of the Nile Valley and Red Sea Regional Program, and Assistant Director General for International Cooperation.

Dr. El Solh holds a PhD in Genetics from the University of California, Davis, USA, and has an impressive record of scientific publications. He has rich experience in donor relations and fund raising, and an in-depth knowledge of needs and aspirations of the national agricultural research and development systems in the Central and West Asia and North Africa (CWANA) region and beyond. Throughout his career his activities have focused on contributing to food security, alleviating poverty, and developing sustainable agricultural systems; planning, implementation, and evaluation of agricultural research for development; capacity building and human resource development in national agricultural systems; and promoting north-south and south-south cooperation. Mr. El Solh is the author of more than 120 publications/papers and articles including books and chapters of books. His contribution to agricultural research and development has been recognized through several prestigious awards from and honors as indicated below.
**Dr. Faisal Taha**

Dr. Taha has Ph.D. University of Wyoming, USA, Major: Plant Sciences—Minor: Natural Resources, a M.Sc. Montana State University, USA, Major: Agronomy—Minor: Ecology and a B.Sc. Utah State University, USA, Major: Range Management—Minor: Animal Production

Dr. Faisal Taha's employment history is summarized below:

2000—Present   Director, Technical Programs, International Center for Biosaline Agriculture (ICBA), Dubai, UAE
1997—2000     Advisor and Senior Scientist, Kuwait Institute for Scientific Research, Kuwait
1993—1997    Professor and Chairman, Plant Production Department, UAE University, AL-Ain, UAE
1991—1993  Program Manager, SSGA/Agric. Development Bank, Regina, Canada
1977—1990    Senior Scientist and Department Manager, Kuwait Institute for Scientific Research, Kuwait

**Dr. Abdullah Droubi**

Dr. Abdullah Droubi is Director of water resources studies department at the Arab Center for the Studies of Arid Zones and Dry Lands—ACSAD since 2002. Before becoming Director, he worked as an expert in the field of water resources management at the same department at ACSAD for more than 20 years. Dr. Droubi was involved in most of the projects and studies that ACSAD has implemented and conducted by ACSAD, since 1977, in the field of water resources assessment, evaluation and management in all the Arab countries. He was involved in several regional and international projects regarding climate change impacts Integrated water resources management. He has more than 100 scientific papers, reports and studies. He is holding a PhD in Water Geochemistry from University of Strasbourg, France.

**Mr. Mark Cackler**

Mr. Mark Cackler is Manager of the Agriculture and Rural Development Department of the World Bank. Mr. Cackler joined the World Bank in 1981, after working as an Overseas Representative for John Deere Intercontinental, Ltd., based in Thailand. Initial assignments in the World Bank’s Washington headquarters included working in agriculture and natural resources divisions for East Africa, China, Indonesia and the Pacific Islands. In 1988, he transferred to the Agriculture Unit of the World Bank's New Delhi Office. Following his return to headquarters from India in 1992, Mr. Cackler joined the Latin America and Caribbean Region. In 2000, he was appointed Manager of the Agriculture and Rural Development for Latin America. In February 2007, Mr. Cackler was appointed Manager of the Agriculture and Rural Development Department of the World Bank, where he oversees the World Bank’s global programs for rural poverty alleviation, agriculture and natural resources management.

Mr. Cackler was raised in Moline, Illinois. He has economics degrees from Oberlin College, Ohio, and the University of Jyvaskyla in Finland, and an MBA from Harvard Business School.
Dr. Atif Kubursi

Dr. Atif Kubursi is Emeritus Professor of economics and also teaches in the Arts and Science Program at McMaster University. Dr. Kubursi taught economics at Purdue University in Indiana, USA, and was senior academic visitor at Cambridge University, UK in 1974/75.

He also served as the Acting Executive Secretary, at the Undersecretary General level, of the United Nations Economic and Social Commission for Western Asia in 2006, 2007 and 2008, and as Senior Development Officer at UNIDO I Vienna. He is the recipient of the Canadian Centennial Medal. He is a fellow of the Economic Research Forum and obtained his Ph.D. in Economic from Purdue University and his B.A. from the American University of Beirut.

Dr. Imed Limam

Dr. Imed is a Tunisian national who holds a Ph.D. and M.A. in economics from the University of Southern California, USA. He is currently Senior Economist at the Arab Fund for Economic and Social Development (AFESD), Kuwait. He served previously as the Deputy Director General of the Arab Planning Institute in Kuwait and as Co-Editor of the Journal of Development and Economic Policies. He is a fellow of the Economic Research Forum and a member of several international professional associations. He has many publications in international and professional journals in the areas of economic modeling, macroeconomics, development policies and the economics of Arab countries.

Mr. Mustapha Rouis

Mustahpa Rouis is currently Lead Economist, Chief Economist Office, Middle East and North Africa Region, The World Bank. He holds several diplomas in economics from the Sorbonne and the ENSAE (École Nationale de la Statistique et de l'Administration Économique), Paris, France. He has been with the World Bank for many years and worked in different capacities on many regions, including East Asia, Africa, Europe and Central Asia, Latin America and the Caribbean, and the Middle East and North Africa. He served as Country Manager of the World Bank for Yemen and Tajikistan. He was the main author of several Bank publications covering different economic topics, including structural adjustment, exchange rate policy, fiscal policy and trade policy. His most recent publication is Arab Development Assistance: Four Decades of Cooperation (2010).