Food and Agriculture Organization of the United Nations

Regional Initiative on Water Scarcity

Towards a Regional Collaborative Strategy on Sustainable Agricultural Water Management and Food Security in the Near East and North Africa Region

Main Report

Second Edition, 2015

FAO RNE

Foreword

The Near East and North Africa (NENA) region is naturally exposed to chronic shortage of water and may be facing the most severe intensification of water scarcity in history. Per capita fresh water availability has decreased by two thirds over the last forty years and will probably decrease by another 50% by 2050. Some 15 countries in the NENA region fall below the deficiency level of 500 cubic meters per capita per annum of the renewable water resources – considered an 'absolute stress' – and almost all accessible water resources in the region have been already over committed.

Key factors driving this scarcity are known: demographic growth, urban expansion, energy demand and overall development, further exacerbated by the negative impact of climate change and the considerable degradation of water quality. Competition for water by various users (cities, agriculture, industry, environment, recreation, etc.) and the relevance of transboundary water resources in the Region (both as rivers and aquifers) are adding considerable strain to the pursuit of sustainable development. Agriculture, which consumes already more than 85% of available fresh water resources in the region, will be the sector suffering most, with possibly major consequences for food security and the rural economy.

To address these challenges, FAO has launched a *Regional Initiative on Water Scarcity in Near East and North Africa* to assist countries in identifying and streamlining policies, governance and best practices that can significantly sustainably improve agriculture productivity and food security in the region. The initiative is premised on the principle that in a so complex field as agricultural water management, and in the enormous diversity of situations across the NENA region, there is a strong advantage in seeking structured ways and means beyond the national level, to understand challenges and potentials, to learn from experiences, to innovate and scale up successful cases. In this context, a *Regional Collaborative Strategy* has been formulated.

The *Regional Collaborative Strategy* will complement and complete existing initiatives, will seek structured mechanisms to address water scarcity beyond the national level and will provide an agricultural water lens to the 'Arab Water Security Strategy' (2010-30).

More specifically, this *Regional Collaborative Strategy*, based on ample consultations with member countries and other organizations involved in agricultural water management in the region, puts forward an agenda for a comprehensive reform, including a number of options, and indicates innovative implementation modalities, including: evidence-based decision-making processes through benchmarking, monitoring, evaluation and reporting; sound governance and institutions, including decentralization of agriculture water management and empowerment of farmers and farmers groups as full partners, food producers and ultimate managers of soil and water resources; synergies in innovation and learning based on exchange of solutions amongst practitioners within and outside the Region; and an all-inclusive multi-stakeholder approach to changes. The Regional Collaborative Strategy will be implemented through regional and national action plans, supported by FAO and Partners.

The present report "Towards a Regional Collaborative Strategy on Sustainable Agricultural Water Management and Food Security in the Near East and North Africa" is a second edition presenting the elements of the Regional Collaborative Strategy that will be an ongoing and dynamic framework, in continuous consolidation and progress towards the sustainable intensification of agricultural production under water-scarce conditions.

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Principal Acronyms

ACSAD	Arab Center for the Study of the Arid Zones and Dry Lands
AMCW	Arab Ministerial Council for Water
AWM	Agricultural water management
BCM	Billion cubic metres
CGIAR	Consultative Group on International Agricultural Research
CIHEAM	International Centre for Advanced Mediterranean Agronomic Studies
CWP	Crop water productivity
DH	Moroccan Dirham
ENTRO	Eastern Nile Technical Regional Office
ET	Evapotranspiration
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GIS	Geographical Information Systems
ICARDA	International Center for Agricultural Research in the Dry Areas
ICBA	International Center for Biosaline Agriculture
INDH	National Initiative for Human Development
IWRM	Integrated water resources management
KSA	Kingdom of Saudi Arabia
LGP	Length of growing period
M&I	Municipal and industrial (water demand)
MCM	Million cubic metres
MASSCOTE	Mapping System and Services for Canal Operation Techniques
MDG	Millennium Development Goal
MOM	Management, operation and maintenance
NBI	Nile Basin Initiative
NENA	Near East and North Africa
O&M	Operation and maintenance
PES	Payments for environmental services
PPP	Public/private partnership
R&D	Research and development
UAE	United Arab Emirates
WUA	Water user association
WE	Water efficiency

Introduction

Main messages

Agricultural water management is critical to boosting agricultural productivity, improving food security and sustaining water resources in the Near East and North Africa (NENA) region. The Food and Agriculture Organization of the United Nation's (FAO) Regional Initiative on Water Scarcity in the NENA region proposes a regional collaborative strategy on agricultural water management and a regional partnership which will work closely with the Arab Strategy for Water Security and other regional or sub-regional strategies

.The current document – "Towards a Regional Collaborative Strategy on Sustainable Agricultural Water Management and Food Security in the Near East and North Africa" - comprises a stocktaking and assessment, and proposals for improvements in agricultural water management in the region which could be adopted by NENA countries and institutions and supported by FAO and other regional and international partners.

Activities and interventions in this report have yet to be filtered in terms of potential and unintended consequences that may arise in different biophysical and societal contexts. This will take place as the Regional Strategy will further develop.

FAO's Regional Initiative on Water Scarcity in the Near East and North Africa

NENA region faces the challenges of addressing a wide range of complex and intertwined issues associated with the management of natural resources, particularly land and water. To address these challenges, FAO has launched a Regional Initiative on Water Scarcity in NENA.

The overall goal of the Initiative is to support member countries in identifying and streamlining policies and best practices in agricultural water management which can contribute to boosting agricultural productivity, improving food security and sustaining water resources. The Initiative will identify critical areas that require action, assist in the formulation of a regional collaborative strategy and build broad partnerships to support its implementation.

Drawing on FAO's publication: "Coping with water scarcity: An action framework for agriculture and food security", the Initiative will bring new impetus to the process of finding sustainable solutions to water scarcity and food security problems through promoting the implementation of cost-effective water investments, advanced technology and management practices. The Initiative will enhance cooperation among member countries and between countries and international and regional partners.

The Initiative will have two major initial outputs: (i) a regional collaborative strategy on sustainable agricultural water management (the 'Regional Collaborative Strategy'); and (ii) a regional partnership to support countries in the implementation of the Regional Collaborative Strategy.

The Regional Collaborative Strategy

The Regional Collaborative Strategy presented in this document is designed to focus on policies, investments, approaches and practices that are necessary to ensure sustainable intensification of agricultural production under water-scarce conditions. In addition to classic conceptual and empirical approaches, the Strategy utilizes innovative assessment methodologies in the accounting of the availability and use of freshwater resources: (1) a rapid ***water accounting*** that reviews the current status of water availability and use and the potential for further agricultural production; (2) a ***food supply cost curve***, a simple but powerful method for identifying and ranking options for future food supply in terms of their cost; and (3) a

gap analysis that reviews experiences in policies and institutional environments and captures knowledge of agricultural water management in the region.[1] In addition, the Strategy is based on ample consultations with countries and other organizations involved in agriculture water management in the region in order to capture their experiences and build a partnership for the Initiative. A summary of the findings and recommendations of the Regional Collaborative Strategy was presented to the 32nd FAO Regional Conference for the Near East in February 2014 and endorsed by the Conference. [FAO 2013a:1]

The approach of the Collaborative Strategy is in two sequential steps. The first step examines the question: "*Where, as a region, does NENA stand today in terms of efficiency and sustainability of agricultural water management and what is the scope for further improving efficiency and sustainability through improved policies, investments, approaches and practices*?"

This step, which is covered by the first three chapters of this report, takes account of two significant features of the region in respect of agricultural water management: the diversity of NENA countries, so that a wide range of situations is examined; and the fact that NENA countries are generally relatively advanced in agricultural water management compared to other regions, which makes the assessment of further potential an exacting task. In this first step, the report conducts a stocktaking organized according to major systems of agricultural water management, makes intercountry and global comparisons, evaluates and benchmarks performance and highlights pointers for further development.

The second step answers the question: "*Where might NENA countries go from here in improving the efficiency and sustainability of their agricultural water management, and how can country choices be backed up and supported at the regional level*?" This step, which is covered in the final two chapters of the report, examines options, constraints and trade-offs, recommends guiding pathways for action and proposes a programme of work in support of country decisions.

Integration with the Arab Strategy for Water Security

In 2009, the Arab Economic Summit in Kuwait requested the Arab Ministerial Council for Water (AMCW) to develop a water security strategy to meet the challenges and future needs for development. The Arab Center for the Study of the Arid Zones and Dry Lands (ACSAD) worked with the Technical Secretariat of the AMCW to prepare a draft strategy in coordination with member states and regional and international organizations. The resulting Arab Strategy for Water Security was adopted by a special session of the AMCW on 15-16 June 2011 and was approved as a guidance document by the Arab Summit in Baghdad on 29 March 2012.

The Arab Strategy for Water Security aims at three objectives: (1) improving water services for drinking, agriculture and sanitation; (2) protecting shared water rights, promoting cooperation on shared water and supporting implementation of Millennium Development Goal (MDG) commitments on water; and (3) institutional development and capacity building, research, awareness and participation.

Subsequently, the AMCW, working once again with ACSAD, has prepared a selective action plan for the first five-year phase of implementation of the Arab Strategy for Water Security.

The main axes of the action plan are:

1. Updated information on water
2. Improved implementation of integrated water resources management (IWRM)
3. Strengthened scientific research and technology transfer
4. Improved sanitation and fresh water
5. Enhanced capacity for climate change assessment and adaptation
6. Mechanisms for protection of rights in shared watercourses

The main aspects of the Arab Strategy for Water Security and its action plan which affect agricultural water management are:

- IWRM, particularly: (i) issues of water resource allocation amongst sectors; (ii) institutional development and human capacity building; (iii) decentralization and participation (a key theme in irrigation management); (iv) water efficiency; and (v) the use of nonconventional water.
- Scientific research and technology transfer, a key area for agricultural water management.
- Climate change assessment and adaptation, particularly: (i) assessment of impacts and vulnerabilities; (ii) preparation of adaptation measures; and (iii) assessment of climate proofing and climate monitoring options.

Key contributions of the Regional Collaborative Strategy will be to provide an agricultural water lens to the Arab Strategy for Water Security, to work out the complementarities between the Arab Strategy for Water Security and the more specific agricultural water priorities of the Collaborative Strategy and to identify axes of work where the Collaborative Strategy can complement the Arab Strategy for Water Security and dovetail into it.

1 Teams from countries in the region have worked to apply these methodologies. Three country reports have so far been drafted (Tunisia, Morocco and Oman) and the preliminary findings have been incorporated in this Strategy.

Background on the NENA region and agricultural water

Main messages

NENA is a very diverse region with some of the richest and some of the poorest countries in the world. Rapid urbanization is changing demand for water and food. Nearly half the population lives in rural areas, where 40 percent of the people are poor. Agriculture remains an important sector.

Awareness of issues in past water management has grown, and considerable changes have been made. Identification of options for next steps is the object of this report.

This section provides a summary background on the NENA region and agricultural water. It looks at economic characteristics of NENA countries, including key facts on Gross Domestic Project (GDP), at demographics and their relation to water and at questions of poverty and malnutrition. A final part looks specifically at commonalities and variations in water and agricultural water in NENA which affect policy and management.

Economic characteristics of NENA countries

The NENA region comprises 14 low- and middle-income countries, and several states in the Arabian Peninsula which are amongst the wealthiest in the world, thanks to their hydrocarbon resources (Table 1). Of NENA's ten largest economies, only Egypt and Morocco are not substantial oil exporters. There is a wide range in the wealth of NENA nations, with some extremely poor countries (three of the poorest in the world) and some extremely rich ones (including the richest country in the world). [World Bank 2013]

Table 1: Key facts on GDP of NENA countries

Total GDP	GDP annual growth	GDP per capita
Countries with annual GDP: • >USD 200 billion annually: Kingdom of Saudi Arabia (KSA), Iran, United Arab Emirates (UAE) (all oil) • > USD 100 billion annually: Egypt, Algeria (oil), Qatar (oil) • > USD 50 billion annually: Kuwait (oil), Morocco, Iraq (oil), Libya (oil)	Countries with GDP growth averaging: • > 5% annually: Qatar, Iraq, Kuwait, KSA, Palestine, Oman	NENA average: USD 9 600 Range from USD 800 to 55 000 annually Countries with GDP per capita: • < USD 1 000: Sudan, Mauritania, Yemen • USD 1 000-5 000: Algeria, Egypt, Iran, Iraq, Jordan, Morocco, Syria, Tunisia • USD 5 000-15 000: Bahrain, Oman • > USD 15 000: Kuwait, Qatar, UAE, KSA

Source: AQUASTAT; FAO

Population and urban/rural balance

Demographically the fast growth of cites and industries is creating ever-increasing demand for municipal and industrial water supplies

The total population of the region is about 400 million people (Table 2). Two NENA countries are populous (over 50 million inhabitants) and eight are medium-sized countries (over 10 million inhabitants). NENA is relatively urbanized compared to other regions (70 percent of the population region-wide live in towns), with only four countries more than 50 percent rural. These generally quite dense urbanized populations are concentrated in areas where water is available. The pace of urbanization is rapid and this is contributing to fast-rising demand for water supply and sanitation, and for food and agricultural products – increasingly for more water-intensive products like meat and dairy. [World Bank 2013; FAO 2001]

Table 2: Key facts on demographics of NENA countries

Total population	Rural-urban population balance
> 50 million: Egypt, Iran 20-50 million: Algeria, Sudan, Iraq, Morocco, KSA, Yemen, Syria 10-20 million: Tunisia	NENA average urban: 70% Fast urbanizing: average 3.3% yearly Current urbanization: • > 80% urban: Kuwait, Qatar, Bahrain, Lebanon, KSA, UAE • 70-80% urban: Iran, Jordan, Libya, WBG, Oman • < 50% urban: Egypt, Mauritania, Sudan, Yemen

Source: AQUASTAT; FAO

However, rural areas and agriculture remain very important in most NENA countries, and 38 percent of the region's households are still engaged in farming

Despite the pace of urbanization, there are still about 170 million rural people in the region. Of the total economically active population of 126 million, 48 million (38 percent) are engaged in agriculture, ranging from under 5 percent in Lebanon and the Gulf States to over 50 percent in Sudan. Rural population growth rates – 1.6 percent a year 1990-2004 – are high, and the rural population is expected to continue growing at over 1 percent annually through to 2030. [FAO 2001: 83, IFAD/FAO 2007: 70, FAO 2010a]

Rural poverty and malnutrition

Poverty in rural areas is widespread and this translates into food insecurity and malnutrition

Today, a quarter of the region's population is counted as poor, and rural poverty is deep and widespread. Overall, 34 percent of the region's rural population are poor, ranging from 8 percent in Tunisia to over 80 percent in Sudan (Table 3). Rural unemployment is high, averaging about 13 percent, with higher rates for women than men, and much higher rates for youth – 26-53 percent depending on the country. [FAO 2001: 84, IFAD 2010, FAO/IFAD 2007: 67, 73]

Table 3: Key facts on poverty and malnourishment in NENA countries

Rural poverty headcount	Prevalence of under-nourishment	Rural potable water access
Average 34% Countries with: • > 50%: Yemen, Sudan, Mauritania • 30-50%: Iraq, Egypt	Countries with more than 25% undernourished: • Iraq, Palestine, Sudan, Yemen	Countries with < 50% of the rural population with access to safe drinking water: • Sudan, Yemen, Mauritania

Source: AQUASTAT; FAO

Poverty affects certain parts especially in the poorest nations of the region and hurts high-risk categories like women-headed households and the landless

Rural poverty is particularly acute in certain parts of the region and under certain specific conditions, and is chronic largely for specific countries and vulnerable segments. In the poorest nations of the region – Yemen, Sudan, Mauritania – rural poverty is chronic and widespread. Elsewhere, rural poverty mainly affects three high-risk categories: households headed by women, the landless and farm labourers. [World Bank 2013]

Recent data show widespread household food insecurity and undernourishment, concentrated in the poorest countries

Over one-fifth of the region's under-five population are stunted. Across the region, rural children are almost twice as likely to be underweight as urban children. Populations are vulnerable, especially in the poorer states, mainly Sudan and Yemen. In Yemen, one of the ten most food insecure countries in the world, about 46 percent of the population (some 10.5 million people) did not have enough food in 2012, and almost half of all households (45 percent) are now purchasing food on credit. [FAO/IFAD 2007: 66, IFAD 2010a; World Bank 2013: 2B; www.ipcinfo.org]

Water and agricultural water in NENA: An overview of commonalities and variations

The NENA region is quite varied, both between countries and within countries, in characteristics of agricultural water and in the ways that water is managed. There are some common features and some significant differences:

- NENA is by and large a very water-short region, and there are significant challenges to the use of water in agriculture stemming from rising demand from other sectors and from depletion of nonrenewable resources.
- Nonetheless, four countries have access to very significant water resources that flow largely from outside their boundaries – Egypt, Sudan, Iraq and Syria. Iran has significant internal resources.
- All NENA countries have embraced the spirit of integrated water resources management to varying degrees. Legal and institutional challenges vary by country, and results for agricultural water management have been mixed.
- Groundwater has become a significant source of agricultural water across the region, and it has been the basis for the rapid growth of new agricultural economies in the Arabian Peninsula. Every country is experiencing the challenge of groundwater depletion.
- There is generally a high level of development of water resources and relatively high levels of performance in agricultural water management. However, very large differences exist in irrigation efficiency and in crop water productivity, and all countries face, in varying degrees, challenges of efficiency and sustainability, and are seeking ways to further raise incomes and employment and to reduce poverty.
- Agriculture remains important in almost all countries of the region, and much of that agriculture has become market-oriented. However, rainfed farming systems still predominate in many countries, and rainfed farmers face particular challenges of low productivity and unpredictable rainfall, which are growing as climates change.

One factor at the political and institutional level is shared across the region. Popular and political awareness of the importance of correct choices in agricultural water management has been raised sharply in recent years, particularly as a result of the 'Arab Spring', and this has opened up criticism of past approaches and a search for new initiatives. This increase in awareness and participation underpins the approach of this Collaborative Strategy.

Chapter 1

The challenge of water and agriculture in NENA and the drivers of water scarcity

Main messages

The NENA region is characterized by high levels of water scarcity – it is the most water-scarce region in the world – and by a high level of dependence on resources flowing from outside the region. As a very arid region, NENA has developed a higher share of its water resources than any other region of the world. As a result, water resources are fully or even over-allocated throughout the Region.

Current challenges stem from the fact that there is little scope for further supply development, yet demand is rising fast due to population pressure and the demand for more water for all uses. In particular, fast growing cities and rising living standards create pressure for more water for municipal and industrial uses, but also create demand for water for agriculture as food demand rises and farmers expect a better living. In recent years, water demand for environmental services has become pressing, whilst throughout the region the resource is increasingly threatened by climate change.

These challenges set a tough agenda for water in agriculture for the coming years: (i) water resources management that promotes efficiency throughout the sector, including the whole food chain; (ii) increases in crop water productivity that can produce more output and provide more income for less water in agriculture; (iii) institutional arrangements and land and water management policies and practices that incentivize sustainable and productive water use; and (iv) heeding the voice of the environment.

This chapter reviews the challenge of water and agriculture in NENA, and summarizes the drivers of water scarcity in agriculture. The chapter looks first at the resource base, at water resources and current uses (1.1). It then assesses the status and trends in agriculture, agriculture's contribution to food security and the likely impacts of climate change on NENA's farming systems (1.2-1.6). A discussion of the extent and role of irrigation in agriculture follows (1.7) and the chapter concludes by summarizing the drivers of water scarcity for agriculture on both the supply and demand side (1.8).

1.1 Water resources and uses

NENA is a very water-scarce region

With 6 percent of world's population but only 0.6 percent of the world's accessible renewable water, NENA has the lowest renewable water resources per capita of any region in the world. Worldwide, water resources average 6 400 m^3 per capita, whereas the NENA average is currently only one-tenth of that level (688 m^3), and most NENA countries have significantly less than that (see Table 1.1). Only five NENA countries are not classified as 'water scarce' (with less than 1 000 m^3 per capita), and six countries are extremely water scarce (less than 100 m^3 per capita). Current levels are just one-third of those 50 years ago: with rapid population growth, resources per capita have plummeted from 3 500 m^3 to current levels of 688 m^3. [ACSAD 2013: 6]

Table 1.1: Key facts on water resources in NENA countries

Total renewable water resources per capita
In NENA, renewable water resources per capita are: • 5 countries > 1 000 m3: Iran, Iraq, Lebanon, Mauritania, Sudan • 2 countries 500-1 000 m^3: Egypt, Morocco • 7 countries 100-500 m^3: Algeria, Jordan, Libya, Palestine, Oman, Syria, Tunisia • 6 countries < 100 m^3: Bahrain, Kuwait, Qatar, KSA, UAE, Yemen

Source: AQUASTAT; Annex Table 1

The implications of water scarcity vary by country within the region

Of NENA water-scarce countries, five are oil-exporting states where water is essential only for municipal and industrial use and where desalination allows the substitution of oil for water. Other countries are middle-income states where agriculture remains important and water dependency is therefore correspondingly higher. The poorest countries of the region – Sudan, Mauritania and Yemen – are highly water dependent, with large agriculture sectors. In Yemen agriculture uses 95 percent of available water (Table 1.3).

NENA countries have developed a higher proportion of their available resources than any other region in the world

Over five millennia, NENA countries have progressively developed available water resources for use. The process accelerated greatly in the second half of the twentieth century, with massive public investment in storage, irrigation and water supply. Today, NENA withdraws almost 80 percent of its available water: this compares to less than 30 percent for the next region –South Asia – and to a worldwide average of around 10 percent.

One reflection of water scarcity is that NENA also has the highest level of water storage in the world

In view of the scarcity of water and the seasonality of flows, and also the high proportion of water which would otherwise flow unused to the sea, a number of countries have built significant interseasonal and long-term storage capacity (Table 1.2). In some countries, the scope for further storage is little, except for small hill dams and water harvesting. However, storage could probably be increased in some countries where water still runs to seas or sinks – Lebanon is one example.

Table 1.2: Key facts on water storage in NENA countries

Total dam capacity		
In NENA, seven countries have more than 1 billion m3 dam capacity:		
1.	Egypt:	168.2 billion m^3
2.	Iraq:	151.6 billion m^3
3.	Iran:	31.6 billion m^3
4.	Syria:	19.7 billion m^3
5.	Morocco:	16.9 billion m^3
6.	Algeria:	5.7 billion m^3
7.	Tunisia:	2.5 billion m^3

The source of water varies greatly by country, and consequently countries face particular challenges in water resource management

In a group of arid countries which nonetheless enjoy some rainfall, the sources of water are predominantly rainwater, storage and diversion from internal rivers, and groundwater: Morocco, Lebanon, Tunisia, and Algeria. These countries face the particular challenge of climate change.

In a group of countries where there is little rainfall but where large rivers flow in from outside the national territory, the main source of water is transboundary water stored and diverted within national territory: e.g. Iraq, Egypt and Syria. Jordan benefits from the Yarmouk River which is fed from both Syrian and Jordanian territory. These countries face the particular challenge of dependence on upstream riparians for the water resource.

For hyperarid countries where there is little or no rainfall, the predominant source of water is groundwater, often nonrenewable: the states of the Arabian Peninsula, plus Libya and Palestine. These countries face the particular challenge of depletion of nonrenewable water resources.

Water scarcity is increasing in the region

With population growth and changes in the pattern of demand that attend urbanization and industrialization, water scarcity is growing, and with it pressure for reallocation of water from lower value uses like agriculture to higher-value uses. The population is expected to grow from the present 395 million to around 500 million by 2025, and average resources per capita are expected to shrink by one-third. Of this drop, about four-fifths is attributed to increased population, and the balance to reduction of supply through climate change impacts. [FAO 2013b: 2, 7]

Water uses by sector

All NENA countries use most of their water for agriculture (Table 1.3). Six major countries use more than 90 percent of their abstractions for agriculture, and a further six use more than 80 percent. Only two countries use less than two-thirds of the water they withdraw in agriculture.

Table 1.3: Shares of water by sector for selected NENA countries

Country	BCM withdrawn for agriculture	Percentage withdrawn by sector		
		Agriculture	Domestic	Industry
More than 90% of withdrawals used in agriculture				
Yemen	6	95	4	1
Syria	19	95	3	2
Iraq	39	92	3	5
Iran	66	91	7	2
Oman	1	90	8	2
More than 80% of withdrawals used in agriculture				
Morocco	11	87	10	3
Egypt	59	86	8	6
Saudi Arabia	17	86	10	3
Libya	3	83	14	3
Tunisia	2	82	14	4
Less than 80% of withdrawals used in agriculture				
Jordan	1	75	21	4
Lebanon	1	67	33	1
Algeria	4	65	22	13

Source: AQUASTAT; World Bank 2007a: 148

1.2 Climate and farming systems

Climate

Most of the NENA region is arid to hyper-arid, with agriculture possible only under irrigation

The dry areas in NENA countries – those with rainfall under 300 mm a year – account for 90 percent of the land (Table 1.4). In these areas, agriculture can only be practiced with various forms of irrigation, including water harvesting. The main land use is pastoral. These areas contain less than 30 percent of the agricultural population.

Table 1.4: Key facts on precipitation and aridity in NENA countries

Precipitation	Aridity and length of growing period (LGP)
Region-wide average precipitation:183 mm Countries with: • more than 300 mm: Lebanon, Morocco, Palestine, Sudan • less than 100 mm: Algeria, Bahrain, Egypt, Libya, Mauritania, Qatar, KSA, UAE	Share of NENA land area that is classed as: • desert (LGP 0): 5% • arid (LGP < 60 days): 73% • dry semi-arid (LGP 60-119 days): 9% • moist semi-arid (LGP 120-179 days): 7% • sub-humid (LGP 180-269 days): 5%

Source: AQUASTAT

The temperate, higher rainfall areas have a Mediterranean climate, typically long dry summers and mild wet winters.

Only in restricted parts of some countries is rainfall enough to grow crops without irrigation. These areas account for under 10 percent of the land area but nearly half of the agricultural population.

In addition to low rainfall, the region is also characterized by high variability of rainfall

All NENA countries experience the unusual and problematic combination of low precipitation and high variability, which not only increases the need for irrigation to bridge dry spells but also makes more uncertain the availability of springs, stream flow and shallow groundwater which are directly recharged by current rainfall.

Farming systems

Farming systems are diverse, varying by geography, climate and natural resource endowments

There are multiple farming systems in the region, their character determined in the large part by the availability and reliability of water sources (Table 1.5). In the higher rainfall areas covering less than 10 percent of the land area, combined cropping and livestock systems support almost half (48 percent) of the agricultural population. Large-scale irrigated areas cover less than 2 percent of the land area, but account for 17 percent of the agricultural population [FAO 2001: 83-4, 87-91].

Table 1.5: Principal farming systems of the NENA region

Farming system	% of the region's		Main livelihoods	Prevalence of poverty
	land area	agricultural population		
Irrigated	2	17	Fruit, vegetables, cash crops	Moderate
Highland mixed	7	30	Cereals, legumes, sheep, off-farm	Extensive
Rainfed mixed	2	18	Tree crops, cereals, legumes, off-farm	Moderate
Dryland mixed	4	14	Cereals, sheep, off-farm work	Extensive
Pastoral	23	9	Camels, sheep, off-farm work	Extensive
Agro-pastoral: millet/sorghum	-	-	Cereals, pulses, livestock	Extensive
Cereals/root crop mixed	-	-	Cereals, root crops, cattle	Limited
Arid zones	62	5	Camels, sheep, off-farm work	Limited

Source FAO 2001; World Bank 2013

In rainfed agriculture, lower value cereals predominate, with yields below world averages

As precipitation falls over most of the Maghreb and Mashreq region in winter, rainfed crops are grown in the winter months, maturing for harvest generally in spring and early summer. The main rainfed crops are wheat, barley, legumes, olives, grapes, and fruits and vegetables. Grain production accounts for two-thirds of the cultivated area (against a world average of 46 percent). Yields for rainfed crops vary widely, depending on the farming system, but are generally below world averages.

By contrast, yields under irrigation are relatively high by global standards

Irrigated areas are cultivated all year round, with peak demand for irrigation water during the dry summer months. Under irrigation, yields can be very good, with yields of irrigated wheat in Egypt, for example, averaging 6.5 tonne/ha.

A wide range of higher-value crops is grown

Fresh fruit and vegetable production accounts for about 10 percent of the cropped area region-wide, but for a much higher share in countries practicing intensive irrigated agriculture (Egypt 20 percent, Jordan 28 percent, Lebanon 37 percent) – and very much less in the largely subsistence agricultural economies of Sudan (1 percent) and Somalia (1 percent). [FAO/IFAD 2007: 47, 49]

Livestock are integrated in all farming systems

Livestock are integrated in all farming systems, providing important synergies and complementarities between and within systems – from extensive pastoralism to feedlots in peri-urban agriculture.

1.3 The contribution of agriculture

Agriculture is a vital economic and social sector in the region

Agriculture's contribution is through: (i) contribution to economic growth and export earnings; (ii) provision of jobs and incomes for 38 percent of the region's economically active population; (iii) poverty reduction and the assurance of household and local level food security; and (iv) contribution to domestic food supply and reducing import dependence [FAO 2013b: 2, 3].

…. and contributes significantly to regional GDP and exports …. and to per capita incomes

Region-wide, agriculture accounts for USD 95 billion of value-added annually, with agriculture adding more than USD 20 billion annually to GDP in Iran, and more than USD 10 billion annually in Egypt and Morocco. Food exports (USD 20 billion annually, 4 percent of total merchandise exports – and more than 10 percent in Jordan and Egypt) make a considerable contribution to the economy of many NENA countries. Agricultural GDP per head of the agricultural population averages about USD 720, ranging from USD 133 in Yemen to USD 1 000 in Tunisia [FAO 2001: 87, FAO/IFAD 2007:72; World Bank 2013: 2].

Agriculture's <u>share</u> of the region's fast expanding economies has been declining, but the sector is still growing in absolute terms

With modernization and urbanization, the share of agriculture in regional GDP has dwindled. Nonetheless, the sector remains key to primary production and is the mainstay of the rural economy. Overall, agriculture contributes 13 percent to regional GDP, and considerably more in some countries, ranging from 2 percent in Jordan to more than 20 percent of the total in Sudan and Syria (Table 1.6).

Table 1.6: Key facts on agricultural contribution to GDP in USD and percent share

Agricultural value added in USD	Agricultural value added as a % of GDP
Agriculture contribution to GDP in USD: • > USD 20 billion annually: Iran • > USD 10 billion annually: Egypt, Morocco, KSA • > USD 2 billion annually: Sudan, Algeria, Syria, Tunisia, Yemen	Agriculture share in GDP: • > 20%: Sudan, Syria • > 10%: Egypt, Iran, Mauritania, Morocco • > 5%: Algeria, Iraq. Tunisia, Yemen

Source: AQUASTAT

1.4 Food security and agricultural water management

Food production and consumption in NENA

No NENA country approaches self-sufficiency in cereals, and most NENA countries import a large share of their food needs

Only four countries – Egypt, Iran, Morocco and Sudan – cover two-thirds of their cereal needs from domestic production (Table 1.7). Six NENA states cover less than 20 percent of their cereals consumption. The two poorest of these countries (Mauritania and Yemen) are vulnerable to national-level food insecurity (see below). Food imports average 13 percent of total merchandise imports, and for two of the poorest countries (Sudan and Yemen) the share of food in merchandise imports exceeds 20 percent. These two poor countries are spending large sums of foreign exchange on importing food [World Bank 2013: 3].

Table 1.7: Key facts on cereals self-sufficiency and food import dependence

Cereals self-sufficiency	Food imports as a share of merchandise imports
NENA countries with rates of cereals self-sufficiency of: • > 70%: NONE • 60-70%: Egypt, Iran, Morocco, Sudan • 40-60%: Algeria, Syria, Tunisia • < 20%: Lebanon, Libya, Mauritania, Palestine, KSA, Yemen	NENA food imports as % of total merchandise imports: • Average 13% • More than 20%: Algeria, Libya, Sudan, Yemen

Source: AQUASTAT

Food security and insecurity

Food security concerns have been a perennial preoccupation in NENA countries

Age-old preoccupations with food security have been redoubled by changes in recent years and have driven policy makers to question whether reliance on markets is sufficient to ensure access to stable affordable food supplies for their peoples [World Bank 2013: 19-20].

At the global level, recent years have seen higher prices and price volatility but long-term forecasts are that food prices will stabilize at lower than current levels

Prices rises and volatility might be exacerbated in the coming years due to climate change, but this is far from certain, as production responses from temperate countries with spare production capacity such as Russia and Ukraine may compensate for expected declines in cereals production in hotter regions. World Bank commodity price forecasts are that food prices will stabilize at lower than current levels into the medium term.

At the national level, any global food price rises or volatility would affect all Arab countries, due to their dependence on imported food, particularly the oil-importing states

As all NENA countries are net food importers, rises or volatility in global food prices would affect them all, but in particular the oil-importing countries, because food and oil prices tend to rise in parallel. Macro-economic impacts would be on the balance of payments, budget deficits and inflation. By contrast, oil exporting countries would be protected by the same parallel movements in prices [McDonnell and Ismail 2011].

At the household level, global best practice on food security seeks to ensure that all households enjoy adequate nutritional status at all times

The primary mechanisms for achieving household level food security are that food markets should make adequate supply available at affordable prices, and that all households should have the means and the knowledge to acquire and consume a balanced and calorie-sufficient diet [IFPRI 2010].

In most NENA countries, both sides of this equation have worked fairly well ….

According to the Global Hunger Index, the region has amongst the world's lowest proportion of undernourished people, the lowest prevalence of underweight children and the lowest under-five mortality rate of any non-Organization for Economic Co-operation and Development (OECD) set of countries, and has registered significant improvements in recent decades. However, poverty and undernourishment are rising again in many countries of the region, attributed to rising food prices and global recession. The International Food Policy Research Institute (IFPRI) have projected that a combination of policies is likely to sustain a continuing drop in rates of malnourishment in children in the region, but that if global food prices continue to rise; this may depress demand amongst the poor and contribute to a return to higher rates of malnutrition [IFPRI 2010].

…. but the picture is not uniform across the region, particularly in rural and remote areas and in the poorest countries

Nutrition status is worse in rural areas and far worse in the very poor countries. In some poorer countries and remote or very poor parts of middle-income countries, markets are often imperfect and households lack the income or information needed to maintain adequate diets. The poorest countries are particularly at risk. The high rate of chronic malnutrition and stunting in Yemen is a witness to this problem. Most at risk are rural nonfarm households which spend a higher share of their income on food, making them more vulnerable to price surges. The periodic catastrophic famines in Sudan bear testament to the more general systemic food security risk of poor countries dependent on a fragile natural resource base, poorly developed markets and institutional environments which hinder both development and relief operations. In addition to these structural problems, the shocks of 2008 have provoked a reflection on whether there are better ways to organize food markets.

Recent policy analysis has found links between agricultural production and food security….

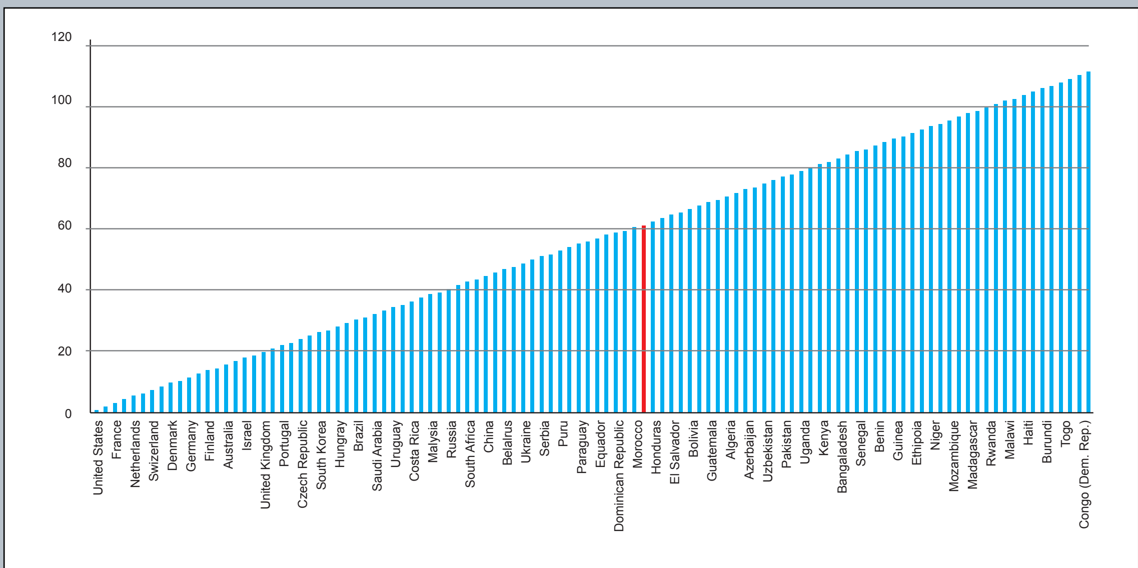
Best practice links food security and insecurity to four factors: availability of food, economic and physical access to food, the ways in which food is used and the stability of these factors over time. The impact of these factors on the food security status of populations varies considerably – see, for example, Box 1.1 concerning the factors which particularly weighed in Morocco. Note that it is not food production but agricultural production as a whole which is a factor contributing to Morocco's food insecurity.

Box 1.1: Factors in food insecurity in Morocco

Morocco ranks 59th out of 107 countries in the Global Food Safety Initiative (GFSI) 2013 index. The main factors contributing to Morocco's relative food insecurity are:

- Volatility of levels of agricultural production
- Low purchasing power
- Low levels of investment in agricultural research

GFSI Global Rankings on Food Security (2013)



Source: FAO 2014a: Regional Initiative on Water Scarcity - Morocco Country Paper: 14

…. but studies have found scant relation between national food security and the level of self-sufficiency in food production

Empirical studies have tried to establish the nature of the relationships between national food security and the level of self-sufficiency in food production. In fact, these studies show the counter-intuitive result that policies which tilt the incentive structure in favour of domestic food production may bring economic losses to the nation and may even increase food insecurity of producing households by reducing their potential incomes. Table 1.8 below shows three categories of NENA countries, together with their main food security vulnerability.

Table 1.8: Food security vulnerability in NENA countries

Country characteristics	Examples	Main food security vulnerability
Poorer countries with vulnerable populations dependent on farming	Mauritania Sudan Yemen	Rural malnutrition and famine
Middle income countries that want moderate food prices for their citizens and to maintain a viable rural sector	Maghreb and Mashreq countries Iran	Price spikes Difficult access and affordability for poorer rural areas and households
Better-off countries requiring assurance of food supplies	Oil-exporting countries of the Arabian Peninsula	Geopolitical risk

1.5 Recent trends: An agriculture already under stress

Land and water use in agriculture

As water is the binding constraint and resources are already over-allocated, improving productivity is the principal path to agricultural growth

Cultivable land is abundant across the region. There are some restrictions on land use due to soil suitability, but everywhere it is water not land that is really the binding constraint. Due to NENA's arid conditions, irrigation has for millennia been the principal path to intensification. As a result, irrigation has become far and away the largest water user, but now water is already fully allocated – or even over-allocated. Hence, further expansion of production is likely to come largely from productivity gains, especially gains in water efficiency in both rainfed and irrigated systems rather than from new diversions [FAO 2001].

In general, pressure on water resources and the environment is expected to grow as populations continue to expand

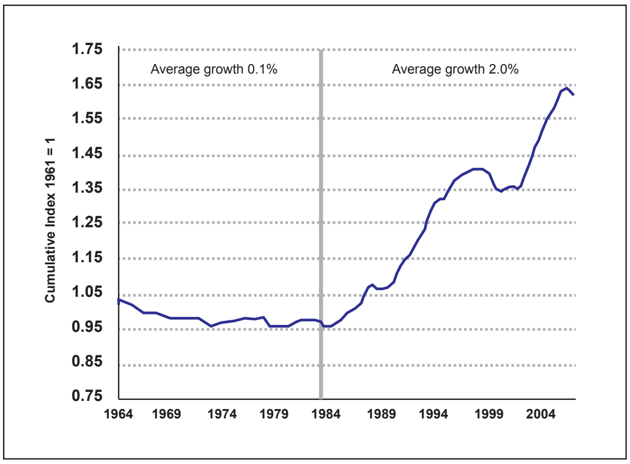
As population grows and agriculture intensifies, pressures on natural resources increase. Water resources, particularly groundwater, are being overused. In-stream environmental flows have diminished. Rangelands too have come under considerable stress. Growth in demand for fresh meat, linked to income growth, has been met by swelling livestock populations, often supported by feed subsidies on imported grains. As a result, livestock populations are today well beyond the carrying capacity of the rangelands. Older systems of rangeland management have not adapted. [FAO 2001: 91]

Productivity, technology and innovation

The last 25 years have witnessed a strong average growth rate of 2 percent per annum in agricultural value added, attributable to more intensive irrigation systems and to an increase in production of higher-value crops

After two decades of little or no growth in agricultural productivity (1964-1984), the subsequent two decades (1984-2004) witnessed a strong average growth rate of 2 percent per annum. Total factor productivity levels in 2004 stood two-thirds above the levels of 1964 (see Figure 1.1). In many countries the agriculture sector is still growing in absolute terms. In six countries of the region (Iran, Jordan, Kuwait, Morocco, Tunisia and Syria), agricultural growth averaged more than 4 percent per annum growth over two decades (1990-2011). High growth rates have occurred predominantly in countries using modern irrigation and moving to high-value exports (regionally and to the EU). Although the causes are complex and vary by country, IFPRI attribute this strong growth to more intensive irrigation systems and to an increase in production of higher-value crops following the start of liberalization in the 1980s.

Figure 1.1: Cumulative agricultural total factor productivity growth MENA (index 1961 = 1)



Source: IFPRI 2010

Growth has been in both high-value products and in food production – but not all countries have shared in this

In recent years, cereal production has accelerated, with improvement in the local, regional, and international terms of trade, and livestock production has also expanded fast. This growth is not, however, shared all across the region. In some countries, productivity improvements have virtually ceased, as access to improved technologies and support services has dwindled (for example, in Yemen, Somalia and Sudan). Research has made a substantial contribution, but has not focused adequately on vulnerable production systems or on more efficient use of water [IFPRI 2010].

Market orientation

Agriculture in the NENA countries has become predominantly market-oriented and commercialized, responding to fast-growing demand from urban and export markets for higher-value products

In the Mediterranean countries, market linkages with demand from Europe and formal trade arrangements with the EU have provided profitable market outlets for fresh fruit and vegetables. Many households have diversified into related off-farm business lines such as catering, tourism, etc.

Policies, institutions and public goods

Investment and the policy environment have favored agriculture in recent years, but some policies have introduced structural distortions:

Many countries across the region have made considerable investment in irrigation, rural infrastructure and farmer services such as research and extension. Agriculture has responded with the rapid growth rates noted above. However, some components of past public policy introduced structural distortions in the sector which reduced its resilience and sustainability, and some of these distortions persist. These policies and distortions included notably:

- Past water policies over-allocated water to agriculture. Now water is becoming more valuable for other purposes, but mechanisms for reallocating water between sectors can be frail. At the same time, lack of demand management through pricing or rationing led to reduced water efficiency in some agricultural uses.
- Lack of regulation of groundwater extraction led to depletion of the resource.
- At times, food self-sufficiency policies promoted food production with negative impacts on land and water resources and with an opportunity cost to both households and the national economy, as they undermined diversification and production of high-value crops.
- Incentive structures favoring commercial and irrigated production disfavoured research and investment in rainfed farming.

Overall, these policies came at the expense of trade-offs with growth, social equity and environmental sustainability and they have been progressively reversed. This trend has, however, been accompanied by a decline in public investment in rural areas.

Recent years have witnessed a move away from these policies towards a more balanced approach, particularly since the structural adjustment of the 1980s. However, rebalancing towards private enterprise was accompanied by a decline in public investment – the net average public investment in agriculture across the region dropped from USD 6.1 billion annually (1986-1990) to USD 1.9 billion (1996-2000). In addition, terms of trade remain generally unfavourable to agriculture, for example in Egypt and Tunisia, and there is scope to remove the remaining constraints and improve incentives. This would foster further inclusive growth.

Recently, countries in the region have also come to a more integrated appreciation of agriculture's role in the economies, ecologies and societies of the region

These new perspectives include appreciation of: (i) the value of conserving ecosystems; (ii) the environmental services provided by rural areas, such as water infiltration and soil conservation; and (iii) socio-cultural services such as cultural heritage or traditional agriculture.

1.6 Impacts of climate change on farming systems

Climate change events anticipated in the region

The NENA region is likely to be highly vulnerable to climate change, which will accentuate the already severe water scarcity and increase existing high levels of aridity

In summary, the main climate change events affecting agriculture in different parts of the NENA countries are expected to be:

- <u>Higher temperatures during the growing season</u> and more frequent and intense <u>heat waves</u>, increasing aridity and changing evapotranspiration patterns. By 2100, temperatures in the region could face an increase of 0.9 to 4.1^{o}C higher (IPCC's Fifth Assessment Report, 2014).

- Less precipitation, with reduction in soil moisture, runoff and groundwater recharge. In some areas, runoff is predicted to decrease by as much as 40 percent.
- Less reliability in timing and quantity of precipitation, making agricultural planning more difficult.
- More extreme rainfall events, causing flooding and erosion.
- Increased frequency and intensity of droughts and floods, increasing uncertainty and reducing agricultural productivity.
- Loss of winter precipitation storage in snow pack, reducing runoff and stream flow in warmer cropping periods.
- Seawater intrusion as sea levels rise, leading to flooding of coastal areas and exacerbating ongoing salinization of coastal aquifers.
- Increases in winter temperatures, with negative impacts on fruit species which need a cold winter to flourish the next season.

These anticipated changes are expected to affect different parts of the region in slightly different ways

The Arabian Peninsula is affected by the monsoon systems of the Indian Ocean with an average annual precipitation of less than 80 mm , and the Maghreb and Mashreq are predominantly affected by Atlantic and Mediterranean conditions (see Table 1.9). Within different countries, too, there are likely to be differences of exposure. Some mountain areas, for example, may benefit from higher temperatures whilst semi-arid interior regions may simply become more arid.

Table 1.9: Exposure - what climate change events are expected to occur

Maghreb[2]	Mashreq[3]	Arabian Peninsula[4]
• Overall a hotter, drier Maghreb • Temperature increase of up to 5°C • Decrease in precipitation, fewer rainy days • More drought events, especially in summer • Overall increase in aridity, with 20% drying • Seawater intrusion	• Overall, a hotter, drier Mashreq • Higher temperatures in both summer and winter • Generally drier, especially in the rainy (winter) season • Rainfall may drop below threshold for some areas	• Relatively uniform warming • May be increase in summer precipitation, but highly uncertain and local • More severe rainfall events

Expected impacts on agricultural water and farming

Water resources

Water availability is the key determinant of agricultural potential throughout the region, and climate change will affect this availability

In the Maghreb, significantly lower rainfall and higher temperatures are likely to lead to a decline in soil moisture availability to the plant roots and to decreased infiltration and runoff, so that groundwater recharge and river flows are likely to diminish. The Mashreq will experience similar increases in water stress, and the many parts of the region that are now dependent on groundwater irrigation will suffer decreased recharge together with continuing loss of groundwater reserves.

Rivers arising within the region are likely to experience decreased flows

Reduction in river flows will result from diminished runoff, and also some change in seasonal distribution through changes in snow patterns, for example in Lebanon and Morocco. The region's major international rivers will be largely affected by events outside of the region. The Nile may experience increased potential flows in the coming three decades, the Tigris and Euphrates the opposite.

Irrigation

Demand for irrigation water is expected to increase

Impacts of climate change on irrigation requirements will be felt through net changes in precipitation and evapotranspiration. Increased frequency of droughts is expected to stress water reservoirs, as more water will be necessary to offset increased crop demand. It is forecast that crop irrigation requirements may increase by 5-20 percent by 2080. Demand for increased irrigation may push up the ratio of irrigation withdrawals to available renewable water resources. A recent FAO forecast suggested that irrigation water withdrawals in the region could rise from 347 million cubic metres (MCM) in 2005/07 to 374 MCM by 2050, bringing the share of renewable water resources withdrawn for irrigation up from 58 to 62 percent[5] [IPCC, 2008; FAO 2010a].

2 Morocco, Algeria, Tunisia, Libya and Mauritania
3 Egypt, Lebanon, Palestine, Jordan, and Syria
4 Yemen, Oman, Qatar, Bahrain, Kuwait, Saudi Arabia and the UAE

5 Of course, whether these extra withdrawals take place depends on policies and investments.

Crop and livestock yields and production

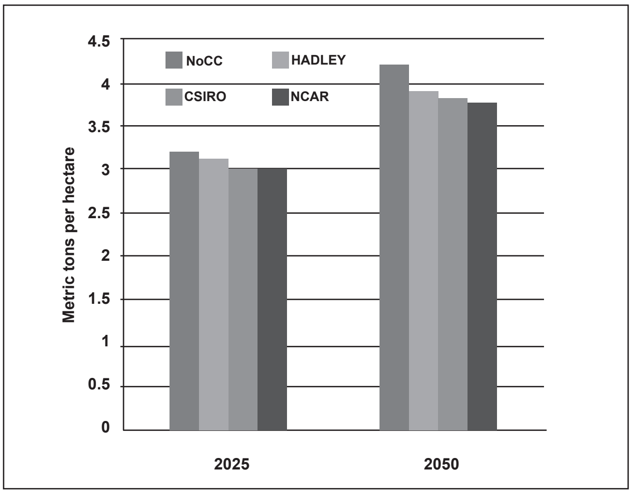
These changes in agro-climatic conditions will impact production

Although the pace and direction of change is far from certain, and will inevitably vary considerably across locations, generally climate change is expected to lead to lower production. For example, it is expected that in the longer run, yields of key rainfed cereals may drop (Figure 1.2), with a projection that in North Africa, maize yields could fall by 15-25 percent if temperatures rise by 3°C. One case study of maize and wheat suggests that by 2080 average yields across the region will decrease by 20 and 12 percent, respectively.

Negative impacts can be offset by improved water efficiency and water productivity, but output would still be below trend

An IFPRI study suggested that cereal yields may still increase, on average, at least until 2050 (see Table 1.10), but by less than would have been the case in the absence of climate change. Overall, the most likely picture on cereals that emerges is that: (i) a combination of improved incentives due to rising commodity prices together with application of productivity-enhancing measures will keep yields rising through to mid-century, after which they will begin to drop off; (ii) natural resource and climate change pressures will contribute to a slow fall in the production area from 2010; and (iii) overall output will rise in most major producing countries – but after 2050, production of wheat and maize across the region will start to decline. IFPRI's comprehensive series of global crop models support this assessment (see Table 1.10 for the example of rainfed wheat in a number of NENA countries) [World Bank 2007b, IFPRI 2010].

Figure 1.2: Average cereal yields in MENA – historic climate and alternative scenarios



Source: IFPRI 2010. NOCC: no change

Table 1.10: Projected rate of annual change for rainfed wheat under one climate change scenario

	Morocco	Egypt	North Africa	Syria	Iraq
Yield: annual rate of increase/decrease					
Baseline 2010	+ 5.4%	+ 1.4%	+ 5.4%	+ 1.3%	+ 4.6%
2020	+ 1.2%	+ 2.4%	+ 2.0%	+ 0.7%	+ 0.7%
2050	+ 0.2%	+ 1.4%	0	- 0.3%	- 0.3%
Area: annual rate of increase/decrease					
Baseline 2010	0	+ 0.5%	0		
2020	-0.1%	+ 0.1%	- 0.5%		
2050	-1.0%	- 0.7%	- 1.0%		
Forecast production (000 mt)					
Baseline 2010	4 634	4 847		4 585	1 851
2020	5 322	6 511		5 106	2 040
2050	5 622	10 848		5 162	2 133

Source: IFPRI crop models (using CSI A1B), taken from the following IFPRI website on 19 December 2011: http://www.ifpri.org/publication/food-security-farming-and-climate-change-2050

An element of uncertainty is introduced by the expected increased variability and increased frequency of extreme events, especially of drought but also of destructive storms, floods and heat waves

These factors will reduce yields in the year of incidence and may also create risk aversion and disincentives to investment, and make planning at household, local and national scale more challenging. Yields of several economically important fruit species (olives, apples, pistachios, nuts, pomegranates) may also suffer reduced yields or crop failure if winter temperatures are too high.

Impacts by farming system

All farming systems will be exposed to increased aridity and to declines in water availability, with rainfed systems most at risk

All systems are sensitive to these changes, especially rainfed systems without access to reliable irrigation sources (Table 1.11). More marginal systems may be pushed further to or beyond their margins: some marginal rainfed lands may revert to pasture or simply go out of production.

Table 1.11: Climate change impacts on farming systems of the NENA region

Farming system	Exposure *What climate change-related events will occur*	Sensitivity *Likely impacts on farming systems*
Irrigated	Increased temperatures Reduced supply of surface irrigation water Dwindling of groundwater recharge	More water stress Increased demand for irrigation and water transfer Reduced yields when temperatures are too high Salinization due to reduced leaching Reduction in cropping intensity
Highland mixed	Increase in aridity Greater risk of drought Possible lengthening of the growing period Reduced supply of irrigation water	Reduction in yields Reduction in cropping intensity Increased demand for irrigation
Rainfed mixed	Increase in aridity Greater risk of drought Reduced supply of irrigation water	Reduction in yields Reduction in cropping intensity Increased demand for irrigation
Dryland mixed	Increase in aridity Greater risk of drought Reduced supply of irrigation water	A system very vulnerable to declining rainfall. Some lands may revert to rangeland. Increased demand for irrigation
Pastoral	Increase in aridity Greater risk of drought Reduced water for livestock and fodder	A very vulnerable system, where desertification may reduce carrying capacity significantly Nonfarm activities, exit from farming, migration

Sources: World Bank 2013 Annex Table 2

The most marginal and affected systems – dryland and pastoral systems – are those for which fewest solutions are available

It is in the most marginal systems that impoverishment is most likely unless there is policy and programme intervention, and even with interventions, exit from farming may still be inevitable for some. Some key research themes on risk management, crop-livestock integration, and communal approaches to resource and risk management become more prominent as climate change stresses intensify.

Intensive research is needed to increase the availability of technology and institutional options

At least some technology and institutional options that can help maintain productivity and livelihoods under climate change are known and are either accessible to farmers or could be made accessible. What is needed are: (1) economic and institutional reforms in the enabling environment to encourage faster and wider adoption of these new technologies; and (2) further research to prioritize and adapt these options to the changing situation in varying locations and farming systems. However, the strength of these adaptive measures declines in inverse proportion to the sensitivity of the system to climate change.

Countries throughout NENA have prepared plans anticipating climate change and preparing to handle impacts on agriculture

Across the region, countries have studied likely impacts and have prepared adaptation and mitigation strategies. Box 1.2 describes the case of Tunisia.

Box 1.2: Anticipating and dealing with climate change impacts on agriculture in Tunisia

With an availability of 500 m^3/person/year of freshwater, Tunisia is confronting a "chronic water shortage" reflected by an imbalance between water availability and agricultural needs.

This shortage is exacerbated by climate change. In particular, droughts where rainfall is 40 percent below average now occur with a frequency of two every six years.

Since 2006, prospective studies on the impacts of climate change have formed the basis for the National Strategy of Adapting Agriculture and Ecosystems to Climate Change (MARH, 2006). The aim of this strategy was to move from crisis management (unpredictable successive droughts, floods, etc.) to risk management. The strategy includes an early warning system so that farmers are forewarned and government can undertake specific measures such as managing water available in dams and the adjustment of water allowances.

Source: FAO 2014b: Regional Initiative on Water Scarcity - Tunisia Country Paper: 5-6

1.7 Irrigation in NENA

The importance of irrigation in NENA

Irrigation has been long-practiced and is very widespread

Irrigation has been long-practiced in NENA and now covers a total of 24.6 million ha. Seven countries in the region have more than 1 million ha under irrigation (Table 1.12).

Table 1.12: Key facts on irrigation and rainfed lands in NENA

High levels of irrigation in NENA countries	High % of irrigation potential has been equipped for irrigation	High % of cultivated land irrigated	Large areas of rainfed land under cultivation
Area under irrigation in NENA countries: • 7 countries with more than 1 million ha: Iran, Iraq, Egypt, Sudan, KSA, Morocco, Syria • 5 countries with 100 000-1 million ha: Yemen, Algeria, Libya, Tunisia, Lebanon	Share of the irrigable area that has been equipped for irrigation in NENA countries: • 4 countries have equipped more than 90%: Algeria, Libya, Jordan, Yemen • 3 countries > 70%: Morocco, Egypt, Tunisia • 4 countries 50-70%: Sudan, Iraq, Lebanon, Iran • Only one country reporting substantial unequipped potential: Mauritania	Share of the cultivated area that is irrigated in NENA countries: • 2 countries > 50%: Egypt, Iraq • 5 countries > 30%: Iran, KSA, Yemen, Lebanon, Jordan • 2 countries > 15%: Syria, Libya • 3 countries > 10%: Morocco, Sudan, Mauritania	Area under rainfed cultivation in NENA countries: • 2 countries with more than 10 million ha of rainfed cultivation: Sudan, Iran • 4 countries 4-10 million ha: Algeria, Morocco, Tunisia, Syria • 3 countries. 0.5 million ha: KSA, Libya, Yemen

Source: AQUASTAT

NENA countries have developed more of the irrigation potential and irrigate a higher share of agricultural land than any other region in the world

A high share of the irrigation potential in NENA has been equipped for irrigation. Five countries have equipped more than 90 percent of their irrigation potential, and a further seven countries have equipped more than 50 percent. Only one country (Mauritania) reports substantial unequipped potential. A high percentage of cultivated land is irrigated (31 percent region-wide), with two countries irrigating more than half their cultivated land, and a further five countries irrigating more than one-third.

At the same time, many NENA countries have large areas of rainfed land under cultivation, on which various forms of agricultural water management are practiced

Region-wide, rainfed cultivated land totals 55 million ha. Two countries have more than 10 million ha of rainfed land each, and four more countries have over 4 million ha each under rainfed agriculture.

Agricultural water withdrawals

Five countries are irrigating on a massive scale, with attendant risks stemming from transboundary waters or from groundwater depletion – or both

Five countries are using vast volumes of water in irrigation (> 20 BCM, Table 1.13). Of these, four have the benefit of huge rivers running through them – Iran, Egypt, Iraq, Sudan – but these rivers are generally transboundary resources, with the accompanying issues. Several countries (particularly KSA and Yemen) are withdrawing very sizable volumes of nonrenewable groundwater for agriculture.

But most NENA countries are dependent on low rainfall and runoff and limited groundwater withdrawals

…and so are highly constrained in the quantities of water they can withdraw for agriculture.

Table 1.13: Agricultural water withdrawals by NENA countries

Volume of water withdrawn for agriculture by NENA countries (in billions of cubic metres):

- 5 countries withdraw more than 20 BCM: Iran 86; Egypt 59; Iraq 52; Sudan 26; KSA 25
- 2 countries withdraw 5-20 BCM: Syria 14; Morocco 11
- 6 countries withdraw 1-5 BCM: Libya 3; Algeria 3; UAE 3; Yemen 3; Tunisia 2; Mauritania 1

Source: AQUASTAT

Countries that have very high rates of withdrawal may be depleting nonrenewable resources and they may be vulnerable to claims from other sectors or to climate change

A number of countries are withdrawing for agriculture more than their entire renewable resource. In the case of several rich arid states, withdrawals of nonrenewable groundwater are several multiples of the renewable resource (up to 25 times), a policy of groundwater depletion that merits an economic review. Other countries at or near 100 percent of withdrawals for agriculture are vulnerable to growing demand from other sectors. These countries – especially the water-scarce urbanizing countries: Yemen, Egypt, Syria, Jordan, Iran, Iraq – may experience pressure for transfer of water out of agriculture. They are also more vulnerable to the impacts of climate change.

Countries withdrawing less than 50 percent of their renewable resources may have options for further development of water for agriculture

Amongst the five countries currently using only 20-50 percent of their water for agriculture – Tunisia, Sudan, Morocco, Algeria, Palestine – there might be some further potential for irrigation expansion, although this is limited by institutional, environmental, economic, and political constraints.

Types of irrigation in NENA

Surface irrigation is the predominant form of irrigation

NENA-wide, surface irrigation accounts for 20.6 million ha, 85 percent of the total irrigated area (Table 1.14). Iran alone accounts for more than one-third of the total, with 7.4 million ha. Pressurized irrigation accounts for just over 3 million ha, 13 percent of the total. Spate irrigation accounts for 0.46 million ha, 2 percent of the total irrigated area.

Table 1.14: Types of irrigation in NENA

Type and extent of irrigation	Main countries (million ha)
Surface irrigation (85%)	
Surface irrigation: 20.546 million ha (6 countries > 1 million ha)	1. Iran: 7.432 2. Iraq: 3.517 3. Egypt: 3.029 4. Sudan: 1.758 5. Morocco: 1.209 6. Syria: 1.043
Sprinkler (7%)	
Sprinkler: 1.680 million ha (5 countries > 100 000 ha)	1. KSA: 0.716 2. Iran: 0.280 3. Egypt: 0.172 4. Syria: 0.187 5. Morocco: 0.152
Localized (6%)	
Localized: 1.396 million ha (5 countries > 100 000 ha)	1. Iran: 0.420 2. Egypt: 0.221 3. UAE: 0.195 4. KSA: 0.198 5. Syria: 0.111
Spate (1%)	
Spate: 0.459 million ha (2 countries > 100 000 ha)	1. Yemen: 0.218 2. Sudan: 0.132

1.8 Drivers of scarcity and the challenge of agricultural water management

Five factors on the supply side are driving the growing scarcity of water for agriculture

Water scarcity is defined here as a structural imbalance between supply and demand for water. On the supply side, the growing water scarcity in the region is being driven by: (1) the low water resource endowment – NENA is the most water-scarce region; (2) the vulnerability of that resource stemming from the high degree of dependence on waters flowing from outside the region; (3) the likely shrinking of the resource under climate change; (4) the rapid depletion of non-renewable groundwater; and (5) the already very high level of development of water resources, which makes the mobilization of new supplies difficult and costly.

…and three demand-side factors increase the scarcity

And on the demand side, scarcity is being driven by: (1) the ever-growing demand, particularly from the municipal and industrial (M&I) sector; (2) the little-voiced but pressing needs for water to meet environmental and ecological requirements; and (3) an enabling environment and incentive framework that encourages over-use of water in agriculture.

The result is the challenge for agriculture in the region for the coming years – more production and more income with less water

This picture of diminishing and vulnerable supply and increasing competition from other sectors drives the challenge of scarcity for NENA's agriculture. Inevitably, in the coming years, agriculture will have no more water, and probably less, yet in so dry a region water is essential to the agricultural growth needed for the rural economy to prosper and contribute more to the GDP, for rural incomes to be maintained or increased and for more food to be produced.

Agriculture must therefore become ever more water-efficient. How this may happen is the subject of the next chapters.

Chapter 2

Policies and institutions for managing NENA's water resources for agriculture

Main messages

This chapter reviews NENA experience with policies and institutions for managing water resources for agriculture and highlights options for future change.

NENA countries have had considerable experience in setting up institutions and adopting policies to implement best practices in integrated water resources management (IWRM). Next steps could be: to further improve existing institutions and management practices and to make iterative adaptive improvements that lead to governance systems that are tailored to the socio-political context; enhance transparency and accountability; strengthen capacity for regulation and investment planning; and further reduce the fiscal burden.

The basin approach has been adopted: a key challenge will be institutional mechanisms for intersectoral water transfer.

Across NENA, water user associations (WUAs) and community natural resource management have been supported: second generation issues concern empowerment and how to organize relations amongst stakeholders.

Supply side management could bring some extra water for agriculture from reservoirs and nonconventional sources, but this requires scrupulous planning and management. Transboundary issues need to be addressed through a patient and flexible strategy, set within political realities. Climate change and groundwater depletion are major threats to the resource and need strategic responses to limit their negative impacts on agricultural production.

On the demand side, there is scope for further careful adjustment of the overall incentive framework that farmers face in agricultural water management.

Chapter 1 reviewed the challenges of water and agriculture in NENA and summarized the drivers of scarcity in agriculture. The present chapter examines the policies and institutions that NENA countries have put in place to allocate water to agriculture and to manage the agricultural water resource efficiently. The chapter opens with a brisk review of how NENA countries have revised their policies and institutions in recent years (2.1), and then reviews in turn: overall water governance and institutions (2.2); IWRM and the basin approach (2.3); subsidiarity, decentralization and participation (2.4); supply management measures, including new supply options and nonconventional water, transboundary issues, tackling climate change and groundwater depletion (2.5); and the incentive framework for promoting water efficiency and water productivity in agriculture (2.6).

2.1 Bringing integrated water resources management to bear on agricultural water management to promote efficiency

Over the two decades since the Dublin International Conference on Water and the Environment and the elaboration of best practice guidance for integrated water resources management (IWRM – see Box 2.1 below), NENA countries have made great strides in improving their water resources management in pursuit of the agreed upon goals of social equity, economic efficiency and environmental sustainability. In general, the countries have embarked on a progressive transition from supply augmentation and direct provision of water services toward a greater focus on water management, decentralization and inclusion.

Steps have been undertaken at various paces in different countries to strengthen water management institutions and to apply principles of decentralization and participation. Supply and demand management measures have been used to manage water scarcity. Countries have practiced integrated water resources planning anchored at basin level and have worked to improve allocative efficiency and to integrate investment programming. Setting and enforcement of environmental regulations have been strengthened.

The objective of bringing IWRM to bear on agricultural water management (AWM) is to achieve higher levels of efficiency: allocative efficiency between and within sectors and water efficiency and water productivity, together with social equity and environmental sustainability. Specifically in the irrigation sector, many countries have moved to improve the efficiency of irrigation through modernization of both infrastructure and institutions. Decentralization and an inclusive approach towards irrigators and the constitution of WUAs have been adopted on a wide scale, together with tariff reform for irrigation. Government agencies responsible for irrigation and drainage planning and investment have been strengthened in many countries. [World Bank 2007a: 24; xxii; xxiv]

This impressive list of measures in a number of countries has certainly improved efficiency of water use and increased output and farmers' incomes. What remains is to apply these measures across the board in all countries, adapted to local conditions. The remainder of this chapter looks in more detail at what has been achieved and what are the options for next steps.

Box 2.1: IWRM - Global best practices in integrated water resource management

Over the last 30 years, global best practices in water management have emerged which are typically grouped under the title 'integrated water resource management (IWRM)'. Essentially, best practice IWRM sets three goals for good water management, and three principles for forming policies and actions.

<u>Three goals for good water management</u>. These are: (a) social equity; (b) economic efficiency; and (c) environmental sustainability.

Under (a) social equity:
- water services are available for all
- existing water uses are respected
- benefits of development are shared equitably, with a care for the poorest

Under (b) economic efficiency:
- income per drop is maximized
- water is available for its highest value economic use

Under (c) environmental sustainability:
- the water resource and the broader environment are not harmed
- the needs of future generations are taken into account

<u>Three 'Dublin Principles' for forming policies and actions</u>. The three principles adopted by the Dublin International Conference in 1992 for forming IWRM policies and actions are: (i) the institutional principle; (ii) the awkwardly named 'instrument' principle; and (iii) the ecological principle.

(i) The institutional principle provides for:
- participation of all stakeholders
- separation of responsibility for water allocation and management from the interests of water users
- decentralization, and management of water at the lowest possible level

(ii) The 'instrument' principle provides for:
- efficient management of supply and demand through an incentive structure reflecting the true value of scarce water to society

(iii) The ecological principle provides for:
- integrated, intersectoral management, with the basin as the unit of management

Source: Ward 2014

2.2 Overall water governance and institutions in NENA

Water institutions in NENA have been rated as 'better on average than in other regions'

Most NENA countries have one ministry responsible for water planning and investment programming. Where these ministries have the responsibility for large investment budgets – as in Iran, Egypt or Morocco – or for service provision – as in Jordan – they are well-staffed and competent, and politically influential. Where they are responsible only for planning and coordination functions, they can be less effective, as is the case in Yemen. In most NENA countries, there are water laws which reflect the Dublin Principles of good water management (see Box 2.1). One study has rated water institutions in NENA, taken together, as 'better on average than in other regions'. [World Bank 2007a: 43-45; World Bank Country Policy and Institutional Assessment Database]

Irrigation agencies are progressively decentralizing

Irrigation development in NENA has typically been the responsibility of central ministries, sometimes decentralized to local boards, as in Iran. In Egypt, separate authorities are responsible for irrigation, drainage and groundwater. Historically these organizations adopted a 'top-down' engineering approach and favoured capital intensive projects. The influence of global best practice approaches of 'subsidiarity' – decentralization and participation – has gradually exerted itself. In Egypt, for example, local-level irrigation and drainage boards have been established, working with water-user organizations on both investment and on management, operations and maintenance (MOM). [World Bank 2007a: 47]

The quality of public investment has been variable, with some capital-intensive investments still showing signs of a 'top-down' engineering approach

Some public investments still show the results of a 'top-down' engineer's approach. For example, Iran has 85 operating large dams and plans to build another 171. Existing dams store enough water to irrigate 3 million ha, but only 400 000 ha are currently being irrigated. A similar imbalance exists in Algeria, where only 8 percent of the area that could be irrigated with water already stored has been developed for irrigation. [World Bank 2007a: 105-106]

Next steps could be to further improve efficiency and accountability and to adopt participatory approaches and strengthened economic analysis in the investment planning process

Areas for further development of overall governance and institutions are essentially to continue the ongoing transition from centralized management and capital-intensive engineering approaches to approaches where public agencies delegate, regulate, monitor and support, and invest efficiently, all with a raised level of transparency and accountability. Specific actions for progress could include: (1) improving the accountability of public agencies and strengthening incentives for their good performance and for transparency; (2) strengthening management and execution capacity for implementing legislation and enforcing regulations; (3) improving the quality of public investment by more participatory and local-level approaches to investment planning and by improving the quality of economic analysis; and (4) further reduction in the fiscal burden and dependence on the general budget, through increased cost sharing and public/private partnerships (PPP) and other mechanisms for moving more towards a business-like relationship between farmers and service providers. [World Bank 2007a; FAO 2013b: 10]

2.3 Integrated water resources management and the basin approach

Basin approach

There have been many initiatives across NENA in integrated basin planning

A key principle of integrated water resources management is intersectoral management of water integrated at the basin scale. Several NENA countries have made progress in this respect. Egypt, for example, has strengthened its integrated management of Nile resources within its territory, and has also worked with upstream riparians on planning at the scale of the entire Nile basin (see below). Morocco and Algeria have established basin agencies and have associated water stakeholders, including civil society, in basin planning. Some basin plans for water resources development and management have been prepared. An integrated planning process for the entire Blue Nile/White Nile basin has been undertaken.

Next steps in basin planning need to build on this experience

Next steps could include: (1) the generalization of the basin approach, both within countries and across borders (on which, see below, Section 2.5); (2) further decentralization of decisions on investments and allocations to the basin level; and (3) an increase in accountability by giving more voice to non-state stakeholders[6]. [World Bank 2007a: 101]

Water allocation and reallocation

The basin approach reflects the multiple interdependencies of agricultural water, and can also confirm specific allocations to the agriculture sector

6 This is particularly important in view of the rising level of disputes about water.

The basin approach well reflects the interdependence of water sources, uses and users within a basin plan: (i) the interdependence of agricultural water management with overall water resources management; (ii) the social interdependence of agricultural water use with other users and other sectors; and (iii) 'ecological interdependence' as AWM interacts with the environment. The approach thus integrates agricultural water management with the entire natural resource and socio-economic context of the basin. It should also bring the advantage that water allocations are firm within the basin plan, which is significantly better than the previous first come, first served approach. In Morocco, for example, water allocations to irrigation are now confirmed within basin plans, and irrigators can plan on this basis. The results have been encouraging: in one basin, allocations were cut to 60 percent of previous levels but the assurance of a set quantity and improvements in agricultural water management resulted in higher yields per ha and high water productivity.

As demand from other sectors grows, institutional mechanisms for orderly transfer of water between uses will become increasingly necessary

Historically, agriculture has had far and away the largest share of water (see Chapter 1). Now, as other claims on water increase, agriculture may have to give up water. The basin framework has thus to provide a mechanism for intersectoral water transfer. To date, this has proved extremely difficult. The transfer of water from Jordan Valley agriculture to Amman municipal use in the 1980s and the replacement of that freshwater with treated wastewater from al-Samra treatment plant created persistent contentions. But this was at least done within an orderly governance framework. By contrast, transfers of groundwater from the Habir and al-Haima valleys to the southern Yemeni city of Ta'iz in the 1990s led to armed clashes that continue to this day. In Sana'a, the stealthier transfer whereby government drills deeper and pumps harder than neighbouring farmers is seen as no less an infringement of existing agricultural water rights. As demand from other sectors grows, institutional mechanisms for orderly transfer of water between uses will become increasingly necessary.

2.4 Subsidiarity, decentralization and participation

Water user associations

All across the region, water user associations (WUAs) have developed as the lowest level of irrigation governance

Central to the implementation of IWRM's 'subsidiarity' principle is the 'bottom-up' participatory approach that has been applied in recent years in irrigation schemes across the region in the form of WUAs. WUAs are essentially the modernized equivalent of the ubiquitous community groups which managed water resources in NENA since time immemorial.

WUAs have taken on tasks ranging from simple representation right up to management at branch canal level

Most NENA countries have helped these modern WUAs to establish themselves and have provided capacity building support. WUA functions have ranged from mere representation of users (for example, as counterparts to a project) up to financing and managing parts of the infrastructure. In Egypt, higher level 'branch canal WUAs' represent a number of lower level 'tertiary WUAs' and manage systems from the district level down, covering not only irrigation and drainage but environmental issues as well. Across the region, where WUAs exist, they are generally responsible at least for tertiary canal management and for collecting and paying over water charges.

There is scope for stocktaking and the drawing of lessons to date

There has been no general study of WUAs in NENA to examine how effective they are in improving water management and reducing fiscal burden. One study found that WUAs were less effective in NENA than elsewhere in the world, primarily because they were not sufficiently empowered, but this was based on a limited sample. After more than a decade of experience, there is scope for stocktaking and the drawing of lessons to date.

Decentralization and community collaboration on broader natural resource and environmental management

The same community-based collaboration has been applied to watershed management, groundwater management and conservation of ecosystems and environmental services

The approach of decentralizing decision making to the lowest possible level, encouraging participation of stakeholders and fostering of local-level community or interest groups as primary agents of development and as counterparts to public services has been applied in AWM beyond formal irrigation schemes. It has been applied, for example, to: (i) watershed-based (rather than individual) soil- and water-management systems; (ii) development of collective groundwater management; and (iii) conservation of ecosystems and environmental services. [FAO 2001: 121]

Experience in Morocco, however, showed that there were difficult trade-offs in promoting community natural resource management

There is considerable experience in the region with this kind of bottom-up and integrated approach – and mixed results. In Morocco, a decade of investment in a series of community-driven integrated rural development projects (Irrigation-based Community Development Project [DRI-PMH], the Rainfed Agricultural Development Project [DRI-MVB] and Oued Lakhdar Watershed Management Project) gave good results but proved expensive, and the needed cross-sectoral approach was difficult to realize in practice. In the end, the effort was absorbed into a larger community-driven approach, the National Initiative for Human Development (INDH) Support Project, which had the advantage of lower costs and nationwide scale, but which lost the focus on community natural resource management.

Public services need to develop and adapt to this kind of integrated collective approach, which also fits new 'business lines' like green agriculture and landscape management

The challenge will be for public services to organize themselves cross-sectorally, so that support is forthcoming not only in agriculture, but also in water management, marketing, downstream processing, off-farm activities, environment, etc., as well as human development aspects key to sustaining livelihoods. Bottom-up community organizations gaining support from top-down 'convergent' public services and community development funds comprise a key set of capabilities that can achieve substantial impact on rural livelihoods. New business lines such as 'green agriculture', eco-tourism, and landscape and cultural heritage management require these public/community partnership approaches. Next steps could start with a region-wide review of successes and challenges. [FAO/IFAD 2007: 61]

2.5 Acting on the supply-side drivers of scarcity

Mobilizing new supplies

As mentioned in Chapter 1, there will be increasing demand for irrigation water, but as climate change reduces the available resource, where would increases in irrigation supply (or water to make up for transfer from agriculture to Municipal and industrial (M&I)) come from? FAO have predicted that water withdrawals for irrigation in NENA will increase from 287 BCM in 1997-1999 to 315 BCM in 2030. Although most countries are already at – or beyond – the limit for safe withdrawal of water, there may still be possibilities of increased impoundment and storage in dams, largely in Iran and Syria, and there is scope for increasing supply of nonconventional water to agriculture. [FAO 2003: 140, Table 4.10; FAO 2013b: 8, Doc 9]

<u>Dams</u>

Although most resources are fully developed, there may be some potential to develop further storage and to optimize releases on existing storage

In many NENA countries, suitable major projects have been exhausted, and under climate change, the reliability and cost-effectiveness of any future storage will decrease. In fact, worldwide, the high cost of large storage dams is usually only justified by hydropower or municipal supply benefits. There is, however, still some limited scope for expansion – Lebanon is an example of a NENA country where storage is low by regional standards and where significant further development is plann- -ed. Some irrigation water could also be added by optimizing release rules on existing dams. Transboundary cooperation on water resources development and management could also increase water available for irrigation. For example, hydropower dams on the Blue Nile in Ethiopia could provide extra irrigation water for Sudan and Egypt downstream. [World Bank 2006a; FAO 2011]

However, the economic and environmental tests for new development will be very hard to pass

Any new storage projects will have to cope with more variable and extreme flows, and they are likely to be set in an environmentally more sensitive landscape. Options will need to be flexible and have low capital and operating costs. Local hill dams, water harvesting or on-farm water storage may prove to be the most economical solution. But all such impoundments require social, economic and environmental assessment of the trade-offs involved. Projects need to be studied within a basin planning framework. In addition, all water storage is likely to suffer increased evaporation due to higher temperatures. The extreme case is Lake Nasser where higher temperatures may cause an additional 2 BCM of water to be lost to evaporation each year. [FAO 2010a: x, FAO 2011: 5.2.4]

Nonconventional sources of water for agriculture

Worldwide, only about 60 percent of water withdrawn is actually consumed, and 40 percent returns to the hydraulic system in the form of used water. Particularly in water-short NENA countries, investment in reuse of treated wastewater and drainage water can offset water scarcity. <u>Treated wastewater</u>, rich in nutrients, will be increasingly used, especially where scarcity is extreme and demand from peri-urban agriculture is strong. Institutional arrangements for allocation and safe use will be required. <u>Drainage water reuse</u> can be an even more important source for agriculture.

Treated wastewater use

There is good experience in the region on treated wastewater use

There are several examples of good practice on wastewater reuse in NENA. Currently, reuse of treated wastewater accounts for around 2 percent of total withdrawals for agriculture region-wide – and for over 4 percent in the Mashreq countries. Use of treated waste water is particularly high in the Arabian Peninsula (see Box 2.2). FAO has been piloting low-cost wastewater treatment and subsequent reuse in Algeria, Morocco, Tunisia and Egypt (see Box 2.3). In Tunisia reuse is common practice, after tertiary treatment. The large-scale return of treated wastewater from the Jordanian highlands to irrigated agriculture in the Valley has been mentioned above. [FAO 2009: 5a]

Box 2.2: Nonconventional water provides 13 percent of Oman's water resources

In the Sultanate of Oman, conventional water resources (including surface and groundwater) represent about 87 percent of the nation's water resources, and nonconventional water resources, including desalination water and treated wastewater, account for 13 percent.

Nonconventional water resources are desalinated seawater or brackish water and treated wastewater. The total volume of desalinated water in Oman reached 196 million m^3 in 2011. The total volume of treated wastewater was 42 million m^3, representing 21 percent of the total desalinated water used for urban purposes. It is expected that the treated wastewater volume will reach 100 million m^3 by 2030. Most of the treated wastewater is being used for landscaping and public gardens. Part of the excess treated wastewater (15 percent) is being discharged to the sea during winter. In Dhofar, 20 000 m^3 of treated wastewater is injected daily in the coastal aquifer to combat seawater intrusion.

Source: FAO 2014c: Regional Initiative on Water Scarcity – Oman Case Study: 1

…but wastewater can only be a modest new source, and a more workable incentive framework is required to maximize reuse

Overall, although cities and M&I use are growing constantly, it is likely that reuse will not exceed 10 percent of influent because of: (1) the high cost, including removal of heavy metals; (2) location, with most effluent arising in coastal cities; and (3) the difficulty of getting farmers to use treated wastewater, largely due to cost. Regulation and restrictions on reuse add to costs and limit benefits. Although untreated wastewater use is not encouraged as a source for irrigation, recent experience in both Lebanon and Yemen has been that farmers can be reluctant to switch from using untreated to treated wastewater, because of cost and loss of nutrients. This is an area where a region-wide study could establish best practice and develop proforma guidelines, including an incentive framework that would maximize reuse. [ICARDA 2007: 80-85]

Box 2.3: Success with treatment and reuse of wastewater

FAO piloted low-cost wastewater treatment in Algeria, Egypt, Morocco and Tunisia with either constructed wetlands or a simplified wastewater treatment plant. Successful results include:

- Algeria: constructed wetlands developed to solve the massive problem of wastewater pollution in the wadis. The effluent has irrigated palms and agro-forestry downstream
- Egypt: wood production over two decades, within a forest management plan
- Morocco: fertigation for the green belt around Marrakech

Source: FAO Rome Technical Discussions, September 2013

Saline and sodic drainage water and groundwater

Salinized and sodic drainage water and groundwater can be reused, again with restrictions

Saline and sodic drainage water and groundwater can be reused, although these relatively saline waters pose risks due to soil salinization and water quality degradation downstream. A legal and regulatory framework is needed, and programmes have to be assessed at the level of overall basin efficiency and socio-economic benefit. These features characterize successful programmes such as that of Egypt, which reuses over 5 BCM of drainage water, equivalent to

10 percent of its annual freshwater withdrawals, without deterioration of the salt balance[7]. Recent research has also revealed the value of brackish water sources for biosaline agriculture (see Box 2.4). [McDonnell and Ismail 2011, FAO 2011a, World Bank 2006a: 177; Abou-Hadid 2007: 62A; ICARDA 2007: 86-90]

Box 2.4: Brackish water sources for biosaline agriculture

Research shows the value of brackish water sources for biosaline agriculture (Taha and Ismail 2010, Taha et. al. 2005). In research commissioned by the International Fund for Agricultural Development (IFAD), the International Center for Biosaline Agriculture (ICBA) analysed the potential use of saline/brackish water resources in NENA countries for animal feed production. The study showed that sufficient saline and brackish water resources exist to irrigate up to 330 000 ha. These findings are particularly relevant to the Arab region, given the increasing salinization of groundwater.

Source: ICBA, McDonnell and Ismail 2011

Transboundary issues

Although transboundary waters are a major challenge, there are no comprehensive agreements in NENA

In the NENA region, 60 percent of surface water is shared across boundaries and huge – largely fossil – aquifers lie beneath several countries. However, there are no comprehensive cooperative agreements or joint river basin organizations. Bilateral agreements do exist – for example between Egypt and Sudan over the allocation of Nile water, but these have not been shared with other riparian countries.

Agreements based on equitable sharing of development opportunities among the riparian countries are the healthy and sustainable way for countries to enjoy economic prosperity, security, and peace for their people.

Egypt and Sudan have been working towards an agreement with all riparians on Nile waters

Egypt and Sudan have been working intensively with upstream riparians within the Nile Basin Initiative (NBI) to work out and agree a cooperative framework agreement on benefit sharing (see Box 2.5). Extensive investment has been made in setting up institutions for information and data gathering and sharing and for joint studies, planning and investment programming. The Eastern Nile Technical Regional Office (ENTRO) of the NBI has prepared an investment planning framework and several transboundary projects on behalf of the Blue Nile riparians (Egypt, Sudan and Ethiopia).

Box 2.5: The Nile Basin Initiative

Recognizing potential gains from cooperation, nine Nile riparian states established the Nile Basin Initiative (NBI) in 1999 as a regional partnership. NBI was intended as a transitional cooperative mechanism. At the same time, a process was launched to study how to draw up a multilateral agreement on cooperative development of the Nile, the Cooperative Framework Agreement (CFA). The NBI seeks to develop the river in a cooperative manner, share socio-economic benefits, and promote regional peace and security. Its mission statement is set out in the *Policy Guidelines for the Nile River Basin Strategic Action Program* (NBI 1999): to achieve sustainable socio-economic development through equitable utilization of, and benefit from, the common Nile Basin water resources'. The *Policy Guidelines* set out the specific objectives of the NBI:

- develop the Nile Basin water resources in a sustainable and equitable way to ensure prosperity, security and peace for all its peoples
- ensure efficient water management and the optimal use of the resources
- ensure cooperation and joint action between riparian countries, seeking win-win gains
- target poverty eradication and promote economic integration
- ensure that the programme results in a move from planning to action

Source: Ward 2010a; Cascao 2009

7 Issues of drainage and drainage water reuse are discussed in full in Chapter 3.

The lack of cooperation between Turkey, Syria and Iraq over the Euphrates has prevented the development of an integrated water management plan for the Euphrates basin, and creates particular risk for Iraq as the downstream riparian of a diminishing and increasingly uncertain flow. At full development, Turkish and Syrian projects could reduce Iraq's share of the Euphrates from the present 19-21 BCM to just 9 BCM, and less in a drought year. Iraq's share of Euphrates water could drop from 75 to 28 percent. [World Bank 2006a, Bingham: 10.67]

A cooperative framework can create win-win benefits

In addition to the risks of noncooperation, there are also very important benefits that can be gained from cooperation, largely because this allows investments to be planned at the basin scale, which can generate considerable extra benefits (see Box 2.6).

Box 2.6: How cooperative development on the Nile could result in win-win outcomes

Cooperative development can greatly increase economic and environmental benefits. Investments and management interventions jointly planned at the basin scale within an integrated framework can produce more benefits than investments limited by national boundaries. One study, for example, estimated that if Nile investments were planned at the basin scale, the annual benefits from the Nile would more than double, from USD 4.2 billion to USD 8.9 billion, and these benefits could be shared so that all nations were better off. More efficient use can be made of the water, which can be first used for hydropower upstream and then for irrigation and water supply downstream. Cooperation would also help preserve ecosystems, increasing sustainability and enhancing environmental assets. Climate change impacts can also best be managed at the basin level.

Cooperation can also have broader benefits. Cooperation on international rivers increases water security, reduces risks of water-related conflict and increases the chances that conflict can be turned to good account. Cooperation can also serve as a catalyst for greater regional integration, both economic and political, with benefits far exceeding those derived from the river itself. For example, the case of the World Bank's Red Sea-Dead Sea Water Conveyance Study programme has demonstrated unprecedented engagement on transboundary environmental and water management issues, even during the most difficult political times.

Unilateral development brings lower economic benefits and social and political problems. In contrast, unilateral development results in suboptimal investment choices, lower overall returns to water and hence lost income for riparians, and could lead to degradation of the river system and result in increased tensions amongst riparians. This in turn can have political and economic consequences in terms of international relations, as well as domestic social and political impacts as constituents within countries wrestle with adverse localized impacts.

Source: Whittington et al. 2005; Ward 2010a; Ruckstuhl 2009

Towards best practice in cooperation on transboundary waters

Best practice in transboundary water management and conflict resolution seeks to achieve the goals of fair distribution of benefits, economic efficiency and environmental sustainability through agreement on some level of cooperation

The ultimate goal would be a comprehensive agreement between all riparians providing for: agreement on how water or benefits are to be shared; institutional mechanisms, rules and organizations for decision taking, conflict resolution and implementation; and arrangements for mutual monitoring[8].

The persuasive concept of benefit sharing – rather than assigning quantified water rights – could be at the heart of cooperation

The economic value of cooperation is not proportional to water diverted or consumed. It is sharing

8 These points essentially reflect the principle of cooperation enshrined in the 1997 *UN Convention on Non-Navigational Uses of International Watercourses*, which requires: equitable utilization; no significant harm; and a duty to cooperate in protection and development. The convention was approved by the General Assembly, but has not been ratified by a number of states, including major riparians on NENA resources (Israel, Turkey and Egypt).

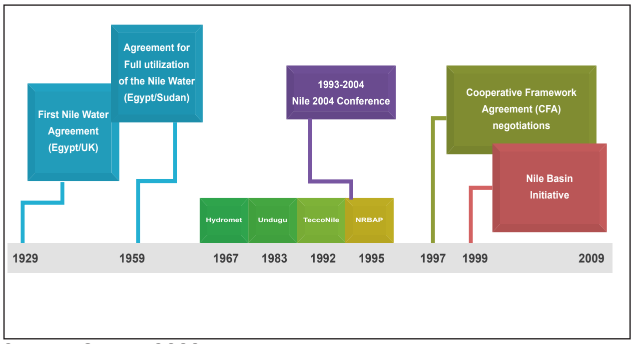
of water-related benefits rather than water allocations *per se* that give the increased value the riparians are seeking. A framework based on benefit sharing rather than water sharing would underpin a more rational planning function based on economic value and would prioritize high value, low consumptive uses such as hydropower.

<u>Lessons on the process of negotiating cooperation on transboundary waters</u>

It is essential to act early before the situation becomes critical and to take advantage of windows of opportunity. In the process, mediation and external support can be key.

Time and stamina are needed. In the case of the Nile, multilateral cooperation began tentatively as a low key technical process in 1967 (see Figure 2.1), and only forty years later is that process gathering real momentum.

Figure 2.1: Timeline of cooperation in the Nile River Basin



Source: Cascao 2009

Communications, transparency, and stakeholder inclusion are vital

The Nile Basin Initiative has invested massively in communications and stakeholder inclusion, and this has brought important dividends in terms of engagement and support. Transparency is essential.

<u>Lessons on tackling the substantive cooperation issues</u>

There is a need to analyse the political economy and to form strategies

Realistic and participatory analysis is required of the political economy of the riparian countries and of their actual and potential relations over the water source, together with other geopolitical issues in the region, such as commerce, defence, etc. Overall, the strategy has to take realistic account of power relations, and to embody mechanisms to empower the weaker riparians. The Nile process, for example, has given a voice to the weaker upstream riparians through their systematic inclusion in all bodies and institutions with an equal voice. The process has enabled these states for the first time to influence the regional water agenda and policies. [Cascao 2009]

A progressive and flexible institutional strategy is needed

Institutional mechanisms are the reflection of the state of agreement of cooperation at any point. A river basin organization cannot be set up until there is agreement on cooperative water management. A flexible approach to institutional design is therefore required. The progressive establishment and development of institutions for the Nile, keeping pace with successive degrees of cooperation amongst the parties, is a good illustration of this step by step approach.

A sequence working from technical cooperation towards institutional and political cooperation will allow confidence and habits of joint working to develop, whilst generating essential knowledge

There is a virtue in starting with lower key technical cooperation which can act politically as a confidence-building measure. If the cooperation proves beneficial, it could represent a first step towards integrated basin planning.

The economic strategy should concentrate on sharing benefits rather than water

Apart from the economic gains that can be made, benefits are less sensitive to negotiate than headline water quantities. Agreeing on an investment programme that brings benefits to all partners is politically easier than negotiating quotas of water.

Early identification of one or two joint multi-purpose operations would be helpful, as they could bring evident economic benefit

In the Nile Basin, for example, the three major riparians – Ethiopia, Sudan and Egypt – have launched preparation of a series of multi-purpose operations both within and between their countries for hydropower, irrigation and watershed management. [USAID 2006-7, Cascao 2009]

The benefits should be considerable, as reaching agreement over water will reduce risk and encourage economically optimal investment for all riparians

As cooperation leads to joint planning at the basin scale, investment and management can be progressively optimized – for example to take account of basin-wide externalities. Reaching agreement over water will reduce risk and encourage economically optimal investment for all riparians. Ultimately, basin level planning can maximize the aggregate value that a unit of water can generate as it moves through the river system before it is consumed or lost.

Next steps on transboundary waters

For the main transboundary resources of the region – the Nile and Tigris/Euphrates – there is a cooperative programme only for the Nile. Consideration could be given to cooperative approaches for Tigris/Euphrates, building on the Nile experience.

Tackling climate change

Background on climate change in NENA

Climate change will have a negative impact on agricultural water availability and will increase farmers' vulnerability

The vulnerability of NENA water resources and agriculture to climate change was discussed in Chapter 1 (Section 1.6). The present section now discusses how the region, its countries and its farmers are adapting, and how they may manage present and future risks. The topic is vital as although patterns of change in precipitation under climate change are not yet clear, water is certainly the region's top vulnerability.

Farmers will devise their own responses – but would benefit from structured support within national adaptation strategies

Farmers are likely to deploy a wide range of adaptive measures as the impact of climate change makes itself felt in different farming systems. The challenge will be to ensure that farmers are properly supported, and that farmer reactions contribute to – and do not undermine – larger national objectives of sustainable, equitable and efficient development. In this respect, climate change serves to highlight a number of opportunities for better integration between farmers, systems and national levels of concern and action. These include: (i) how to develop the needed climate modelling and resource monitoring; (ii) the preparation of adaptation strategies; and (iii) policies and programmes to support farmers.

Climate modelling and resource monitoring

Good data and modelling are essential to preparing responses to climate change

In order to plan for climate change adaptation in agriculture, NENA countries need access to good data. Hydrological and crop modelling needs to be coordinated in order to anticipate likely impacts of climate change on water availability and crop production and to assess the effectiveness of adaptation options. This would allow governments to inform all stakeholders of what changes are likely, to plan in a participatory way for the correct balance of local initiative and top-down interventions, and to design appropriate support programmes. The same data would allow governments to manage food security and social protection programmes related to climate change-induced poverty and migration. [FAO 2010a]

New technologies for tracking change are freely available and need to be accessed

New technologies, particularly remote sensing, are contributing to mapping and monitoring a wide range of natural resource parameters. Satellite data combined with Geographical Information Systems (GIS) now have the capability to measure changes in land cover, forecast crop yields, monitor crop stress and quantify production and yields, measure stream flows, soil moisture and water storage, and follow pollution plumes in water or in the soil. Using recent developments in information and geospatial technology, a number of international programmes are developing resource inventory and monitoring tools, including use of evapotranspiration remote sensing-based water management approaches such as the CropWatch System (Bingfang Wu et. al., 2014). The potential of these spatial technologies for improving land and water management is enormous, and many of these tools are open-access (see Annex 2). [FAO 2011]

Preparation of adaptation strategies

Experience shows that adaptation strategies require an iterative top-down/bottom-up approach based on evidence, research and farmer experience

Best practice adaptation strategies for agriculture in NENA may have several key characteristics:

- working from the top down (from climate models and data) and from the bottom up, basing strategy on the actual constraints, possibilities and incentives that shape farmers' adaptation capacity;
- building on and refining existing improvements and trends in soil, water and crop management, which are already adapted to the water-stressed conditions of NENA countries;
- investing in further adaptation technologies drawn from both farmer innovation and from adaptive research;
- prioritizing 'no regrets' options that are nonetheless robust, given that variability is likely to increase; and

- developing solutions that integrate adaptation and mitigation.

An example of an innovative approach that satisfies all the above criteria would be the adoption of slow-release nitrogen fertilizers that improve efficiency and reduce the amount applied, so that production costs are reduced, output and income increased, the greenhouse gas (GHG) cost of production is less, and the mobilization of nitrous oxide (a GHG) reduced. [FAO 2010a]

The options for different farming systems, for institutional development and for public investment would be driven by the context, and also by public policy according to the relative priority accorded to: equity in benefit amongst stakeholders; impacts on ecosystems; rural development and urbanization policy; economic and fiscal costs; and the trade-offs amongst these varying policy objectives.

Responses need to clearly target agricultural productivity and environmental protection

Responses should anticipate changes and opportunities rather than just react, should be comprehensive and innovative and should mobilize all stakeholders, including local communities and local knowledge. Strategies should be developed with both technical and institutional measures to: enhance agricultural productivity through crop, water and land management supported by knowledge dissemination and increased investment; and develop the institutional setting at different levels to support investment, collective action and environmental protection. [Clements et al. 2011, FAO 2010a]

Policies and programmes to support farmers in adapting agricultural practices

A practical partnership approach between farmers and public agencies is needed

Farmer responses to climate change and to the underlying natural resource scarcities indicate the direction that sustainable intensification of farming will take and highlight how other stakeholders can support beneficial change. As discussed above, farmers who come under pressure from climate change effects will respond by managing risk and introducing improvements. There is a clear role for government support in:

- ensuring that the policy and incentive framework facilitates adaptation;
- providing information about likely climate change effects and impacts;
- ensuring that adaptive technology is available;
- ensuring farmers have access to the technical and financial resources necessary to change;
- promoting appropriate institutional change, such as participatory local planning, farmer cooperatives and farmer field schools;
- integrating changes from the local level into higher level planning, e.g. for water resources planning and allocation at the basin scale, for development of irrigation, etc.;
- ensuring that externalities – particularly environmental impacts and upstream/downstream impacts – are managed equitably and sustainably;
- conducting research to ensure optimal productivity and risk management measures are available;
- facilitating development of appropriate forms of crop/weather insurance; and
- improving meteorological capacity and services geared to farmers' needs.

…but at the limit a change of farming system may be needed, or even assisted out-migration

However, natural conditions may deteriorate to the extent that a 'system change' will be necessary: semi-arid croplands may become rangelands, humid seasonally dry lands may become semi-arid, and so on. At the limit, the solution may be retirement or abandonment. Here, too, there is a role for government in accompanying transition of farming systems, and in preparing for and assisting changes in livelihoods and eventual migration of people. [FAO 2010a: xi, FAO 2001: 123A]

Research, extension and information are critical components

Throughout the region, governments have provided research and extension services to agriculture, backed up by regional and global research institutions. The presence of the International Center for Agricultural Research in the Dry Areas (ICARDA) in the region has been a valuable asset in developing technologies and practices for the arid conditions of the region, and this research should intensify in the face of climate change. At the national level, governments are already reviving farmer services, notably through participatory approaches, involving farmers in planning and in practical research and extension. Recent successes in reorienting services include mobile veterinary clinics in Sudan and the development of farmer-to-farmer extension through 'farmer field schools', and these could be scaled up. Local communities and stakeholder groups can play an active part in technology development and dissemination. In a recent study in Syria, it was found that farmer-to-farmer seed distribution was an efficient means of enhancing uptake of new drought-resistant barley varieties. Two-way learning processes between farmer groups and extension agencies can help in learning and dissemination [McDonnell and Ismail 2011, Mazid et al. 2007, FAO/IFAD 2007: 55].

As climate change effects are felt, more attention will be needed at both national and regional level to the development of climate change resilient technical packages, and also to updating systems of farmer information, education and training, including distance learning, internet technology for technical themes, market information, and extension based on a variety of public and private providers. [FAO/IFAD 2007: 59]

Learning from and with farmers will be vital

Farmers are likely to be innovative and proactive in adapting to climate constraints, and an understanding of their behaviour will help match services to needs and assist in broader adoption and dissemination of best practices. It will be important to study and capture such responses across farming systems and countries throughout the NENA region.[FAO 2010a: x, FAO 2011: 3.29, 3.55].

…including from traditional farmer knowledge

Traditional agricultural systems, usually characterized by a high degree of complexity and plant biodiversity, can provide valuable knowledge for adaptation. Traditional agricultural systems comprise indigenous forms of ecological agriculture resulting from the co-evolution of social and environmental systems. Much can be learned from the very specific use of environmental knowledge and natural resources in these systems. It will be necessary to evaluate, document and disseminate good practice at farm, system and strategic levels [FAO 2010a].

Finance will be required, including rural financial services…

Finance is important for adaptation strategies, helping households widen their economic opportunities, increase their asset base, and diminish vulnerability to shocks. This will require development of rural financial services, particularly microcredit and savings and loan approaches [McDonnell and Ismail 2011, Saab 2009]

…and Community Driven Development (CDD-type financing) for natural resource management

There has been considerable success with investments in communal infrastructure supported by Social Funds such as those in Egypt and Yemen. INDH in Morocco is a successful home-grown version of the same approach that is supporting agricultural projects as well as community investments. Extension of these activities to communal investment in natural resource management – watersheds, irrigation development etc. – could support adaptation[9] [FAO/IFAD 2007: 57]. Furthermore, special adaptation funds with lower interest rates for qualified uses are another option.

Groundwater depletion

The groundwater boom has revolutionized agriculture in many countries

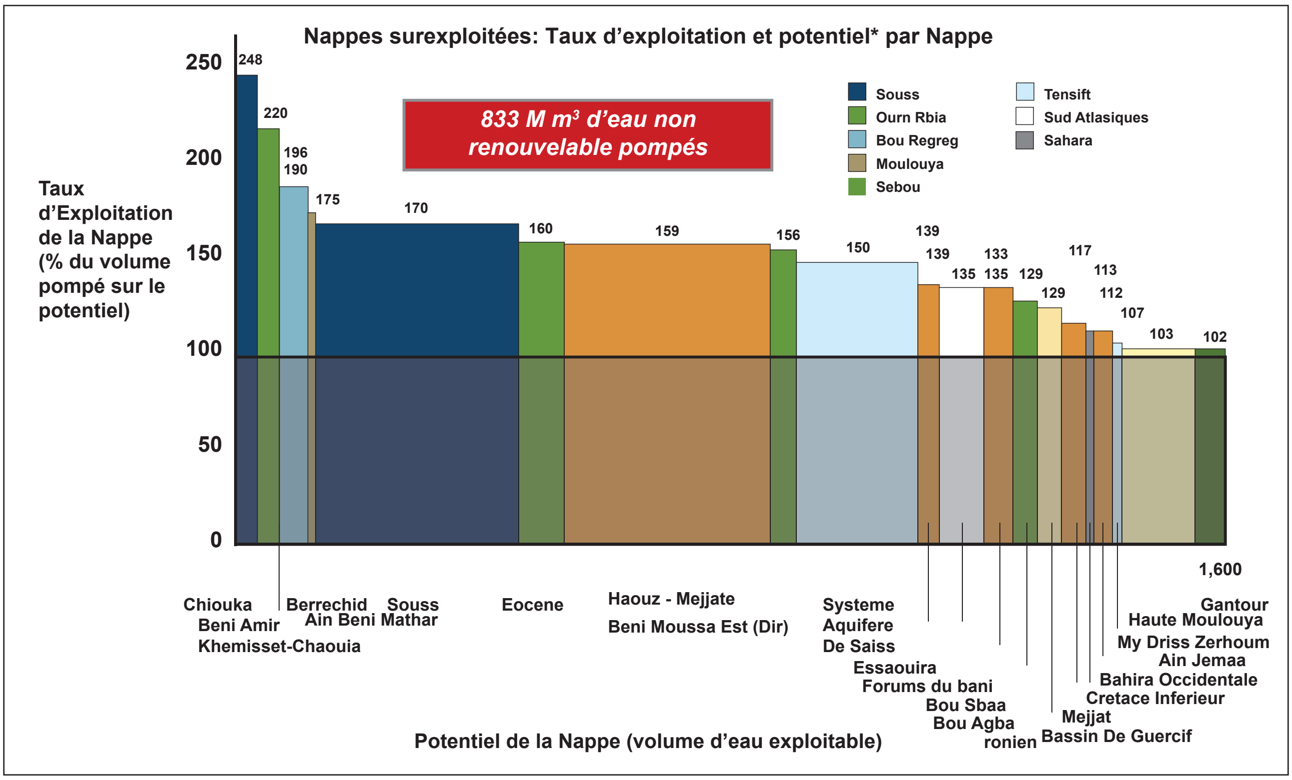
From the 1970s, all countries of the region experienced the arrival of the tube well and motorized pump technology at the same time as internal and export markets for higher-value agricultural produce were growing. This happy combination revolutionized the economics of agriculture based on groundwater use and led to rapid growth of private irrigated agriculture and of farm incomes. The rate of adoption was accelerated by favourable government programmes, including tax-free imports, cheap credit and low-cost energy, and by the absence of any regulation of groundwater development. The use of groundwater for supplementary irrigation also boosted rainfed agriculture in many locations.

…but unregulated development has led to inequitable access and now to rapid depletion in many locations

Alongside these benefits, two negative results emerged. First, the 'open access' nature of the resource and the absence of institutions to regulate development and abstraction led to a free-for-all in which water rights have been appropriated by the more nimble or more powerful, and other related rights have been attenuated – for example, where groundwater abstraction has led to the drying up of springs. Second, the common pool nature of the resource has led to a 'race to the bottom', as no individual has any incentive to conserve the resource, but rather to pump it out before his or her neighbour does. These two results have contributed to conflict and have driven rapid depletion of the resource in many locations (see Figures 2.2-2.4).

9 Next steps in climate change adaptation at national and regional level are discussed in Chapter 4 (Section 4.2).

Figure 2.2: Morocco – Annual renewable groundwater potential and current withdrawal rates



Source: SNE – Monitor from the Regional Initiative on Water Scarcity – Morocco Country Paper

Figure 2.3: Drop in the water table at Souss

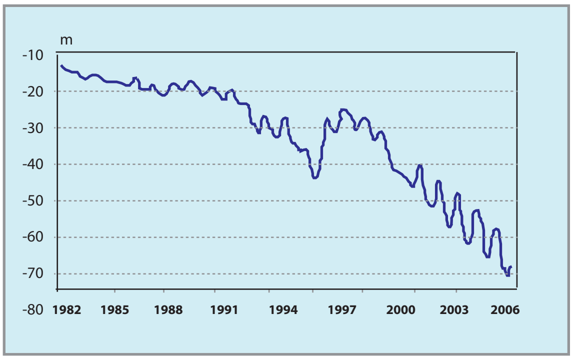
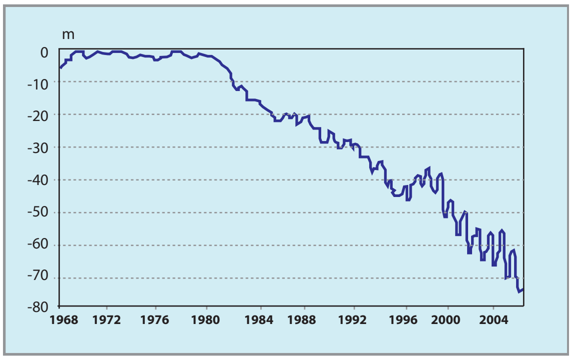


Figure 2.4: Drop in the water table at Saiss



Source: DRPE from the Regional Initiative on Water Scarcity – Morocco Country Paper

Establishing a governance framework for groundwater is exceptionally hard

The NENA countries have tried to recover state control over groundwater through licencing and regulation systems, but these – as everywhere in the world – have proved extraordinarily difficult to impose. The case of Jordan is amongst the more successful: this combined a military-style licencing and regulation operation with incentives to compliance in the form of permits to sell groundwater to the profitable potable water market.

Attempts in Yemen to reduce over-abstraction simply by raising the price of diesel were not successful, as this led to price rises throughout the economy which provoked considerable civil turmoil. Subsequently, Yemen has registered more success with approaches that decentralize water resources management to local areas and communities and give incentives to greater water efficiency through subsidies to water-conserving infrastructure (in-field pipe distribution, hydrants, pressurized irrigation) and which advise on water management and irrigated cropping. Supply side measures like aquifer recharge enhancement, rainwater harvesting and urban wastewater reuse increase incentives.

A similar approach has been successful in Egypt, for example at Salhiya in the East Delta where a local groundwater association established a common management system and invested in a piped network, and now manages the aquifer sustainably. [World Bank 2006a: 110]

Options thus include both top-down and bottom-up approaches – or a blend

Problems and solutions on groundwater depletion are discussed in full in Chapter 3 below (Section 3.4), and next steps are assessed in Chapter 4 (Section 4.2). In practice, options for NENA countries are:

- a rights and regulation approach;
- changing the incentive structure to favour conservation and efficiency;
- decentralizing groundwater resource management to the local level;
- The use of evapotranspiration remote sensing-based water management approach.
- complementary supply-side measures to increase water availability; and
- monitoring, information, education and communication. [World Bank 2006a: 108-114]

2.6 The incentive framework for promoting water efficiency and water productivity in agriculture

NENA countries have long recognized the need for demand management in irrigation through adjustment to the incentive structure to encourage water conservation and more efficient use

Policy analysis in recent years has pointed to the role of the incentive structure in promoting over-use and inefficient use of water in irrigation. A recent study lists four 'perverse incentives for excess irrigation': barriers to imports, domestic price support, subsidized credit and energy subsidies, and then goes on to document how the irrigation incentive structure in most NENA countries practices all four of these perverse incentives – and in only two NENA countries where irrigation is important are *any* of these distortions absent[10]. NENA countries have therefore long recognized the need to adjust the incentive structure in irrigation to encourage water conservation and more efficient use. This section looks at three components of the incentive structure where there has been progress in NENA – but where there is scope for further steps: (i) irrigation water pricing; (ii) protection of domestic production; and (iii) energy subsidies. [World Bank 2006a: 13]

Irrigation water pricing

'Best practice' would suggest water prices should reflect scarcity and opportunity cost…

A best practice principle within IWRM is that the price of water should reflect not only its production cost but also its value in alternative uses. This would mean, for example, that water that could be switched from agricultural use to satisfy industrial demand should be priced to farmers at the margin at the price that industries are prepared to pay for it.

…but this does not happen in practice except in private water markets

In the cases where functioning intersectoral water markets exist – for example, the rural-to-urban water sales in Yemen or Jordan – this pricing mechanism works automatically[11]. However, no NENA government has considered adopting scarcity or opportunity cost for irrigation water pricing, on the grounds that water has been allocated to agriculture and prices should reflect only production costs within that sector. In the case of private irrigation, particularly private groundwater irrigation, this has resulted in prices of water considerably below economic levels, notably where water is scarce and/or nonrenewable. This under-pricing has promoted over-use.

NENA governments have generally sought to recover management, operation and maintenance costs (MOM) and sometimes a share of the capital costs

On publicly managed schemes, NENA governments have concentrated their approach on covering costs, normally only MOM costs, although in some cases a land betterment charge or a fee to cover costs of rehabilitation has been levied. [World Bank 2007a: 71-72]

…and there is a shortfall on many schemes, which limits autonomy and may impair services

Since 1984, Morocco has operated volumetric tariffs linked to supply costs. Tunisia also operates a volumetric tariff system. In 1996, following a lengthy study of the costs of providing irrigation water in the Jordan Valley, Jordan introduced a block tariff system designed to cover costs. None of these approaches have yet arrived at full coverage of MOM costs and hence no NENA irrigation scheme has achieved the financial autonomy that would come from full coverage of MOM by farmers. Either governments continue to subsidize, which reduces the benefits of decentralization and allows central government to continue to dictate, or MOM is underfunded.

10 Only Iraq does not set barriers to imports, and only Lebanon does not offer subsidized credit.

11 Although prices do not necessarily reflect resource cost.

Not recovering costs also limits the scope for private sector participation

The shortfall in cost recovery has also reduced the scope for public/private partnership (PPP) in irrigation. Only on the Guerdane perimeter in Morocco has a PPP project become operational – and then only in the circumstances of heavy government capital subsidy and well-off commercial fruit farmers.

Protection of domestic production

Protection still keeps farm gate prices high in many countries, distorting incentives

Protection of domestic cereals production or direct price support to local cereals production encourages the use of water for lower value cereals cultivation. One striking example has been KSA where domestic production of wheat has been procured at three times the import parity price or more. Recognizing the economic cost of this policy, several countries where there are alternative higher-value crops that could profitably be produced using the same water have reduced or eliminated barriers to cereals imports or phased out price support to cereals in recent years. In addition, the rise of cereal prices globally in recent years has made domestic production more competitive. Nonetheless, import controls and price support persist across the region; while phasing them out would improve incentives to water productivity in agriculture (USD per drop). Food security concerns often prevail to argue for maintaining the existing incentive framework [World Bank 2007a: 13].

Energy subsidies

Cheap energy prices have driven groundwater depletion in several countries

In many NENA countries, energy subsidies have made it cheaper to pump water, and this has improved the financial profitability of both surface water lift pumping for irrigation and of groundwater abstraction. This has contributed to the decline of nonrenewable groundwater reserves in some locations. The most extreme examples are in the Arabian Peninsula where, at current rates of abstraction for agriculture, groundwater in the supply areas of two national capitals (Riyadh and Sana'a) will run out in the next two to three decades at most.

Adjusting the entire incentive structure

Adjusting the incentive structure requires careful balancing of trade-offs

Often the incentive structure is highly complex and comprises elements from not only the agriculture sector and water sector policies but also elements of broader macro-policy. Apart from national food security considerations, in KSA, for example, adjustment was required on a number of levers in order to reduce incentives to over-use of water in agriculture and to reallocate water to higher-value crops (see Chapter 3).

Next steps are discussed in Chapter 4 (Section 4.2). They could begin with a region-wide review of the components of incentive structures for agricultural water use, and of the results from adjustments – what happens when the incentive structure is changed?

Chapter 3

Water efficiency and crop water productivity in agricultural water management in NENA

Main messages

This chapter reviews each of NENA's agricultural water management systems in turn and asks the questions: *How efficient are they, and how can productivity be boosted*?

Overall, water efficiency and crop water productivity are relatively high in NENA, as expected in so arid a region. There is, nonetheless, considerable scope for further increase.

NENA performance on surface irrigation is at the higher end of the global range but can be raised further by improving the flexibility, equity and reliability of water service, by in-field intensification to raise crop water productivity, and by further modernization of both infrastructure and institutional arrangements.

Pressurized irrigation has proved efficient and profitable, although costs and risks are relatively high. Governments could help farmers, particularly poorer ones, to overcome barriers to entry and to manage risks.

Groundwater is a bountiful resource but overuse has led to widespread depletion. Technical and economic measures can help manage demand but institutional measures are needed to develop groundwater governance for sustainability.

Rainfed agriculture is the predominant farming system in NENA. New technology, investment and institutional adaptation are needed to raise productivity and to help farmers adapt to climate change.

Watershed management has worked where approaches have been participatory and conservation techniques have been profitable to farmers. In the dry and degraded lands, water is the vital input for forestry, for livelihoods and for anti-desertification. Successful models of watershed management have been tested. The challenge is scaling up.

Drainage has been the poor relation to irrigation, yet both drainage and reuse of drainage water have proved to be low cost ways to boost productivity.

Chapter 2 discussed the overall management of water resources and the policies and institutions that guide efficient allocation of water to agriculture and the incentive framework that motivates farmer behaviour. The present chapter looks at how water service providers and farmers manage agricultural water for maximum efficiency and productivity.

The first section (3.1) discusses the relevant measures: measures of efficient water service – water efficiency and irrigation efficiency – and measures of water productivity – physical crop water productivity and economic crop water productivity.

The following sections then assess a range of agricultural water management systems: larger-scale surface irrigation and the challenge of modernizing systems to improve irrigation efficiency and crop water productivity (3.2); pressurized irrigation (3.3); groundwater irrigation (3.4); rainfed agriculture (3.5); and watershed management and drylands agriculture (3.6). A final section reviews issues of salinization, waterlogging and drainage and drainage water reuse (3.7).

3.1 Water efficiency and crop water productivity

Water efficiency (WE) is here defined as the proportion of water consumed through plant transpiration (and so contributing to to plant growth) over the total water applied[12]. It is a dimensionless ratio, often expressed in percentage.

Crop water productivity (CWP) is here defined as the production per unit of water transpired or 'crop per drop'. The simplest measure is kg/m^3 transpired (***physical CWP***), but another meaningful measure is net income per unit of water transpired (USD/m^3 or ***economic CWP***).

There are three broad ways to improve water efficiency and crop water productivity

In broad terms, agriculture has three options for improving the efficiency and productivity in a specified domain:

- Increase the efficiency of water use by reducing non-beneficial consumptive water uses and non-recoverable non-consumptive water uses;
- Increase the productivity of water use via measures that increase, for example, crop yields;
- Reallocate water from low to higher value uses.

Box 3.1 Different perceptions of water efficiency (Knox et al, 2012)

For many (possibly most) farmers, concepts of water efficiency are linked to maximising the farm's economic productivity rather than saving water, except perhaps when their own allocated resources may be inadequate. As a consequence, using financial criteria for water efficiency rather than engineering criteria appears to be a sensible approach when assessing irrigation performance at the farm level, since any managerial (e.g. scheduling) and operational (e.g. equipment) inefficiencies associated with irrigation are implicitly included in the assessment. Hence, the concept of catchment or basin level irrigation efficiency is largely irrelevant to most farmers. Instead they aim for best (or reasonable) use of a potentially limited water supply, aiming not to over or under irrigate, whilst minimising any non-beneficial losses. This is often described as 'applying the right amount of water at the right time in the right place'. Any water 'saved' would be allocated to additional crops. In contrast, water regulatory authorities whose prime objective is to balance the water needs of all abstractors (including the aquatic environment) generally view increasing water efficiency as a means of saving water and promoting environmental sustainability.

Reducing apparent water losses may recover much less water for other uses than expected

Excessive emphasis is often placed on the first option, with efforts aimed at reducing water 'losses' from water supply or distribution systems (FAO, 2011). In many contexts, the scope for and impact of water loss reduction is limited because only part of the water 'lost' is non-recoverable either within or outside the specified domain. Field studies, functional analysis and modelling can be used to: (1) measure or estimate the volume of non-consumptive water use that is non-recoverable in space and time and (2) provide the input data for calculating water productivity at different temporal and spatial scales

Increasing productivity with respect to water can be achieved throught improved water control, soil management and agronomic practices and is a high potential option

In most cases, the single most important avenue for managing water demand in agriculture is through increasing agricultural productivity with respect to water. Yield increases can be achieved through improved water control, improved land management and agronomic practices. This includes the choice of genetic material, and improved soil fertility management and plant protection. It is important to note that plant breeding and biotechnology can help by increasing the harvestable parts of the biomass, reducing biomass losses through increased resistance to pests and diseases, reducing soil evaporation through vigorous early growth for fast ground cover, and reduced susceptibility to drought. Therefore managing overall demand through a focus on water productivity rather than concentrating on the technical efficiency of water use alone is an important consideration (FAO, 2012a).

Reallocatin from lower to higher value crops is also a good choice - but may face technical,, financial and market challenges

If productivity is considered in terms of added value and not production, reallocating supply from lower value to higher value crops is an obvious choice for farmers seeking to improve income levels. For this to happen, changes are required in both the management and technology associated with irrigation to

12 This measure, just one of several ways to express water efficiency, is sometimes called, in the opaque lexicon of specialists, 'effective efficiency'. [IWMI 2007: 139]

provide farmers with a much higher level of control of water supply. In addition, shifts to higher value crops also require access to inputs, including seeds, fertilizers and credit, as well as technology and know-how, and reasonable conditions to operate in much more competitive market conditions. However, in practice, not all farmers are able to make this choice since the market for higher value crops is limited compared with the market for staples.

Another means of improving water efficiency and productivity is to limit or cap the water available to farmers. This often has the result of encouraging farmers to seek out opportunities that improve efficiency and/or productivity. Ultimately, it is at the farmer level that most water is consumed. Their behaviour and their capacity to adapt can be altered by incentives such as improved reliability and increased flexibility of water supply.

Water efficiency (WE)

Despite generally high WE in NENA, there is still scope for improvement in many situations - but costs rise steeply at the margin

There is very little monitoring data available for comparison or benchmarking. In practice, subsidiary component indicators easier to measure tend to be used, and each has its value. The two most common are: the consumptive fraction (total water consumed through evaporation and evapotranspiration divided by total abstractions), and irrigation efficiency (total water delivered to the farmer divided by total abstractions).

Globally, the consumptive fraction in irrigated agriculture averages about 59 percent. Efficiency can be increased to 70 percent or beyond, and in the case of protected agriculture or drip to almost 100 percent. However, in open irrigation, going beyond 70 percent could lead to salinization and pollution, especially if leaching is ignored.

In open channel surface irrigation, irrigation efficiencies of 40-50 percent are usual, but efficiency can reach 70 percent or more with lined canals, more with closed pipe irrigation. However, low irrigation efficiency does not necessarily mean a low consumptive fraction, as water not transpired by the plant may not be lost through nonbeneficial evaporation: it may return to the system as canal seepage or as drainage water and be available for reuse downstream within the basin. In Morocco, the water accounting case study conducted as part of the Regional Initiative on Water Scarcity found that about 35 percent of water supplied to irrigation was 'lost' but of that between 22 and 34 percent were potentially reusable[13] [IWMI 2007: 119, 295].

The objective of irrigation and agricultural water management is to increase WE to the maximum whilst taking account of the cost of improvement at the margin. WE can approach 100 percent with drip irrigation in greenhouses, but drip irrigation may be more expensive than open field furrow irrigation, particularly in terms of operating costs. Therefore, the cost per m^3 transpired has to be set alongside the WE as a performance indicator.

WE can be improved by improving water service to the field through minimized canal losses, timely delivery, correct quantity and quality, all areas served including the tail end; and by in-field water management, conveying water efficiently to the plant root zone at the right time and in the right quantity and minimizing nonproductive evaporation from the field. The Regional Initiative Case Study for Morocco found that improved water service and in-field water management could improve irrigation efficiency on average by 25 percent. Box 3.2 shows how investment in modern water savings in Tunisia increased the efficiency of water service to the field and in-field water management, and so improved irrigation efficiency.

Crop Water Productivity (CWP)

There is a range of soil, crop and water management options to improve CWP in NENA - but again cost-benefit ratios are critical

As indicated above, CWP can be improved by soil, crop and water management. Parameters include:

- crop and varietal choice to provide increased yield per unit of water consumed or to consume less water;
- soil and water management to promote soil fertility and reduce salinity;
- land preparation, including soil moisture conservation through zero or minimum tillage;
- using deficit, supplemental or precision irrigation, especially when combined with other management practices;
- improving irrigation water management to reduce stress at critical moments in crop growth;
- nutrient management;
- lessening nonproductive water consumption (evaporation) by mulching, enhancing soil infiltration and storage properties, enhancing canopy cover, subsurface drip irrigation, matching planting dates with periods of less evaporative demand;
- weed and pest management; and
- harvest and post-harvest management. [IWMI 2007: 301, 280]

Again the costs of inputs and husbandry in relation to benefits at the margin are relevant, as well as the calculation of risk. A very high input crop may not yield the highest financial return to water. It might, therefore, have a high physical CWP but a lower economic CWP.

13 FAO 2014a: Regional Initiative on Water Scarcity - Morocco Country Paper*: 25, Table 2*. For the water accounting exercise, see the Introduction to this paper.

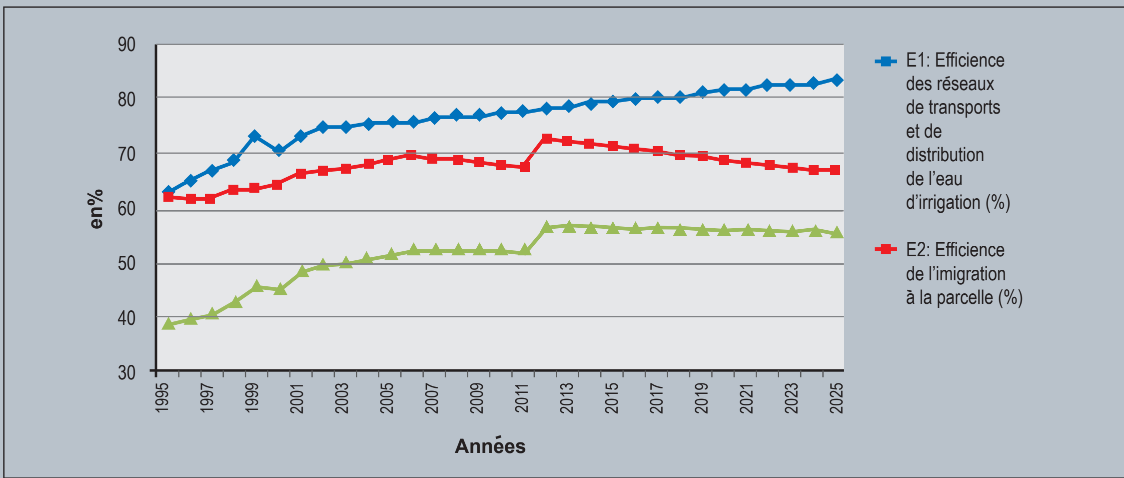
There is a key role for technology development to increase CWP. Plant breeding and biotechnology can develop planting material to increase the harvest index and strengthen drought and pest resistance, or to allow earlier planting or maturing or extend the growing period, etc.

Box 3.2: In Tunisia, water efficiency and crop water productivity are boosted by modern irrigation

In Tunisia, the current average water demand per hectare actually irrigated is estimated at 4 500 m^3, varying depending on the crop and climatic zones from 1 000 to 2 000 m^3/ha for cereals and fodder in the north up to 15 to 20 000 m^3/ha for date palms in the oases of the south.

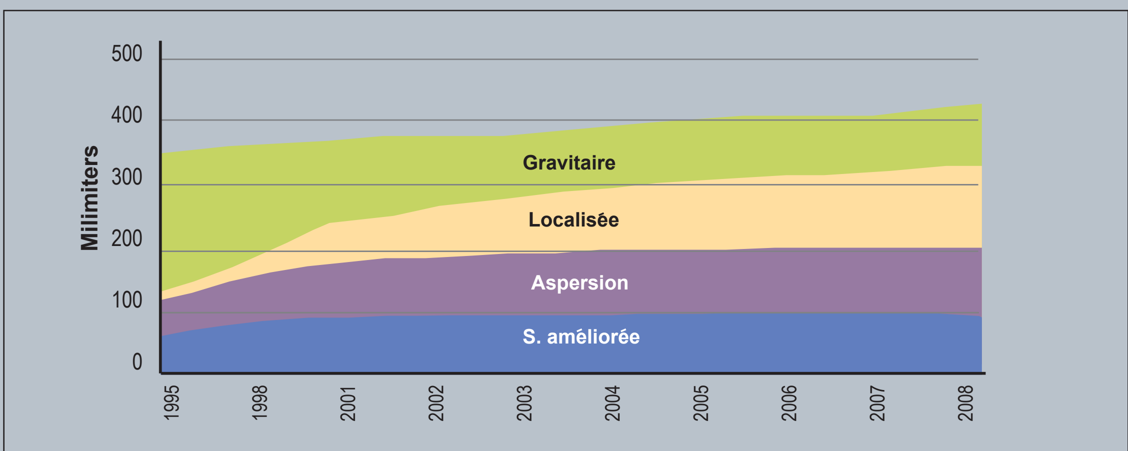
Irrigation efficiency (water arriving at the field divided by total abstractions) varies from 60 percent for older gravity systems to 90 percent for modern pressurized systems, with a nationwide average of 80 percent (up from 60 percent 20 years ago). In-field efficiency averages 72 percent (in 2012), ranging from 50 to 60 percent for traditional gravity irrigation to 80 to 90 percent for localized irrigation. Average water consumption for tomatoes dropped from 7 275 m^3/ha in 1995 to 6 100 m^3/ha today, and for potatoes from 4 763 to 4 075 m^3/ha.

Tunisia: Improvements in water conveyance efficiency and in-field efficiency



Currently about 374 000 ha – 77 percent of the irrigated area – are equipped with modern water-saving technology, including 135 000 ha under drip (22 percent), 112 000 ha under sprinkler (27 percent) and 98 000 ha uner improved surface irrigation (28 percent) . The spread of drip irrigation has been particularly rapid (see chart below).

Tunisia: Development of water-saving irrigation technology 1995-2009



Average productivity of water for cereals varies between 0.88 and 1.5 kg/m^3 for crops grown in semi-arid and sub-humid lower Tunisia. Irrigation produces much greater water productivity and lower interannual variations.

Source: FAO 2014b: Regional Initiative on Water Scarcity - Tunisia Country Paper: 6-7, 33-35

Available information suggests that there is everywhere scope for improvement in CWP

Although growing conditions and farming systems vary enormously around the world, available information suggests that there is everywhere scope for some improvements in CWP. Table 3.1 below shows that physical crop water productivity varies between and within locations and systems by factors of from 2 to 10, and economic crop water productivity varies by factors of from 2 to 8. The table also shows that there is a huge variation between crops in CWP, with cereals and legumes providing relatively much lower economic CWP than vegetables and fruits.

Table 3.1: Physical and economic crop water productivity ranges for selected crops

Crop	Assumed price (US cents/kg)	Physical CWP (kg/m^3)	Economic CWP (US cents/m^3)
Wheat	20	0.20-1.20	4-30
Rice	31	0.15-1.60	5-18
Maize	11	0.30-2.00	3-22
Lentil	30	0.30-1.00	9-30
Faba bean	30	0.30-0.80	9-24
Potato	10	3.00-7.00	30-70
Tomato	15	5.00-20.00	75-300
Onion	10	3.00-10.00	30-100
Olive	100	1.00-3.00	100-300
Date	200	0.40-0.80	80-160

Source: Based on IWMI 2007: 292 Table 7.3

…and in NENA there is some scope for improvements in both physical and economic crop water productivity

In order to assess the scope for improving CWP in NENA, some benchmarking is needed. Limited work has been done on this, but what there is discussed later in this chapter (Section 3.2). In general, in a water-scarce region like NENA, physical CWP is already quite high but with scope for improvement, particularly in progressive conversion to pressurized irrigation and protected agriculture to improve WE and physical CWP, and in switch to higher-value crops to improve economic CWP.

Chapter 4 (Section 4.3) summarizes issues on water efficiency and water productivity, and proposes a specific agenda, including actions at both country and regional levels.

3.2 Surface irrigation: increasing WE and CWP through modernization

The NENA region has practiced irrigation for more than five millennia, and constant improvements have made irrigated agriculture highly productive

The NENA region pioneered irrigation even before history began, and NENA's earliest civilizations were founded on the people's skill in harnessing water for productive agriculture. Improvements in technology and management have been continuous since then, and today irrigated production in NENA can boost yields per hectare by up to four times compared to rainfed production. In one study on a 100 000 ha scheme in Morocco, irrigated yields for wheat, faba beans and sugar beet were more than twice as high as rainfed yields – and four times as high in the case of maize (see Table 3.2). The case for irrigated cultivation is technically very strong. The main constraints are water availability and economic viability.

Table 3.2: Irrigated versus rainfed yields measured at Doukkala 2010/2011

	Area on which measured (ha)	Average irrigated yield measured (tonne/ha)	Average rainfed yield measured (tonne/ha)	Irrigated/rainfed
Wheat (winter)	78 700	3.87	1.75	2.2 times
Faba bean (winter)	17 500	3.96	1.67	2.4 times
Sugar beet (winter)	7 100	51.94	23.26	2.2 times
Maize (summer)	6 700	4.71	1.10	4.3 times
	110 000			

Source: WaterWatch 2011

This section discusses ways in which water efficiency and crop water productivity can be improved on NENA's larger surface irrigation systems. These account for some 20 million ha, 85 percent of the total irrigated area. Hence, improvements on these larger schemes would have a considerable impact on production and incomes.

Comparing NENA irrigation with global performance

<u>Recent benchmarking studies show that NENA schemes are relatively efficient overall at delivering a timely, quality water service</u>

In a series of recent studies, FAO worked with country teams to measure performance on seven NENA irrigation schemes and to compare that performance with a sample of 50 schemes in other regions of the world. The schemes included both surface water diversion schemes and groundwater-based schemes, and included both pumped and gravity fed systems. Scheme size varied from 362 ha to 96 000 ha. Overall, results were comparable across all types and sizes of scheme. The NENA schemes examined were: Morocco Doukkala; Jordan Valley; Syria Monshahat; Egypt Mit Yazid; Iran Dez; Tunisia Ain Bou Marra; and Lebanon Dardara.

NENA irrigation infrastructure and operating systems generally compare favourably with those elsewhere

The studies found that NENA irrigation infrastructure and operating systems are generally good, and 'far better than those found elsewhere'. Unsurprisingly, modernized schemes were found to do better, although it took time for modernization improvements to bring tangible results. At the Iran Dez scheme, for example, all parameters improved after modernization but only gradually over a ten-year period.

Water delivery service is rated higher in NENA than elsewhere at all levels of the system

The studies found that, measured against criteria of flexibility, reliability, equity and control/flow, water delivery service at all levels of the system was more efficient in NENA than elsewhere. At lower levels (lowest level operated by a paid employee, and at the individual farmer level) performance was somewhat less strong, a fall off attributed to loss of control and lack of flow measurement.

In addition to specific factors, the overall political environment, management and staff competence were found to be factors affecting performance

The studies found that a good political environment and strong scheme management made a difference. Staff quality and development were also key factors in the higher levels of staff productivity, which were more than 50 percent higher in NENA than globally. With average staffing density for canal systems of 165 ha/staffer, and for pressurized systems of 68 ha/staffer, NENA schemes were well below comparator staffing densities. NENA schemes are certainly not bloated. [CIHEAM/FAO 2013: 14]

<u>Generally good water service translates into yields/ha and yields/m^3 which are well above global averages</u>

On NENA schemes, land productivity was found to be high compared to irrigation systems in other regions

The studies found that the median value of production for NENA was USD 4 071/ha against a global median of USD 1 400/ha. Analysis showed that the reason was that NENA production systems are more intensive and a higher proportion of high-value cash crops is grown. NENA schemes are thus achieving high land productivity.

Physical crop water productivity is at the high end of the global range

For specific crops, physical crop water productivity (kg/m^3) on one scheme in Morocco compared well with the global average (see Table 3.3). Physical crop water productivity for irrigation water was above the global average for wheat, and for maize towards the higher end of the global range. Crop water productivity for faba bean was above the top end of the global range. The results suggest that NENA schemes are relatively water-efficient, with the corollary that further gains will be harder to attain. However, there were considerable variations found within schemes and between schemes, suggesting potential for improvement. This view is strengthened by the existence of a considerable yield gap (see below).[14] [WaterWatch 2011; Doukkala: local study on yield gaps]

Table 3.3: Physical crop water productivity measured at Doukkala 2010/2011

	Area on which measured (ha)	Average CWP measured: all water (kg/m^3)	Average CWP measured: irrigation water (kg/m^3)[13]	Global range CWP (kg/m^3)
Wheat (winter)	78 700	0.93	1.29	0.20-1.20
Faba bean (winter)	17 500	1.08	1.47	0.30-0.80
Sugar beet (winter)	7 100	14.20	20.17	n.a.
Maize (summer)	6 700	1.18	1.44	0.30-2.00

Source: WaterWatch 2011; global range from Table in 3.1

Economic crop water productivity is almost five times that on schemes in other regions

With a median value of USD 0.47/m^3 compared to USD 0.087/m^3 for other schemes, economic crop water productivity across all systems in NENA was found in the studies to average five times that on schemes in other regions. At USD 0.85/m^3, pressurized systems in NENA achieved almost twice the median for pressurized systems globally. Comparing these figures for economic crop water productivity with the global ranges in Table 3.1 above, the NENA performance is certainly at the higher end – but with some global comparators returning well in excess of USD 1.00/m^3, there should be scope for further increases.

There is nonetheless a wide variation between schemes, particularly in overall irrigation efficiency, where the most water-scarce schemes are the most efficient

There is nonetheless a wide variation between schemes in NENA, particularly in overall irrigation efficiency. The studies found an inverse correlation between the depth of water applied and water productivity, with the most water abundant schemes having the lowest return per m^3. Similarly, the more water abundant schemes have lower overall irrigation efficiency. This suggests that the most water-scarce schemes are the most efficient. [CIHEAM/FAO: 29]

There is also wide variation in performance amongst farmers on the same scheme and a considerable 'yield gap'

A large-scale study of an area of 110 000 ha (80 percent irrigated) at Doukkala in Morocco showed considerable yield gaps under irrigated conditions (see Table 3.4 below). Average yields were well above the national average for wheat (more than double) and maize (more than four times the national average), but there were nonetheless yield gaps under irrigated conditions of between 2 and 44 percent depending on the crop. These yield gaps represent the difference between average yields and the maximum attainable yields as measured by the best actual yields recorded in the study area. There was a wide variation of yields around the average.

…which improved agricultural water management could help to close

Given that farmers, soils, planting material and crop husbandry are broadly similar throughout the Doukkala study area, most of the yield gap could be explained by differences in AWM. These findings suggest that even in a fairly intensive production system, there are many farmers who could greatly improve their productivity and close the yield gap through improved AWM, for example: (i) improved quality of water service; and (ii) better in-field water management (including conversion to pressurized).

14 One recommendation is to follow up with the *AquaCrop* model to identify why areas with lower productivity occur and what improvements could close the gaps in yield and water productivity [WaterWatch 2011:74].

Table 3.4: Yield gap measured at Doukkala 2010/2011

	Area on which measured (ha)	Average yield measured (tonne/ha)	Max attainable yield (t/ha)*	Average yield gap (%)	National average yields (tonne/ha)
Wheat (winter)	78 700	3.41	6.47	33	1.49
Faba bean (winter)	17 500	3.68	5.70	23	n.a.
Sugar beet (winter)	7 000	47.78	98.37	29	52.19
Maize (summer)	6 700	3.99	7.18	44	0.69

Source: WaterWatch. National average yields from WaterWatch: 82.
** 98 percentile value measured*

There is thus scope to improve crop water productivity (more USD for less drop)

This could include not only actions to improve system-level efficiency through infrastructure modernization and investment in software and staff but also in-field water management and agronomic choices and levels of husbandry. Strengthening control and measurement at lower levels through use of measurement devices and strengthening the quality of staff, particularly at lower levels, could improve service considerably.

Emerging constraints

Three areas where improvement is indicated but where there are trade-offs to be considered in any modernisation programme are:

<u>Empowering WUAs</u>

WUAs in NENA are considered weaker than in other regions, and more study and investment are needed to establish and develop empowered user associations

As discussed in Chapter 2 (Section 2.4), WUAs have developed throughout the NENA region as the lowest level of irrigation governance. In the cross-country benchmarking studies discussed above, although WUAs were established and functioning, they were perceived as under-performing, largely because they were not empowered in water distribution and members considered that they had little influence over real-time water deliveries. [CIHEAM/FAO 2013:22] The pathway would be to strengthen WUA capacity and empower WUAs so that they are able to influence outcomes. There is some good experience with WUAs in the region along these lines. The basic conditions for a WUA to work are well known – legal framework and mandate, empowerment, with responsibility, capacity building – and there are some NENA-specific lessons emerging – for example that larger WUAs with paid employees tend to work better. [FAO 2012b:11-13] Irrigation managers and professionals are unanimous that empowered WUAs have an important role to play in improving water service and in cost recovery. However, despite this knowledge and good practice and intentions, WUAs remain under-performing in the region, for which there must be both context-specific and socio-political reasons. While some studies and investment are indicated (see Section 4.2 below), further analysis is required.

<u>The energy/AWM nexus</u>

Energy costs are high, particularly on pressurized or lift schemes, and this makes for high operation and maintenance (O&M) costs. Investments to raise irrigation efficiency may not always be cost-effective as energy prices rise

The cross-country benchmarking studies revealed high energy consumption on nearly all schemes. This was attributed to the use of lifting and pumping on most schemes. On some schemes, overall irrigation efficiency was relatively low, and this resulted in relatively higher energy costs/m^3 as substantial quantities of water were being lifted only to go to non-beneficial uses. Here a solution would be to work to improve overall irrigation efficiencies (see Table 3.5 below on raising overall system efficiency). However, this is a scheme-specific challenge and not necessarily energy-reducing (for example, in cases where excess water would have to be pumped back up). In the case of pressurized schemes, or pressurized farms within schemes (e.g. pumping from basins), the farming becomes even more energy-intensive. The irrigation/energy nexus is likely to become a key area for trade-offs, with water efficiency becoming less viable as energy prices rise. [CIHEAM/FAO 2013: 29, 34]

Table 3.5: Raising overall system efficiency

System	Estimated overall irrigation efficiency (%)	Possible improvements
Iran Dez	30	Large savings can be made at both canal and field level.
Syria Monshahat	40	
Egypt Mit Yazid	48	Could reuse outflows downstream but this would require pumping, with consequent energy cost.
Lebanon Dardara	50	Water supply is double the design requirements. Hence, irrigation efficiency is already at its maximum.
Tunisia Ain Bou Marra	67	
Morocco Doukkala	75	Eliminate water losses along the canal. Improve field water application techniques.
Jordan Valley	100	Fully piped and pressurized system. No action.

Source: CIHEAM/FAO 2013: 29 (Table 18)

<u>Financing operations and recovering costs from farmers</u>

Scheme management, operation and maintenance are often not adequately financed, and farmer contributions are frequently too low

Policy issues on irrigation water pricing and cost recovery were discussed in Chapter 2 (Section 2.6). At the practical, scheme level, one key finding from the cross-country benchmarking studies was that recovery of the costs of scheme management, operation and maintenance (MOM), although considerably increased in recent years, was still everywhere short of what wolud be required to cover MOM. In no scheme studied was MOM fully financed, and in no scheme did farmers cover 100 percent of MOM, even though revenues were high enough for farmers to afford to pay. This resulted in lack of budget for MOM, and also in a less accountable scheme service. Even after years of study that show that full financing of MOM by farmers increases autonomy and accountability and improves scheme performance, and even after legion bruising political battles, cost recovery in NENA remains too low to finance scheme operations, leading to substandard performance. Full cost-recovery for MOM would allow schemes to be free of subsidy and hence farmers to play a full role in determining their programmes and to hold management accountable.

Yet in general, irrigation farmers' incomes in NENA are relatively high because of the higher-value cash crops grown, and incomes should allow farmers to pay full MOM costs

With median value of production for NENA at USD 4,071/ha (against a global median of USD 1,400/ha), MOM costs generally represent 10 percent or less of production revenue. Table 3.6 below shows the potential on selected regional schemes.

Table 3.6: Cost recovery on selected schemes: actual and potential

Scheme	Cost/ha	% of gross revenues assuming USD 4 000/ha	Cost/m³	Current cost recovery	Potential for full cost recovery of MOM
Morocco Doukkala	USD 144	4%	USD 0.065 (dry year) USD 0.047 (normal year)	USD 0.044/m³	O&M cost is reasonable. Full cost recovery is affordable.
Jordan Valley	USD 572 (with rehab costs) USD 236 (O&M)	14% 6%		USD 179/ha	O&M cost is reasonable (pressurized system). Full cost recovery is affordable.
Syria Monshahat	USD 392	10%		USD 78/ha	O&M cost is high as 80% is for energy. Nearby groundwater farmers pay pumping costs of USD 485/ha.
Egypt Mit Yazid	USD 46 (MOM) USD 129 (MOM + rehab and modernization)	1% 3%		n.a.	O&M cost is very reasonable. Full cost recovery is affordable.
Iran Dez	USD 96	2%		USD 92/ha	O&M cost is reasonable Full cost recovery is affordable

Source: CIHEAM/FAO 2013

Planning for irrigation modernization

Modernization packages should integrate physical, economic, institutional and agronomic improvements

Each scheme is different and work is required at the scheme level to define modernization objectives and to draw up modernization programmes. Modernization must comprise both hardware and software. Integrated rather than single solution approaches are needed, incorporating physical improvements to the delivery system, along with economic, institutional and agronomic improvements. Given NENA's existing high levels of efficiency and in the light of experience with modernization to date, the following package contains most of the elements likely to be appropriate for modernization of a NENA scheme. [CIHEAM/FAO 2013: 34ff; World Bank 2006a: 157]

1. *Raising water efficiency by improving the flexibility, equity and reliability of water delivery services. This could include:*
   - infrastructure investments in gates and control structures, lining of canals, construction of interceptor canals and reservoirs;
   - modern information and control systems like the supervisory control and data acquisition (SCADA) system that permit monitoring of actual deliveries to farms and comparison with target deliveries, and allow sharing of data with farmers, to ensure equitable and predictable service, and ultimately permit a volumetric tariff schedule;
   - implementation of rotational delivery schedules with variable intervals rather than a fixed rotation; and
   - (on piped systems), higher-frequency deliveries on demand to permit sprinkler or drip irrigation.
2. *Improving water productivity.* This could include:
   - encouraging investments in improved irrigation technology and improvements in better on-farm water management; and
   - encouraging investments in crop intensification and diversification and improvements in crop husbandry.
3. *User participation in modernization strategy, system management and full cost-sharing.* This would be targeted at achieving improved system performance, service-oriented management and financial self-sufficiency, and could include:
   - development of effective, empowered and self-sufficient WUAs at different levels in the system that could take part in water distribution and influence the quality of water service; and
   - full cost-sharing that would allow the scheme to be free of subsidy and hence farmers to play a full role in determining its future. [FAO 2012b:13]

Elements for an action plan

Modernization measures could focus on eight sets of investments

Again, all schemes differ and modernization measures need to be identified at scheme level. Box 3.3 below describes the Mapping System and Services for Canal Operation Techniques (MASCOTTE) tool that can help identify the required measures. Modernization measures could focus on eight sets of investments: [CIHEAM/FAO 2013: 35]

1. Upgrading of physical infrastructure to improve water services and irrigation efficiency.
2. Measurement, control and monitoring of system operation and of irrigation delivery services, including: installation of measurement devices; and procedures for service monitoring, water accounting and volumetric tariffs.
3. Accountable contracting for water service, with special reference to flexibility and equity.
4. Establishment or strengthening of empowered WUAs, with powers to influence water distribution scheduling and the quality of water service, and with responsibility for covering MOM.
5. Capacity building for managers, operators, WUAs and farmers, through the whole chain from diversion down to field application.
6. Increasing water efficiency to convey water to the plant roots more efficiently (including moving to pressurized and drip irrigation, provided that the energy bill is not too high.
7. Improving yields per m^3 of water consumed by providing irrigation advisory and extension services to farmers and other means to improve irrigation water management and crop husbandry by managing cropping patterns, farming practices, input costs and marketing to increase incomes and employment per m^3 consumed.
8. Introducing systematic periodic benchmarking.

Issues on irrigation modernization are summarized in Chapter 4 (Section 4.3), together with suggested actions at both country and regional levels.

Box 3.3: Mapping System and Services for Canal Operation Techniques (MASSCOTE)

MASSCOTE has been developed by FAO from the rapid assessment and benchmarking tools elaborated by Burt and Styles in 1999 (FAO/IPTRID/World Bank) to provide a complete evaluation of external and internal performance indicators and help with design of practical modernization programmes.

MASSCOTE organizes project development through an iterative process based on 11 successive steps in a sequence:

- Mapping system characteristics, the water context and the actors that affect management
- Delimiting manageable subunits
- Defining a strategy for service and operation of each unit
- Aggregating and consolidating the operating strategy at the main system level

The 11 steps include five designed to collect baseline information:

1. Rapid assessment of current performance
2. Assessing the capacity and sensitivity of the system
3. Analysing perturbations
4. Assessing the hierarchy of the infrastructure networks and the water balance
5. Mapping the costs of MOM

The six subsequent steps are to develop a vision and help with planning for system modernization:

6. Mapping and economic analysis of services to be provided to users
7. Dividing the system into discrete management units
8. Assessing the resources, opportunities and demand for improvements
9. Identifying the improvement options for each management unit
10. Integration of the preferred options at system level
11. Finalizing a modernization strategy and a capacity building plan, and monitoring and evaluation (M&E) arrangements

The following specific modules have also been incorporated in MASSCOTE:

- MASSLIS: for lift irrigation systems
- MASSMUS: where there are multiple uses of water in the command area
- MASSFISH: where fisheries are associated with irrigation
- MASSPRESS: for pressurized irrigation systems

Applying MASSCOTE in NENA

MASSCOTE was applied to selected irrigation systems in seven NENA countries, 2007-2012. FAO and the International Centre for Advanced Mediterranean Agronomic Studies-Mediterranean Agronomic Institute of Bari (CIHEAM-MAI Bari) worked with local teams, typically involving about 20 local engineers and staff over a period of two weeks per scheme, to measure performance on seven NENA irrigation schemes and to compare that performance with a sample of fifty other schemes in other regions of the world.

3.3 Pressurized irrigation and high-value agriculture

NENA is a global leader in pressurized irrigation

In the last two decades, farmers worldwide have adopted pressurized and micro-irrigation – drip and sprinkler. Currently, about 1 percent of the worldwide irrigated area is under drip, and about 4 percent under sprinkler. Development has been much faster in the very dry and water-scarce countries of NENA, where about 6 percent of the irrigated area (1.4 million ha) is under drip and about 7 percent (1.7 million ha) under sprinkler (Table 3.7). The 1.4 million ha of drip irrigation in NENA countries represent about 40 percent of the global total of 3.2 million ha. In the region, Iran (420 000 ha) and Egypt (220 000 ha) are the largest drip irrigators, and Saudi Arabia (720 000 ha) and Iran (280 000 ha) are the largest sprinkler irrigators. Two-thirds of Jordan's irrigated area has been converted to pressurized irrigation.

Table 3.7: Key facts on pressurized irrigation in NENA

Drip	Sprinkler
Drip irrigation: about 1.4 million ha across NENA, 6 percent of the total irrigated area, with five NENA countries having more than 100 000 ha equipped: • Iran: 420 000 ha • Egypt: 221 000 ha • UAE: 195 000 ha • KSA: 198 000 ha • Syria: 111 000 ha	Sprinkler irrigation: about 1.7 million ha across NENA, 7 percent of the total irrigated area, with five countries having more than 100 000 ha equipped: • KSA: 716 000 ha • Iran: 280 000 ha • Egypt: 172 000 ha • Syria: 187 000 ha • Morocco: 152 000 ha

Source: AQUASTAT

There are many advantages to pressurized irrigation

Drip is often used in greenhouse agriculture but also in open field irrigation for vegetables (often with plastic tunnels) and for tree crops. With appropriate management, drip irrigation can increases water efficiency to as high as 90-100 percent, as little or no water is lost either to seepage and percolation or to non-beneficial evaporation. Drip also increases economic water productivity as it allows a shift to higher-value crops. It also allows savings on inputs (for example through fertigation, where fertilizer is applied mixed in with the dripped irrigation water) and on labour, as fewer workers are required to open and close gates etc. In Yemen, conversion of open channels to pressurized hydrants allowed farmers to reduce labour inputs by half. It also does not require the land levelling that conventional irrigation does, and allows cultivation of lower quality lands, including hilly, sandy and rocky lands. [Abou-Hadid 2012: 60, 116]

Box 3.4: Rapid adoption of drip irrigation technology for high-value crops in Jordan

Water shortage in the Jordan Valley is extreme, and demand management measures have long been practiced, including irrigation water quotas and a step tariff that penalizes excess water use. However, farmers also have profitable market outlets for high-value fruit and vegetables. As a result, about two-thirds of the farmers in the Valley have shifted from surface to drip irrigation over a ten-year period. Farmers have constructed on-farm storage reservoirs to provide the flexibility required for drip irrigation.

Source: Author; World Bank 2006a:165

However, pressurized irrigation also leads to higher levels of cost and risk and to vulnerability to energy prices

Depending on the system, capital costs can be very high, as much as USD 5 000/ha and more. The O&M costs are also high, particularly energy costs. Pressurized irrigation requires a readily available water source. It is best suited to groundwater, which is reliable and clean (and so does not clog the emitters on drip systems). Using pressurized irrigation where water is being supplied by canals on a scheme is more problematic, as water may not be available when required. Many farmers have overcome this constraint by constructing on-farm water storage. This relatively hi-tech system requires skills to get the best out of it, and it requires a supply chain for equipment, parts and maintenance. Perhaps most importantly, the investment will only pay good returns if there are profitable ready markets for higher-value produce. Overall, pressurized irrigation, in the conditions of NENA, is a first-rate technical solution, but it is dependent on the existence of profitable market outlets, and vulnerable to market risks and price variability.

Options for future development

Interventions may be needed to reduce barriers to entry

The entry cost is typically high, so that adoption is constrained, and poorer people are excluded. Options may be to encourage the development of lower-cost technology (see Box 3.5), and to consider programmes to improve the efficiency of the supply chain (for example, training of stockists). Programmes to make credit available through hire purchase, leasing or micro-finance may help. Capital cost sharing, possibly targeted to poorer farmers, may also be an option: ***Plan Maroc Vert***, for example, provides a 50 percent cost sharing on adoption of pressurized irrigation (see Box 3.6 on Doukkala below).

Box 3.5: Irrigation subsidies slow down adoption of drip technology

Drip and sprinkler technologies were aggressively promoted in India since the mid-1980s; yet, after two decades, the area under them was only 60 000 ha. A big part of the problem was subsidies that, instead of stimulating the adoption of these technologies, actually stifled their market. Subsidies have been directed at branded, quality-assured systems, but in the process have not allowed viable, market-based solutions to mature.

Subsidies are channelled through the big irrigation equipment companies. Their equipment typically costs USD 1 750/ha, which puts it out of reach of most farmers – apart from the few that manage to access the subsidy programmes.

Fortunately, a grey market of unbranded products began to offer drip systems at USD 350/ha. Then, one innovative manufacturer introduced a new product labelled 'Pepsi' – basically a disposable drip irrigation system consisting of a lateral with holes. At USD 90/ha, Pepsi costs a fraction of all other systems.

Source: World Bank 2006a:136, van Steenbergen 2002

Interventions may also be needed to ensure profitable market outlets

For pressurized irrigation to be viable, there must be access to profitable markets. Moving to higher input agriculture, farmers face increased market risk and there may be scope for developing market risk management instruments – price information, promoting increased competition among buyers, promotion of cooperative marketing institutions, storage to allow sales to be spaced out, outgrowers contracting, etc.

Research may develop packages that can help farmers manage risk

Cropping patterns must balance profit and risk management. For example, on one scheme in Morocco, farmers converted to drip irrigation and opted to grow sugar beet because they could get advances on inputs and a sure price. However, as they needed cash in the house to live on and with the beet they had to wait until after delivery to get their money, they also grew fodder which had a lower return but which could provide a regular short term income. [FAO 2012a]

Chapter 4 (Section 4.3) summarizes issues and options on pressurized irrigation and suggests an agenda for action at both country and regional levels.

Box 3.6: Helping small farmers convert to drip on Morocco's Doukkala scheme

Morocco's Doukkala scheme (96 000 ha) is experiencing water shortages, and has received in recent years only 50-60 percent of the designed supply. To eke out the reduced quantity of water, larger farmers introduced drip irrigation on 2 500 ha. Smaller farmers were excluded as they could not afford it. The Government therefore implemented a project (2009-2010) to test the conditions under which drip irrigation could be adopted profitably by smaller farmers.

The approach was to group farmers with a total of about 40 ha of land holding around a storage basin and to train and accompany these farmers in the installation and operation of drip irrigation. The management agency, *Office Régional de Mise en Valeur Agricole de Doukkala* (ORMVAD), was contracted to supply a specific quantity of water at set intervals. The approach was tested and evaluated on four pilot sites, with technical options adapted to each. Results on the positive side were:

- diversification of cropping patterns away from lower value cereals and fodders to higher-value horticultural and industrial crops;
- more intensive land use, including more double cropping in summer thanks to water stored in the storage basin;
- reduction in water consumption by 30-50 percent;
- increased return per m^3 of water, with a gross margin per m^3 amounting to > Moroccan Dirham (DH) 8/m^3 (equivalent to USD 1.00/m^3), compared to the average for the whole scheme of DH 5/m^3 (equivalent to USD 0.57/m^3). One site was getting even higher returns of DH 13/m^3 (USD 1.50/m^3) for tomatoes and DH 18/m^3 (USD 2.07/m^3) for sugar beet; and
- WUA were well organized and were motivated to prompt payment of water charges, as water supply was conditional on this.

In farmers' eyes the negative side was increase in costs:

- the cost of water went up to DH 0.7/m3 (USD 0.08/m3) from DH 0.3/m3 (USD 0.03/m3). Including the cost of equipment, the cost of water came to an average DH 1.28/m3 (USD 0.19/m3); and
- high cost of energy – DH 0.32/m^3 (USD 0.04/m^3) – although this varied between sites and better water management could reduce it.

Lessons

- It is possible to help small farmers convert from open channel irrigation to pressurized irrigation if a package of technical and marketing support is offered.
- In view of the high capital costs, some cost sharing is essential. In this case, Plan Maroc Vert gave 50 percent capital subsidies.
- The irrigation agency ORMVAD proved capable of reorienting itself towards groups and basins, and was able to ensure reliable water services.
- As the technology is quite demanding, introduction of pressurized irrigation has to be in close collaboration with farmers, with good follow-up and technical training and advice.

Source: FAO 2012a

3.4 Sustainable groundwater irrigation

Policy and institutional issues of groundwater and groundwater depletion were discussed in Chapter 2 (Section 2.5). The present section discusses groundwater from the viewpoint of farmers and from the perspective of groundwater irrigated farming.

Eight of the world's top 20 groundwater irrigating countries are in NENA

Over 11 percent of the world's groundwater-irrigated area is in eight NENA countries which figure on the list of the world's 'top 20' users of groundwater for irrigation (Table 3.8). Two of these countries – Iran and Saudi Arabia – irrigate together 5.2 million ha with groundwater, 7.5 percent of the world's total. In six of the eight countries, groundwater is the predominant source of irrigation water, even in Iran, which also has vast surface water resources.

Table 3.8: Eight of the world's top 20 groundwater irrigating countries are in NENA

Country	Area under groundwater irrigation ('000 ha)	Share of global groundwater irrigated area (%)	Share of irrigated area (%)	Share of total cultivated area (%)
Iran	3 639	5.3	50	21
Saudi Arabia	1 538	2.2	96	40
Syria	610	0.9	60	11
Libya	464	0.7	99	22
Morocco	430	0.6	29	5
Yemen	383	0.6	80	23
Egypt	361	0.5	11	11
Algeria	352	0.5	62	4

Source: Adapted from IWMI 2007: 401 Table 10.2

The advantages of groundwater

There are many reasons why groundwater development and abstraction have proved very popular with farmers throughout the region

Everywhere in the world, groundwater has proved extraordinarily popular. It is an 'open access' resource that farmers can typically appropriate simply by drilling a well on their own land. Once developed, groundwater offers full water control – it can essentially be turned on and off like a tap. It is generally managed as an individual resource, through a well on the farmer's own land. The farmer is sovereign in his or her decisions about use, and there is no need for challenging collective management arrangements. It is typically a high quality source of water, suitable for irrigating without restrictions. It adapts readily to pressurized irrigation and is ideal for the demands of high-value cropping. It is easy to convey, through flexible hoses, and does not require heavy fixed investment in canals or high annual maintenance. It also has multiple uses in addition to agriculture and can readily be conveyed to other points of use – domestic, home garden, etc. [Abou-Hadid 2012: 61].

Groundwater also plays a key buffer role in maintaining optimal soil moisture during dry spells, and this role will grow with increasing climatic variability

Groundwater productivity can be improved by conjunctive use, and by adopting precision techniques such as drip irrigation, combined with agronomic measures such as fertigation and protected greenhouse agriculture.

The problems of groundwater

The principal problem with groundwater is the obverse of the 'open access' characteristic. As discussed in Chapter 2 (Section 2.5), this characteristic has led to competitive over-pumping, mining of nonrenewable resources, deterioration of water quality, saline intrusion, and in some locations collapse of the geological formation and sinking of the land. The governance and incentives issues and options are also discussed in Chapter 2. [Abou-Hadid 2012: 62]

The rest of this section explores how two neighbouring but very different countries in the Arabian Peninsula – Saudi Arabia and Yemen – are facing up to the groundwater challenge in agriculture.

Groundwater in KSA

<u>Groundwater depletion is threatening the nation's future</u>

The Kingdom is blessed with very extensive reserves of nonrenewable groundwater. However, the nation is using four times as much water as is replenished

At present, KSA is depleting its nonrenewable resources by about 12 BCM a year. If nothing changes, it is likely that the rate of depletion would increase to 13 BCM, and that this precious resource will be effectively exhausted within two to three generations – sooner around major population centres. Municipal water supply targets can be met – but only at very high economic, fiscal and environmental cost.

In the Riyadh supply area, groundwater will be exhausted within 30 years

Even before reaching this final point, there will be a continuous deterioration in the quality and in the economic and technical conditions for exploiting the resource: more and more wells will be drilled ever deeper and ever more distant from water-using centres to squeeze out water of continually worsening quality and at spiralling cost.

<u>KSA's important agriculture sector is not sustainable</u>

Agriculture is almost entirely dependent on mining of the fossil water resource

Agricultural depletion has slowed down recently, but the sector still accounts for 85 percent of the unsustainable rate of drawdown. The effects of depletion already threaten the future of agricultural production in many locations.

Yet the use of most agricultural water produces little or no benefit for the nation. More than half the water used in agriculture actually produces a negative social benefit, reducing GDP

In 2010, more than half of the annual abstraction of the nation's nonrenewable water capital (8 BCM) was used to produce a reduction in GDP of 0.1 percent.

<u>There is planning for an agricultural transformation</u>

The Kingdom is forming a national consensus around a clear strategy for reducing dependence on nonrenewable groundwater

Strategic options are available under which the overdraft of nonrenewable resources could be held at 5 BCM – increasing the life of the resource to more than 200 years – and under which irrigation, raising efficiencies across the board, can live within a leaner water budget, whilst agricultural GDP, employment and incomes are held steady.

The future of both agriculture and of the water resource requires a plan for transformation of agriculture into a highly water-efficient industry, coupled with a plan for sustainable water resources management

An agricultural transformation strategy could, in fact, reduce agricultural water use over time to as little as 5 BCM whilst protecting – or even enhancing – farm incomes, employment and GDP, if the quota were used for crops for which KSA has a comparative advantage. This agricultural transformation plan would need to be accompanied by a clear plan for returning groundwater extraction to sustainable levels, and by an engagement from government to back up the plan with stable water allocations to agriculture and needed investment and safety nets for small farmers. This strategy could produce two beneficial outcomes: a sustainable, profitable agriculture sector, and conservation and optimal use of precious, nonrenewable groundwater. Following intensive policy analysis supported by FAO, the Kingdom is adjusting a number of levers in order to reduce incentives to overuse of water in agriculture and to reallocate water to higher-value crops (see Table 3.9). The result is expected to be water conservation, improved allocative efficiency, and improved water efficiency and water productivity.

Table 3.9: Saudi Arabia's plan for transformation to a more sustainable agriculture

Measures	Status	Impact
Promoting water-saving irrigation and developing efficient agricultural practices	Ongoing. Major new programme starting up.	No systematic monitoring data, but improvements likely
Phasing out support for cereals production	Started in 1996. Ongoing reduction in public purchases at support prices.	Cereals area declined by 65 percent in 1995-2010, groundwater use in agriculture dropped by 40 percent
Phasing in a ban on export of vegetables grown in the open field	Vegetable export ban started in 2012	
Removing tariffs on agricultural imports	Most have been removed	
Direct regulation of groundwater use by halting well drilling, plugging unlicensed wells, and imposing metering and tariffs	So far, applied only for industrial supply wells	
Suspending new land development	No wells developed in new areas	
Developing a national groundwater management programme	Water resource assessment and well inventory almost compete. No groundwater management plan or regulation yet	Capacity for management is being built, but there has been no impact on groundwater over-abstraction to date.

Source: Author's compilation

Groundwater boom and bust in Yemen

A challenging case of groundwater depletion is Yemen, which is fast depleting its reserves but which lacks the financial resources of the richer states to move progressively to a less water-dependent economy or to develop new nonconventional sources such as desalination.

Agriculture consumes more than 90 percent of Yemen's water and is the source both of much prosperity and of Yemen's chronic water problems, particularly of the very rapid depletion of the nation's nonrenewable groundwater

The rapid growth of markets and demand for higher-value products, including the much-reviled ***qat***, and the explosive spread of tubewell technology and profitable groundwater irrigation have driven growth and employment in agriculture. Now, however, productivity is stagnating and groundwater availability is fast declining. A second transformation is needed, focused on boosting productivity and conserving water.

Agricultural water management faces critical challenges. Traditional water harvesting is widely uneconomic, and springs have largely dried up. Large spate schemes under government management have suffered from the pervasive fiscal crisis. Groundwater irrigation is in full transition from boom to bust. A national programme to build small hill dams has generally brought little benefit and at high cost.

Public programmes have been successful in introducing piped groundwater conveyance, less so in promoting pressurized irrigation. Coverage of improved irrigation technologies remains limited, and there is little spontaneous adoption by farmers. Without an institutional framework to regulate abstractions, it is not even clear that 'saved' water really is saved and not just used elsewhere. The rationale for public subsidy looks questionable, as most of it goes to the better off to enhance a private good.

Reforms in irrigation in Yemen to improve efficiency and sustainability essentially aim at two related goals: to sustain (or even improve) farmer incomes whilst reducing groundwater use – not just more income per drop but more income for less drop

Yemen's water strategy is striving towards these twin goals through three means: (1) changes in the incentive structure, so that farmers have a motive to pursue water efficiency and groundwater conservation; (2) the spread of knowledge about technology that can bring more crop for less drop, and empowerment of farmers to adopt it; and (3) development of an institutional structure that will allow farmers to understand the challenge of groundwater depletion and to take collective action to control it. So far, results are mixed – government's adjustment of the energy price has reduced incentives to groundwater use but costs have fallen mainly on the poor and have driven up prices throughout the economy. The knowledge agenda is lagging. Water user associations formed at the behest of projects are proliferating, with variable results – from empty shells set up to garner subsidies to associations that look capable of taking collective action on water resources management.

The best hope is to build from the bottom up on the many initiatives of communities for managing their own groundwater resources, in partnership with public agencies

It is clear that in the Yemeni situation, state-led water governance is weak and decision-making over water is generally decentralized to the level of the microcatchment, the local community and the household. In practice, many communities have become well aware of the need for collective action, and there are many examples of communities organizing themselves to reassert control over their local water resources and to manage them for sustainability. In some cases, these initiatives have benefitted from public support for information, monitoring and investment. The challenge is to catalyse the replication of this bottom-up partnership approach across all areas of the country.

Options for further development

Initially, groundwater has proved a bountiful resource which has revolutionized agriculture and the lives of farmers in many locations in NENA countries. However, rapid depletion has led to an unsustainable situation in many locations. Future development pathways need to promote higher levels of productivity coupled with sustainability of groundwater quantity and quality and with equitable access.

- <u>Technical measures</u> can include water-saving technology to reduce non-consumptive water use, such as protected agriculture, changes to higher-value or more water-efficient crops, and improvements in water management, farming and post-harvest.
- <u>Economic measures</u> could address the incentive framework which influences the revenue side (e.g. trade policy) and the cost side – the cost of pumping (e.g. energy policy) and the cost of technological upgrading (e.g. cost-sharing programmes like those in KSA and Morocco).
- <u>Institutional measures</u> set the regulatory framework, which in high-governance countries may comprise the application of laws (as in Jordan); or – in lower-governance environments – may

decentralize resource management on a partnership basis to the local level (as in Yemen).

- Social measures can help, through targeted programmes, to remove barriers to entry or improvement for those with difficult access (e.g. the poor, women).

Chapter 4 (Section 4.2) summarizes groundwater issues and suggests agendas at both country and regional levels.

3.5 Rainfed agriculture

Across NENA countries, the three farming systems that are wholly or predominantly rainfed – highland mixed, rainfed mixed, and dryland mixed (see Chapter 1) – cover barely 13 percent of the total land area but support almost two-thirds of farming households (62 percent). The main crops (see Section 1.2) are cereals, legumes and tree crops, with cereals predominating – two-thirds of the cultivated area. Cropping is integrated with livestock keeping. Incomes are generally low and poverty is prevalent in many communities. Raising productivity of these systems, including through improved water management, would have a significant impact on reducing poverty.

Rainfed agriculture in NENA faces multiple constraints

Although varying greatly by locations, the main natural resource constraints faced in NENA's rainfed systems are: low and variable water availability; and environmental and soil problems of salinity, temperature and lack of nutrients. Although technological change has occurred, there has never been a Green Revolution for rainfed agriculture, and the availability of technical solutions to NENA farmers is limited. Risks are prevalent – climatic and hydrological risk, including drought and floods, and intensified by climate change risks, market risk and land and water tenure risk. Farming strategies are naturally characterized by risk aversion and low levels of investment. [FAO 2001: 82-4]

Pathways to improved productivity

A number of possibilities for improved productivity and risk management are known

These possibilities include: soil moisture management; rainwater harvesting; supplementary irrigation; managing crop water risk by choosing the right crops and varieties; soil fertility; and integrated soil, crop and water management. Among the more attractive and low-risk of these options are:

Soil moisture management

WE and CWP can be improved by a combination of soil moisture management and choice of crops and varieties

In dry areas, soil moisture conservation techniques – changed tillage and mulching practices, intercropping and shade planting – can reduce nonbeneficial evaporation and make more moisture available to the plant roots, so improving water efficiency. These techniques can be combined with the adoption of more drought-tolerant or shorter-cycle varieties and (where available) supplementary irrigation, so improving crop water productivity.

Rainwater harvesting

Farmers may use rainwater harvesting techniques to increase soil moisture

Rainwater harvesting techniques have been practiced since time immemorial in the rainfed systems of the region. The terrace systems of the Yemeni highlands, for example, are legendary, and some date back at least 3 000 years. Rainwater harvesting captures runoff from a managed catchment area and reserves it either in a storage area or in the soil profile (Box 3.7). Technologies range from simple in-field structures diverting water to a planting pit, through structures in the catchment which divert runoff to storage or run-on fields, to permanent terraces or to dams.

Box 3.7: *In situ* rainwater harvesting allows cropping in areas of just 120-130 mm rainfall

The NENA region is home to some of the global best practices in *in situ* water harvesting, a technology which concentrates runoff on individual plants or trees. In the Muwaqqar area of Jordan, for example, where rainfall averages only 125 mm and droughts are frequent, almond trees planted in small basins (*negarim*) have been growing and producing crops for more than two decades. In the Mehasseh area of the Syrian steppes, where rainfall averages only 120 mm, shrubs were planted in microcatchments with a survival rate of 90 percent. At Matruh in Egypt, with rainfall averaging 130 mm, small water harvesting basins with catchments of just 200 m^2 support olive trees. In the same area of northwest Egypt, rainwater harvested from greenhouse roofs provides half the water for vegetables grown inside the greenhouse.

Source: IWMI 2007: 336-7; Oweis and Taimeh 1996; Somme et al. 2004

Rainwater harvesting can boost yields by two to three times over conventional rainfed agriculture, especially when combined with improved varieties and minimum tillage methods that conserve water

Several of the Consultative Group on International Agricultural Research (CGIAR) centres, particularly ICARDA, are researching issues of rainwater harvesting, and related issues of drought-tolerant and water-efficient germplasm and agronomic management for dryland conditions. [FAO 2011: 5.3.4]

If rain events become more concentrated under climate change, this may increase the availability of water for water harvesting and irrigation

Concentration of rain events reduces water available in the soil and therefore reduces beneficial evapotranspiration (ET) and plant growth – but it also increases runoff and surface water availability. Concentration of rain events may thus reduce the productivity of rainfed agriculture but increase the availability of water for irrigation and water harvesting. Farmers are likely to seek to develop more surface irrigation and water harvesting infrastructure to capture the increased runoff.

Supplementary irrigation

Supplementary irrigation provides a 'just in time' source of water in rainfed systems

Even in areas with adequate rainfall, there is always risk of delayed or poorly spaced rains, and also of drought and floods. Supplementary irrigation, typically from water harvesting or from wells or springs, can provide a 'just in time' increase in moisture available to the plant to avoid water stress and maintain optimal growth. Supplementary irrigation is thus a first-class risk-management instrument for rainfed cropping. Where more than one source is available, conjunctive management of rainfall and surface and groundwater irrigation provides even better risk management.

Supplementary irrigation provides famers with a range of risk management options

Unpredictable rainfall may translate into delayed planting, with negative impact on yields. At the limit, if planting is delayed by more than a few weeks, crops may fail to mature. There may be crop failure or reduced yields. In addition, unpredictable rainfall may lead to drought spells during the growing season, contributing to yield losses. These risks can be managed if supplementary irrigation is available. For example, the impact of delayed rains could be offset by using supplementary irrigation early in the season. Farmers

Furrow-enhanced rainwater (runoff) harvesting, Syria (courtesy F. Turkelboom)

can also use supplementary irrigation to bridge any unexpected drought spells during the growing season, and to extend the growing season into the autumn.

Managing crop water risk by choosing the right crops and varieties

Faced with risks of unpredictable rainfall, farmers may use drought-tolerant or shorter-cycle crops, or change their cropping calendar. For example, the impact of delayed rains could be offset by growing shorter-cycle crops or varieties. Farmers may also switch to fast-growing crops, such as maize, that can be planted later.

Soil fertility

Maintaining soil texture and fertility will improve crop water productivity

Soils throughout the region are generally low in natural fertility and are likely to suffer further depletion through erosion and decline in organic matter. Low fertility and poor soil composition reduce the water retention capacity and impede water and nutrient uptake, reducing crop water productivity. A wide range of soil conservation measures is available. Soil fertility can be restored through integrated soil fertility management, including manuring and crop rotations. Inclusion of nitrogen-fixing legumes in the rotation improves the nutrient balance in the soil. Farmers may seek to further diversify their mixed farming systems with crop rotation, intercropping and agroforestry. This diversity will reduce risks, and also allow restoration of soil nutrients. Chemical fertilizers can also play a role. To conserve moisture and prevent erosion through runoff, farmers may also combine structural measures like terraces with vegetative or agronomic measures. [FAO 2011: 5.3.1]

Integrated soil, crop and water management

Farmers can adapt and adopt any of the above techniques, and they will certainly blend them into an integrated approach to soil, crop and water management which will optimize productivity and obtain the highest income with manageable risk. Table 3.10 shows the choices that farmers can make and combine to improve water efficiency and overall crop water productivity.

Table 3.10: AWM strategies and techniques for improving rainfed productivity

Aim	AWM strategy	Purpose	Techniques
Improve water-efficiency by increasing water available to the plant roots	Soil and water conservation	Concentrate rainfall around crop roots	Planting pits
		Maximize rainwater infiltration	Terracing, contour cultivation, conservation agriculture, dead furrows, staggered trenches
	Water harvesting	Mitigate dry spells, protect springs, extend growing season, enable off-season irrigation	Surface dams, subsurface tanks, farm ponds, diversion and recharging structures
	Evaporation management	Reduce nonproductive evaporation	Dry planting, mulching, conservation agriculture, intercropping, windbreaks, agroforestry, early plant vigour, vegetative bunds
Improve water productivity by increasing productivity per unit of water consumed	Integrated soil, crop and water management	Increase proportion of ET flowing as productive transpiration and so obtain 'more crop per drop'	Increase plant water uptake capacity through conservation agriculture, dry planting (early), improved crop varieties, optimum crop spacing, soil fertility management, optimum crop rotation, intercropping, pest control, organic matter management

Source: adapted from IWMI 2007, Table 8.3 page 331

Adapting rainfed farming in NENA under climate change

Chapter 1 (Section 1.6) assessed the possible dimensions of climate change in NENA and the likely impacts on the water resource, whilst Chapter 2 (Section 2.5) looked at options for countries to adapt to climate change and mitigate its impacts. But what about the impacts at farm level, particularly in the vulnerable rainfed farming systems? The region's rainfed famers in fact face a series of new challenges with the likelihood of climate change. Although impacts will vary greatly, overall conditions are expected to be hotter and drier with a general increase in aridity and drought, more floods and increased variability within years and between years. Rainfed farmers will have to adapt to these new challenges (see Box 3.8). The risk management strategies described above will become more relevant, and in different systems new adaptations may be needed.

Box 3.8: Yemeni farmers grasp the challenge of adapting to climate change

A study found that most Yemeni farmers (77 percent) knew about climate change and thought that it could affect their farms (64 percent). Most farmers thought that climate change was manifested through increases in average temperature, variability and irregularity of rainfall, and higher frequency of extreme events such as droughts. These views coincide with those of climate scientists.

Many farmers (37 percent) said that they had changed their agricultural practices in the past to cope with adverse climate conditions, and more than half of farmers (54 percent) thought they should start now to adjust their farm activity to cope with possible future adverse climate conditions. The options they proposed consisted of a mixture of traditional and modern farming practices, such as changing cultivation practices, rehabilitating terraces and spate irrigation systems, switching to higher-value crops and increasing the scale of farm operations.

The researchers commented: “Farmers appear to take a dim view of climate change as a further curse on their already precarious livelihoods, but at the same time they seemed confident about their adaptation capacities, and in several cases even thought that climate change might offer positive opportunities (such as a longer growing season)”.

The study concludes: “Climate change may be a fruitful source of innovation in that it inspires old and new remedies, more respectful of the environment, more preoccupied with recovering traditional land management techniques and plant varieties, and in general more attentive to the needs and the capabilities of rural communities”.

Source: Climate change, risk and adaptation in Yemeni agriculture by Pa`squale Scandizzo and Adriana Paolantonio. World Bank 2010

Combined changes in water availability and temperature under climate change may encourage farmers to switch to better adapted cropping patterns, to ‘conjunctive management’ of rainfall and surface and groundwater and to efficient protected agriculture and pressurized irrigation

If aridity increases, farmers may switch to better-adapted crops. A first level of response could be to switch between crops with differing responses to climate change within an agro-ecologically homogeneous ‘crop group’ – for example, switching between faba beans and lentils within the legume crop group. The most prevalent crop switch is likely to be from wheat to barley, accompanying a switch in farming systems from cereals production for human consumption to production of barley and straw as part of an integrated semi-intensive production of sheep and goat meat to satisfy rising domestic demand. The role of barley as an adaptation strategy is enhanced by the fact that even during very dry years when grain yields are minimal, straw production or ‘green grazing’ for flocks remain viable production alternatives.

Alternatively, farmers might switch to a different crop group. For example, where temperate fruit yields are affected by failure to meet vernalization requirements, farmers may begin to plant subtropical fruits like citrus in new zones and elevations that are less exposed to frost due to climate change.

Growing salinization will prompt changes in cropping patterns and soil and water management

Salinization is likely to increase in coastal areas due to the effect of rising sea levels and seawater intrusion into aquifers. Farmers generally may also use more saline water as depleting aquifers grow more salty and water scarcity drives development of more saline water sources. Farmers will seek out more salt-tolerant crops, use freshwater to blend with saline sources and use off-season freshwater sources to leach salt residues in the soil profile.

Where rainfall is higher, for example in highland mixed farming systems, warmer temperatures under climate change could improve yields provided that adequate soil moisture is available

In Yemen, for example, where rain falls in the summer months, an increase in average temperatures of 2^0C could be expected to extend the growing season by about six weeks. [World Bank 2013: 6-9]

Technology, institutional adaptation and the research agenda

Adaptation and adoption are continuous throughout farming systems (see Box 3.8 on Yemen above). Often the process has been aided by action-research programmes and by projects, such as the Tunisia North-West Highlands Projects or the Morocco Integrated Community Development in Rainfed Areas Project (DRI-MVB).

Institutional adaptation needs to accompany technological innovation

Some of this institutional adaptation and enhanced partnership can occur spontaneously at the local level, for example farmer organization for better catchment management; collaborative approaches to spate, spring or groundwater management; or community management of pasture. Some adaptation and adoption requires partnerships with public agencies – research and technology transfer; adjudication and regulation of land and water rights; decentralization of management of common assets or public goods such as water, forest and rangeland, resource management at the watershed scale; or payments for environmental services to compensate for externalities. Table 3.11 below summarizes both technology options and institutional aspects, as well as the research agenda.

Table 3.11: Technology options, institutional adaptation and the research agenda for NENA rainfed farming systems

Farming system	Technology options, institutional adaptation and the research agenda
Highland mixed	**Selected technology options**: (i) watershed management; (ii) conservation tillage; (iii) better integration of crops and livestock; and (iv) agronomic and post-harvest improvements. **Institutional adaptation measures**: (i) participatory approaches, equitable sharing of benefits; (ii) compensation for externalities and downstream benefits (payments for environmental services [PES]); and (iii) reducing overgrazing through more equitable regulation and control of common grazing resources – with participation, plus investment in water points, and eliminating subsidies on animal feed.
Rainfed mixed	**Selected technology options:** (i) improved management of water; (ii) terrace restoration and soil contouring; and (iii) agronomic and post-harvest improvements. **Institutional adaptation measures**: (i) land consolidation; (ii) community-based watershed management; and (ii) support mechanisms like PES. **Further research agenda**: technologies on crop-livestock integration, risk management.
Dryland mixed	**Selected technology options**: windbreaks, water harvesting, water management and conservation, zero tillage, together with agronomic and post-harvest improvements. **Institutional adaptation measures**: (i) communal land and water management; (ii) participatory research and development (R&D); and (iii) financial support mechanisms like PES. **Further research agenda**: (i) varieties with shorter growing period, drought resistance, improved grain and straw quality; (ii) new varieties and techniques such as intercropping; and (iii) systems research on crop-livestock interaction and resource conservation, with a focus on risk reduction and sustainability.

Sources: FAO 2001: 87-91, FAO/IFAD 2007. Summarized from Annex Tables 3 and 4 of World Bank 2013

What next?

Given the importance of rainfed farming to agricultural production, rural incomes and poverty reduction, there needs to be a full focus on technology and institutions for improved productivity in rainfed farming systems. The following are possible next steps:

- A focus on rainfed agriculture in the basin and watershed context, integrating upstream resource management with downstream management of water quantity and quality. The watershed management approach in Morocco's Oued Lakhdar Project provides an example at a pilot scale of how this can be effected, building on bottom-up community-based approaches and technological and institutional innovation [IWMI 2007: 344].

- Promoting research, innovation, 'adaptive adoption' and strategies for risk reduction, through knowledge development and sharing as an iterative process between local people and technical staff and researchers. This includes indigenous knowledge drawn from farmer experience.
- Strengthening land tenure jointly with local people, through land consolidation, land tenure confirmation and co-management arrangements for common or state land (forests, rangeland).
- Integrated development programmes for rainfed areas, incorporating both cropping and livestock, with research, technology development and transfer; farming services such as extension and strengthening of input and product marketing chains; rural finance; and rural infrastructure development, particularly farm to market roads and water infrastructure.
- Joint monitoring of climate change trends and the development of adaptive strategies and investment programmes at the local and regional level.
- Introduction of diversification and innovative sources of financing, such as PES.

Chapter 4 (Section 4.3) brings together all the issues on rainfed farming and proposes elements for agendas at both national and regional levels.

3.6 Watershed management and water management in NENA drylands

Watershed management

Watershed management typically targets land and water management in the upper catchment with twin objectives: improved upstream livelihoods and improved water resources downstream

Watershed management is the integrated use of land, vegetation and water in a particular drainage area. Typically, watershed management programmes have been conceived at the basin or sub-basin scale and have twin interrelated objectives: (i) to improve water resources quantity and quality in the basin by increasing infiltration, reducing floods and erosion, enhancing orderly runoff and stream flows and minimizing damage to water quality; and (ii) to improve land and water management and farming practice in the upper catchment to the benefit of the inhabitants. Typically programmes have been conceived within some structured land and water management plan or basin plan, and have often had downstream goals such as reducing siltation of reservoirs or enhancing water for downstream uses, such as municipal water use. Watershed management interventions typically have also had poverty-reducing objectives because of the links between resource depletion in the upper catchment and poverty.

The challenge has been to find packages that achieve the downstream objective and are also profitable enough to make it worthwhile for upstream farmers to sustain them

After a false start with a top-down, engineering approach in the 1970s and 1980s, approaches from the 1990s emphasized farming systems and demand-driven approaches implemented at the decentralized level. Although this approach was attractive in terms of poverty reduction and 'putting people first', it was confronted by two dilemmas: (i) could packages be found that achieved the soil and water conservation objectives in the upper catchment that were also attractive enough for farmers to adopt them and – more importantly – to sustain them once outside support ended; and (ii) would the combination of investments adopted by the demand-driven approach actually achieve the downstream objectives of improving hydrological services and reducing negative externalities? [World Bank 2008b: ES]

Projects have succeeded in improving livelihoods upstream, but downstream results are questionable – and the approach is costly to replicate

Experience globally has been mixed. A 2008 review of 15 years of experience of watershed management projects concluded that projects had been by and large successful in the upper catchments in improving integrated management of land and water, in improving local people's incomes and in laying the ground for sustainability of the conservation actions. However, little evidence could be found that the downstream objectives had been met, although this was in part due to the lack of proper baseline and monitoring. These conclusions are illustrated by an experience in one NENA country, Morocco (Box 3.9), where problems of erosion and siltation have been particularly acute, threatening half the area of watersheds in the country [*FAO 2014a: Regional Initiative on Water Scarcity - Morocco Country Paper: 26*; World Bank 2008b]

Box 3.9: Matching community expectations and programme objectives in the Morocco Lakhdar Project

The Morocco Lakhdar Project was developed to test in one watershed the feasibility of a broad national watershed management approach aimed at the twin objectives of improving livelihoods in the poor upland areas through a community-driven development approach and reducing the rate of siltation of Morocco's important reservoir system.

A menu of intensification and conservation measures was offered to the communities. Initially communities opted entirely for the intensification components, particularly for irrigation improvement. A balanced programme had to be negotiated, with the financial allocations to the intensification measures capped and with agreement from the communities that they would implement the conservation measures – but only in the latter years of the project. In the event, many of the conservation measures – terracing, check dams, fruit tree planting – were designed to be economically attractive, so that by the end of the project some degree of sustainable momentum for the conservation measures could be detected.

At the broader scale, however, there was no monitoring that could demonstrate an impact on downstream objectives. The Lakhdar Project did not lead into a generalized watershed management approach either in the Oued Lakhdar or in the country as a whole. It was essentially a successful community-driven development pilot project which proved too costly and demanding to replicate on any scale.

Source: Author

Although a wide range of interventions are practiced, five components are most typically found, which combine objectives of conservation, natural resource use and livelihoods improvement. These components are: (1) increasing water availability through water harvesting and storage; (2) crop production; (3) rangeland management; (4) planting trees (both fruit and fuel); and (5) livelihoods diversification.

Best practice adopts participatory approaches and uses conservation techniques that are also profitable for farmers

The best results come where there are conservation techniques that are also profitable for farmers, and where participatory approaches are used that create ownership amongst the local community. Current best practice in watershed management approaches therefore emphasizes:

- watershed management as part of local socio-economic development processes;
- multistakeholder participation and collaboration;
- flexible demand-driven programme design;
- long-term planning and financing;
- local institutions such as committees and associations responsible for implementation, with programmes and official agencies playing a subsidiary and facilitating role;
- upstream-downstream linkages well defined, and local actions linked to overall basin outcomes;
- constant action-research; and
- social capital building and continuing negotiations over access, tenure and social conflict. [FAO 2006]

In addition, the approach of PES has been used with some success elsewhere in the world, and could be piloted in NENA (see Boxes 3.10 and 3.11).

Issues on watershed management are summarized in Chapter 4 (Section 4.3), together with an agenda for action at both country and regional levels.

Box 3.10: Advantages and limits of payment for environmental services

Advantages

- *Efficiency*: PES conserves only what is considered worth conserving from the economic standpoint. It can make differentiated payments according to the degree to which services are provided.
- *Sustainability:* PES generally requires that service providers be paid indefinitely for the services they provide. This requires that service users be satisfied that they are receiving the services they are paying for. Hence, sustainability depends on objectively verifiable quality of service.
- *Auto-financing*: PES generates its own funding without requiring substantial budgetary outlays from the government.

Limits

- *A good understanding of upstream-downstream linkages is needed*: PES has to be based on valuation of services provided by upstream management interventions.
- *Needs continuous readjusting*: changes in market conditions may make a PES payment that is acceptable today insufficient tomorrow.
- *Market based*: PES can only value quantifiable services which can be priced. Externalities that cannot be quantified or priced – biodiversity, for example – may not be suitable for the approach.
- *Transaction costs* for setting up and administering the payment mechanism may be high, especially if beneficiaries are not already organized or if the watershed is large and densely populated.
- *Not necessarily a poverty reduction mechanism:* in many upper watersheds, a large proportion of the population is likely to be poor, but even within watersheds with primarily poor populations, there is no guarantee that payments will reach the poorest.
- *There will remain a substantial role for governments*: there is still a need for public financing. Financing for research and monitoring is a clear role for governments. Governments also have to help develop and supervise the institutional and regulatory framework.

Source: World Bank 2008b: Box 40 (Pagiola and Platais 2006)

Box 3.11: Examples of PES in Latin America

In Colombia, irrigation water user groups and municipalities in the Cauca valley are paying to conserve the watersheds that supply them with water (Echevarría 2002a).

In Ecuador, the city of Quito has created a water fund, Fund for the Protection of Water (FONAG), with contributions from the water utility and the electric power company to pay for conservation in the protected areas from which it draws its water (Echevarría 2002b).

In Costa Rica, the town of Heredia has established an 'environmentally adjusted water tariff', the proceeds of which are used to pay landholders to maintain and reforest watershed areas (Castro 2001; Cordero 2003).

Source: World Bank 2008b: Box 41 (Pagiola and Platais 2006)

Water and forestry

Water management and forestry go hand in hand in reforestation on degraded lands, in peri-urban tree planting using treated wastewater, and in agro-sylvo-pastoral farming systems

Within the Global Partnership on Forests and Landscape Restoration, with financing from the Department for International Development (DfID) and the International Union for Conservation of Nature (IUCN), FAO is helping countries to plan for reforestation on degraded lands worldwide. On the 2 billion ha of degraded land worldwide, the target is 150 million ha of reforestation by 2020. The focus is on drylands, and NENA countries are participating. There is already success in NENA with associating water management and forestry, including afforestation using treated wastewater in Egypt, Algeria and Tunisia; and with reforestation under the Lebanon National Forestry Programme, where there is potential for water management for reforestation. The Tunisia National Strategy for Development of the Forest Sector has targeted the rehabilitation of 500 000 ha of rangeland and afforestation on a further 320 000 ha. In addition, there is a focus region-wide on urban and peri-urban forestry and the role of trees in cities, plus peri-urban protection of urban water sources, which is very important for fast-urbanizing dry areas like NENA. [Technical discussions, FAO Rome, September 2013; ICARDA 2007: 16]

Water in the drylands

Drylands are continental areas of low rainfall and high evapotranspiration, and with restricted growing periods. Drylands are defined as regions having an 'aridity index' of 0.65 or less (see Table 3.12 below). Drylands are furthermore subdivided into four zones: hyper-arid, arid, semi-arid and dry sub-humid. The aridity index ranges used to define these four zones appear in Table 3.12 below [ICARDA 2007: 11-14].

Table 3.12: Aridity index ranges used to define drylands

Dryland zone	Aridity index range
Hyper-arid	0.00 – 0.05
Arid	0.05 – 0.20
Semi-arid	0.20 – 0.50
Dry sub-humid	0.50 – 0.65

Sources: FAO 2001: 87-91, FAO/IFAD 2007. Summarized from Annex Tables 3 and 4 of World Bank 2013

Defined in this way on the basis of the aridity index, about 40 percent of the earth's land surface is drylands, but nearly all of MENA (89 percent) is drylands. Drylands are characterized by high variability between years and by frequent droughts. Storage of the scant rain is generally an expensive proposition. Progressive further drying is predicted as a result of climate change. Where farming is possible, mixed pastoral/arable systems prevail in the semi-arid and sub-humid zones but activity is very sparse indeed in the 62 percent of the region which is classed as arid or hyper-arid. [ICARDA 2007:18]

Three sets of measures are generally practiced for improving productivity in NENA drylands through agricultural water management:

- <u>Increasing water availability</u> through water transfer and water harvesting to capture and direct rainfall onto fields (see 3.5 above). Water transfer has long been practiced in the region – for example the Ghor canal bringing water from the Yarmouk to the Jordan Valley, the Nile water carriers taking water to the desert new lands, and – the most ambitious of all – the Great Man-Made River in Libya, originally intended to irrigate agriculture in the coastal region. Generally these are social rather than economic projects. New lands development in Egypt has been halted since the fall of the old regime.
- <u>Increasing water productivity</u>, either through increasing the moisture in the soil profile, or by using soil moisture more efficiently, for example by improving soil conservation and fertility, or by adopting integrated agro-sylvo-pastoral approaches, or simply by planting trees and bushes.
- <u>Reuse of wastewater</u> or <u>use of marginal water</u> such as saline water or drainage water.

Programmes to support water management in very dry areas have been implemented across the region, with some success, for example, that at Matruh in Egypt. Substantial yield increases can be achieved but costs and risks are high (see Box 3.12 below).

Box 3.12: In Egypt, water harvesting and improved agronomic techniques increased yields by 250 percent

In a drylands programme in the Umm al Ashtan watershed in Egypt, an agrotechnical package of improved wheat and barley varieties was introduced, watered by harvested runoff. The seeds were soaked and coated with biofertilizer, and plots were tilled and fertilized with slow release fertilizer. Grain and straw yields increased by 250 percent.

Source: ICARDA 2007: 70

Water and desertification

Much land in NENA is under threat from desertification, and much is lost each year. Some 9 million ha are threatened in Algeria and about 7 000 ha of arable land is being lost each year. Some of this is simply natural process, but much is due to changes in land use, for example, change from sustainable pastoral use to crop production. In Morocco, the spread of cereals cultivation onto marginal ***bor*** lands during the times of high cereals procurement prices led to soil erosion and sand dune invasion. In Tunisia, increased stocking rates led to overgrazing and sand dune invasion into rangelands, a process that can be reversed but only with considerable effort and cost (see Box 3.13). [Abou-Hadid 2012: 66-67]

Chapter 4 (Section 4.3) brings together the issues on water and forestry, water in the drylands and anti-desertification, and suggests actions for national programmes and regional collaboration.

Box 3.13: Sand dune fixation in Tunisia using tree/bush combinations

In Tunisia, a programme in the dryland Gabes area used tree-bush combinations to stabilize sand dunes that were emerging in overgrazed areas. Using harvested water, drought- and salt-tolerant bushes and trees (including date palms and olives) were planted both as sources of cash and as dune stabilizers. By the end of the sixth year, which included years of drought, sand drift was totally arrested, natural vegetation was spontaneously emerging and range productivity increased fourfold.

Source: ICARDA 2007:73

3.7 Salinization, waterlogging and drainage

The discussion in Chapter 2 (Section 2.5) on supply-side issues for water resources management raised the challenge of drainage and the reuse of drainage water as a resource for agriculture. The present section examines the issues of drainage and the potential for reuse in detail.

Much of the world's irrigated land suffers from drainage problems, and an estimated 30 million ha worldwide need improved drainage. The resulting waterlogging and salinity due to the rise of water tables and the accumulation of salts are reducing productivity over wide areas. It is estimated that 45 percent of Syria's irrigated area suffers from salinization, and in Egypt 50 percent. On the positive side, at most only about 60 percent of irrigation water is actually consumed in direct evaporation. The rest is returned to the hydrological system, and much can be recovered for reuse. However drainage is often the poor relation, with attention and investment going to upstream irrigation and farming. Opportunities for increasing the water available to agriculture through drainage water reuse are missed. [Abou-Hadid 2012: 67; FAO 2011: 155]

Reasons for neglect of drainage

Few countries have integrated drainage planning and investments within overall water resources management. The reasons are in part institutional…

Globally, there are many reasons why drainage has been a neglected area of planning, investment and management. Some of these are institutional, particularly in countries where there has been a lack of an integrated approach to agricultural water management and where drainage has typically been seen as a separate activity. Yet, the experience of modern irrigation right from the time of the irrigated cotton revolution in Egypt in the 19th century has been that there should be no investment in irrigation without planning for drainage. The neglect of drainage at the planning stage is reflected in governance and institutional arrangements, where drainage is usually a subsidiary task of an irrigation agency[15] which serves primarily agriculture and emphasizes resource development over integrated resource management. This institutional failing is multiplied in modern irrigation with the advent of decentralized WUAs, as these are rarely called on to deal with drainage. Many countries lack a legal framework for setting up drainage organizations, or for levying fees.

...and also economic, as investment in drainage has been limited and cost recovery has proved problematic

The institutional shortcomings are mirrored at the *economic* level. In many countries, there is no financially sustainable system for investing in and managing drainage. Government investment budgets for drainage are low, and cost recovery is rarely properly factored in. Often, stakeholders do not understand why they should pay for drainage.

...and drainage has been little considered in either water or agricultural policy

Drainage is rarely integrated into agricultural or water *policy*. For example, many countries promote more and more irrigation, sometimes with low overall efficiencies that result in very large quantities of drainage water. With these policies may come also promotion of heavy fertilizer use but there is rarely any countervailing consideration of downstream effects.

The impacts have fallen mainly on the poor

Inattention to drainage raises *social* issues of inequity. The bad effects of lack of drainage are mostly on tail enders and on the often poorer downstream population, who receive all the pollutants.

The case for drainage in NENA

Drainage can improve productivity at relatively low cost and investments bring good returns

Drainage improves land productivity, reduces the need for new land development and has positive impacts on health and the environment. Costs are low: from USD 100-200/ha for on-farm surface drainage up to USD 1 000/ha for pipe drainage in arid areas. Production responses are good: in Egypt gross production increased with drainage by USD 500/ha and net income by USD 200-375/ha. With a good benefit stream and relatively low costs, drainage investments produce good rates of return.

In water-scarce NENA, the priority is on salinity control and on the potential for reuse

Drainage is particularly important where water is scarce or where there is a productivity problem related to waterlogging or salinization or where drainage can contribute to flood control, groundwater or wetland conservation etc. In water-scarce NENA the priority is on salinity control and on the potential for reuse.

Good practice: policy issues and trade-offs

Drainage should be seen as a multifunctional investment within an IWRM approach, serving all water sources and users, a legal and governance framework needs to be set up and a participatory approach should be applied

Drainage is a complex phenomenon with multiple impacts, positive and negative, on other functions of the resource system, resulting in the need for an IWRM approach and multifunctional investment. Planning and decisions should be taken at the basin scale.

Drainage needs to be built into the design of irrigation systems from the start, along with consideration of reuse. An integrated planning tool should be used that can take account of all social, economic and technological aspects. One example is DRAINFRAME, developed and used in Egypt, which evaluates all the different functions of the resource system at the values society places on them and then optimizes investments.

Planning and management require participatory approaches involving all upstream and downstream stakeholders. Because of the trade-offs involved – between upstream and downstream, between water use and the environment – a multistakeholder governance and management structure is required that can arbitrate these trade-offs and seek compromises amongst stakeholders.

The legal framework needs to provide for the levying of fees on an equitable basis, and here stakeholders need to be involved throughout, so that they understand why they may be asked to pay.

15 Or of a separate but weaker drainage agency.

Technology and investment choices

Various technologies and innovations are available, which have to be adapted to the local situation

Best investments are often very site-specific. The most widespread application of drainage technology in NENA has been in Egypt (see Box 3.14), but Iraq, Iran and Tunisia have also invested on a wide scale. There have been innovations in drainage technology in recent years that have reduced costs and increased functionality. One example is the use of controlled drainage to slow down the movement of water through the soil profile and so reduce loss of moisture and nutrients. Other approaches include evaporation ponds and biodrainge, especially using trees.

Box 3.14: Egypt's National Drainage Programme

Draining over two-thirds of its irrigated lands, Egypt is the world leader in land drainage practice

Beginning in the late 1960s, Egypt has invested heavily in land drainage and has become a world leader in technology and practice. The extensive National Drainage Programme has been developed over the last four decades to control waterlogging and salinity. About 6 million feddan out of the total 8.5 million feddan (70 percent of the cultivated area) are equipped with subsurface drainage.

Drainage water in the Valley is returned to the Nile for possible reuse. In the Delta it may be pumped directly back into the canals for reuse or it is pumped to the lakes or the sea.

The Programme is one of the largest water management investments in the world, with investment exceeding USD 1 billion. The result has been reduction in salinity and increase in productivity. Cost recovery is reported to be good, in fact better than for irrigation.

Drainage water is reused on a massive scale – but water quality problems prevent expansion

From the beginning of its drainage programme, Egypt also invested in reuse on a wide scale as a way to increase overall system efficiency at the basin scale. Drainage water is reintroduced into the irrigation system at points where it can be economically mixed with freshwater. Currently, up to 5 BCM is reused in this way, 10 percent of Egypt's total Nile resource of 54 BCM, and reuse is practiced on 90 percent of the irrigated area. Over time, the deterioration of water quality due to rising levels of poorly treated sewage and industrial effluent has begun to limit reuse. It is estimated that these quality problems prevent the reuse of up to 3 BCM more drainage water that could be reused and for which the infrastructure is in place.

Source: Abou-Hadid 2012: 62; Fahmy (personal communication)

Drainage water reuse

Drainage water represents a considerable water resource and, with careful planning, participatory approaches and investment, it can add 10 percent or more to national water resources, as in Egypt

Farmers can reuse drainage water for irrigation, either as a sole source, mixed or alternated with freshwater from canals, groundwater or rainfall. Drainage water reuse requires a recovery loop system that can bring drainage water back into the system. Gravity systems that require low investment can typically be added on to existing systems, through installation of pumps to lift water from drains to canals, construction of mixing basins etc. Farmers may invest themselves and pump water from the drains, but this has to be guided by a framework of rules. Egypt has the most advanced national system, reusing over 10 percent of the annual freshwater withdrawal without deterioration of the salt balance (see Box 3.14). Reuse of drainage water on a more limited scale is practiced in Iraq, Saudi Arabia and Syria. Based on Egypt's experience, the following are the features that characterise successful programmes for drainage water reuse: [World Bank 2006a: 174-5; Abou-Hadid 2012: 62]

- Drainage water reuse has to be assessed at the level of overall basin efficiency and socio-economic benefit. A particular issue is the downstream environmental effect: there may be less salt discharged but reduced return to watercourses.
- A legal and regulatory framework is needed to control drainage water reuse. This framework would include: (i) regulation of water quality, par-

ticularly salt content and agricultural chemical residues that may have an impact on productivity; and (ii) protection of human health – reintroducing drainage water into the hydraulic system may hold some dangers. Mechanisms are needed to monitor the volume and quality of drainage water and to provide management information for decision making.

- Programmes for drainage water reuse need to be developed in association with users and to be the subject of explicit water entitlements in the same way as fresh canal water. Farmer awareness and training for this relatively saline water is essential.
- There are trade-offs that need to be managed. The two most important are: (i) reuse may reduce environmental flows, so reuse needs to be assessed and trade-offs decided on in an overall basin framework; and (ii) quality problems need careful control, or salts and contaminants will build up in the soil profile, and judgements have to be made – as in Egypt - about cut-off levels for the quality of water to be used. [World Bank 2006a: 167-170]

Drainage and drainage water reuse issues are summarized in Chapter 4 (Section 4.3), which also suggests elements for national programmes on drainage and reuse, as well as an agenda for regional collaboration.

Chapter 4

Options for change – national programmes and regional collaboration

Main messages

This chapter reviews options for improving agricultural water management, assesses the scope for collaboration at the regional (and international) level to help NENA countries draw up and carry out the needed changes, and discusses how to design and gain consensus on programmes of investment.

Scope for regional collaboration to improve management of NENA's water resources for agriculture

The priorities for governance and institutions are to improve efficiency and accountability, strengthen participatory approaches and improve the investment planning process; here, regional learning and technical cooperation could assist.

Regarding IWRM and the basin approach, a regional review of past experience and sharing data, information and knowledge could help countries to build on experience and generalize the basin approach (***collaboration here also forms part of the plan of action for the Arab Strategy for Water Security)***.

The agenda for subsidiarity, decentralization and participation could benefit from a region-wide assessment of WUAs and subsequent regional technical cooperation to empower WUAs and strengthen their capacity.

More broadly, regarding community-based water management, a review of regional experience and best practice and constraints, together with cross-country exchanges and development of guidelines, could help in strengthening institutions for local-level natural resource management.

There are several ways in which regional collaboration could help NENA countries act on the supply-side drivers of scarcity:

- To maximize economic reuse of treated wastewater, a region-wide exchange of experience could help to establish best practice and guidelines; and regional or bilateral cooperation programmes could help with benchmarking, capacity building, applying standards and regulatory frameworks, etc.
- Ways to optimize benefits from transboundary resources at the basin scale form a priority topic for the region (***collaboration here forms part of the plan of action for the Arab Strategy for Water Security***).
- Regarding climate change, there is scope for regional collaboration on modelling and monitoring, and for regional technical cooperation on preparation of adaptation strategies and on research and technology development (***collaboration here also forms part of the plan of action for the Arab Strategy for Water Security)***.
- Establishing a governance framework for groundwater could benefit from region-wide sharing of data, information and knowledge, as well as from a review of experience across the region and in other regions.

Regarding demand management, region-wide review of the components of incentive structures and development of best practices could help NENA countries to establish an incentive framework for promoting water efficiency and water productivity in agriculture. A regional focus on awareness raising could also help win consensus on the framework.

Scope for regional collaboration to improve water efficiency and crop water productivity through agricultural water management

Research, technology development and technology transfer are needed to increase efficiency and productivity. This agenda would benefit from a regional approach, working through a partnership of international, regional and national research agencies.

Increasing water-use efficiency and closing the yield gap in surface irrigation requires irrigation modernization, which would benefit from: a regional process to share data, information and knowledge on modernization and best practices; regional technical cooperation on methodologies, benchmarking, capacity building, etc.; and regional alignment on the MASSCOTE planning tool and development of regional centres of excellence.

NENA countries will need to factor the implications of the rising cost of energy into planning and operations, and this could be helped by a regional collaborative review of the implications of the energy/water nexus.

On pressurized irrigation, a regional programme of research and development, capacity building and technical cooperation could help countries design programmes to increase efficiency and productivity, and to reduce barriers to entry and help farmers manage price risk.

For NENA's very important rainfed farming systems, synergy and joint work across the region in research, exchange of best practice, mutual farmer visits, etc. could provide a full focus on technology and institutions for improved productivity.

For watershed management and water management in drylands, a regional review and establishment of best practice could help countries to build on experience and develop second-generation programmes.

Regarding water and forestry, regional collaboration for sharing of data, information and knowledge, establishment of best practices and R&D could help with programmes to develop forests and trees on degraded lands, around cities and for antidesertification.

Programmes for drainage and drainage water reuse could be helped by regional collaboration for sharing of data, information and knowledge on drainage and reuse; establishment of best practices; benchmarking; capacity building; and regional technical cooperation.

Deciding on trade-offs

Reforming governance and institutions and making changes in investment strategies will call for trade-offs, including between productivity and food self-sufficiency, and between free trade and protection. Mechanisms and processes need to be found to arbitrate between the incentives the farmer faces and the perspectives of society.

Drawing on the assessments in Chapters 2 and 3, this chapter looks at options for change within country-level initiatives, and at the scope for collaboration at the regional level to support the development and implementation of national programmes of improvement in agricultural water management. The chapter first looks at the formulation of country-level strategies and at how regional collaboration might complement national policy analysis and strategy formulation (4.1). The chapter then reviews ways of improving management of water resources for agriculture in NENA countries and examines how regional collaboration could contribute (4.2), looking in turn at governance and institutions; IWRM and the basin approach; subsidiarity, decentralization and participation; at ways of managing supply side issues; and at how to adjust the incentive framework.

The following section (4.3) takes the same approach to look at options for improving the use and value of water within agriculture and for regional collaboration, looking in turn at: measures to raise water efficiency and crop water productivity in the various water management systems; issues of irrigation modernization; pressurized irrigation; improving practices and productivity within rainfed systems; watershed management and water management in drylands; and the key topic of drainage and drainage water reuse.

Section 4.4 then addresses the trade-offs that nations have to face in making choices about agricultural water management. These include the issues of: productivity vs. food self-sufficiency; free trade vs. protection; and alignment of incentives between the farmer's perspective and society's perspective.

Section 4.5 discusses how to create a momentum for change, looking at the drivers of change within NENA and then drawing a series of important lessons from other, largely Australian, experience on how to design and reach consensus on change programmes for water, and how to implement the changes.

The final section (4.6) summarizes, in table form, the scope for regional approaches and cooperation on agricultural water management.

Annex 2, ***Existing cooperation related to agricultural water in NENA***, reviews available mechanisms for cooperation, including: regional and international cooperation on agriculture and agricultural water management research; mechanisms for coordinated policies and actions; and new partnerships and mechanisms. The annex also assesses regional and international cooperation on data and modelling, and highlights possible sources of extra finance for agriculture and agricultural water management (e.g., payment for environmental services or PES).

4.1 The scope of discussion

This final chapter is intended to set out an agenda for change in agricultural water management for the NENA region. The options highlighted build on experience over recent decades, and much of the material has long been common currency in strategies in the region. So, how do the approaches suggested differ from previous sets of recommendations? The answer is not so much in the measures suggested as in the ways in which they are approached – in innovative approaches to preparing national agendas, and in new ways of mobilizing the contributions of regional and international collaboration.

New approaches to formulating national programmes for agricultural water management

Clearly NENA countries have progressed on many fronts to improve agricultural water management and this has raised productivity, supported a shift to higher-value cropping, brought many more farmers into the market and strengthened household-level food security through higher incomes and improved market functioning.

Growing water scarcity, rising farmer expectations and the needs of the two-thirds of NENA farmers dependent largely on rainfall imply that further improvement in sustainable agricultural water management is imperative. The list of options highlighted in this paper is long. Many of them are a continuation and scaling up of existing changes – the governance and institutional measures, IWRM and the basin approach, supply and demand management, measures to improve water efficiency and crop water productivity. What is new for the coming years is not so much the lists of measures but the approaches suggested for applying them. Four linked and innovative approaches could be adopted in the preparation of national agendas in agricultural water management in NENA.

<u>Evidence-based approach</u>. This employs benchmarking, monitoring, evaluation and reporting to assess the results of measures applied and to feed the knowledge gained back into adjustments. The evidence-based approach can apply across the whole range of measures: policies and strategies; changes to institutions and incentives; and technical and socio-economic interventions.

<u>Farmers as full partners</u> in building policies and programmes that correspond to the farmers' needs and constraints. Innovative approaches to farmer involvement can go beyond consultation to recognizing their status as commercial operators in the value chain - as businesses not beneficiaries. This has implications both for the value chain – farmers and farmer organizations

working directly with suppliers and buyers – and for farmer/public agency accountability: for example, the public/private partnership of a public irrigation scheme supplying water to farmers involves a commercial contract of water services in exchange for client payment for the value of those services.

Effective synergies in innovation and learning. In so complex a field as agricultural water management, and in the enormous diversity of situations across the NENA region, there is a strong advantage in seeking structured mechanisms beyond the national level to understand challenges and potential, to learn from experiences, and to innovate and scale up successful innovations. The process is founded on the evidence-based approach and on the primacy of the farmers' viewpoint, but it needs to bring together institutions and programmes at all levels, from the local to the regional and global, and it needs to forge more effective partnerships and ways of collaborating, from farmer to farmer exchanges in, for example, Farmer Field Schools, to exchanges of solutions amongst practitioners rather than through conventional capacity building, to region-wide partnerships like the Arab Strategy for Water Security, and to global partnerships such as the CGIAR network.

An inclusive approach to change. Recent years have seen the emergence of new ways in which change comes about across the NENA region. Education and social changes have heightened awareness of water issues across broad constituencies, and a new political openness has encouraged inclusive debate. There is broader understanding that objective problems of scarcity, intersectoral competition and climate change are worsening, and that water institutions are not always well-adapted to this changing context. Future programmes for improving agricultural water management can be founded on inclusive processes of study and debate leading to consensus amongst stakeholders[16].

The contribution of regional collaboration

Over many years, regional collaboration has been strong and fruitful in NENA. A recent example under the Regional Collaborative Strategy has been the use of the Food Supply Cost Curve (see Introduction) to help Tunisia to determine the optimal balance between increasing domestic production through improved water management or other means, and trade (Box 4.1).

Box 4.1: Applying the Food Supply Cost Curve – the case of Tunisia

The Tunisia Case Study for the Regional Initiative on Water Scarcity applied the methodology of the food supply cost curve to determine the optimal balance between increasing domestic production through improved water management or other means, and trade.

Projections show that by 2020, demand for cereals in Tunisia will be about 2.8 million tonnes, and that domestic production is likely to meet only 61 percent of that demand (1.7 million tonnes). Where should the balance of 1.1 million tonnes come from – domestic production or imports?

Analysis done for the Regional Initiative on Water Scarcity – Tunisia Case Study showed six technically feasible options for increasing domestic production:

1. Improved productivity of rainfed wheat production on 0.8 million ha in the sub-humid zone of Tunisia
2. Improved productivity of rainfed wheat production on 0.45 million ha in the semi-arid zone
3. Expansion of wheat production under sprinkler irrigation on 15 000 ha
4. Expanding the area of irrigated wheat production from 70 000 to 130 000 ha
5. Increased yields in irrigated agriculture on 70 000 ha
6. Reduction of losses in the food chain from the current 30 percent to 20 percent in 2020

Using the Food Supply Cost Curve, the study showed that all six options applied together would produce an extra 1.1 million tonnes of wheat, essentially eliminating the likely deficit in 2020. However, applying an economic lens, the exercise showed that Option 2 (wheat productivity in semi-arid zones) and Option 5 (increasing yields in irrigated agriculture) would not be economically justified – it would be cheaper to import wheat. The recommendations, therefore, would be to adopt four options, which taken together would produce an extra 820 000 tonnes a year, and to import the balance of 320 000 tonnes. In terms of virtual water, these imports would save around 320 million m^3 annually.

Source: FAO 2014b: Regional Initiative on Water Scarcity - Tunisia Country Paper: 14

16 For a full discussion of this approach – and for the luminous example of Australia's National Water Initiative – see below (Chapter 5).

A wide range of further opportunities for regional, subregional and country-to-country collaboration has been identified throughout this paper, and these opportunities are summarized and discussed in the following sections. This kind of collaboration can add enormous value given the commonality of issues, policies and institutions across the region and the synergy that can be generated by a cross-country sharing of knowledge and effort. In proposing this approach, strategic focus and prioritization are essential, for which the following criteria have been adopted:

- The topic should address issues of economic importance relevant to improving sustainable agricultural water management and food security.
- There should be scope for evidence-based change and for benchmarking, monitoring and evaluating progress.
- There should be scope for involving farmers and building in a farmer perspective.
- The expected benefits from cross-country collaboration at the bilateral, subregional and regional level should be clear and important, and the topic should not already be covered by effective regional collaboration such as the Arab Strategy for Water Security.

4.2 Managing NENA's water resources for agriculture: gaps and options

Governance and institutions[17]

Over the two decades since the Dublin Conference and the elaboration of best practice guidance for IWRM, NENA countries have made great strides in improving their water resources management in pursuit of the agreed goals of social equity, economic efficiency and environmental sustainability. In general, the countries have embarked on a progressive transition from supply augmentation and direct provision of water services toward a greater focus on water management, decentralization and inclusion.

Steps have been undertaken at various paces in different countries to strengthen water management institutions and to apply principles of decentralization and participation.

The objective of bringing IWRM to bear on agricultural water management is to achieve higher levels of efficiency: allocative efficiency between and within sectors, water efficiency and water productivity, together with social equity and environmental sustainability.

In fact, water institutions in NENA have been rated as 'better on average than in other regions'. Irrigation agencies are progressively decentralizing. The quality of public investment has improved, although there remains a legacy of capital-intensive, supply-driven investments still showing signs of a 'top-down' engineering approach.

- ➢ Next steps for NENA countries could be to further improve efficiency and accountability and to adopt participatory approaches and strengthened economic analysis in the investment planning process. Areas for further development of overall governance and institutions are essentially to continue the ongoing transition from centralized management and capital intensive engineering approaches to approaches where public agencies delegate, regulate, monitor and support, and invest efficiently, all with a raised level of transparency and accountability.
- ➢ Specific actions for progress could include: (1) improving the accountability of public agencies and strengthening incentives for their good performance and for transparency; (2) strengthening management and execution capacity for implementing legislation and enforcing regulations; (3) improving the quality of public investment by more participatory and local-level approaches to investment planning and by improving the quality of economic analysis; and (4) further reduction in the fiscal burden and dependence on the general budget, through increased cost sharing and public/private partnerships (PPP).
- ➢ Given the pervasive nature of these issues, this is an ideal opportunity for <u>regional learning across countries</u>, through sharing of knowledge and best practices in governance and institution building. There could also be scope for <u>regional technical cooperation</u>.

Integrated water resources management and the basin approach[18]

Several NENA countries have embarked on integrated water resources planning anchored at basin level. Basin planning has improved allocative efficiency and helped to integrate investment programming. Setting and enforcement of environmental regulations have been strengthened.

The basin approach has the advantage of confirming sectoral allocations, which provides certainty and transparency even if allocations are reduced. This has been a driver of greater efficiency in irrigation. In the future, as demand from other sectors grows, basin-level institutional mechanisms for orderly transfer of water between uses will become increasingly necessary.

17 This section draws on the discussion in Chapter 2 (Sections 2.1 and 2.2).

18 This section draws on the discussion in Chapter 2 (Section 2.3).

- Next steps in basin planning at country and basin level need to build on NENA's generally positive experience. This could include: (1) the generalization of the basin approach, both within countries and across borders; (2) further decentralization of decisions on investments and allocations to the basin level; and (3) an increase in accountability by giving more voice to non-state stakeholders.
- Given the varied nature of the experience and the critical need for orderly water resources allocation and management as demand pressures grow, the agenda might include: a regional review of past experience, drawing pointers and guidance for the future; and sharing at the regional level of data, information and knowledge on basin planning, particularly with respect to provisions for and impacts on agriculture, and related results. The review and the sharing process could help consolidate and improve approaches to basin management in NENA countries, and thereby help improve allocative efficiency, water efficiency and crop water productivity. This topic also forms part of the plan of action for the Arab Strategy for Water Security, where the IWRM programme is to focus particularly on: (i) issues of water resource allocation amongst sectors; (ii) institutional development and human capacity building; (iii) decentralization and participation; (iv) water efficiency; and (v) the use of nonconventional water.

Subsidiarity, decentralization, participation[19]

A leading principle of integrated water resource management is 'subsidiarity', and this has underpinned initiatives in many NENA countries towards decentralization and community collaboration on natural resources and environmental management. The approach has been extensively applied on irrigation schemes in the shape of WUAs, but the same community-based collaboration has been applied in NENA to watershed management, groundwater management and conservation of ecosystems and environmental services.

Empowering water user associations

All across the region, WUAs have developed as the lowest level of irrigation governance, taking on tasks ranging from simple representation right up to management at branch canal level. However, WUAs in NENA are considered weaker than in other regions, largely because they are not sufficiently empowered, for example in water distribution. Yet irrigation managers and professionals are unanimous that empowered WUAs have an important role to play in improving water service and also in sustaining scheme operations through cost recovery.

19 This section draws on the discussion in Chapter 2 (Section 2.4).

- There has been no general study of WUAs in NENA to examine how effective they are in improving water management and reducing fiscal burden. The basic conditions for a WUA to work are well known – legal framework and mandate, empowerment with responsibility, and capacity building, but how these are applied and in what sequence, what are the accompanying measures – these issues will vary by country, and each country needs to formulate its own action plan. As there are many common threads, these subjects could be addressed in a region-wide assessment that could help identify areas of strengths and weakness, draw up best practice, and define guidelines for further development. Subsequently, the development and empowerment of WUAs could be the subject of regional technical cooperation, benchmarking and capacity building.

Strengthening institutions for local-level natural resource management

Experience in NENA has shown that there are difficult trade-offs in promoting community natural resource management, particularly the cost of support programmes and the difficulty of organizing the needed cross-sectoral support. Nonetheless, bottom-up community organizations, supported by top-down 'convergent' public services and community development funds, have achieved substantial impact on sustainable resource management and also on rural livelihoods. The approach is becoming more relevant with the likelihood of climate change and growing pressure on natural resources.

- The question of how best to organize with communities and public programmes to support local-level natural resource management is relevant for many aspects of agricultural water management – including local level small scale irrigation, groundwater management and watershed management. Much has been done in the region, but scaling up has proved challenging. NENA countries need to conduct stocktaking, evaluate results and plan for structured next steps. A review of regional experience and best practice and constraints, and the development of cross-country exchanges and guidelines, could be helpful.

Acting on the supply-side drivers of scarcity[20]

Mobilizing new supplies

Although most resources are fully developed, there may be some potential to develop further storage and to optimize releases on existing storage. How-

20 This section draws on the discussion in Chapter 2 (Section 2.5).

ever, the economic and environmental tests for new development will be hard to pass. Any new storage projects will have to cope with more variable and extreme flows, and are likely to be set in an environmentally more sensitive landscape. Options will need to be flexible and have low capital and operating costs. Local hill dams, water harvesting or on-farm water storage may prove to be the most economical solution. But all such impoundments require social, economic and environmental assessment of the trade-offs involved, and projects need to be studied within a basin planning framework.

Wastewater and brackish/salline water

There is good experience in the region on treated wastewater use. As cities grow and invest in treatment plants, the resource will increase and can provide a useful – if relatively modest – new source for agriculture. There are barriers of cost, location and incentives to overcome, and a regulatory framework and a workable incentive structure are required. Similarly, salinized and sodic drainage water and groundwater can be reused, again with restrictions.

- Potential and issues vary by country and location, and each country needs a legal, regulatory and incentive framework. Region-wide exchange of experience could establish best practice and develop proforma guidelines, including an incentive framework that would maximize reuse. Subsequently, regional or bilateral cooperation programmes could assist with research, benchmarking, capacity building, technical cooperation on applying standards and regulatory frameworks, etc.[21]

Optimizing benefits from transboundary resources at the basin scale

Although the absence of a cooperative framework has been a constraint for the optimal development of the region's major transboundary rivers (Nile, Tigris, Euphrates), progress has been made in recent years to reach varying degrees of cooperation. The benefits of cooperation can be considerable: one study estimated that cooperation amongst Blue Nile riparians (Egypt, Sudan and Ethiopia) could increase net annual benefits from the river by as much as USD 5 billion. Riparians have an interest in reaching cooperative agreements on benefit sharing, along the lines intended under the ***Nile Basin Initiative***.

Best practice in transboundary water management seeks to achieve the goals of fair distribution of benefits, economic efficiency and environmental sustainability through agreement on some level of cooperation. The persuasive concept of benefit sharing – rather than assigning quantified water rights – could be at the heart of cooperation.

Overall, the benefits to be brought by cooperation are likely to be considerable, as reaching agreement over water will reduce risk and encourage economically optimal investment for all riparians. A cooperative framework can create win-win benefits, as planning and investment can be conducted at the basin scale, allowing upstream hydropower development, for example, whilst securing downstream benefits from irrigation and water supply. A cooperative framework also removes contentious issues that may harm the interests of other riparians.

- For the main transboundary resources of the region – the Nile, Tigris/Euphrates – there is a cooperative programme only for the Nile. Cooperative approaches to other transboundary waters within the region could learn from the Nile experience, and region-wide and subregional collaboration could be extremely valuable. This topic forms part of the plan of action for the Arab Strategy for Water Security.

Climate change

Climate change will have a negative impact on agricultural water availability and will increase farmers' vulnerability. Farmers will devise their own responses – but would benefit from structured support within national adaptation strategies.

- At the regional and national level, climate modelling and resource monitoring are essential to preparing responses to climate change. Technologies for this are now well developed and are freely available. For the preparation of adaptation strategies, experience shows that an iterative top-down/bottom-up approach based on evidence, research and farmer experience yields best results. The responses need to clearly target agricultural productivity and environmental protection. Research, extension and information are critical components in adaptation strategies, and learning from and with farmers will be vital, including from traditional farmer knowledge. For implementation, policies and programmes will be needed to support farmers in adapting agricultural practices based on a practical partnership between farmers and public agencies. At the limit, support may be required for a change of farming system, or even outmigration.
- NENA countries have good experience in preparing adaptation strategies and sharing this experience amongst countries. Regional technical

21 There is already a significant regional research programme on biosaline agriculture.

cooperation on modelling and monitoring and on aspects of implementation, such as research and technology development, would bring substantial benefits. This topic also forms part of the plan of action for the Arab Strategy for Water Security.

Tackling groundwater depletion

Groundwater has proved a bountiful resource which has revolutionized agriculture and the lives of farmers in many locations in NENA countries – eight of the world's top 20 groundwater irrigating countries are in NENA. Groundwater has proved very popular as an easily developed, flexible source of just-in-time water under the farmer's direct control. Groundwater also plays a key buffer role in maintaining optimal soil moisture during dry spells, and this role will grow with increasing climatic variability.

However, the 'open access' characteristic of groundwater has led to unregulated development, inequitable access and competitive overpumping, resulting in mining of nonrenewable resources and rapid depletion in many locations. Depletion has been accompanied by deterioration of water quality and saline intrusion.

Future development pathways need to promote more robust governance conducive to higher levels of productivity coupled with sustainability of groundwater quantity and quality and with equitable access.

- Country progammes to improve ***productivity*** could include technical, economic, institutional and social measures. Technical measures can include ever more efficient and water-saving technology, especially pressurized and localized irrigation and protected agriculture, changes to higher-value or more water-efficient crops, and improvements in water management, farming and post-harvest. Complementary supply-side measures such as recharge infrastructure to increase water availability may be available. Economic measures could address the incentive framework which influences the revenue side (e.g. trade policy) and the cost side – the cost of pumping (e.g. energy policy) and the cost of technological upgrading (e.g. tariffs on equipment and cost-sharing programmes like those in Saudi Arabia and Morocco). Institutional measures set the regulatory framework, which in high-governance countries may comprise the application of laws (as in Jordan); or the decentralization of resource management on a partnership basis to the local level (as in Yemen). Social measures can help, through targeted programmes, to remove barriers to entry or improvement for those with difficult access (e.g. the poor, women).
- Country programmes to improve ***sustainability*** have to recognize that establishing a governance framework for groundwater is exceptionally hard once the resource has been fully developed. This is true whether top-down or bottom-up approaches are selected – or a blend. In practice, options for NENA countries to manage groundwater demand are: (i) a rights and regulation approach; (ii) changing the incentive structure to favour conservation and efficiency; (iii) decentralizing groundwater resource management to the local level, supported by (iv) monitoring, information, education and communications.
- Region-wide sharing of data, information and knowledge on groundwater governance and management would be useful, including sharing of regional best practices in governance and institution building. A start has been made with a review of experience across the region and in other regions. This should help to identify best practice and allow country-to-country exchange of experience and skills.

The incentive framework for promoting water efficiency and water productivity in agriculture[22]

NENA countries have long recognized the need for demand management in irrigation through adjustment to the incentive structure to encourage water conservation and more efficient use. Cost recovery also ensures financing of services and reduces the fiscal burden. All NENA counties have implemented reform of the incentive structure along these lines. The picture is one of real progress but with still some way to go to eliminate lingering distortions.

Most NENA countries have revised the basis for charging farmers for irrigation water, and fees have been increased everywhere. Best practice would suggest water prices should reflect scarcity and opportunity cost, but this does not happen in practice except in private water markets. As a proxy, NENA governments have generally sought to recover management, operation and maintenance costs (MOM) and sometimes a share of the capital costs. However, there is a shortfall on many schemes and fees paid by users do not cover full costs, which limits autonomy and may impair services. Not recovering costs also limits the scope for private sector participation. Yet, in general, irrigation farmers' incomes in NENA are relatively high because of the higher-value cash crops grown, and recent FAO studies show that farmer incomes in the region are high enough to allow them to pay full MOM costs.

NENA countries have moved progressively towards free trade and compliance with their commitments under the World Trade Organization (WTO). Nonethe-

22 This section draws on the discussion in Chapter 2 (Section 2.6).

less, remaining protection of domestic production still keeps farm-gate prices high in many countries, distorting incentives and encouraging uneconomic use of water. Energy prices below border parity continue to drive groundwater depletion in several countries.

The incentive structure is linked to food security strategy, in which the optimum situation at the household level is adequate incomes and access to reliable food markets, and at the national level a trade and food supply policy founded on the principles of comparative advantage and virtual water. Ensuring that farmer incentives are aligned with this optimal paradigm is hard, especially when production and market risks are high. Here the key is to ensure that the underlying economics the farmer faces are favourable (otherwise social protection measures or a move out of farming may be in order), that the value chain in which the farmer operates is efficient with no insurmountable barriers to access, and that he or she faces incentives aligned with the economics. In this situation, the farmer can farm efficiently and make an income sufficient to meet family needs and ensure household level food security, and also to pay the fair cost of services.

- Often the incentive structure is highly complex and comprises elements from not only the agriculture sector and water sector policies but also elements of broader macroeconomic policy. An objective basis is required for countries to revise the incentive structure, and here a regional dimension could be most helpful. Next steps could begin with a national and/or region-wide review of the components of incentive structures for agricultural water use and of the results from adjustments to date – to know what are the components of incentive structures for agricultural water use that drive farmer behaviour, how well does the incentive structure support household-level food security and what are the results from adjustments to date. Evaluation should assess what happens to the use of the resource and to the people who use it when the incentive structure is changed, and how closely incentives are aligned with the underlying economics, how well value chains function and how barriers to access are removed. This review could form the basis for an evidence-based set of best practices and for moves by NENA countries to further adjustments that reflect national objectives in the water sector and that are also consistent with broader policy objectives such as growth, employment, rural poverty reduction and environmental sustainability. A regional focus on awareness raising on the reasons for adjustments to incentives could be helpful.

4.3 Improving water efficiency and crop water productivity: gaps and options

Water efficiency and water productivity[23]

Overall, water efficiency (WE) and crop water productivity (CWP) are relatively high in NENA, as expected in so arid a region. There is, nonetheless, considerable scope for further increase, especially economic CWP.

The objective of irrigation and water management is to increase water efficiency (WE) to the maximum whilst taking account of the cost of improvement at the margin. WE can be improved by improving water service to the field through minimized canal losses, timely delivery, correct quantity and quality, all areas served including the tail end; and by in-field water management, conveying water efficiently to the plant root zone at the right time and in the right quantity and minimizing nonproductive evaporation from the field.

Crop water productivity (CWP) is production or net income per unit of water consumed by the plant. CWP can be improved by soil, crop and water management. Parameters include crop and varietal choice, soil and water management, irrigation water management, nutrient management, weed and pest management and harvest and post-harvest management.

- In general, in a water-scarce region like NENA, efficiency and productivity are already relatively high. There is nonetheless scope in most countries for improvement, particularly in progressive conversion to pressurized irrigation and protected agriculture, in switching to higher-value crops and in improving all aspects of irrigation and of land, crop and water management.
- There is a key role for technology development (in a broad sense) to increase productivity. Plant breeding and biotechnology can develop planting material to increase the harvest index and strengthen drought and pest resistance, or to allow earlier planting or maturing or extend the growing period etc. There is also water accounting, auditing and scope for research on water management and on integrated land/crop/water management. In order to assess the scope for improving efficiency and productivity in NENA, benchmarking is also needed. A regional approach to this research is highly desirable, with a partnership of international, regional and national agencies working on a combination of basic research, applied and adaptive research and farming systems research, together with benchmarking, monitoring and evaluation. Collaboration here forms part of the Arab Water

23 This section draws on the discussion in Chapter 3 (Section 3.1).

Security Strategy, which focuses on scientific research and technology transfer.

- There is an increasing risk that interventions aimed at enhancing efficiency and productivity of rainfed and irrigated farming systems will have the unintended consequence of contributing to a net increase in consumptive water use.

Surface irrigation: increasing WE and closing the yield gap through modernization[24]

The NENA region has practiced irrigation for more than five millennia. Recent benchmarking studies show that NENA irrigation schemes are relatively efficient overall at delivering a timely, quality water service. Irrigation infrastructure and operating systems generally compare favourably with those elsewhere, and water delivery service is rated higher in NENA than elsewhere at all levels of the system. In addition to site specific factors, the overall political environment has favoured irrigation, and management and staff are generally effective and motivated. The resulting generally good water service translates into yields per ha and yields per m^3 which are well above global averages. Financial returns per unit of water can be as much as five times those on schemes in other regions.

There is nonetheless a wide variation between schemes, particularly in overall irrigation efficiency, where the most water-scarce schemes are the most efficient. There is also wide variation in performance amongst farmers on the same scheme and a considerable 'yield gap' which improved agricultural water management could help to close. There is thus scope to improve crop water productivity.

Irrigation modernization

The best approach to improving the efficiency and productivity of irrigation schemes is integrated modernization, incorporating physical improvements to the delivery system, along with economic, institutional and agronomic improvements.

- Planning modernization: Within a country's irrigation sector, a multitude of site-specific conditions will exist. The first step in planning is identification of objectives and prioritization of schemes and measures according to those objectives. Each scheme is different and work is required at the scheme level to define specific modernization objectives and to draw up modernization programmes. Integrated rather than single solution approaches are needed. Modernization of a NENA scheme should typically cover: (1) infrastructure, software and management changes to raise water efficiency by improving the flexibility, equity and reliability of water delivery services; (2) investments, technology transfer and capacity building to improve water productivity; and (3) institutional changes to ensure user participation in modernization strategy, system management and full cost-sharing. What would be helpful to the development of national improvement programmes would be a regional process to share data, information and knowledge on modernization and best practices. What could also be envisaged is regional technical cooperation on methodologies, benchmarking, capacity building, etc.
- Programming modernization investments: Actual investments may include: upgrading of physical infrastructure; measurement, control and monitoring of system operation and of irrigation delivery services; accountable contracting for water service; establishment or strengthening of empowered WUAs; capacity building for managers, operators, WUAs and farmers; infrastructure and management measures to increase water efficiency; advisory and extension services to improve crop water productivity; and introduction of systematic periodic benchmarking.
- Using the MASSCOTE planning tool: To prioritize investments amongst and within schemes, a planning tool is needed. There has been success region-wide and globally with MASSCOTE (Mapping System and Services for Canal Operation Techniques) developed by FAO, and which can be applied not only to conventional gravity schemes but also to lift and pressurized systems and to multi-functional schemes. MASSCOTE can be applied to both large and small schemes. There is already demand from within the region for further application of MASSCOTE. An option would be to standardise the use of this tool, and to develop regional centres of excellence that can help countries and schemes to apply it. Already, Tunisia has proposed to adopt MASCOTTE as its standard methodology for evaluating any pumped system.
- Tools to improve crop water productivity: As on-farm management tools, FAO provides ***AquaCrop*** for field crops management strategies to increase crop water productivity, and CROPWAT particularly in the presence of tree crops and other field crops not calibrated for ***AquaCrop*** use.

The energy/water nexus

Energy costs are relatively high in NENA, particularly on pressurized or lift schemes, and this makes for high O&M costs. As a result, investments to raise irrigation

24 This section draws on the discussion in Chapter 3 (Section 3.2).

efficiency may not always be cost-effective as energy prices rise. In many countries, farmers have been protected by what are in effect energy subsidies, but this has introduced its own distorted incentives.

- On the cost side, rising energy prices create a new reality for pump-based irrigation, which needs to be factored into planning and infrastructure. On the recovery side, there are significant trade-offs involved in decisions about whether to pass on the real cost of energy to farmers. Low energy prices keep agricultural employment and incomes up but create incentives to overuse and misapplication. Economic pricing is politically more difficult, it can lead to impoverishment of farmers, and it will have knock-on effects throughout the economy. A regional collaborative review of the implications of the energy/water nexus, both within NENA and worldwide, could provide a menu of options for governments in the region.

Pressurized irrigation[25]

NENA is a global leader in pressurized irrigation, which can lead to significant increase in returns per m^3. However, pressurized irrigation also leads to higher levels of cost and risk and to vulnerability to energy prices.

- Interventions may be needed in country programmes to reduce barriers to entry for poorer people, for example by encouraging the development of lower-cost technology and improving the efficiency of the supply chain (for example, training of stockists). Programmes to make credit available may also help: for example, hire purchase, leasing and microfinance, or capital cost-sharing. Interventions may also be needed to ensure profitable market outlets and help farmers manage price risk: price information, promoting increased competition among buyers, promotion of cooperative marketing institutions, storage to allow sales to be spaced out, outgrowers contracting, etc. Research may also develop packages that can help farmers manage risk. Given the shared nature of the technology, a regional programme of research and development, capacity building, and technical cooperation could be envisaged.

Rainfed agriculture[26]

Across NENA countries, the three farming systems that are wholly or predominantly rainfed – highland mixed, rainfed mixed, and dryland mixed – support almost two-thirds of farming households (62 percent). Incomes are generally low and poverty is prevalent in many communities. Raising productivity of these systems, including through improved water management, would have a significant impact on reducing poverty.

There are a number of possibilities for improved productivity and risk management through agricultural water management, generally combined with other factors. Productivity can be improved by a combination of soil moisture management and choice of crops and varieties. Farmers may use rainwater harvesting techniques to increase soil moisture, which can boost yields by two to three times over conventional rainfed agriculture, especially when combined with improved varieties and minimum tillage methods that conserve water. Where supplementary irrigation is available, it provides famers with a range of risk management options. Farmers can manage crop water risk by choosing the right crops and varieties. Maintaining soil texture and fertility will improve crop water productivity. All these elements can be combined together in integrated soil, crop and water management.

However, rainfed farmers face multiple constraints and barriers to adoption of improved techniques, including low and variable water availability; and environmental and soil problems of salinity, temperature and lack of nutrients. Risks are prevalent – climatic and hydrological risk, including drought and floods, which are intensified by climate change risks; market risk; and land and water tenure risk. Farming strategies are naturally characterized by risk aversion and low levels of investment. In addition, there has never been a Green Revolution for rainfed agriculture, and the technical solutions listed are inherently quite low yielding. The need for new solutions is pressing, and is exacerbated by the prospect of climate changes which are likely to be drying and warming and to herald increasing unpredictability and extreme events.

- Given the importance of rainfed farming to agricultural production, rural incomes and poverty reduction, there needs to be a full focus across national programmes on technology and institutions for improved productivity in rainfed farming systems. The following are possible next steps:
    - Promoting research, innovation, 'adaptive adoption' and strategies for risk reduction, through knowledge development and sharing as an iterative process between local people and technical staff and researchers.
    - Institutional adaptation accompanying technological innovation. Some of this institutional adaptation can occur spontaneously at the local level, for example farmer organization for better catchment management, collaborative

25 This section draws on the discussion in Chapter 3 (Section 3.3).
26 This section draws on the discussion in Chapter 3 (Section 3.5).

approaches to spate, spring or groundwater management, or community management of pasture. Some adaptation and adoption requires partnerships with public agencies – research and technology transfer, adjudication and regulation of land and water rights, decentralization of management of common assets or public goods such as water, forest and rangeland, resource management at the watershed scale, or payments for environmental services to compensate for externalities.

- A focus on rainfed agriculture in the basin and watershed context, integrating upstream resource management with downstream management of water quantity and quality. The watershed management approach provides an example of how this can be effected, building on bottom-up community-based approaches and technological and institutional innovation.
- Integrated development programmes for rainfed areas, incorporating both cropping and livestock, with: research, technology development and transfer; farming services such as extension and strengthening of input and product marketing chains; rural finance; and rural infrastructure development, particularly farm to market roads and water infrastructure.
- Strengthening land tenure jointly with local people, through land consolidation, land tenure confirmation, and co-management arrangements for common or state land (forests, rangeland).
- Joint monitoring of climate change trends and the development of adaptive strategies and investment programmes at the local and regional level.
- Introduction of innovative sources of financing, such as payment for environmental services (PES).

Although all countries in the region have worked extensively on the above agenda, there would be multiple benefits from synergy and joint work across the region in research, exchange of best practice, mutual farmer visits, etc.

Watershed management and water management in drylands[27]

Watershed management

Watershed management typically targets land and water management in the upper catchment with twin objectives: improved upstream livelihoods, and improved water resources downstream. The challenge has been to find packages that achieve the downstream objective and are also profitable enough to make it worthwhile for upstream farmers to sustain them. This challenge has been partly met – programmes in the region have succeeded in improving livelihoods upstream, but downstream results are questionable – and the approach is costly to replicate.

- ➢ The best results come where there are conservation techniques that are also profitable for farmers, and where participatory approaches are used that create ownership amongst the local community. In addition, the approach of PES (payment for environmental services) has been used with some success elsewhere in the world, and could be piloted in NENA. Given the experience in the region, but the current hesitation over next steps and scaling up, a regional review and establishment of best practice would help countries to articulate or update national-level programmes.

Water in the drylands and antidesertification

Three sets of measures are generally practiced for improving productivity in NENA drylands through agricultural water management: (i) increasing water availability through water transfer and water harvesting; (ii) increasing water efficiency, either through increasing the moisture in the soil profile, or using soil moisture more efficiently; and (iii) reuse of wastewater or use of marginal water such as saline water or drainage water. Programmes to support water management in very dry areas have been implemented across the region, with some success.

Much land in NENA is under threat from desertification, and much is lost each year. Some of this is simply natural process, but much is due to changes in land use, for example, change from sustainable pastoral use to crop production or increased stocking rates leading to overgrazing and sand-dune invasion.

- ➢ Given the extensive experience in the region on these themes at the pilot scale, and the ongoing larger scale programmes in some countries, this is an area where regional collaboration could bring major benefits, including in particular: sharing of data, information and knowledge; establishment of best practices; and research and development. A regional technical cooperation programme could be envisaged.

Water and forestry

Water management and forestry go hand in hand, in reforestation on degraded lands, in peri-urban tree planting using treated wastewater, and in agro-sylvo-pastoral farming systems.

27 This section draws on the discussion in Chapter 3 (Section 3.6).

- Regional collaboration for sharing of data, information and knowledge, establishment of best practices and R&D could help with programmes to develop forests and trees on degraded lands, around cities, and for anti-desertification. Forestry or trees should be factored in to all planning for treated wastewater use, and the role of trees in both rainfed and irrigated farming systems should be considered.

Drainage and drainage water reuse[28]

Waterlogging and salinity due to the rise of water tables and the accumulation of salts are reducing productivity over wide areas in NENA. It is estimated that 45 percent of Syria's irrigated area suffers from salinization, and in Egypt 50 percent. On the positive side, drainage water can be collected and reused, so that drainage gives the possibility of increasing effective water resources.

Few countries in the world have integrated drainage planning and investments within overall water resources management. The reasons are in part institutional, and also economic, as investment in drainage has been limited and cost recovery has proved problematic. Drainage has been little considered in either water or agricultural policy. Yet drainage can improve productivity at relatively low cost and investments bring good returns. In water-scarce NENA, the priority is on salinity control, and on the potential for reuse.

- Across the region, countries need to pay particular attention to drainage, which should be seen as a multifunctional investment within an IWRM approach, serving all water sources and users. A legal and governance framework needs to be set up, and a participatory approach should be applied. Various technologies and innovations are available, which have to be adapted to the local situation.

Drainage water reuse

Drainage water represents a considerable water resource and with careful planning, participatory approaches and investment, it can add 10 percent or more to national water resources, as in Egypt.

- As for drainage, drainage water reuse has to be assessed at the level of overall basin efficiency and socio-economic benefit. A particular issue is the downstream environmental effect: there may be less salt discharged but reduced return to watercourses.
- A legal and regulatory framework is needed to control drainage water reuse, and programmes for drainage water reuse need to be developed in association with users and to be the subject of explicit water entitlements in the same way as fresh canal water.
- There are trade-offs that need to be managed, the two most important of which are: (i) reuse may reduce environmental flows, so reuse needs to be assessed and trade-offs decided on in an overall basin framework; and (ii) quality problems need careful control, or salts and contaminants will build up in the soil profile, and judgements have to be made – as in Egypt – about cut-off levels for the quality of water to be used.
- Given the uneven levels of experience with both drainage and drainage water reuse, regional collaboration could be very helpful, including, in particular: sharing of data, information and knowledge on drainage and reuse; establishment of best practices; benchmarking; and capacity building. Regional technical cooperation could be envisaged.

4.4 Trade-offs

Every policy choice involves a trade-off to some extent: there is always a 'road not taken'. Nations balance the pros and cons and make the best choices they can in line with their objectives. In recent years in NENA countries the mechanisms for dealing with trade-offs have become more transparent and participatory. There is open discussion in the press and national debate, and the people have a voice that has grown louder since the 'Arab Spring'. It is therefore all the more important that the major trade-offs involved in policy choices over agricultural water management be clearly set out. This section discusses just three, but analysis of others is implicit or explicit throughout this report.

Productivity versus food self-sufficiency

The self-sufficiency trade-off

There is a cost to aiming at food self-sufficiency, and a potential trade-off with productivity and incomes

A series of shocks since the First Gulf War have sharpened preoccupations in the region about food security and have led to calls for increased food production to achieve a higher level of self-sufficiency. As discussed in Chapter 1 (Section 1.4), no country in the region is self-sufficient in cereals, although four major countries are two-thirds self-sufficient (Egypt, Iran, Morocco and Sudan). National strategy may call for increases in levels of food self-sufficiency. This may sometime be in the interests of the nation on eco-

28 This section draws on the discussion in Chapter 3 (Section 3.7).

nomic grounds as well as security grounds: Egypt, for example, is amongst the world's most efficient producers of rice, and it may be that at the margin it is in the interests of both farmer and the nation that the choice of crop be rice. In other situations, the state may call for cereals production but the farmer won't comply: in Yemen, for example, there is a call for cereals production, but the farmer knows that he can get ten times the return per m^3 of water if he produces vegetables (or ***qat***) for market, and he has a family to feed from his half-hectare plot. At the macroeconomic scale, the cost of the trade-off involved can be massive (see Box 4.2 on Morocco).

Box 4.2: Morocco – trade-offs between self-sufficiency and food security

A recent study showed that Morocco could achieve 85 percent self-sufficiency in cereals at current yields, and that full self-sufficiency could be achieved if yields rose by 40 percent. However, this self-sufficiency would come at a high cost – about USD 10 billion, 2008-2022 – through revenue forfeited by not producing higher-value crops. If Morocco produced instead the high-value crops, the USD 10 billion could be used to purchase a much greater quantity of imported cereals. In addition, production of higher-value crops would create far more agricultural employment for landless labourers than cereals production.

Magnan, N. et al. 2011, Lampietti et al. 2011

For poor rural areas and farming systems, actions to raise the productivity of all crops would certainly improve household-level food security

The challenge of food security is different at the local or household level, particularly in the remoter areas and in the semi-subsistence farming systems of poorer countries like Yemen, Mauritania and Sudan. The most at-risk households are those of the landless and where women are the heads, but where poor households have land, food crop production is necessarily a priority unless there is a possibility of producing and selling high-value cash crops. It is not only economics that drives the extensive cereals cultivation across NENA's rainfed systems – cereals cultivation accounts for two-thirds of NENA's cultivated area. There is no doubt that investment in the productivity of rainfed cereals cultivation – and of all crops – alongside investment in rural infrastructure and services, would strengthen the food security of these poor households, and national food security policies need to align with agricultural and rural development programmes to this end.

Alternative food security approaches

Following the shocks of 2008, policy analysis for the region has emphasized the need for: (1) improved data and strengthened capacity for evidence-based decision making; (2) protecting vulnerable households nationwide by strengthening safety nets (cash transfers, labour-intensive employment programmes, health and nutrition interventions, with a particular focus on women and children), education, family planning; (3) protecting rural households and contributing to national food supply and price stability by a rural livelihoods strategy principally focussed on enhancing agricultural and off-farm incomes and production through investment in R&D, rural infrastructure and market development; and (4) reducing exposure to supply and price risks.

Mechanisms to manage supply and price risks include: an export-led growth strategy to earn foreign exchange to import food; improving supply chain efficiency; and introducing cost-effective risk management instruments (food reserves, buffer stocks, forward contracting, financial hedging products, etc.) Countries in the region have also discussed how to promote and support regional and global responses to protect against price volatility. Food security strategies clearly have to be adapted to the nature of the risks. A variety of strategic responses is possible for different groups of countries (see Table 4.1).

Table 4.1: Food security strategy options

Country characteristics	Examples	Main food security risks	Principal strategic responses
Poorer countries with vulnerable populations dependent on farming	Mauritania Sudan Yemen	Rural malnutrition and famine	• Safety nets, education, family planning • Rural livelihoods strategy focussed on agricultural productivity and risk management • Bilateral and multilateral agreements for food aid
Middle income countries that want moderate food prices for their citizens and to maintain a viable rural sector	Maghreb and Mashreq countries	Price spikes Difficult access and affordability for poorer rural areas and households	• Safety nets, education, family planning • Rural livelihoods strategy focussed on agricultural productivity and risk management, off-farm, etc. • Improving supply chain efficiency.
Better off countries requiring assurance of food supplies	Oil-exporting countries of the Arabian Peninsula	Geopolitical risk	• Improving supply chain efficiency. • Risk management instruments.

Free trade vs. protection

As discussed above, NENA countries have moved progressively towards free trade and compliance with their commitments under the WTO. Nonetheless, there are arguments for keeping a measure of protection of domestic production – to prevent dumping, to counteract the effect of subsidies in major exporting countries, and to ensure that local production, on which the livelihoods of the poor depend, remains profitable.

The contrary arguments have also been mentioned above: distortions in the incentive structure induce choices which are wasteful for the economy, create an agricultural structure that will ultimately not be sustainable, with dire repercussions for the farmer, and encourage overuse of water and land resources.

Extreme water scarcity makes the NENA region heavily dependent on imported agricultural commodities, and also makes it vital that each drop of water earn the highest income. NENA agriculture, therefore, has good reason to specialize in production – and often export – of high-value commodities like cotton, fruits and vegetables, and so generate the resources needed to import lower value commodities like grains. This kind of economic exchange, conceptualized recently as 'virtual water trade', helps achieve good use of water resources, provided that the global trade system is well-functioning.[29]

Most NENA countries are already net importers of agricultural goods, therefore importing large volumes of virtual water. Jordan imports about 6 BCM of virtual water per year and withdraws only 1 BCM from domestic sources. Apart from national food security considerations, for the future, economic policy in the NENA countries could concentrate scarce water on encouraging the production of crops that have the highest returns and on ensuring that trade functions well, for example by aligning with WTO requirements [FAO 2001: 117-8, McDonnell and Ismail 2011].

Managing trade-offs and aligning incentives

Adoption of techniques to improve water productivity requires an enabling policy and institutional environment that aligns the incentives of producers, resource managers and society and that provides a mechanism for dealing with trade-offs that inevitably arise from the differing interests of farmers and the rest of the nation. Table 4.2 below highlights how the individual farmer wants to maximize his benefits, whereas society frequently has other views. Trade-offs take place to better align incentives. [IWMI 2007: 280-281]

29 The concept of virtual water developed by Professor Tony Allan is that a well-functioning global trade system would induce countries to either export or import goods based on their natural resource endowment: water and/or land poor countries would be net importers of agricultural commodities produced by water-abundant countries.

Table 4.2: Identifying misaligned incentives and deciding on trade-offs

The farmer's perspective	Society's perspective	How is trade-off decided?
Farmer needs a high price to encourage investment and risk taking	Consumer wants lower prices	Probably best through income support to the poor. Align social and agricultural policy
More production leads to price drop, reducing the farmer's incentives	Government and consumers want more production	Probably best to leave it to the market. Align trade and business policy with agricultural policy
Farmer is reluctant to improve water efficiency as this increases risks	Water is short and the nation wants efficient use of scarce water resources	Government may develop markets or provide limited support to investment in e.g. drip irrigation. Align agricultural and water policies
New technology is costly and there are barriers to entry, particularly for the poor and for women	Society sets the goal of equity	Government may provide limited targeted support to investment, help credit mechanisms to develop, etc. Align agricultural and water policies
More efficient or more influential farmers may obtain a larger share of resources or subsidies		Government may refine targeting mechanisms and adopt pro-poor approaches. Align agricultural and water policies
Farmer may increase production at the expense of the environment	Society has an interest in environmental conservation	Environmental laws and regulations implemented in consultation with farmers
Producer wants as much water as possible	Society may have higher-value uses for that water	Water resource management strengthened
	There may be downstream uses for the water	
Producer has little incentive to conserve a common pool resource like groundwater	Society may wish to conserve groundwater for the future	

Source: Author's compilation based on IWMI 2007: 280-281

Chapter 5
Towards a regional collaborative strategy

Main messages

Creating momentum for change requires first an understanding of the drivers of change and of the interests of different constituencies. Successful change programmes respond to imperatives such as severe water shortages and disputes amongst sectors, and may be helped by 'decisive moments'. They are founded on an inclusive process of study and debate leading to consensus on a national water reform agenda and coherent policies. Successful programmes provide for good water governance arrangements, with well-designed institutions having clear authority, the necessary resources and stability. Finally, the change process is evidence-based, systematically using data, science and knowledge, and the practical application of economics.

Regional collaborative actions are identified within the domain of improving management of NENA's water resources for agriculture: governance and institutions, IWRM, subsidiarity, decentralization and participation, supply- and demand-side management. Scope for regional collaboration to improve water efficiency and crop water productivity through agricultural water management is also identified.

5.1 Creating momentum for change

Drivers of change in the water sectors of NENA countries

Although each country context is different, it is possible to identify a number of changes in attitudes, in awareness of problems, and in institutions and power relations that, taken together, have created a context for change in NENA countries.

The thinking about water amongst different NENA constituencies has changed. Demographics and economic growth have led to a rapid urbanization and to increased consumption of water and of water-intensive food products. As a result, NENA's urban constituencies are now an important voice in water. Accompanying this change, education and broader social change, including in the status of women, have led to more emphasis in the region on potable water and safe sanitation, and less emphasis on water for agriculture. Government thinking has evolved, too, and policies which in the past favoured supply increase and tended to skew demand through subsidies and protection have moved more towards concerns for efficiency, environmental protection and reduction in the fiscal burden.

These changes in attitude have been accompanied by the emergence across NENA of serious water problems that are now the subject of open discussion. The groundwater revolution has led to unmanageable over-exploitation. The rapid expansion of supply investments has created an inflexible pattern of rights and expectations. Climate change is introducing costs and risks that are hard to manage. There is awareness that management of environmental degradation has been neglected. Public and private investments in water infrastructure are altering existing water rights, in some cases increasing inequity.

There is an awareness too that water sector institutions are not always adapted to this changing context. New technology and the development of resources, particularly groundwater, have outstripped the governance mechanisms that should have regulated them. More generally, there is a sense that governments have developed the resource and allocated water between sectors and to users but have not developed the flexible and participatory institutional mechanisms and accountability structures needed to respond to changing demand, create accountability or resolve conflicts. There is an awareness too that access to water is not always equitable, and that vulnerable and marginalized groups are most at risk as they lack the resources to manage the systemic factors that contribute to poverty.

All these developments create a climate receptive to change, and this may be given an impulse by some 'decisive moment'. Crisis can focus attention on lingering problems and trigger beneficial change by sudden, dramatic events. For example, riots in Algeria in 2002-4 were a stimulus to acceptance of water reforms. Conflict in Iran has demonstrated the need for a more consultative approach to relocation issues. Successive severe droughts in Morocco in the early 1980s stimulated water policy reform, including the passage of the 1995 Water Law. A long interruption in urban water supply in Ta'iz, Yemen, in 1995 triggered a national debate and the start of water sector reform. [World Bank 2007a:74]

Introducing best practice water policies

Experience from elsewhere in the world can show how a programme of best practice changes in the water sector can be decided and implemented by consensus. Australia has many characteristics similar to NENA countries in terms of aridity, water shortages, and stresses between sectors competing for water. Over a decade, Australia debated its water problems and developed a comprehensive reform programme of water management. Box 5.1 below shows the main elements in the Australian reform programme, and identifies the elements of the reform that have contributed to its success in improving water management.

Box 5.1 Comprehensive reform of water management in an arid country: Australia's National Water Initiative

Driven by growing water shortages, Australia conducted an inclusive process of study and debate to arrive at consensus on its ***National Water Initiative***. This comprehensive reform plan says:

<u>Resource management</u>

- Return all water systems to sustainable levels of extraction
- Manage groundwater sustainably
- Respect needs for environmental water

<u>Water allocation</u>

- Provide secure water entitlements for irrigators
- Provide secure water entitlements for the environment
- Introduce water sharing plans with legal force

<u>Demand management</u>

- Encourage open trading of water rights
- Introduce water pricing based on economics
- Ensure support for affected communities where irrigation supplies are reduced

<u>Governance and institutions</u>

- Invest in knowledge about water, and build capacity for good water management
- Improve water data collection and water accounting

<u>Water services</u>

- Improve the management and security of urban water supplies

The Initiative has led to greatly improved water management by:

- Building up <u>certainty</u> for water investors and communities
- Building <u>science and evidence</u> into water management
- Building up <u>markets</u> in the water sector
- Building the <u>environment</u> into water management
- Building the <u>private sector</u> into the water sector
- Building <u>capacity</u> for good water management
- Building water into the national <u>infrastructure</u> program
- Building up a national <u>narrative</u> for water reform

Source: Adapted from Water Reform in Australia – the Key Success Factors, a presentation by Ken Matthews AO, Former Chairman and CEO, Australian National Water Commission. 8 June 2011. *ken.matthews100@gmail.com*

The question is: what were the elements in the process which enabled Australia to bring about such sweeping reforms. The key factors in this success have been five:

- An imperative for reform: Australia was experiencing severe water shortages and over-allocation to agriculture and the situation was worsening with climate change. These realities became 'drivers of change' – the triggers that drove policy action and led to consensus that something had to be done.
- An inclusive process of study and debate leading to consensus on a national water reform agenda: A long process of study, national debate and political discussion led to agreement on objectives and on a national water reform agenda, the ***National Water Initiative***, which acted as a blueprint for the changes.
- Policy coherence: The ***National Water Initiative*** contained the right suite of policies to achieve the policy objectives and the right measures to tackle the many water challenges within a coherent, integrated national plan.
- Good water governance arrangements: The reforms established the right institutions, with clear authority, the necessary resources, and stability (see Box 5.2 below).
- An evidence-based process: The ***National Water Initiative*** was based on the systematic use of data, science and knowledge, and on the practical application of economics, taking account of key concerns like property rights, and introducing the discipline of markets.

Box 5.2: Governance and institutions matter: Australia's experience establishing the right institutions, with clear authority, the necessary resources, and stability

Australia's National Water Initiative adopted the principle: ***Governance and institutions are always critical to good water management and to the success of reform***. As a result, institutional change and strengthening were at the heart of Australia's water sector reform.

Reform of government agencies comprised:

- A federal water department and legislation where there previously was none
- A new independent authority for the Murray Darling Basin
- Intergovernmental coordination committees
- Oversight by the Council of Australian Governments (Prime Minister and State Premiers)
- An independent public assessor of progress (the National Water Commission)

The National Water Commission as independent assessor:

- Is required by law to report on reform progress
- Reports to the Prime Minister
- Publishes assessments and reports
- Can suggest new reform needs (e.g., groundwater, water data, water science)
- Advocates reform and change
- Invests in reform and better water management

Other specialist institutions were set up or strengthened:

- Catchment management authorities
- Environmental water managers
- Irrigation and urban supply utilities
- Environmental regulators
- Health regulators
- Water market regulators

…all administratively separate

There was emphasis on institutions to build capacity for data, information and knowledge:

1. A major new agency and funding for water data (the Bureau of Meteorology)
2. Major investments in water science
3. National Water Commission inputs to public debate and understanding about water

Source: Adapted from Water Reform in Australia – the Key Success Factors, a presentation by Ken Matthews AO, Former Chairman and CEO, Australian National Water Commission. 8 June 2011. *ken.matthews100@gmail.com*

5.2 Themes for regional approaches and cooperation on agricultural water management

The discussion in Section 4.2 above identified a number of themes and objectives where regional collaboration could contribute to improving management of NENA's water resources for agriculture. This collaboration might cover in particular: sharing of data, information and knowledge on agriculture water management; best practices in governance and institution building; benchmarking; research and development; capacity building; technical cooperation; and awareness raising. Table 5.1 below gives a synoptic view of options as a basis for discussion and prioritization.

Table 5.1: Scope for regional collaboration to improve management of NENA's water resources for agriculture

Theme	Next steps	Possible scope for regional collaboration
Governance and institutions		
	Improve efficiency and accountability, strengthen participatory approaches, and improve the investment planning process.	• Regional learning through sharing of knowledge and best practices in governance and institution building. • Regional technical cooperation.
IWRM and the basin approach		
	Generalization of IWRM and the basin approach, further decentralisation to the basin level, and an increase in accountability would help improve allocative efficiency and agricultural productivity.	*Collaboration on this theme forms part of the plan of action for the Arab Strategy for Water Security*.
Subsidiarity, decentralization, participation		
Empowering WUAs	Next steps on empowering WUAs and farmer organizations need to be evidence-based, grounded in an understanding of their role in the value chain and of their potential and limitations in specific contexts.	• Region-wide assessment to identify strengths and weakness, draw up best practice, and define guidelines for further development • Regional technical cooperation, benchmarking, and capacity building.
Community-based water management	Strengthen institutions for local-level natural resource management	• A review of regional experience and best practice and constraints • Cross-country exchanges and guidelines
Acting on the supply-side drivers of scarcity		
Use of brackish and waste water	Help farmers to develop and use brackish water and treated wastewater resources.	• Region-wide exchange of experience to establish best practice and guidelines • Regional or bilateral cooperation programmes for benchmarking, capacity building, applying standards and regulatory frameworks, etc.
Transboundary	Optimize benefits from transboundary resources at the basin scale	*This topic forms part of the plan of action for the Arab Strategy for Water Security*
Climate change	Priorities are modelling and monitoring, preparation of adaptation strategies, research and technology development.	*Collaboration here forms part of the plan of action for the Arab Strategy for Water Security*.
Groundwater depletion	Options include rights and regulation, adjusting incentives, decentralized management, and education.	• Region-wide sharing of data, information and knowledge • Review of experience across the region and in other regions
Demand management options and the incentive framework		
	Evidence-based adjustments founded on a better understanding of the relationship between the incentive framework, the use of resources, and the impact on farming households (incomes, food security, etc.)	• Region-wide review of the components of incentive structures and development of best practices • Regional focus on awareness raising

Similarly, the discussion in Section 4.3 above identified topics where regional collaboration could help to improve water efficiency and crop water productivity through better agricultural water management. These topics are summarized in Table 5.2, which again is designed simply to give a synoptic view of options as a basis for discussion and prioritization.

Table 5.2: Scope for regional collaboration to improve water efficiency and crop water productivity through agricultural water management

Theme	Next steps	Possible scope for regional collaboration
Research, technology development and technology transfer to increase efficiency and productivity		
	Conduct basic research, applied and adaptive research, and farming systems research, together with benchmarking, monitoring and evaluation and technology transfer to increase efficiency and productivity	*Collaboration here forms part of the Arab Strategy for Water Security.*
Surface irrigation: increasing water efficiency and closing the yield gap		
Irrigation modernization	Irrigation modernization and benchmarking which involves farmers in the decision-making process.	• Regional process to share data, information and knowledge on modernization and best practices • Regional technical cooperation on methodologies, benchmarking, capacity building, etc. • Regional alignment on the MASSCOTE planning tool and development of regional centres of excellence
The energy/water nexus	Factor the implications of the rising cost of energy into planning and operations	• A regional collaborative review of the implications of the energy/water nexus
Pressurized irrigation		
	Increase efficiency and productivity, and reduce barriers to entry along the value chain and help farmers manage price risk.	• Regional programme of research and development, capacity building, and technical cooperation
Rainfed agriculture		
	Increase productivity and reduce barriers to sustainable intensification and help farmers manage price risk.	• Assessment of yield and water productivity gaps through modern technologies (remote sensing, modelling)
	Focus on technology and institutions for improved productivity in rainfed farming systems	• Synergy and joint work across the region in research, exchange of best practice, mutual farmer visits, etc.
Watershed management and water management in drylands		
Watershed management	Build on experience and develop second generation watershed management programmes	• Regional review and establishment of best practice
Water and forestry	Develop forests and trees on degraded lands, around cities, and for anti-desertification	• Regional collaboration for sharing of data, information and knowledge; establishment of best practices; and R&D • Regional technical cooperation
Drainage and drainage water reuse		
	Programmes for drainage and drainage water reuse are a high priority in NENA, and some countries – notably Egypt – are world leaders. Next steps include understanding the challenges and options, establishment of best practices, capacity building, and investment.	• Regional collaboration for sharing of data, information and knowledge on drainage and reuse; establishment of best practices; benchmarking; and capacity building. Regional technical cooperation

Setting priorities for collaboration above the national level

The themes presented in Tables 5.1 and 5.2 above were discussed with national representatives from 14 countries and with 12 regional and international organizations in the *Land & Water Days* held in Amman in December 2013. Based on the discussion and on the application of the agreed criteria (see Section 4.1 above), a short list of priority themes has been drawn up (Table 5.3). These themes were validated at the FAO Regional Conference in February 2014.

Table 5.3: Themes proposed for collaboration under the Regional Collaborative Strategy

Improving management of water resources for agriculture			
Multi-stakeholder scenario building	• IWRM and allocation efficiency	• Water-food-energy nexus analysis	• Policy, institutions and overall governance revision
Improving water efficiency and crop water productivity			
Farming system	**Governance and policy issues**	**Resource management issues**	**Productivity issues**
Rainfed systems	• Community-based natural resource management	• Climate change • Watershed management (including forestry, rangeland) • Water harvesting	• Research, technology development and transfer • Reducing yield gap • Increasing water productivity
Surface irrigated systems	• Empowering water user associations	• Nonconventional water use • Demand management and intersectoral reallocation • Climate change adaptation	• Irrigation modernization • Increasing efficiency and productivity in water use
Groundwater systems	• Groundwater governance and policy issues	• Collective water management • Monitoring of groundwater depletion	• Increasing efficiency and productivity in water use

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Internal Renewable Water Resources of NENA countries

Countries with occasional or no water stress	IRWR (m^3/year per capita)
Iran (Islamic Republic of)	1753
Countries with water stress	
Iraq	1170
Lebanon	1144
Countries with chronic water scarcity	
Morocco	918
Oman	503
Countries with absolute water scarcity	
Tunisia	413
Syrian Arab Republic	336
Algeria	327
Mauritania	124
Jordan	111
Libyan Arab Jamahiriya	95
Saudi Arabia	95
Yemen	92
Qatar	44
Sudan	40
United Arab Emirates	33
Egypt	22
Bahrain	5
Kuwait	0

Source: FAO-AQUASTAT

Annex 2

Existing cooperation related to agricultural water in NENA

Regional and international cooperation on agriculture and agricultural water management

Research

International agricultural research has been one of the shining examples of successful cooperation and has achieved significant impacts on livelihoods in NENA countries. Coordinated by the CGIAR, the cooperation includes 15 international centres of excellence. The work of ICARDA based in Syria has been particularly productive for the arid conditions of NENA countries. The International Centre for Biosaline Agriculture (ICBA) – not a member of CGIAR – is doing pioneering work on cropping in marginal production systems. [FAO 2011a, McDonnell and Ismail 2011]

Coordinated policies and actions

NENA countries are linked by a number of regional and international cooperation institutions. Regional cooperation on land and water has been driven by the existence of multiple shared agendas - economic linkages, shared land and water resources; and common development challenges, including climate change. There have already been regional initiatives covering anti-desertification. Mauritania also participates in the Club du Sahel, a discussion and information exchange forum for the West African drylands. Sudan participates in IGAD - the Intergovernmental Authority on Development - a regional agricultural research coordinating body for the Horn of Africa. In addition, NENA countries are participating in international programmes such as the ***UN Convention to Combat Desertification*** (UNCCD) and the ***Global Environment Fund*** (GEF). [FAO 2011a]

New partnerships and mechanisms

A number of recent initiatives and partnerships from the private sector such as Fairtrade and organic labelling can have positive effects on farm incomes and also on sustainable land and water management. Ecotourism, for which there is strong consumer demand, also has the potential to conserve the environment and simultaneously to create opportunities for local and rural poor communities. The key to sustainable ecotourism is sustainable ecosystem management with benefit sharing among local populations. A number of environmental interest groups are actively engaged in partnerships to promote sustainable land and water management. They play both a financing and an advocacy role to promote policies and programmes to enhance agricultural productivity, address climate change impacts and enhance biodiversity, water quality and quantity. Private foundations, such as the Rockefeller, Ford and Bill & Melinda Gates Foundations, are promoting sustainable agriculture. [FAO 2011a]

Regional and international cooperation on data and modelling

For planning and managing water for agriculture, NENA countries need access to good data. Hydrological and crop modelling needs to be coordinated in order to assess supply and demand and to anticipate likely impacts of climate change on water availability and crop production and to assess the effectiveness of adaptation options. [FAO 2010a]

New technologies, particularly remote sensing, are contributing to mapping and monitoring a wide range of natural resource parameters. Satellite data combined with GIS now have the capability to measure changes in land cover, forecast crop yields, monitor crop stress and quantify production and yields, measure stream flows, soil moisture and water storage, and follow pollution plumes in water or in the soil. Using recent developments in information and geospatial technology, a number of international programmes are developing resource inventory and monitoring tools. The potential of these spatial technologies for improving land and water management is enormous, and many of these tools are open-access. [FAO 2011a]

Table: Programmes for data generation, harmonization and sharing

Programmes	Goal related to land and water management	URL
GEOSS	Earth Geospatial data network	http://www.earthobservations.org/
UNEP/FAO digital charts	Provide information on land cover and population density	http://www.fao.org/docrep/009/a0310e/A0310E09.htm
Geonetwork	Support decision making in L&W management through providing better access to spatial data and information	http://www.fao.org/geonetwork/srv/en/main.home
FAO L&W Digital Media Series	Provides data as well as educational resources on land and water issues	http://www.fao.org/landandwater/lwdms.stm
Global soil partnership (under discussion)	Harmonization of global soil databases	http://www.fao.org/nr/water/news/soil-db.html ; http://www.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/index.html
Wocat	Global network to disseminate knowledge on SLWM practices	http://www.fao.org/ag/agL/agll/wocat/default.stm
Global Soil Map Consortium	Soil analysis to inform land management practices	http://www.globalsoilmap.net/
LADA	Land degradation assessment in drylands	http://www.fao.org/nr/lada/
UN-Water	Fostering information-sharing and knowledge building across all UN agencies and external partners dealing with freshwater management	http://www.unwater.org/flashindex.html
GTOS	Interagency coordinating mechanism for earth observation of natural resources	

Source: FAO 2011a

Sources of extra finance for agriculture and agricultural water management

Carbon markets

One important innovation is the development of carbon markets. At present, the Clean Development Mechanism (CDM) under the Kyoto protocol excludes agriculture However, work is underway to reverse this. In addition, new initiatives are under discussion to allow reward for carbon sequestration in all landscapes.

Markets in environmental services

The trade in environmental services through Payment for Environmental Services (PES) mechanisms has attracted interest and financing both within countries and from international investors. PES systems exist for a number of initiatives, including watershed services, biodiversity conservation, benefit sharing in transboundary river basin development, and reduction in carbon emissions. PES could be a key instrument for supporting improved agricultural water management and climate change adaptation in the *Highland mixed* and *Rainfed mixed systems* (compensation for externalities and downstream benefits of watershed management), and could also support conservation investments like terracing, biodiversity conservation or the maintenance of traditional agricultural heritage in a number of systems, including *Dryland mixed* and *Pastoral systems*. [FAO 2011a]

Annex 3

Preliminary results from the Regional Initiative on Water Scarcity Country Case Studies

Applying the Food Supply Cost Curve – the case of Tunisia

The Tunisia case study for the Regional Initiative on Water Scarcity applied the methodology of the food supply cost curve to determine the optimal balance between increasing domestic production through improved water management or other means, and trade.

The study showed that the main avenues for improving water productivity are:

- Reduction of all forms of loss: drainage, infiltration, percolation, and evaporation
- Increase in crop yields per unit of water transpired
- Increasing the efficient use of rainfall, stored water and nonconventional water

A series of policy options was identified to achieve the above, of which four were subject of economic evaluation and ranking as part of the exercise. The options were:

Within agricultural production and agricultural water management

- Anticipate climatic risks and manage drought (not evaluated)
- Intensify irrigation to improve water efficiency and water productivity (evaluated)
- Mobilize remaining conventional water resources (evaluated) and nonconventional resources (not evaluated)
- Improve productivity of rainfed agriculture, particularly for staples (evaluated)
- Promote intensive smallholder agricultural water management (not evaluated)
- Manage hot spots: overexploited aquifers, areas subject to salinization due to poor agricultural practices or saline intrusion (not evaluated)
- Promote local level water governance, more subsidiarity and empowerment of local populations (not evaluated)

Outside agricultural production

- Act upstream and downstream from the food chain to reduce food losses (evaluated)
- Determine food import policy on the basis of comparative advantage and 'virtual water' analysis (not evaluated)

The case study concludes by recommending the evaluation of the remaining options in order to rank them and so guide water management, production and trade policy.

Source: Regional Initiative on Water Scarcity – Tunisia Case Study

Applying the Food Supply Cost Curve – the case of Oman

The Case Study for Oman conducted under the Regional Initiative on Water Scarcity examined the potential options available to bridge the gap between supply and demand of water. The Study showed that supply increase options, such as recharge dams and storage dams, result in a high cost per cubic meter and are unprofitable. The least expensive demand management options were to improve surface irrigation, followed by a change in cropping pattern, then adoption of modern irrigation systems.

The Study then evaluated the Food Supply Cost Curve for wheat, potato and tomato. For each of the products three alternative options of supply increase were considered. The results showed that production of soft wheat and of potatoes is not recommended as the expected costs of production are higher than the international market price. For tomato the results are more encouraging as domestic cost of production is below import parity. However, domestic market is quite small and both economics and production requirements are different if export surpluses are produced. Exports would require organization of the supply chain and respect of the international standards in terms of pesticides and chemical uses, packaging, storage and transportation to the final destination. These requirements would, however, have a positive impact on quality of vegetables sold in the local market in the long term.

Source: Regional Initiative on Water Scarcity – Oman Case Study

An agenda for improving agricultural water management in Morocco

The exercise conducted by Morocco for the Regional Water Scarcity Initiative came up with an agenda for improving agricultural water management in the country:

- Morocco faces growing food production risks (volatile international markets, climate change), whilst production is increasingly constrained by economically available water and its cost. Demand is rising and supply is highly constrained. Therefore, improving agricultural water productivity is a top priority.

- Options are many, starting from the very tops of watersheds (e.g. erosion control) right down through irrigation efficiency and potential for improving rainfed agriculture (e.g. direct seeding, supplementary irrigation) to farm level (e.g. reduction of evaporation and other losses).

- Economic analysis shows that many options for improving water productivity are viable and can be achieved through a combination of investment adapted to local needs and an appropriate incentive structure.

- Institutional change is an essential accompaniment to provide more flexible and responsive management of water resources and irrigation services. Ongoing and planned legal and institutional reforms open up pathways to these improvements.

Source: Regional Water Scarcity Initiative – Morocco Case Study: 8