Food and Agriculture
Organization of the
United Nations

International
Water Management
Institute

Towards a new generation of policies and investments in agricultural water in the Arab region

Fertile ground for innovation

Background paper prepared for the high level meeting on agricultural water policies and investments

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ISBN 978-92-5-131431-9 (FAO)
ISBN 978-92-9090-887-6 (IWMI)

Attribution. Please cite the work as follows: Borgomeo, E.; Santos, N. 2019. *Towards a new generation of policies and investments in agricultural water in the Arab region: fertile ground for innovation.* Rome, Italy: FAO; Colombo, Sri Lanka: International Water Management Institute (IWMI). 124p. doi: 10.5337/2019.207

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FOREWORD

The Arab region needs a new generation of policies and investments in agricultural water. Agricultural water management has always posed challenges and opportunities in the Arab world. However, unprecedented and accelerating drivers such as climate change, population growth, and land degradation make agricultural water management a more urgent priority than ever before. In addition, as part of the 2030 UN Agenda for Sustainable Development, Arab countries have committed to work towards an ambitious set of development targets, the Sustainable Development Goals (SDGs). Unless the right policies and investments are put in place, it will be difficult to achieve the SDGs, including ending hunger and providing clean water and sanitation for all.

This paper is part of an ongoing collaboration between the Food and Agriculture Organization of the United Nations (FAO) and the International Water Management Institute to foster dialogue on agricultural water policies and investments in the context of the FAO led Regional Water Scarcity initiative. The purpose of the paper is to frame the key challenges and opportunities in the sector – including emerging innovations in digital agriculture, water accounting, water supply and wastewater reuse – and to lay out broad strategic directions for action.

Based on existing studies and global datasets, this paper provides a comprehensive review of investment and policy trends in agricultural water in the region. In most Arab countries, spending in agricultural water has been stagnating and policies initially designed to ensure food self-sufficiency have over time created a complex network of subsidies and distortions. These policies have also indirectly contributed to negative food and water security outcomes, including unhealthy diets and depletion of groundwater resources. To make the most of the region's scarce land and water resources, it is time to reexamine these policies and, in particular, move away from food self-sufficiency while protecting the most vulnerable through targeted social protection measures.

Agricultural water management is key to addressing the triple challenge of sustainable land and water use, climate change resilience, and food security. As demonstrated in this report, delivering on these three fronts requires policy coherence and institutional coordination. There is a need to consider the synergies and trade-offs between social protection, trade and agricultural water policy to better align incentives and behaviors towards more sustainable management of the region’s scarce land and water resources.

As the Arab region works towards a new generation of policies and investments, the Food and Agriculture Organization of the United Nations and the International Water Management Institute will continue to work in partnership with governments, regional organizations, civil society and the private sector to enhance the region’s sustainable development prospects.

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ABOUT THIS REPORT

Agricultural water presents a set of challenges and opportunities for Arab countries as they work towards sustainable development. While water scarcity and variability in the region have been known and addressed for centuries, accelerating pressures from a range of drivers, including urbanisation, forced displacement and climate change, mean that water poses a growing threat to sustainable development and stability. At the same time, the Arab region has a unique opportunity to harness emerging innovations and financing mechanisms to address water-related challenges. Unless action is taken, Arab countries may miss out on opportunities for economic development and face the impacts on people's well-being and social stability. To make agricultural water work for sustainable development, food security and poverty reduction, these countries need to focus on emerging opportunities and innovations to create momentum for policies and investments and sustain it over time. A new generation of policies and investments is needed to face these challenges, transform the agriculture sector and accelerate progress towards sustainable development.

The Food and Agriculture Organization of the United Nations (FAO) and the International Water Management Institute (IWMI) prepared this report to inform the second Near East and North Africa FAO Land and Water Days (Cairo, Egypt, 31 March–4 April 2019). This paper is aimed at policy makers, representatives of international financial institutions, development partners and the private sector. The purpose of the paper is to provide strategic directions to guide high-level political dialogue on policy and investment in agricultural water management in the Arab region. The paper acknowledges that there is significant heterogeneity in the sociopolitical, economic and environmental contexts of countries in the region, and is therefore not intended to provide country specific insights for policy and investment, which would require additional analysis. The purpose is rather to frame the key challenges and state the main principles underlying a new generation of policies and investments in agricultural water management. The paper thus focuses on laying out broad strategic directions for agricultural water policy of relevance to all countries in the region.

The report is structured in six sections. The first section reviews the key agricultural water challenges in the Arab region, and quantifies country progress towards agricultural water-related Sustainable Development Goals (SDG). Section two makes the case for investing in the agricultural water sector. It provides estimates of the costs of inaction and the benefits of action in agricultural water in the Arab region. Section three reviews the trends and composition of investments in agricultural water. It includes a review of financing for agricultural water from national public funds, international development assistance, private funds and emerging sources of funding. Section four describes four emerging innovations that will shape agricultural water investments in the coming years. These include innovations to augment water supplies, improve water governance, enhance water productivity and scale-out controlled-environment agriculture.

The final two sections of the report focus on reviewing policy and investment trends and recommending a new way forward. Section five reviews the evolving policy landscape, including the major themes directing agricultural water policy in the region. Given the importance of the overall policy context in determining agricultural water policy outcomes, the section also reviews the themes and priorities in broader agricultural and food security policies. The final section sets the main principles and directions for a new generation of investments and policies in agricultural water, identifying priority areas for policy and investment.

ACKNOWLEDGEMENTS

This publication is a joint product of the Food and Agriculture Organization of the United Nations (FAO) and the International Water Management Institute (IWMI).

The authors of this paper are Edoardo Borgomeo (Advisor, IWMI) and Nuno Santos (Senior Economist, FAO), with contributions from Boris Sterk (Economist, FAO) on nutrition and food security.

The team gratefully acknowledges guidance and support received from Abdessalam Ould Ahmed (Assistant Director-General and Regional Representative, FAO Regional Office for Near East and North Africa), Mohamed Manssouri (Director, Investment Centre Division) and Wafaa El Khoury (Service Chief, Europe and Central Asia, Near East and North Africa, Latin America and the Caribbean, Investment Centre Division) from FAO, and Claudia Sadoff (Director-General) and Julie van der Bliek (Director, Partnerships and Knowledge Management) from IWMI.

The authors would also like to thank numerous FAO colleagues who provided guidance and comments on this paper: Alessandra Gage (Environment and Climate Change Specialist), Benjamin Kiersch (Land and Water Development Division Consultant), Ismail Oudra (Irrigation and Rural Infrastructure Engineer), Jippe Hoogeveen (Senior Land and Water Officer), Luis Loyola (Irrigation and Rural Infrastructure Engineer), Maher Salman (Senior Water Officer), Marc Fantinet (Senior Investment Support Officer/Economist), Maria Ricci (Environmental Engineer/Project Specialist), Mohamed AlHamdi (Senior Land and Water Officer and Delivery Manager of the Regional Water Scarcity Initiative), Khaled Mohammed (FAO Integrated Service Desk), Pasquale Steduto (Senior Water Advisor), Rimma Dankova (Senior Adviser), Samvel Ghazaryan (Irrigation and Rural Infrastructure Engineer) and Scott Christiansen (Land and Water Consultant). In particular, Jean-Marc Faurès (Regional Programme Leader, FAO Regional Office for the Near East and North Africa) provided excellent guidance on the key messages included in the paper and ideas on how to structure them more effectively.

The authors wish to thank the internal IWMI peer reviewers: Alan Nicol (Strategic Program Leader – Promoting Sustainable Growth), Rachael McDonnell (Principal Researcher), Soumya Balasubramanya (Research Group Leader – Water Innovations in Transforming Economies) and Amgad Elmahdi (Head of IWMI's office in the Middle East and North Africa region). Ian Masias (Development Strategy and Governance Division, International Food Policy Research Institute [IFPRI]) provided guidance on the Statistics on Public Expenditures for Economic Development (SPEED) database.

A draft version of this paper was presented at a High Level Meeting hosted by the League of Arab States and co-organized by FAO in Cairo, Egypt, on April 4, 2019. Comments received from the participants, which included the FAO's Director-General and several Ministers from Arab countries, are gratefully acknowledged.

ACRONYMS AND ABBREVIATIONS

AUEA	Communautés d'Irrigants and Association d'Usagers de l'Eau Agricole
BCWUA	Branch Canal Water User Association
BMI	Body Mass Index
BRI	Belt and Road Initiative
CA	Conservation Agriculture
CASCF	China-Arab States Cooperation Forum
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
COP	Conference of the Parties
CSA	Climate-smart Agriculture
DAC	Development Assistance Committee
EBRD	European Bank for Reconstruction and Development
FAO	Food and Agriculture Organization of the United Nations
GASC	General Authority for Supply Commodities
GCF	Green Climate Fund
GDA	Groupement de Développement Agricole
GDP	Gross Domestic Product
GWP	Global Water Partnership
IFAD	International Fund for Agricultural Development
IFI	International Financial Institution
IFPRI	International Food Policy Research Institute
IMF	International Monetary Fund
IMPACT	International Model for Policy Analysis of Agricultural Commodities and Trade
IMT	Irrigation Management Transfer
ISIC	International Standard Industrial Classification
IVR	Interactive Voice Response

IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
LARI	Lebanese Agricultural Research Institute
MAD	Moroccan Dirham
MASSCOTE	MApping System and Services for Canal Operation TEchniques
MDG	Millennium Development Goal
MENA	Middle East and North Africa
MLD	Million litres per day
O&M	Operation and Maintenance
ODA	Overseas Development Assistance
OECD	Organisation for Economic Co-operation and Development
ORMVA	Office Regional de Mise en Valeur Agricole
PIM	Participatory Irrigation Management
PPP	Public-private Partnership
R&D	Research and Development
SDG	Sustainable Development Goal
SITC	Standard International Trade Classification
SMS	Short Message Service
SPaRC	Solar Power as Remunerative Crop
SPEED	Statistics on Public Expenditures for Economic Development
UAE	United Arab Emirates
USD	United States Dollar
WaPOR	Water Productivity through Open access of Remotely sensed derived data
WHO	World Health Organization
WUA	Water User Association
WUU	Water Users Union

SECTION 1

WATER IS KEY TO ACHIEVING THE SUSTAINABLE DEVELOPMENT GOALS

1. WATER IS KEY TO ACHIEVING THE SUSTAINABLE DEVELOPMENT GOALS

HIGHLIGHTS

- The Arab region is a global hotspot of water resources depletion and unsustainable water use.
- By 2050 the region's urban population is expected to double and reach nearly 400 million people. Rapid urbanisation and expected high population growth will continue to put pressure on the region's food systems through higher demands for water and food, paired with a shift towards water-intensive diets rich in animal products.
- Competition for water between agriculture and other sectors is set to increase.
- Climate change adaptation is central to the region's agricultural water management policy debate. Climate change will have a range of impacts, including a potential 20 to 60 percent increase in the frequency and severity of drought by the end of the century and saline intrusion in coastal aquifers due to sea-level rise.
- Conflict and ensuing forced displacement and migration are taking an enormous toll on human lives and well-being, as well as compounding agricultural water challenges in refugee and host communities.
- The entire SDG agenda, and SDG 2 on zero hunger in particular, will rely heavily on the region being able to tackle the agricultural water challenge.
- To achieve SDGs, new strategies and approaches, such as the water-energy-food nexus, are needed to leverage the synergies amongst different goals and navigate the trade-offs.
- Unless agricultural water management issues are addressed and progress on SDG 6 is made, the region will face significant challenges in meeting all other SDGs, notably SDG 2 on zero hunger.

THE EVOLVING CHALLENGE OF COPING WITH WATER SCARCITY

For thousands of years, societies in the Arab region have coped with water scarcity. Succeeding generations have adapted to the region's arid landscapes through investments and innovations in water management and irrigated agriculture, with the region hosting some of the world's oldest irrigation systems. Although the region has historically been able to adapt to water scarcity, rapidly changing environmental, social and economic circumstances mean that water scarcity and a host of other water-related challenges pose a growing threat to the region's sustainable development and people's well-being.

The dynamics of population growth, urbanisation, environmental degradation and climate change – all occurring in complex geopolitical and economic environments – mean that water challenges are now different and more urgent than before. The drivers making agricultural water challenges more urgent and complex than before are summarised in Figure 1. According to the United Nations, the total population of the Arab region is likely to reach 668 million by 2050 from today's 434 to 414 million[1]. These high rates of population growth, about 2 percent annually (compared to a world average of 1.1 percent), and rapid urbanisation, with the region's urban population expected to double by 2050 to nearly 400 million, are putting pressure on already scarce arable land and water resources.[2] As with any type of projection, there is a degree of uncertainty surrounding these estimates, for instance, in relation to future trends in fertility. Growing population, paired with rising incomes and changing lifestyles, mean that the demand for food is expected to continue to increase and the demand for water-intensive animal food products is also set to increase. For instance, the demand for dairy products is expected to grow at an annual rate of 2.6 percent until 2030[3]. With domestic production constrained by limited land and water resources, the region will increasingly be dependent on the world market to meet its basic food needs. The Arab region is the largest net importer of cereals in the world[4] and one of the largest in the world for other food commodities (poultry meat, sheep meat, milk powder)[5]. By 2030, net imports of wheat into the region will be twice the amount of the regional supply, and meat imports, which currently amount to about 4.1 million tons, will increase to around 6 million tons[6].

FIGURE 1
DRIVERS SHAPING AGRICULTURAL WATER MANAGEMENT CHALLENGES IN THE REGION

POPULATION GROWTH & URBANISATION

The total 414 population of the Arab region is likely to reach 668 million by 2050 from today's 414 million, with a growth rate of 2 percent per year. 59 percent of the region's population lives in cities, compared to 55 percent in the rest of the world. By 2050, 75 percent of the region's population will live in cities. Youth employment will become a critical issue in an urbanising Arab world.

CHANGING LIFESTYLES & DIETS

Diets in the region are currently dominated by vegetal foods, however projections suggest a shift towards water-intensive animal rich diets as a large share of the region's population moves into cities and incomes rise. If meat consumption was to be limited and paired with food loss reduction, then water use could be reduced by as much as 33 percent.

UNCERTAIN ENERGY PRICES

Uncertain energy market developments are a critical uncertainty. Operating costs of desalination and economic feasibility of renewable energy desalination plants depend on energy prices, as does the price of wastewater reuse for irrigation. Energy subsidies to the agricultural sector are also influenced by global energy prices.

CLIMATE CHANGE

Climate change is leading to higher temperatures during the growing season, changing evapotranspiration patterns. It is also leading to less and more variable precipitation. North Africa and the Mashreq are hotspots where climate change makes drought more likely. The frequency of drought might increase by more than 20 to 60 percent by 2100. Coastal aquifers are likely to suffer heavily from sea-level rise and related salinisation. Climate change adaptation is becoming a priority for the region.

ENVIRONMENTAL DEGRADATION

Costs of environmental degradation range from 2.1 to more than 6 percent of countries' GDP. Loss of agricultural land, forest loss, waste, chemical contamination, dam sedimentation and urban sprawl are some of the environmental damage categories making it increasingly difficult to manage agricultural water.

CONFLICT & MIGRATION

The region hosts over 10 million internally displaced people and more than 6 million registered refugees. Conflict and migration have taken an enormous toll on human lives and well-being, with women suffering disproportionately. They have also compounded water challenges faced by host communities. Conflict has also destroyed institutions and infrastructure, setting-back hard-won agricultural development gains.

SOURCE: Authors

- **Conflict, violence and forced displacement are causing enormous human suffering, and exacerbating many water and food security challenges.** Conflict has contributed to the large and growing numbers of food-insecure people in urban areas, including internally displaced people and refugees.[7] Nearly one in five individuals in Lebanon is a refugee and about one in ten in Jordan.[8] In Somalia, at least 3.6 million people have been displaced, 2.6 million internally and a million forced to flee the country.[9] Complex migration flows have affected all countries in the region, including in North Africa. Household food insecurity and undernourishment are widespread and concentrated in the poorest and conflict-affected countries, with stunting affecting over one-fifth of the region's under-five population.[10] Conflict has also reversed some of the region's Millennium Development Goal (MDG) gains and seriously challenges progress toward achieving the SDGs.

- **Climate change will compound existing water challenges in the region.** Some of the projected impacts include higher temperatures, changing evapotranspiration patterns and increasing crop water requirements.[11] Impacts will be high in a 2 °C world, with annual water discharge, already critically low, projected to drop by another 15–45 percent (and by as much as 75 percent in a 4 °C world) and heat waves projected to affect about one-third of the land area with consequences for food production.[12] The Arab region is also expected to become a global hotspot for drought, with projections suggesting that, by the end of the century, the frequency of drought could increase by 20–60 percent compared to current levels.[13] Sea-level rise, more intense rainfall events and loss of winter precipitation storage are other water-related impacts of climate change set to undermine agricultural production in the region.[14] In addition, volatile energy prices are a significant uncertain factor and can pose additional challenges: they influence water management operation and prices, for instance, by influencing the feasibility of desalination or energy subsidies,

- **Finally, the region's high levels of rural and youth unemployment will add to the water scarcity challenge.** Despite the pace of urbanisation, there are still about 170 million rural people in the region. Rural population growth rates – 1.6 percent a year during the period 1990-2004 – are high, and the rural population is expected to continue to grow at over 1 percent annually through to 2030 in North Africa, especially in Egypt and Sudan, and at lower rates of about 0.3 percent a year in the Middle East, with the highest anticipated growth in Iraq (around 1.6 percent a year until 2030).[15] Overall, 34 percent of the region's rural population is poor, ranging from 8 percent in Tunisia to over 80 percent in Sudan.[16] 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.[17] To escape rural poverty and search for better services and job opportunities in cities, many young women and men are migrating from rural to urban areas, compounding the challenges of urbanisation.[18]

AGRICULTURAL WATER AT THE CENTRE OF THE SUSTAINABLE DEVELOPMENT GOALS

In the vision of the 2030 Agenda for Sustainable Development, food and agriculture, people's livelihoods and the management of natural resources are addressed not separately but as one. With its 17 SDGs and 169 associated targets, the agenda increases the scale, ambition, and interconnection of international development efforts. From ending poverty, hunger and malnutrition to sustaining natural resources and responding to climate change, the SDGs cover a wide spectrum of interlinked objectives. Given the interlinkages and trade-offs amongst these objectives, the SDGs include key targets for developing an integrated approach to their implementation, such as the SDG target 17.14 (enhance policy coherence for sustainable development). This focus on policy coherence offers the opportunity to understand and navigate the synergies and trade-offs amongst the objectives, in order to ensure that progress is made across all dimensions of sustainable development in the Arab region.

While SDG 6 is dedicated to water, the achievement of this goal will also heavily condition the success of the entire SDG agenda. Eradicating poverty (SDG 1), ending hunger (SDG 2) and sustainably managing terrestrial ecosystems (SDG 15) can only be achieved through sustainable and equitable water management. In particular, the interlinkages between water-related SDGs and other SDGs require a focus on integrated water resources management (IWRM). The 2030 Agenda fully commits Member States to IWRM and transboundary cooperation over water resources. This is expressed in Target 6.5: "*By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate.*"

The SDGs bring opportunities to build momentum for action and investment in agricultural water management. SDG 6 has been dedicated completely to water, and is not limited to targets related to water supply and sanitation, but includes aspects of water quality, water use and efficiency, water-dependent ecosystems and IWRM amongst others. This broader spectrum of water-related targets reflects an increasing recognition that, if the world is to achieve sustainable development, a set of ambitious targets related to water resource management, resilience and governance need to be achieved as well. This is even more the case in the context of the Arab region, where scarcity already makes water a binding constraint to development and well-being.

THE REGION NEEDS TO ACCELERATE THE PACE OF REFORM TO SUSTAINABLE DEVELOPMENT TARGETS

While countries in the Arab region are advancing at different speeds, overall, much more progress is needed to achieve the water-related SDGs. Table 1 summarises progress made so far on seven key dimensions related to the SDGs. Most countries are not on track to achieve sustainability of water use, which also means that freshwater ecosystems are under pressure and that most countries are not doing enough to protect them. Arab countries also contribute to water depletion in other parts of the world through virtual water trade,[19] and large-scale land acquisitions (popularly known as 'land and water grabbing').[20] In terms of water-use efficiency, it is only the wealthy Gulf countries that are on track to meet the SDG target, underscoring these countries' endeavours to make every drop count, but also their economic systems largely based on high-value services and oil revenues.

As a result of poor water governance, water use in the region is largely unsustainable and rapid groundwater depletion is a major concern.[21] The Arab region is a global hotspot of unsustainable water use, with at least 30 percent of current water consumption exceeding sustainability limits.[22] The groundwater situation is of particular concern, with global and local studies reporting the systematic depletion of groundwater resources across the region.[23] Projections suggest an increasing trend of water consumed from unsustainable water sources in the region, with 40 percent of water use exceeding sustainable limits by the end of the century.[24] Dramatic declines in aquifers, for instance, in Morocco's Souss-Massa Basin[25] and in the

TABLE 1: COUNTRY PROGRESS TOWARDS AGRICULTURAL WATER-RELATED SUSTAINABLE DEVELOPMENT GOALS
Country scores for selected agricultural water challenges and their related SDG 6 targets and indicators (2018). Bottom row presents sources used to quantify each indicator.

Development challenge	Undernourishment	Overweight and obesity	Poverty	Water stress	Water use efficiency	Water quality	Integrated Water Resources Management
Related SDG target	**SDG 2** "End hunger, achieve food security and improved nutrition & promote sustainable agriculture"	**SDG 2** "End hunger, achieve food security and improved nutrition & promote sustainable agriculture"	**SDG 1** "End poverty"	**SDG 6.4** "Increase water-use efficiency and ensure freshwater supplies"	**SDG 6.4** "Increase water-use efficiency and ensure freshwater supplies"	**SDG 6.3** "Improve water quality, wastewater and safe reuse"	**SDG 6.5** "Implement Integrated Water Resources Management"
Indicator	Prevalence of undernourishment (% population)	Prevalence of obesity, BMI ≥ 30 (% adult population)	Poverty headcount ratio at $1.90/day (% population)	Freshwater withdrawals as a percentage of total renewable water resources	Aggregated water-use efficiency (USD/m³)	Percentage of safely treated wastewater flows from households	Status of IWRM implementation
Algeria	4.6	27.4	0.3	88	10-40	25% or less	31-50
Bahrain	1.2	29.8	0.1	205	40-80	50-75%	NA
Comoros	NA	7.8	21.4	1.2	10-40	NA	0-30
Djibouti	12.8	13.5	14.8	7.9	NA	NA	NA
Egypt	4.5	32	0.7	159.9	<10	50-75%	31-50
Iraq	27.8	30.4	1	93	<10	25% or less	0-30
Jordan	4.2	35.5	0	118.4	10-40	75-100%	51-70
Kuwait	2.5	37.9	0	2 603	40-80	75-100%	71-90
Lebanon	5.4	32	0	33.3	10-40	NA	31-50
Libya	NA	32.5	12.5	1 072	10-40	25% or less	31-50
Mauritania	5.3	12.7	6.2	15.9	<10	NA	31-50
Morocco	3.5	26.1	0.4	49	<10	25-50%	51-70
Oman	6.2	27	0.1	106.2	10-40	NA	31-50

High | Medium-High | Medium-low | Low | No data

Development challenge	Undernourishment	Overweight and obesity	Poverty	Water stress	Water use efficiency	Water quality	Integrated Water Resources Management
Related SDG target	**SDG 2** "End hunger, achieve food security and improved nutrition & promote sustainable agriculture"	**SDG 2** "End hunger, achieve food security and improved nutrition & promote sustainable agriculture"	**SDG 1** "End poverty"	**SDG 6.4** "Increase water-use efficiency and ensure freshwater supplies"	**SDG 6.4** "Increase water-use efficiency and ensure freshwater supplies"	**SDG 6.3** "Improve water quality, wastewater and safe reuse"	**SDG 6.5** "Implement Integrated Water Resources Management"
Indicator	Prevalence of undernourishment (% population)	Prevalence of obesity, BMI ≥ 30 (% adult population)	Poverty headcount ratio at $1.90/day (% population)	Freshwater withdrawals as a percentage of total renewable water resources	Aggregated water-use efficiency (USD/m³)	Percentage of safely treated wastewater flows from households	Status of IWRM implementation
Qatar	1.2	35.1	0	472.5	>80	75-100%	51-70
Saudi Arabia	4.4	35.4	0.1	1 242.6	10-40	50-75%	51-70
Somalia	NA	8.3	52.6	30.3	<10	25% or less	11-30
Sudan	25.6	NA	17.8	93.7	<10	NA	31-50
Syria	NA	NA	NA	109.4	<10	NA	NA
Tunisia	5	26.9	0.6	94	10-40	50-75%	51-70
UAE	3.8	31.7	0	2 346.5	40-80	75-100%	71-90
Yemen	28.8	17	86	227.7	<10	NA	31-50
West Bank and Gaza	NA	NA	29.6	50	10-40	NA	NA
Source	Sachs et al. (2018)	Sachs et al. (2018)	Sachs et al. (2018)	Sachs et al. (2018) FAO AQUASTAT for West Bank and Gaza	United Nations (2018)	UN Environment (2018)	Sachs et al. (2018)

High | Medium-High | Medium-low | Low | No data

SOURCES: Authors based on United Nations. 2018. *Sustainable Development Goal 6 Synthesis Report 2018 on Water and Sanitation*. New York, United Nations; UN Environment. 2018. *Progress on integrated water resources management. Global baseline for SDG 6 Indicator 6.5.1: degree of IWRM implementation*. Nairobi, United Nations Environment Programme; and Sachs, J., Schmidt-Traub, G., Kroll, C., Lafortune, G. & Fuller, G. 2018. *SDG Index and dashboards report 2018*. New York, Bertelsmann Stiftung, and Sustainable Development Solutions Network (SDSN). Note: NA = Not available. The water-use efficiency indicator is a crude measure of a country's water-use efficiency as defined in the United Nations SDG 6 Synthesis report 2018 on water and sanitation (UN 2018). This indicator is defined as the change in value added divided by the volume of water used (in USD/m³) over time in a given major sector (showing the trend in water-use efficiency). The actual indicator, not yet estimated by the United Nations, is based on the change in water-use efficiency computed at the country level. The water quality indicator is based on treatment technology data, meaning that it rates the expected performance of wastewater treatment based on existing capacity, not the actual performance, which may be lower than reported due to overloading, unpermitted discharge, and poor operation and maintenance of treatment facilities.

transboundary Tigris–Euphrates Basin,[26] are compromising the lives of many farmers across the region. In some countries, where green water (water held in soils as moisture) is a key resource, its potential to meet agricultural water demands has not yet been fully utilised or assessed.

- **Rapidly worsening water quality is adding to the water scarcity challenge.** Surface water over-exploitation, uncontrolled discharge of human waste, industrial effluents, and fertiliser and pesticide runoff from agricultural fields all result in high concentrations of harmful pollutants in receiving water bodies across the region. In Lebanon, for instance, water quality issues have compromised the Litani River, the largest water resource in the country, forcing the government to adopt a national plan to halt the river's degradation.[27] At least 55 percent of the region's wastewater is discharged untreated in surface water bodies.[28] Countries with very low rates of wastewater treatment include Algeria, Libya, Iraq and Somalia, as shown in Table 1.[29] The discharge of untreated wastewater poses risks to public health and ecosystems, and limits the opportunities for wastewater reuse.

- **Water-related ecosystems are suffering.** Recent estimates suggest that the area of water-related ecosystems decreased by 1 percent and 5 percent in the Middle East and North Africa, respectively, between 2011 and 2015, and that about half of the freshwater species endemic to the region are now at high risk of extinction.[30,31] Most countries are performing poorly in relation to freshwater biodiversity conservation, as shown in Table 1. Desalination based on current technology poses additional challenges to water-related ecosystem conservation, especially in coastal environments. A major challenge associated with desalination technologies is the production of a typically hypersaline concentrate (called 'brine') that requires disposal. Brine production in Saudi Arabia, United Arab Emirates, Kuwait and Qatar accounts for 55 percent of global production.[32] Discharge of brine effluents from desalination plants into coastal environments not only negatively affects marine ecosystems,[33,34] but it also reduces the efficiency of desalination processes by increasing salinity levels in seawater.[35]

- **There is still a long way to go with fully implementing IWRM in the Arab region (SDG 6.5).** Putting IWRM into practice will arguably be the most comprehensive step that countries can take towards achieving SDG 6. In a water-scarce world where river basins are 'closed' and water resources are fully allocated, IWRM focuses policy on understanding the needs, benefits and trade-offs linked to multiple uses of water, and on the interdependencies amongst these uses, arising, for instance, from pollution. This focus on multiple uses and benefits also offers a framing to guide cooperation over transboundary water resources. IWRM needs to be strengthened in the Arab region, in particular the management instruments needed for some of the existing institutions to sustainably and equitably manage water.[36] In 2017–2018, the regional average degree of IWRM implementation was 54 percent, compared to a global average of 48 percent, but with great variation amongst countries.[37]

AGRICULTURE IS KEY TO SUSTAINABLE DEVELOPMENT IN THE ARAB WORLD

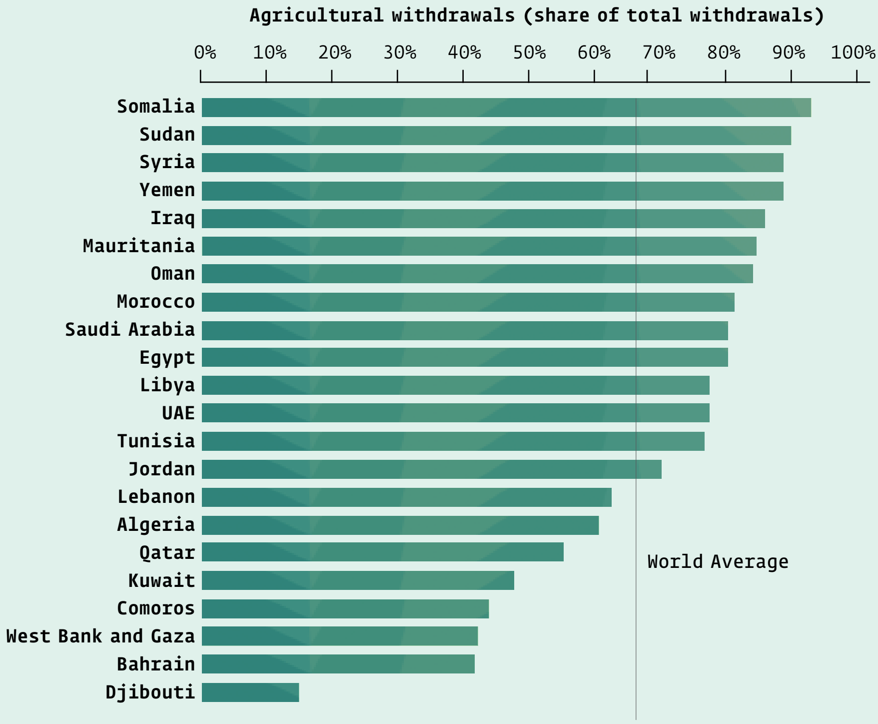
Agriculture's disproportionate role in water use and employment compared to global averages contributes to its economic and political importance in the region. Agriculture is central to water use, conservation and security, as 85 percent of total water used in the region is utilised for irrigation; higher than the global average of 70 percent (see Figure 2). Given the widespread utilisation of unregulated and unmonitored groundwater wells in the region,[38] the actual share of agricultural water use is likely to be even higher than what is reported in national statistics. With growing water demands from other sectors and high uncertainty about the future impact of climate change, efficient water use in agriculture and – more broadly – efficient sectoral water allocation are set to become defining issues for sustainable development. In addition to water conservation and efficiency, increasing existing supplies through strategic solutions such as wastewater recycling become essential.

Agriculture is at the heart of the sustainable development challenge in many other ways beyond water and food security. Employment, poverty and gender inequality are all closely related to agriculture, rural-urban migration and land use change. The gross domestic product (GDP)–employment share gap narrows with higher incomes, but with fast GDP growth, the share of agriculture in GDP usually falls much faster than the share of agriculture in the labour force. The gap becomes larger before it closes, which means that in the Arab countries, it has taken a long time to fully integrate agriculture with the rest of the economy.[39] Therefore, the number of people employed in agriculture is still high (from 20 to more than 60 percent) in many lower middle-income countries,[40] and probably even higher given the

FIGURE 2

AGRICULTURAL WATER USE IS GREATER THAN GLOBAL AVERAGES IN MOST ARAB COUNTRIES

Agricultural water withdrawals as a share of total withdrawals.



SOURCE: FAO AQUASTAT, latest year available. This is based on self-reported estimates and should be treated with caution as country contexts and reporting procedures differ.

very high shares of informal employment in agriculture in the region, which are higher for women than men.[41] This means that inevitably informally employed women earn a lower income from labour and also have a higher exposure to income shocks.

Rural incomes have fallen behind those of workers in non-agricultural activities, representing a significant part of countries' income inequality.[42] Lagging agricultural incomes can create political tensions, pushing governments to protect the agriculture sector from international competition or to use different policy instruments to support farmers (for more details, see Section 6 of this report). Clearly, this income gap cannot be analysed simply as an agricultural policy problem, as it is a much broader problem touching, for instance, issues of broader economic transformation, and social and gender equity. The path to close this gap will require the use of new technologies, increased investment in physical and human capital, gender equity laws, enhanced infrastructure, well-functioning factor markets and more efficient allocation of resources between sectors.[43] Most importantly, it will require policy coherence and coordination amongst sectors to identify appropriate policy instruments. For instance, subsidies and price protection may not always be desirable to make the agriculture sector competitive, as they contribute to undermine the resource productivity of the very sector they are trying to protect.

While agriculture is important to Arab women and Arab women are important to agriculture, there is still substantial progress to be made in closing the gender gap. Gender differences matter in farming systems throughout the region, with ownership, labour division and management of agricultural water resources defined by culturally specific gender roles. About 33 percent of Arab women's formal employment is in agriculture, higher than the global average of 26 percent.[44] Despite this high contribution to agricultural labour, the role of women in farming is not formally recognised. For example, women's ownership of agricultural land is extremely low in the region. The highest share of female agricultural landholders is in Lebanon, where around 7 percent of agricultural land is owned by women, which is still far below the already low global average of 18 percent.[45] Gender inequalities influence access to agricultural extension services and technological resources, in turn creating significant barriers to any effort aimed at improving the productivity of agricultural systems.[46]

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SECTION 2

WHY AGRICULTURAL WATER? CASE FOR ACTION AND INVESTMENT

2. WHY AGRICULTURAL WATER? CASE FOR ACTION AND INVESTMENT

HIGHLIGHTS

- While there are uncertainties and data limitations in all economic assessments of water scarcity, existing analyses make a strong case for policy action and investment in the sector to avoid the significant negative consequences of water scarcity and seize the benefits of improved agricultural water management.

- Failure to address water scarcity and other water-related risks can have consequences on social and environmental systems, compounding existing fragilities and exacerbating tensions.

- Expected economic losses from climate change-induced water scarcity are significant and could cost the region between 6 and 14 percent of gross domestic product (GDP) by 2050.

- Investing in agricultural water creates jobs and generates economic gains. Ten million new jobs could be added to the existing 33-million strong agricultural workforce, if more sustainable agricultural practices were pursued within broader efforts to support and transform the region's agriculture sector, and fight poverty and food insecurity.

- Improving the way in which water is stored and delivered to irrigation water users could lead to an estimated USD 7–10 billion in welfare gains per year, amounting to about 0.5 percent of regional GDP.

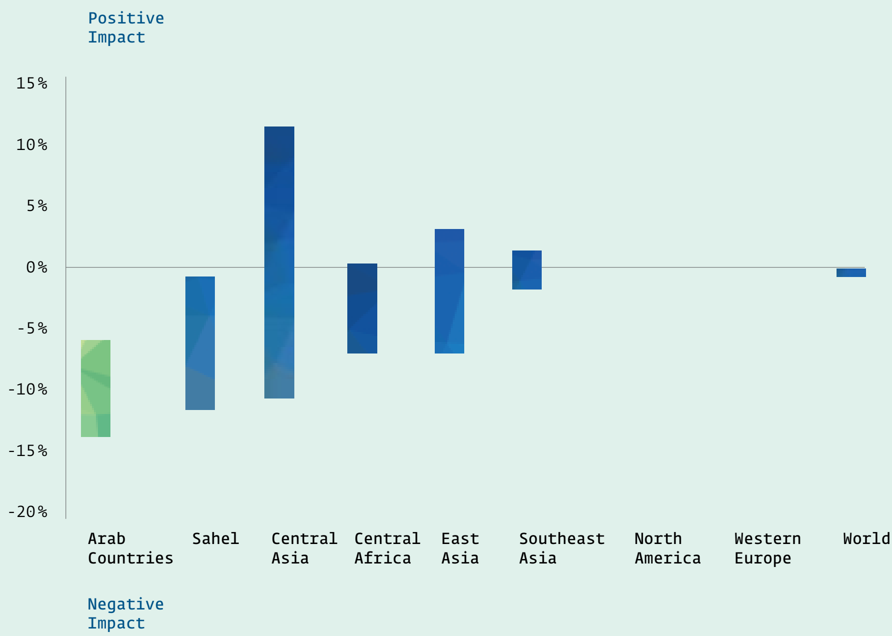
THE COST OF INACTION: RECOGNISING THE NEGATIVE CONSEQUENCES OF WATER-RELATED CHALLENGES

- **The Arab region's agriculture sector – and the region's wider economy – are already facing significant losses from water scarcity and other water-related challenges.** Agricultural systems – and the land and water resources upon which they depend – can be directly damaged by droughts, floods and contamination. In Morocco, for instance, water-related challenges have been estimated to cost the economy about MAD 11.7 billion, or 1.26 percent of GDP.[1] In Egypt, water pollution alone was estimated to cost the country in the range of 1.6 to 3.2 percent of GDP.[2] Beyond direct economic impacts, water-related challenges can harm the economy in multiple ways, for instance, through weaker investor confidence. Shifts in market sentiment might occur as a result of awareness of potential economic shocks and related losses in financial portfolio value related to current and future water crises, especially under climate change.[3] Water-related challenges under climate change also become a problem of extreme risks and impacts, meaning that losses might considerably exceed anything experienced so far.[4]

- **The economic losses from climate change-induced water scarcity are expected to be very high.**[5] Given the complex economics of water, it is difficult to estimate the economic impacts of water scarcity. Nonetheless, most available evidence suggests that these impacts can be very large, of the order of a few points of GDP.[6,7] For the Arab region, existing estimates from the World Bank suggest that climate change-induced water scarcity could cause losses of 6–14 percent of regional GDP.[8] These losses were estimated using a global general equilibrium economic model[9] that takes into account possible global future developments in demography, policy and climate change as represented in the Shared Socioeconomic Pathways.[10] These estimates include losses in agriculture, health, income and property arising from water shortages, but do not include additional economic losses related to, for instance, the political and social disruptions caused by water shortages. In a business-as-usual scenario where water allocation policy does not respond to growing shortages and the overall allocation regime remains unchanged, the region is expected to face the highest economic losses in the world by 2050, estimated at 14 percent of its expected GDP (lower bound in Figure 3). In an alternative scenario, where 25 percent of water is allocated to higher value uses, the region is still expected to face significant economic losses amounting to 6 percent of its expected GDP by 2050. Even under a scenario of moderate allocation of water to higher value uses, the World Bank estimates that the Arab region will still likely face the negative effects of water scarcity. This suggests that, in order to minimise the economic consequences of climate change-induced water scarcity, water use and allocation need to be significantly reformed and paired with key investments in non-conventional water supplies.[11]

FIGURE 3
THE ARAB REGION FACES THE LARGEST EXPECTED GDP LOSSES FROM CLIMATE CHANGE-INDUCED WATER SCARCITY IN THE WORLD

Impact of climate change-induced water scarcity, as a share of regional GDP in 2050 (range determined by policy)



SOURCE: World Bank. 2016. *High and dry: climate change, water, and the economy.* Washington, DC. Note: This estimate for the Arab region excludes Mauritania, Somalia and Sudan. Upper bound depicts a world where 25 percent of water is allocated to higher value uses. Lower bound depicts a world where water allocation remains unchanged, not responding to growing water shortages and with different productivity levels amongst sectors. These estimates do not include the potential losses arising from the impacts of water scarcity on the stability of social and environmental systems.

Inaction is leading to increasing impacts of water scarcity with consequences on the stability of social and environmental systems. Water scarcity strains livelihoods and impacts populations, fueling perceptions of institutions not doing enough, exacerbating existing grievances and tensions.[12] Water crises can amplify social tensions and fragility risks, if action is not taken to promote sustainability, inclusion and resilience in the face of scarcity. In the Arab region and across the world, institutional failure to address water scarcity has been identified as one of the factors contributing to instability.[13] In Kenya, for instance, there is evidence of violent conflict over access to water resources: in 2012, at least 80 people were killed in ethnic violence over water resources between the Orma and Pokomo people in the drought-prone Tana River County.[14] It is not just scarcity, but also pollution. In the Palar River Basin in Tamil Nadu in southern India, pollutant discharge from tanneries made water unsuitable for irrigation and consumption.[15] This unmanaged pollution led to a drinking water crisis, which in turn caused protests and disputes between the tanning industry and the irrigators. These examples do not necessarily imply that there is a direct causal linkage between water crises, social tensions and unrest, migration or other manifestations of fragility. However, what is clear is that institutions and policy choices can mediate water-related impacts on people and economies, and that failure to address these impacts plays into the complex, and more fundamental, political and economic dynamics behind protests and conflict.[16]

Unless agricultural water issues in the rural world are addressed, many cities in the region may face a 'day zero' water crisis. The negative impacts of agricultural water challenges are not restricted to the rural world where most agricultural activities take place, but reverberate on the region's growing urban areas. Water availability and use in cities are strictly connected to the river basin or aquifer system on which they depend and on the agricultural users sharing these resources. The water crises in Cape Town, South Africa, in 2018, and in São Paulo, Brazil, in 2014, are a stark reminder of the consequences of poor planning of interlinked water resources systems.

THE BENEFITS OF ACTION: PROMOTE SUSTAINABLE DEVELOPMENT AND STABILITY

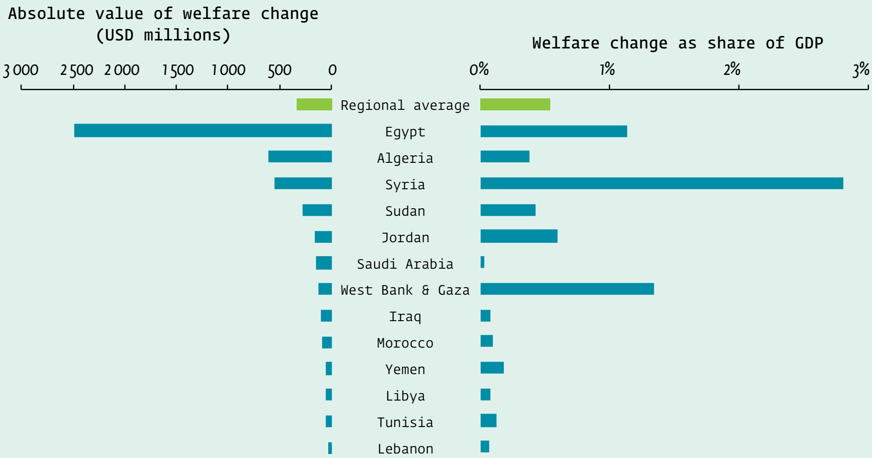
It is not all doom and gloom: investing in the agricultural water sector can yield significant benefits and build resilience in the face of the inevitable impacts of water scarcity. Studies looking at investments in agricultural water management provide evidence of such benefits.[17] Agriculture has a key role to play in preparing and adapting to water scarcity in the context of the accelerating changes taking place in the region. Given its dominance in water use and employment, agriculture is likely to remain a key economic sector in the coming decades.

Better agricultural water management – ranging from improved irrigation service delivery to on-farm sustainable practices – leads to a more stable food production and benefits to the wider economy. Across the region, existing infrastructure for water storage and delivery is often not operated to its full potential, meaning that it is unable to maximise the use of water allocated to the sector, and it is unable to buffer food production from the effects of hydrological variability. Increasing the resilience of food production to hydrological variability becomes even more important under climate change, which is set to increase this variability. According to a study conducted by the Global Water Partnership (GWP) and the Organisation for Economic Co-operation and Development (OECD),[18] if infrastructure for water storage and delivery – two key aspects of agricultural water

FIGURE 4

IMPROVED IRRIGATION SERVICE DELIVERY COULD LEAD TO GDP GAINS OF THE ORDER OF TEN BILLION DOLLARS EVERY YEAR

Welfare gains in a scenario where there is more water available for irrigation due to improved irrigation water service delivery, helping to suppress the effects of hydrological variability, by Arab country in USD millions per year and as a share of 2015 GDP.



SOURCE: International Food Policy Research Institute (IFPRI). Note: Absolute value of welfare change is shown on the left and welfare change as a percentage of GDP (from 2015) on the right. Values were generated using IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) model, assuming improvements in water storage and delivery that maximise water availability for agriculture. Welfare gains are calculated from measures of consumer and producer surpluses (reduced food prices for consumers and increased water availability for producers), and spillover effects from agriculture to the rest of the economy. Irrigated areas and irrigation methods remain unchanged in the simulation. No data for Bahrain, Djibouti, Comoros, Kuwait, Qatar, Oman, Somalia and the United Arab Emirates.

management – were better managed to maximise the use of water and suppress the effects of hydrological variability, benefits to the region's economy could be of the order of USD 7 to USD 10 billion per year, or about 0.5 percent of regional GDP (Figure 4).[19] These benefits are expected to accrue as a result of increased water productivity, improved public health and better-protected environmental resources.[20] In addition, better agricultural water management would contribute to increasing agricultural productivity and farmers' incomes, and improving the region's food trade balance.

- **Investments in agricultural water can create jobs, contribute to gender equity and revitalise rural areas.** Supporting agricultural revitalisation could have significant benefits beyond the direct benefits in terms of improved land and water resources. It could boost employment, enhance social justice and reduce rural-urban migration. Research from the Arab Forum for Environment and Development estimates that 10 million new jobs could be added to the existing 33 million,[21] formally employed in agriculture if the sector was prioritised (through well-designed extension services, capacity building efforts and the use of improved seed varieties) and more sustainable agricultural practices (irrigation efficiency, improved farming practices and soil conservation) were pursued.[22] Adopting sustainable agricultural water management practices could also reduce pollution from agriculture, preventing the impacts of water contamination and degradation on labour productivity.[23]

- **In addition to thematic studies, available evidence from donor-supported investment operations suggests that the returns of different types of agricultural water investments typically extend beyond primary crop production activities to affect the rural economy.** Evidence on the rate of return of agricultural water investments varies from country to country, but evidence from the region shows that it averages between 16 and 36 percent in most cases (see Table 2). Although there are no comprehensive datasets on the impact of agricultural water investments in the region, existing global analyses suggest that irrigation investments have a positive effect on agricultural growth and poverty,[24] and on reducing the number of people at risk of hunger.[25] According to the World Bank, irrigation can have a strong multiplier effect on local economies (up to two to three times direct benefits).[26] Improvements in agricultural water management, through better soil moisture management or irrigation, remain a key resource to reduce the income variability of poor farmers. This is particularly the case in areas that have experienced conflict and violence. In Iraq, for instance, restoring agricultural water systems has been recognised as the first step to improve food security and incomes, and to allow for the return of internally displaced people.[27] In addition, economic analysis of the rate of return of agricultural water projects often does not include a number of additional benefits, such as increased livestock production, flood protection and increased groundwater recharge, meaning that overall benefits are often underestimated.

TABLE 2

RATES OF RETURN OF AGRICULTURAL WATER INVESTMENTS RANGE FROM 11 TO 36 PERCENT DEPENDING ON COUNTRIES AND CONTEXTS

Economic rates of return of selected World Bank irrigation and drainage projects in selected countries in the Arab region (1994-2018).

Country	Project title	Year	Economic Internal rate of return (%)	Estimate
Egypt	Farm-level Irrigation Modernization	2010-2017	22	At completion
	Egypt Irrigation Improvement Project	1994-2006	12.2	At completion
Jordan	Badia Ecosystem and Livelihoods	2012-2017	25	At appraisal
Morocco	Large Scale Irrigation Modernization Project	2015-2022	From 11.6 to 32.2 depending on status of irrigation system	At appraisal
	Modernization of Irrigated Agriculture in the Oum Er Rbia Basin	2010-2017	21	At completion
Tunisia	Irrigated Agriculture Intensification Project	2018-2024	11 to 19 depending on cropping patterns	At appraisal
Yemen	Groundwater and Soil Conservation Project	2004-2012	36.4	At completion
	Irrigation improvement project	2000-2008	11.2	At completion

SOURCE: World Bank Operations Portal (http://projects.worldbank.org/). Note: This is not a comprehensive list of all World Bank irrigation and drainage projects in the Arab region.

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17. Studies on the benefits of action tend to focus on estimating the economic impact of specific packages of activities (such as disseminating improved agricultural practices), and the results are, therefore, not directly comparable to those of the studies mentioned in the first part of this section (which takes a broader cross-sectoral view when evaluating costs of inaction).

18. Sadoff, C.W., Hall, J.W., Grey, D., Aerts, J.C.J.H., Ait-Kadi, M., Brown, C., Cox, A. *et al*. 2015. *Securing water, sustaining growth. Report of the GWP/OECD Task Force on Water Security and Sustainable Growth*. Oxford, UK, University of Oxford. 180 pp.

19. Sadoff, C.W., Hall, J.W., Grey, D., Aerts, J.C.J.H., Ait-Kadi, M., Brown, C., Cox, A. *et al*. 2015. *Securing water, sustaining growth. Report of the GWP/OECD Task Force on Water Security and Sustainable Growth*. Oxford, UK, University of Oxford. 180 pp.

20. Abaza, H., Saab, N. & Zeitoon, B. 2011. *Green economy: sustainable transition in a changing Arab world*. Beirut, Arab Forum for Environment and Development (AFED). p. 61.

21. This is a conservative estimate and is based on the World Bank World Development Indicators on employment in agriculture, also shown in Figure 9.1 in World Bank. 2007. *World development report 2008: agriculture for development*. Washington, DC.

22. Abaza, H., Saab, N. & Zeitoon, B. 2011. *Green economy: sustainable transition in a changing Arab world*. Beirut, Arab Forum for Environment and Development (AFED). p. XI.

23. United Nations World Water Assessment Programme (WWAP). 2016. *The United Nations world water development report 2016: water and jobs*. Paris, United Nations Educational Scientific and Cultural Organization (UNESCO).

24. Mogues, T., Yu, B., Fan, S. & McBride, L. 2012. *The impacts of public investment in and for agriculture: synthesis of the existing evidence*. ESA Working Paper No. 12-07. Rome, Food and Agriculture Organization of the United Nations (FAO).

25. Ringler, C. 2017. *Investments in irrigation for global food security*. IFPRI Policy Note. Washington, DC, International Food Policy Research Institute (IFPRI).

26. Darghouth, S., Ward, C., Gittinger, P., Roux, J. & Srivastava, A. 2008. *Poverty analysis in agricultural water operations of the World Bank*. Washington, DC, World Bank.

27. Food and Agriculture Organization of the United Nations (FAO). 2018. *Iraq: restoration of agriculture and water systems sub-programme 2018–2020*. Rome. 110 pp.

SECTION 3

INVESTMENT TRENDS IN AGRICULTURAL WATER

3. INVESTMENT TRENDS IN AGRICULTURAL WATER

HIGHLIGHTS

- Investment priorities have shifted: in the 1970s and 1980s, expansion of irrigation and drainage infrastructure was the main theme. From the 1990s onwards, there was a shift towards investment focused on modernisation, demand management, decentralisation and resource management.
- Given the lack of opportunities to mobilise new agricultural water sources, modernisation is expected to remain the key focus of investments in the coming years.
- Public expenditure is still the key source of funding (for both new and recurrent investments), but most evidence suggests that it is insufficient to even meet management, operation and maintenance needs.
- Agricultural water received a very minor share of development assistance: aid flows to the sector show high year-to-year variation, accounting for about 1 percent of the total aid to the region and this has not increased over the past decade.
- Egypt, Sudan and Morocco received 78 percent of international aid directed at agricultural water over the past ten years.
- Some bilateral donors, notably China, are becoming important sources of investment, and new forms of climate financing, such as the Green Climate Fund, the Clean Development Mechanism and green bonds, are gaining in importance.
- Private investors play a significant, yet often unaccounted for, role in agricultural water investments both in irrigation expansion through groundwater wells, and in the operation and maintenance of surface irrigation schemes.
- There is a growing awareness of the need for national governments to become better enablers of private investment, including through the transformation of agricultural water authorities into financially autonomous and commercially oriented undertakings, capable of generating revenue streams sufficient to service their own debt.
- Countries, especially in the Gulf, are investing in and scaling up controlled-environment agricultural technologies such as hydroponics and aquaponics.

FROM IRRIGATION EXPANSION TO MODERNISATION AND FARMER-MANAGED SYSTEMS: TRENDS IN THE TYPE OF AGRICULTURAL WATER INVESTMENTS

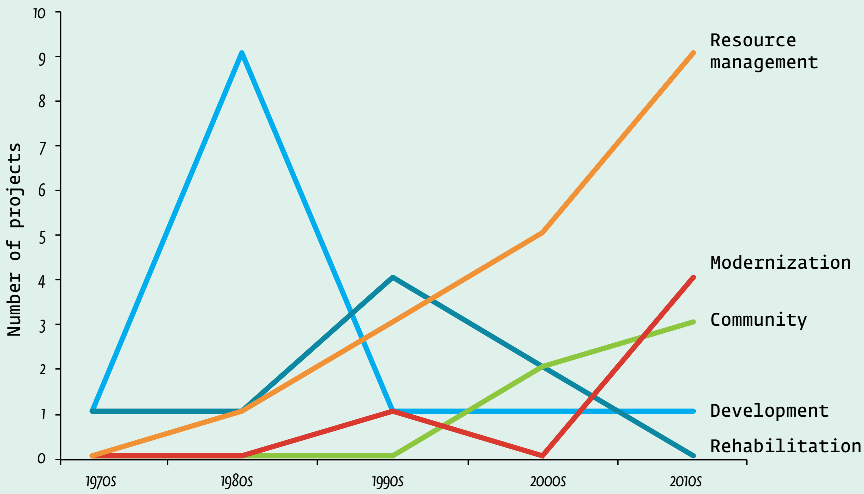
Agricultural water investments have traditionally been a mainstay of agricultural investment in the region; however, the type of investments has changed through time. Rapid expansion of large-scale irrigation systems took place worldwide and in the Arab region from the 1960s onwards, including dam and canal construction. From the 1990s onwards, a progressive shift in the focus of agricultural water investments took place. Attention moved away from developing resources and expanding infrastructure to the rehabilitation of existing infrastructure, community-based irrigation management and institutional development.

This shift was a result of an increasing emphasis in global policy agendas on community driven development, participatory water management and decentralisation. From the 1990s onwards, governments started turning many aspects of public irrigation systems over to water user associations (WUAs).[1] This type of decentralisation reform was supported by the general argument that user participation and private sector involvement, if properly structured, can provide the incentives needed to stabilise and improve the efficiency of irrigation and water supply systems.[2] Donors and development banks increasingly framed their projects in a participatory rhetoric, whereby water users/beneficiaries would build a sense of ownership (of infrastructure or organisations) and co-manage irrigation systems, with emphasis on the concepts of Participatory Irrigation Management (PIM) and Irrigation Management Transfer (IMT).[3] The name given to these water user groups or organisations differs from country to country, depending largely on the country's institutional set up, its history and culture. For instance, Morocco uses the terms *Communautés d'Irrigants* and *Association d'Usagers de l'Eau Agricole* (AUEA). **Tunisia** uses *Groupement de Développement Agricole* (GDA). Egypt uses the term "water user association" (rabta) for tertiary mesqa level (tertiary level) in the old lands of the Nile Delta, Water Users Unions (WUU) (or *itihad*) for the new lands and Branch Canal Water User Associations (BCWUAs) for the secondary level.[4] This increased focus on community based agricultural water investments is reflected in the increasing number of World Bank projects in the Arab region categorised under 'irrigation and drainage', which mention community in their project title (as shown in Figure 5).

FIGURE 5

THE INCREASE IN INVESTMENTS FOCUSED ON MODERNISATION, COMMUNITY AND RESOURCE MANAGEMENT IN WORLD BANK PROJECTS IN THE REGION

Occurrence of five key words (development, rehabilitation, community, modernisation, resource management) in the titles of World Bank projects in the Arab region (1970-2018).



SOURCE: Authors with data from the World Bank Operations Portal. Note: This only considers closed or active World Bank projects in the region (1970-2018) categorised under the 'irrigation and drainage' sub-sector in the World Bank taxonomy of sector codes (http://projects.worldbank.org/sector?lang=en&page=). Rehabilitation is intended to be an upgrading of infrastructure only. Data for Comoros, Djibouti, Mauritania, Somalia and Sudan are not included.

While farmer involvement in decision-making and operation and maintenance is appealing in principle, experiences show that participatory irrigation management and irrigation management transfer often do not deliver the expected benefits. The expectation that increased farmer involvement in operation and maintenance will deliver on cost recovery, user participation, equity and ultimately irrigation performance has not always been realised in the region.[5,6] There are numerous factors explaining the mixed success of decentralisation of management, and operation and maintenance responsibilities. First, the ability of these groups to deliver their expected functions is shaped by the quality of existing water management infrastructure and the broader sociopolitical context, which cannot be shaped by agricultural interventions alone.[7] Second, the representation of women is often limited and overlooks their role in agricultural water management.[8] Third, these organisations often have unclear legal status and are financially weak because of inadequate and insufficient transfer of responsibility.[9] In addition, issues such as lack of capacity and transaction costs have been found to influence the effectiveness of decentralisation of agricultural water management.[10] While it is clear that participatory irrigation management can offer one way of improving agricultural water outcomes, both in terms of sustainability and equity, the debate regarding the best functioning models and performance monitoring indicators is still open.[11]

The shift away from irrigation and drainage expansion is largely a result of the constraints posed by water scarcity and land degradation. By the 2000s, water resources in most river basins had been fully exploited and there was no further potential in many locations to expand irrigation, with water often over-allocated to agriculture.[12] The increased focus on resource management can be observed in Figure 5, which shows how the number of World Bank projects categorised as 'irrigation and drainage' that focus on resource management, including groundwater management, has increased over the past two decades. Given the limited scope to mobilise additional water resources, investments in agriculture focus more and more on conserving existing resources and promoting sustainable consumption. This focus on resource management and conservation in the Arab region is accompanied by a shift from supply side responses or mere upgrading of infrastructure (rehabilitation) to a demand management approach, which involves infrastructural and managerial improvements in irrigation systems as well as institutional reforms. This shift is captured in the word '**modernisation**',[13] which is becoming a prominent focus and framing of many agricultural water-related investments in the region and globally (see Figure 5). As a result of this shift towards modernisation, the number of projects framed as only irrigation and drainage development has been decreasing since the 1980s.

Agricultural water investments in the region are expected to continue to focus on modernisation and climate change adaptation. The growing challenges of climate change and water scarcity, and the continued emphasis on macroeconomic stability and economic liberalisation amongst many donors, mean that investments are expected to focus on modernisation and climate change adaptation over the coming years. The Arab region's agriculture sector and livelihoods are amongst the most vulnerable sectors to climate change,[14] making adaptation to climate change in land and water a key priority. Some Arab countries, especially in the Gulf, are already taking steps to build resilience in the water sector in the face of scarcity and climate change, by expanding and improving climate-smart and water-saving controlled-environment agricultural technologies such as hydroponics and aquaponics.[15] Moreover, recognition of the value of water (and the high cost of turning a water source into a service delivered to a farm) means that agricultural water investments aimed at reforming water use and service delivery, and at obtaining the maximum value per unit of water used in agriculture are gaining increasing prominence. As the debate over the value of water takes centre stage,[16] investments in agricultural water will also likely see the greater involvement of other sectors and actors beyond agriculture, such as cities and industries but also institutions that go beyond the line Ministries mandated with agriculture and water policy, such as agencies tasked with trade, tax and labour policy.

There is still much room for investments by the public sector in the modernisation of irrigation infrastructure in the Arab region. This should be accompanied by policies to promote high-value, export-oriented agriculture in order to maximise economic returns to such investments. According to World Bank estimates, annual irrigation replacement costs of existing capital, upgrade, efficiency and new capital investments in countries in the Mashreq and North Africa region (so, excluding Mauritania, Somalia, Sudan and the Gulf) average between 0.08 and 0.16 percent of regional gross domestic product (GDP).[17] In this context, agricultural water investments in the region are expected to focus on the following areas in the coming years:

- **Modernisation:** a broad category of investments involving technical and managerial upgrading of irrigation schemes combined with institutional reforms, with the aim of promoting sustainable, efficient and equitable resource use and service delivery in irrigation systems. Given the number of emerging innovations and tested approaches (such as the Food and Agriculture Organization of the United Nations [FAO] MApping System and Services for Canal Operation TEchniques [MASSCOTE] approach[18]), these projects are expected to increasingly focus on the piloting and upscaling of proven innovations.

- **Improved irrigation water service delivery:** improvements in irrigation service delivery and quality have been identified as key components to uplift the sector, generate private sector interest and secure new market opportunities for farmers pursuing irrigated agriculture of high-value crops.

- **Contribution to climate change mitigation and adaptation efforts:** investments in agricultural water are expected to contribute significantly to the resilience of rural areas to climatic shocks. Emerging innovations in solar irrigation pumping and desalination using renewable energy, and wastewater reuse are likely to attract investments as they help to achieve carbon neutrality and a buffer against drought shocks.[19]

PUBLIC FINANCE BEARS MOST OF THE COST BURDEN OF INVESTMENTS AND FUNDING FOR OPERATION AND MAINTENANCE

Historically, the cost burden of developing and maintaining agricultural water infrastructure, especially surface irrigation and drainage schemes, has been borne almost entirely by public finance. Governments have traditionally provided funding for capital investment as a grant or in the case of a long-term loan, it has been effectively written off as non-repayable. This practice may be justified if irrigation infrastructure has elements of a public good or if it is reckoned to be part of a government's food, social or regional policy. Even so, some capital cost recovery may be warranted on economic and financial grounds.

Currently, the main sources of funds for management, operation and maintenance are government subsidies, revenues from irrigation service fees, and other secondary revenue sources. However, the lack of systematic procedures for estimating operation and maintenance requirements of systems means that the budgetary allocations are made on an ad hoc basis generally depending on financial resources available within the government and not on the basis of actual requirements.[20] In some countries, allocations are provided on the basis of centralised, top–down estimations of needs, which are often way off the mark for actual local requirements. In Egypt, the World Bank estimated that up to 10 percent of total public expenditure was absorbed by irrigation water services in the 2000s.[21] The bulk of many management, operation and maintenance budgets goes to administrative overheads, leaving little for essential field operations and instead supporting a large irrigation bureaucracy.[22] In Egypt, the agricultural water sector shows a pattern of frequent variances between actual and budgeted expenditures for both recurrent and investment expenditures, but particularly for maintenance expenditure, and a pattern of unbudgeted supplementary funding being provided to some authorities.[23] Low public investment and budget execution efficiency have also been reported for the water sector in Lebanon[24] and Algeria[25], amongst others.

This involvement of public finance for irrigation has a cost to the central ministries of finance, and growing fiscal burden, shrinking fiscal space and low financial viability of irrigation authorities have meant that governments have been underspending in the sector.[26,27] This underspending in the agricultural water sector reflects broader trends in public expenditure in agriculture overall. Most Arab countries show sluggish growth in public agricultural expenditures, with the exception of Algeria and Egypt (see Figure 6, top panel). Some of the highest increases in public spending in agriculture have occurred in response to food crises, such as the 2008-2009 crisis.[28] In per capita terms, public spending in agriculture shows even lower rates of growth across the region (Figure 6, lower panel).

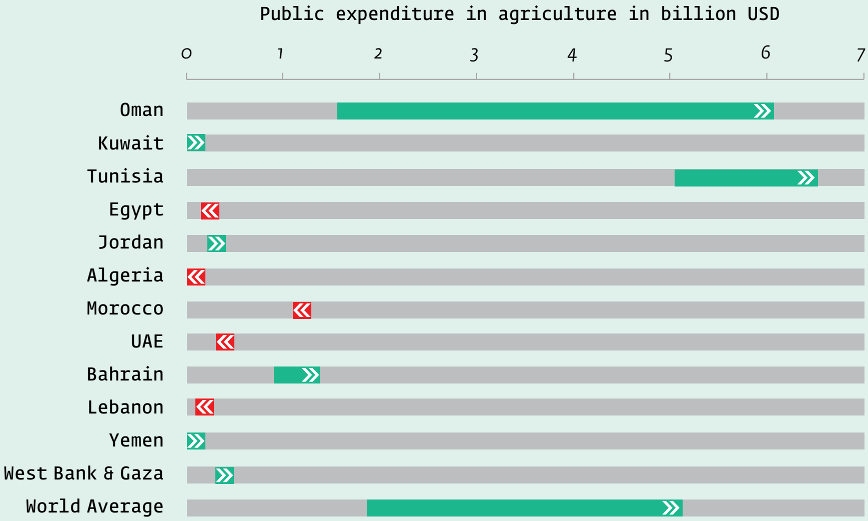
Old and deteriorating irrigation and drainage infrastructure, soil salinisation, and low land and water productivity in the region suggest that there is much room for improving the quality of spending in agricultural water, as well as raising the level of spending to cover operation and maintenance needs.[29,30] High water losses from conveyance networks, aging irrigation infrastructure and poor services in surface irrigation systems reported, for instance, in Egypt,[31] Tunisia,[32] and Jordan,[33] suggest that spending in agricultural water is inadequate. Inefficient surface irrigation systems are symptoms of inadequate maintenance and low levels of spending in the agricultural water sector, partly a result of large deficits and low financial viability of irrigation authorities.[34] This situation has led many farmers to supplement their supply with groundwater (in many cases through illegal wells), which often uses subsidised energy including electric power and diesel.[35]

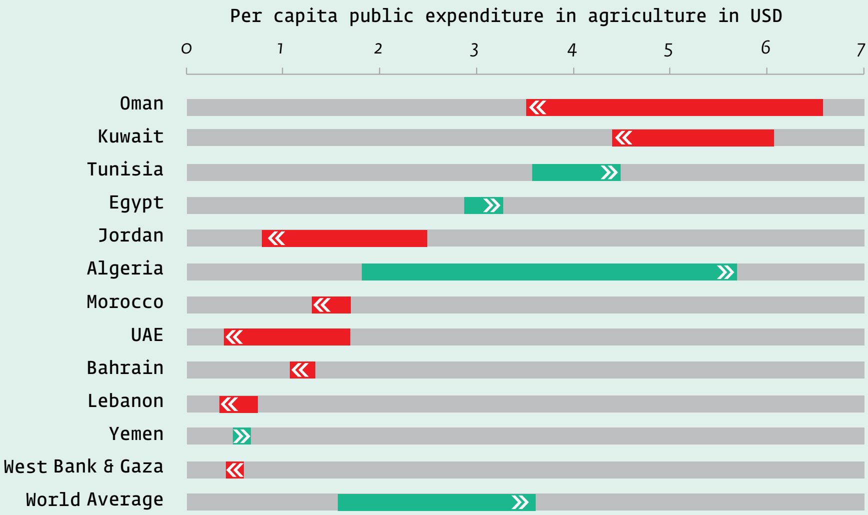
Underspending in agricultural water reflects low levels of public spending in agriculture. In the 2003 Maputo and 2014 Malabo declarations, African governments (including Arab countries in Africa) set a goal to allocate at least 10 percent of public budgets to agriculture in order to achieve 6 percent growth in the sector.[36] All Arab countries are spending below this 10 percent target; however, country

FIGURE 6

TRENDS IN PUBLIC EXPENDITURE IN AGRICULTURE DIFFER AMONGST ARAB COUNTRIES, WITH MANY COUNTRIES SHOWING STAGNANT OR DECLINING TRENDS

Top: Public expenditure in agriculture in billion 2005 USD purchasing power parity; decadal averages for the 1990s and 2010s for selected Arab countries and the world. Bottom: Per capita public expenditure in agriculture in 2005 USD purchasing power parity; decadal averages for the 1990s and 2010s for selected Arab countries and the world. Green (red) arrows show increasing (decreasing) trends.





SOURCE: Authors using data from the International Food Policy Research Institute (IFPRI) Statistics on Public Expenditures for Economic Development (SPEED) database. No data were available for Comoros, Djibouti, Iraq, Libya, Mauritania, Qatar, Saudi Arabia, Somalia, Sudan and Syria. The world average was calculated taking the average of the 130 countries listed in IFPRI's SPEED database and excluding Arab countries. These agricultural expenditures also include research and development (R&D), expansion, seeds, forestry, fishing and not just spending in agricultural water.

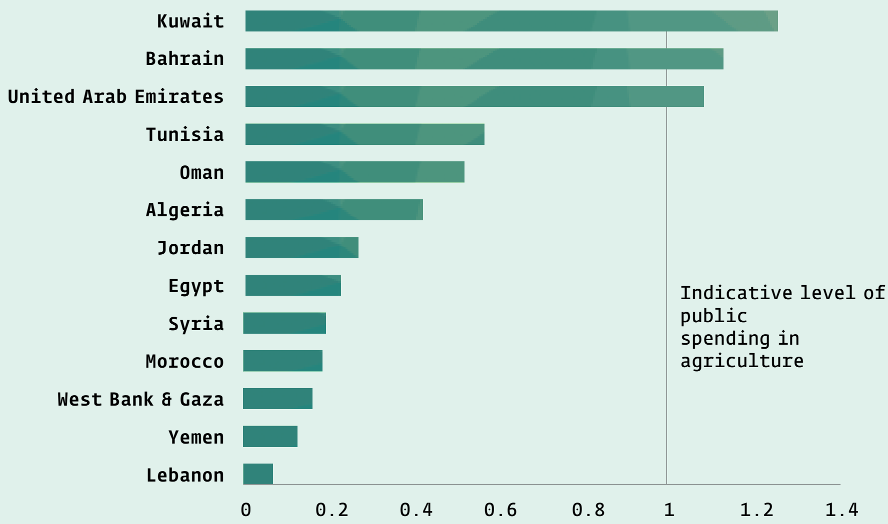
conditions and spending contexts differ widely. This spending target is arguably less meaningful in countries with relatively small agricultural GDP and employment shares in the overall economy,[37] such as Kuwait or Oman. An alternative metric called the Agriculture Orientation Index shows the relationship between central government spending in agriculture and the sector's share of national GDP.[38] A value of one (1) indicates that the government spends a share of its budget in agriculture which is exactly proportional to the sector's contribution to the overall economy.[39] The Gulf countries with a small agriculture sector have an index close to one. However, as shown in Figure 7, most countries spend much smaller proportions of the public budget on agriculture than the sector's share in the economy. Of the 13 countries for which the Agriculture Orientation Index could be computed, 8 had a value lower than 0.4. This suggests that in some Arab countries central governments had a low orientation towards the agriculture sector relative to the sector's contribution to the economy. This might reflect under investment in agriculture or might reflect greater spending in other sectors that face higher degrees of market failure or income inequality. The Agriculture Orientation Index's focus on central government spending means that agricultural expenditures from lower levels of government are ignored, providing only a partial picture of overall agricultural spending in a given country.

While some public expenditure reviews in the agricultural water sector and agriculture sector have been conducted in the past, there is a lack of updated comprehensive data to disaggregate agricultural expenditures by sub-sector. It is difficult to make meaningful analysis of the use of public funds in agriculture (e.g. input subsidies, irrigation expansion, modernisation, R&D), and to identify what type of agricultural public expenditure is more productive. This lack of data and associated analysis hinders the ability of ministries of agriculture (and related ministries) to attract and make good use of public funds. In particular, to the extent that the ministries responsible for agricultural water can demonstrate that their programmes are an efficient and high-impact use of public funds, they can make a stronger case to ministries of finance and planning for increasing their budgets. In this sense, collecting data on public spending in agricultural water and showing the returns to these investments are key elements to increase expenditure in agriculture. Given that responsibilities for agricultural water are often spread across different ministries, this adds to the challenge of obtaining consistent information on public spending in the sector.

FIGURE 7

MOST CENTRAL GOVERNMENTS HAVE A LOW ORIENTATION TOWARDS AGRICULTURE EXPENDITURE

Agriculture Orientation Index for selected Arab countries (ratio of the share of agriculture in public spending relative to its contribution to GDP in 2012).



SOURCE: Authors using data from the IFPRI SPEED database Note: No data were available for Comoros, Djibouti, Iraq, Libya, Mauritania, Qatar, Saudi Arabia, Somalia and Sudan. The Agriculture Orientation Index is the ratio of the share of agriculture in public spending relative to its contribution to GDP. A value of one (1) would indicate that the government spends a share of its budget on agriculture exactly proportional to agriculture's contribution to GDP. Following the classification in the IFPRI SPEED database,[40] agriculture corresponds to International Standard Industrial Classification (ISIC) divisions 1 to 5 and includes forestry, hunting and fishing, as well as the cultivation of crops and livestock production. It does not include spending in social protection or energy subsidies for agriculture.

FICKLE AND UNEVENLY DISTRIBUTED INTERNATIONAL AID FLOWS

Aid flows to the agricultural water sector account for about 1 percent of the total aid to the region and show no increase over the past decade. In absolute terms, international aid flows to the agriculture sector totaled USD 6.9 billion between 2008 and 2017, and averaged USD 700 million over the same period. This figure includes aid received from bilateral donors, multilateral and regional development banks (Islamic Development Bank, African Development Bank), and other donors detailed in Appendix 1. In the past, agricultural water constituted a much bigger share of international aid. In the 1980s, the share of international aid devoted to irrigation was around 26 percent, and it varied between 19 and 39 percent in the 1990s.[41]

International aid flows to the sector are fickle. Aid to the agricultural water sector shows significant year-to-year variability (Figure 8). It does not show any significant trend over the past ten years for which data are available, as also observed in lending data from key multilateral donors such as the World Bank.[42] Similarly, international aid flows to all sectors do not show a particular trend. Of the USD 20 billion per year committed to all sectors, on average, between 2008 and 2017, 1.3 percent (about USD 270 million) was committed to the agricultural water sector. This amounts to a total of about USD 2.7 billion committed to the agricultural water sector over ten years. International aid flows fluctuate across the years due to changes in national political context, budgets, priorities and external factors, such as a financial crisis or food price volatility. The high year-to-year variation underscores the risks involved in international assistance, and the need for recipient countries to have contingent plans in the short and medium term to address unexpected cuts in donor assistance, and to reduce donor dependence over the long term.[43]

FIGURE 8

FICKLE INTERNATIONAL AID FLOWS TO AGRICULTURAL WATER

Donor (bilateral, multilateral, private) commitments to all sectors (left axis) and the agricultural water sector (right axis) for Overseas Development Assistance (ODA) recipient Arab countries (2008-2017). All values in USD millions.

SOURCE: Authors using data from the Organisation for Economic Co-operation and Development (OECD) Creditor Reporting System database. Note: No data available for Libya. Includes all official donors listed in the OECD Creditor Reporting System database: Development Assistance Committee (DAC) countries, multilaterals (including World Bank, regional development banks, United Nations), non-DAC countries (including United Arab Emirates and Saudi Arabia), and private donors. Total for all sectors estimated using the economic sectors in the OECD database with the exception of the agricultural water sector.

- **International aid flows to agricultural water vary by country, with Egypt and Sudan receiving the lion's share.** Looking more closely at the aid flow data, between 2008 and 2017, Egypt and Sudan received USD 981 million and USD 804 million, respectively, in international aid for agricultural water. In relative terms, this means that Egypt and Sudan account for about 35 percent and 28 percent, respectively, of the total aid received by the agricultural water sector in Overseas Development Assistance (ODA) recipient Arab countries (Figure 9). Morocco and Lebanon also received a significant share of international aid, accounting for 14 percent and 6 percent, respectively, of the total. This is proportionally much higher than the total ODA received by all sectors in these countries, shown by the blue bars in Figure 9.

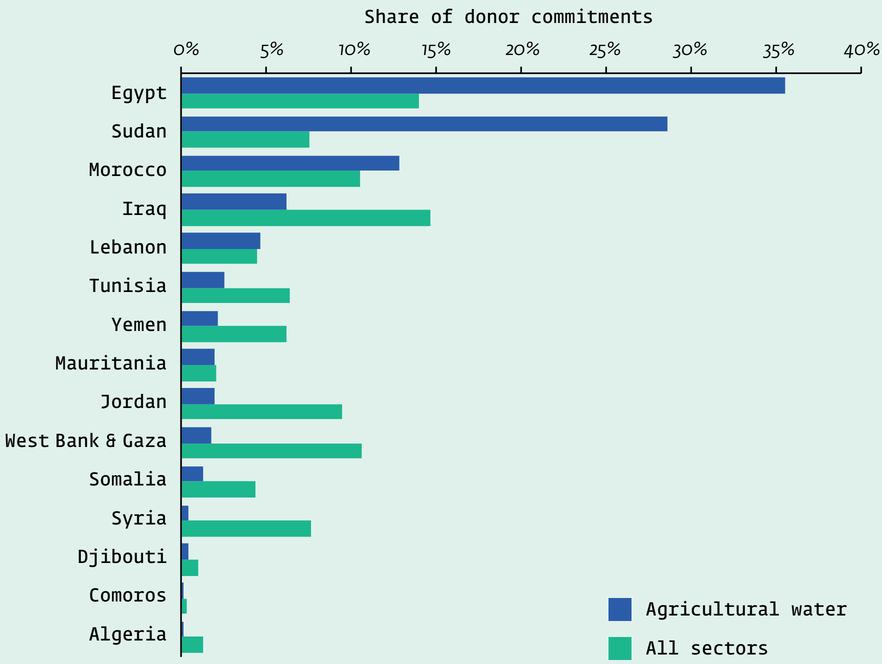
- **Although Iraq, Syria, West Bank and Gaza, and Yemen are amongst the top countries for ODA assistance to all sectors, they account for a much smaller share of investments in agricultural water.** Given the importance of the agricultural water sector in supporting economic activities and employment, donors and countries will arguably need to direct more attention to this sector in these countries. Unless these countries unlock new funding sources and donors increase their spending in land and water, they might be missing out on the significant opportunities to improve food security and stabilise incomes offered by the rehabilitation of agricultural water systems.

- **The Arab region receives about 11 percent of total global ODA support for agricultural water from all donors, which rises to 28 percent when considered on a per capita basis.** Analysis of the distribution of aid for agricultural water by region shows that the Arab region received about 11 percent of the total international aid targeted at agricultural water between 2008 and 2017. The largest recipients in absolute terms are sub-Saharan Africa (33 percent) and Central and Southern Asia (32 percent), followed by East Asia and the Pacific (20 percent). On a per capita basis, the Arab countries received 28 percent of ODA support to agricultural water, second only to sub-Saharan Africa (33 percent) and before South Asia (20 percent). Bilateral donors are the main source of international aid to agricultural water in the Arab region. The contribution of multilateral donors, such as international financial institutions and regional development banks, has also been significant and increasing in recent years.

FIGURE 9

EGYPT, SUDAN AND MOROCCO ACCOUNT FOR THE LION'S SHARE OF DONOR COMMITMENTS TO AGRICULTURAL WATER WHILE DONOR COMMITMENTS TO ALL SECTORS ARE MORE BALANCED

Donor commitments to agricultural water (BLUE) and to all sectors (GREEN) for Overseas Development Assistance (ODA) recipient Arab countries, shown as a share of the total commitments (2008-2017).



SOURCE: Authors using data from the OECD Creditor Reporting System database. Note: No data available for Libya. Includes all official donors listed in the OECD Creditor Reporting System database: Development Assistance Committee (DAC) countries, multilaterals (including World Bank, regional development banks, United Nations), non-DAC countries (including United Arab Emirates and Saudi Arabia), and private donors.

Although international aid flows are fickle and lower than public and private investments, they should be promoted because they can play a key role in influencing priorities and supporting innovations. International aid brings innovations to the regions, and priority themes receiving donor support often involve the application of new technologies or institutional approaches. Priority themes receiving donor support include modernisation and broader rural development projects, with a focus on building resilience to climate change and creating jobs, especially amongst rural communities affected by conflict and migration.[44,45]

BEYOND PUBLIC SPENDING: NEW PLAYERS, NEW FUNDING MODALITIES

Much of the public and development assistance investment in agricultural water management has focused on large-scale irrigation systems, with private investors financing groundwater development for irrigation. Perhaps, because of this, national irrigation statistics sometimes do not even attempt to include the areas funded by private sector investments, particularly those of individual farmers. Across the region, between half[46] and two-thirds[47] of all groundwater development for irrigation has been financed entirely by the private sector, ranging from smallholder farmers with no more than 1–2 hectares (for instance, in Cap Bon, Tunisia) to large private landowners (for instance, in Souss, Morocco, or in the Western Desert, Egypt).[48] In Morocco, 30 percent of the country's irrigated area depends on privately owned and managed wells.[49] In addition, a large share of irrigated areas within schemes developed by public authorities are estimated to have benefited from private investments in irrigation, bringing the total share of privately developed irrigated areas to 43 percent.[50] In Yemen, private owners control more than 100 000 wells across the country, which extract more than 90 percent of the total 3 billion cubic metres pumped out each year.[51] Most use the water for their own farms; some sell it to other farmers either through pipes or tankers; some sell or give water to local communities for domestic use; and an increasing number sell water to urban settlements, some through a private network, but mostly by sale to the individual tanker trade. While farmer-driven investments are key to agricultural water management, there are also consequences related to uncoordinated private irrigation development, notably groundwater depletion.

Private sector financing through public-private partnerships (PPPs) has also been an area of increasing interest and activity. Although PPPs have existed in many areas of public sector service delivery, such as water supply, sanitation and health, for a long time, adoption of the PPP approach in the agricultural water sector has been somewhat slower. However, recently, there has been a growing interest in the role of private agribusiness to enhance land and water productivity, with some of the first examples stemming from the Arab region (El Guerdane project in Southern Morocco),[52] as discussed more in section 5 of this report. Factors driving the interest in PPPs have been poor performance of some irrigation schemes, a continuing lack of adequate funding for maintenance, constraints on public finances, and difficulties of reforming and modernising public agencies responsible for the management, operation and maintenance of irrigation schemes. In some locations, participatory approaches and WUAs have not always performed as expected, and this has led to a search for new approaches. A significant driver has also been the belief that the private sector can bring innovation and modern management practices, and that service delivery will be improved leading to improved crop production and incomes, and thus a greater ability and willingness to pay irrigation service fees which cover the actual operation and maintenance costs. One of the key obstacles to PPP development in agricultural water management has been the ability and willingness of farmers to pay for water (especially in the case of non-commercial smallholders), as well as other risks involved (property rights, agriculture-related risks).

In the last decade, China has been channeling significant and growing direct investments to the Arab region. Some of these investments constitute large-scale, high-impact projects requiring access to and management of land and water resources. These projects are reshaping the land and water investment landscape, as well as posing new challenges and opportunities for sustainable and equitable resource management. China's investments in the region are underpinned by the China-Arab States Cooperation Forum (CASCF) and the Belt and Road Initiative (BRI). China's Arab Policy Paper, issued by the Chinese government in 2016, provides the overarching vision and policy agenda for these investments. The paper includes a chapter on agricultural cooperation, which identifies arid zone agriculture and water-saving irrigation as key areas for China-Arab bilateral and multilateral cooperation.[53]

Some estimates suggest that China invested in the order of hundreds of millions of dollars in the Arab region's agriculture sector between 2008 and 2017.[54] These investments include dam construction in Algeria and agricultural modernisation projects in Egypt, including building of the world's largest greenhouse,[55] and Sudan. Since the foundation of CASCF, a range of construction, agricultural equipment and chemical (fertiliser) entities have led direct Chinese investment in agriculture in Arab countries. Chinese investments in agriculture across the region are only a small fraction (about 1 percent) of total Chinese investment in the region, with sectors such as energy, transport and real estate acquisition and development receiving much more investments. Over the last ten years, Chinese investments across all sectors in Arab countries are estimated to be in the range of USD 10–12 billion/year.[56] Incomplete reporting makes it difficult to look more closely at the role of China (and other global and regional powers) in large-scale farmland acquisition, and its related sustainability and equity effects.

- Foreign direct investment in agricultural water creates opportunities and challenges. These include employment opportunities, potential transfer of land and water technologies to farmers (including smallholders), development of rural infrastructure, and greater food security in the host countries and the global market, in general. Potential negative impacts of local and foreign land acquisitions include loss of land rights for landholders without formal title deeds, and also undue influence on policy directions and instruments, which can incentivise unsustainable water consumption. Investors from high-income countries, where environmental standards and enforcement are higher, may use cheaper inputs or land management practices that could contribute to land degradation, environmental pollution, and over-exploitation of water and other resources in developing countries.

- Apart from the foreign direct investment, a renewed interest from private giving foundations in agricultural water is emerging. Private philanthropic foundations have always played a role in the agricultural water sector, especially in funding R&D and innovative and experimental solutions, and testing them and providing scope for scaling up and out solutions that work. For instance, the Rockefeller Foundation and Ford Foundation played a key role in promoting science-based agricultural modernisation.[57] More recently, agricultural development has become one of the main focus areas of the Bill & Melinda Gates Foundation, showing a renewed interest from private foundations on issues related to agricultural productivity and food security. Regional foundations (for instance, Arab Foundations Forum), private agribusinesses and venture capital high-impact investments are also emerging as a means to finance development. There is little research so far to understand the long-term impacts of this way of financing agricultural water management.

- In the last few years, a number of new ways of financing agricultural water investments have arisen. These include green bonds, the Green Climate Fund, Clean Development Mechanism (CDM), Adaptation Fund and blended finance.

- **Green bonds** are intended to raise finance for projects that help the transition to low-carbon and climate-resilient development. The green bond market has seen explosive growth in the past decade, presenting an unrivaled opportunity in climate finance. Annual issuance has now risen from zero to more than $155 billion globally in 2017, with more growth ahead. Modernisation of irrigation schemes could, in principle, qualify for this mechanism.[58] In 2009, the World Bank issued two green bonds to fund Tunisia's Water Sector Support Program, which consisted of a series of investments in irrigation, rural water supply, groundwater mobilisation and environmental protection.[59]

- The **Green Climate Fund** (GCF) will become potentially important in funding the creation and adaptation of existing and new irrigation systems, and agricultural water management practices to make them more climate resilient and more energy efficient. In Morocco, the GCF is supporting (1) a project to provide sustainable irrigation to improve the climate resilience of subsistence oasis farming and larger-scale date and olive agriculture within the Boudnib Valley;[60] and (2) a water conservation project co-financed by the European Bank for Reconstruction and Development to build a bulk water transfer scheme from the M'Dez Dam to the Saïss Plain, along with the preparation of a PPP to implement new irrigation networks.[61]

- The **Clean Development Mechanism** (CDM) allows emission reduction projects in developing countries to earn certified emission reduction (CER) credits, each equivalent to 1 tonne of carbon dioxide. These credits can be traded and sold, and used by industrialised countries to meet a part of their emission reduction targets under the Kyoto Protocol. In Egypt, the CDM has been used for an irrigation and drainage pumping stations modernisation programme, the basis of the emission reductions resulting through energy savings.[62]

- **Blended finance** refers to public budget funds (loans, grants or guarantees) invested alongside private sector capital, including commercial finance (market-based repayable finance). It aims at primarily crowding in additional commercial finance that is not currently invested for development outcomes.[63] Blended finance approaches can be categorised into mechanisms and instruments. Investment funds and PPPs are examples of blended finance mechanisms, with the latter used in Jordan to finance a wastewater reuse for irrigation plant (case study 1). Blended finance also includes a range of stand-alone instruments used to mitigate risk and crowd in additional capital. These include equity, debt or mezzanine investment directly into companies or projects, as well as credit enhancement in the form of insurance and guarantees.[64] Blended finance instruments also include grants and technical assistance, which close the viability gap that often exists in water-related projects, strengthening the project's capacity to attract commercial investments, as done, for instance, in Jordan to promote wastewater reuse (case study 1) or in Morocco, through the Fonds de Développement Agricole to deploy drip irrigation equipment. Innovative risk pooling mechanisms, such as the Water Finance Facility, which develops country level financing facilities that issue bonds in their capital markets to provide long-term loans to water utilities, demonstrate the potential for commercial finance to support water-related investments.

CASE STUDY 1

BLENDED FINANCE FOR WASTEWATER REUSE: AS-SAMRA, JORDAN [65]

The As-Samra wastewater treatment plant was designed and constructed with the purpose of supporting agricultural production in the Jordan valley as well as treating Amman's wastewater. It was set up as a PPP (25 years, build-operate-transfer contract). The As-Samra plant was the first in the Middle East to use a combination of private, local government and donor financing, using a Viability Gap Funding scheme. This is a grant (one time or deferred) which is provided to support infrastructure projects that are economically justified but fall short of financial viability. Although the economic benefits of an investment may be high, in situations where the incomes of end users are low, it may not be possible to collect sufficient user fees to cover costs. Viability Gap Funding reduces the upfront capital costs of pro-poor private infrastructure investments by providing grant funding at the time of financial close, which can be used during construction. In this set up, government funds and donor grants are used to leverage private sector investment and involvement in the construction, operation and maintenance of the facility. Under the coordination of the Ministry of Water and Irrigation, the construction was facilitated by a 20-year commercial loan and a comprehensive risk sharing arrangement, and completed in 2015. Today, 10 percent of the country's agricultural water consumption is met through treated wastewater from the As-Samra plant, which is able to provide Jordan with up to 133 million cubic metres of treated water per year. In addition, the As-Samra plant is able to generate up to 95 percent of its energy needs, supported in part by a favourable topography. For this model to work, a stable regulatory and political environment is a prerequisite for partners to engage.

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SECTION 4

INNOVATIONS SHAPING AGRICULTURAL WATER MANAGEMENT

4. INNOVATIONS SHAPING AGRICULTURAL WATER MANAGEMENT

HIGHLIGHTS

- New technologies open up opportunities to mobilise new sources of water and greening the agricultural water management sector, including wastewater reuse, desalination, solar irrigation and managed aquifer recharge.
- Innovations to improve water governance include water data acquisition and analytics, and water accounting, enabling real-time water infrastructure operation and management, and giving insights to farmers on when to conserve or use water.
- Integrating emerging digital technologies with agricultural water management practices contributes to increase water productivity, with the public sector playing a key role as an enabler and regulator of digital agricultural technologies.
- Controlled-environment agricultural technologies such as hydroponics reduce land and water requirements, and have the potential to improve food security and livelihoods, including in communities affected by violence and conflict.

INNOVATIONS FOR INCREASING WATER AVAILABILITY AND GREENING

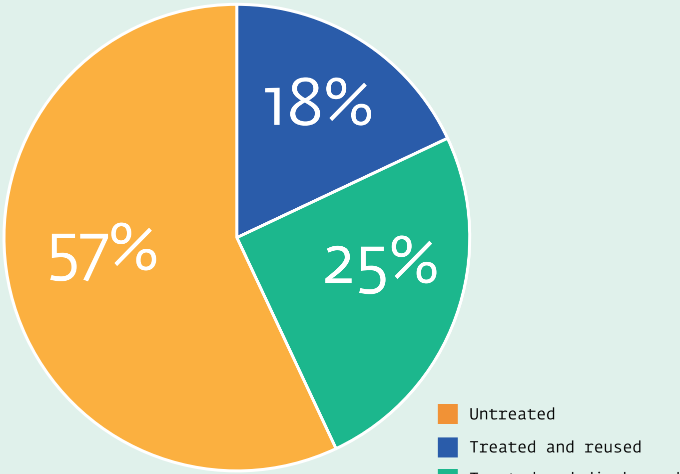
Innovations have the potential to unlock new water sources at scale. Advances in nanotechnologies, notably graphene-based membranes, provide opportunities to develop diversified and climate-resilient sources of water supplies. The highly efficient, modular and multifunctional processes enabled by nanotechnology provide high performance, affordable water and wastewater treatment solutions.[1] These solutions (called nano-absorption) are already commercially available, and given their low cost and modularity, they can play a key role in expanding wastewater treatment and reuse across the region.

While some countries have started to capture recent innovations in safe reuse of wastewater, most of the region's wastewater is still discharged untreated to water bodies. Countries in the region have proactive policies to seize the opportunity of safe reuse, with Jordan, Kuwait and Oman using at least secondary treatment prior to water use in agriculture.[2] Nonetheless, most countries in the region still have significant proportions of untreated wastewater and at least 55 percent of the region's wastewater is discharged untreated to water bodies (Figure 10).[3] This presents a significant missed opportunity to increase treatment, improve water quality, and mitigate water scarcity through productive reuse for irrigation and groundwater recharge. Global experience, for instance, in Singapore and Namibia to name a few, shows that wastewater reuse is now a viable water supply option even for domestic purposes.[4] Treating all of the region's untreated wastewater for safe reuse would generate an additional 10–11 billion cubic metres of water per year, equivalent to about 5 percent of current total water withdrawals.[5] To identify promising innovations and validated reuse models, the International Water Management Institute (IWMI) and its partners launched the ReWater MENA project in 2018 with the aim of helping to expand the safe reuse of water in the region.[6]

FIGURE 10

TREATING ALL OF THE REGION'S WASTEWATER WOULD GENERATE AN ADDITIONAL 10–11 BILLION CUBIC METRES OF WATER PER YEAR

Share of wastewater collected that is untreated, treated and reused in irrigation



SOURCE: Authors based on World Bank. 2018. *Beyond scarcity: water security in the Middle East and North Africa*. Washington, DC.

Technological advances could also disrupt the desalination market, making desalination for agricultural applications feasible in the next decade. Use of nanotechnologies in desalination could halve the cost it takes to turn non-traditional sources into potable water and double the capacity in the next 3 to 5 years.[7] Given the declining costs of desalination[8] and the potential for desalination using renewable energy,[9,10] the use of desalinated water to irrigate high-value crops is likely to become increasingly cost-effective in the future (Table 3).[11] These innovations are already being deployed around the world (see case study 2 on Australia's Sundrop farms) and also being seized in the region. In 2017, for instance, Morocco commissioned the construction of the world's largest wind energy desalination plant to supply domestic and irrigation water needs.[12] In southern Spain, desalinated water has been shown to be a viable strategy to sustain highly productive agriculture, especially if paired with hydroponic systems.[13] Nonetheless, the impacts of using desalinated water in irrigation need to be better understood and quantified. The Palestinian Ministry of Agriculture has piloted the use of desalinated water to irrigate crops, showing how this actually leads to lower production levels compared to using other water sources, and suggesting that desalinated water needs to be blended with brackish water to avoid soil degradation and to achieve good levels of production.[14] In addition, discharge of brine effluents from desalination plants poses environmental challenges which are largely unaddressed.[15]

CASE STUDY 2

PRODUCING TOMATOES IN THE DESERT – AUSTRALIA'S SUNDROP FARMS

Since 2016, Sundrop farms operate a fully commercial 20-hectare greenhouse facility in South Australia. The greenhouse is solar-powered and uses a combination of solar energy generation and desalination infrastructure to produce around 17 000 tonnes of tomatoes annually besides other fruits and vegetables. Unlike conventional greenhouses that use groundwater for irrigation, gas for heating and electricity for cooling, this Australian company's state-of-the-art solar technology provides power to the plant growing systems, and to heat and cool the greenhouses, as well as to feed into the desalination process.

TABLE 3
TECHNOLOGICAL ADVANCES ARE EXPECTED TO REDUCE THE COST OF DESALINATED WATER BY 20 PERCENT IN THE NEXT 5 YEARS AND BY UP TO 60 PERCENT IN THE NEXT 20 YEARS

Forecast of desalination costs for medium and large size projects

Parameter for Best-in Class Desalination Plants	In 2016	Within 5 Years	Within 20 Years
Cost of Water (USD/m^3)	0.8 – 1.2	0.6 – 1.0	0.3 – 0.5
Construction Cost (USD/MLD)	1.2 – 2.2	1.0 – 1.8	0.5 – 0.9
Electrical Energy Use (kWh/m^3)	3.5 – 4.0	2.8 – 3.2	2.1 – 2.4
Membrane Productivity (m^3/membrane)	28-47	35-55	95-120

SOURCE: International Water Association. Note: MLD = Million litres per day.

Renewable-energy irrigation pumps (in particular, solar) are emerging as an innovation to expand irrigation access while keeping its costs affordable and minimising its carbon footprint. Solar irrigation pumps provide daytime uninterrupted clean power, offering reliability and convenience to farmers. However, expansion of solar irrigation pumps has broad and deep economic and ecological impacts on the way regional groundwater irrigation regimes function.[16] In fact, access to uninterrupted free solar power for irrigation can accelerate groundwater use in agriculture, contributing further to depletion.[17] Harnessing the innovation of solar irrigation requires a nuanced understanding of the region's energy-groundwater nexus, the way it plays out in different geographies and institutional contexts of the region, and how the promotion of solar irrigation pumping can be best designed to address specific objectives in each context.

The solar revolution is very rapidly emerging as a key agricultural water innovation in the region, but needs to be accompanied by adequate groundwater governance. The Arab region is experiencing a boom in solar photovoltaic energy, with production increasing by 112 percent between 2008 and 2011.[18] Solar irrigation is also catching on, with experiences and studies from the Gulf countries,[19] Yemen,[20] Morocco[21] and Egypt[22] demonstrating its feasibility. In Egypt, pilots have been shown to be largely feasible and cost-effective, generating interest from water users and farmers, as well as a growing interest from national governments and international financial institutions.[23]

Given the region's water scarcity and the observed dangerous declines in groundwater, technology deployment policies need to be carefully designed to avoid contributing further to scarcity and groundwater depletion. In this regard, projects and programmes promoting solar irrigation through subsidies or other incentives need to be carefully designed, in particular, to avoid the potential negative impacts on the environment caused by groundwater over-abstraction and equity issues related to access to resources. There is no 'right' strategy to promote solar irrigation, and different models might be suitable for different contexts. Through decades of work in South Asia, IWMI has identified alternative models for promoting solar power amongst farmers,[24] as detailed in Appendix 2. Interestingly, the 'technological upgrade' through renewable energy-powered groundwater pumps can also offer new possibilities in terms of improving water governance mechanisms, as described in the following section.

INNOVATIONS FOR WATER GOVERNANCE

Innovations in sensing and monitoring platforms are unlocking a wealth of previously unobtainable water data at multiple scales to improve water governance and planning by authorities at several levels. Advanced sensing and monitoring platforms can be defined as all fixed and mobile physical, chemical and biological sensors for direct and indirect sensing of myriad environmental, natural resource and biological asset variables from fixed locations or in autonomous or semi-autonomous vehicles in land, machines, air, oceans and space.[25] Sensors can inform and guide a range of agricultural water decisions at multiple scales. At the farm level, drones equipped with hyperspectral, multispectral or thermal sensors help farmers detect more accurately and quickly where fields are dry and in need of irrigation.[26] Over larger spatial scales, remote sensing from satellites can help systematically monitor water productivity[27] in an objective and cost-effective way to identify and measure productivity gaps, and to help close these gaps (case study 3).

Building on these advances, water accounting tools are being developed to support water governance in the region. Water accounting (1) is an indicator framework to structure water resources-related information and the services generated from consumptive use in a river basin (or any other geographical area, such as a country); (2) increasingly promoted as an indispensable tool, particularly in water-strained areas; (3) informs water governance by analysing whether a given domain is sustainably using water within the limits of the hydrological system;[28] (4) identifies physical environmental factors that cause or help drive hydrological change; and (5) will quantify which parts of the hydrology of the domain need to change, if the domain is to transition from being unsustainable to sustainable. It provides information on the hydrological consequences of different supply and demand management scenarios that can support dialogue.

CASE STUDY 3

WAPOR: REMOTE SENSING TO MONITOR WATER PRODUCTIVITY

The Food and Agriculture Organization of the United Nations (FAO) portal to monitor Water Productivity through Open access of Remotely sensed derived data (WaPOR) provides access to 10 years of continued observations over Africa and the Near East. The portal provides open access to various spatial data layers related to land and water use for agricultural production, and allows for direct data queries, time series analyses, area statistics and data download of key variables to estimate water and land productivity gaps in irrigated and rain-fed agriculture. The key function is the portal's ability to produce maps showing how much biomass and yield are produced per cubic meter of water consumed, allowing decision-makers to track water productivity through time and space. The tool can also produce detailed assessments to monitor the functioning of a selected set of irrigation schemes, supporting modernisation plans as well as helping assure that improvements do in fact result in all water users receiving more reliable and cost-effective water services that are more adapted to increased climate variability.

Renewable energy-powered pumps can also lead to improved governance when deployed through models such as those providing farmers with energy buy-back options (see more details in Appendix 2). Experiments conducted in Indian villages provide some cause for optimism. The Solar Power as Remunerative Crop (SPaRC) approach provides farmers guaranteed buy-back of the surplus solar power they produce, provided they are connected to the electricity grid. This guarantee allows farmers to invest in solar-powered pumps, which reduce the use of carbon-intensive diesel pumps on farms, while at the same time providing an economic incentive to counteract excessive groundwater pumping.[29] Encouraging the sale of excess energy to the grid provides additional income to farmers, becoming a potentially important demand-management element for groundwater governance.

DISRUPTIVE TECHNOLOGIES TO INCREASE WATER PRODUCTIVITY AT MULTIPLE SCALES

- Innovations to improve water productivity span from updating water harvesting practices in rain-fed systems to digital extension services. Use of water harvesting as a supplemental water source in the region ranges from farm- to catchment-scale solutions. Arab governments have recognised the importance of water harvesting for agriculture. Jordan and Egypt, for instance, have identified the expansion of traditional water harvesting as an important component in addressing the hydrological challenges in the agriculture sector, especially in rain-fed systems.[30] Beyond traditional water harvesting, new approaches for water harvesting from air powered by natural sunlight could disrupt the water technology landscape in the coming decades.[31]

- On the technology front, innovations arise from the merging of digital technologies with agricultural water management practices. These technologies are being applied to make farming more precise, productive and profitable,[32] and tend to be implemented with the goal of increasing productivity per unit of land and water input. They can be a natural complement to other services offered through digital platforms (e.g. insurance, credit). Digital channels such as short message service (SMS), interactive voice response (IVR), low-cost video, phone apps and digitally delivered financial services are creating true interactivity directly with small-scale farmers in ways that were not possible just a few years ago, allowing farmers to activate their pumps with mobile phones or upload on-the-ground soil moisture conditions to complement satellite data.

- Compared to some of the other emerging innovations, digital innovations influence the entire agricultural supply chain and not just agricultural water. In fact, not only does digital agriculture contribute to increasing productivity, but it also provides a number of benefits: greater efficiency in the use of inputs can increase the value derived from farming a unit of land, reducing incentives to convert more land to agriculture (a key driver of greenhouse gas emissions on a global scale); the data generated can be used for analysis and sustainability planning at a landscape or system level; and digitisation enables new linkages with markets that can help improve value chain coordination and reduce post-harvest losses.[33]

CONTROLLED-ENVIRONMENT AGRICULTURE

Controlled-environment agricultural innovations generate opportunities for employment and enable the production of food with minimal land and water requirements. Controlled-environment agriculture is a term for water-smart agricultural technologies that comprises horticulture production applying hydroponic systems, hence growing vegetables with significantly reduced water usage (80–95 percent), minimal land area and less inputs compared to traditional farming.[34] Currently, hydroponics is mainly used to grow tomatoes, cucumbers, peppers, leafy greens, and a variety of specialty herbs and crops. Plants use equal amounts of water in hydroponics and conventional soil methods. However, a hydroponic system delivers water more efficiently to plant roots, so overall water use is significantly reduced. People that have limited or no access to land, and those who cannot use traditional farming methods such as refugees, can be provided with opportunities to produce climate- and water-smart nutritious food with hydroponics and aquaponics (combination of hydroponics and fish farming within a closed recirculating system) (case study 4).

CASE STUDY 4

AQUAPONICS IN GAZA[35]

In response to the conflict in Gaza and given the high number of food-insecure female-headed households in urban areas, FAO has been piloting and implementing several small-scale rooftop aquaponic units in partnership with European donors since 2010. The objective was to improve the availability of high-quality fresh vegetables for the rural and urban poor and protein in the form of fish, while encouraging the sustainable use of scarce resources. With little daily physical effort and the comfort of carrying out these activities in their own homes, all the beneficiaries increased their household food consumption as a result of the gardens. To date, this pilot project and its subsequent scaling up is one of a growing number of examples around the world where aquaponics is being successfully integrated into medium-scale emergency food security interventions. However, many attempts are ad hoc and opportunistic, in many cases leading to stand-alone, low-impact interventions. Given the urgency to engage with and support populations affected by conflict and violence, a priority for the region is to better assess the viability of hydroponic and aquaponic projects, and overcome challenges of cost and scalability while taking advantage of the technical support provided by local organisations, universities and international institutions.

FOSTERING INNOVATION IN PRACTICE

Over the past 30 years, countries have grappled with the question of how to get better at innovation. In recent decades, the policy framing around this challenge has witnessed a major shift from managing the scale, quality and priorities of investments in science and technology (the creation of ideas and knowledge) to a much broader perspective that focuses on the necessary conditions needed to make use of these ideas.[36] It is in this context that the idea of an innovation system has emerged. An innovation system can be defined as "*a system that brings together actors from the public, private and civil sector to bring new products, processes and organisational forms into economic and social use, together with institutions and policies that affect actors' interaction and how knowledge is used and exchanged.*"[37]

Innovation is a process rather than a technological artefact per se. Innovation then requires interaction amongst key protagonists that mediates the ways in which ideas are mobilised, combined, adapted and put into use to create new value. Partnerships, alliances and various forms of multi-stakeholder processes facilitate this interaction. Innovation is a systemic process in the sense that the creation of novelty (innovation) does not occur independently of the wider systems of players, practices and policies in which it is located and embedded.

Unless gender issues are considered when introducing innovations, interventions are not going to yield the expected benefits. Global evidence suggests that taking into account the gendered nature of farming systems when introducing agricultural water innovations yields greater benefits in terms of agricultural outcomes (for instance, productivity) while contributing to narrow the 'gender gap.[38,39,40] Considering gender as a key component to foster innovation in practice improves the chances of uptake, and results in solutions that meet the needs and priorities of both men and women. It also expands the nature of the benefits, for example, by not only increasing income but also improving health through improved domestic water supply, enhanced nutrition, more money spent on health care, and by empowering women and girls through more time available for education. Finally, from a strictly economic point of view, gender-sensitive innovation results in higher gains in household income and overall productivity, since it fulfills the productive potential of both women and men. Because gender relations and issues vary widely, there can be no blanket strategy for gender-sensitive introduction of agricultural water management innovations, and strategies such as gender mapping should be adopted to inform the design and monitoring of interventions.[41]

To mainstream innovations, the public sector can take on a more supportive role by investing in research and forging new partnerships. Regional experiences show how the public sector can take on a supportive role by investing in agricultural research and development and by promoting partnerships, while creating an enabling environment for private sector research and the development of firms providing digital technologies to farmers. In Tunisia, the Union Tunisienne de l'Agriculture et de la Pêche (Tunisian Union of Agriculture and Fisheries) established a formal partnership with Tunisie Telecom– the country's largest telecom operator – to support the development and the delivery of digital agricultural services.[42] In Lebanon, the Lebanese Agricultural Research Institute (LARI) has developed an early warning system to share hydro-meteorological information with farmers through mobile apps.[43]

Extension systems play a key role in innovation and in promoting effective adoption of new technologies. Extension and capacity development services (public and private). need to be able to interpret the needs of farmers and find out what innovative solutions are available to address these needs. For instance, farmers rarely deal with raw data, so unless extension agents act as data intermediaries, the potential for digital and data-driven innovations for smallholders will not be harnessed.[44] Where information constraints are a major bottleneck in the uptake of modern inputs and production techniques, as it is often the case for water-saving agronomic practices, public funding (although not necessarily provision) of extension can be a cost-effective way of fostering innovation.[45]

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SECTION 5

THE EVOLVING POLICY LANDSCAPE

5. THE EVOLVING POLICY LANDSCAPE

HIGHLIGHTS

- Despite good progress in adding value to the agriculture sector and, in particular, to some of the region's irrigated areas, there is still substantial room for improvement through a more consistent set of policies that value water, add value to the agriculture sector, and simultaneously create the conditions for achieving social and environmental outcomes, including food security and poverty reduction.
- High food import dependency through virtual water trade does not necessarily imply low food security – if appropriate social protection and trade policies are in place – and in fact is a significant instrument to cope with water scarcity.
- While there have been attempts at modernisation and some successful examples, the region still lacks flexible and modern systems that can support the transition of its agriculture sector towards a resource-efficient sector, which would include policies that recognise the value of irrigation water to alternative uses and price it accordingly.
- Progress can be made through a move towards agricultural self-reliance and away from food self-sufficiency. Modernisation and water-saving policies should be implemented as part of a policy mix that aims to leverage comparative advantages and support the export growth of higher value-added products. Unlike food self-sufficiency, agricultural self-reliance policies target a country's agricultural trade balance in value terms rather than aiming for self-sufficiency in key commodities.
- Despite the recognition of the importance of gender equity in water management as a catalyst for change across the United Nations Sustainable Development Goals (SDGs), policies to achieve gender equality are still lacking.
- Steps have been undertaken at various paces in different countries to strengthen water management institutions, apply principles of decentralisation and participation, and establish frameworks for groundwater governance, though these policies have proved difficult to implement in practice.
- Public-private Partnerships (PPPs) in irrigation are still evolving, and active public sector collaboration is needed to help projects succeed. There are a few examples of PPPs in irrigation in the Arab region, and where they do exist, results are mixed and success is limited.

Over the last decades, some parts of the Arab region have seen progress in adapting agricultural water policies to the evolving needs of the region. Nonetheless, new themes and priorities are deserving attention in the continuous process of policy reform, especially in light of the recently established SDGs. The SDGs emphasise the importance of policy coherence, which in the context of agricultural water policy means understanding its linkages with broader food security, rural development, trade, health, gender and education policies. Rural development and food security policies often have the potential to influence the success and effectiveness of agricultural water policies. Many of the incentives and distortions at the core of agricultural water policy in the Arab region have originated from countries' general policies on trade, taxes and subsidies, investment and private sector participation, food security and poverty reduction, and not directly from policies that specifically target agricultural water. As discussed in this section, failure to properly account for these policy interlinkages has sometimes led to policies which have not achieved the desired objectives. Prominent examples include the use of domestic policies to affect agricultural trade, which have incentivised suboptimal use of limited resources and unhealthy diets in some countries.

FOOD SECURITY AND SOCIAL PROTECTION POLICY

Food self-sufficiency remains a top policy priority in the region. However, food self-sufficiency through market protection has largely failed on a range of levels and has been very costly for governments. Policies prioritising food self-sufficiency and protection of staple crops seem to have also exacerbated the labor productivity gap between agriculture and other sectors, and have been costly not only in terms of the government's budget but also in terms of efficiency, productivity growth and income growth in rural areas.[1]

Food subsidies can play a key role as social protection measures in the political transition; however, they also have many well-recognised disadvantages and have been shown not to deliver expected results. For many decades, Arab governments have relied on food subsidies as key instruments to protect the poor and redistribute wealth. Nonetheless, subsidies have also been reported not to deliver the expected benefits for the most vulnerable. For instance, the International Monetary Fund (IMF) reports that bread subsidies are not performing as expected: in Egypt, the top 40 percent richest households in the income distribution receive an estimated 50 percent of the *Baladi* bread benefits and about one-third of the bread subsidies in Jordan and Lebanon.[2]

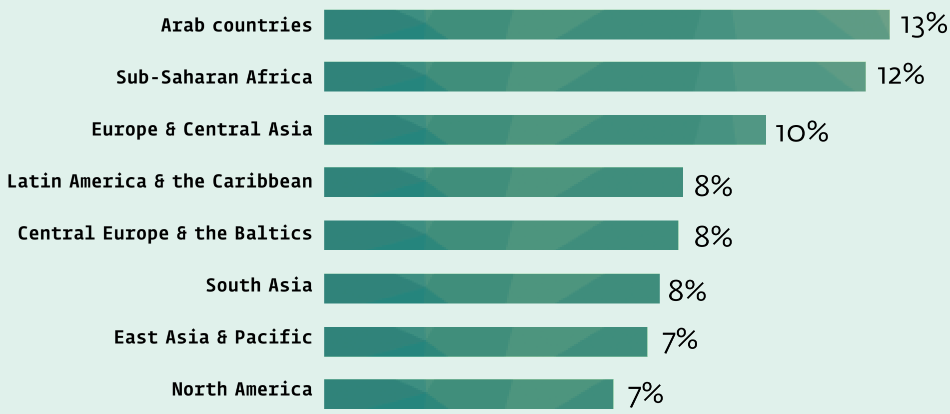
Achieving food self-sufficiency is becoming increasingly difficult. The region is expected to continue to face high and growing levels of food – in particular cereal – import dependency[3] because of its particular agro-climatic situation and scarce land and water resources, coupled with the effects of rapid population growth. The food import bill of the Arab world is the largest in the world, as it accounts for 13.6 percent of the region's total merchandise imports – comparable to, but still higher than, sub-Saharan Africa's 12 percent and much higher than every other world region.[4] (see Figure 11). Most Arab countries have more than a 40 percent rate of cereal import dependency; Egypt, in particular, is the world's largest wheat importer, while Sudan is the least dependent on cereal imports, importing only 26 percent of its needs.[5] The region currently accounts for 20 percent of wheat imports worldwide, with Egypt and Algeria alone accounting for 10 percent. In a context of increased food import dependency (in quantity terms)[6] and with technologies available at present, it is difficult to expect the region to be able to keep up in terms of food self-sufficiency, especially when sustainable resource management is taken into account. Focusing on broad economic development (including sectors beyond agriculture) and maximising value addition in agriculture rather than reducing food trade deficit in quantity terms and by sub-sector is, therefore, increasingly a sensible strategy. In this context, trade in agricultural products can improve the returns to water, directly influencing water productivity, and promote market-based agriculture that can contribute to create wealth and jobs.[7]

Countries are increasingly tapping into virtual water trade to achieve food security, and this means there are gains to be made through investments in improved food import logistics and, more generally, through improvements in import value chain efficiency. Reliance on virtual water trade does not necessarily imply low food security, if appropriate policies are in place, and in fact is a significant instrument to cope with water scarcity.[8] Arab countries, including Morocco, Tunisia and Jordan, are already following this 'virtual water' strategy: promoting high-value, export-oriented irrigated production that can generate the foreign exchange to import low-value crops and can contribute to increased available income and consumption. Understanding the difficulties in achieving food self-sufficiency results

FIGURE 11

THE ARAB REGION IS THE TOP NET FOOD IMPORTER IN THE WORLD

Food imports (share of merchandise imports), 2016



SOURCE: Authors with data from World Bank. Note: Food comprises the commodities in Standard International Trade Classification (SITC) sections 0 (food and live animals), 1 (beverages and tobacco), and 4 (animal and vegetable oils and fats), and SITC division 22 (oil seeds, oil nuts and oil kernels).

in giving a renewed attention to import food chain logistics, in order to improve efficiency and consequently increase food security in the countries. Policy action in this direction includes investments in logistics (including infrastructure) by the public sector, but also through creating conditions for private sector investment, simplifying regulatory procedures while safeguarding food safety, promoting competition at several levels of value chains and diversifying origins of imports. In Egypt's wheat sector, for example, an FAO-EBRD 2015 study estimates around USD 70 million in savings potential through a shift towards wheat import infrastructure owned and managed primarily by the private sector, and by streamlining import rules and procedures (such as those related to government tenders for wheat). The study also estimates that without investments, food import costs will continue to increase as a result of projected consumption and trade growth (see case study 5 below).

Case study 5

EGYPT: IMPROVING FOOD SECURITY THROUGH MORE EFFICIENT IMPORT LOGISTICS

Egypt is the largest wheat importer globally, with its wheat imports over the last 5 years (2013–2017) averaging around USD 2.5 billion per year, or about 8 percent of world wheat trade and about 1 percent of the country's gross domestic product (GDP). The government is heavily involved in the wheat sector, both as the only major purchaser of domestic wheat (at a subsidised price) and as a major importer of wheat with its General Authority for Supply Commodities (GASC) responsible for around half of the country's wheat imports. The overall yearly cost of the government's expenditure in the wheat value chain through its input (fertiliser), output (high domestic procurement price) and consumer subsidies (under the Baladi bread programme) is estimated at over USD 2 billion.

Nevertheless, there is scope for reducing the cost of wheat imports for the government, if a number of inefficiencies related to import logistics are addressed. A 2015 Food and Agriculture Organization of the United Nations (FAO)-European Bank for Reconstruction and Development (EBRD) review of the Egyptian wheat sector estimated that potential savings from efficiency improvements could be as high as USD 70 million per year.[9] The study suggests that a shift towards wheat import infrastructure owned and managed primarily by the private sector could lead to considerable savings. For example, a switch to modern, privately owned silos could result in potential savings of over USD 43 million per year, ensuring a quick return on investment and lower costs to the Egyptian budget. In addition, simply streamlining import rules and procedures (such as those related to government tenders for wheat) could also result in significant savings.

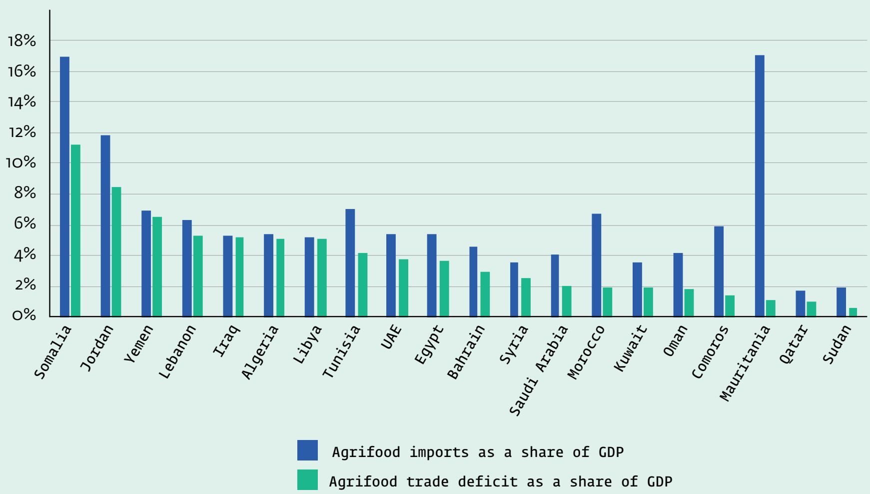
While EBRD has already started partnering with the private sector by committing financing of up to USD 100 million to local and international companies involved in the Egyptian grain sector, further investments, both from public and private sector players, will be needed to guarantee the country's food security in the near future. For instance, berth and port storage capacity at Egyptian ports needs to be increased to reduce the average waiting times of 17–18 days that are reported by some grain suppliers in the country as compared with 1–3 days in Europe. Without investment, the economic costs of imports will only increase in view of the projected consumption and trade growth.

While the region will always rely on imports for commodities such as wheat, maize or sugar, some countries have the potential to reduce their food trade deficits significantly in value terms in the near future. Morocco has managed to do so in the last 10 years, by increasing its exports of high value-added agri-food commodities such as fresh fruit and vegetables (case study 6). The country's agri-food trade deficit plummeted from an average of USD 1.3 billion in the period 2007–2009 to an average of USD 413 million in the period 2015–2017. Thus, while Morocco's agri-food import bill has increased and currently stands at almost 7 percent of the country's GDP, its agri-food trade deficit is just under 2 percent of GDP. This is a significant contribution to food security in a country which, in some years, relies on imports to meet over half of its domestic cereal needs. As shown in Figure 12, however, this development is far from being the rule in the region. With the design and implementation of adequate agricultural policies and more efficient logistics, however, a number of countries (such as Jordan, Tunisia or Egypt) may be in a good position to maximise their respective comparative advantages in higher value-added crops, and take advantage of the proximity to developed markets (such as the European Union and Gulf countries), to optimise water use and improve their food security situation.

FIGURE 12

SOME ARAB COUNTRIES HAVE POTENTIAL TO CONSIDERABLY REDUCE THEIR AGRI-FOOD TRADE DEFICITS

Agri-food imports and trade deficits (share of GDP), 2016



SOURCE: Authors using FAOSTAT 2016.

Case study 6

INCREASING AGRICULTURAL SELF-RELIANCE - GENERATING VALUE IN HORTICULTURE IN MOROCCO

Morocco's agri-food trade bill is highly dependent on the country's import needs in cereals (in particular, wheat) in a given year. The extreme variability of domestic cereal production (ranging from 2.5 to 11.5 million tonnes per year between 2007 and 2017), mostly due to differences in weather conditions from year to year, means that cereal imports over the last 10 years have oscillated between USD 1.1 and USD 2.3 billion, driving the country's trade deficit up considerably in years with low cereal productivity (Figure 13).

However, by increasing its exports of high value-added agricultural commodities such as fruit and vegetables, Morocco has managed to considerably reduce its agri-food trade deficit in recent years. In just 10 years, the country managed to double its horticultural exports, reaching a value of over USD 2 billion in 2017, which is equivalent to its cost of cereal imports in the worst years (i.e. with the lowest domestic cereal production, such as in 2012).

In particular, tomato exports almost tripled from USD 230 million in 2007 to USD 580 million in 2017, and currently represent over 11 percent of Morocco's total agri-food exports. Contrastingly, this significant contribution to the Moroccan economy is generated in greenhouses occupying a mere 0.02 percent (or around 7 300 ha) of its total agricultural area. Comparing the net profitability of cereal production with that of greenhouse horticulture requires taking into account significant differences in capital intensity: cereals are rain-fed and grown in the open air while the investment required to set up a greenhouse with the associated irrigation equipment is significantly higher per hectare. Nevertheless, it is estimated that at about USD 310 million, the gross profitability of greenhouse tomato production in Morocco in 2017 was much higher than that of wheat production and occupying a much larger land area.

FIGURE 13

FRUIT AND VEGETABLE EXPORTS HAVE ALLOWED MOROCCO TO DRASTICALLY IMPROVE ITS AGRI-FOOD TRADE BALANCE

Value of trade and agri-food trade deficit (in USD thousands), 2007–2017

SOURCE: Authors

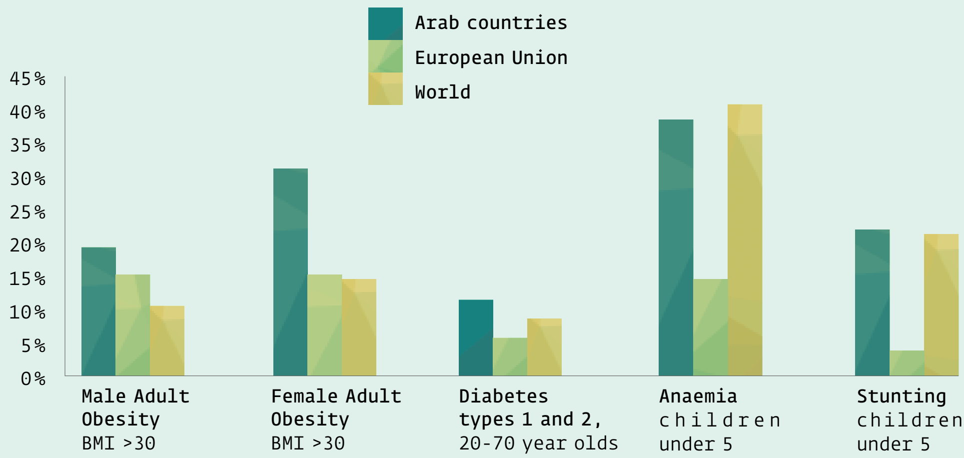
Nutrition is taking centre stage in the food security agenda, and it is set to become a priority theme in the future. The region faces an important and complex nutrition challenge. As shown in Figure 14, the region exhibits a high prevalence of obesity (especially female obesity) and diabetes as well as anaemia and stunting in children under the age of five, not only in comparison to the European Union but also to world averages.

In particular, poor dietary diversity related to the high consumption of high-calorie foods such as sugar and vegetable oil poses significant challenges for food security. [10] On average, around half of all calories consumed across the region originate from cereals (Figure 15), with wheat accounting for over two-thirds of these. In a number of countries, the combined consumption of cereals, sugar, vegetable oil and animal fat accounts for over three-quarters of per capita calorie intake. These dietary practices are in contrast to WHO and FAO recommendations for a healthy diet, which advise limiting both sugar and saturated fat consumption to a maximum of 10 percent of daily

FIGURE 14

THE REGION FACES A NUMBER OF NUTRITION CHALLENGES

Prevalence of obesity, diabetes, anaemia and stunting (percentage of population group), latest year for which data were available



SOURCE: World Health Organization (WHO) for obesity in the world and Arab countries (2017), diabetes (2017), anaemia (latest available year between 2007 and 2017) and stunting (latest available year between 2007 and 2017), and 2014 Eurostat data for obesity in the European Union. As data on the prevalence of anaemia and stunting are not available for all European Union and Arab countries, averages were calculated based on prevalence in countries for which data were available.

calorie intake (or down to 5 percent for sugar for increased health benefits),[11] reducing refined grain consumption to the benefit of whole grains, which should ideally represent half of cereal consumption[12] and encourage the consumption of fruit, vegetables and legumes.[13]

A 2016 study[14] has shown that the prevalence of obesity is positively associated with wheat availability, while the availability of maize and mixed cereals has not demonstrated independent associations with the prevalence of obesity.[15] These poor dietary practices partly explain the alarming levels of prevalence of diabetes in certain countries such as Saudi Arabia (18 percent) or Egypt (17 percent), which also represent a significant burden on national healthcare systems. A 2016 study estimated the financial burden of diabetes mellitus types 1 and 2 in Egypt (in terms of direct and indirect costs incurred by both government and private sectors) at USD 3.5 billion, or over 1 percent of the country's GDP.

FIGURE 15

CEREALS, SUGAR, OILS AND FATS ACCOUNT FOR A HIGHER SHARE OF ENERGY INTAKE IN THE REGION THAN THE GLOBAL AVERAGE

Origin of calorie intake in Arab countries and the world (in percentage of total calorie intake) in 2013

SOURCE: Authors using FAOSTAT 2013.

This situation partly arose as a result of policy interventions in the region aimed at maintaining social cohesion through low prices of poor diet-quality products (mainly bread, vegetable oils and sugar). Research[16] suggests that the food subsidy programme implemented in Egypt following World War II resulted in price reductions for energy-dense, nutrient-poor food items such as bread, sugar and oil in real and in relative terms as compared to healthier items such as fruits and vegetables. In turn, such a high differential in energy costs leads households to choose high energy but poor diet-quality foods. Other policy interventions in the region aimed at maintaining social cohesion through low prices of poor diet-quality food products may have similar effects. This is the case of trade policies, subsidies and other distortionary interventions. Tackling nutritional issues in food security in the region will, therefore, require a more nutrition-sensitive set of policies, that is, policies that take into consideration possible negative consequences of the distortions introduced in the final household food consumption mix.

Addressing the nutrition challenge will thus require a cross-sectoral approach that includes education, health systems and the elaboration of social protection policies, which encourage a change in prevailing dietary practices while targeting those most in need. In 2013, Egypt took a significant step in this direction by introducing the so-called "smart card" under the *Baladi* Bread Programme. Nevertheless, replacing the in-kind subsidies that exist in many of the region's countries with cash transfers might be a better strategy for ensuring food security and positive nutritional outcomes.

As countries' food security policies shift to give priority to demand factors such as income, health and nutrition, so do incentives for agricultural water management and use. A focus towards production of higher value-added crops is likely to bring about an increase in the productivity of water use, at the same time generating more profit opportunities for farmers and the private sector. This push towards higher value-added irrigated agriculture could also bring about a renewed interest in water management in rain-fed agriculture, as a way of maintaining a level of internal cereal production. In addition, the production of high value-added horticultural crops, which generate more value per unit of the region's scarce water resources, could also be seen as a way of improving the region's food security by generating revenue that could mitigate the risks of an increasing import bill for commodities such as cereals or sugar.

AGRICULTURE AND RURAL DEVELOPMENT POLICY

Over the last 15 years, there has been some progress towards removing distortions (reforming agricultural policies to reduce their interference with production); however, the region's agri-food sector is still a long way from realising its potential in terms of value addition and employment creation. Protectionist policies in international trade and domestic markets are a major aspect of agricultural policy. For decades, governments in the Arab world intervened in the commercialisation of cereals, vegetables, oil and sugar, purchasing and financing substantial amounts of these commodities and adopting trade measures (tariff/non-tariff barriers). These were essentially social protection measures aimed at maintaining political stability and food security; however, they had significant unintended consequences on resource depletion and nutritional outcomes. Over the last 15 years, broad agriculture sector and specific sub-sector liberalisation reforms, including through new trade policy strategies, were designed to facilitate agricultural growth and competitiveness. Despite trade liberalisation and significant reduction of tariff barriers, protection in most Arab countries is still high, largely because of non-tariff barriers (e.g. quotas, import licensing systems, sanitary regulations).[17]

Agricultural policy focused on developing internal and export markets has been shown to drive investment and productivity growth in the agricultural water sector. Well-functioning, profitable markets promote irrigation modernisation and improve water productivity. Reducing protections for staple crops should increase the contribution in total output of crops for which the region has a comparative advantage – fruits, vegetables and oil crops – and contribute to higher water-use efficiency.[18] In Egypt, Jordan and Morocco, and outside the region in Turkey, market development has promoted more efficient and less water-intensive crop management practices and higher-value cropping patterns – fruits, vegetables, flowers. In Morocco, the *Plan Maroc Vert* provides a good example of this strategic focus: the plan has targeted the development of high-value and high-performing agriculture while simultaneously combating rural poverty by supporting small farmers in marginal areas.

Attempts at reforming subsidies have been central to agricultural and rural development policy, yet farmer incentives are still distorted, leading to negative consequences in terms of agricultural value addition, productivity and environmental protection. Agricultural production under irrigation has high energy requirements, with most irrigated areas equipped with a pumping system. To lower the costs of production, Arab governments subsidised energy, covering petroleum products (diesel) and electricity. These subsidies made it cheaper to pump groundwater, thus removing incentives for efficient water use and favouring water depletion. Energy supplies for tube wells were indirectly subsidised, for instance, in Morocco (butane gas), and Algeria and Tunisia (electricity), where they contributed to the development of a rural groundwater economy.[19] Arab countries with lower than average diesel prices are characterised by higher water depletion than those that have increased diesel prices.[20] Reducing energy subsidies, thus raising the effective price of pumping, can reduce the incentive for irrigating. It can also have an impact on farmers' planting decisions and agricultural policies, as countries and farmers might switch out of low-value, water-intensive crops, promoting high-value irrigated agriculture or relying on imports instead.[21] While the region has recently experienced a wave of energy subsidy reforms, success has been mixed, and subsidies are still pervasive and likely to continue to create distortions in agricultural production systems.[22]

- **The urgent need to adapt to climate change is becoming a key theme for agricultural and rural development policy.** The Arab region is already experiencing some of the impacts of climate change, which are expected to worsen in the future.[23,24] In this context, Arab countries are endeavouring to promote action on climate change and hosted three of the 24 Conference of the Parties (COP) held so far. Agricultural and rural development policy is slowly integrating adaptation as a key priority area, and promising policies and approaches are being adopted with a view to better integrate agricultural development and climate-responsiveness. For instance, climate-smart agriculture (CSA) is an integrated approach to managing landscapes – such as cropland, livestock, forests and fisheries – that aims to achieve increased and sustainable productivity, enhanced resilience and reduced emissions. In the region, CSA approaches are being piloted in Egypt, Jordan, Morocco and Tunisia.[25] Conservation agriculture (CA) – also known as zero till and no till – can be well suited to farming the region's drylands, especially under rain-fed conditions, and is also being adopted as an adaptation and mitigation measure.[26]

- **Land tenure issues subsist and remain an important constraint to further development, including domestic and foreign private investment.** Land fragmentation is common in North Africa,[27] mostly as a result of sub-divisions of land for inheritance as well as poorly formalised land rights and persistent land tenure insecurity. Land fragmentation affects the extent to which various agronomic practices and technologies are adopted, and the system-scale effectiveness of these practices and technologies in reducing overall water use. Land fragmentation can also act as a significant productivity constraint – more than water scarcity in some areas – though its effects on farm productivity also depend on wider agrarian political economy questions.[28] The effects of land fragmentation on agricultural water in the Arab region are not well understood, though global evidence suggests that it can act as an impediment to improvements in agricultural water-use efficiency.[29] Some attempts at tackling land tenure issues have been made in the region to foster domestic and foreign direct investment in agriculture. In Morocco, as part of the *Plan Moroc Vert*, land was tendered under concessions which resulted in important investments, namely in fruit trees and an expansion in modern olive production systems.

While agricultural policy has focused on employment, rural development and food security objectives, it has not sufficiently addressed the potential negative impacts of agriculture on natural resources, undermining the sector's sustainability. Agriculture has an important environmental footprint and intensification in some instances has not always been accompanied by governance and regulatory advances to ensure integrated approaches to water conservation, allocation and planning. The effects on the environment of impounding water, diverting watercourses, and reducing volumes in the water cycle through consumptive use in irrigated agriculture were one of the factors in the slowdown in irrigation development and expansion.[30] Today, there is an understanding that rural development policy cannot be neutral to the environment and that an integrated approach must be adopted to account for the rights of all users – including ecosystems – to access water of acceptable quantity and quality. Policy instruments used to assess and manage the water-related trade-offs arising from rural development, agricultural water management and ecosystems include Integrated Water Resources Management (IWRM), implementation of which is key to the achievement of SDG 6 (clean water and sanitation for all). In Jordan, for instance, the National Water Strategy stresses the need to adopt an integrated approach in the evaluation and appraisal of all water investments.[31]

AGRICULTURAL WATER POLICY

Expansion of large-scale public irrigation was the main theme of agricultural water policy until the 1990s. From the 1990s onwards, it became clear that policies focused only on infrastructure were not achieving the increases in productivity that were expected, and that hydraulic infrastructure started to deteriorate rapidly due to a lack of adequate maintenance and efficient operation. At the same time, international financial institutions promoted a new wave of water sector reforms driven by the emergence of new themes in agricultural water policy. First, participatory irrigation management and decentralisation, which emerged, in part, in response to concerns about the performance of government agencies in operating and maintaining these large schemes. Second, financial sustainability and cost recovery, linked to the desire from national governments to lessen the burden of significant recurring operation and maintenance (O&M) costs of large irrigation and water investments on public finances.

Participatory irrigation management, decentralisation and irrigation management transfer remain major themes of irrigation policy, though their adoption has had mixed results. The focus on participatory management has translated into policies introducing internal management systems conducive to greater efficiency and financial autonomy, including asset management planning. It has also led to the increased participation of farmers in the process of water policy formulation, assessment and appraisal. The available options for decentralisation range from the management of irrigation schemes by a reformed and financially autonomous government agency (for instance, the *Office Regional de Mise en Valeur Agricole* (ORMVA) in Morocco) to the transfer of certain functions, such as canal water distribution or levying of maintenance fees, from national irrigation authorities to water user associations (WUAs) or other farmers' groups or local bodies. Experience with the implementation of WUAs in the Arab world has been characterised by a trial-and-error process and has had varied success,[32] as discussed in section 3.

Modernisation and water saving have become central themes of agricultural water policy, yet their impacts on water availability and crop yields could benefit from additional assessments. Modernisation is interpreted here as a push for institutional reforms that contributes to improved service delivery to irrigation users, and to an overall reduction of government intervention and spending, and more efficient and sustainable use of land and water resources. For instance, Egypt's *Sustainable Agricultural Development Strategy towards 2030* mentions three key aspects related to modernisation policies: (i) a gradual improvement of the efficiency of irrigation systems, (ii) sustainable expansion in reclaimed areas by using the water saved through more efficient irrigation, and (iii) maximising returns to rain-fed agriculture through improved water harvesting techniques.[33] Water-saving policies are often included within broader modernisation efforts, but they have also been implemented separately to improve the performance of existing schemes without necessarily being accompanied by the institutional changes typically promoted by modernisation. In Morocco, for instance, the national programme for irrigation water saving was launched in 2002 – and then consolidated through the *Plan Maroc Vert* – to increase irrigation efficiency by replacing much of the flood and sprinkler irrigation systems with drip irrigation.[34] While some experiences with on-farm modernisation in Egypt show that, indeed, it leads to improvements in agricultural outputs, lower irrigation operating costs and improved equity,[35] other assessments are more cautious, suggesting that on-farm modernisation in the country has not led to substantial improvements in terms of crop yields, water productivity and irrigation water service delivery.[36] Far from undermining efforts towards modernisation, these preliminary assessments demonstrate the importance of careful and context-specific interventions to fully realise the benefits of these types of investments.

- **Operation and maintenance, as well as implementation of modernisation and water-saving policies, still rely to a large extent on public financing.** O&M funds mainly come from governments, though progress has been made in improving cost recovery through irrigation service fees. Morocco and Tunisia have introduced volumetric pricing for public irrigation, by charging farmers for the amount of water they use rather than being based on the area (hectares) under cultivation.[37] Subsidies also play a big part in promoting the adoption of water-efficient technologies such as drip irrigation. For instance, the *Plan Maroc Vert* aims to convert 50 percent of the Moroccan irrigated agricultural land area by 2020 to drip irrigation through a national subsidy programme.[38] The plan raised the level of subsidies to 80 percent for areas over 5 hectares and 100 percent for farms below 5 hectares.[39]

- **Public-private partnerships are becoming an area of focus of agricultural water policy.** Public-private partnerships[40] (PPPs) involving private management and possibly financing are being tested as a policy option for irrigation service delivery and O&M. However, bringing private participation into this sector is complicated, and it is necessary to develop a better understanding of whether and how the private sector can deliver a better service.[41] PPPs in irrigation are still evolving, and active public sector collaboration is needed to help projects succeed. There are a few examples of PPPs in irrigation in the

Arab region, and where they do exist, results are mixed and success is limited (see Appendix 3). Experiences from around the world suggest that PPPs work better with new developments rather than with existing schemes, and that financial, legal and political aspects – including O&M costs, performance monitoring indicators and public opinion – need to be carefully considered in the planning stages for PPPs to be viable.[42] In Peru, for instance, PPPs are being used to develop irrigation in the coastal desert area of Olmos; however, the project has generated some controversy because most of the agricultural land has been sold through auctions to large commercial farms and international agribusinesses.[43] Given the complexity and nascent track record of PPPs in irrigation, concessional financing in one form or another has been the primary modus operandi to enable private sector involvement.[44] This fact underlines the recognition that – in most cases – a measure of public support is needed to make the schemes sustainable. This is because, typically, the required level of investment is far greater than what can reasonably be recovered through water user fees alone.

Despite the recognition of the importance of gender equality in water management as a catalyst for change across the SDGs,[45] policies to achieve gender equality are still lacking.[46] Policy and decision-making regarding land and water management have traditionally been the domain of men. As a result, policies and programmes have not typically considered women's unique knowledge, needs or unequal ownership rights. This is increasingly changing as more emphasis is placed on streamlining gender and ensuring adequate representation of women in water user associations. Nonetheless, women continue to face severe constraints in decentralised agricultural water management institutions, where they are often selected to represent domestic water uses and not agricultural uses, and where their role is typically downplayed.[47] Women farmers need to be actively involved in the planning and implementation of land and water management programmes, and must be able to participate in developing the policies that affect their access to and control of these resources.[48]

While climate adaptation is high on the policy agenda, agricultural water investments to follow-up on policy commitments have been lagging. Although there is increasing attention paid to rain-fed agriculture, as demonstrated by Egypt's interest to expand this type of cultivation in the north coast, policies aimed at enhancing its productivity are still lagging.[49] Productivity of rain-fed agriculture is still below its potential, with rain-fed wheat yields, for instance, being two or three times lower than yields obtained in experimental fields. Research on rain-fed agriculture shows promising returns to investment. For instance, research on water harvesting through micro-catchment management was shown to raise water productivity of open field crops in Jordan, Syria and parts of North Africa.[50] Outside the Arab region, in eastern Africa and South Asia for instance, investments in water harvesting have improved the stability of crop yields and raised productivity.[51]

Use of renewable energy to generate supplies and power irrigation systems is attracting policy-makers' attention; however, policy advances are lagging behind the technology. Solar-powered irrigation is being hailed as a potential approach to expand irrigation in previously uncultivated areas and to fight rural poverty.[52] Numerous pilots have appeared through Arab countries; however, there has not been a strong focus or debate on the type of models to regulate the use of this technology and avoid unintended negative consequences, or an evaluation of its effects on poverty and gender equity. In addition, weak groundwater governance regimes in some countries[53] mean that uncontrolled adoption of this technology could further contribute to groundwater depletion, as detailed in section 4.

Although progress has been made, the region still lags behind in establishing legal instruments to regulate agricultural water use – in particular groundwater abstraction – in the context of modernisation. Given the increasing competition over water resources, creating a reliable legal permitting system for agricultural water allocation becomes essential.[54] Having a robust and stable legal environment will also facilitate testing and uptake of innovative financing instruments, and help create a framework for PPPs. In Jordan, for instance, the Organisation for Economic Co-operation and Development (OECD) has found that regulatory gaps, in particular, in relation to tariff setting and monitoring of water service performance, act as barriers to effective agricultural water policy and as sources of risk for the private sector. [55]

When regulations do exist, enforcement and application of these principles remain a significant challenge. Countries in the region have put in place institutional and organisational mechanisms to control and reduce groundwater over-abstraction. In Jordan, despite comprehensive regulatory frameworks aimed at limiting abstractions, issuing permits for wells and establishing bans on drilling, wells are still being drilled without permits, control or monitoring from the state.[56] This mismatch between regulation and enforcement highlights the existing gap between policy and practice in the region.

There is a growing interest in tools to recognise the value of water and promote its flexible allocation; however, no Arab government has adopted scarcity or opportunity costs in irrigation water pricing.[57] Most Arab countries have revised or are in the process of revising the basis for charging farmers for irrigation water, and irrigation service fees have been increased everywhere. However, best international practice suggests that the price of water should reflect not only its production cost (for instance, capital investment, and operation and maintenance costs) but also its value in alternative uses. In the Arab region, this is observed to some extent in places where inter-sectoral water markets exist (e.g. the rural-to-urban water sales in Jordan and Yemen).[58] Jordan's active involvement in the United Nations High-Level Panel on Water suggests that regional leaders are increasingly interested in exploring and promoting innovative solutions for flexible water allocation within and between sectors, in ways that are politically feasible, culturally and socially acceptable, environmentally sustainable and economically efficient.[59]

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SECTION 6

TOWARDS A NEW GENERATION OF AGRICULTURAL WATER INVESTMENTS AND POLICIES IN THE ARAB REGION

6. TOWARDS A NEW GENERATION OF AGRICULTURAL WATER INVESTMENTS AND POLICIES IN THE ARAB REGION

HIGHLIGHTS

- A new generation of agricultural water policies and investments in the Arab region starts by revisiting the policy interface between water, agriculture and social protection, and requires an in-depth revision of individual policy instruments at country level to create the right incentives for realising the region's potential.
- To maximise the value of the agriculture sector and revitalise the rural economy, policies need to focus on (1) reducing protection of crops for which the region has no comparative advantage; and (2) increasing the productivity of competitive staple crops and crops with export potential, by stimulating investments in technologies and institutions to more efficiently use water for irrigation.
- Investments in modernisation and more flexible irrigation systems are needed. Technological advances for improved quality of water delivery can support farmers in transitioning towards commercial, modern farming systems.
- Adoption of digital technologies can also support the efficiency of critical water management institutions at several levels (e.g. basin, scheme, water user association [WUA]) and result in more sustainable use of resources.
- Measurement underpins valuation, so the region needs to accelerate investments to harness the digital revolution to close the data gap, in particular, to enhance its water measurement, accounting and modelling capabilities.
- Food security policies targeting self-sufficiency of staple crops, as well as social protection measures which create major price distortions in agri-food markets, should progressively give way to efficient social safety nets which contribute to reducing poverty and vulnerability, addressing key risks, and supporting improved nutritional outcomes and health.
- There is a need to collect data to better understand policies and associated investments in agricultural water and, in particular, what is being financed (subsidies, irrigation expansion, modernisation, research and development) and what type of investments are more productive.

THE URGENCY FOR ACTION ON A NEW GENERATION OF POLICIES AND INVESTMENTS IN THE ARAB REGION

- The analysis in this report suggests that the collision of drivers, in particular, climate change, with the disruptions caused by emerging innovations, offers the opportunity for a new generation of investments in agricultural water. The negative impacts of climate change on water, and the spillover effects on economies and societies, make climate change adaptation an overarching priority for all agricultural water policies and investments in the region. A climate-resilient agricultural water sector is an asset for the region, hence policy-makers need to focus on formulating and implementing policies that promote better adaptation at all scales, from the farmer to agricultural supply chains.

- Water will be key to achieving the United Nations Sustainable Development Goals (SDGs). Investment that leads to greater productivity and increased ability to manage climatic variability will be key to adaptation, as well as contributing substantially to poverty reduction and food security related SDGs. This latter contribution of agricultural water investments and policies is crucial and can be tracked within the framework of the SDGs. The SDGs provide the line of sight to development impact, in terms of eradicating poverty (SDG 1) and ending hunger (SDG 2), for all agricultural water policies and investments. In practice, this means considering the synergies between agricultural water management and the SDGs in policy evaluation and investment planning, implementation and monitoring. Clearly, agricultural water policy and investment are key to make progress on water-related SDG targets (SDG 6), including more efficient water use, Integrated Water Resources Management (IWRM) and improved water quality.

- There are substantial benefits from a new generation of policies and investments in agricultural water, and a renewed commitment in terms of public spending and donor investments. As described in section 2, investing in agricultural water creates jobs and generates economic gains. It also contributes to climate change adaptation. Agricultural water has thus a central role in food security and in stabilising incomes of the millions of Arabs living in rural areas. Adding value to the agriculture sector and, in particular, to some of the region's irrigated areas, will also contribute to improving the region's food trade balance, and reducing the burden of market protection and subsidies on already strained public finances. In this context, section 3 in this report highlighted that there is scope for increasing public investment in agriculture and agricultural water. Arab countries have been showing stagnant or declining trends in public expenditure in agriculture, and often spend well below the share of the sector in the economy. Moreover, the state and operating capacity of public irrigation and drainage infrastructure suggest that, in many instances, spending is suboptimal.

- **Progress in attracting investments, in particular private sector investments, can only be achieved if accompanied by the right set of policies.** This is because policies provide signals and incentives, and set the regulatory frameworks that influence the actions of all actors involved in agricultural water management, from consumers and farmers to private investors and donors. Policies need to address fundamental price distortions and articulate clear national strategies with consistent objectives across sectors and with a line of sight towards the SDGs. Given the scale of the agricultural water challenge, new financing modalities and actors are likely to play a greater role, requiring the public sector to strengthen frameworks for governing private and foreign direct investments, and avoid negative consequences in terms of sustainability and equity.

- **Despite progress on many fronts, the current policy mix in the region is not expected to deliver on the challenges ahead and, in particular, the SDG agenda.** As indicated in the policy analysis in section 5, perverse incentives and distortions at the core of agricultural water policy persist. Agricultural policy has not sufficiently addressed the potential negative impacts of agriculture on natural resources, undermining the sector's sustainability and the region's water resources. Gender has not been mainstreamed in policy, limiting agriculture's potential to reduce poverty in rural areas. Distortions stemming from the use of price-based policy instruments for social protection also result in negative impacts on critical dimensions of food security, such as nutrition. Finally, with some good exceptions, the current policies are not able to accelerate the development of a modern and highly efficient agriculture sector that is able to maximise water productivity, generate wealth and improve the agricultural trade balance.

- **The Arab region is highly heterogeneous.** The extent to which different countries will be able to invest to develop policies and harness technologies to revitalise the sector will naturally depend on contexts.

Nonetheless, the principles and direction of travel will be similar for most countries, offering significant opportunities for collaboration, partnerships and knowledge exchange amongst Arab leaders. In countries affected by conflict, a new generation of policies and investments in agricultural water will offer opportunities to support recovery and reconstruction efforts.

PRINCIPLES OF ENGAGEMENT FOR A NEW GENERATION OF POLICIES AND INVESTMENTS

Five principles of engagement for a new generation of policies and investments emerge from the analysis included in the different sections of this report. These five principles of engagement are highlighted at the top of Figure 16, and form the guiding principles of the proposed new generation of policies and investments: (1) policy coherence, (2) sustainability, (3) innovation, (4) inclusiveness, and (5) private sector engagement. The principles of engagement constitute cross-cutting factors that are key to the success of the strategic directions outlined further below (see Figure 16). Most importantly, they also highlight new features in the proposed set of policies and investments.

POLICY COHERENCE

Policy coherence translates into an efficient choice of policy instruments and investments to attain the desired objectives across the three strategic directions (Figure 16). In considering policy design and implementation, it is essential to understand the extent to which agricultural water policies are coherent with, and supportive of, the achievement of the SDGs – in particular, SDG 1 (no poverty), SDG 2 (zero hunger) and SDG 6 (clean water and sanitation). Policy coherence[1] for agricultural water policy means that Arab countries should avoid negative spillovers that would negatively affect their progress towards other SDG goals and, more positively, should seek to exploit potential synergies in a way in which they pursue their agricultural water management objectives.[2] The importance of this principle is highlighted in SDG 17.14, which calls on all countries to enhance policy coherence for sustainable development. Lack of policy coherence often results in suboptimal outcomes.

FIGURE 16
POLICY FRAMEWORK FOR A NEW GENERATION OF AGRICULTURAL WATER POLICIES AND INVESTMENTS

PRINCIPLES OF ENGAGEMENT FOR A NEW GENERATION OF AGRICULTURAL WATER POLICIES AND INVESTMENTS

- PRIVATE SECTOR ENGAGEMENT
- INNOVATION
- POLICY COHERENCE
- INCLUSIVENESS
- SUSTAINABILITY

STRATEGIC DIRECTIONS

VALUE WATER

- Seize water accounting innovations
- Harness digital revolution to build evidence base for water governance
- Adjust water service fees as part of water governance reform
- Consider water allocation reform
- Expand water supply through nonconventional sources including wastewater reuse
- Address water pollution from agriculture
- Modernise existing systems and invest in flexibility

ACCELERATE AGRICULTURE SECTOR TRANSITION

- Promote climate resilient agri-food supply chains
- Reduce protection on agricultural activities for which region has no comparative advantage
- Foster competitiveness of domestic markets through food safety, quality and marketing improvements
- Invest in capacity building and professional development to promote modern agribusiness ventures
- Reduce food losses and waste
- Support technology transfer for increased productivity and efficiency in activities with export potential
- Seize digital technologies to improve value chain efficiency at all levels (including extension services)

TARGET EFFICIENT SOCIAL PROTECTION

- Include nutrition concerns in support measures
- Establish international trade links with key food exporters
- Improve efficiency and targeting of social protection programs
- Develop compensation policies to facilitate implementation

MAKING AGRICULTURAL WATER WORK FOR SUSTAINABLE DEVELOPMENT & FOOD SECURITY

SOURCE: Authors

- Applying policy coherence as a principle of engagement means avoiding market distortions, which undermine agriculture's added value and sustainability, and compromise food security. The previous sections of this report illustrate this strong interaction: more often than not, countries in the Arab region use water and agricultural policies to reinforce their social protection policies. The ensuing situation is that of a complex network of conflicting, distortionary support measures originating from different government institutions with separate mandates. The outcomes are unsurprising: an overall poor nutritional performance compared to international standards, low productivity of scarce land and water resources, and difficulties in attaining higher levels of agricultural sector development, including potentially through much narrower agri-food trade deficits.

- Finally, policy coherence encourages countries to consider social protection objectives as a core area of focus for their agricultural water management policies. Social protection is not typically a core area of focus for agricultural water policy. Nonetheless, the evidence presented in this report and global experiences suggest that, in order to address water scarcity and water quality constraints, policy-makers need to introduce adequate reforms at the agriculture, water and social protection interface and not just consider them separately.[3] This report suggests that in the context of the Arab region, a third strategic direction should also be considered in the policy interface towards achieving the SDGs related to water and agriculture, namely that of social protection policies.

SUSTAINABILITY

- Environmental sustainability is an integral part of the policy framework. It forces investments and policies away from over-exploitation and pollution, towards a resource utilisation paradigm that recognises the scarcity of water, and the need to conserve it and value it accordingly. This is explicitly highlighted in the first strategic direction: value water, but also in several measures proposed that seek to reduce the carbon footprint of the sector, including food losses and waste reduction, and renewable energy use in irrigation.

- Financial sustainability is also key to all policies and investments. To apply the financial sustainability principle, countries need to focus on: (1) sustaining and increasing funding for investment from existing sources, mainly national governments and international donors, by making agricultural water a more attractive and credible sector for public financing through better data and analysis; (2) improving the supply of reliable recurrent funding for management, operation and maintenance from water user charges and other sources, while reducing the relative size of public subsidies; and (3) integrating investment and recurrent finance by coupling the planning of capital and operation and maintenance costs and provisions for covering these costs, thus minimising future investment needs and ensuring adequate funds for essential ongoing maintenance. In addition, financial sustainability is also about improving the public finances through a more efficient policy mix and investments on agriculture and social protection. As an example, the agricultural self-reliance drive suggested in this report can lead to a reduction in the pressure applied on public finances by an intricate set of subsidies and other support measures.

INNOVATION

Innovation is needed to harness new technologies such as digital agriculture and remote sensing, but also to seize new financing opportunities. To pursue the strategic directions in Figure 16, countries need enabling policies and associated investments that contribute to the deployment of best available technological innovations. These innovations include reuse and desalination to augment water supplies, data and analytics for improved governance of water, and digital agriculture for productivity improvements and improved value chain efficiency. Financing innovations, such as blended finance and de-risking mechanisms, have to be leveraged to support the region's efforts towards improved agricultural water management.

Innovation also directs countries towards data-driven policy analysis and investment appraisal. An improved understanding of investment performance and quality helps determine the investment contributions needed to achieve the SDGs and climate change-related targets. Better data and information systems would also allow policy-makers to better link their investments with effects, helping to understand whether agricultural water policies are meeting their objectives. Moreover, data and analysis on the hydrological situation of specific basins through water accounting, as well as on the impacts of irrigation modernisation, can lead to improved planning and investment design.

INCLUSIVENESS

Inclusiveness requires policies and investments to consider the distribution of costs and benefits, especially in terms of gender. Agricultural water management can reach its full potential only by closing the gender gap. The key word here is gender mainstreaming,[4] which calls for countries to institutionalise gender in the agricultural water sector as a precondition for investments and policies to be effective. In practice, this means including a gender analysis that aims to result in positive gender outcomes in the design, implementation, monitoring and evaluation of each investment and policy. To apply the gender equity principle in practice, the World Bank[5] identifies four key actions: (1) expand women's access to land and rural finance; (2) link women to agricultural value chains; (3) improve rural women's access to training and information; and (4) produce knowledge, data and tools that promote gender equality in agricultural water sector projects.

In addition, the proposed framework brings social safety nets, temporary support measures and other social protection instruments to the forefront of the debate. As discussed in the report and outlined in Figure 16, the reduction in distortions to maximise the value added by agriculture and put the region on a sustainability path need to be accompanied by more efficient redistributive measures in the Arab region. This is a fundamental principle of the framework and can have important impacts not only on poverty but also on nutritional outcomes.

PRIVATE SECTOR ENGAGEMENT

One of the key principles of engagement of the new generation of policies and investments is a more consistent private sector engagement. This includes a shift in paradigm on the role of the government towards becoming more of an enabler in many instances and cuts across the three strategic directions outlined in Figure 16. In practice, private sector engagement is key to accelerate agriculture sector transition in the Arab region. It may translate into reforms such as liberalising specific agricultural value chains, supporting multiple extension service provider models (including private), providing regulatory and critical infrastructure support for value chain development or engaging in public-private dialogue for improved policy making. It can also result in a selective development of public-private partnerships (PPPs) for building, operating and maintaining irrigation and drainage infrastructure (when conditions support such an option). More generally, it also means using market-friendly policy instruments that do not crowd out private sector investment.

IMPLEMENTATION

In applying the five principles of engagement to pursue the strategic directions, countries need to capitalise on regional knowledge and networks. The efforts of the League of Arab States to promote sustainable development need to continue, and could be strengthened with the establishment of regional dialogues on emerging themes such as (1) use of digital technology in agriculture and agricultural water management, (2) efficient investments in modern irrigation, and (3) public-private policy on agri-business sector development. The League of Arab States could also spearhead efforts to develop a regional water accounting database.

The process of implementation of policies and investments is challenging because it spans multiple stakeholders and levels of decision-making. Depending on the type of investment and policies, jurisdictions and mandates might overlap. For instance, food security policies are national matters, while irrigation service fees are typically collected at subnational scales, so policies targeted at improving irrigation fee cost recovery would have to be implemented at local and regional levels. The process of policy identification and implementation in a specific and local context should typically seek the close involvement of those stakeholders directly concerned by reforms.

STRATEGIC DIRECTIONS FOR POLICY AND INVESTMENT

The five principles of engagement provide the underlying principles to guide the pursuit of three strategic directions for policy and investment:

- Direction 1**:** ***Value water*** *to safeguard its quality and quantity in a sustainable way for multiple uses, especially in the face of climate change*
- Direction 2: ***Accelerate agriculture sector transition*** *to maximise its value and contribute to a prosperous rural economy with strong employment creation*
- Direction 3: ***Target efficient social protection*** *measures to ensure healthy diets, fight malnutrition and tackle obesity*

A new generation of agricultural water policies and investments in the Arab region starts by revisiting the policy interface between water, agriculture and social protection. It requires an in-depth revision of individual policy instruments at country level to create the right incentives for realising the region's potential. A more sustainable incentive framework creates an entry point for increased public sector spending and donor financing in agricultural water.

For each strategic direction, this section describes a set of policies and investments available to Arab policy-makers, including in situations affected by conflict. These are meant to provide broad recommendations, as the process of prioritisation and design of specific policy and investment interventions will inevitably be based on the close involvement of those stakeholders directly concerned, and will depend on country contexts and existing policies. In the case of situations affected by conflict and violence, the report makes specific recommendations on investments that should be prioritised in these contexts. In a traditional sense, only the first strategic direction is directly related to agricultural water. However, as argued above and in section 5, the close interlinkages between policies mean that a *new generation of policies and investments in agricultural water* necessarily needs to consider – and be coherent with – broader rural development and food security objectives beyond those strictly related to modernising irrigation and drainage (Figure 16).

STRATEGIC DIRECTION 1: VALUE WATER

Valuing water is an essential part of the region's policy agenda to safeguard its quality and quantity for multiple uses, especially in the face of mounting pressures from climate change and other drivers. With the United Nations/World Bank High-level Panel on Water having launched the Valuing Water Initiative in 2017 to chart principles and pathways for valuing water, the region has a real opportunity to join the global debate and rethink the value of water. A number of regional initiatives and networks, including those promoted by the Food and Agriculture Organization of the United Nations (FAO) Water Scarcity Initiative, the League of Arab States, the Arab Water Council and the United Nations Economic and Social Commission for West Asia, provide the opportunity to increase regional momentum and foster action to value water. In practice, this motivates investments and accompanying policy reforms that recognise the multiple values of water, its opportunity costs and its scarcity, and promote IWRM – the coordination of allocation and investment decisions at the basin scale.

- Seize the digital revolution to close the water data gap. Measurement underpins valuation, so the region needs to fill in persistent gaps in its knowledge about water quantity and quality, and water usage and waste. Persistent gaps in water usage data hide evidence of inefficiency, waste, misallocation and theft, hindering any type of water allocation reform and management process. As discussed in section 5, recent developments in water measurement, accounting and modelling technologies have started to close some of these gaps through remote sensing and low-cost monitoring devices. Water accounting provides the overarching indicator framework to link these different data streams and ensure that information is brought to bear on water management and governance. The establishment of water accounting platforms would give countries the evidence-based system needed to strategically plan water allocation, as also recognised in the Arab Water Security Strategy.[6] In addition, water accounting contributes to increasing transparency and accountability in the water sector, and provides the basis for all water-related investments, including those aimed at supporting drought preparedness.

- Leverage digital technologies and innovations to support institutional development for improved governance in the water sector. Irrigation system-level institutions, such as WUAs, basin-level organisations and national-level institutions, can benefit from digital technologies to gain better insight into the quality and quantity of available water, notably groundwater. In turn, this can lead to more accurate and responsive allocation and pricing mechanisms. Digital technologies also provide new opportunities to support a range of interactions between users and institutions, ranging from economic transactions, for instance, through mobile payments for irrigation water services, to data and information, to train farmers on best practices through mobile apps.

- Adjust water service fees for agriculture as part of broader changes in water governance and infrastructure. Pricing instruments applied to agriculture would help create the conditions for greater financial sustainability of the agriculture sector, and incentivising more efficient use of water at the same time. These irrigation fee increases should be carefully planned in consultation with farmers. Experience from other arid countries[7] shows that farmers are often willing to pay high water service fees, if these result in observable improvements in the reliability of the services and investments in supply infrastructure to mitigate water scarcity, such as wastewater reuse facilities or water harvesting structures.

- **Consider water allocation reform and trading as a potential economically efficient tool for managing water under scarcity.** The potential to reform water allocation based upon water rights which can be bought and sold, enabling water to be transferred from one user to another, should be explored further. At least eight Arab countries[8] have already established water allocation systems based on the issuance of water rights – an essential precursor for water markets – and in Morocco, Tunisia and Yemen, there is evidence of reallocation of water through trade, according to The Nature Conservancy.[9] Water allocation reform is not a solution to all water scarcity situations, but – if carefully constructed and regulated – it can be a powerful policy instrument to manage limited resources, and contribute to the conservation and restoration of water-related ecosystems. In the context of transboundary river basins, cooperative water allocation mechanisms could go a long way in promoting sustainable water use and help the region make progress towards achieving SDG 6.5.2, 'Proportion of transboundary basin area with an operational arrangement for water cooperation'.

- **Expand water availability through alternative sources.** Despite its known advantages, few Arab countries have succeeded in developing extensive, successful and safe reuse, even in light of considerable technological innovation.[10] Improving and promoting cost recovery in irrigation systems through service fees, extending wastewater management and treatment, and developing incentives for water quality management (for instance, polluter pays principle) could contribute to increasing the coverage of wastewater treatment and help make a stronger economic case for reuse. In addition, valuing water calls for investments to make the most of rainwater and green water (soil moisture held in soils) in rain-fed systems. For rain-fed farming systems, effective approaches are needed to address the region's constraints in terms of low and variable water availability, soil salinity and lack of nutrients. Measures include integrated soil, crop and water management; water harvesting, for instance, through subsurface tanks; managed aquifer recharge; and water conservation. Focusing on rain-fed agriculture has the potential to greatly contribute to efforts to eradicate poverty and hunger, as small, poor producers in remote areas are typically more reliant on rain-fed production for subsistence agriculture.

- **Support modernisation of irrigation schemes.** Modernisation contributes to achieving a range of objectives, notably more sustainable and productive use of scarce water resources. There is considerable room for improvement in water-use efficiency and crop water productivity in the Arab region, especially through adoption and expansion of new technologies. Water-use efficiency can be improved at the water service level by minimising canal losses and timely delivery, and at the field level by efficient water conveyance to the root zone, irrigation at the right time and quantity, and minimisation of evaporation. While much progress has been made on rapidly deploying drip irrigation technology, there is significant room for improvement in the performance of such systems through capacity building and knowledge transfer. Crop water productivity can be improved through, amongst others, soil, crop and water management (including switching to higher value-added crops and drought-resistant varieties). Investments in modernisation include construction and rehabilitation of physical infrastructure, such as conversion to pressurised irrigation and measurement, control and monitoring systems, and institutional upgrading, such as the development of appropriate accountability mechanisms and capacity building. Investments in modernisation need to be accompanied by policy instruments such as regulation and legislation to facilitate this transition and enable private sector engagement in the provision and implementation of some of these technologies. For modernisation to be effective, investments in support services and capacity building are essential. These include demand-driven agricultural extension assistance, training in financial management, simple accounting, determining levels of irrigation services fees and applying new management tools. Capacity building investments need to take into account the gendered nature of farming systems to yield expected benefits.

- **Invest in flexible infrastructure and institutions capable of accounting for the scarcity and opportunity costs of water.** Flexibility of irrigation delivery infrastructure is an investment required to improve operational performance and provide capacity to adapt to changing capacity requirements, changing levels of service and changing water allocation regimes. In the short term, flexibility allows to deliver water more efficiently and reliably depending on the needs of the particular crop, which are known to vary during the irrigation season. In the long term, flexibility allows for better adaptation to a range of drivers, including changes in crop type and water availability, resulting either from climate change or reallocation. In addition, investing in flexible infrastructure gives the ability to move water into, within or outside of an irrigation district, influencing opportunities to develop regulated water markets.

Invest in low-carbon approaches to agricultural water management, taking advantage of emerging opportunities from 'green' finance. Overall, there are significant opportunities to invest in and scale up low-carbon irrigation technologies and practices, and for tapping into related funding sources and climate finance mechanisms. Investing in capacity for project formulation to identify and quantify greening opportunities in agricultural water management investments can improve access to 'green' finance even for initiatives which are not purely related to renewable energy. In the case of renewable energy powered irrigation, solar irrigation is a key area of investment; however, institutional arrangements and incentives need to be put in place to avoid potential negative impacts on the environment caused by groundwater over-abstraction. For solar irrigation to keep its promise, there is a need to monitor groundwater availability and use, target subsidies and improve overall governance of the resource.

STRATEGIC DIRECTION 2: ACCELERATE AGRICULTURE SECTOR TRANSITION

Remove distortions in agricultural policies to maximise the value of the sector and revitalise rural economies. Removing distortions means reforming agricultural policies so that they reduce their interference with production decisions. This is achieved through reducing the protection on agricultural activities for which the region has no comparative advantage. Global experience shows how limiting the distortionary influence of price support on production and trade does not necessarily reduce farmer incomes when combined with appropriate direct payments and other compensation mechanisms.[11] This also requires acknowledgment that trade is beneficial for food security in the region, particularly for countries that are able to diversify sources of key import commodities and increase efficiency of imports (through infrastructure investments and fostering competition).

- **Foster the competitiveness of domestic markets and promote the emergence of modern agribusiness ventures through food safety, quality and marketing improvements.** This requires investments in public goods such as regulatory and enforcement capacity for food safety and quality regulations (including consumer fraud and informality), capacity building of industry actors, and supporting transfer of knowledge and equipment from trade partners in other countries (including European markets). It can also benefit from enhanced regional trade integration, which can allow Arab countries to fully exploit opportunities in internal (Gulf countries) and or neighbouring (Europe) high-income markets. Finally, promotion of a modern agribusiness industry can be supported at national level through the reinforcement of industry associations and representation, as well as developing public-private dialogue platforms for improved policy-making.

- **Promote local agribusiness industry representation and public-private policy dialogue for improved sub-sector policies.** Governments have a key role in promoting improved business climates, or enabling environments, for agribusiness and agro-industry in the region. Donors and international organisations also have key roles in activities such as advocacy, funding and provision of technical assistance in enabling environment assessment, and reform planning and implementation.[12] The Arab region's agri-food private sector has a key role in advancing the agribusiness development agenda, advocating for improved chain coordination mechanisms, supporting productivity gains and competitiveness, as well as the internationalisation of promising agri-food sub-sectors. Establishing and deepening country level public-private policy dialogue can be an important factor in accelerating the modernisation of the region's agri-food sector. In Morocco, for example, the emergence of inter-professions as a result of the country's *Plan Maroc Vert* is an interesting development and can be built upon through further capacity building of the emerging industry organisations.

- **Increase productivity and efficiency in agricultural activities with export potential and high water productivity.** These increases are obtained by stimulating investments in new technologies, and establishing policies and institutions to more efficiently use water for irrigation. Transfer of knowledge from countries with more modern agri-food sub-sectors should be encouraged, as well as facilitating the development of private business and technical support services (including through industry associations). Investments in new technologies are already taking place in the region, and can be combined with government subsidies to promote uptake.

- Reduce food losses and waste. These reductions can be achieved by using a mix of policy instruments and investments in infrastructure and capacity building. The first includes incentives for more sustainable consumption and behaviour, and better coordination across supply chains to ensure that farmers plan harvests according to market needs. In terms of investment, improved storage facilities, local food processing services, and dry and cold transportation facilities are needed to facilitate safe preservation of produce. If food waste reductions were to be paired with changes in diets and a cap on animal-based proteins and meat, water use could be reduced by as much as 33 percent.[13] This highlights the importance of linking food security and agricultural water policies.

STRATEGIC DIRECTION 3: TARGET EFFICIENT SOCIAL PROTECTION

- Reduce vulnerability to volatile food prices. As net importers of food, Arab countries are vulnerable to global price shocks. One way to reduce variability of consumer prices is for countries to maintain strategic stocks of key commodities. At the same time, Arab countries have a lot to gain by promoting regional and international initiatives that would render their increasing dependence on the trade option much more secure, predictable and sustainable in the long term. These include establishing international trade links with key food exporters and diversifying origin of imports, as well as promoting transparency and competition in import value chains.

- Improve efficiency and targeting of social protection programmes, especially for the rural and urban poor. Cash transfers – both conditional payments, through systems such as adaptive safety nets, and unconditional transfers – provide a more efficient and effective response to food security concerns than price distorting interventions (including those that focus on lowering consumer prices for specific agricultural commodities). In the face of climate change, social protection programmes could target poor and smallholder farmers in rain-fed areas through production input support, and weather, crop and livestock insurance.[14] In the context of the Arab world and, in particular, in post-conflict situations, targeted social protection programmes could also take the form of public work programmes to rehabilitate and develop agricultural water infrastructure. In addition, education, capacity building and awareness campaigns will be needed in order to shift to healthier lifestyles and diets to reduce the region's malnutrition and obesity problems.

- Develop compensation policies to accompany agricultural water reforms. Compensation for farmers, such as payments or in-kind support, needs to be considered as part of agricultural water reform packages. Compensation generally facilitates implementation and provides a monetary transfer to target farmers that have been made worse off as a result of a policy reform.[15] Transfers, compensation mechanisms, investments in capacity building and, more generally, policies aimed at developing opportunities for youth are required to advance inclusive and equitable outcomes in agricultural water without excluding vulnerable and already marginalised groups from the benefits of reform. In Australia, for instance, irrigators in the Murray-Darling Basin were invited to participate, on a voluntary basis, in government programmes to purchase water entitlements for environmental use, or to upgrade their on-farm irrigation infrastructure while returning a share of water efficiency savings to the environment (again in the form of water entitlement).[16]

FINANCING A NEW GENERATION OF INVESTMENTS

- International financial institutions (IFIs) such as the Islamic Development Bank, African Development Bank, World Bank, and the New Development Bank need to spearhead adoption of innovations in their projects. IFIs should capitalise on their position and influence to promote the new generation of investments in agricultural water identified in this report, and gather the support of co-financiers, for instance, through blended finance instruments. In addition, IFIs should continue to act as a catalyst for innovation and technology transfer, while working to reduce the variability in their commitments.

- Several recent developments in climate finance present future financing opportunities for agricultural water. These include green bonds, the Green Climate Fund, the Clean Development Mechanism and the Adaptation Fund. To seize these financing opportunities, Arab countries need to strengthen the climate change adaptation and mitigation dimensions of all agricultural water investments. In addition, these countries should invest in capacity building on climate change finance in key institutions to enhance organisations' institutional capacities to understand the modalities of climate funds, to prepare project and programme proposals, and to access and use climate finance.[17]

- **National governments will need to step up in terms of allocating funds to agricultural water management.** Public institutions will retain their central role in financing, both as financiers and, more importantly, as enablers of a financially sustainable sector. This role will include ensuring adequate funding for ongoing operation and maintenance, while promoting the necessary reforms for a more financially sustainable sector at the same time. Transforming the sector into a financially autonomous and commercially oriented undertaking is key to attract commercial financing and increase private sector participation.

- **There is scope to reinforce private sector participation as a financier of the agricultural water sector.** PPPs are not just a way of gaining access to financing, but also to expertise and private sector efficiency. While they cannot be applied everywhere (preferably tailored for modern farming), there is merit in seeking to develop such and other innovative arrangements for building and operating infrastructure. Furthermore, the greater involvement of users in irrigation scheme operation and maintenance including financing has also shown mixed results, but the models can be further tested and improved.

INVESTMENTS IN CONFLICT AND POST-CONFLICT SITUATIONS

- **Water and agriculture can contribute to promoting recovery and stabilisation in conflict and post-conflict situations.** Typically, agriculture is the first sector to recover from crisis, because the factors of production, including water, can be more rapidly mobilised. Water and agriculture are also key inputs to recovery. They are a first point of entry for mitigating the impact of conflict on food insecurity, poverty, employment and economic growth. Producing and selling food, generating rural incomes and employment, rebuilding household-level food security, supplying drinking water, and rebuilding social cohesion and institutions from the bottom up, water and agriculture are key to stabilisation and ultimately to peace-building.[18]

- **In conflict and post-conflict situations, innovative financing mechanisms and partnerships are often key to deliver the necessary investments.** In Somalia, for instance, FAO, the World Bank and the International Committee of the Red Cross have partnered to implement a USD 50 million emergency drought response and recovery project to rapidly deliver food, water, cash and basic goods to half a million people, and provide vaccinations or treatment to the livestock of 200 000 people.[19] This set of short-term measures is accompanied by investments to support medium-term recovery, including rehabilitation of existing irrigation canals, restoration of catchments and erosion control.

- **Investment should focus on maintaining key services and facilitating emergency relief efforts, while building capacity and promoting sustainable water use.** To sustain basic services, one-off subsidies to maintain or quickly restore key infrastructure assets and services, and to retain skilled staff in irrigation authorities are recommended. This type of support is promoted based on the recognition that maintaining basic services, as well as national implementation capacity and structures, helps to preserve the foundations for post-conflict recovery of the agricultural water sector, as well as other sectors. In Iraq, for instance, the restoration of agriculture and irrigation water systems has been identified in the National Development Plan as a key investment, which will allow for the return of millions of internally displaced people to their areas of origin.[20] Alongside labour-intensive restoration, this project promotes, amongst other themes, training for the beneficiaries in improved and climate-smart, high-value crop production and agri-food processing.

- **Joint approaches, inclusiveness and flexibility are vital when designing investments in situations affected by conflict.** Because of the essentially local nature of the water and agriculture problems and intervention responses, community consultation, participation and ownership are vital, as is working with whatever local institutions may exist on the ground.[21] These principles have been applied by the International Labour Organization to devise a labour-intensive employment project to construct water harvesting structures and promote agricultural production in refugee-hosting communities in northern Jordan.[22]

NOTES AND REFERENCES

1. Policy coherence has been defined by the Organisation for Economic Co-operation and Development (OECD) as the systematic promotion of mutually reinforcing policy actions across government departments and agencies creating synergies towards achieving the agreed objectives.

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APPENDIX

APPENDIX 1: KEY DEFINITIONS

The **agricultural water** sector is interpreted here as encompassing all activities and investments strictly related to agricultural water (irrigation, reservoirs, hydraulic structures, groundwater exploitation for agricultural use) as well as activities and investments related to agricultural land (soil degradation control, soil improvement, drainage of waterlogged areas, soil desalination, agricultural land surveys, land reclamation, erosion control, and desertification control), following the definitions given by the Organisation for Economic Co-operation and Development (OECD) Development Assistance Committee (DAC).

Investments are interpreted here as funding into agricultural water from governments, international development assistance and the private sector. In terms of international development assistance, the report includes commitments from all donors, both bilateral and multilateral, contained in the OECD DAC database. Commitments to agriculture include all aid flows to support agricultural policy, agricultural development, food crop production, livestock, agricultural extension, and agricultural land and water resources management. Commitments measure donors' intentions and permit monitoring of the targeting of resources to specific purposes and recipient countries. They fluctuate as aid policies change, and reflect how donors' political commitments translate into action. They, thus, give an indication about future flows, and this is why they are examined here in more detail.

Aid flows are estimated as the sum of all flows from the following donors unless specified: DAC countries, European Union institutions, World Bank, Islamic Development Bank, African Development Bank, United Nations and non-DAC countries, including Saudi Arabia and the United Arab Emirates.

This report focuses on **country level indicators.** However, even if country level indicators give an overall picture of a country's agricultural water challenges and responses, they do not give the full picture as significant disparities and differences exist within countries. National-level statistics need to be interpreted carefully because they mask significant heterogeneity at country level. For instance, the national-level statistics for water use in Morocco or the West Bank show that water use in these countries has not yet exceeded renewable freshwater resources, but resource over-exploitation and degradation has been observed in several aquifers in these countries, such as the Saiss plain aquifer in Morocco and the coastal aquifer in Gaza. Similarly, indicators of water-use efficiency only provide a crude estimate without differentiating by sector and economic structure. Ultimately, any effort to benchmark countries' performances based on a selected number of indicators will be limited by the choice of indicators, quality and availability of data, and by country specific details and heterogeneities. For these reasons, benchmarking exercises will never be complete, and at best they can offer common definitions and metrics to categorise water-related challenges and identify regional hotspots where more analysis and data are required.

This report seeks to quantify, as much as possible, the quantity and quality of investments in agricultural water. However, due to data limitations, it was not possible to isolate the amount of public spending in the agricultural water sector alone, as well as to detail all the intricate patterns of subsidisation and other support measures that influence each stakeholder's decisions. In addition, the lack of detailed sector studies and rigorous impact assessments on the returns to investment in agricultural water, meant that it was not possible to thoroughly assess the quality and impact of the region's investments in the sector. Unless the data are collected and made available, determining the appropriate level of allocation (the 'investment gap') and understanding the quality of spending will remain an obstacle to improved investment planning in the region, and will make it more difficult for the sector to attract both public and private investments.

APPENDIX 2: MODELS FOR PROMOTING SOLAR IRRIGATION PUMPS

The International Water Management Institute's (IWMI's) work in India suggests that, if promoted alongside a set of institutional structures and incentives, solar-powered irrigation can be a key part of the solution to expand affordable irrigation and enhance resilience to climate change. IWMI identified a set of criteria to guide the selection of the most appropriate model to deploy solar-powered irrigation. The criteria are:

1. offer farmers more reliable and affordable energy for irrigation than at present;
2. ensure that energy price correctly signals scarcity or abundance of groundwater;
3. reduce power subsidy burden on government;
4. minimise the carbon footprint of irrigation;
5. maximise farmer contribution to investment in irrigation equipment;
6. enhance smallholder incomes; and
7. offer rapid scalability.

South Asia is experimenting with several promotional models for solar irrigation pumps, each addressing one or two of the above criteria but not all. These models can be grouped into the following seven major categories:

1. Subsidy saving model: central government offers capital cost subsidy on solar irrigation pumps in lieu of grid power connections to ease the subsidy burden on power utilities.
2. Developer-centred, farmer-dedicated solar plant. Private investors build tail-end solar power plants (1–2 MWp in size) on government land to energise an entire separated agricultural feeder. The utility offers investors feed-in tariff on total generation, while farmers

get free daytime solar power. Surplus power would flow back into the grid and the deficit would be provided by the grid.

3. Developer-centered distributed generation model. Farmers give up their free grid power connections in lieu of free solar pumps on their fields with 1.5 times more panels than the rated pump capacity. Surplus solar power is sold to the utility, with about 80 percent retained by the utility to recover capital cost, interest and developer profit. Farmers get free solar power instead of free grid power, but have no incentive for energy and water conservation and it does not offer any income flow to farmers.

4. Farmers as land-leasers to solar companies. Farmers with barren wasteland rent it to solar companies and receive an income, and the government is saved from the trouble of land acquisition.

5. Non-subsidy market model. Solar pump promotion is left to market forces without any subsidy. Adoption may then be slow and left to large commercial farmers.

6. Solar irrigation service provider (S-ISP) model. Encourage solar pump owners to sell irrigation services to other farmers.

7. Solar power as a remunerative crop (SpaRC). Promote solar energy that farmers can 'grow' on their fields as a new cash crop. Under this model: (1) tube well owners in a village give up grid power connections for subsidised solar pumps of equivalent capacity; (2) solar pumps are formed into a micro-grid managed by a cooperative of their owners; and (3) the utility buys, at a remunerative feed-in tariff, all surplus solar power of the cooperative at a single metred point.

The performance of each of these models in the South Asian setting according to seven criteria is shown in Table A1.

Table A1

ALTERNATIVE MODELS FOR PROMOTING SOLAR POWER AMONGST FARMERS AND THEIR PERFORMANCE ACCORDING TO SEVEN CRITERIA IN SOUTH ASIA

Objectives	Utility centric subsidy saving model	Developer centred farm dedicated solar plant	Developer centric distributed solar model	Farmers as land leasers to solar companies	Open market solar pump promotion	Solar irrigation service provider model	Solar power as a remunerative crop (SPaRC)
Example	Prevailing model in all Indian States	PRAYAS model Maharashtra	Suryaraitha, Karnataka	Uttarkhand's MW-scale solar plant on farmers' land	Pakistan & Sri Lanka	IDCOL in Bangladesh	Dhundi model, Gujarat Government's SKY scheme
Will it offer farmers more reliable and affordable energy for irrigation than at present?	•••	•••	•••	NA	••	•••	•••
Will it ensure that energy price correctly signals scarcity or abundance of groundwater?	•	•	•	NA	• Pakistan ••• Sri Lanka	•••	•••
Will it reduce power subsidy burden on government?	•••	•	•	NA	NA	•••	•••

Will it minimise the carbon footprint of irrigation?	••	•••	•••	NA	•••	•••	•••
Will it maximise farmer contribution to investment in irrigation equipment?	••	NA	•	NA	•••	••	•••
Will it enhance smallholder incomes?	NA	NA	•	•••	NA	•••	•••
Does it offer rapid scalability?	••	••	•	•••	•	•••	•••

SOURCE: Shah, T., Rajan, A., Rai, G.P., Verma, S. & Durga, N. 2018. Solar pumps and South Asia's energy-groundwater nexus: exploring implications and reimagining its future. *Environmental Research Letters*, 13(11):115003.
Notes: SIP - Solar irrigation pump; IDCOL - Infrastructure Development Company Limited; SKY - Suryashakti Kisan Yojana; NA – Not available.

APPENDIX 3: PUBLIC-PRIVATE PARTNERSHIPS (PPPS)

TABLE A2 - EXAMPLES OF PPPS IN IRRIGATION IN THE ARAB REGION

Source: Compiled from Mandri-Perrott, C. & Bisbey, J. 2016. *How to develop sustainable irrigation projects with private sector participation*. Washington, DC, World Bank.

Country	Scheme	Size [hectares]	PPP model	Farming activity	Project costs	Economic details	Other details
Morocco	Guerdane	10 000	Design Build Operate	Cash crops	USD 85 million for infrastructure	Gross irrigation productivity: USD 1.0 – USD 2.0/m^3 (for 8,000 m^3/ha) Water pricing: USD 0.15 – USD 0.20/m^3	
Mauritania	Nakhlet	27	Operation and management	Rice	NA	Gross irrigation productivity: USD 0.030/m^3 Irrigation water value: USD 0.015/m^3 Price of the water service: USD 0.002/m^3	Village scheme/cooperative with 29 farmers Finances the cropping season with its working capital
Jordan	Adasiyeh	400	Operation and management	Citrus	NA	Gross irrigation productivity: USD 2.72/m^3 Irrigation water value: USD 2.49/m^3 (citrus) Price of the water service: USD 0.021/m^3	A successful experiment, whereby quotas were enforced and well respected as an alternative to the incumbent rotation of water distribution for water management

Saudi Arabia	Business farms	2 000 000	NA	Wheat, alfalfa	NA	The government offered free land as part of a vast programme of highly subsidised irrigated agriculture in 1980, including free groundwater, free credit and a guaranteed purchase price of USD 1,000/ton of wheat. The programme covered eight highly capitalistic business farmers; medium-sized farms and traditional Bedu farms
Egypt	Dina Farm	4 400	Concession	wheat, berseem clover, alfalfa, corn, banana, tomato, potato, other vegetables	Gross irrigation productivity: USD 0.32/m^3 (banana)	Though an entirely private investment, the Government of Egypt provides a partly free groundwater supply at an estimated average of 20,000 m^3/ha, annually

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ISBN 978-92-5-131431-9

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CA4445EN/1/08.19

ISBN: 978-92-5-131431-9 (FAO)
ISBN: 978-92-9090-887-6 (IWMI)