2030 WATER RESOURCES GROUP

Accelerating water sector transformation in Jordan

FINAL REPORT

20 October 2011

CONFIDENTIAL

About this report

This report is the culmination of a 4 month project by the 2030 Water Resources Group for the Ministry of Water and Irrigation, Government of Jordan. This report is a synthesis of the findings of the project and should be read in conjunction with the detailed appendices (included at the end of the report) and the presentation shared with the Steering Committee and taken in the context of the several Steering Committee meetings, workshops and discussions held during the project.

This draft final version of the report is a draft for discussion with the key stakeholders within the Ministry of Water and Irrigation, other Ministries of the Government of Jordan and key external stakeholders for comment and feedback on the key messages. These will then be incorporated in the final report to be submitted to His Excellency Minister of Water and Irrigation.

The 2030 Water Resources Group

The 2030 Water Resources Group (WRG) was formed in 2008 to contribute new insights to the increasingly critical issue of water resource scarcity. The group aims to help governments across the world ensure sustainable water resources for economic growth through cost effective and productive supply development and use of water.

WRG consists of a range of organizations from the private and social sectors that provided the collaboration and counsel needed to tackle this complex topic:

- Global and regional development agencies such as the International Finance Corporation, the Asian Development Bank and the Swiss Agency for Development and Cooperation
- Private sector players – The World Economic Forum providing leadership through its convening of the private sector and leading global companies such as Nestle, the Coca Cola Company, PepsiCo, Veolia Water and Firmenich
- McKinsey and Company providing analytical support, fact base development and project management
- Support provided by a group of leading think tanks and academics such as the Organisation for Economic Co-operation and Development and John Briscoe of Harvard University

In addition, the initiative in Jordan was closely supported by the Global Environment and Technology Foundation and the USAID.

WRG aims to address three key changes needed to accelerate the transformation of the water sector across the globe and usher in a productivity revolution in the use of this scarce resource:

- Elevating water as a national policy priority to an economy-wide problem
- Rebalance focus on all elements of water enabled growth (supply and demand-side; scarcity and access) with fact-based prioritisation of solutions
- Developing a new holistic approach to the solution with engagement of all stakeholders, including the private sector

WRG aims to achieve this though three-fold approach:

- **Decision-oriented analysis –** Creating a comprehensive fact base with broad agreement on future demand scenarios based on economic plans, economic options and trade-offs and the prioritised spectrum of available solutions
- **Convening –** Creating multi-stakeholder platforms such as the Jordan Business Alliance on Water to help governments shape, test and prioritise programs
- **Transformation** – Providing multidisciplinary assistance to improve water resource management and water adaptation planning through national working groups, catalogue of best practices and long term transformation plans

About the project

The project on "Accelerating Water Sector Transformation in Jordan" was carried out by the 2030 Water Resources Group on behalf of the Ministry of Water and Irrigation, Government of Jordan. The project was structured and carried out in the spirit of collaboration and co-creation with the Government and a broad group of stakeholders.

The project was conducted under the guidance of H.E. Minister of Water and Irrigation with direct supervision from Eng. F. Bataineh and Eng. B. Telfah. A Steering Committee chaired by H.E. M. Najjar consisted of the Secretary Generals of MWI, WAJ, JVA, Ministry of Agriculture and Ministry of Planning as well as representatives of WRG (U. Rao-Monari and A. Attiga from IFC, A. Mung from WEF and M. Stuchtey from McKinsey & Co.) and representatives from USAID.

In the spirit of co-creation and extensive syndication, the project built on the existing work and projects within and outside MWI. Data was sourced from MWI, WAJ, JVA, Department of Statistics, Ministry of Agriculture and other relevant Ministries. A series of intensive workshops were held to align on the data and syndicate the analysis and key conclusions. Extensive engagement and thought leadership was provided by:

- **MWI** - H. E. M. Zoubi, A. Subah and NWMP team, and J. Hijazi
- **WAJ -** H. E. M. Oweis, Dr. K. Hadidi, F. Al-Azzam, A. Ulimat and B.Saleh
- **JVA -** H. E. S. A. Hammour, Y. Hassan, Q. Oweis and F. Ejeilat
- **PMU** – B. Telfah and the PMU team
- **Miyahuna** leadership
- **Ministry of Agriculture** - H. E. Dr. R. Al Tarawneh, M. Abu Jamous, O. Allaham, M. Telfah, A. Akour and S. Sawalha
- **Ministry of Planning and International Cooperation** - H. E. J. Hassan and H. E. S. Al-Kharabsheh
- **(Former) Ministry of Mega Projects** - H. E. I. Fakhoury

In addition, the project received support and inputs from the Jordan Atomic Energy Commission (Prof. K. Araj and Dr. K. Khdier), Natural Resources Authority (Dr. M. Hijazin), Ministry of Tourism (H. E. I. Gammoh), Ministry of Industry (A. Zhair and J. Mahasneh) and the National Centre for Agricultural Research and Extension.

The project has received extensive support from USAID (T. Rhodes, A. Bani-Hani and S. Tutundjian) and its projects such as IDARA (Dr. M. Chebaane and L. Qaqish). It has also received support from GIZ (G. Honore, D. Rothenberger and their team) and its projects such as the Highland Water Forum.

The project has worked closely with the Jordan Business Alliance on Water under the patronage of H. R. H. Prince Faisal bin Al-Hussain.

Contents

Executive summary

In October 2010, the Government of Jordan and the 2030 Water Resources Group (WRG) embarked a pioneering initiative to determine how Jordan could most effectively ensure adequate water to support the country's National Agenda– a **water economy** that can transform the economic development of Jordan.

In synthesis, the findings are:

Under current plans, Jordan will target doubling its GDP between 2009 and 2017 and reduce unemployment from 12.5% in 2004 to 6.8% by 2017. By 2030, this increase in economic activity and wealth will require a doubling of water demand to 1,550 MCM - 650 MCM more than current and funded supply.

- Total water need will grow from 866 MCM today to ~ 1,550 MCM by 2030 driven by industrial demand growing from 36 MCM to 150 MCM (mainly from mining), today's negligible demand for energy generation growing to about 150 MCM, population pressure and higher consumption more than doubling allocation need from 320 MCM to 736 MCM and agricultural allocation remaining at current levels (about 510 MCM excluding unreported ground-water abstraction).

- Jordan's total sustainable water supply in 2009 was 708 MCM, with an additional 158 MCM from groundwater over-abstraction resulting in a total current supply of 866 MCM. If implemented as planned, the 325 km pipeline Disi-Amman conveyor would add 100 MCM of supply, As-Samra) the largest waste water treatment plant extension) would add 45 MCM, other new waste water treatment plants to deal with increased wastewater from newly connected customers would add 31 MCM and the Kufranja dam will add 5 MCM of supply, bringing Jordan's total accessible water supply to 889 MCM.

- Assuming that groundwater over-abstraction will have been be stopped by 2020, as per MWI's current plans, by 2030, Jordan will require approximately 650 MCM more water than the currently financed sustainable supply.

The Jordan Red Sea Project (JRSP), which will provide 930 MCM of desalinated water to Jordan by 2055 (370 MCM by 2025) to meet future water needs and refill the Dead Sea is critical to meeting this future need for water. At an estimated investment of JD 8-10 billion, JRSP is the most expensive water project globally in the last five years, and could be difficult to finance and substantially increase the future cost of water. Jordan's current water use efficiency and productivity, especially in agriculture and municipal use, provides opportunities for flexibility against the high future cost of supply.

  - At 0.35 JD/m^3, water in Jordan is already expensive by global standards. Future water supply is expected to be even more expensive, at an average of 0.9 JD/m3 across current and new sources in 2025 after the completion of the Phases I and II of the JRSP. Successful realization of planned non-water revenues (currently planned at ~40% of total revenues) and international grants could reduce the future cost of water but the marginal cost could remain > 1 JD/m^3.

- In addition, the high investment need of JRSP (JD 8-10 billion) represents a significant financing challenge and risk to Jordan's debt and deficit targets in the National Agenda objectives. Opportunities for more efficient and productive water use could provide flexibility in reducing the magnitude and timing of JRSP's financial impact.
- Non-revenue water (NRW) in municipal areas is as high 43% on average increasing to 60% in some cases. At today's NRW levels, Jordan could lose 320 MCM of expensive municipal water by 2030 – an amount equal to today's total municipal water supply. Hence, NRW reduction has substantive potential to addressing the future allocation need and avoiding the high marginal cost of water.
- Agriculture uses 60% of today's water supply, but has low productivity. The Jordan Valley, where 167 MCM are used, has a large share of high productivity crops, including bananas, citrus fruits and dates, and has average productivity of 0.8 JD/M3. But in the Highlands, where 344 MCM are used, average productivity is 0.3 JD/M3, and irrigated olives, which represent roughly half of Highlands water demand, are on average a value-destroying crop after removing subsidies.

To address its water challenges and ensure a water-secure economic future, Jordan needs to craft a roadmap for an integrated solution, coupling the effective delivery of supply-side projects like JRSP with efficiency of water use and productive choices in agriculture. Jordan should:

- **Increase the efficiency and productivity of water use as a priority**. This report identifies relatively easy-to-implement measures that can save approximately 400 MCM of water. Jordan should accelerate existing demand management, including IDARA on increased enforcement of water-efficiency regulations, the Water Demand Management Unit for water-efficiency, the Highlands Water Forum to develop agricultural water policies, and the Jordan Business Alliance on Water, focused on water management in commerce and industry
- **Gain flexibility through economic choices in agriculture.** According to current plans, current crop mix and agricultural techniques, Jordan's annual water allocation need for agriculture will remain at current levels of approximately 510 MCM. But in a High-value agriculture scenario, Jordan would see an alternative crop mix that keeps current supply, expands irrigated land, shifts water supply from water-intensive trees to high-value, low-water vegetables, raising demand to 550 MCM but almost doubling value-add from irrigated agriculture and providing about 15,000 new full-time equivalent jobs in agriculture. At the other end of the spectrum, an alternative crop mix on current cultivated area, shifting 50% of agricultural land currently under fruit trees to high-value, low-water vegetables[1] could reduce the need for agricultural allocation to 400 MCM while increasing value add by 80% and keeping agricultural employment at approximately current levels. Policy makers will need to evaluate these trade offs in the

[1] More aggressive crop change scenarios were discussed but excluded from analysis

context of National Agenda objectives and craft an agricultural strategy to implement these trade-offs.

- **Ensure water security through supply side efficient mega-projects.** Potential of about 130 MCM of additional supply exists from relatively cost effective supply measures. Within this, the greatest potential for additional water supply comes from waste water re-use (62 MCM). Finally, JRSP is needed for long term supply security but its high cost and considerable implementation risks makes it critical to optimize the size and timing of its phases against flexibility gained from "must-do" efficiency measures and economic choices in agriculture. In addition, measures such as supply-side capital efficiency have savings potentials exceeding JD 50m.

Delivering on the transformation roadmap and ensuring water-enabled growth over the next 10 years requires immediate steps from all stakeholders in Jordan. This is a water-enabled development path that is consistent with National Agenda objectives and leads to a productive, cost-optimal and sustainable future for Jordan.

The Government of Jordan should engage national and global stakeholders to set up a **Cross-Ministerial Delivery Unit** to ensure optimal decision making around water and a **Project Management Office.** These are immediate prerequisites to planning, delivering and ensuring impact of the complex transformation journey ahead. This should to be followed by immediate workstream to drive **agricultural productivity in the Highlands and the Jordan Valley** and to **drive industrial water use efficiency**. In addition**, financing, capital efficiency and data management workstreams** will be immediately needed to ensure financing for the transformation programme and establish a single "source of truth" for decision-making across the country and conduct regular public-private dialogue. Workstreams focusing on **municipal efficiency and efficiency in energy and mining** should be subsequently set up in the following months.

Introduction

As of one of the most water-poor countries in the world, Jordan has a strong track record of taking action and innovating in the management of its scarce water resources, It has set up a strong institutional structure for water resource management with the Ministry of Water and Irrigation, the Water Authority of Jordan, the Jordan Valley Authority and water companies such as Miyanuna, the Aqaba Water Company and the Yarmouk Water Company.

In order to proactively establish a long term vision for the sector, high level national water strategies developed in 1998 and “Water for Life” developed in 2009. A National Water Master Plan was developed in 2004 that analysed future water use demand and assessed consolidated supply measures against future demand needs.

Policy measures for entitlements and abstraction management (e.g., 2002 by-laws for groundwater use) were put in place for better management of groundwater resources. In addition, Jordan has been a leader in the use of treated urban waste water for irrigation in the Jordan Valley and has been leading in the development of new urban supply (Disi-Amman conveyor and the Jordan Red Sea Project).

Jordan has also seen long term engagement and support from development agencies such as USAID, GTZ, AfD and JICA embedded within the Ministry of Water and Irrigation and providing skills and expertise.

Jordan has also been a leader in the deployment and use of state of the art tools for water resource management. Real-time meter and telemetry data is available from across the country at central operations hubs. Software based analysis and planning tools such as WEAP, WIS, ArcGIS and PIS are in use and integrated into the Ministry’s planning and operations processes.

However, while the technical solutions required are largely known, given the acuteness of the water-economy challenge that Jordan faces, ensuring a water-secure future require new mindsets, a new contract between sectors and groups of the national economy, a new institutional infrastructure and clear leadership focused on a fact-based approach to the difficult decisions needed.

the need was felt for a step change in water resource management that builds on current initiatives and progress. In October 2010, the Government of Jordan and the 2030 Water Resources Group (WRG) agreed a pioneering initiative to determine how Jordan could most effectively ensure adequate water for a high-value economy to support the country’s National Agenda aspirations. The initiative has five core objectives:

- Understand **Jordan's future supply and demand** for water
- Identify and prioritize the **technical solutions** on the demand and supply side that can address the future water requirement
- Identify **economic choices** open to Jordan faces that can impact future demand
- Quantify the **impact on National Agenda objectives**

- Outline the **implementation road map** to accelerate the transformation

Above all, the initiative aims to **elevate the water challenge on the agenda of all key stakeholders across the government, private sector and civil society**, ensuring that decisions on water resources fully support Jordan's economic objectives.

The initiative has focused on conducting rigorous analysis to support decision makers, building on the excellent existing fact bases developed by Jordan's ministries, multilateral organisations, and other external sources. All data, assumptions, and conclusions have been aligned with relevant experts and decision makers on an ongoing basis. (Key stakeholders are listed in the "About the project" section earlier).

This report synthesises the findings of the initiative. It is structured in four chapters:

Chapter 1, "Jordan needs a step change in water provision by 2030", shows that Jordan will need approximately 650 million cubic metres (MCM) of additional water by 2030 to meet its National Agenda aspirations under a "business as usual" scenario – more than half of its current supply

Chapter 2, "Opportunities exist for better water resource management", identifies opportunities as low water productivity and end-use efficiency that can reduce the exposure to the high cost of planned supply mega-projects

Chapter 3, "Ensuring a water-secure economic future: roadmap for an integrated solution", highlights that if Jordan is to address its water challenges and ensure a water-secure economic future, it needs to change the way resources are managed.

Chapter 4, "Now is the time: action steps to transform Jordan's water sector", recommends that Jordan should embark on a multi-year transformation process to ensure long term water security and water-enabled growth for Jordan.

The **Appendix** sets out the key analyses in detail.

Chapter 1
Jordan needs a step change in water provision by 2030

Water is a key resource required across the economy of a country. National objectives of economic growth are a key driver of the future water need of the country – all aspects of a country's water economy across agriculture, industry, energy generation and municipal use will determine the water provision needed. In order to create a holistic fact-based picture of Jordan's future water economy, we started by identifying Jordan's projected water need in 2030 based on current aspirations outlined in the National Agenda.

Through its National Agenda, Jordan has set itself ambitious economic growth aspirations. This Chapter examines those aspirations and calculates the water supply that will be required to deliver on the National Agenda.

JORDAN HAS AMBITIOUS GROWTH ASPIRATIONS

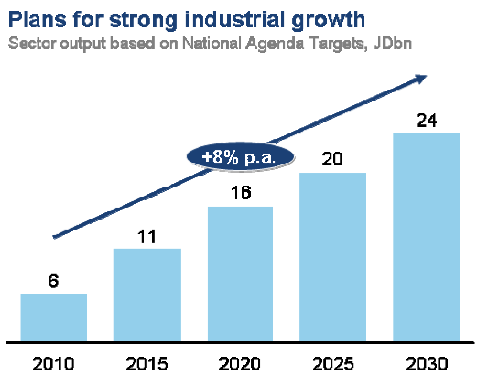
Jordan's National Agenda set ambitious economic and social growth aspirations. It envisaged Jordan's real GDP almost doubling between 2009 and 2017, representing an annual growth rate of 7.2%. It also sought to turn a budget deficit of 11.8% of GDP in 2004 into a surplus of 1.8% by 2017, reducing public debt as a percentage of GDP from 61% in 2009 to 36% by 2017. Social stability is a key focus of the National Agenda: it aimed to reduce unemployment to 6.8% by 2017 (from 12.5% in 2004), while rolling back poverty.

Jordan will need to support aggressive economic growth plans with limited investment headroom; it will need to focus on creating jobs, especially in under-developed areas; and it will need to push rapid industrial and services growth as key drivers of overall economic growth, with an energy buildout to support them. Further, Jordan will need to cater for increased population growth[2] and higher consumption levels, particularly in the cities. Jordan's growth outlook by sector is outlined in the following sections.

Industrial growth

National Agenda targets for industrial growth, set from 2005 to 2017, show an aggressive growth of 12% per year especially driven by double-digit growth in apparel, tourism and food, which would account for almost 75% of Jordan's industrial sector output by 2017. However, independent estimates of Jordanian economic growth forecast less rapid growth, in light of the global economic crisis. For

EXHIBIT 1



SOURCE: National Agenda; IHS Global Insight

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example IHS Global Insight expects an annual growth rate of 4-5%. For the purposes of this study we have combined National Agenda growth aspirations of 12% per year until 2020 with longer term independent forecasts of 5% per year between 2020 and 2030 into a composite picture of future growth (Exhibit 1). For the purposes of estimating future industrial demand of water in this report, a base case scenario for Jordan's future industrial growth was used as agreed and reviewed by the Steering Committee.

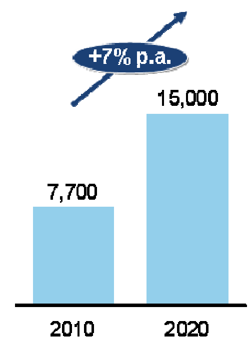
Energy growth

Primary energy demand is expected to double to 15 million TOE by 2020 according to the National Energy Strategy (Exhibit 2). Assuming the same growth rate for the following years, primary energy demand would triple by 2030 to 30 million TOE.

EXHIBIT 2

Plans for energy expansion

Primary energy demand, TOE, thousands



SOURCE: National Energy Strategy

Jordan's National Energy Strategy aims at shifting the primary energy mix towards local sources including nuclear/uranium and oil shale, as well as renewable technologies including wind and solar. Under this strategy, Jordan's post-2020 energy mix would include about 70 % from traditional oil and gas sources, 14% from oil shale, 6% from nuclear, and 10% from renewables. This will lead to creation of new energy industries both in power generation as well as energy resource mining.

For power generation a 6.4 GW capacity gap is projected for 2030, based on a peak load capacity demand of 8.4 GW greatly outweighing the 1.6 GW in installed and committed capacity by 2030. Jordan plans to close this gap by developing four nuclear plants by 2030, each with 1 GW capacity; and by generating 700 MW from oil shale, 1 GW from wind, 300-600 MW from solar and the remaining 500-800 MW from traditional gas power generation.

In energy resource mining, the country plans to add significant uranium and oil shale extraction capacities. Currently an annual uranium extraction capacity of 20,000 tons over 15 years is planned, which will create resources which can be exported and used for local nuclear plants after refinement abroad. Furthermore, oil shale extraction capacity of 15m barrel per year will create substitute sources for oil.

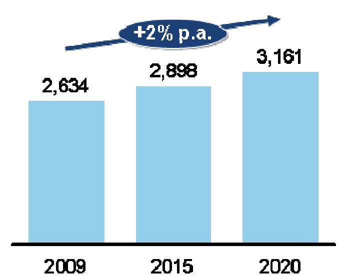
Agricultural growth

Only limited growth at 2% per annum is expected, based on the Ministry of Agriculture's current review of its agricultural strategy (Exhibit 3). This strategy plans for a 15-25% increase in crop production without increasing irrigation water allocated to agriculture. Growth would come from two main drivers: expansion of rain-fed areas, which is intended to account for the large majority

EXHIBIT 3

Limited agricultural growth

Crop production, thousand metric tons

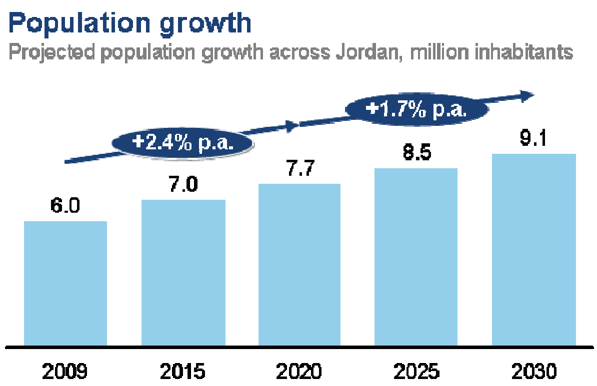


SOURCE: Ministry of Agriculture interviews of the increased production; and increasing crop productivity on a per-hectare basis for both rain-fed and irrigated areas.

Population growth

The Department of Statistics projects Jordan's population of 6.0 million in 2009 to grow to 9.1 million in 2030, with the population growth rate dropping from 2.4% per annum for 2010-20 to 1.7% per annum for 2020-2030 (Exhibit 4). However, potential future increases in population growth could be influenced by factors such as immigration driven by geopolitical events.

EXHIBIT 4



SOURCE: Jordan Department of Statistics

Amman, which accounts for 39% of the country's population or 2.4 million people today, would grow to 3.5 million people in 2030, assuming Amman's share of national population remains the same. The three remaining significant governorates account for another 39% of the population, spread across Irbid (1 million people), Zarqa (0.9 million people) and Balqa (0.4 million people). In all, 83% of people across the country live in urban areas, of which 84% live in these four largest urban areas.

DESPITE ALLOCATION POLICIES, WATER REQUIREMENTS WILL ALMOST DOUBLE BY 2030

Based on these growth aspirations, Jordan is likely to see significant overall growth in water demand for domestic, industrial and energy uses. Water demand in 2030 for each of these sectors was estimated based on specific requirements for each sector, e.g. for municipal demand, from water allocations defined by MWI and population growth projections and for energy demand, from current build-out plans for water-intensive generation technologies (see Box 1, "How should water demand, allocation need, and supply be defined").

Overall water demand is expected to almost double from 866 MCM supplied today to ~1,550 MCM by 2030, mainly driven by strong growth in municipal water demand, new energy industries and extension of water-intensive mining industries.

BOX 1

How should water demand, allocation need, and supply be defined?

A working understanding of water resource demand and supply is a required point-of-departure for our analysis.

We use **demand** to refer to an unconstrained demand, or the projected water requirements if efficiency is unchanged and the policy environment is static. This demand is measured as the actual withdrawals from surface water, groundwater or nonconventional sources (for example, desalination). A portion of the withdrawn water may subsequently be available for other uses, depending on the time, place and quality of the “return flow”. In defining water demand, the choice of focus on withdrawals differs from a focus on consumption, which is the net between the initial withdrawal and any return flows.

Jordan is a severely water constrained economy with a steep marginal cost of supply. Therefore, in addition to unconstrained demand, we consider **allocations** for two user sectors – agriculture and municipal use. Given the current situation of water scarcity, in the case of agriculture, the Government of Jordan has a stated policy of limiting agricultural water use to current levels to be able to provide water for municipal and industrial use. In the case of municipal use, the Government has stated targets of litres per capita per day at-tap supply for domestic use. For the purposes of this study, the **2030 allocation need** was derived by combining the **allocation need** for agriculture and domestic use with the unconstrained **demand** from industrial, commercial and energy use.

We assess water **supply** to be current financed, accessible, safe yield supply. To calculate this, we considered the water supply flow (for surface water) and abstraction (for groundwater) for a typical year (2009 for the analysis in this report). In order to ensure sustainability, we decreased this total by the amount of current groundwater overabstraction. We also added the supply capacity under development by the currently funded project stream. While other plans for supply augmentation exist, these were not included in the calculation of current financed, accessible, safe yield supply. Rather, we have considered these plans in the range of solutions available for providing the future allocation need.

Future supply of water in Jordan will also be affected by changes in precipitation brought out by climate change. Detailed analysis in Mexico and other countries has shown the climate change will reduce future precipitation , thus decreasing supply from current infrastructure and requiring further supply augmentation and demand-side efficiency. This report does not estimate the impact of climate change in decreasing future available water resources or in increasing the direct and indirect demand for water due to higher temperatures, or in causing more volatile precipitation and runoff patterns.

All demand and supply figures are calculated at the **bulk water level** in order to make demand comparable across sectors and also against bulk water level supply. Compared to demand at the demand unit, e.g. tap in municipal uses or crop in agricultural uses, bulk water level figures also account for the losses in any conveyance infrastructure, e.g. NRW in municipal systems and inefficiencies in conveyance to farm units and irrigation systems. The current IDARA programme and the Water Demand Management Unit have been running municipal efficiency programmes that have already seen an increase in water efficiency which has been included in the current baseline. They will play an important role in implementing solutions such as efficient toilet, showers and taps that are discussed further and detailed in the appendices.

The projected demand by sector is as follows (Exhibit 5):

- **Agricultural** demand will be limited through existing allocation policy decisions that focus on the use of treated waste water, and limit water supply to current consumption levels (about 500 MCM) by driving efficiency and crop mix changes. It should be noted that this figure does not include unreported groundwater abstraction especially in the Highlands.
- The high population growth in cities will see demand for **municipal** water supply more than double between 2009 and 2030, driven by the projected growth in population. This projected growth in municipal demand factors in the Government’s targets for providing at-tap supply (post non-revenue water losses) of 120 litres per capita per day (l/c/d) in Amman, 100 l/c/d in other urban centres and 80 l/c/d in rural areas. (See Box 2, “Calibrating Jordan’s municipal water demand”.)
- Planned **industrial** growth will require a sharp increase in water demand, from 36 MCM in 2009 to 150 MCM by 2030, driven largely by mining and planned

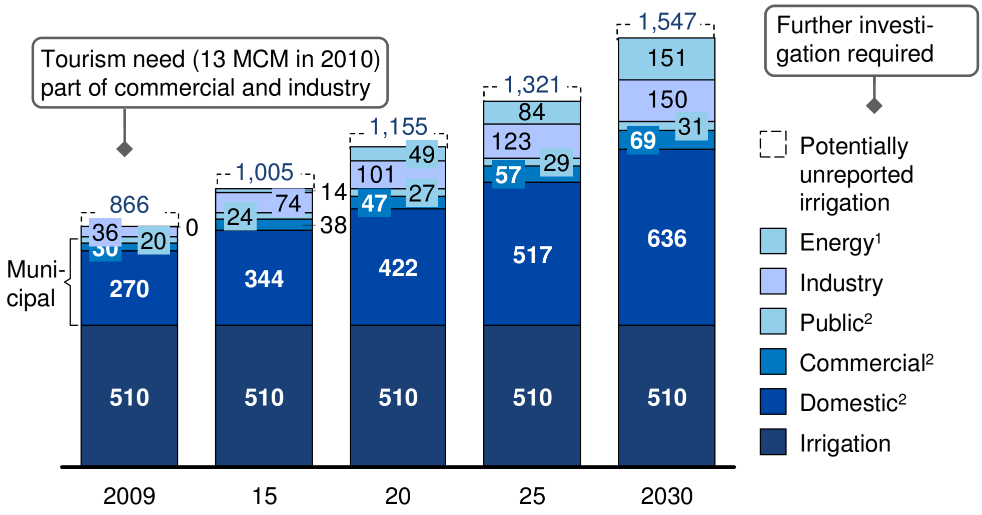
economic zones. Other sectors such as tourism and petrochemicals the will be further drivers of industrial demand.

- Water requirement for **energy** will increase from a negligible demand today to about 150 MCM by 2030, driven mainly by requirements for the up to four nuclear reactors planned. (See Box 3, "Water demand from future nuclear power generation".) Plans for uranium and oil shale mining will require additional water. Changes to Jordan's energy mix plan such as a move to higher degree of renewables (solar cells and wind) could reduce the future water demand but will be expensive and have higher intermittency than the current nuclear build-out plan.

EXHIBIT 5

Water allocation need

MCM, bulk water allocation need



1 Water demand for nuclear generation assumed at 30 MCM/year per GW; Solar CSP plants currently under consideration
2 Municipal allocation need projected for 2030 assuming constant growth rate for 2015, 2020, 2025

SOURCE: MWI, PMU Allocation Plan, IDARA, WAJ, JVA, DOS; Ministry of Industry, Natural Resources Authority, JAEC, team analysis

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BOX 2

Calibrating Jordan's residential water demand

Today, residential water supply in Jordan is 270 MCM at the national, bulk water level, including non-revenue water (NRW) losses of 44% in the municipal system. This represents 153 MCM of water delivered to households "at the tap", translating to 70 litres per capita per day. This low per capita water use is due to limited and intermittent domestic water supply with the additional inherent domestic demand supplemented by expensive water supply from tankers.

NRW includes both physical and administrative losses. Physical losses refers to water lost through leakage throughout the distribution network. Avoiding or reducing physical losses will increase the water delivered to the tap and hence, decrease the bulk water demand in the municipal network. Administrative losses refer to water lost through theft and municipal water supply that is not billed or collected on. While this water is physically used, reduction in administrative losses can reduce demand slightly by ensuring that users pay for their consumption and the collections on the water supplied support further investment into the municipal system and user efficiency.

MWI has taken an allocation policy decision (PMU policy note) for the provision of residential demand in 2030, setting targets for delivery of water at the tap to residential users as follows:

- Amman (urban): 120 liters per capita per day (l/c/d)
- Urban population: 100 l/c/d
- Rural population: 80 l/c/d

Assuming today's share of urban and rural population remains roughly the same, 83% of people will live in urban areas in 2030 and receive 120 l/c/d per capita in Amman, or 100 l/c/d per capita in other areas. The remaining 17% would live in rural areas and receive an allocation of 80 l/c/d per capita.

Based on the Department of Statistics' population growth projections, 9.1 million people will be living in Jordan in 2030. According to the allocation policy set out above, this population would receive a total 636 MCM of bulk water, including NRW at today's rate of 44%. This would translate to 357 MCM at the tap, or an average of 107 l/c/d per capita, an increase of 53% on today's level.

This allocation will without doubt increase today's standards of living significantly allowing people to use more water for their daily uses.

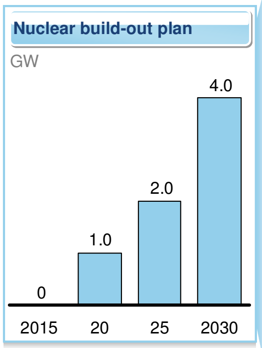
BOX 3

Water demand from future nuclear power generation

The Ministry of Energy and Mineral Resources (MEMR) and Natural Resources Authority (NRA) plan four 1 GW nuclear power plants by 2030. Water demand from these plants will be substantial, but will vary significantly depending on the locations and technologies chosen (Exhibit 6).

EXHIBIT 6

Preferred option



Cooling options and water estimates

MCM, water demand per 1 GW installed capacity running at ~90% availability

Location	Technology	Water MCM	Own power MW
As-Samra (desert area, treated waste water available)	**Mechanical tower** (waste water)	22-30 +0.8 (freshwater)	8
	Natural draft (groundwater)	> 30 +0.8 (freshwater)	2
Aqaba (seashore)	**Desalinated water**	60 - 70	8
	Natural draft (seawater)	>100	2

SOURCE: JAEC; MWI; team analysis

The location of the plants could be either in the south near Aqaba and the Red Sea, or north-east of Amman near the As-Samra water treatment plant – the currently preferred location due to its low water requirement (22-30 MCM per year for 90% availability of 1 GW capacity) driven by its location in the desert. A location near Aqaba and the Red Sea was the preferred choice until 2010 due to its proximity to sea water for cooling. However, the location's situation on a fault line with high earthquakes risk has raised concerns against the location.

The preferred technology is a mechanical cooling tower, which uses fans powered by electricity to cool down the plant, reducing water needs significantly. Alternatively, natural draft from groundwater could be used for cooling, but this would require significantly more water than 30 MCM.

Final decisions on these questions have not been made and are subject to the IPP bidding process, which is currently ongoing. Water is already an important criterion in this process, as water-efficient technologies are being selected and decisions are taken based on water need. This should continue to be in the focus of the bidding process, in order to make sure reliable water can be supplied, and that it is used in the most efficient way possible.

BASED ON CURRENTLY FUNDED PLANS, JORDAN CAN PROVIDE SUSTAINABLE SUPPLY OF ABOUT 900 MCM

Jordan's total water supply in 2009, as set out in the MWI's water budget, was 866 MCM. Of this, 274 MCM was sourced from surface water, 480 MCM from groundwater, and the remainder from unconventional sources including treated waste water (103 MCM) and desalination (10 MCM).

Of the supply from groundwater, 158 MCM was sourced from over-abstraction (withdrawals above the safe abstraction rate of basins), and 71 MCM from non-renewable sources. Over-abstraction from basins is not sustainable: it depletes groundwater resources, leading to falling groundwater tables; and it decreases water quality of water from these sources due to higher salinity

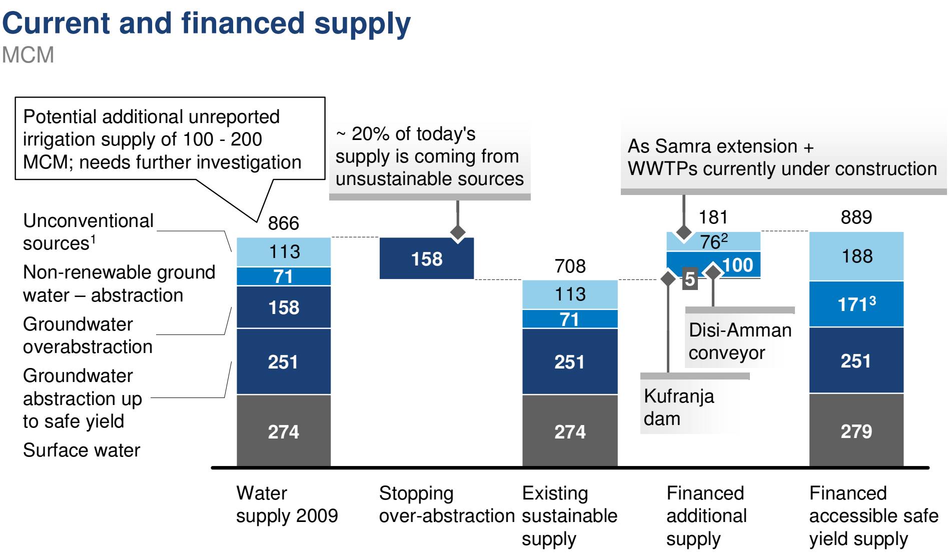
An assessment of Jordan's water supply that accounts for sustainable sources only would therefore need to exclude 158 MCM from over-abstraction. This leads to the country's existing sustainable supply being quantified at 708 MCM.

Jordan has currently committed and financed plans to expand water supply infrastructure in four areas:

- Disi-Amman conveyor (100 MCM).
- As Samra waste water treatment plant extension (45 MCM)
- Construction of new waste water treatment plants (31 MCM)
- Building Kufranja dam (5 MCM)

After completion of these projects, Jordan's total financed accessible water supply would total 889 MCM (Exhibit 7).

EXHIBIT 7



1 Includes desalination, treated waste water and transfers between governorates
2 45 MCM from As Samra plant extension and 30.5 MCM from WWTPs currently under construction
3 Includes 40 MCM above safe abstraction rate for Disi; requires decision regarding agricultural supply in Ma'an
Note: Numbers subject to rounding

SOURCE: MWI; WAJ; JVA; team analysis

Disi-Amman conveyor

Disi-Amman conveyor, a 325 km pipeline abstracting non-renewable water from the Disi area in the south of the country to Amman and the northern governorates, is currently under construction (30-40% completed) and is expected to be completed by 2013. The project is a Build-Operate-Transfer (BOT) project run by DIWACO (Disi Water Company), a public-private partnership formed by the Turkish GAMA company and the Government of Jordan. Financing has been conducted by DIWACO, including a $400 million equity stake on the part of the Government and a $100 million soft loan by AFD and the European Development Bank.

The exact allocation of the water from the project to the Disi area is still to be finalised, as the 100 MCM planned for transfer via the Disi-Amman conveyor is assumes that current abstractions for agricultural uses in the Disi area (40 MCM) will be stopped by the end of 2011. Failure to do so could result in abstractions from the Ram aquifer in excess of the safe abstraction rate – decisions will be needed on water supply agreements with the farmers in the area.

As Samra waste water treatment plant extension

As Samra is currently the largest waste water treatment plant in Jordan, treating most of its waste water. It is run as a 25-year BOT project with significant financing provided from international donors. Investment costs of $170 million have been financed by USAID (46%), a consortium of regional banks (36%), the BOT consortium (10%) and the Government of Jordan (8%). Expansion by 45 MCM has been committed for 2015, again financed largely by donors – in this case the Millennium Challenge Corporation (40%), money raised in the private market (47%) and the operating consortium (13%).

JORDAN WILL NEED AN ADDITIONAL 650 MCM OF WATER BY 2030

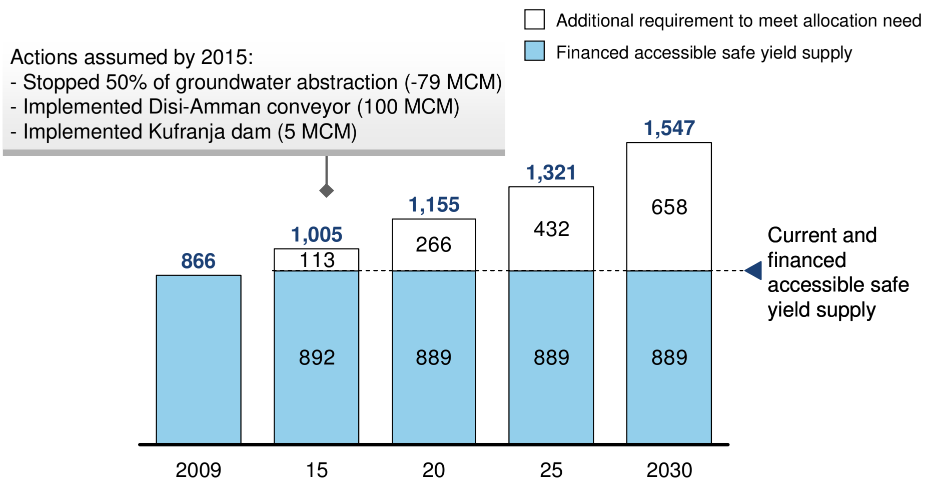
Jordan will therefore require approximately 650 MCM more water by 2030, on top of the currently financed sustainable supply of approximately 900 MCM, in order to meet a total projected water requirement in 2030 of approximately 1,550 MCM (Exhibit 8). This additional water will need to be phased over the next few years – the need will be 113 MCM by 2015, growing to 432 MCM by 2025 and 650 MCM by 2030.

This assessment assumes that all currently committed and financed supply projects – namely Disi-Amman conveyor, new wastewater treatment plants and Kufranja dam – will be implemented on time and realize their planned supply potential. This assessment also assumes that groundwater over-abstraction will have been be stopped by 2020, and that groundwater over-abstraction will already have been reduced by 50% by 2015, as per MWI's current plans.

EXHIBIT 8

Water requirement (2009-30)

MCM, bulk water supply and allocation need



SOURCE: Team analysis

Chapter 2
Opportunities exist for better water resource management

Jordan's current plans to meet its future water requirements are challenged by expensive supply options. The current low levels of water efficiency and productivity challenge the economics of Jordan's future **water economy**. This calls for step change in the productivity of water use and an acceleration in efficiency improvements over historic trajectories.

CURRENT WATER-USE EFFICIENCY IS LOW

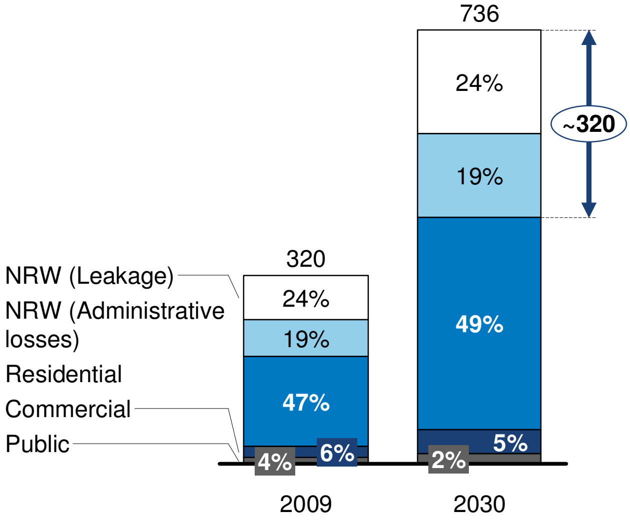
Water use is particularly inefficient in municipal areas, where non-revenue water (NRW) from leakages and administrative losses is as high as 43% on average and water-efficient appliances are not used or only reach a low penetration of ~5%.

To put this wastage in perspective: at current NRW levels, Jordan would lose some 320 MCM of expensive municipal water in 2030, equal to today's total municipal water supply (Exhibit 9).

EXHIBIT 9

Municipal demand

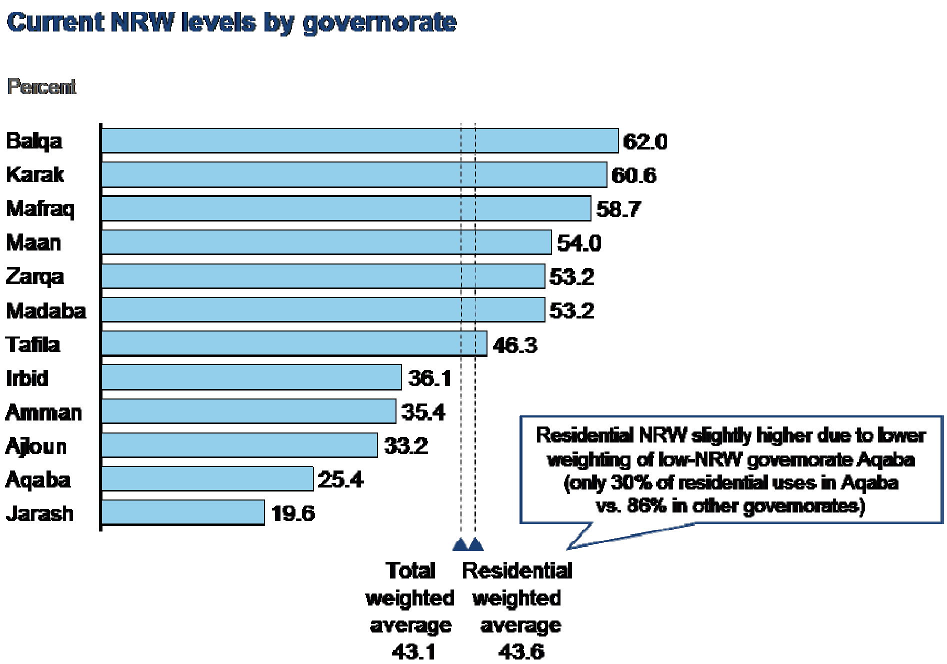
MCM



SOURCE: WAJ; IDARA "Water Efficiency Plan for Miyahuna"; MWI; team analysis

Municipal NRW levels vary significantly by city ranging from ~20% to >60% in places (Exhibit 10). Amman has recently seen an NRW reduction from 50% to 35% as part of a larger ~JD 250m restructuring of its water utility. NRW reduction programmes are being planned in several other cities.

EXHIBIT 10



SOURCE: Assessment of water use and efficiency in the Hashemite Kingdom of Jordan (September 2010); IDARA; team analysis

While Jordan generally makes good use of efficient irrigation technologies such as drip irrigation, penetration is inconsistent across different regions and governorates, leading to variable average efficiencies in irrigation systems (Exhibit 11). Irrigation efficiency for each governorate depends on three key factors:

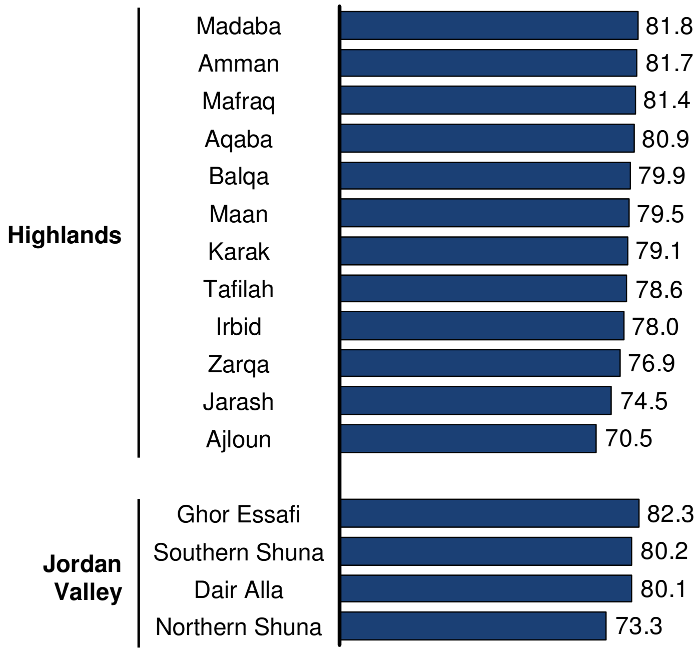
- Irrigation method used (e.g. drip: 84%; sprinkler: 75%; surface: 60%)
- Prevalence of each irrigation system per crop (e.g. onions use 28% drip, 43% sprinkler, and 29% surface)
- Prevalence of each irrigation system per region (e.g. Irbid uses 67% drip, 8% sprinkler, and 25% surface)

Furthermore, there are efficiency losses in distribution networks feeding from the King Abdullah Canal in the Jordan Valley, with overall conveyance efficiency estimated at 85% currently.

EXHIBIT 11

Irrigation system efficiency depends on irrigation method

Weighted average irrigation efficiency, %



SOURCE: NWMP; Department of Statistics; team analysis

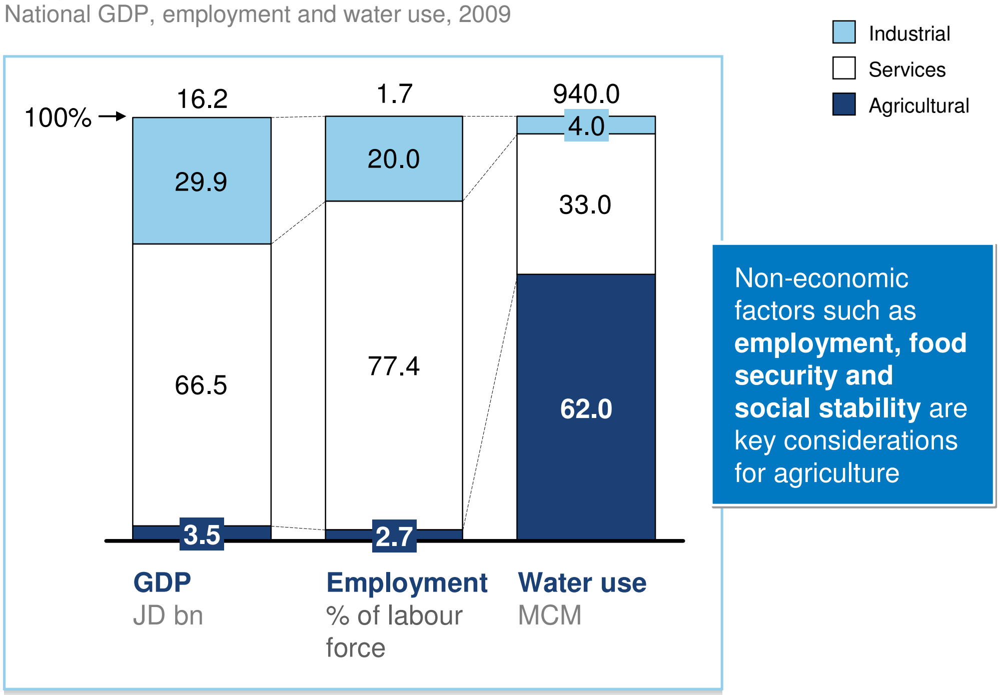
CURRENT WATER PRODUCTIVITY OF AGRICULTURE VARIES SIGNIFICANTLY AND MUST INCREASE

Agriculture is currently by far the largest user of water in Jordan, currently consuming about 60% of water supply. However, it is characterised by a disproportionately small contribution to both employment and Jordan's GDP (Exhibit 12). Even allowing for a higher employment and GDP contribution due to agro-industries such as food processing and transportation, the low economic and social contribution of agriculture is cause for concern. In addition, the importance of agriculture as a source of social stability and development in rural areas only underlines the need for greater GDP contribution and employment generation from agriculture.

EXHIBIT 12

Agricultural sector's economic contributions are not proportionate to its water usage

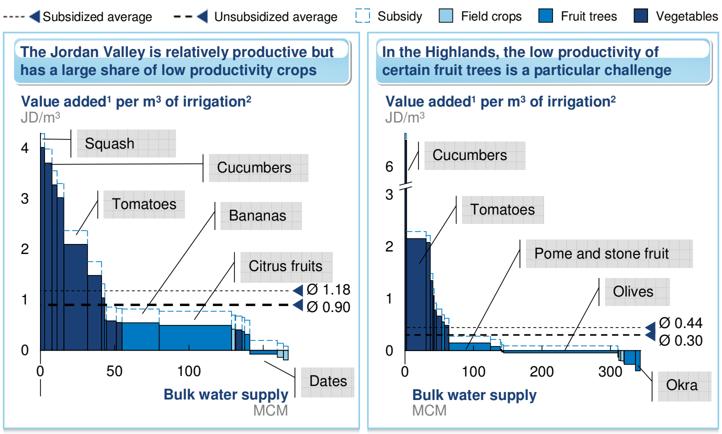
National GDP, employment and water use, 2009



SOURCE: CIA World Factbook; Jordan National Water Strategy; team analysis

Based on these assessments, this study compared the value add of each main crop, separating the Jordan Valley and the Highlands (Exhibit 32). On the graph, value-add per cubic meter of actual current water supply is plotted on the vertical axis, and current supply on the horizontal axis. Tall spikes on the left of each graph represent high-value-add crops, driven by high prices or high per-hectare productivity. Crops which fall below the horizontal axis destroy value from an economy point-of-view:. Note that the graph shows both subsidized and unsubsidized value-add. (See Box 4 – “Calculation of value-add)

EXHIBIT 13



1 Value-added defined as profits plus wages from agriculture 2 Bulk water supply – includes water lost through distribution

SOURCE: Ministry of Agriculture; Department of Statistics; Agricultural Credit Corporation; team analysis

We generally see higher crop productivity in the Jordan Valley of 0.90 JD/m³ on average after exclusion of subsidies – although it has a large share of low productivity crops, including bananas, citrus fruits and dates. In the Highlands, the low productivity of fruit trees is a significant challenge bringing down average productivity to 0.30 JD/m³ excluding subsidies. In particular, the analysis found that that the value added of olive cultivation, which dominates the Highlands, is lower than the cost of the water consumed – making olives on average a value-destroying crop after removing the effects of subsidies (see Box 5, "The olive story").

Box 4
Calculation of value-add

This study analysed the economic value added of the main crops cultivated in both the Jordan Valley and the Highlands. Value add is defined as the sum of **profits to landowners** and **wages to farmers**, less the **value of subsidies** that go into water, including energy subsidies for water (such as subsidized fuel or electricity used to operate pumps for groundwater abstraction). In this analysis, we take the economy view of the value-add provided by agriculture; for example, the farmer may be able to make a profit growing a certain crop, but cultivation of that crop may generate negative value add for the economy overall.

The **costs** used to calculate value add include all costs needed to produce the crop (such as fertilizers, seeds and pesticides) and distribute the harvest to market (packaging, transport, etc.). Labour costs are not considered because they are included in the value add from the agricultural economy. **Revenues** are estimated based market prices which vary depending on where the crops are sold (there are regional variations within Jordan as also between exported crops and those for local consumption). **Value add** is the difference between the revenues and factor costs.

In assessing the value add of crops, **subsidies** are estimated as the difference between the true cost of water and the average water tariff paid, both of which vary between the Highlands and the Jordan Valley. The cost of water supply in the Highlands is lower and therefore the subsidy is also smaller (mostly in the form or energy subsidies for groundwater abstraction. In the Jordan Valley, by contrast, there are significant capital, operation, and maintenance costs associated with King Abdullah Canal and its associated distribution network.

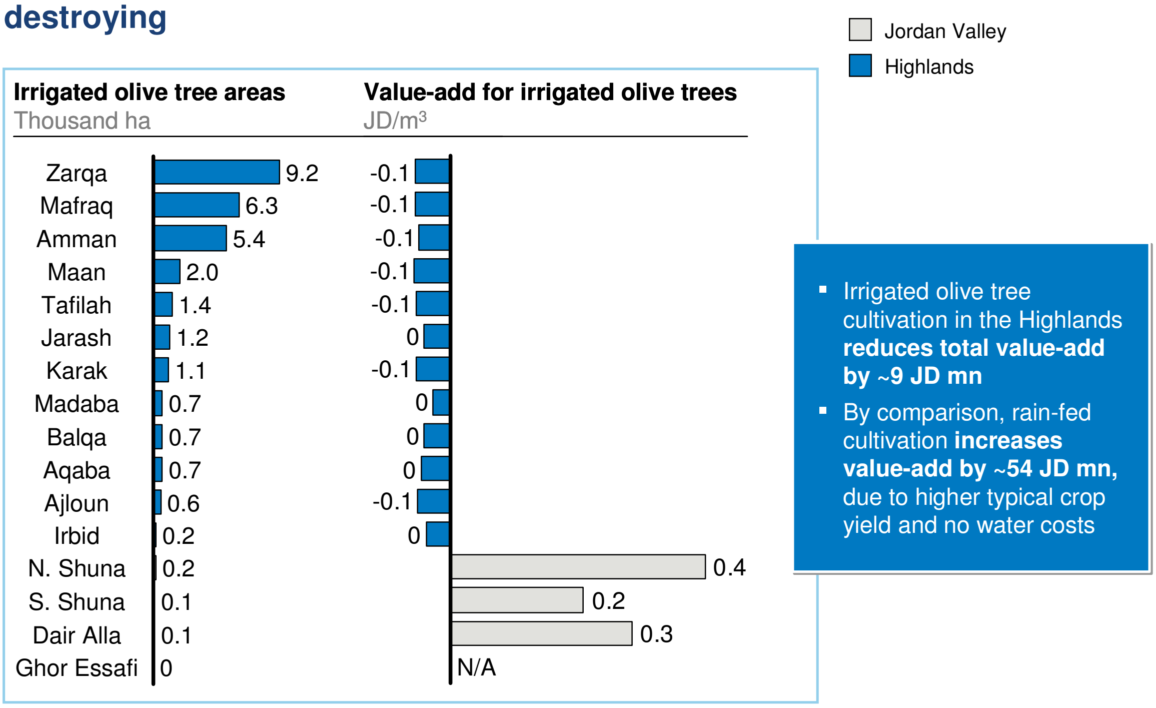
Box 5
The olive story

Cultivation of olives is very ingrained in Jordanian culture with a long tradition of rain-fed olive cultivation. While rain-fed olives still are an important source of olive production in Jordan today, the increasing cultivation of olives with significant supplementary or full irrigation needs to be explored further. In several cases, once the effect of subsidies has been taken into account, irrigated olives destroy value for the amount of water they consume.

In all the Highlands areas analysed, the irrigated value add of olive cultivation is negative – resulting in value destruction of roughly JD 9 million across all these areas. By contrast, irrigated value add for olive cultivation in the Jordan Valley is positive, to the tune of JD 1 million (Exhibit 14).

EXHIBIT 14

Irrigated cultivation of olive trees in the Highlands is largely value-destroying



SOURCE: Ministry of Agriculture; Department of Statistics; Agricultural Credit Corporation; team analysis

In the Highlands, the yield of olives is 1.7 Metric Tons per hectare (MT/ha) for rain-fed cultivation, as against 1.6 MT/ha for irrigated. Compared to the Jordan Valley these yields are extremely low – in the Jordan Valley, rain-fed olives produce 29.2 MT/ha and irrigated olives produce 15.2 MT/ha. The lower yield in irrigated areas is likely due to the fact that rain-fed olives are in areas where rainfall is adequate to meet the trees' needs, whereas actual irrigation practices in non-rainfed areas often do not provide the olive trees with as much water as they need.

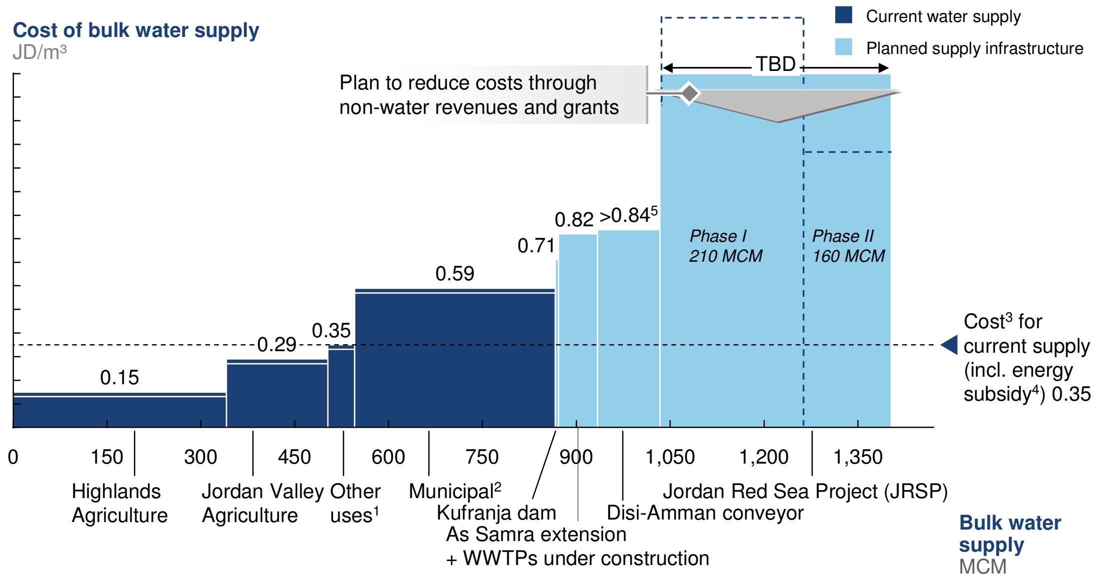
A recent study of farming practices in the Highlands found olive tree orchards where the trees were much smaller than would be expected for their age, and this was attributed to irrigation practices which do not provide adequate water for the trees' requirements. Also, water requirements vary in different agro-climatic zones: in the Highlands, irrigation requirements for olive trees are some 30% higher than in the Jordan Valley.

Jordan will also need to consider how to improve the value add from other elements of the olive value chain, such as olive oil. There could be better export markets for olives that could be tapped. More pilots and primary data on actual irrigation behavior is needed, especially to understand to what extent irrigated olive cultivation is about supplementary irrigation of land which is primarily rain-fed. Finally, Jordan will need to look at farmer-level economics, in terms of the large investment in olive orchards and the longer horizon for payoff – compared to vegetables or field crops, which are planted and harvested each season.

HIGH COSTS AND RISKS OF FUTURE WATER SUPPLY PROJECTS

Water in Jordan is already expensive by global standards, at 0.35 JD/m^3 (for example, the average cost of potential future water supply solutions in India is 0.04 JD/m^3, in China 0.11 JD/m^3, and in South Africa 0.12 JD/m^3). However, plans for future water supply such as Disi Conveyor and the Jordan Red Sea Project (JRSP) will result in much more expensive water at marginal cost of supply >0.8 JD/m^3. Based on high level outside-in estimates, Jordan's water cost will stand at 0.9 JD/m3 in 2025 after the completion of the Phases I and II of the JRSP (Exhibit 15).

EXHIBIT 15



1 Includes industry and livestock, which have not been analyzed in detail; assumed average costs of current supply in other sectors
2 Cost of tap water supply: 1.33 JD/m^3 3 Weighted average cost 4 Assumed that water sector share of energy demand (15%) also applies to share of subsidy provided to energy sector of JD 100m – therefore included a subsidy of JD 15m on 866 MCM of supply translating to 0.02 JD/m^3
5 0.84 JD/m^3 based on BOT price excl. potential subsidy from GoJ equity holding and energy cost
SOURCE: MWI; WAJ; JVA; team analysis

The cost of supply sources has been calculated on a bulk water level accounting for specificities of water supply per sector and different types of infrastructure used. Annualized capital cost and operating costs have been considered across WAJ, JVA and the water companies to estimate cost of supply for each source with calculation details provided in the appendices.

Highlands agriculture receiving water at a cost of 0.15 JD/m^3 is mainly irrigated by groundwater wells, which account for ~60% of water resources at an estimated cost of 0.07 JD/m^3. However, 20% of sourced from more expensive treated waste water (0.34 JD/m^3) as well as imports from WAJ (0.57 JD/m^3).

Jordan Valley agriculture receives water at a cost of 0.27 JD/m^3, ~95% of which are sourced from King Abdullah canal, which is operated by the Jordan Valley Authority (JVA). Based on a review of JVA's 2009 P&L with the JVA Finance Department, the cost of operating the water delivery infrastructure in the Jordan Valley is estimated at 0.21 JD/m^3 (including the annualized capital expenditure). On top of this, the BOT price for treated waste water provided from As-Samra treatment plant paid for by WAJ (0.20 JD/m^3) increases cost for water provided to Jordan

Valley farmers further. The remaining ~5% of water provided to Jordan Valley agriculture are sourced from less expensive groundwater abstraction (0.07 JD/m³).

Municipal bulk water cost of 0.57 JD/m³ for delivering ~320 MCM can be estimated by taking into account bulk water supply prices charged by WAJ to water utilities and the cost recovery needed on top of this price. For the biggest municipality Amman, WAJ delivers bulk water to the water utility Miyahuna at a price of 0.21 JD/m³. Based on a review of the WAJ P&L 2009 with the WAJ Finance Directorate, WAJ would need to increase its revenues by 172% in order to achieve cost recovery on its current losses, which would translate to a true cost of municipal water of 0.57 JD/m³ including a 0.36 JD/m³ difference needed to recover costs.

New supply will be even more expensive than the current supply of municipal water. This is mainly driven by the two new big water supply projects Disi-Amman conveyor and JRSP.

Water delivered from the Disi-Amman conveyor (100 MCM) is currently expected to be charged to WAJ at a BOT-price of 0.84 JD/m³ on average over 25 years. This price will cover all cost of financing and operating the project under the current BOT agreement with DIWACO. However, further subsidies could increase the true cost of water but have not been taken into account here (e.g., financing cost incurred for the government's equity holding and subsidized cost of energy applied in the water sector).

For JRSP, the cost of freshwater supplied to the country will be higher than all other current and future sources of water supply (see Box 6, "Jordan Red Sea Project (JRSP)"). The ongoing RFP process for JRSP will detail the future cost of water from this project based on the specific proposal by the future BOT consortium: This proposal will not only depend the cost of building and operating the water supply infrastructure but also on the grants received for financing as well as additional revenue streams (e.g., from development projects along the JRSP corridor) which could decrease the cost of water further.

Box 6
Jordan Red Sea Project (JRSP)

The Jordan Red Sea Project – goals and plans

With an investment in the region of JD 8-10 billion, Jordan is planning a mega-project to provide desalinated water to Jordan and refill the Dead Sea. It should be noted that there are two similar proposed projects to connect the Red with the Dead Sea: The Red-Dead Project, a regional project in collaboration with Israel and the Palestinian Authority; and the Jordan Red Sea Project, a Jordanian version of the project (Exhibit 16). For the purposes of this study, the latter project is assessed.

The JRSP's project goals are to:

EXHIBIT 16

- Convey approximately 2,000 MCM of seawater from the Red Sea to the Dead Sea
- Provide 930 MCM of desalinated freshwater to Jordan
- Refill the Dead Sea with the remaining brine
- Use JRSP as a basis for further economic development in the region (for example, new urban centers, resort areas, and gated communities)

Source: JRSP Company

The Government of Jordan is currently in the midst of a bidding process to identify a master developer for the project by the end of 2011 and move to implementation planning in 2012. The JRSP's water infrastructure is planned to be built in five phases spread over the next 40 years (Table 1).

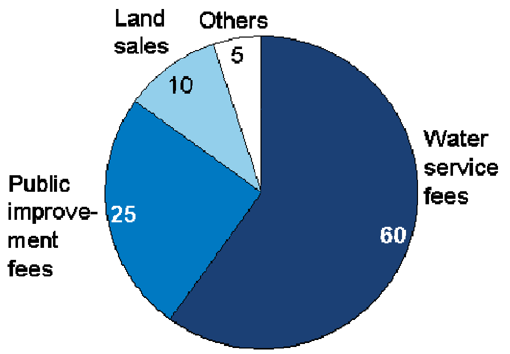
TABLE 1

	Freshwater production for Jordan	Brine used to refill the Dead Sea
Phase 1 (2018)	210	190
Phase 2 (2025)	160	140
Phase 3 (2035)	190	180
Phase 4 (2045)	160	570
Phase 5 (2055)	210	140

It should be noted that the business case of JRSP is very dependent on revenue streams not originating from water: approximately 40% of all revenues would accrue from non-water sources such as public improvement fees and land sales. The project, therefore, relies on the success of the envisioned large-scale urban and resort development programme.

EXHIBIT 17

Potential revenue sources
Percent



SOURCE: MWI; JRSP investment brochure, Infrastructure Journal; team analysis

Challenges and risks in supply projects

In order to achieve future water security, Jordan requires both an efficient and productive water economy as well as additional supply-side projects, which can ensure long-term security of water supply. JRSP is such a critical project for the future, which by itself would increase Jordan's water supply by more than 40% over today's supply by 2030 (370 MCM) and could more than double water supply by 2050 (930 MCM).

To ensure successful completion and operation of such a project potential challenges need to be recognized and addressed – including in financing, the viability of the business model, and implementation.

With a total financing requirement of JD 8-10 billion, JRSP would be the most expensive water project globally in the last five years; only projects in the oil and gas and power sectors have attracted investments of this magnitude. Even if only the JD 3 billion investment required for Phase I is taken into account it still stands out as one of the largest projects in the world especially in the water sector:

- Out of public global water infrastructure projects financed between 2005 and 2010 the next biggest water infrastructure projects are Victorian Desalination project currently under construction in Australia at an investment cost of ~ JD 4bn and the JD 2.5 bn Saur portfolio acquisition conducted in France in 2007.
- Even amongst all gobal mega-infrastructure-projects financed between in the few last years (2008-10), JRSP is among the biggest compares in size to projects in the oil and gas sector, e.g. ExxonMobil's PNG LNG project Phase I in Papua New Guinea (JD 12.9 bn), the Asia Trans Gas Pipeline (JD 7.8 bn) and the Saudi Kayan Petro-chemical Complex in Saudi Arabia (JD 7.1 bn).
- In addition, keeping in mind the recent economic situation in the world and political situation in the Middle-East, financing investments of this size could represent a challenge.

Furthermore, while the business case for JRSP will be developed as part of the international tender process, the high reliance on non-water revenues in JRSP's business case could put the economic viability of critical future supply at risk. Reduction in the realized revenues in these cases will result in increased water prices to the Government of Jordan.

Finally, such large infrastructure projects require complex planning and coordination in order to overcome critical risks over the project's timeframe from planning to operation:

- **Finance risks**: Access to adequate capital at good rates, even after being completed in the initial financing phase, can be a risk at later stages, e.g., due to changes in the project's debt-equity ratios during the course of the project, refinancing needs at later stages under different market conditions and the reliance on state guarantees for debt in a new financial market environment.
- **Construction risks**: Overruns in time and cost can increase financing requirements as well as put the on-time delivery of much needed water at risk. This could be driven by several internal and external factors, such as underestimation in planning, delays in supply of key infrastructure elements or changes in national and global market prices.
- **Operational and maintenance risks**: Operating and maintenance cost can be impacted especially by increases in factor cost, mainly energy and labour,

as well as by unforeseen events, such as higher maintenance requirements than initially planned for.

Other desalination options could be considered as alternatives to JRSP to reduce the cost (e.g., link to Disi-Amman conveyor as part of a national water grid). International benchmarks indicate desalination costs in the region of JD 0.6/m^3 which could apply with additional transfer costs to alternatives. The final costs of JRSP need to be evaluated in the context of viable non-water revenue streams and the benefits of refilling the Dead Sea.

Chapter 3
Ensuring a water-secure economic future: roadmap for an integrated solution

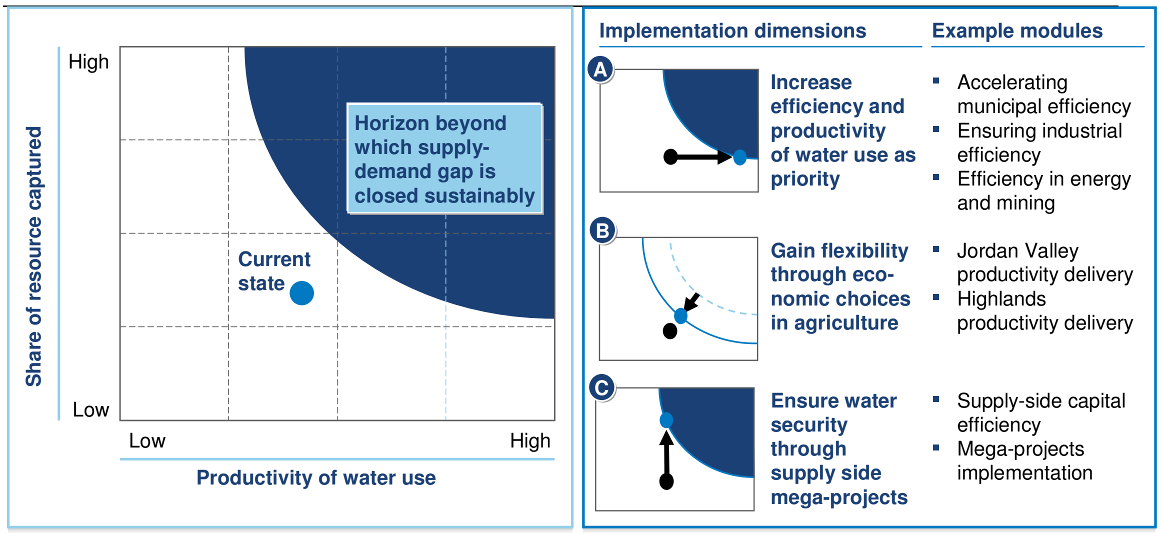
Jordan has already been using the National Water Master Plan in conjunction with the Water For Life Strategy and specific focus initiatives such as IDARA, the Demand Management Unit and the Highland Water Forum to drive an integrated programme of water management

However, given the scale of the challenge ahead, we recommend that to address its water challenges and ensure a water-secure economic future, Jordan needs to craft a roadmap for an integrated solution, spanning three dimensions (Exhibit 18):

- Increasing the **efficiency and productivity** of water use as a priority
- Gaining **flexibility** through economic choices in agriculture
- Ensuring **water security** through supply side mega-projects

This chapter examines each of these dimensions in turn. To assess possible solutions on both the demand and supply sides, it sets out water "cost curves" which compare the potential and cost of each individual demand or supply measure (see Box 7, "Assessing the cost of delivering water – the cost curve for incremental water availability".)

EXHIBIT 18



SOURCE: 2030 Water Resources Group

Box 7
Assessing the cost of delivering water – the cost curve for incremental water availability

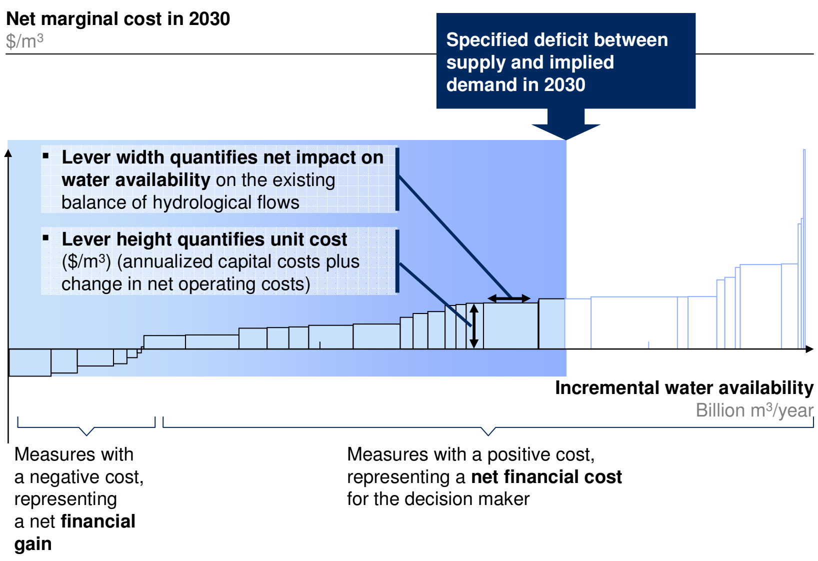
To close the gap between projected demand and existing supply for a particular basin, the possible solutions can be prioritised on a cost curve (Exhibit 19).

The cost curve's horizontal axis measures the amount of water made available by each measure to close the supply-demand gap. In applying the cost curve in the case study countries, we estimated the net impact of each measure on water availability, taking into account return flows (the water that, once withdrawn and used, flows back into the system). Some measures are more complicated than others to estimate – drip irrigation being a case in point. At a farm level, drip irrigation can have massive efficiency impacts, but at an aggregate level the impact could be different: by reducing return flows, this measure could actually reduce the supply available to others currently dependent on these flows and therefore diminish the true aggregate impact on closing the gap.

The vertical axis of the cost curve measures the cost per unit of water released by each measure in the year of the cost curve. This is the annualized capital cost, plus the net operating cost compared to business as usual. These are costs as measured from an integrated view – in other words the actual financial savings, rather than redistribution effects such as subsidies.

EXHIBIT 19

The water cost curve and specified supply-demand deficit



SOURCE: 2030 Water Resources Group

The wider a measure on the horizontal axis, the larger its net impact on water availability to close the supply-demand gap. A measure's height on the vertical axis, on the other hand, indicates its financial cost – or savings – to the decision-maker.

Such a solution would require a fundamental change in the way water resources are managed in Jordan. Today's approach is characterised by:

- Independent planning and decision-making driven by individual ministries;
- Department-level cost allocations with cross-subsidisation across users hiding the true cost of water provision for each use;
- Siloed focus on demand management, new supply creation and agricultural water use preventing a holistic approach to optimizing supply and demand;
- Multiple sources of data across departments and distributed accountabilities resulting in different "sources of truth" driving decision making

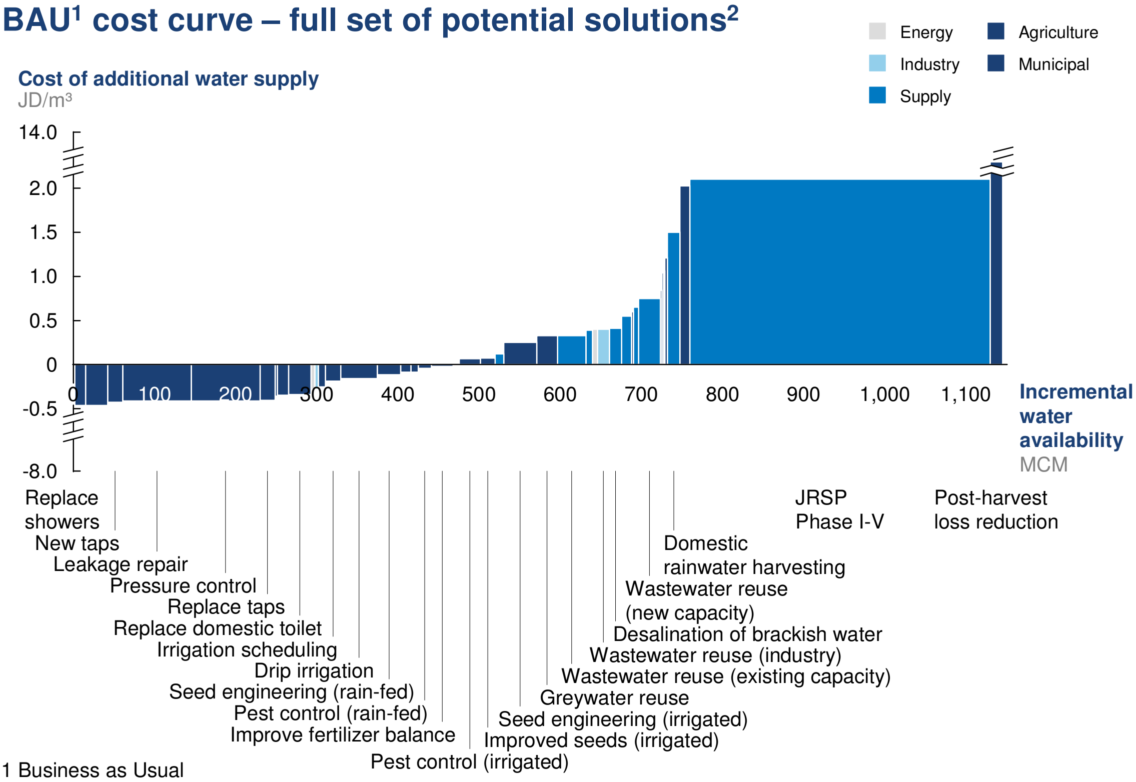
To achieve a water-secure economic future, we would recommend that Jordan move to integrated **cross-Ministerial planning and decision-making**, with water as a constrained resource **and transparency on the true cost of water** based on type of supply. An **integrated plan** could drive demand reduction and new supply generation across the economy; a single **integrated "source of truth"** could support decision-making within MWI and across ministries; regular **public-private dialogue** will be needed, along with sector-level initiatives driven by industry. Finally, a **comprehensive, binding and aligned road map** will help put in place, with central review and steering mechanisms.

FULL SET OF EFFICIENCY MEASURES AND SUPPLY OPTIONS

A comprehensive "cost curve" of potential demand- and supply-side solutions available to the Jordan could potentially yield more than 1,100 MCM of water by 2030 including 370 MCM from the supply mega project JRSP in Phase I & II (Exhibit 20). While this set of solutions seems to be more than sufficient to meet Jordan's additional water needs of ~650 MCM by 2030, several factors have to be taken into consideration to evaluate the country's options for the future and structure a program, which can provide true water security. These factors particularly include considerations on difficulty of implementation based on various dimensions, such as social, political and technical feasibility assessed for each solution individually. When prioritizing solutions for further investigation and implementation, both economic considerations as well as implementation challenges have been taken into account. While the "cost curves" seek to provide the most cost effective and implementable set of solutions to address Jordan's particular water challenge, funding the solutions could be challenging. Support from development agencies in implementing the appropriate set of solutions will be critical.

EXHIBIT 20

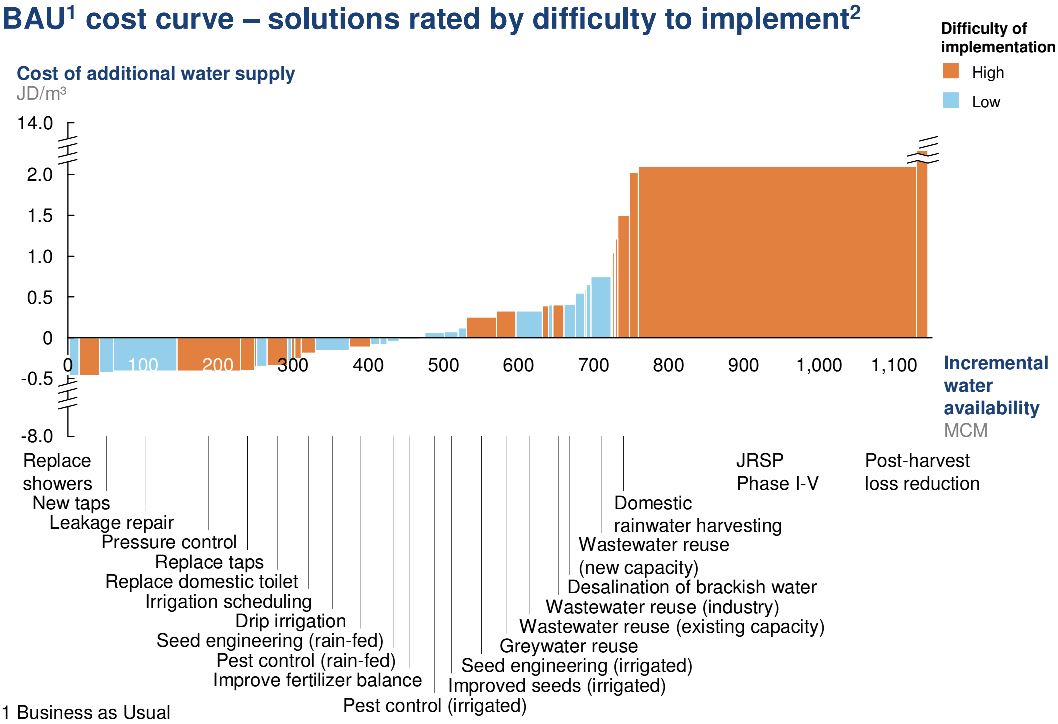
BAU[1] cost curve – full set of potential solutions[2]



1 Business as Usual
2 Solutions with volume potential <15 MCM are not labelled

SOURCE: MWI; USAID; team analysis

BAU[1] cost curve – solutions rated by difficulty to implement[2]



1 Business as Usual
2 Solutions with volume potential <15 MCM are not labelled

SOURCE: MWI; USAID; team analysis

Non Revenue Water reduction

As can be seen from the cost curve, two of the lowest cost – highest volume efficiency solutions are pressure control and leakage reduction which are two key municipal efficiency reduction levers that contribute to reduction of non-revenue water.

These levers are very dependant on type and number of specific losses in municipal systems and vary significantly based on local circumstances – therefore, specific detailed review of the savings potential and capital and operating costs per city and governorate is needed to refine the assessment of the cost and potential from the solution.

However, initial benchmarks position both leakage reduction and pressure control as a “must-do” solutions that are very cost-effective especially situations with a high cost of water as for Jordan.

Experience from Amman’s earlier significant NRW reduction program as part of a larger restructuring effort of its water utility from 1999-2009 reduced NRW from 50% to 35%. The overall program cost ~JD 250m including other initiatives such as corporatisation and a significant extension of water and sewage network coverage.

Internal experience indicates an annual investment of JD 30-40m in large cities to maintain low NRW levels. A benchmark by The World Bank estimates investment costs in range of 250-500 USD/m^3/day in developing countries with high NRW levels (examples from Bangkok and the state of Selangor in Malaysia). Based on a 165 MCM decrease in NRW for Jordan, 12 % interest rate and 10 year programme lifetime, a 20 year program would cost JD 240-480m in upfront investment or 0.09-0.17 JD/m^3.

Our analysis has assumed a range of JD 200-500m initial investment for the overall NRW reduction programme resulting in a unit cost of water saved of a very cost-effective 0.42-0.50 JD/m^3 due to the high current cost of municipal water. This is further enhanced by the more expensive water that will be delivered to Amman in future through the Disi conveyor and JRSP with cost of delivery exceeding 0.84 JD/m^3.

Further analysis is needed for this key solution to a water secure future, including a governorate and city-level review of on-going improvement initiatives and planned (but not funded) future improvement projects (which have been included in the cost curve). A further detailed analysis of specific leakages and optimisation opportunities outlining their detailed investment needs will be necessary to achieve a sustainable NRW reduction of 20%, which is a significant reduction on today's average NRW of 43% (which can be as high as 60% in some parts of the country).

INCREASED FLEXIBILITY THROUGH GREATER WATER PRODUCTIVITY IN AGRICULTURE

The low economic value add from some crops in agriculture provides opportunities for more productive use of water in agriculture. This study identified four scenarios of water use in agriculture – a business-as-usual scenario, and three others that can drive up the productivity of water use through changes to the cropping pattern:

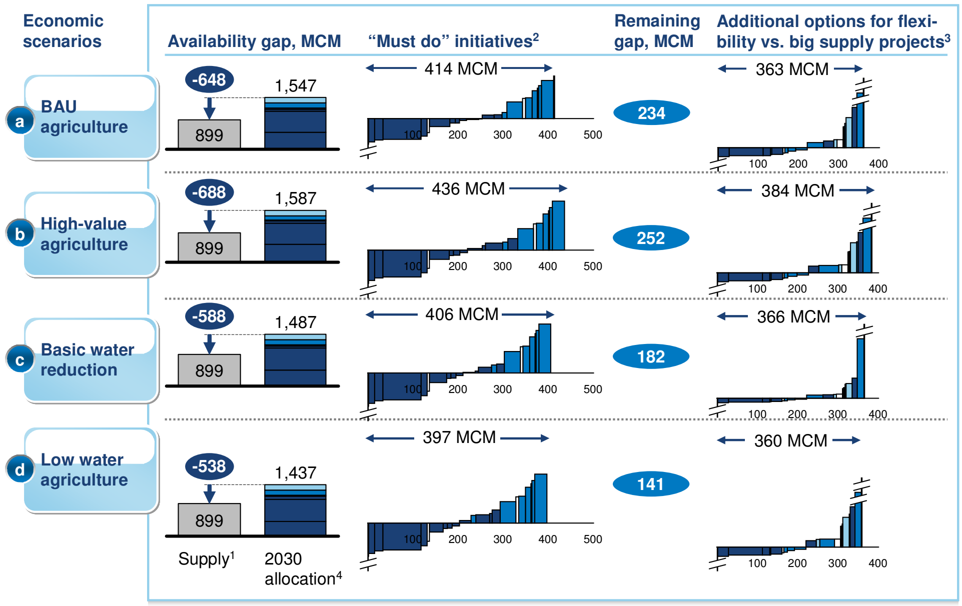
- **Business-as-usual agriculture** – Required to meet production targets according to current plans, crop mix and agricultural techniques. Jordan's annual water requirement for agriculture under this scenario would remain at current levels of approximately 510 MCM.
- **High-value agriculture.** This scenario would see an alternative crop mix which keeps current supply but expands irrigated land, by shifting water supply from water-intensive trees to high-value, low-water vegetables. The annual water requirement for agriculture would rise to 550 MCM.
- **Basic water reduction.** This scenario envisages an alternative crop mix which maintains current cultivated area but reduces overall irrigation demand: 25% of agricultural land currently under fruit trees would be shifted to high-value, low-water vegetables. The annual water requirement for agriculture would be reduced to 450 MCM.
- **Low-water agriculture.** This scenario also envisages an alternative crop mix on current cultivated area, but further reduces overall irrigation demand: 50% of agricultural land currently under fruit trees would be shifted to high-value, low-water vegetables[3]. The annual water requirement for agriculture would be reduced to 400 MCM.

MUST-DO EFFICIENCY AND SUPPLY MEASURES

Changing cropping patterns in line with the basic water reduction or low-water agriculture scenarios would provide Jordan with additional flexibility to balance difficult demand side measures with reduced water consumption in agriculture. The water savings of the low-water agriculture scenario, for example, would be 110 MCM compared to the business-as-usual scenario. This would make it possible to meet about 75% of Jordan's incremental 2030 water requirement through "must-do" demand management and efficiency measures, reducing the water needed from large supply projects (Exhibit 21).

[3] More aggressive crop change scenarios were discussed but excluded from analysis

EXHIBIT 21

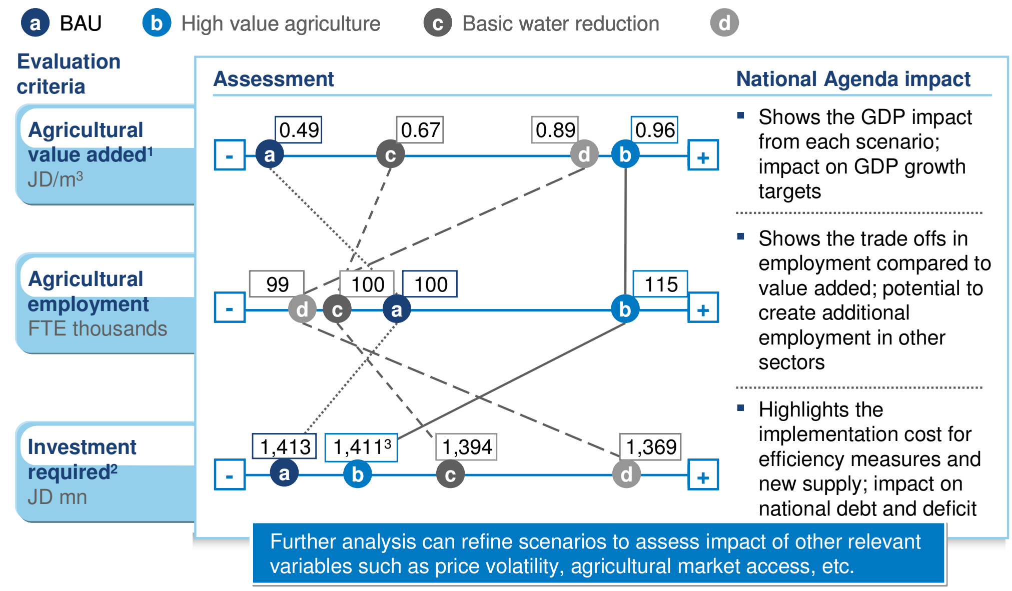


1 Financed, accessible, safe-yield supply in 2030
2 Low challenge solutions below current water cost
3 Solutions that are difficult to implement but can provide flexibility regarding timing of supply mega-projects, e.g. JRSP
4 Based on demand projections and allocation policies

SOURCE: Team analysis

Since the scenarios drive up productivity, they impact agricultural value add, agricultural employment and total investment needs – requiring decision-makers to consider trade-offs when identifying the most appropriate scenario to meet Jordan's priorities (Exhibit 22). While Jordan does not currently have a framework or law to balance economic and public good uses of water to allow the trade-offs needed, Exhibit 22 aims to support the cross-sectoral decision making needed.

EXHIBIT 22



1 Defined as profits plus wages less subsidies 2 Upfront CAPEX needed to close gap with "must-do" solutions and lowest cost "optional" solutions; does not include costs for implementing and supporting cropping pattern changes 3 Excluded greywater re-use lever due to high capex requirement to achieve a comparable scenario and replaced with seed engineering (slightly higher marginal cost, but no upfront capex needed)

SOURCE: Team analysis

The main dimensions along which trade-offs need to be considered are

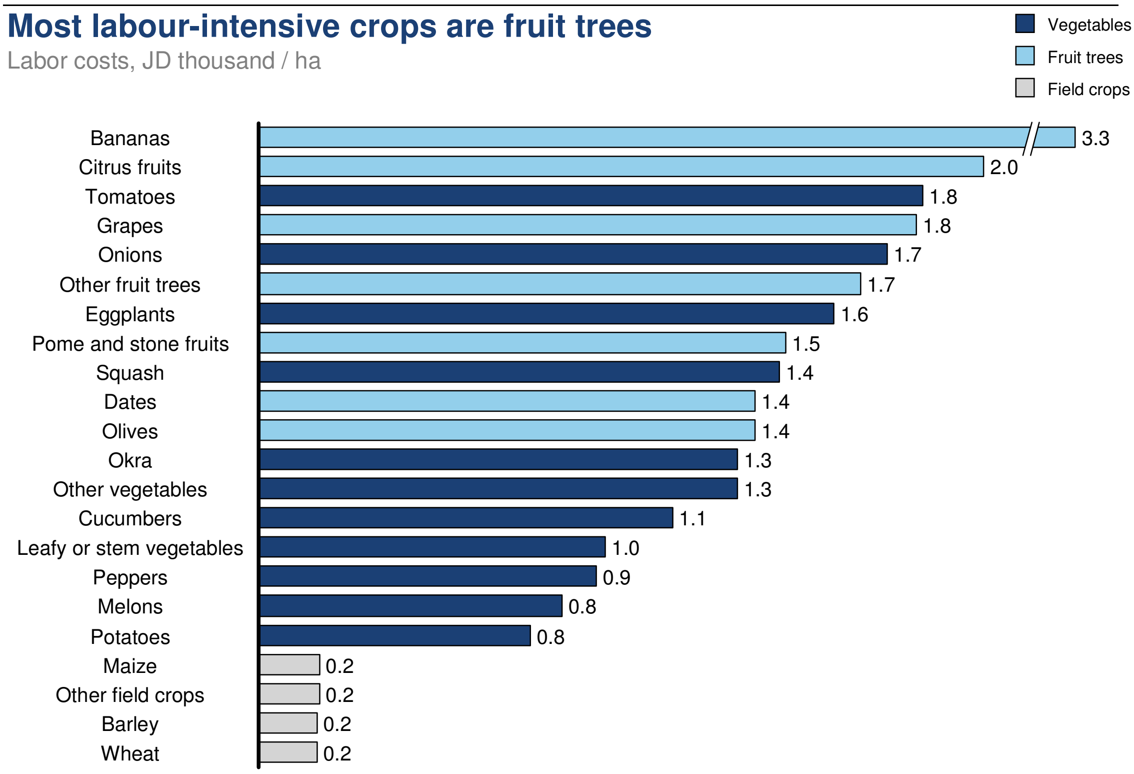
- **Value add** – The sum of profits to farmers and wages to agricultural labourers, this a key measure of the productivity of water use in agriculture. This impacts the 2017 National Agenda target for agricultural output per cubic meter (5 USD/m^3). This measure can be increased with higher profits and wages from the same water use or with less water use, which is why scenarios B and D both rate highly on this scale. **Value add does not currently include multiplier effects**, e.g., additional output at fertilizer companies due to increased agricultural production and value from the agricultural value chain such as transport and food processing.

- **Employment** - Number of full-time-equivalent jobs involved in crop production (Exhibit 23), this provides an indication of social implications of each scenario and contributes to achieving National Agenda overall 2017 unemployment target (6.8%). The major variation is in Scenario B, which is the only scenario to change areas under cultivation. Increasing area under cultivation is the most effective way of increasing employment in our scenario analysis. This effect counter-acts the per-hectare employment reduction that comes with a shift away from cultivation of trees to cultivation of other crops, which tend to be less labor intensive on a per-hectare basis. Our analysis does not account for nationality of workers – it is generally agreed that a large percentage of labourers in agriculture is non-Jordanian, particularly in the Jordan Valley where there are many workers of Egyptian or Pakistani origin.

EXHIBIT 23

Most labour-intensive crops are fruit trees

Labor costs, JD thousand / ha



SOURCE: Agricultural Credit Corporation – Agricultural Cost Guide (2005)

- **Capital requirement -** Total capital investments needed to implement technical cost-curve solutions to meet the 2030 water requirement at a national level for each of the scenarios across all sectors. This shows the effect of crop mix choices on the public and private cost of meeting future water needs. This impacts 2017 National Agenda goals for overall budget surplus (1.8% of GDP) and overall public debt (36% of GDP). This is impacted by the changes in agricultural water demand (and hence, the future water need) and the potential from agricultural efficiency measures due to changes in the nature of agricultural demand.

Other factors to consider include risk to farmers (some crops are considered more risky due to price fluctuations or susceptibility to disease) and value chain requirements such as storage, transportation, access to markets (especially export markets), technical skill requirements of different crops and the difficulty of implementing a shift in crop mix to those crops.

EFFICIENCY AND PRODUCTIVITY MEASURES CAN BE IMPLEMENTED BY ACCELERATING EXISTING INITIATIVES

Jordan should accelerate current demand management initiatives to capture the potential from efficiency measures across agriculture, municipal and industrial uses. Due to the complex cross-sectoral nature of the programme, each workstream should clearly outline an implementation roadmap with clear interim targets and review mechanisms. Current initiatives that can be leveraged include:

- **IDARA**, whose objectives include institutional capability building, increasing enforcement of laws and regulations promoting water-efficiency, and demonstration of solutions for water efficiency to the public. It has driven these objectives through a USAID-sponsored, multi-year programme conducted with big water utilities including Miyahuna, Aqaba Water Company and Yarmouk Water Company. IDARA has helped put in place an implementation and management framework across institutions; this is an ongoing, accepted effort, which has already built momentum in the municipal sector.
- The **Water Demand Management Unit**, the policy-setting unit for water-efficiency in the Ministry of Water and Irrigation, dealing with efficient water use in municipalities, with selective involvement in other sectors. The unit is participating in the IDARA programme, and is coordinating national efficiency programs with municipal utilities such as Miyahuna and Aqaba Water Company.
- The **Highlands Water Forum**, which is developing agricultural water policies jointly with farming communities. It consists of representatives from the local farming communities, Jordanian government bodies such as Ministry of Water and Ministry of Agriculture, and international development agencies such as GTZ and AfD. Its current efforts are focused on water-use policies and regulations for agriculture, particularly pricing and allocation issues. It serves as a platform to involve farmers, as the regulated party, in the formulation of more effective policies that are likely to be accepted. The Forum is focused on establishing a better model for working

with the farming community, finding ways to sustain agricultural economy while abating groundwater overabstraction. This is in recognition of the fact that previous regulations based on volumetric pricing schemes have not been fully effective.

To accelerate implementation of these measures, five workstreams focused on demand efficiency in their respective sectors are needed (Exhibit 24).

EXHIBIT 24

I Jordan Valley productivity delivery

- **Description:** Specially-formed team led by JVA and including relevant bodies in the agricultural sector and representatives of farming community in the Jordan Valley
- **Target outcomes**:
  - Implementation of technical levers
  - Transition to technical agribusiness
  - Long-term cropping pattern changes to increase value-add from agriculture
  - Increased returns to farmers through access to higher-value markets
- **Responsibilities:**
  - Lead: Jordan Valley Authority
  - Support: Ministry of Agriculture
  - Support: NCARE
  - Support: Agricultural Credit Corp
- **Current initiative:** Agricultural extension efforts, e.g. NCAR; Cropping policies, e.g. suspending summer vegetable cultivation due to dry conditions
- **Start date:** Immediately after establishment of cross-ministerial delivery unit

II Highlands productivity delivery

- **Description:** Specially-formed team led by Ministry of Agriculture, including relevant bodies in the agricultural sector, with particular emphasis on the Highlands Water Forum
- **Target outcomes**:
  - Implementation of technical levers
  - Transition to technical agribusiness
  - Long-term crop mix which sustains agriculture within safe-yield groundwater use
  - Full accounting of Highlands irrigation, with high adherence to policies and laws
  - Increased returns to farmers
- **Responsibilities:**
  - Lead: Ministry of Agriculture
  - Support: Highlands Water Forum
  - Support: NCARE
  - Support: Agricultural Credit Corp
- **Current initiative:** Highlands Water Forum; Ministry of Agriculture project to review agricultural economics; Agricultural extension efforts, e.g. NCAR
- **Start date:** Immediately after establishment of cross-ministerial delivery unit

SOURCE: Team analysis

III Accelerating municipal efficiency

- **Description:** Accelerate the implementation of municipal efficiency solutions
- **Target outcomes**:
  - Reduction of urban NRW losses to 25%
  - Reduction in utility operating expenses and capex spend
  - Reduction of domestic demand
- **Responsibilities:**
  - Lead: MWI (IDARA and WDMU)
- **Current initiative:** IDARA Project
- **Start date:** 2-3 months following establishment of cross-ministerial delivery unit

IV Ensuring industrial efficiency

- **Description:** Sub-organization to be established within the Industrial Development Directorate establishing industrial water policies
- **Target outcomes**:
  - Standards for industrial water use
  - Improved industrial water efficiency and productivity to meet standards and sector commitments
- **Responsibilities:**
  - Lead: Ministry of Industry and Trade
  - Supported by JBAW
- **Current initiative:** JBAW
- **Start date:** Immediately

V Efficiency in energy and mining

- **Description:** Support creation of a highly water-efficient energy industry and provide adequate volume and quality of water for future energy needs
- **Target outcomes**:
  - Coordination between energy and water
  - High efficiency in generation and mining
  - Reliable water provision
- **Responsibilities:**
  - Lead: Ministry of Energy
- **Current initiative:** None
- **Start date:** 3-6 months following establishment of cross-ministerial delivery unit

SOURCE: Team analysis

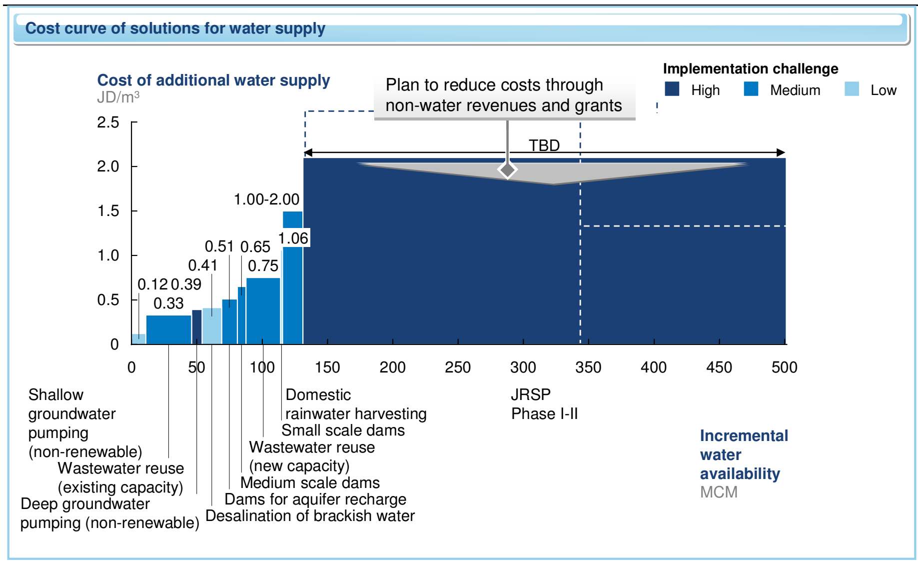
MAJOR SUPPLY PROJECTS REQUIRED FOR LONGER TERM WATER SECURITY

Finally, relatively expensive supply side projects are required to ensure that Jordan has long term water security to ensure economic and social growth. A "cost curve" of solutions for water supply (Exhibit 25) shows that potential of only about 130 MCM of additional supply exists from relatively cost effective supply measures. In particular:

- Jordan has already exploited most of the cheap opportunities to create new water supply infrastructure. Groundwater abstraction, especially, reached its limit years ago, so there is no opportunity to build additional wells
- The only remaining groundwater resources after introduction of Disi-Amman conveyor in 2013 will be small non-renewable resources of 19 MCM, about half of which would be sourced from expensive and technically challenging deep groundwater aquifers
- In addition, desalination of brackish groundwater can make use of the last remaining groundwater potential (15 MCM)
- The greatest potential for additional water supply comes from waste water re-use (62 MCM). One key way to meet this potential will be to utilize full capacity in existing plants by connecting more people to the sewage network and connecting more potential users of waste water to treatment plants (for example, agriculture and industry). A further option is to build new capacity by building new, smaller scale treatment plants
- Domestic rainwater harvesting can be a practical measure for households to add some additional, proprietary water resource to complement their water supply. However, this comes at relatively high cost of 1-2 JD/m³ due to comparably high investment cost needed for harvesting tanks vs. low rainfall in the country

JRSP offers long term supply security – it has been dealt with in detail before.

EXHIBIT 25



SOURCE: MWI, WAJ, JVA, team analysis

It should be emphasized that the extent of additional supply need could vary significantly depending on factors including:

- The success and speed of efficiency programmes and cropping changes
- The effective marginal cost of infrastructure (driven by capital markets and the level of international support achieved)
- Water security requirements
- Climate change effects

Two supply-focused workstreams can reduce the cost and risk from supply side projects (Exhibit 26):

- **Supply-side capital efficiency.** This workstream, led by MWI's proposed Asset Management unit, would establish capital efficiency and productivity practices for implementation of supply projects (excluding mega-projects). Its target outcomes would be to ensure maximum value creation at minimum cost over lifecycle of supply projects; and establish strategic and operational asset and capital project management capability.
- **Mega-project implementation (derisking JRSP).** This workstream, led by MWI, would build central capability to manage, finance and implement the country's large supply project, JRSP. Its target outcomes would be to ensure international financing support; create reliable revenue elements/streams supporting the project's business model; co-create non-water developments accounting for additional revenue streams; and deliver the project on time and at low cost.

EXHIBIT 26

VI Supply-side capital efficiency

- **Description:** Establish capital efficiency and productivity practices for implementation of supply projects (excl. mega-projects)
- **Target outcomes**:
  - Ensure maximum value creation at mini-mum cost over lifecycle of supply projects
  - Establish strategic and operational asset and capital project management capability
- **Responsibilities:**
  - Lead: MWI (Asset Management unit)
  - Support: WAJ
  - Support: JVA
  - Support: Ministry of Finance
- **Current initiative:** Selective capital efficiency practices used in functional silos, but no overarching capability established
- **Start date:** Immediate

VII Mega-project implementation (Derisking JRSP)

- **Description:** Build central capability to manage, finance and implement the country's large supply project (JRSP)
- **Target outcomes**:
  - Ensure international financing support
  - Create reliable revenue elements/streams supporting the project's business model
  - Co-create non-water developments accounting for additional revenue streams
  - Deliver project on time and at low cost
- **Responsibilities:**
  - Lead: MWI
  - Support: MOPIC
- **Current initiative:** Two representatives of MWI and WAJ as contact for consultant teams
- **Start date:** Immediate (Developer bidding process running)

SOURCE: Team analysis

ENSURING DELIVERY

Ensuring the transformation programme delivers the targeted impact will require a set of key enablers to be put in place (Exhibit 27). These include:

- **Cross-ministerial Delivery Unit.** This unit would be the "catalytic driver" for cross-sectoral decision making and coordinating economic decisions around water; it would champion the transformation programme. Its target outcomes would include quick decision making and cross-ministerial coordination; proactive assessment of water impact for economic decisions; and realisation of target benefits.
- **Project Management Office.** A dedicated project management unit would be responsible for tracking and ensuring implementation of the transformation programme. Target outcomes would include implementation support to the Delivery Unit, highlighting achievements and challenges; and implementation of initiatives on time and budget.
- **Financing.** Adequate, timely and cost effective financing would be ensured through a comprehensive financing strategy and cross-sectoral view of financing requirements. Target outcomes would include on time project financing; reduction in cost of capital for project financing; and better access to donor capital
- **Data management and decision support.** Cross-ministerial data management and decision support systems would be needed, working closely with the Delivery Unit and PMO. Target outcomes include relevant and timely data to support key decisions across Ministries; and common defined set of key indicators, sources and processes to manage data.

EXHIBIT 27

VIII Cross-ministerial Delivery Unit

- **Description:** "Catalytic driver" for cross sectoral decision making and coordination around water. Champions and monitors transformation programme
- **Target outcomes**:
  - Quick decision making and cross-ministerial coordination
  - Proactive assessment of water impact for economic decisions
  - Realisation of target benefits
- **Responsibilities:**
  - Lead: Cabinet/ Prime Minister's Office/ Royal Court
- **Current initiative:** None
- **Start date:** Immediate

IX Project Management Office

- **Description:** Dedicated project management unit responsible for tracking and ensuring implementation of transformation programme
- **Target outcomes**:
  - Implementation support to the Delivery Unit highlighting achievements and challenges
  - Implementation of initiatives on time and budget
- **Responsibilities:**
  - Lead: MWI
- **Current initiative:** None
- **Start date:** Immediate

SOURCE: Team analysis

X Financing

- **Description:** Ensures adequate, timely and cost effective financing through a comprehen-sive financing strategy and cross-sectoral view of requirements
- **Target outcomes**:
  - On time project financing
  - Reduction in cost of capital for project financing
  - Better access to donor capital
- **Responsibilities:**
  - Lead: Ministry of Finance with MWI
- **Current initative:** Selective efforts by financing departments in WAJ and JVA
- **Start date:** Immediate

XI Data management and decision support

- **Description:** Cross-ministerial data management and decision support systems working closely with the Delivery Unit and PMO
- **Target outcomes**:
  - Relevant and timely data to support key decisions across Ministries
  - Common defined set of key indicators, sources and processes to manage data
- **Responsibilities:**
  - Lead: Joint MWI and MOPIC unit supported by University of Jordan
- **Current initiative:** Plans to establish a National Information System
- **Start date:** Immediate

SOURCE: Team analysis

Further, it will be a key priority to ensure that the right tariff mechanisms are in place for cost recovery and to incentivize efficiency. A review of current tariffs across all sectors should be conducted for alignment with water strategy objectives. Target outcomes include consistent tariff strategy across agricultural, municipal and industrial users; and increased cost recovery and user efficiency driven by tariff incentives. Exhibit 28 provides an example of options for pricing in irrigation systems, that can improve the cost recovery from agricultural supply and incentivize productivity and efficiency.

EXHIBIT 28

Example: Options for pricing in irrigation systems can improve the cost recovery from agricultural supply and incentive productivity/efficiency

Pricing method	Types	Examples
Volumetric	Direct volumetric	
	Implicit volumetric block pricing (e.g., delivery time charging)	Maharashtra, India
	Tiered pricing (e.g., multirate and 2-part tariff based on marginal cost and fixed access charge)	Jordan, California, Israel
Non-volumetric	Output pricing (e.g., on production)	
	Input pricing (e.g., on fertilizer)	
	Area pricing	Warabandi in Punjab and Haryana in India, Pakistan (combined with volumetric)
	Betterment levers (e.g., on improved value of irrigated land)	
Market based	Informal	India, Mexico, and Pakistan
	Formal	Australia

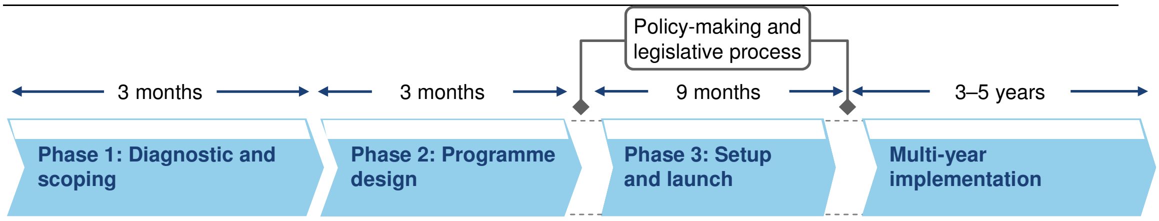
Additional considerations
- Non-tariff action (e.g., energy, tax)
- Desired/required level of cost recovery
- Speed of required change
- Link with education/ information programs
- Status of metering capability

SOURCE: Team analysis

Chapter 4
Now is the time: action steps to transform Jordan's water sector

Water sector transformation is a complex multi-year process that affects all parts of the economy, is an integral part of economic development and requires difficult cross-economic decisions.

EXHIBIT 29



Source: Team analysis

A typical country water sector transformation process would involve 4 phases (Exhibit 29):

PHASE 1: DIAGNOSTIC AND SCOPING

The current work completed a four month phase that has focussed on:

- **Analysis** – Developing the **fact base** on supply and demand across agriculture, industry, energy and municipal uses based on economic plans, and analysing **solution options** and **economic choices** based on water availability potential and economics
- **Convening – Aligning stakeholders** (government, development agencies, private sector and civil society) around the fact base and solution options through workshops and interviews
- **Transforming** – Outlining the **implementation roadmap**, including elements of the transformation objective, prioritisation criteria and key work packages

PHASE 2: PROGRAMME DESIGN

This phase will take a further four months and focus on:

- Developing an economy-wide transformation implementation mandate from the government with commitment from development agencies and the private sector
- Defining **vision and sector priorities**, including developing sector focus areas based fact base, and prioritising solutions based on defined criteria

- **Designing of programme elements** and syndication of work packages under the transformation programme with clear definitions of programme elements, financing and resourcing requirements and timeplan.
- Sequencing work packages into **implementation plan** with clear timelines and responsibilities
- **Team and capability building** to ensure clear responsibilities and mandate to ensure implementation of the transformation plan across the economy.

PHASE 3: SETUP AND ACCELERATED LAUNCH

This phase, lasting nine months would focus on supporting the accelerated rollout of high impact modules under the implementation roadmap. It would include a policy-making and legislative process to:

- Ensure **funding** for long-term implementation plan
- Ensure relevant **legislative and policy actions** (Acts, regulation, and so on)
- Implement the **programme management office** and work stream teams
- Implement **monitoring and governance processes**

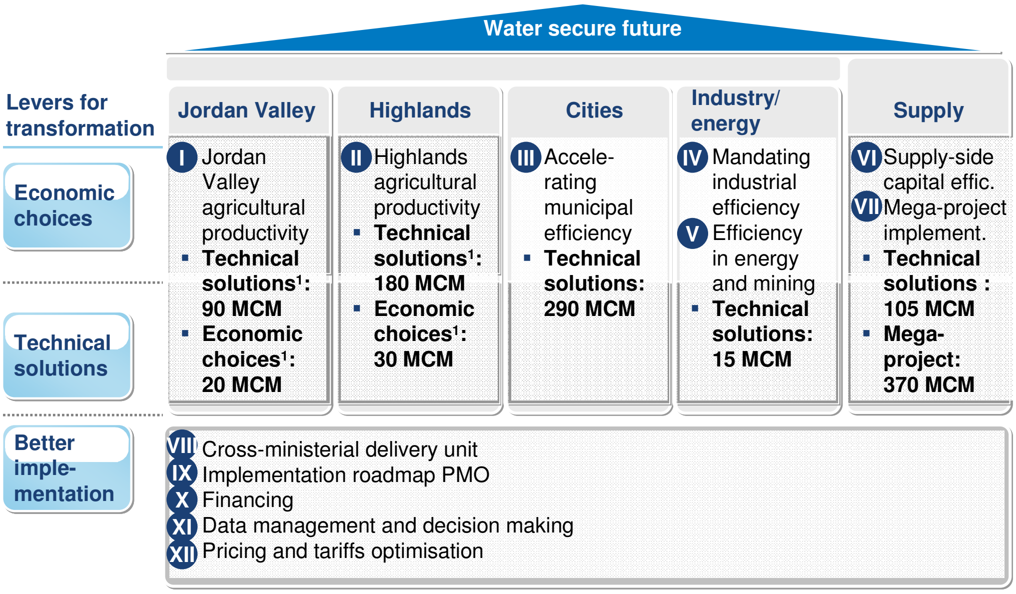
MULTI-YEAR IMPLEMENTATION

Over the following 4-9 years, implementation to defined milestones for realising benefits and programme maintenance would be driven across the following sectors and priorities:

- **Agriculture** – implement changes to crop patterns, efficiency measures and supply-side interventions
- **Industry** – implement programmes for greater efficiency and reuse
- **Municipalities** – implement measures for ensuring service quality, NRW reduction and use efficiency
- **Regulation/policy** – ensure implementation of enacted regulation and policies
- Strengthen **institutional capacity and capability**
- Develop **new technologies**
- Implement **new funding models**

Such a programme based on the workstreams outlined in Chapter 3 is an ambitious and complex undertaking but a critical one that Jordan needs to embark on immediately to ensure water security by 2030. Success will require coordinated focus across all twelve workstreams in the water transformation outlined in Chapter 3 (Exhibit 30).

EXHIBIT 30



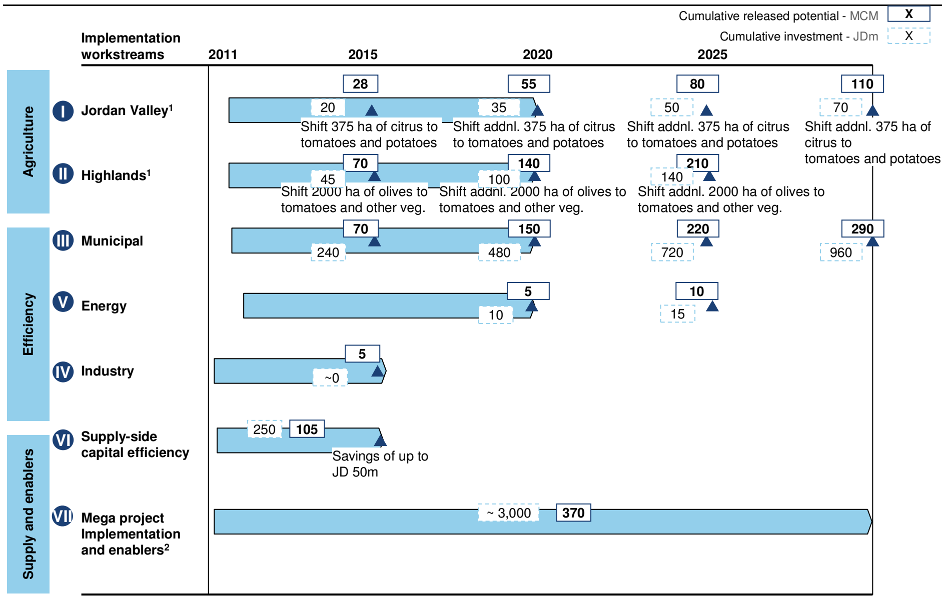
Note: Included solutions needed to close gap in BAU scenario with “must-do” solutions and lowest cost “optional” solutions

1 Provides significant yield and GVA benefits in addition

SOURCE: Team analysis

To ensure achievement of objectives will require clear upfront planning and identification of interim milestones and key performance indicators across a spectrum of dimensions relevant to each defined worksteam such as water savings, capital investment needs, hectares of crop changes achieved, % of houses fitted with water saving appliances and capital expenditure savings from capital efficiency. Exhibit 31 illustrates such a KPI map at the programme level – further levels of detail will need to be identified in Phase 2.

EXHIBIT 31



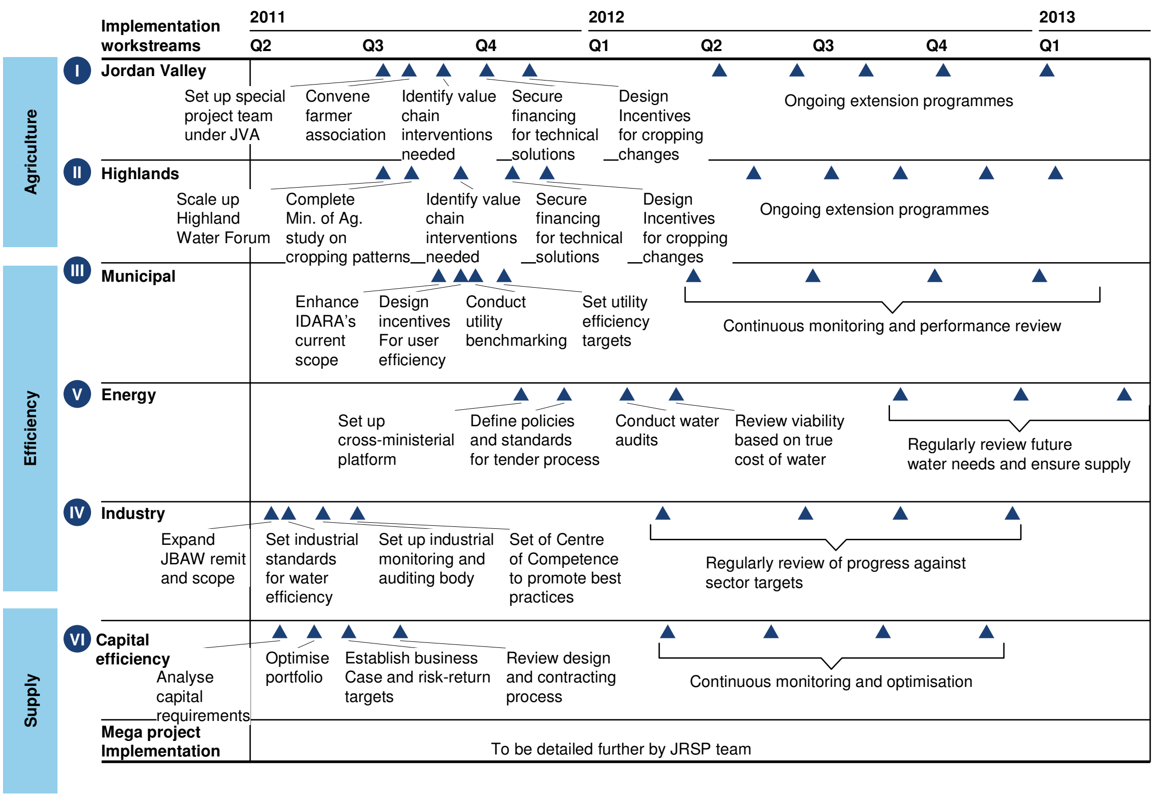
Note: Included solutions needed to close gap in BAU scenario with “must-do” solutions and lowest cost “optional” solutions
1 Output KPIs shown for “Basic Water Reduction” scenario; does not include costs of implementing cropping pattern changes
2 Does not include investments needed to run enabler programmes
SOURCE: Team analysis

Taking the transformation programme forward will require identification of immediate identification of key interventions in each of the implementation workstreams. For example, implementing a new agriculture in the Highlands (Workstream II) will require:

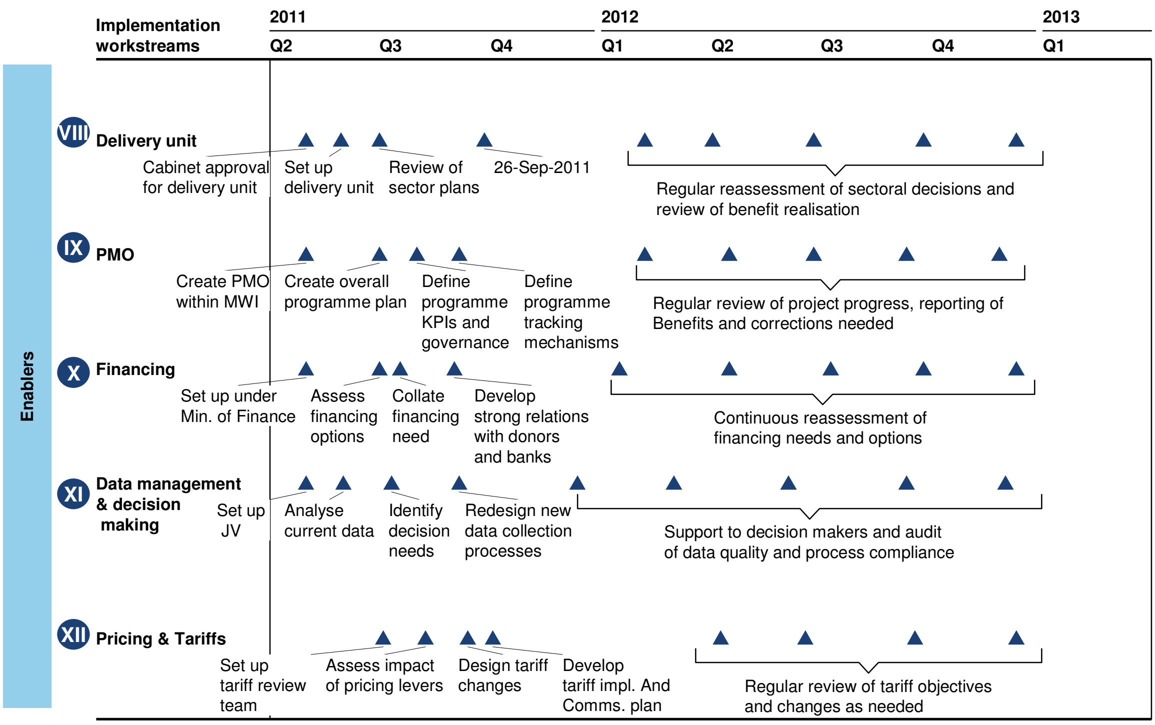
- Scaling up the current Highland Water Forum to increase the scope of the agricultural efficiency and crop change projects being considered
- Completing the current study by the Ministry of Agriculture on cropping patterns to understand the feasibility and specific requirements for changing to higher value crops in the Highlands and reduction in the hecterage under high water low productivity crops
- Identification of value chain interventions such as cold chains, local food processing units, improved roads to farms and central storage units, export promotion corporations, improved agricultural financing and export MoUs needed to support the move to higher value crops in the highlands
- Ensuring adequate government, development aid and private sector financing to meet the needs for agricultural efficiency and value-chain interventions
- Design of incentives to farmers (e.g., assured offtake prices, long term contracts, subsidies) to incentivise the implementation of efficiency measures and move to higher value crops
- Design and implementation of ongoing implementation programmes to provide the farmers with the awareness building, expertise, training, support and financing needed in an integrated way on an ongoing basis.

Similar immediate interventions are needed over the next 18 months to ensure momentum across each of the workstreams. Exhibit 32 illustrates some of the necessary interventions across each of the workstreams.

EXHIBIT 32



SOURCE: Team analysis



SOURCE: Team analysis

Conclusion

Jordan is one of the most water-scarce countries in the world, and delivering sufficient water to meet its ambitious growth aspirations is a very challenging task. This study shows that it *can* be done. But this will require Jordan's leaders across all key sectors to take a rigorous approach in identifying and assessing water solutions – whether those solutions modify demand, augment supply, or shift agriculture to more productive water-use. They will need to put the water challenge at the top of their agenda, ensuring that decisions on water resources fully support the country's economic objectives. And they will need to drive a comprehensive transformation programme encompassing the entire water sector.

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Municipal

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Appendices - Preface

- This document is part of the final deliverables of the 2030 Water Resources Group's study of Jordan's water sector
- This document is only part of the complete final product; it provides the detailed data, assumptions and calculations that underline the key messages and must be read in conjunction with the report that it is an Appendix to.

Appendices structure

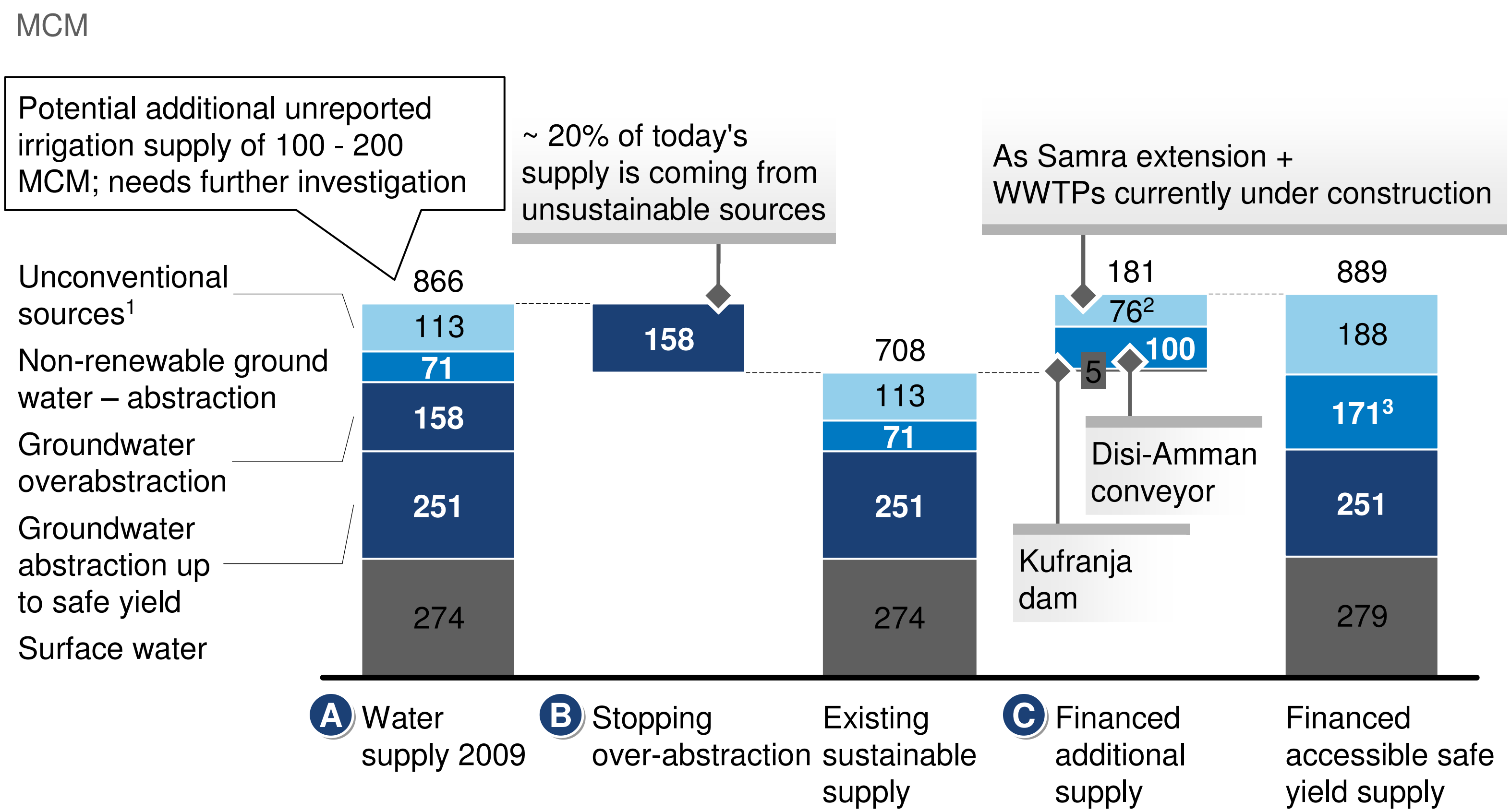
- Appendix 1 – Supply
- Appendix 2 – Agricultural use
- Appendix 3 – Energy use
- Appendix 4 – Municipal use
- Appendix 5 – Scenario comparisons

Appendix 1 - Supply

- **Current supply**
- Planned supply projects
- Cost of supply
- JRSP
- Supply solutions

Jordan has a plan to ensure water sustainability, a combination of limiting abstraction to safe yields and creating new supply

Current and financed supply



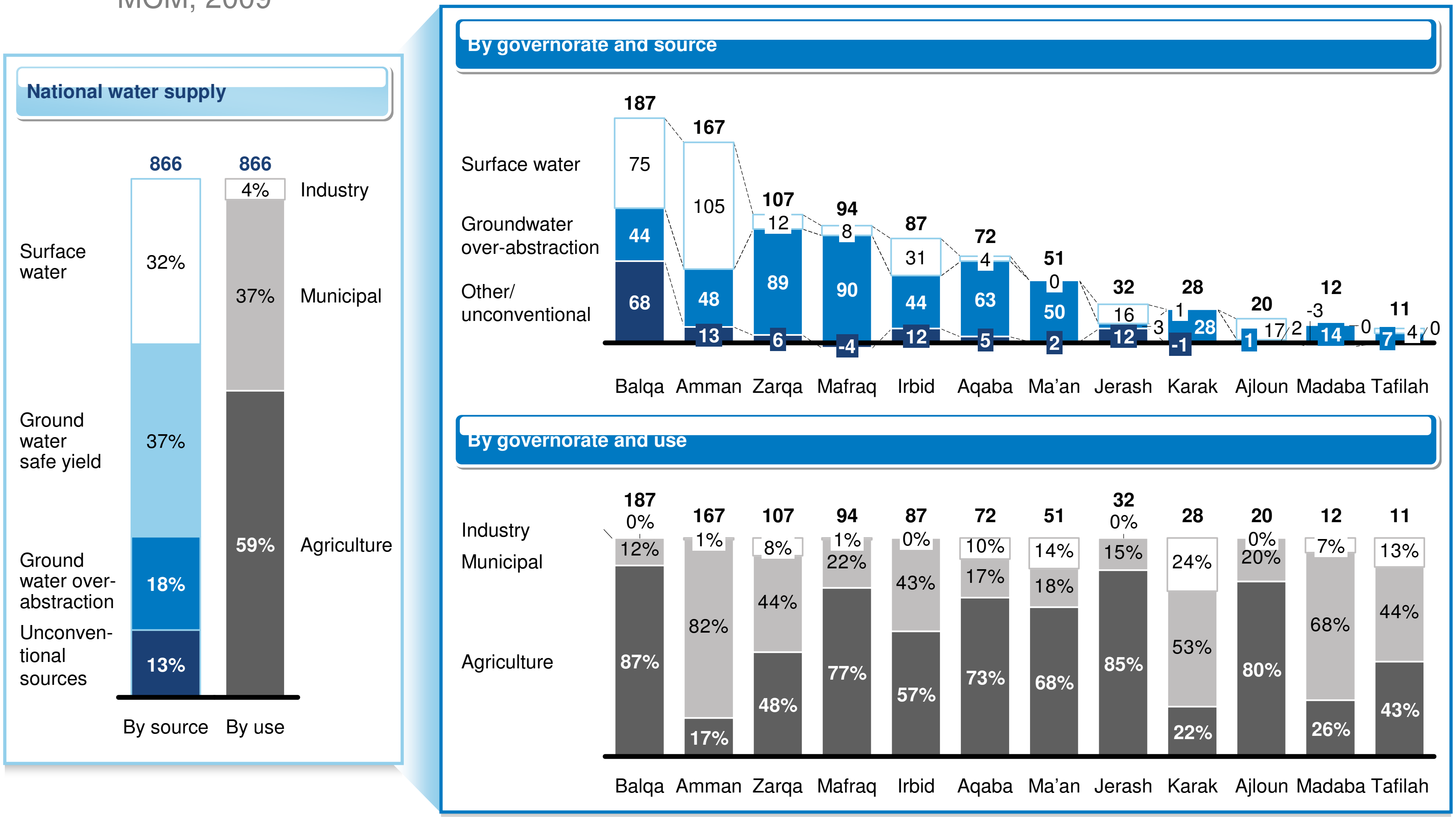
1 Includes desalination, treated waste water and transfers between governorates 2 45 MCM from As Samra plant extension and 30.5 MCM from WWTPs currently under construction 3 Includes 40 MCM above safe abstraction rate for Disi; requires decision regarding agricultural supply in Ma'an

Note: Numbers subject to rounding

SOURCE: MWI; WAJ; JVA; team analysis

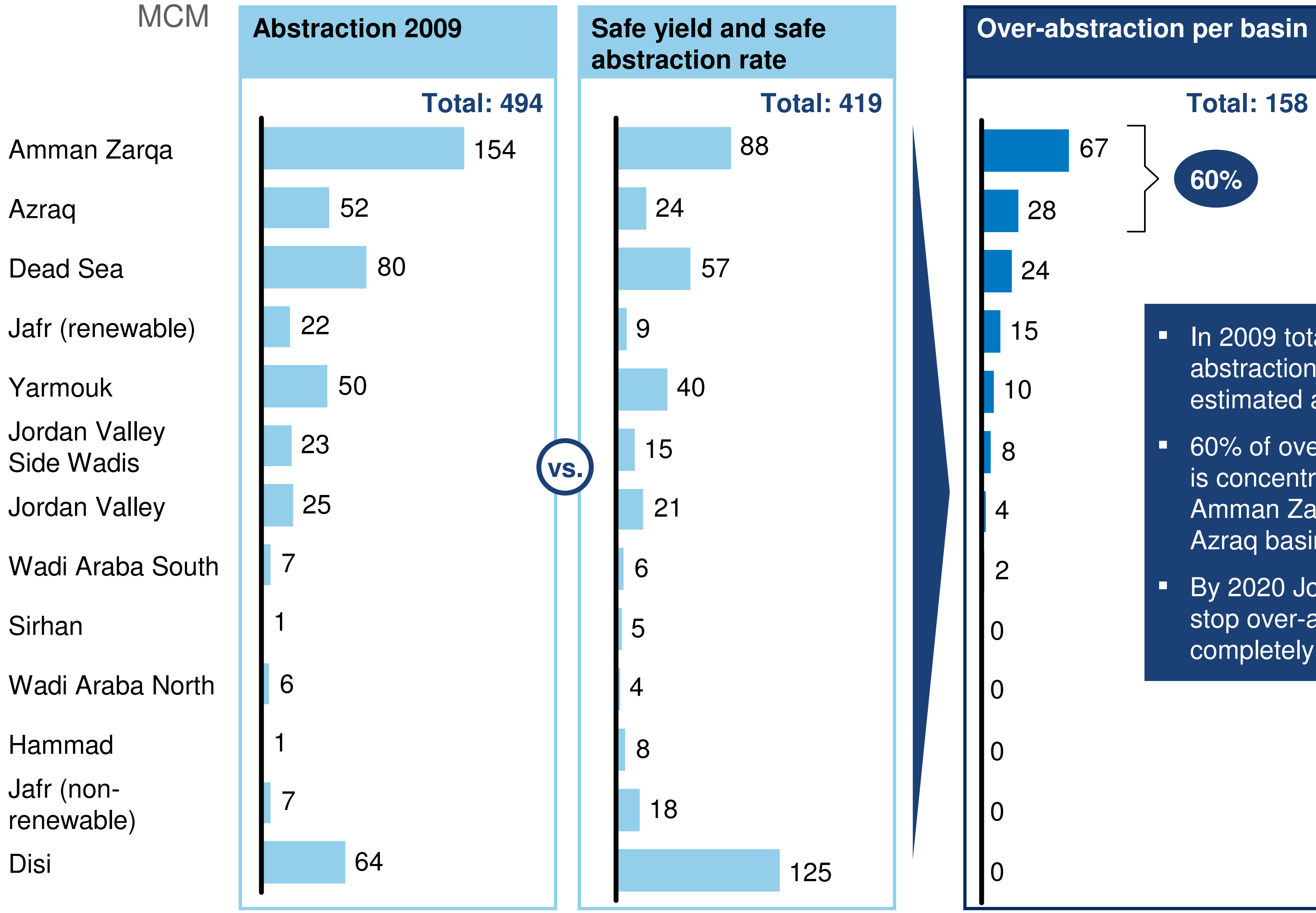
Today Jordan provides ~870 MCM of water mainly to the Agriculture and Municipal sectors of which ~ 20% is sourced from groundwater over-abstraction above safe yield

MCM, 2009



SOURCE: MWI; team analysis

Out of Jordan‘s current groundwater supply ~160 MCM are sourced from over-abstraction, which is planned to be stopped by 2020

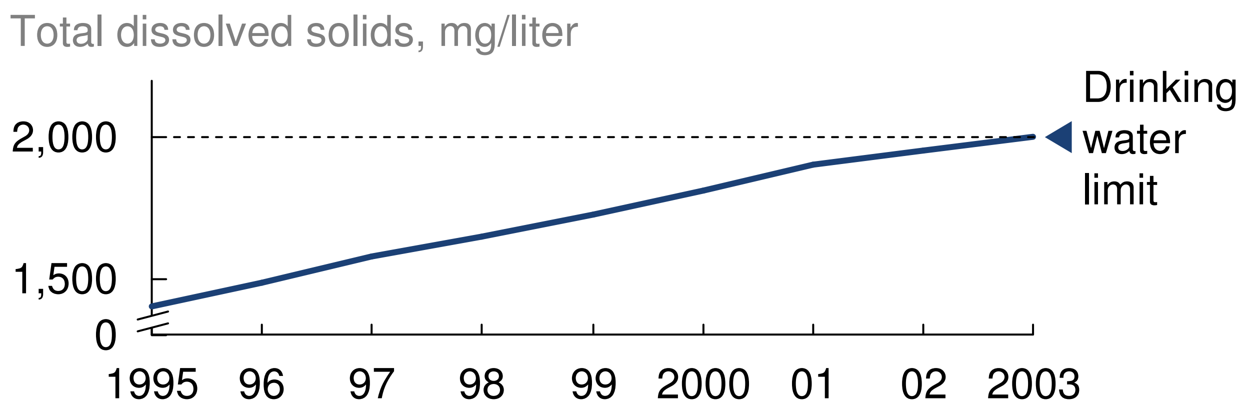


- In 2009 total over-abstraction was estimated at 158 MCM
- 60% of over-abstraction is concentrated in Amman Zarqa and Azraq basins
- By 2020 Jordan plans to stop over-abstraction completely

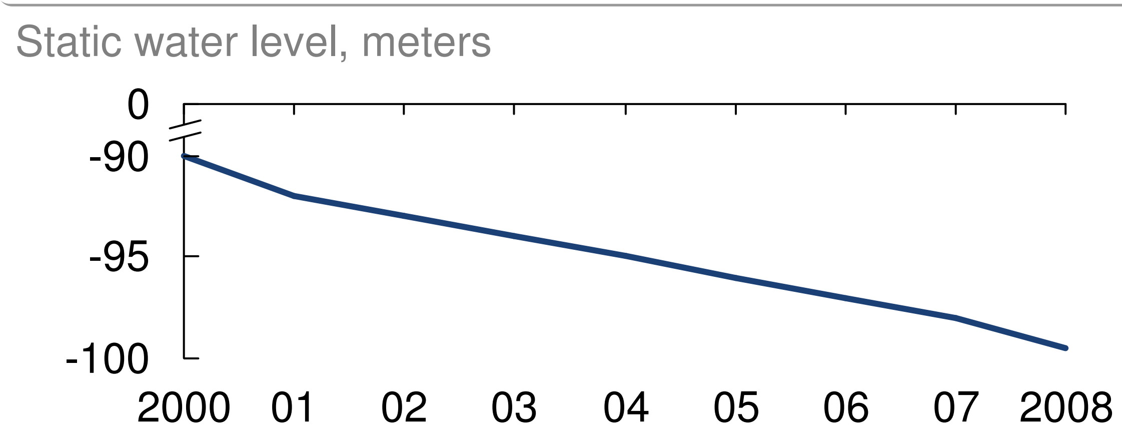
SOURCE: MWI; team analysis

In the Highlands, groundwater over-abstraction has led to lower water quality and lower water levels

Increasing water salinity at a sample well[1]



Decreasing groundwater resources at a sample well[2]



- While over-abstraction continues, Highland farmers will face
  - Lower yields due to increasing salinity
  - Higher pumping costs due to receding water levels
- Highland aquifers are at risk of permanent damage if over-abstraction continues at current level

1 Al Hashmieh 3 2 Hallabat 6

SOURCE: MWI over-extraction reduction plan for Amman-Zarqa and Al-Azraq; MWI Water Budget 2009

Appendix 1 - Supply

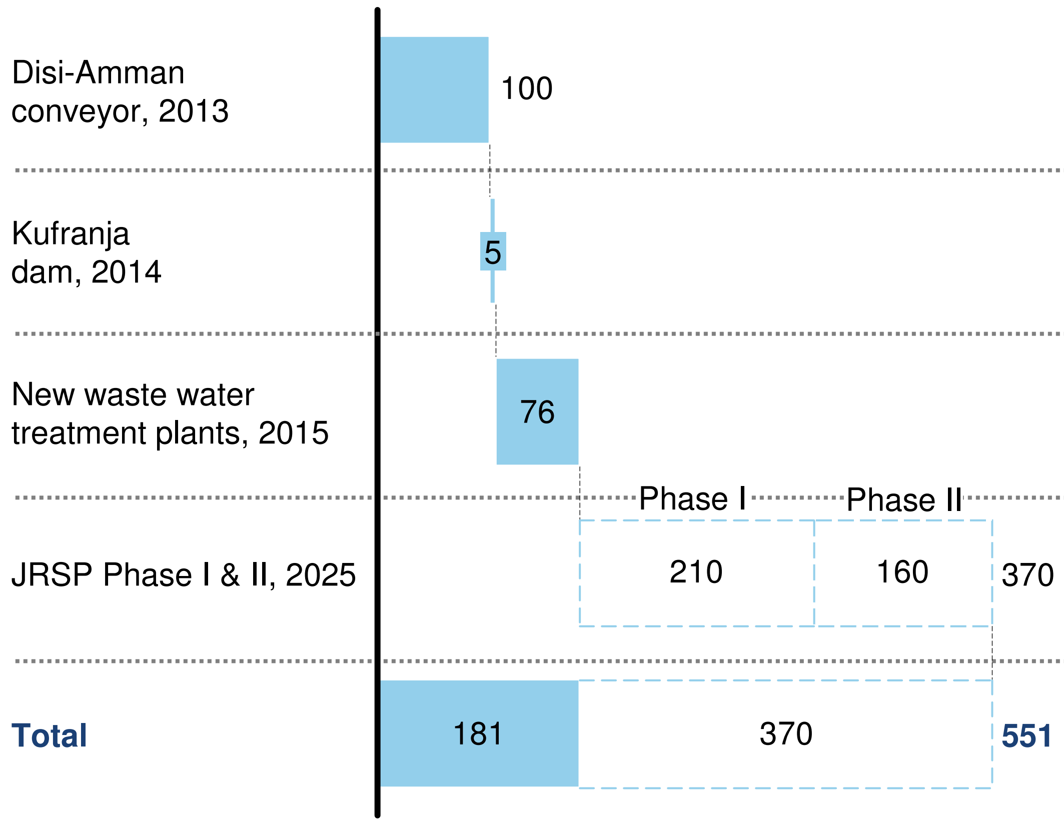
- Current supply
- **Planned supply projects**
- Cost of supply
- JRSP
- Supply solutions

To cope with increasing water demand MWI currently plans to further increase national water supply by ~550 MCM by 2025

MCM

Financed/committed supply | Planned supply

Planned infrastructure projects



Current status

Disi-Amman conveyor is currently ~ 30-40% progressed and estimated to be finalized by end of 2013

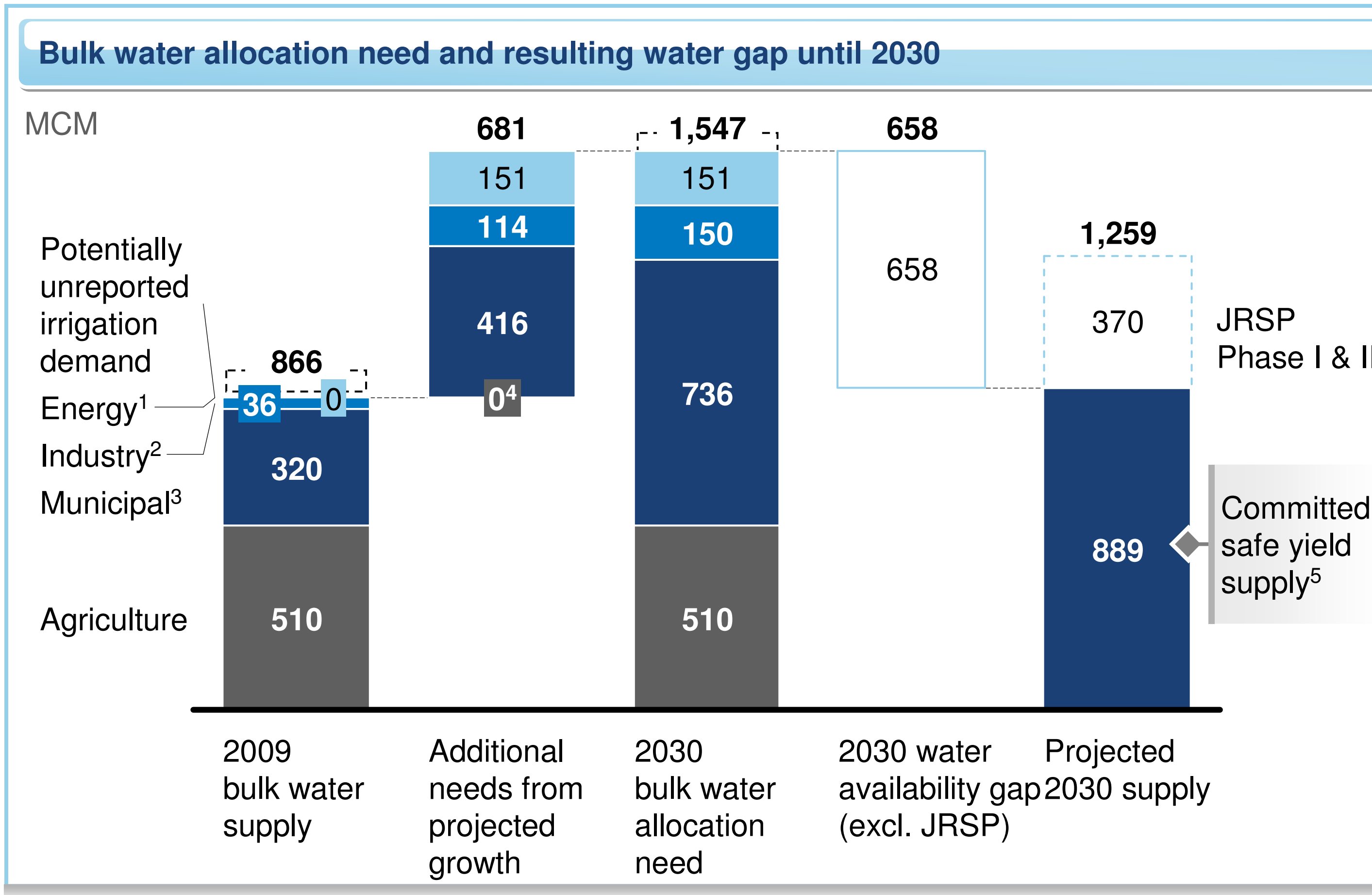
Construction of Kufranja dam is **scheduled to start in 2011**

As-Samra extension (45 MCM) and new treatment plants (30.5 MCM) **currently under construction**

Feasibility of JRSP is currently being reviewed with results on environmental impact analysis expected by mid of 2011

SOURCE: MWI; team analysis

However, these plans will not be sufficient to close the water availability gap of ~650 MCM until 2030



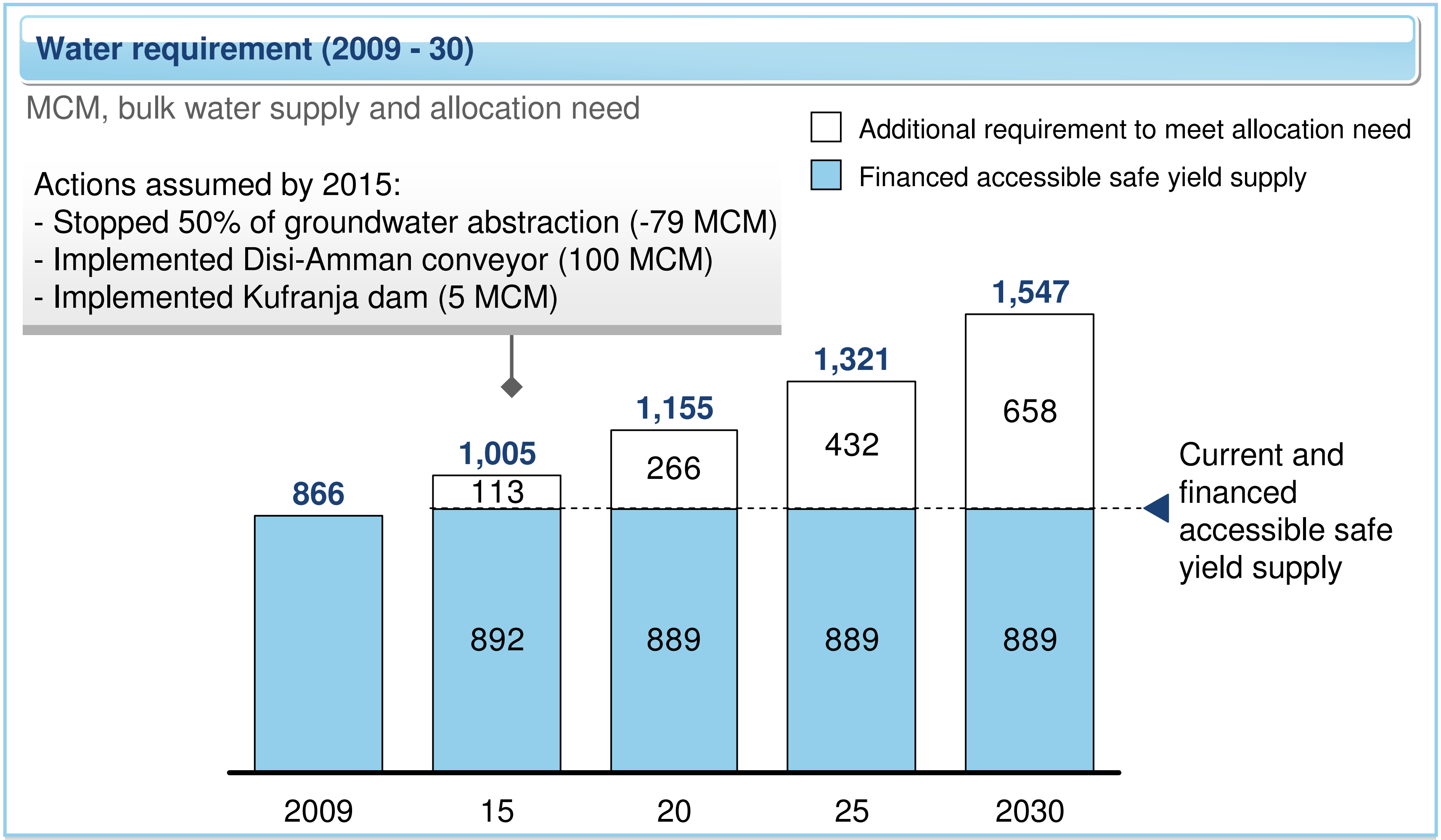
Key challenges

- **A** Increases in bulk water allocation needs to ~1,550 MCM create a **~650 MCM water availability gap** by 2030
- **B** Current plans to provide additional supply will increase the average **cost of water** from ~0.34 JD/m3 today to **>0.86 JD/m3 post 2025**
- **C** Implementing the large **JRSP** supply project will pose a significant **financing and implementation challenge**

1 Higher end of water demand range included for energy 2 Industry water demand projected indicatively in line with National Agenda growth targets
3 Municipal demand projected for 2030 – assumed constant growth rate for 2015, 2020, 2025 4 No growth in agriculture expected due to restriction of land used and water allocated to agriculture 5 Includes financed additional supply from Kufranja Dam (+5 MCM), Disi-Amman conveyor (+100 MCM), As Samra extension and WWTPs currently under construction (+76 MCM) and reduction of groundwater (-158 MCM) based on 2009 supply of 866 MCM

SOURCE: MWI; team analysis

Increases in bulk water allocation needs to ~1,550 MCM create an additional requirement of ~650 MCM by 2030

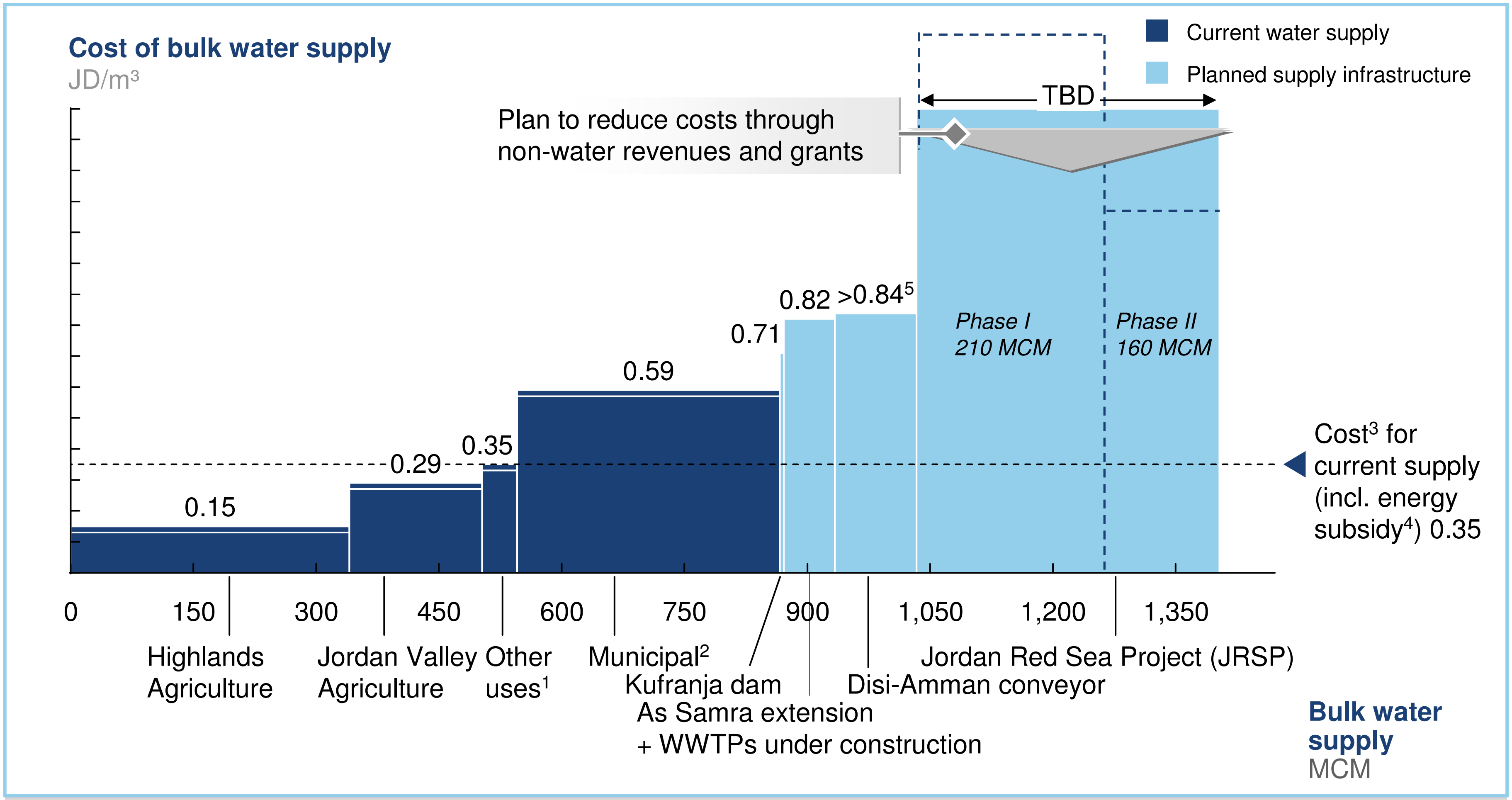


SOURCE: Team analysis

Appendix 1 - Supply

- Current supply
- Planned supply projects
- **Cost of supply**
- JRSP
- Supply solutions

Current plans to provide additional supply will increase the average cost of water from ~ 0.35 JD/m3 today to > 0.85 JD/m3 post 2025

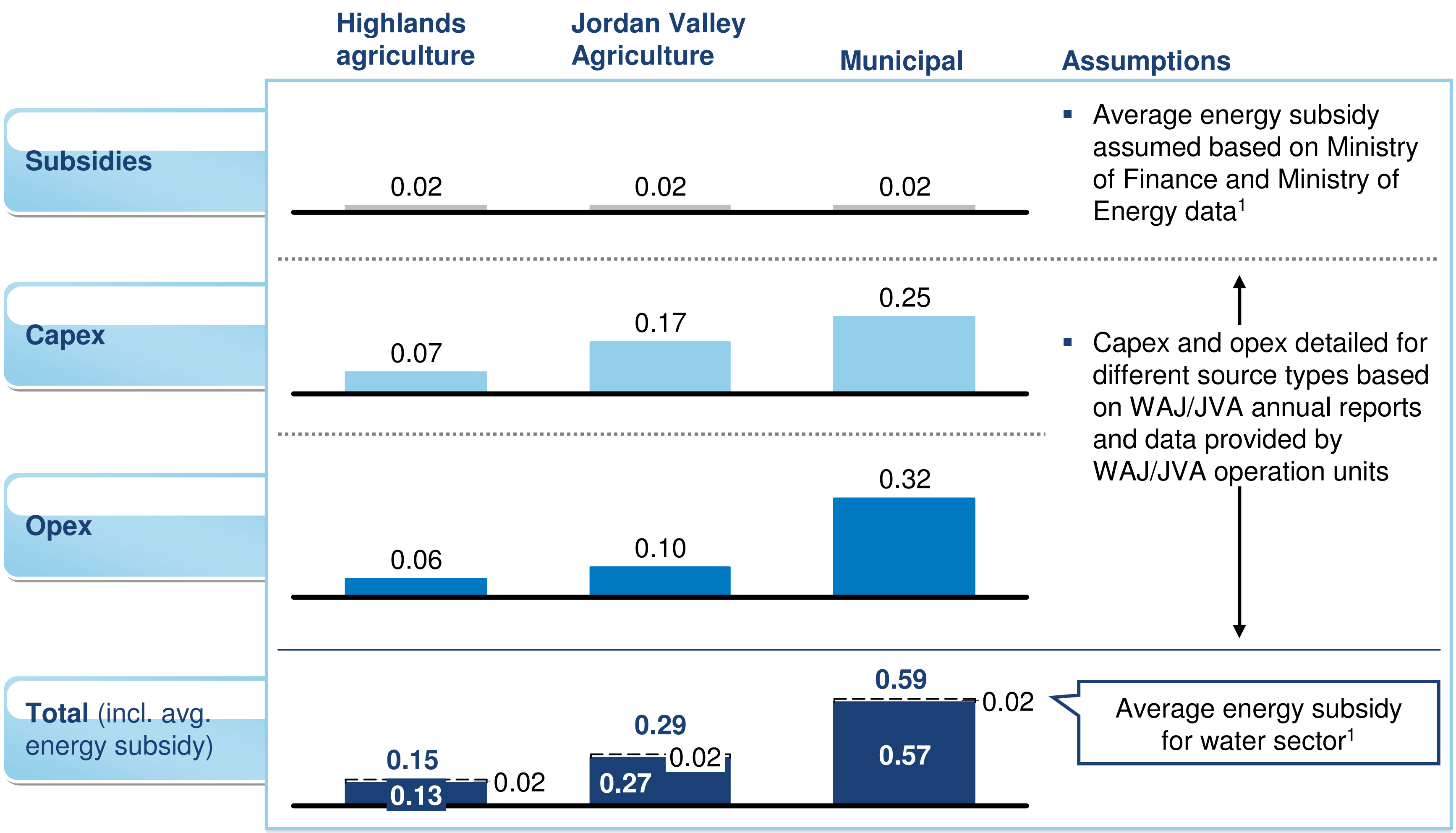


1 Includes industry and livestock, which have not been analyzed in detail; assumed average costs of current supply in other sectors
2 Cost of tap water supply: 1.33 JD/m³ 3 Weighted average cost 4 Assumed that water sector share of energy demand (15%) also applies to share of subsidy provided to energy sector of JD 100m – therefore included a subsidy of JD 15m on 866 MCM of supply translating to 0.02 JD/m³
5 0.84 JD/m³ based on BOT price excl. potential subsidy from GoJ equity holding and energy cost

SOURCE: MWI; WAJ; JVA; team analysis

Cost for current and water supply ranges between 0.15 JD/m³ and 0.59 JD/m³

Cost of bulk water, JD/m³, 2009



1 Assumed that water sector share of energy demand (15%) also applies to share of subsidy provided to energy sector of JD 100m – therefore included a subsidy of JD 15m on 866 MCM of supply translating to 0.02 JD/m³ on average

SOURCE: MWI; WAJ; JVA; team analysis

Jordan's future supply is going to be even more expensive than it currently is, at more than 1 JD/m³

Cost of bulk water, JD/m³

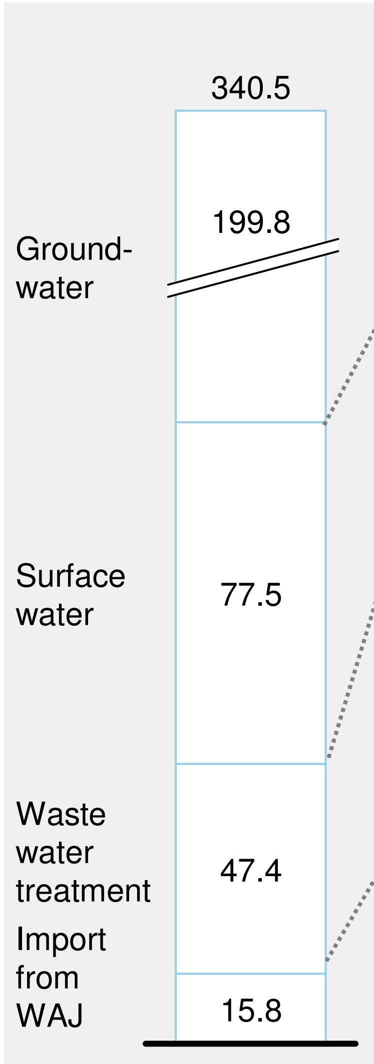
	Disi-Amman conveyor	Jordan Red Sea Project (JRSP)	Assumptions
Subsidies	N/A	N/A	▪ Disi: Potential subsidy from GoJ equity holding and energy cost – not included in calculation ▪ JRSP: Potential subsidy depending on capital structure and other subsidies, e.g. energy, tax
Capex	N/A	N/A	▪ Disi: No direct capital expenditure due to BOT price agreement – however, indirect capital expenditure through GoJ equity holding (see subsidies) ▪ JRSP: Not evaluated due to on-going RFP process
Opex	0.84	N/A	▪ Disi: Average BOT price for time of contract currently set at 1.18 USD/m³ ▪ JRSP: Not evaluated due to on-going RFP process
Total	**> 0.84**	**N/A**	

SOURCE: MWI; WAJ; JVA; team analysis

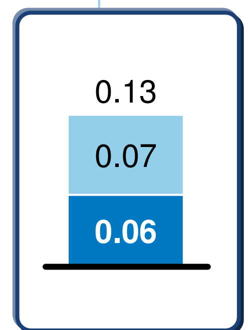
Highlands agriculture

MCM, water used, 2009

Capex Opex



Cost of bulk water supply, JD/m³	Assumption	Source
0.07 (Capex 0.02; Opex 0.05)	▪ Applied cost for shallow groundwater pumping estimated by WAJ for cost curve solutions	▪ WAJ, team analysis
0.06 (Capex 0.05; Opex 0.01)	▪ Remaining cost of dams for Highlands allocated from JVA P&L ▪ Split capex and opex as per split for dams in JVA P&L	▪ JVA P&L 2009, team analysis
0.34 (Capex 0.23; Opex 0.11)	▪ Average cost of current treated waste water accounting for different costs of As Samra (0.20 JD/m³) and other plants (0.49 JD/m³) ▪ Split capex and opex as per split for plants excl. As Samra	▪ WAJ waste water treatment department ▪ WAJ P&L 2009
0.57 (Capex 0.25; Opex 0.32)	▪ Cost of bulk water supply to Municipal uses applies as this is imported from there ▪ Assumption detailed on next page	▪ WAJ, team analysis



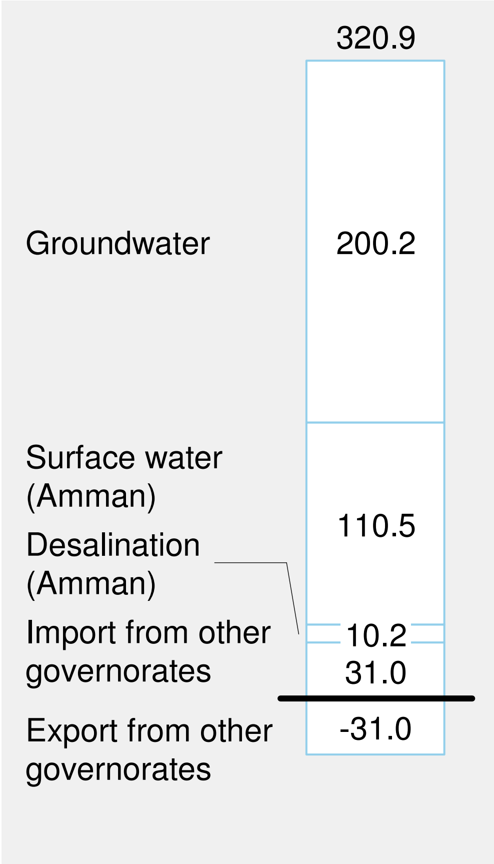
1 Alternative estimates range from 0.07 (NWMP 2004) to ~0.05-0.15 (Selective estimates by Highlands Forum taking into acocunt energy cost only estimated based on total energy cost divided by total water pumped per farm)

SOURCE: MWI; WAJ; JVA; team analysis

Municipal (1/2)

MCM, water used, 2009

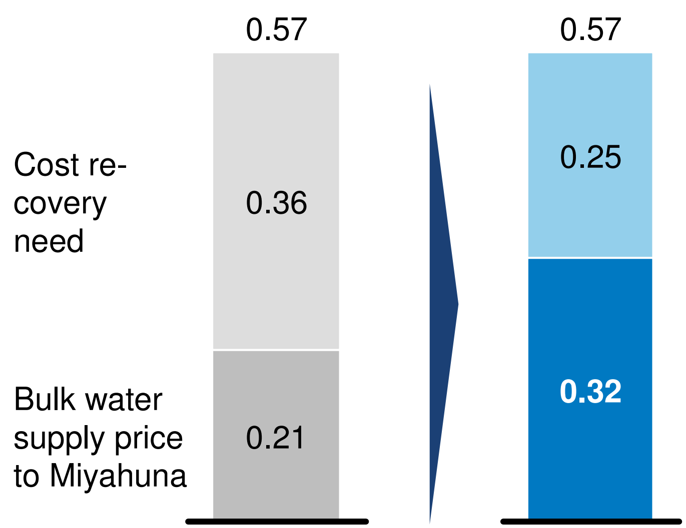
Capex Opex



Cost of bulk water supply

JD/m^3

Assumption **Source**



Assumption

- Cost for bulk water supplied by WAJ to Miyahuna (0.21 JD/m³) can be a proxy of general municipal water supply cost
- Applying the 172% revenue increase needed for the Water Authority to achieve cost recovery, leads to an increase in the total cost estimate by 0.36 JD/m³
- Capex/Opex ratio of WAJ applied to the total cost of 0.57 JD/m³ (Capex 44%, Opex 56%)

Source

- Miyahuna water supply price agreement
- WAJ P&L 2009

SOURCE: MWI; WAJ; JVA; team analysis

Municipal (2/2) – WAJ P&L 2009

JD, 2009 actuals

Revenues	Water Authority	Miyahuna	Aqaba Water	North Water	Total before settlement	Settlement
Water cost Revenues	28.251.988	40.165.553	8.217.784	12.508.932	89.144.257	-
Subscription, application and connection fees	1.697.496	10.679.087	550.152	1.905.751	14.832.486	-
Sewer utility charges	3.875.268	11.038.482	2.090.076	1.168.948	18.172.774	-
Sewage taxes	5.361.110	9.665.350	418.946	-	15.445.406	-
Miscellaneous Revenues	1.641.519	2.396.704	837.927	2.170.592	7.046.472	256.560
Station and meter maintenance for related parties	2.809.075	-	-	-	2.809.075	(2.809.075)
Revenues of the Wadi Musa Station Management Contract	-	-	705.573	-	705.573	(705.573)
Revenues of the Maan Station Management Contract	-	-	415.638	-	415.638	(415.638)
Private wells fees	491.961	-	-	-	491.961	-
Water meter maintenance charges	606.514	511.058	89.558	257.671	1.464.801	-
Costs of treated water	-	-	256.560	-	256.560	(256.560)
Costs of water in tanks	123.755	217.789	123.662	481.217	946.423	-
Bank interest	356.979	-	475.223	9.634	841.836	-
Water sales for the Authority	-	2.954.289	-	359.465	3.313.754	(3.313.754)
Water sales to related parties	5.696.438	-	-	-	5.696.438	(5.696.438)
Total revenues	50.912.103	77.628.312	14.181.099	18.862.210	161.583.724	12.840.478
Expenses						
Wages and salaries and related items	20.668.595	11.689.178	2.795.715	7.669.266	42.822.754	-
Operating and maintenance expenses	21.558.132	38.980.401	3.957.032	16.098.830	80.594.395	(3.975.300)
Water treatment and sewage	-	10.471.402	-	-	10.471.402	-
Administrative expenses	621.286	2.498.009	495.014	627.962	4.242.271	27.464
Water purchases from the Authority	-	2.560.284	3.091.140	-	5.651.424	(5.651.424)
Water purchases from related parties	3.313.754	-	-	-	3.313.754	(3.313.754)
Other expenses	-	27.464	-	-	27.464	(27.464)
Total Expenses	46.161.767	66.226.738	10.338.901	24.396.059	147.123.464	(12.840.478)
Revenues in excess of expenses before depreciation, interest on loans, currency exchange differences, and allocations	4.750.336	11.401.574	3.842.198	(5.523.848)	14.460.260	-
Depreciation	(67.568,402)	(1.796.312)	(1.897.581)	(2.921.137)	(74.183.432)	-
Revenues on use of property, equipment and machinery	(9.269.000)	(9.269.000)	-	-	-	-
Interest on loans and bank facilities	(21.637.189)	-	-	-	(21.637.189)	-
Currency exchange differences	(9.355.762)	-	-	-	(9.335.762)	-
Debt deemed uncollectible	(2.920.097)	(43.360)	(53.732)	-	(3.017.189)	-
Affiliate companies income tax	-	(273.226)	(137.206)	-	(410.432)	-
Recruitment, Training and professional and vocational training fund	-	(39)	(15.646)	-	(15.685)	-
Annual deficit	(87.442.114)	19.637	1.738.033	(8.454.985)	(94.139.429)	-

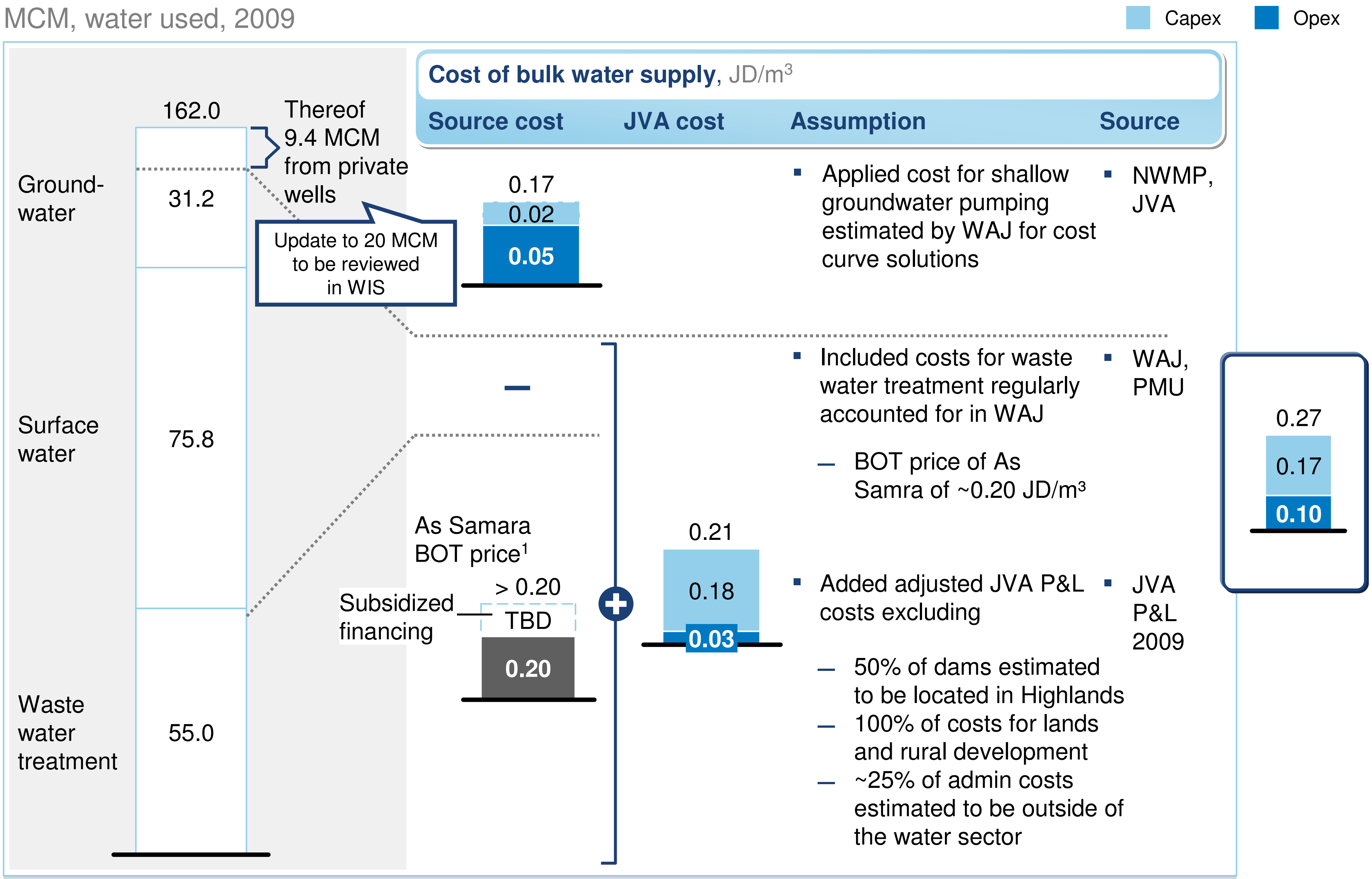
Revenue increase needed for cost recovery (87.4/50.9)=172%

Capex/Opex ratio
Capex: 74.2+21.6+9.3=105.1 (44%)
Opex: 147.1 (56%)

SOURCE: WAJ; team analysis

Jordan Valley Agriculture (1/2)

MCM, water used, 2009



1 BOT price counted as part of opex

Jordan Valley Agriculture (2/2) – JVA P&L 2009

JD, 2009 actuals

JVA programs	2009 actual				Adjusted		
	Total	Capex	Opex	Share used	Total	Capex	Opex
Operations, Maintenance and Mechanics	7.896.299	4.010.020	3.886.279	67%	5.290.520	2.686.713	2.603.807
Irrigation	18.473.787	18.296.677	177.110	100%	18.473.787	18.296.677	177.110
Southern Ghor and Wadi Araba	2.339.998	1.690.301	649.697	100%	2.339.998	1.690.301	649.697
Dams	8.865.656	8.145.339	720.317	50%	4.432.828	4.072.670	360.159
Admin	1.405.344	268.346	1.136.998	78%	1.096.787	209.428	887.359
Lands and rural development	1.552.359	1.283.378	268.981	0%	-	-	-
Total JVA	40.533.443	33.694.061	6.839.382		31.633.920	26.955.789	4.678.131

Assumptions

- Operation, Maintenance and Mechanics: 23% relate to water supplied to WAJ from KAC (49 MCM out of a total of 211 MCM)
- Dams: Roughly 50% of dams outside of JVA area
- Admin: Adjusted expenses equal 76% of total JVA expenses in 2008 (excl. Admin)
- Lands and rural development: Excluded as this does not refer to any water projects

0.21 JD/m³ **0.18 JD/m³** **0.03 JD/m³**

(Cost per m³ based on volume of 152.6 MCM administered by JVA excl. private wells)

SOURCE: JVA; team analysis

Appendix 1 - Supply

- Current supply
- Planned supply projects
- Cost of supply
- **JRSP**
- Supply solutions

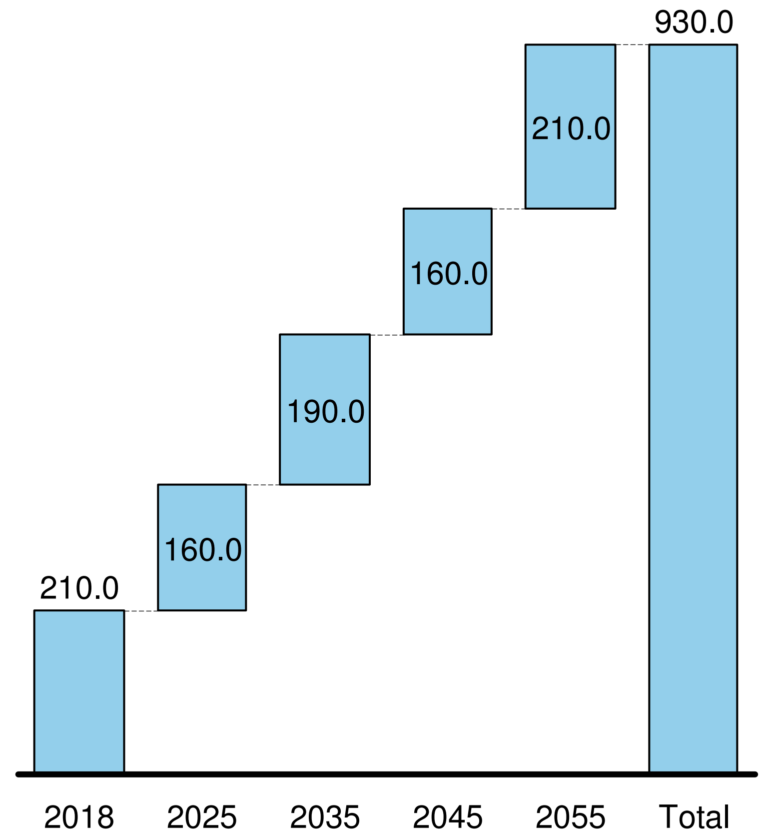
JRSP – Overview

JRSP project goals

- **Convey ~ 2,000 MCM of seawater** from the Red Sea to the Dead Sea
- Provide ~ **900 MCM of desalinated freshwater** to Amman and Palestine
- **"Refill" the Dead Sea** with the remaining salt water from the Red Sea
- Use JRSP as a **basis for further economic development in the region** (e.g. new urban centers, resort areas, gated communities, industrial zones)

JRSP is a 930 MCM supply project split into 5 phases of 160-210 MCM

Investment volume, USD bn



SOURCE: MWI; Ministry of Mega Projects; team analysis

Jordan aims at generating revenues from multiple beneficiaries of the JRSP development

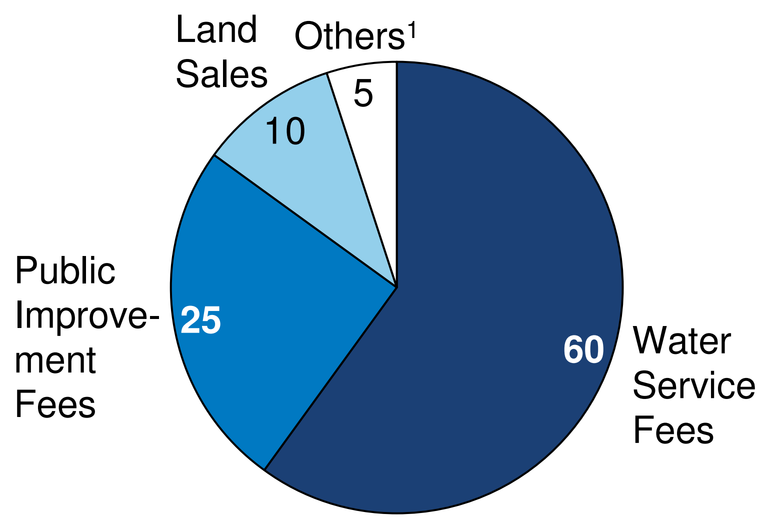
JRSP aims at supporting further economic developments

- new urban centers near Aqaba, south of the Dead Sea and south of Amman
- multiple resort areas to accommodate the growing tourism demand
- gated communities
- industrial zones for JRSP related businesses and new manufacturing industries
- further JRSP related business opportunities throughout the JRSP service area and other areas of Jordan

Planned revenues from multiple beneficiaries

Percent

Total: N/A[2]



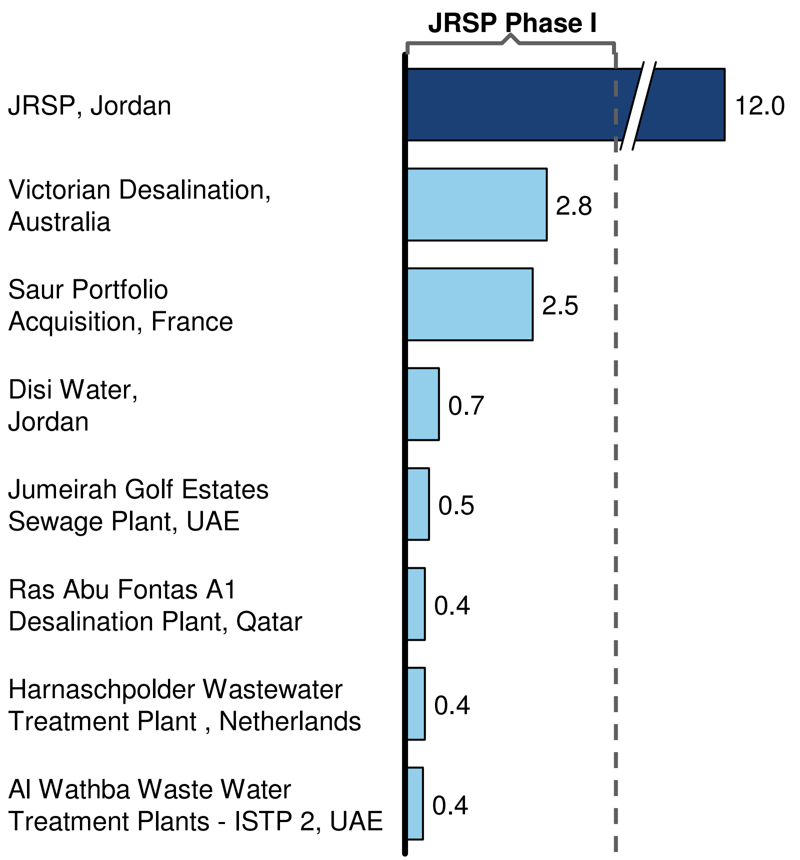
1 Others includes Water Connection Fees, Seawater Revenues, Reclaimed Water Revenues, Dead Sea Restoration Fees
2 No projection available so far

SOURCE: MWI; team analysis

The investment volume of JRSP is high compared to regional as well as global infrastructure investments

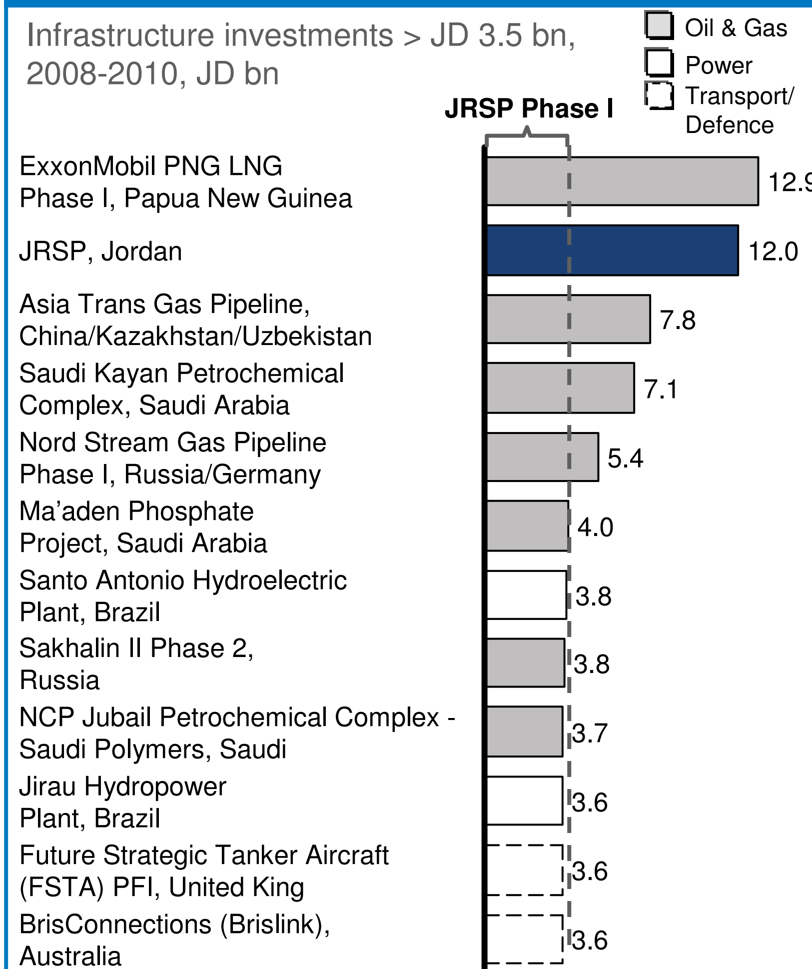
JRSP will be the largest public water project in the last 5 years, even when conducting Phase I only

Water infrastructure investments > JD 400 mn, 2005-2010, JD bn



Global infrastructure investments of comparable size have so far concentrated on Oil&Gas and Power Generation

Infrastructure investments > JD 3.5 bn, 2008-2010, JD bn

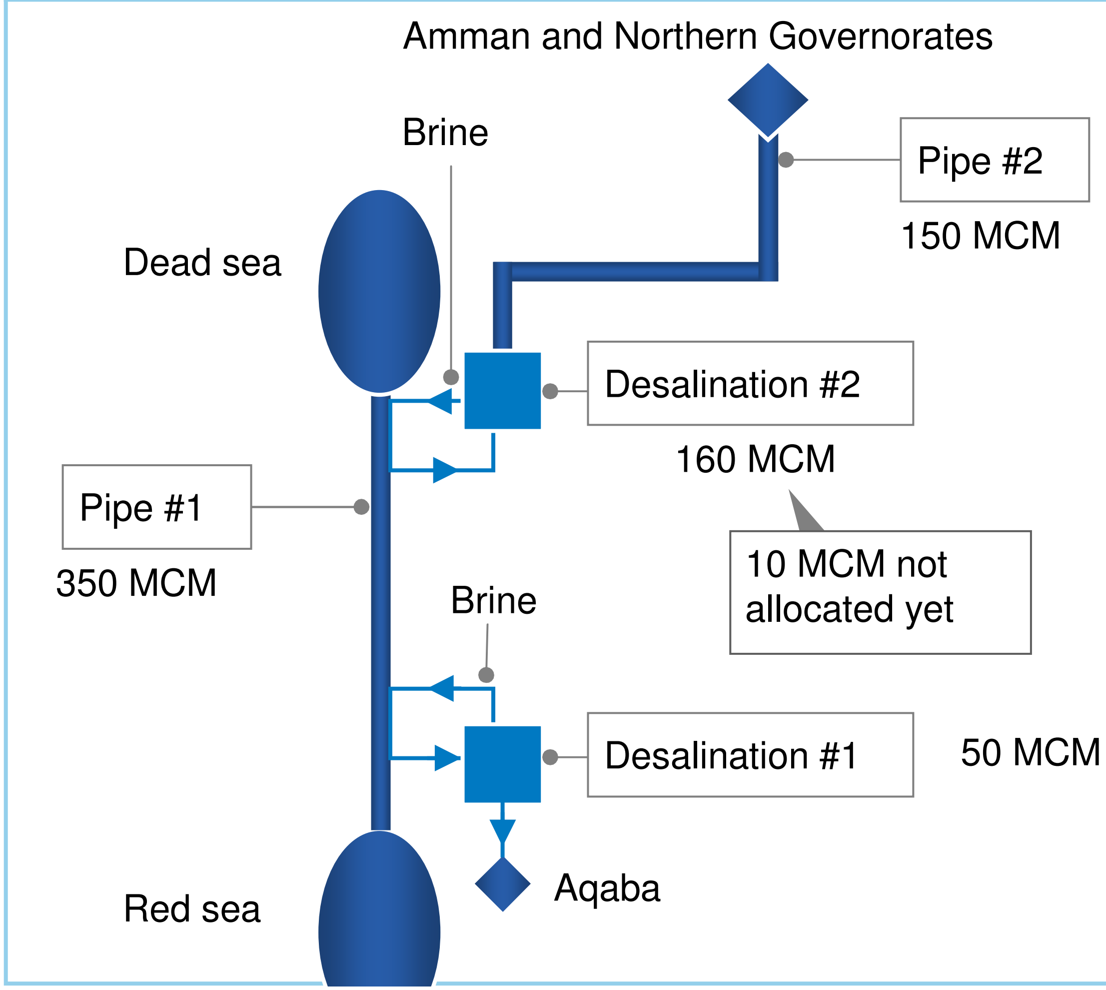


SOURCE: Infrastructure Journal, Team analysis

JRSP – Phase I

HIGHLY PRELIMINARY - OUTSIDE-IN

Simplified illustration of JRSP infrastructure



Infrastructure investment

- Desalination:
  - Amman (160 MCM): ~ JD xxm[1]
  - Aqaba (50 MCM): ~ JD xxm[1]
- Pipeline:
  - Red Dead (620 MCM)
  - Amman (290 MCM)

  ~JD xxbn[2]

~JD xxbn
(~USD xxbn)

Cost for Phase I (per m^3 of freshwater)

- Increm. freshwater 210 MCM
- Annualized capex xx JD/m^3
- Opex desalination xx JD/m^3 [3]
- Opex pumping xx JD/m^3 [4]

Combined cost of water
xx JD/m^3

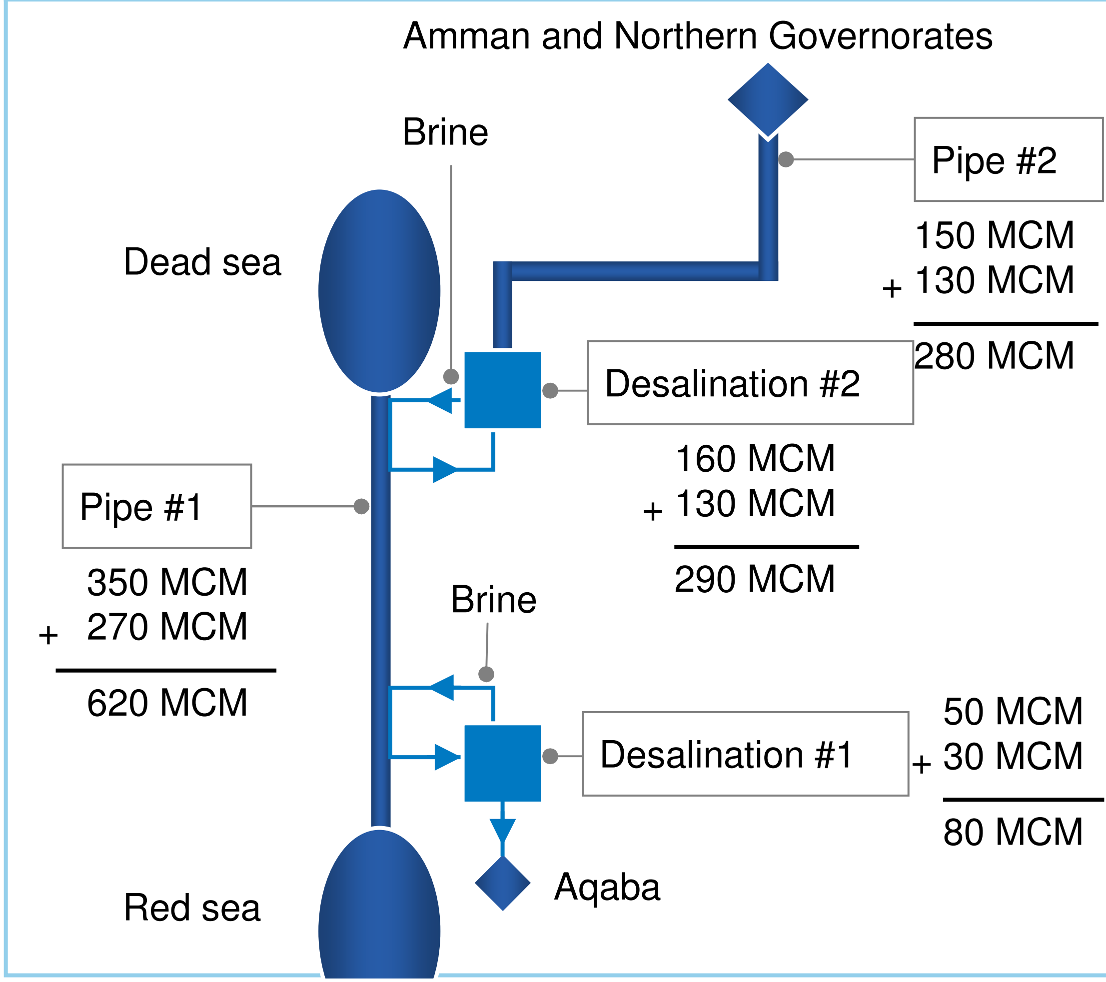
1 Assumed USD xxm for desalination of 210 MCM in phase I
2 Assumed remainder of total investment cost of USD xxbn (~JD xxbn) after build-out of desalination: ~JD xxm/MCM
3 Benchmark cost of RO sea water desalination of 0.6 JD/m^3 excl. 0.2JD/m^3 from capex = 0.4 JD/m^3
4 10% of total investment cost
SOURCE: MWI; JRSP investor presentation in January 2011; WRG benchmark; team analysis

Due to sensitivity, financial data from analysis was shared only with MWI

JRSP – Phase II

HIGHLY PRELIMINARY - OUTSIDE-IN

Simplified illustration of JRSP infrastructure



Infrastructure investment

- Desalination:
  - Amman (130 MCM): ~ JD xxm[1]
  - Aqaba (30 MCM): ~ JD xxm[1]

~JD xxm
(~USD xxm)

Cost for Phase II (per m³ of freshwater)

- Increm. freshwater 160 MCM
- Annualized capex xx JD/m³
- Opex desalination xx JD/m³ [3]
- Opex pumping xx JD/m³ [4]

Combined cost of water
xx JD/m³

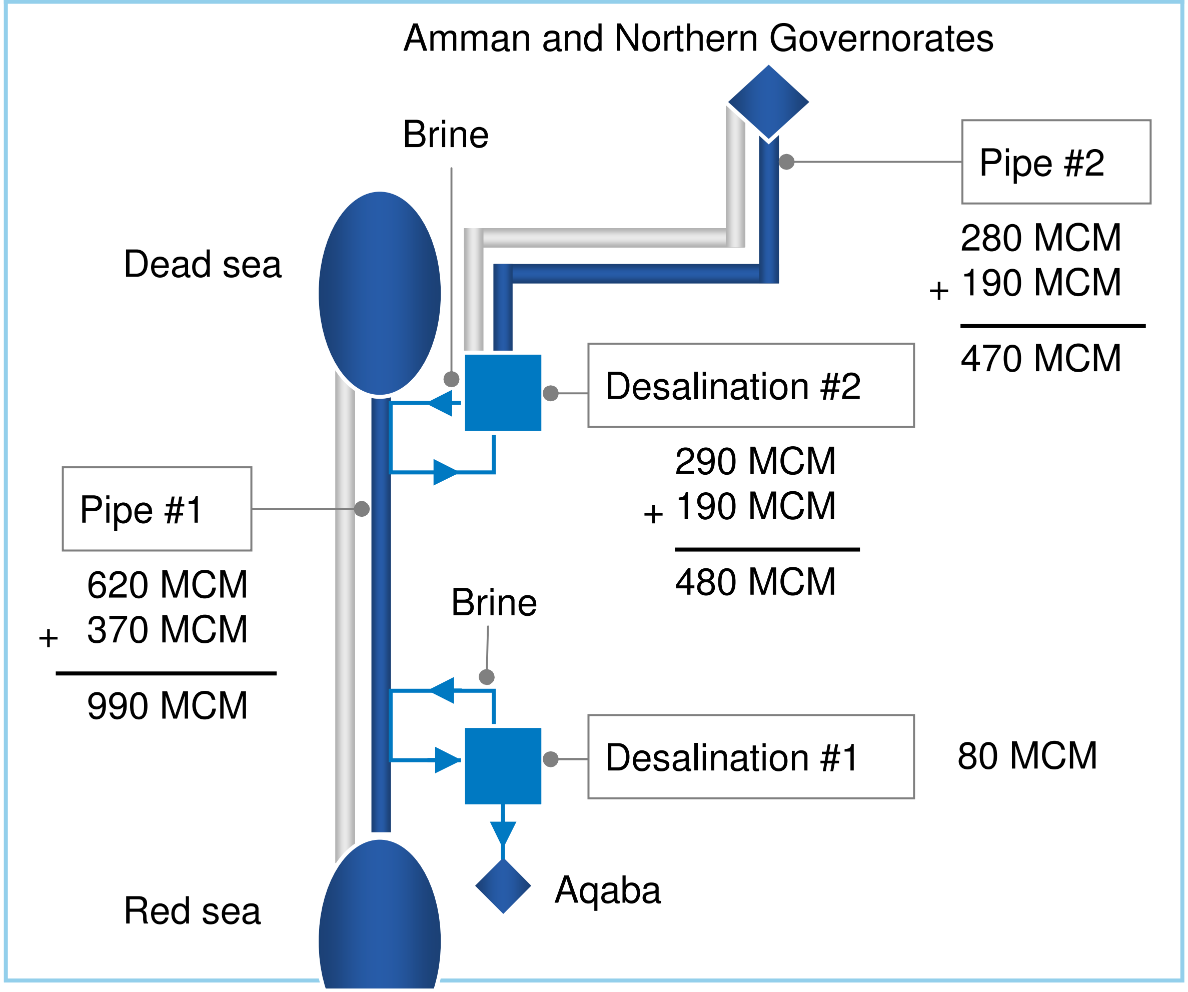
1 Assumed USD xxm for desalination of 210 MCM in phase I
2 Assumed remainder of total investment cost of USD xxbn (~JD xxbn) after build-out of desalination: ~JD xxm/MCM
3 Benchmark cost of RO sea water desalination of 0.6 JD/m³ excl. 0.2JD/m³ from capex = 0.4 JD/m³
4 10% of total investment cost
SOURCE: MWI; JRSP investor presentation in January 2011; WRG benchmark; team analysis

Due to sensitivity, financial data from analysis was shared only with MWI

JRSP – Phase III

HIGHLY PRELIMINARY - OUTSIDE-IN

Simplified illustration of JRSP infrastructure

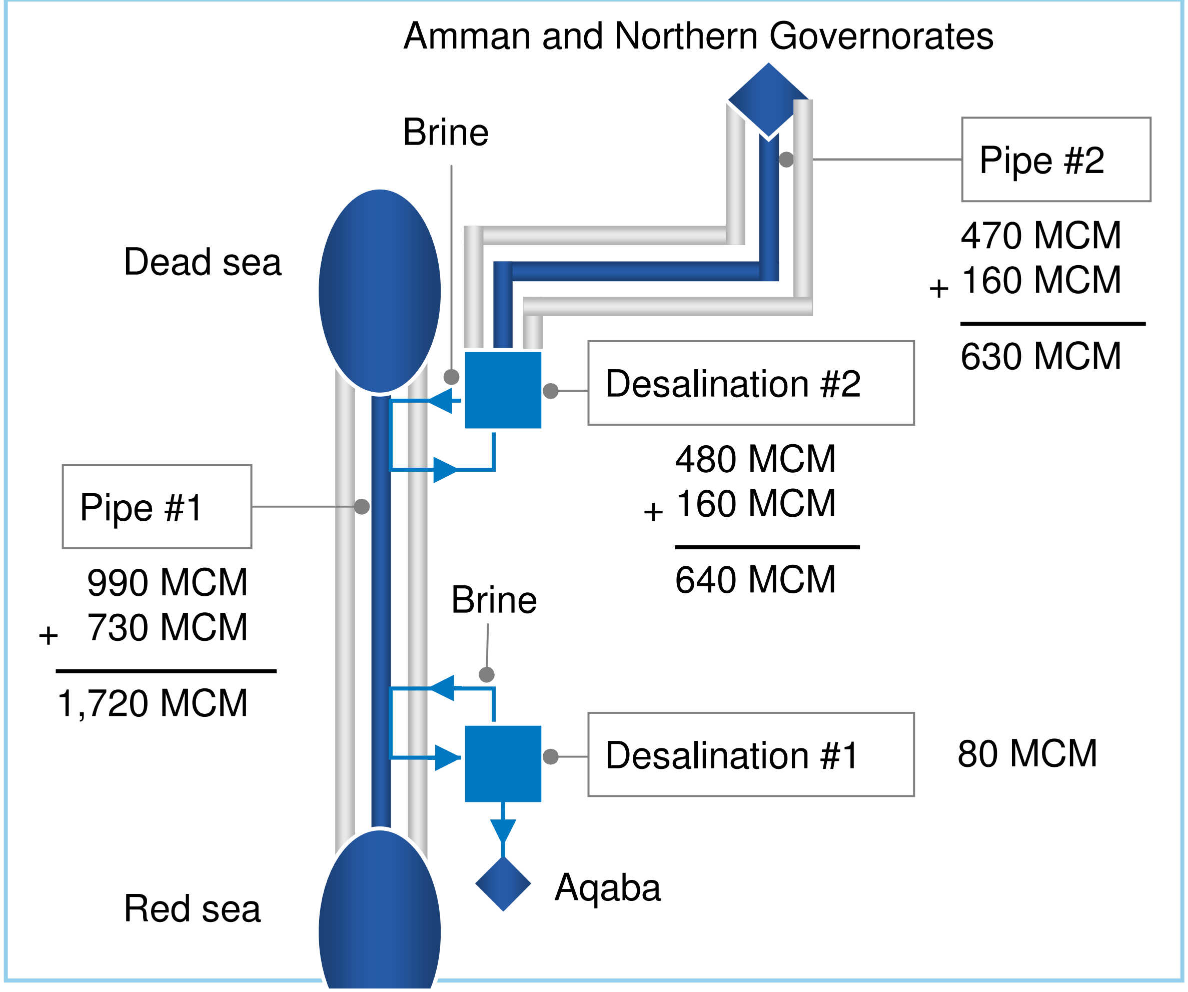


SOURCE: MWI; JRSP investor presentation in January 2011; WRG benchmark; team analysis

JRSP – Phase IV

HIGHLY PRELIMINARY - OUTSIDE-IN

Simplified illustration of JRSP infrastructure

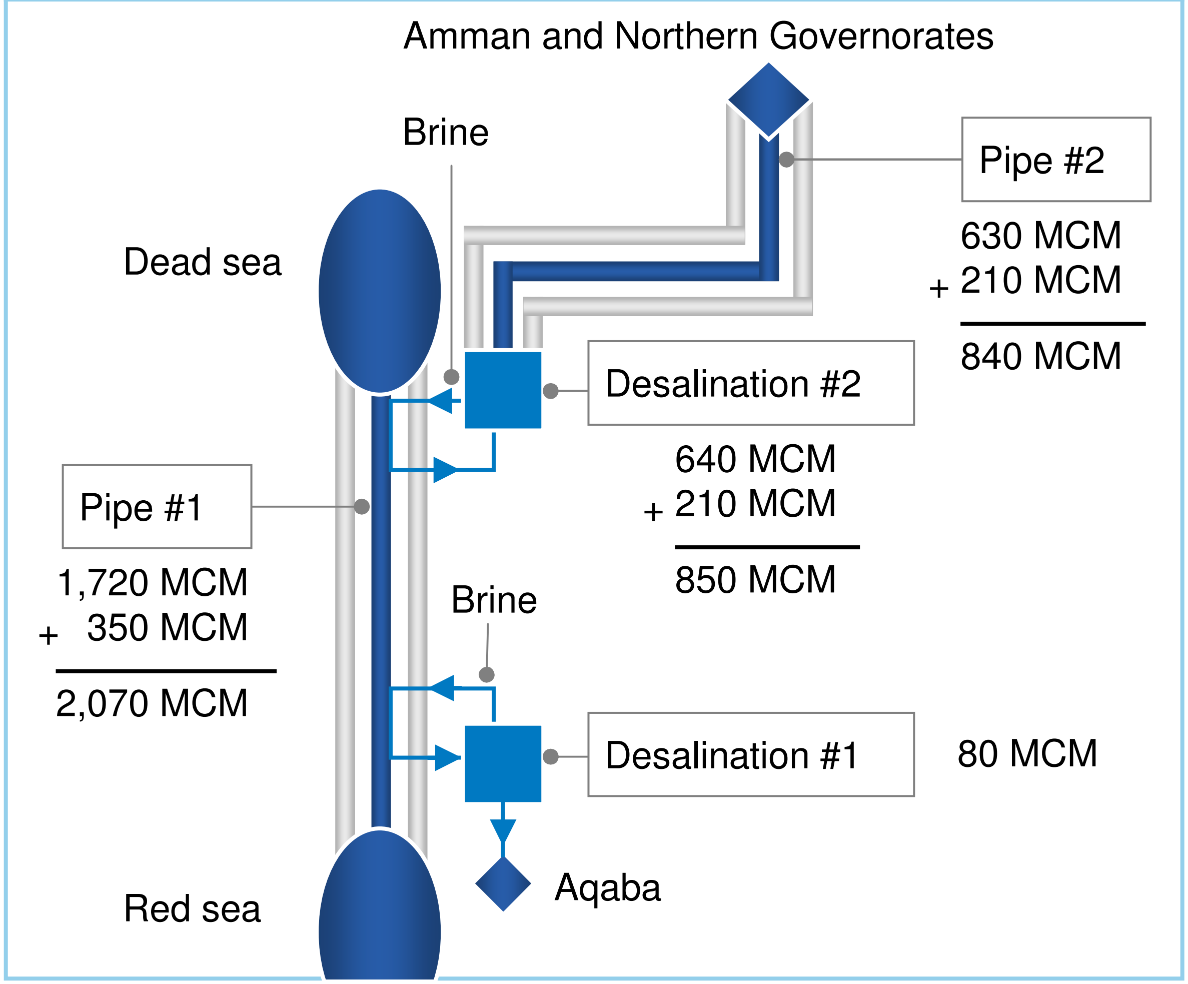


SOURCE: MWI; JRSP investor presentation in January 2011; WRG benchmark; team analysis

JRSP – Phase V

HIGHLY PRELIMINARY - OUTSIDE-IN

Simplified illustration of JRSP infrastructure



SOURCE: MWI; JRSP investor presentation in January 2011; WRG benchmark; team analysis

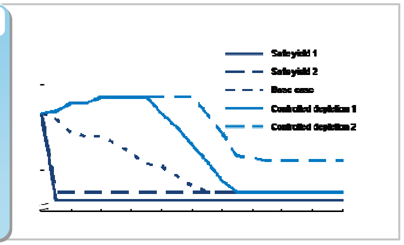
Appendix 1 - Supply

- Current supply
- Planned supply projects
- Cost of supply
- JRSP
- **Supply solutions**

To achieve more sustainable, future supply Jordan could introduce controlled depletion of groundwater resources, complementary supply measures as well as capital efficiency and productivity

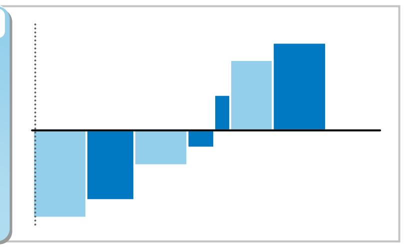
Effect

A **Controlled depletion of groundwater resources**



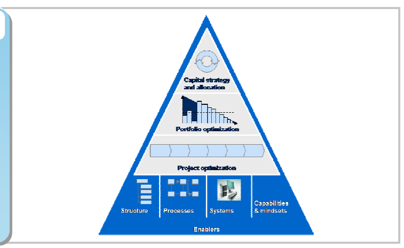
- Stopping groundwater over-abstraction through controlled depletion could yield an average of ~15 MCM additional supply until 2030

B **Complementary supply measures**



- Implementing complementary supply measures could yield additional ~500 MCM of water supply

C **Capital efficiency and productivity**



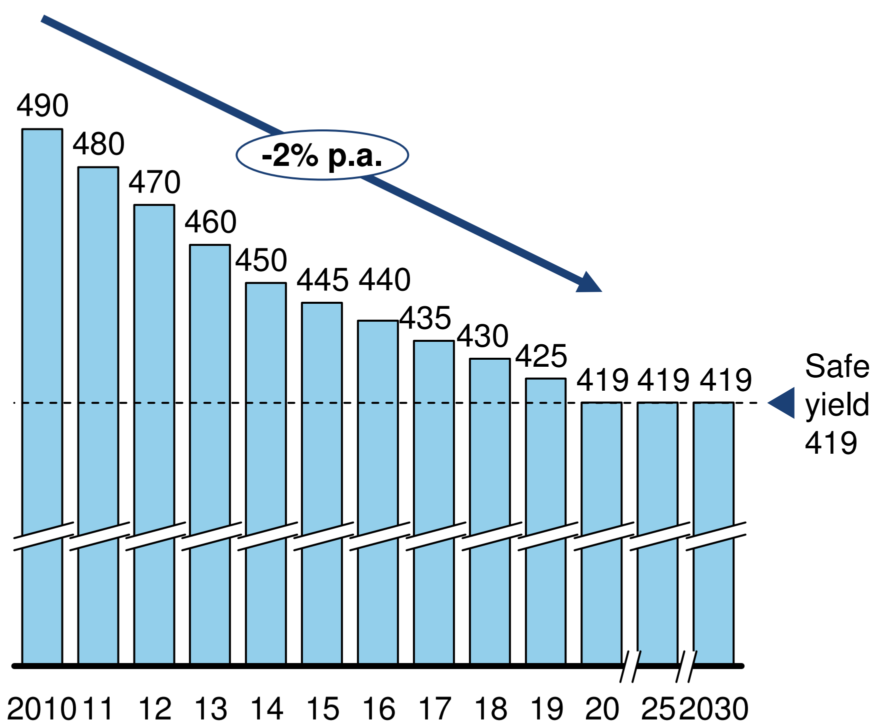
- Introducing capital efficiency and productivity could improve value for supply projects by 20-30% of capex spend

SOURCE: Team analysis

Ⓐ Stopping groundwater over-abstraction through controlled depletion could yield an average of ~15 MCM additional supply until 2030

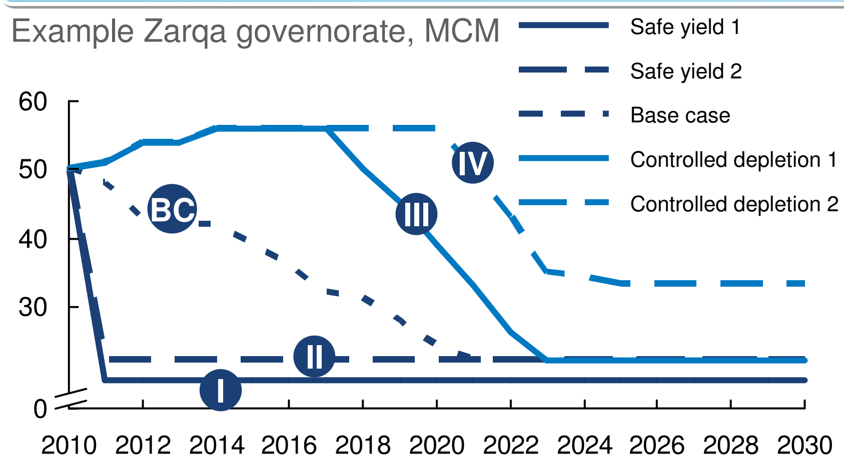
MWI aims at achieving sustainable groundwater abstraction rates by stopping over-abstraction by 2020

MCM



Stopping over-abstraction through controlled depletion could yield an average of up to 16 MCM over 20 years

Example Zarqa governorate, MCM

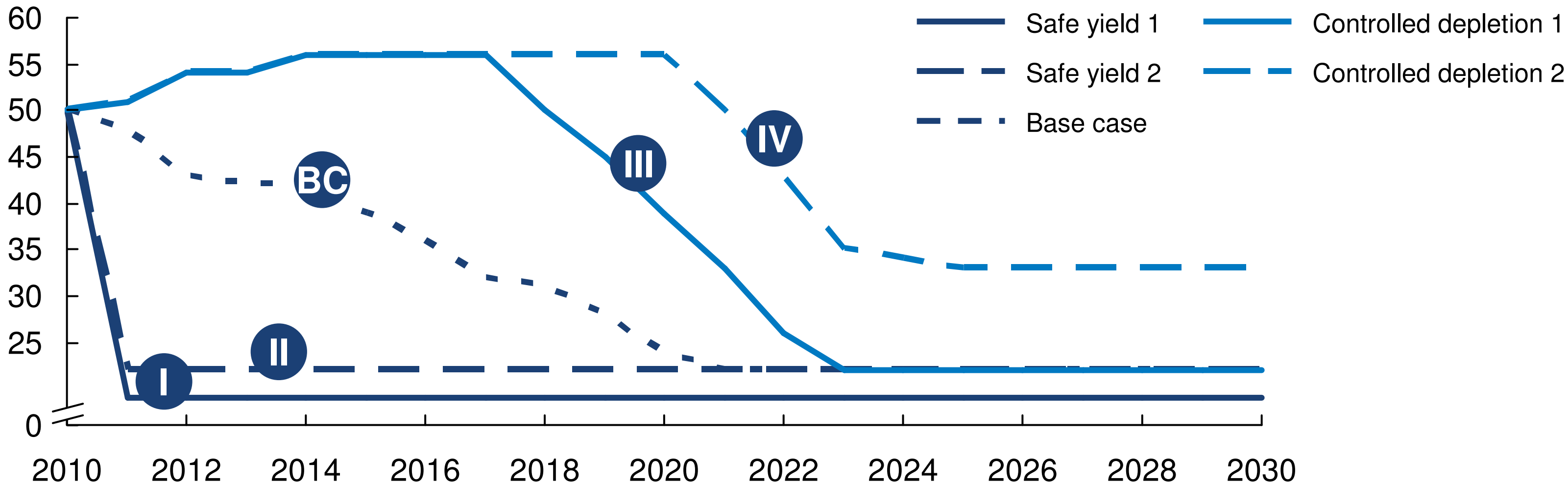


Scenario description	Yield p.a.
BC Base case scenario: Gradual reduction of abstraction based on life-time of wells	0
I, II Safe yield scenarios: Immediate reduction of abstraction to safe-yield by 2011	-7-10
III Controlled depletion 1: Achieve safe-yield by 2023 and continue over-abstraction by refurbishing wells	+8
IV Controlled depletion 2: Achieve lower over-abstraction level by 2023 (~10 MCM above safe yield) and continue over-abstraction by refurbishing wells	+16

SOURCE: PMU, MCC, DAR

A Groundwater over-abstraction scenarios in detail

Scenarios for reduction of over-abstraction



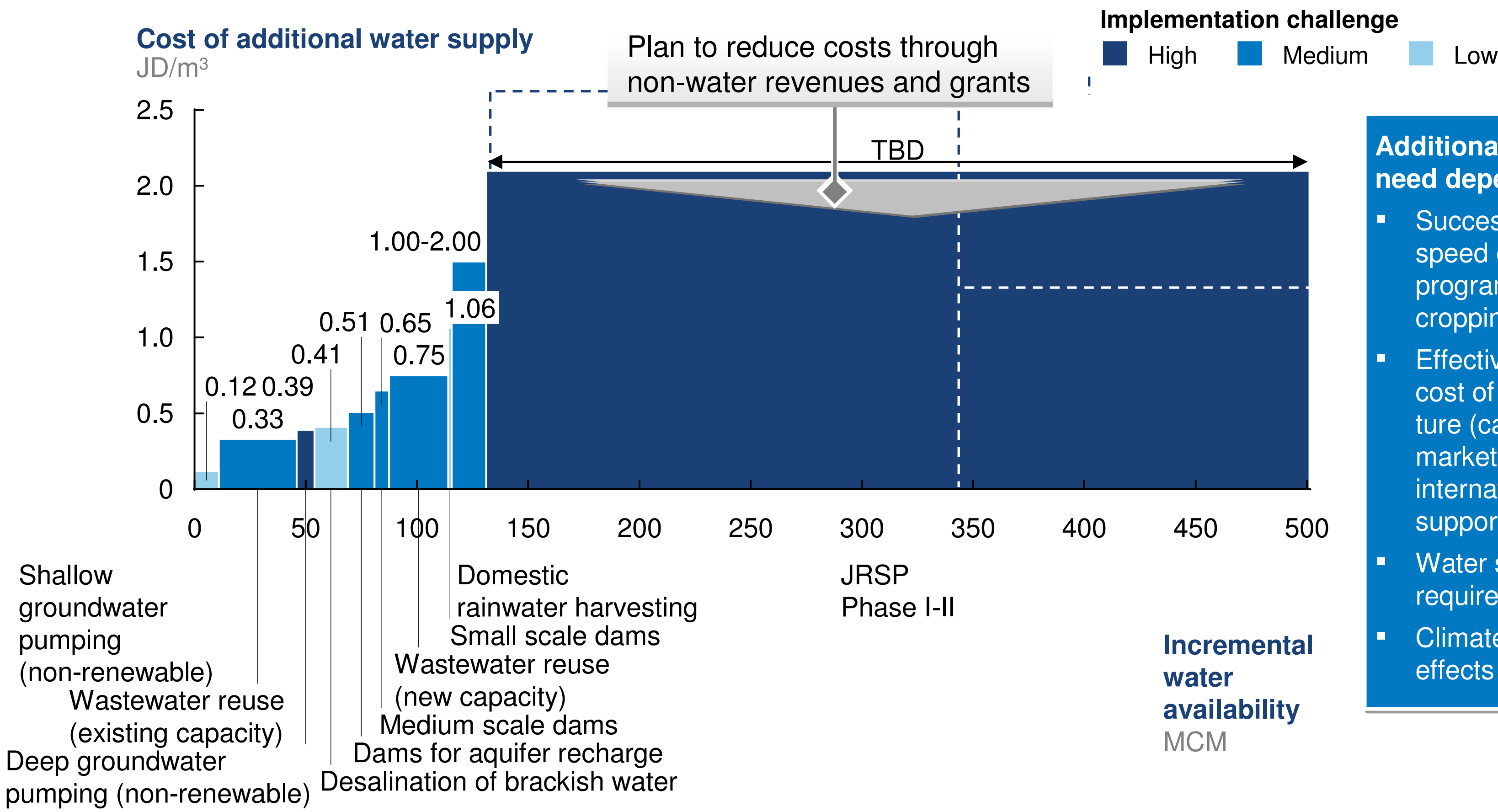
Scenario | **Groundwater over-abstraction difference vs. base case scenario** | **Average yield per year**

Scenario																						Average yield per year
I Safe-yield 1		-29	-24	-23	-23	-20	-17	-13	-12	-9	-5	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	Ø -10
II Safe-yield 2		-26	-21	-20	-20	-17	-14	-10	-9	-6	-2	0	0	0	0	0	0	0	0	0	0	Ø -7
III Controlled depletion 1	0	3	11	12	14	17	20	24	19	17	15	11	4	0	0	0	0	0	0	0	0	Ø +8
IV Controlled depletion 2	0	3	11	12	14	17	20	24	25	28	32	28	21	13	12	11	11	11	11	11	11	Ø +16

SOURCE: MCC, DAR, team analysis

B Implementing complementary supply measures could yield additional ~500 MCM of water supply by 2030

Cost curve of solutions for water supply



Additional supply need depends on

- Success and speed of efficiency programmes and cropping changes
- Effective marginal cost of infrastructure (capital markets, international support)
- Water security requirements
- Climate change effects

SOURCE: MWI, WAJ, JVA, team analysis

B There are a number of supply solutions which can increase water availability (1/2)

Solution	Description
1 Shallow groundwater pumping (non-renewable)	▪ Raise extraction of shallow non-renewable groundwater to full potential
2 Deep groundwater pumping (non-renewable)	▪ Raise extraction of deep non-renewable groundwater to full potential
3 Wastewater reuse (existing capacity)	▪ Increase utilization of existing plants up to 100% of treatment capacity
4 Wastewater reuse (new capacity)	▪ Create new plants for waste water treatment to reuse-grade (grey water reuse is not included here)
5 Small-scale dams	▪ Create new dams < 3 MCM outflow
6 Medium-scale dams	▪ Create new dams > 3 MCM outflow
7 Dams for aquifer recharge	▪ Increase the safe yield of existing aquifers by recharging with rainwater collected in new dams

SOURCE: MWI, WAJ, JVA, team analysis

B There are a number of supply solutions which can increase water availability (2/2)

Solution	Description
8 **Domestic rainwater harvesting**	▪ Collect rainwater from roof tops for municipal uses
9 **Desalination of brackish water**	▪ Extract and desalinate brackish groundwater
10 Jordan Red Sea Project (JRSP) – not detailed in this document	▪ Build large-scale sea water transport and desalination capacity supplying freshwater while linking the Red Sea to the Dead Sea

SOURCE: MWI, WAJ, JVA, team analysis

1 Shallow groundwater pumping (non-renewable)

Description
- Extract non-renewable groundwater not captured yet

	Value	Description	Source
Volume	▪ Ma'an: 11 MCM	▪ Increase abstraction up to long-term abstraction rate of 18 MCM for Jafr ▪ Currently reviewed by study	▪ MWI NWMP team
Cost	▪ 0.12 JD/m^3	**Capex 0.02 JD/m^3** ▪ Drilling: 88,000 JD/100m^3/day ▪ Equipment: 4,000 JD/100 m^3/day ▪ Asset lifetime: 10 years ▪ Discount rate: 10% **Opex 0.10 JD/m^3** ▪ Energy: 0.09 JD/m^3 (current energy cost of 0.045 JD/m^3 based on a subsidized tariff of 0.042 JD/m^3 – commercial, unsubsidized rates are ~2x higher at 0.086 JD/m^3) ▪ Maintenance: 0.01 JD/m^3	▪ WAJ, team analysis

2 Deep groundwater pumping (non-renewable)

Description
- Extract water from deep aquifers not captured yet

	Value	Description	Source
Volume	▪ Karak: 8 MCM	▪ Increase abstraction up to long-term abstraction rate of 14 MCM for Lajjoun ▪ Further potential currently in exploration based on AFD study	▪ MWI NWMP team
Cost	▪ 0.39 JD/m³	**Capex 0.12 JD/m³** ▪ Drilling: 388,500 JD/100 m³/day ▪ Equipment: 50,000 JD/100 m³/day ▪ Asset lifetime: 10 years ▪ Discount rate: 10% **Opex 0.27 JD/m³** ▪ Energy: 0.25 JD/m³ (current energy cost of 0.124 JD/m³ based on a subsidized tariff of 0.042 JD/m³ – commercial, unsubsidized rates are ~2x higher at 0.86 JD/m³) ▪ Maintenance: 0.02 JD/m³	▪ WAJ, team analysis

❸ Wastewater reuse (existing capacity)

Description
- Increase utilization of existing plants up to full treatment capacity

	Value	Description	Source
Volume	▪ National: 35 MCM – Governorate split: Existing based on WAJ data	▪ 35 MCM of additional capacity available up to design flow (20 MCM in As Samra, 15 MCM in other treatment plants)	▪ WAJ
Cost	▪ 0.33 JD/m³ (As Samra: 0.20 JD/m³; Other plants: 0.49 JD/m³)	**BOT price 0.20 JD/m³ (As Samra)** ▪ As per BOT agreement **Capex 0.34 JD/m³ (other plants)** ▪ Investment cost: Initial investment cost per plant ▪ Asset lifetime: 25 years ▪ Discount rate: 10% **Opex 0.15 JD/m³ (other plants)** ▪ Current average operating cost of waste water treatment plants excluding As Samra	▪ WAJ

4 Wastewater reuse (planned capacity)

Description

- Create new plants for waste water treatment to reuse-grade (requires higher municipal water use e.g. more supply; grey water reuse is not included here)

	Value	Description	Source
Volume	▪ National: 26.5 MCM – Amman: 3.5 – Ajloun: 3.3 – Mafraq: 2.4 – Karak: 2.0 – Zarqa: 2.0 – Irbid: 1.3 – Not clear yet: 12.0	▪ Wastewater treatment plants currently under study (14.5 MCM) ▪ Reaching the goal of 247 MCM set in the water strategy (12 MCM)	▪ WAJ, MWI
Cost	▪ 0.75 JD/m^3	**Capex 0.57 JD/m^3** ▪ Investment cost: Mafraq: JD 24m (2.4 MCM); Kufranja: JD 10m (3.3 MCM); Al Karak: JD 9m (1.9 MCM); Az Zarqa: JD 1.8m (0.8 MCM); Nauore: JD 12m (3.5 MCM); Barqish: JD 19m (2.7 MCM) ▪ Asset lifetime: 25 years ▪ Interest rate: 10% **Opex 0.18 JD/m^3** ▪ Average of currently running wastewater treatment plants	▪ WAJ

5 Small-scale dams

Description
- Create new dams < 1 MCM outflow

	Value	Description	Source
Volume	▪ National: 1.5 MCM – Karak: 0.5 MCM – Madaba: 0.9 MCM – Ma'an: 0.1 MCM	▪ Planned build-out outflows estimated based on rainfall statistics	▪ JVA
Cost	▪ 1.06 JD/m^3	**Capex 0.97 JD/m^3** ▪ Investment cost: Zarqa Maeen: 10.5 JDm (0.88 MCM); Lajjoun: 2 JDm (0.52 MCM); Adlagha: 1.5 JDm (0.07 MCM) ▪ Asset lifetime: 50 years ▪ Interest rate: 10% **Opex 0.09 JD/m^3** ▪ Share of investment cost: 1%	▪ JVA

6 Medium-scale dams

Description
- Create new dams 1-5 MCM outflow

	Value	Description	Source
Volume	▪ National: 6.6 MCM – Karak: 6.6	▪ Planned build-out outflows estimated based on rainfall statistics	▪ JVA
Cost	▪ 0.65 JD/m^3	**Capex 0.59 JD/m^3** ▪ Investment cost: Ibn Hammad: 30 JDm (2.55 MCM) Karak: 8.5 JDm (4 MCM) ▪ Asset lifetime: 50 years ▪ Interest rate: 10% **Opex 0.06 JD/m^3** ▪ Share of investment cost: 1%	▪ JVA

7 Dams for aquifer recharge (extension)

Description
- Increase the safe yield of existing aquifers by recharging with rainwater collected in new/expanded dams

	Value	Description	Source
Volume	▪ Madaba: 12 MCM	▪ Planned recharge from extension of Wala Dam (12 MCM)	▪ NWMP (Vol. 5, groundwater, p. 37)
Cost	▪ 0.51 JD/m³ (0.22 JD/m³ as long as wells are not being used)	**Capex 0.24 JD/m³** ▪ Investment cost: - Dam extension: JD 24m - Wells: JD 4m (8 x JD 0.5m) ▪ Asset lifetime: 50 years (25 years for wells) ▪ Interest rate: 10% **Opex 0.27 JD/m³** ▪ Dam extension: 1% (Share of investment cost) ▪ Wells: Cost of groundwater pumping (0.17 JD) +50%	▪ NWMP (Vol. 8, economics, p. 10) ▪ Water Resource Group benchmark

8 Domestic rainwater harvesting

Description

- Collect rainwater from roof tops for municipal uses

	Value	Description	Source
Volume	▪ National: 15.5 MCM – Governorate split: TBD	▪ Estimate based on – Area of housing units (DOS) (assuming 6 apartments per multi-storey building) – Rainfall data (MWI) (assuming 80% of water can be captured)	▪ MWI WDMU (JUST study, IDARA study – to be confirmed and detailed)
Cost	▪ 1.0 – 2.0 JD/m³	**Capex 1.0 – 2.0 JD/m³** ▪ Cost estimate based on review of pear and concrete tanks ▪ Cost of water saved of ~ 1 JD/m³	▪ WAJ WDMU (IDARA study – to be confirmed and detailed)

9 Desalination of brackish water

Description
- Extract and desalinate brackish groundwater

	Value	Description	Source
Volume	▪ Balqa: 15-20 MCM	▪ Identified potential for new brackish water desalination plants in Hasban-Kafreinh area (15 - 20 MCM)	▪ WAJ
Cost	▪ 0.41 JD/m^3	**Capex 0.09 JD/m^3** ▪ Investment cost: Hasban: 8.5 JDm ▪ Asset lifetime: 25 years ▪ Interest rate: 10% ▪ Pumping: 0.03 JD/m^3 (Assumptions: see groundwater pumping levers) **Opex 0.32 JD/m^3** ▪ Desalination: 0.20 JD/m^3 ▪ Pumping: 0.12 JD/m^3 (Assumptions: see shallow groundwater pumping solution)	▪ WAJ

B Solutions need to be assessed on their difficulty of implementation across four broad categories

Challenge type	Examples for challenges	Description
Financial	▪ Insufficient access to capital	▪ End user cannot access financial resources to pay for the necessary up-front costs of a lever
	▪ High up-front costs	▪ Up-front costs are too high even if access to capital is possible
	▪ High transaction costs	▪ Logistical cost of implementing a solution is prohibitively high
Technology and capability	▪ Technology use	▪ Certain levers might use complicated technology or the lead time time in developing technology is high
	▪ Capability	▪ The use of equipment or application of practices requires high skill level at the end user
Structural and organizational capacity	▪ Fragmentation of opportunity	▪ Certain levers require implementation and buy-in from many end users to reach water-saving potential
	▪ Limited management capacity	▪ The existing capacity in government or private sector is not sufficient to carry out proposed projects
	▪ Unclear or fractured lines of authority	▪ The responsibility to implement a lever lies across agencies without a clear line of authority
Social and behavioral	▪ Water has low "mind-share" for end user	▪ Improving water efficiency is not a key element of end-user decision-making
	▪ Difficult for end user to measure consumption	▪ Lever adoption is not reinforced because it is hard to evaluate, measure and verify savings
	▪ Lack of awareness or information	▪ End users are not aware of how a specific efficiency lever or service can be beneficial
	▪ Negative impact on constituencies	▪ Certain levers might disrupt the lives or adversely affect interests of constituents

SOURCE: Team analysis

B Assessing difficulty of implementation provides a framework for prioritizing supply solutions (1/2)

○ Low
◐ Medium
● High

Solution	Challenge type: Financial	Challenge type: Technology & capability	Challenge type: Structural & organizational	Challenge type: Social & behavioral	Overall implementation challenge
1 Shallow groundwater pumping (non-renewable)	○	○	○	○	○
2 Deep groundwater pumping (non-renewable)	●	●	○	○	◕
3 Wastewater reuse (existing capacity)	◐	◐	○	◐	◐
4 Wastewater reuse (planned capacity)	●	◐	○	○	◐
5 Small-scale dams	◐	◐	○	○	◔
6 Medium-scale dams	●	◐	○	○	◐
7 Dams for aquifer recharge (extension)	●	◐	○	○	◐

SOURCE: Team analysis

B Assessing difficulty of implementation provides a framework for prioritizing supply solutions (2/2)

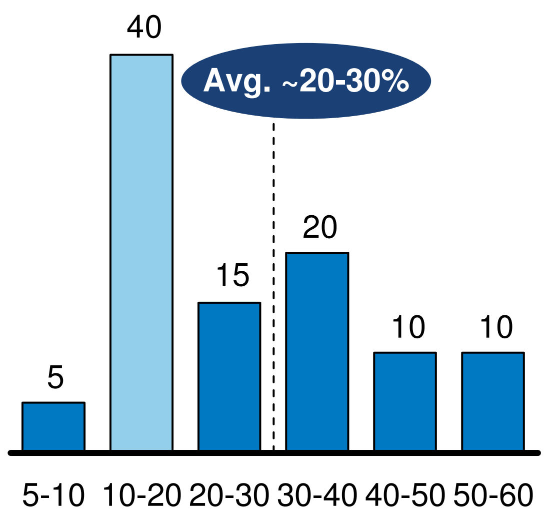
○ No challenge
◐ Moderate challenge
● Infeasible

Solution	Challenge type: Financial	Technology & capability	Structural & organizational	Social & behavioral	Overall implementation challenge
8 Domestic rainwater harvesting	◐	○	○	●	◐
9 Desalination of brackish water	◐	○	○	○	◔

SOURCE: Team analysis

C Introducing capital efficiency and productivity could improve value for supply projects by 20-30% of capex spend

Typically value of capital projects can be optimized by 20-30% of capex spend
Percent of optimizations



Additional value created as share of planned capex spend
Percent

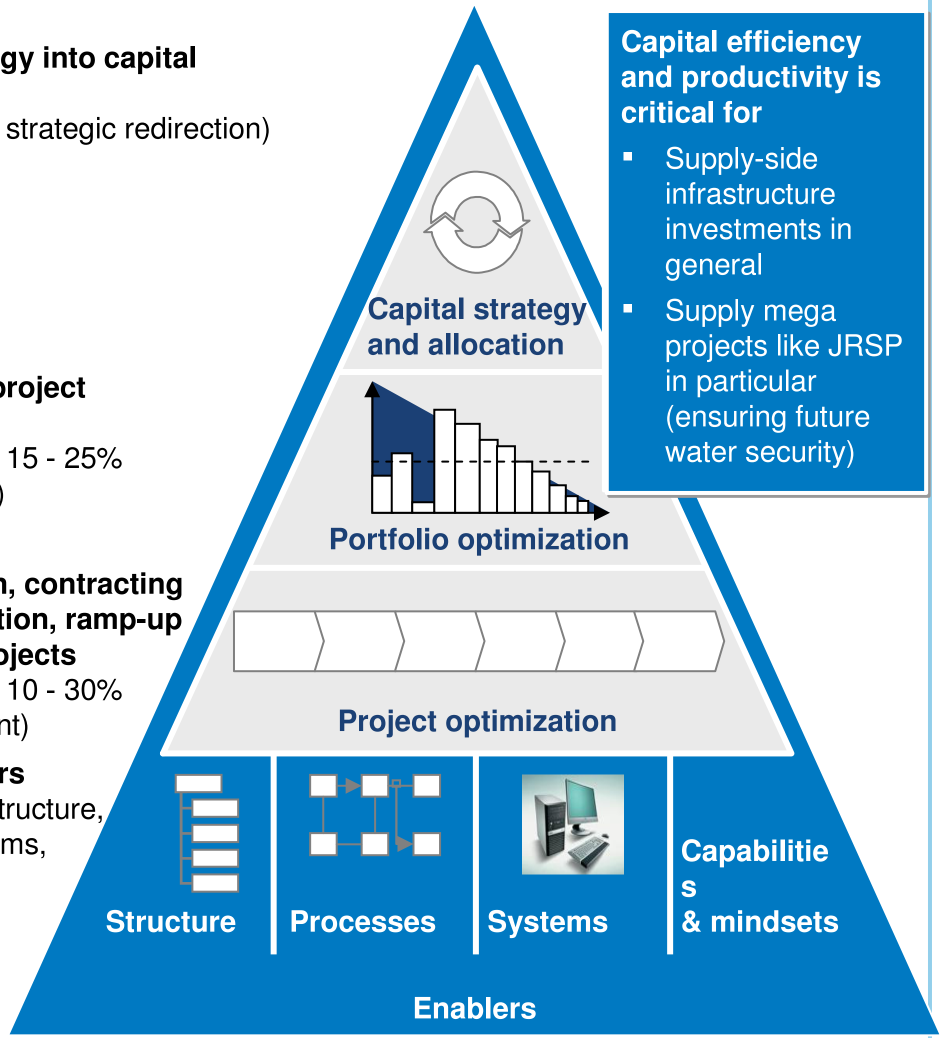
Capital efficiency and productivity can be optimized along 4 steps

I Translate strategy into capital allocation
(Typical impact[1]: strategic redirection)

II Select optimal project portfolio
(Typical impact[1]: 15 - 25% Capex reduction)

III Optimize design, contracting strategy, execution, ramp-up of individual projects
(Typical impact[1]: 10 - 30% NPV improvement)

IV Develop enablers
(organizational structure, processes, systems, and aptitude) **to support world-class capital performance**



Capital efficiency and productivity is critical for

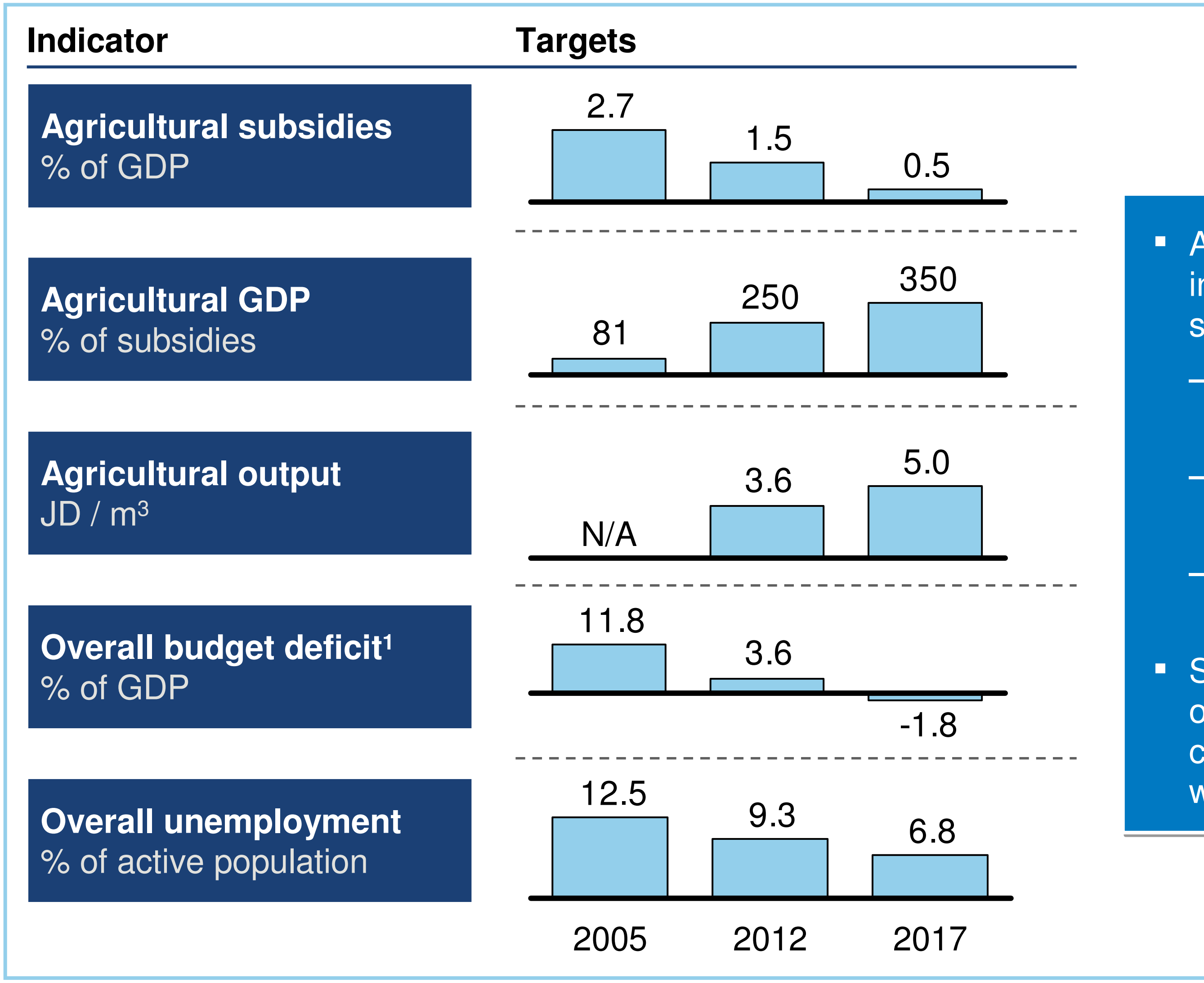
- Supply-side infrastructure investments in general
- Supply mega projects like JRSP in particular (ensuring future water security)

SOURCE: WRG benchmark; team analysis

Appendix 2 – Agricultural use

- **Agricultural aspirations and targets**
- Unconstrained demand vs allocation
- Agricultural water productivity
- Economic choices
- Technical solutions

Jordan’s National Agenda has outlined aspirational targets relevant to the agricultural sector



- Agricultural ambitions indicate a future agricultural sector which:
  - Exhibits high productivity and returns
  - Depends less on government support
  - Combats unemployment, particularly in rural areas
- Simultaneously achieving all of these goals, within the constraint of limited water, will be a challenge

1 Excluding grants

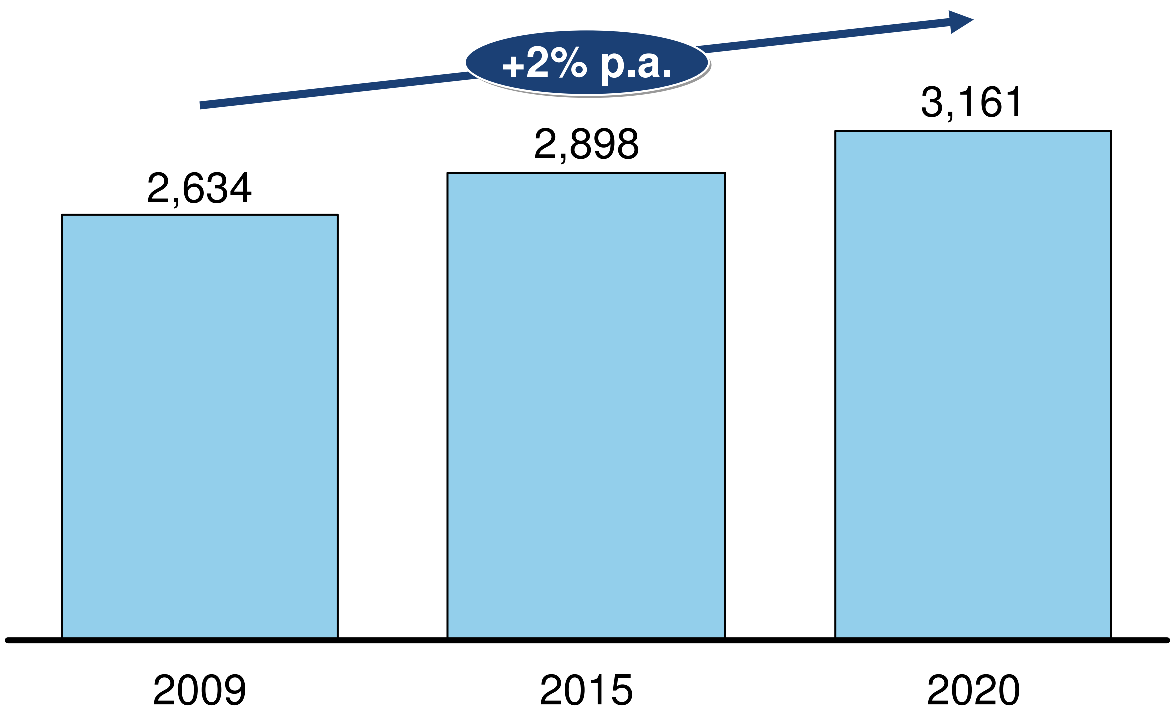
SOURCE: National Agenda (2004); team analysis

PRELIMINARY

Furthermore, agricultural strategies currently being considered aim to increase agricultural production by ~15-25% over 10 years

Limited agricultural growth targets[1]

Crop production, thousand metric tons



- Agricultural output increases to be achieved through
  - Expansion of rain-fed areas
  - Increases in per-hectare crop productivity
- If successful, this approach would require no additional water beyond current allocation

1 Ministry of Agriculture strategy is currently under development and has not been finalized or approved

SOURCE: Ministry of Agriculture interviews; team analysis

To achieve its goals, Jordan's agriculture faces three key water challenges

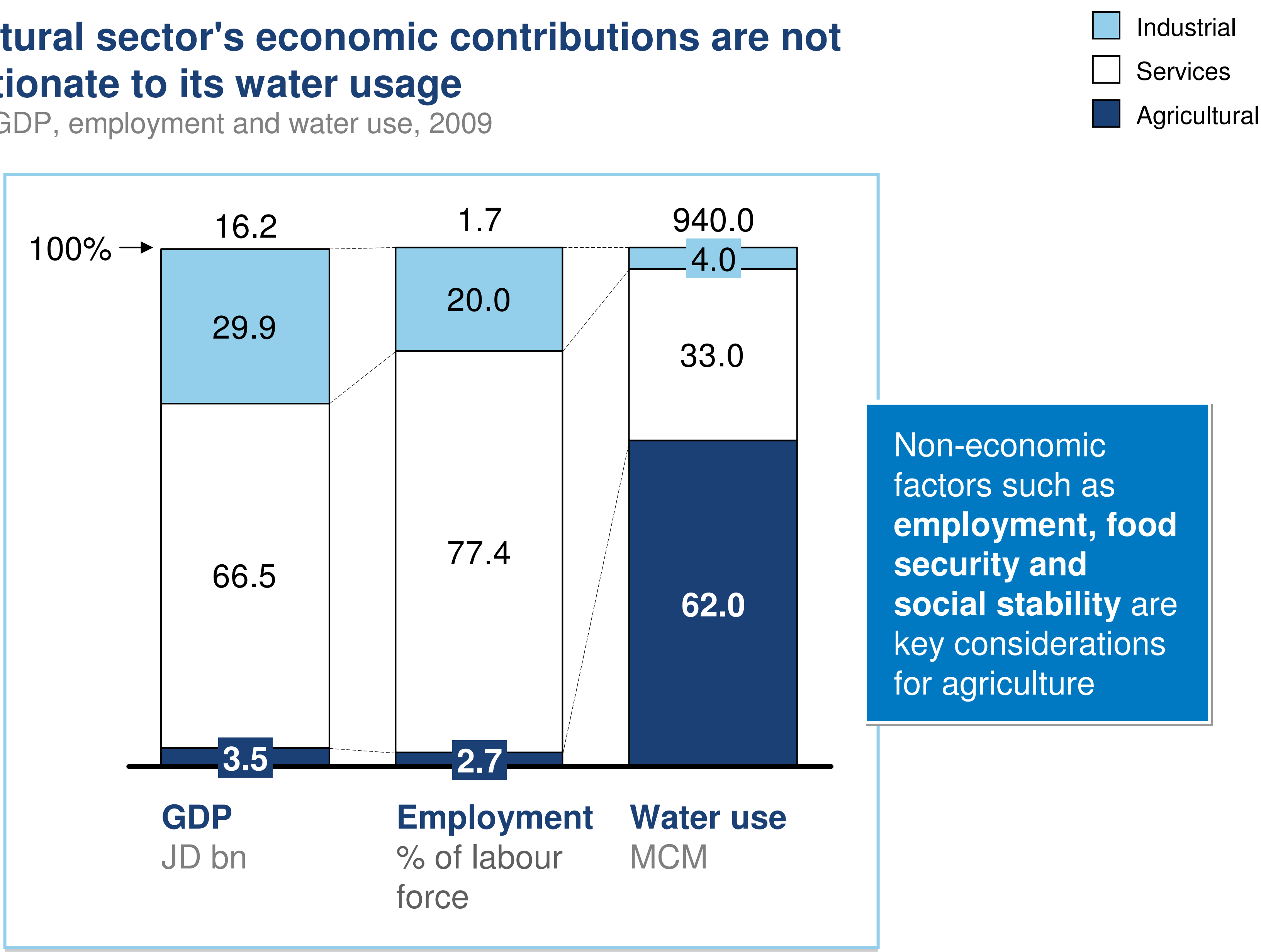
Challenge	Description
Irrigation water quantity	▪ Supply of irrigation water is significantly lower than estimates of unconstrained irrigation demand, with a gap of roughly 500-700 MCM
Irrigation water quality	▪ Low water availability threatens irrigation water quality, with higher groundwater salinity and more reliance on treated wastewater (Jordan Valley)
Irrigation water productivity	▪ Limited irrigation water is used to cultivate a range of crops, some of which destroy rather than add value to the Jordanian economy

- To address these challenges, we will assess two types of solutions
  - Alternate crop mix scenarios for agriculture
  - Technical measures to increase water availability in agriculture and other sectors

SOURCE: Team analysis

Agricultural sector's economic contributions are not proportionate to its water usage

National GDP, employment and water use, 2009

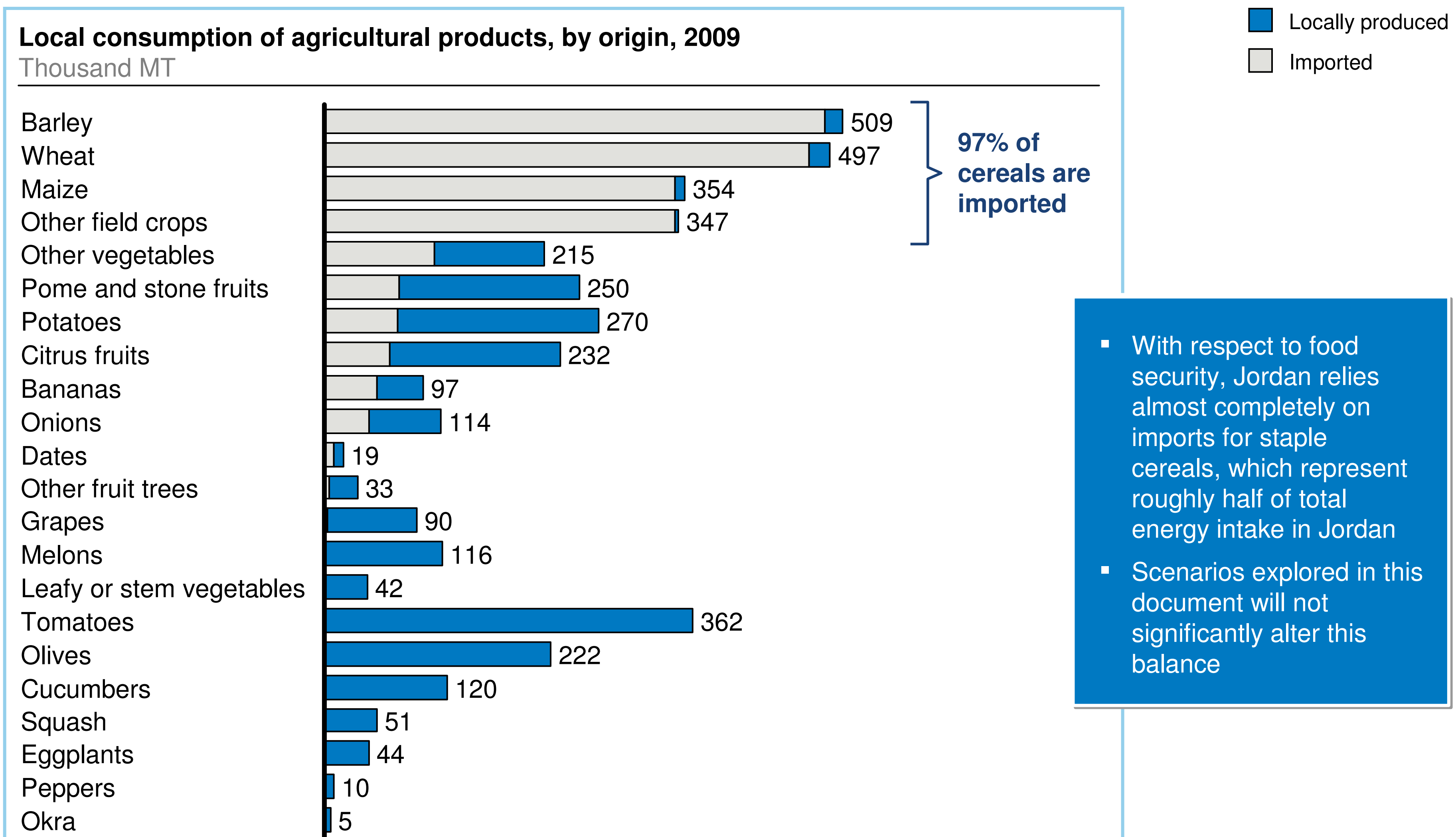


Non-economic factors such as **employment, food security and social stability** are key considerations for agriculture

SOURCE: CIA World Factbook; Jordan National Water Strategy; team analysis

Scenarios will not significantly affect Jordan's food security due to high reliance on imports to supply basic staple cereals

Local consumption of agricultural products, by origin, 2009
Thousand MT



- With respect to food security, Jordan relies almost completely on imports for staple cereals, which represent roughly half of total energy intake in Jordan
- Scenarios explored in this document will not significantly alter this balance

SOURCE: UN Comtrade; Department of Statistics; Ministry of Agriculture; Hamoudi 2007; team analysis

Appendix 2 – Agricultural use

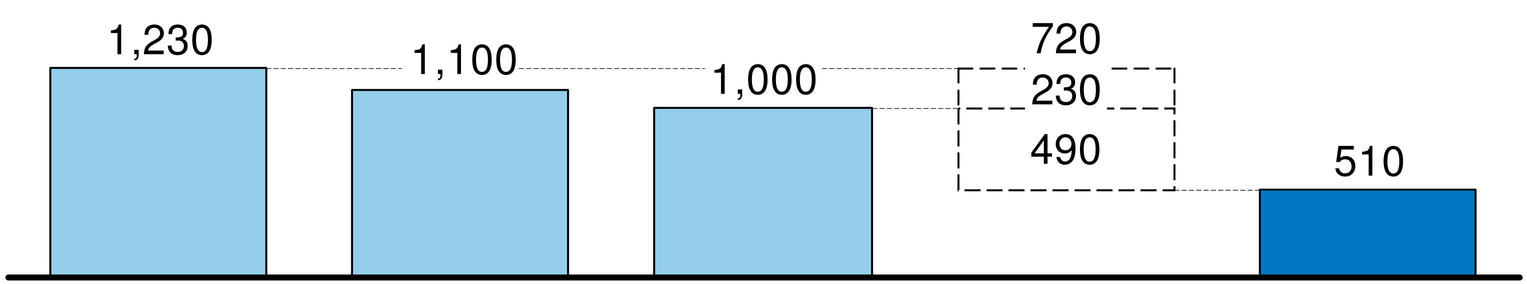
- Agricultural aspirations and targets
- **Unconstrained demand vs allocation**
- Agricultural water productivity
- Economic choices
- Technical solutions

Estimates of unconstrained irrigation demand range from 1,000 to 1,200 MCM

Bulk irrigation water, MCM

Bulk irrigation demand figures

WRG estimate	NWMP estimate	MWI water budget	Unknown agri-cultural gap	Known agric-cultural supply
▪ Irrigation demand including: – Leaching – Efficiency losses	▪ Gross irrigation requirements from National Water Master Plan	▪ Irrigation demand figure from MWI water budget	▪ Gap of ~500-700 MCM which may be due to: – Unreported supply – Under-irrigation	▪ Known national irrigation water supply including surface, ground, and treated waste-water

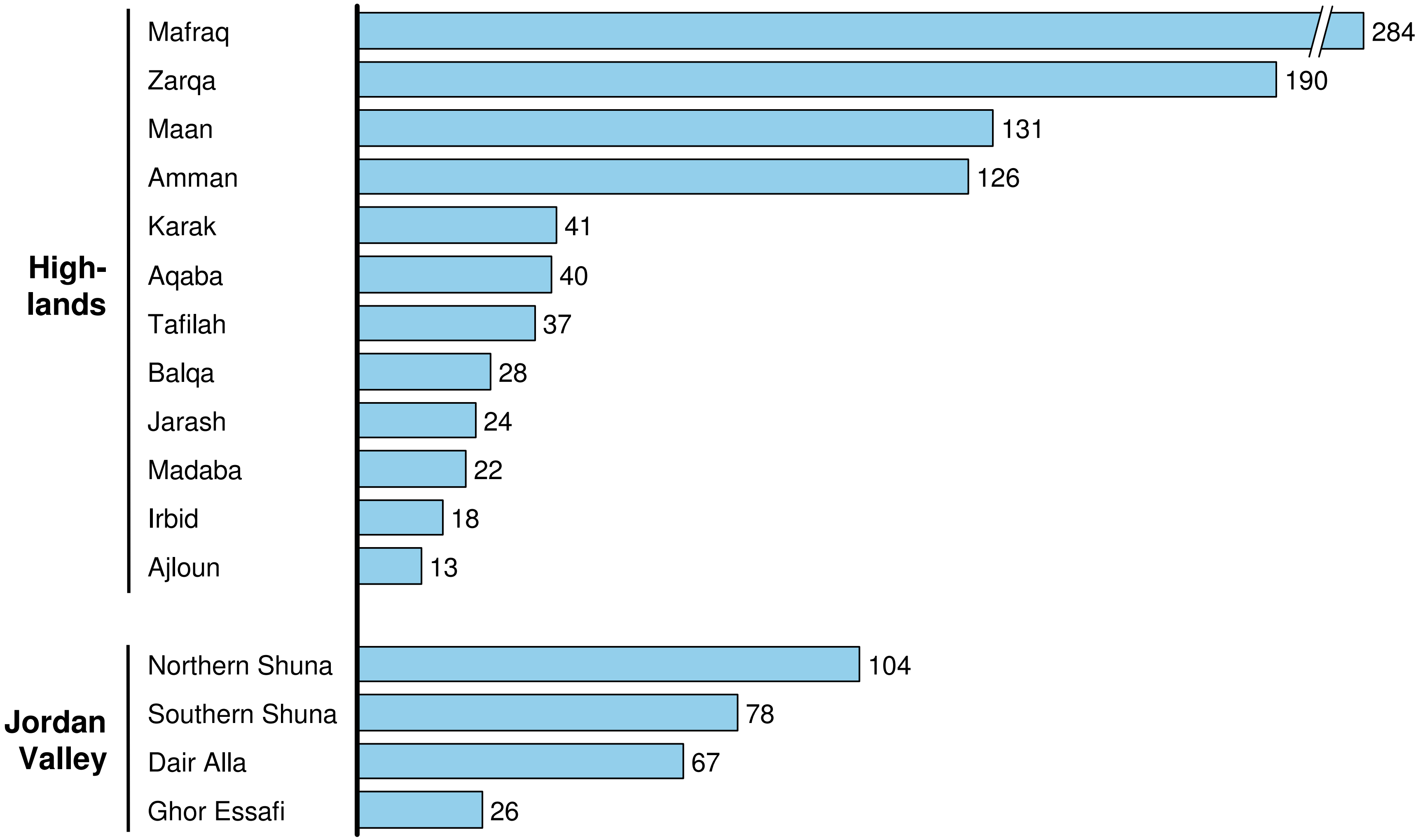


Main calculations (e.g. scenarios, cost-curve) are **based on known agricultural supply**

SOURCE: MWI water budget; NWMP; WAJ; JVA; team analysis

Irrigation water demand totals 1,230 MCM

Unconstrained irrigation water demand, 2009, MCM

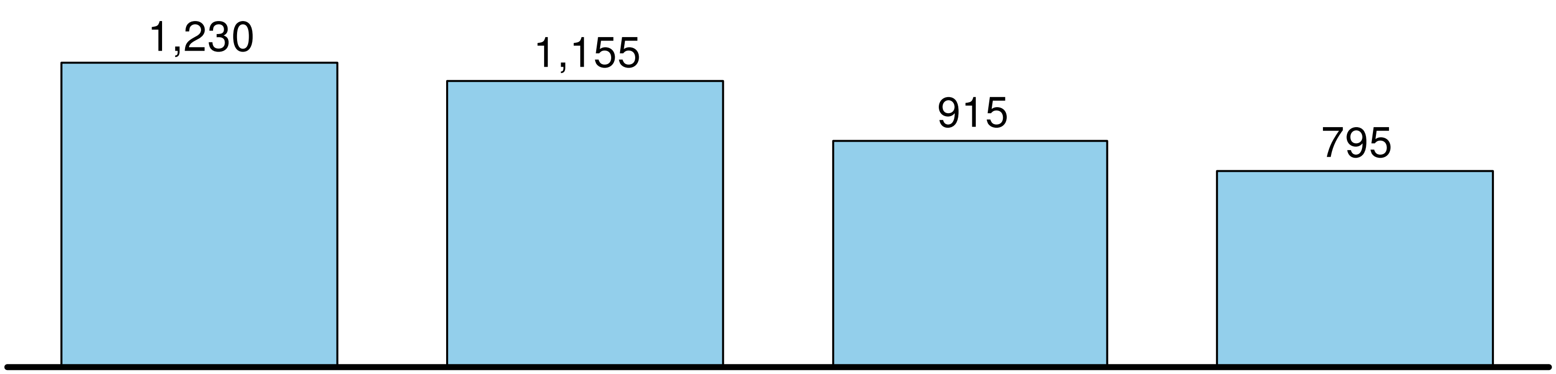


SOURCE: Department of Statistics; Ministry of Agriculture; NWMP; team analysis

We have estimated unconstrained irrigation demand at various levels

	Bulk level (source)	Farm-gate level	Field level	Plant level
Description	▪ Farm-gate level demand plus **efficiency losses due to irrigation conveyance methods[1]**	▪ Field-level demand plus on-farm **efficiency losses due to irrigation method**	▪ Plant-level demand plus **leaching requirements** to maintain soil salinity	▪ Theoretical water volume required by the plant for **optimal growth** ▪ Depends on agro-climatic zone

Total 2009 demand estimate (MCM)



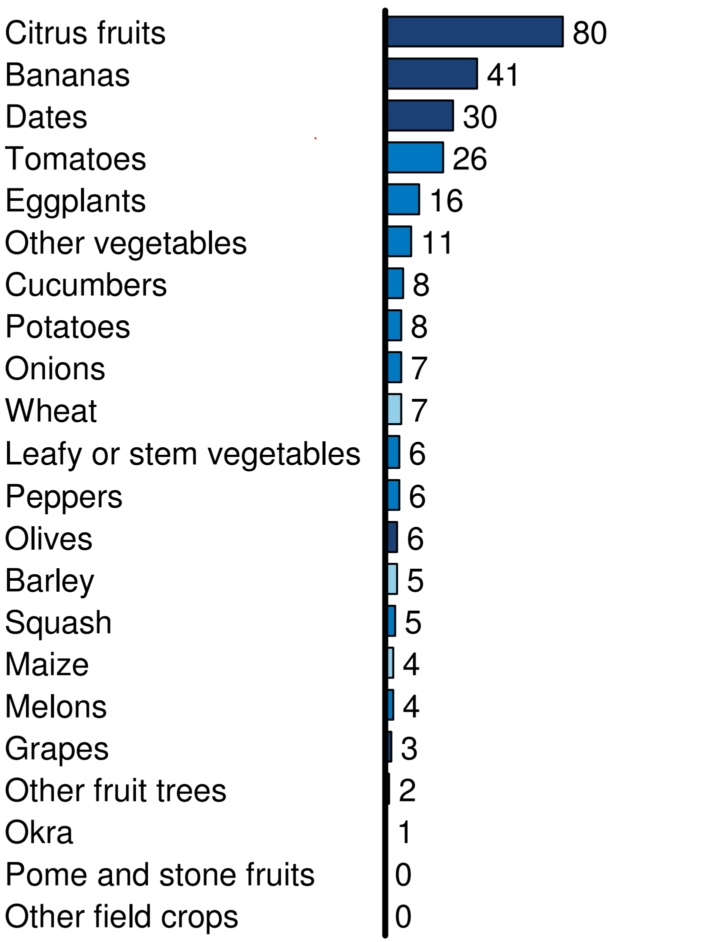
1 Not applied to groundwater-irrigated areas

SOURCE: Team analysis

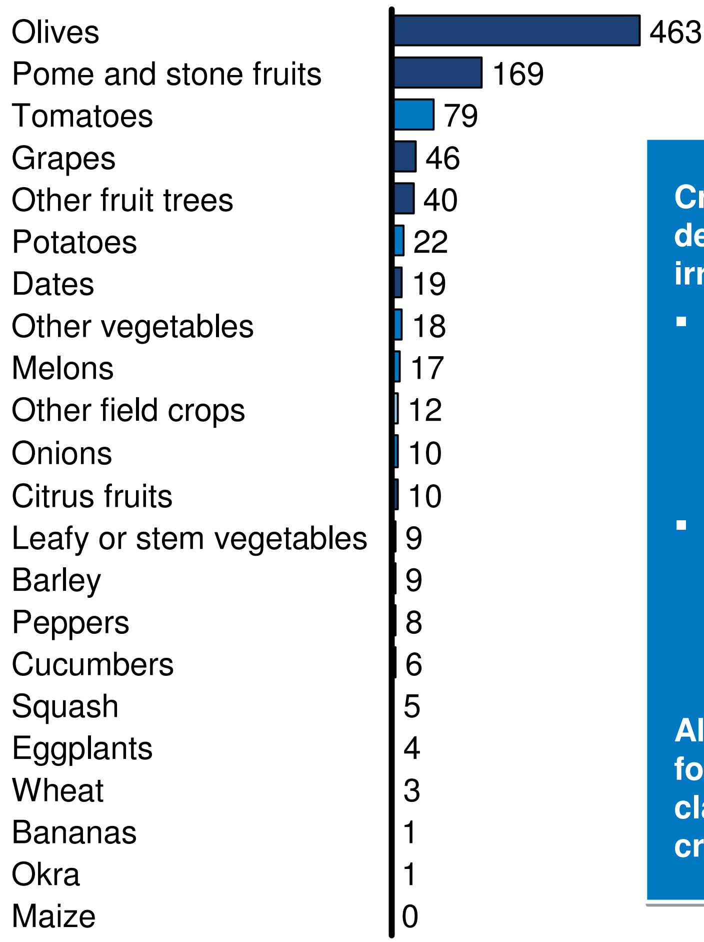
Unconstrained irrigation water demand in Jordan is concentrated in a few major crops

Fruit trees
Vegetables
Field crops

Bulk irrigation water demand, Jordan Valley
MCM



Bulk irrigation water demand, Highlands
MCM



Crop mix is a major determinant of irrigation demand

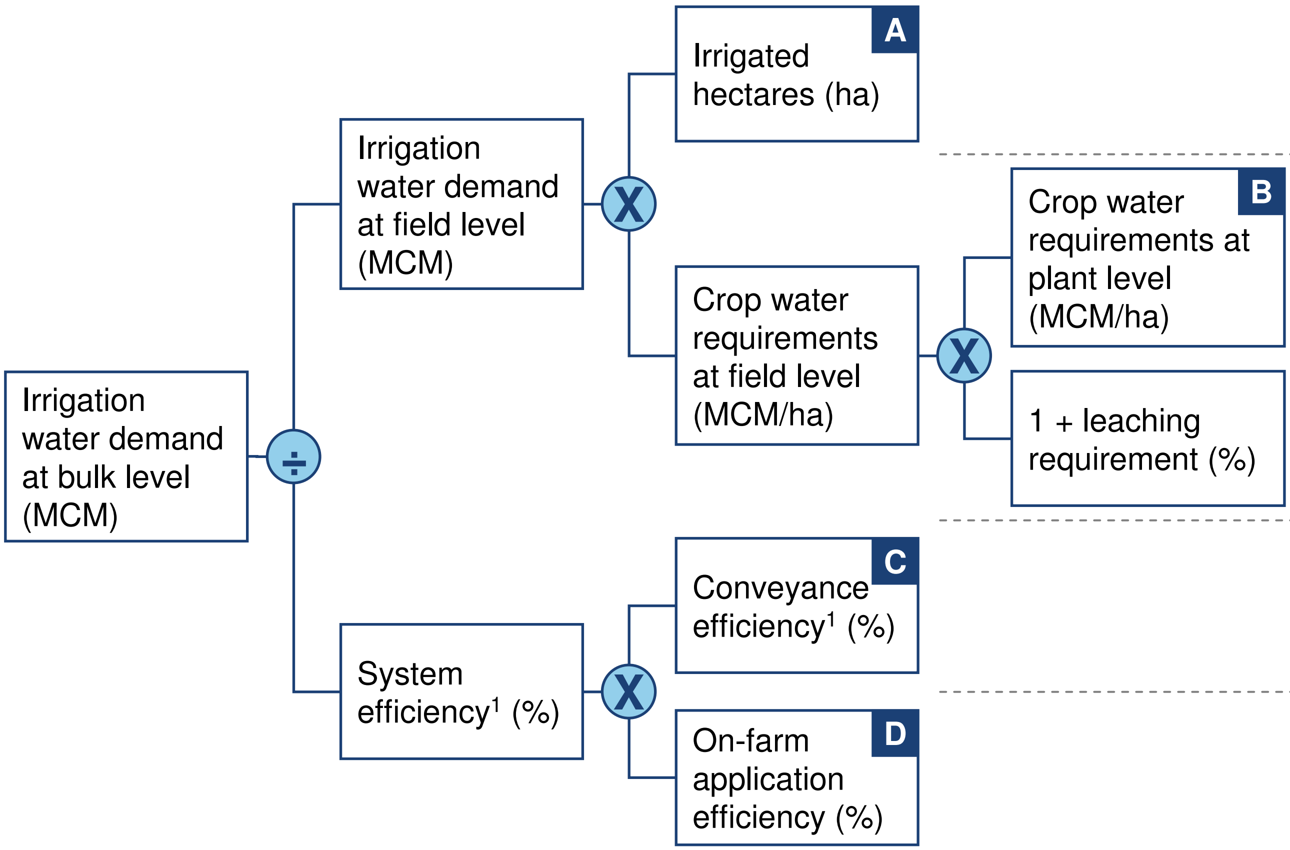
- Top six water-demanding crops account for roughly 75% of total irrigation water demand
- Five of those six crops are fruit trees, which tend to be the biggest users of water, both in total and per hectare

Alternative scenarios for agriculture will clarify the impact of crop mix changes

SOURCE: Department of Statistics; Ministry of Agriculture; NWMP; team analysis

Bulk irrigation water demand calculations relied on numerous data from multiple sources

Calculation method for irrigation demand



Data sources

- Ministry of Agriculture (2009)
- Department of Statistics (2006-2008)

- NWMP[2] net irrigation requirements, by crop and by agro-climatic zone

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- NWMP[2] leaching requirements; estimated at 15%

- NWMP[2] conveyance efficiency data, by region
- JVA discussions

- Department of Statistics (2006-2008)
- NWMP[2] efficiency data per irrigation system

Estimates were calculated by governorate and by crop, where possible

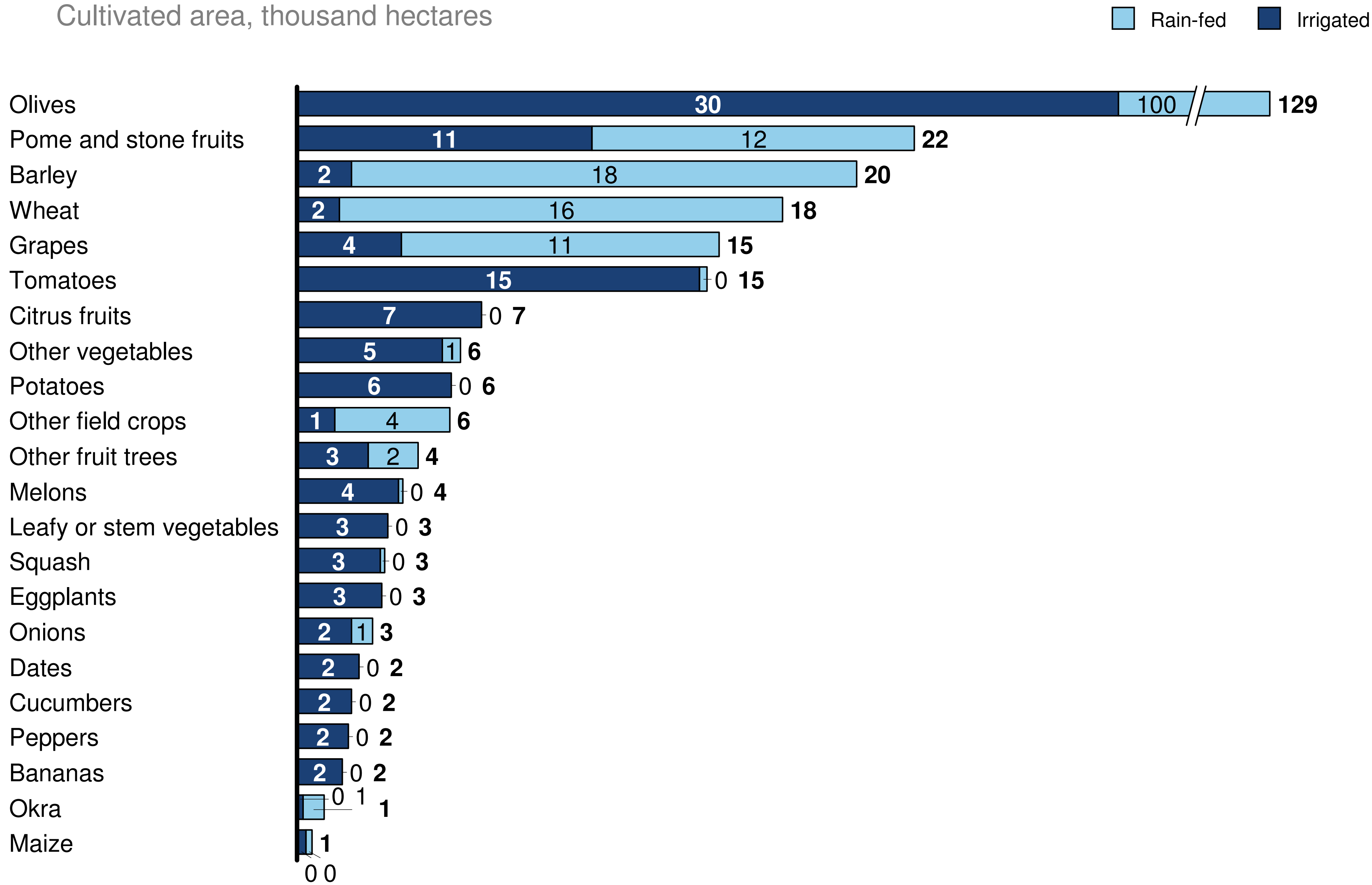
1 Only applies to areas irrigated with surface water

2 National Water Master Plan prepared in 2004

SOURCE: Team analysis

A Cultivated area is available by crop

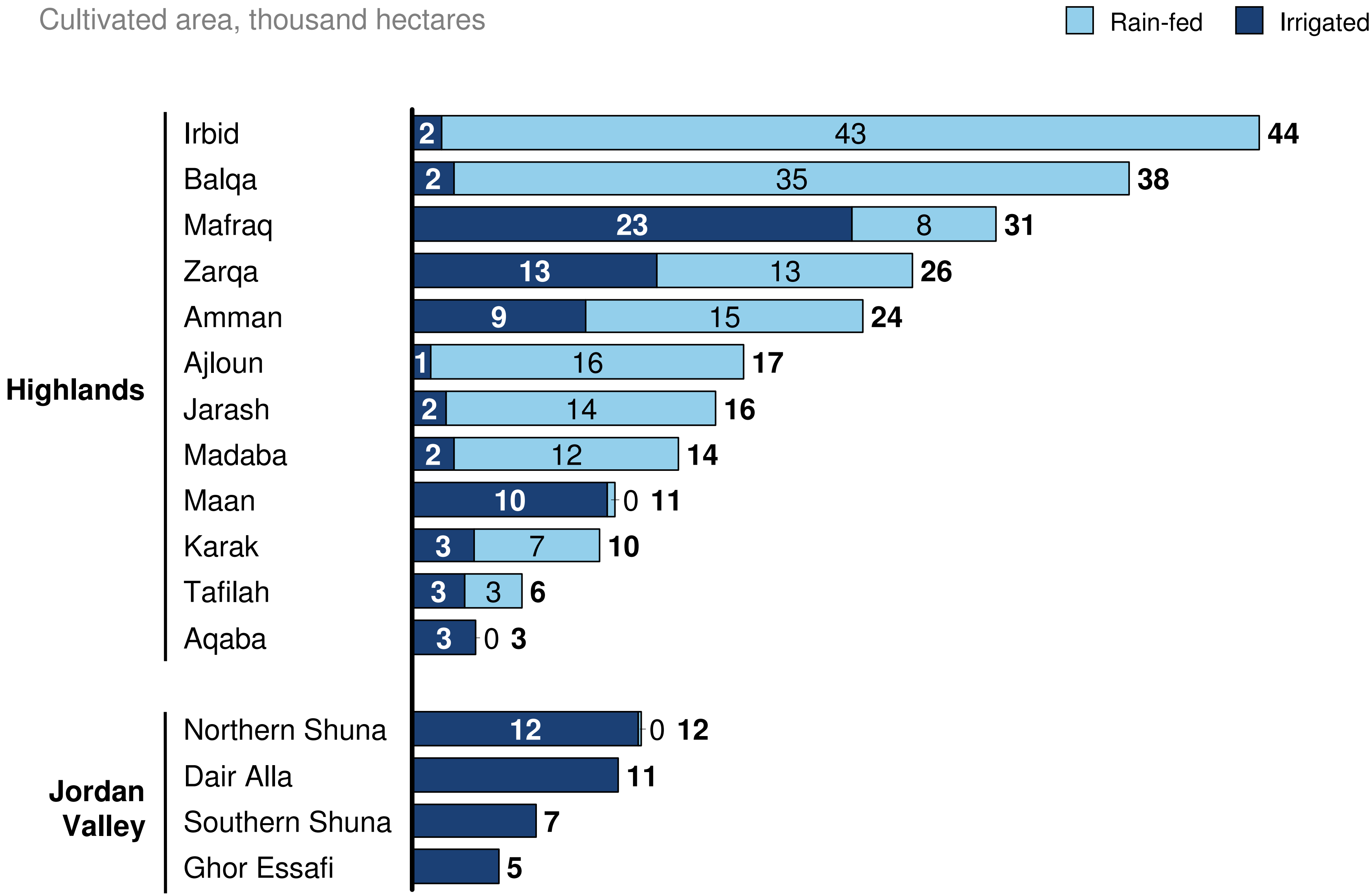
Cultivated area, thousand hectares



SOURCE: Ministry of Agriculture statistics 2009; Department of Statistics 2006-2009

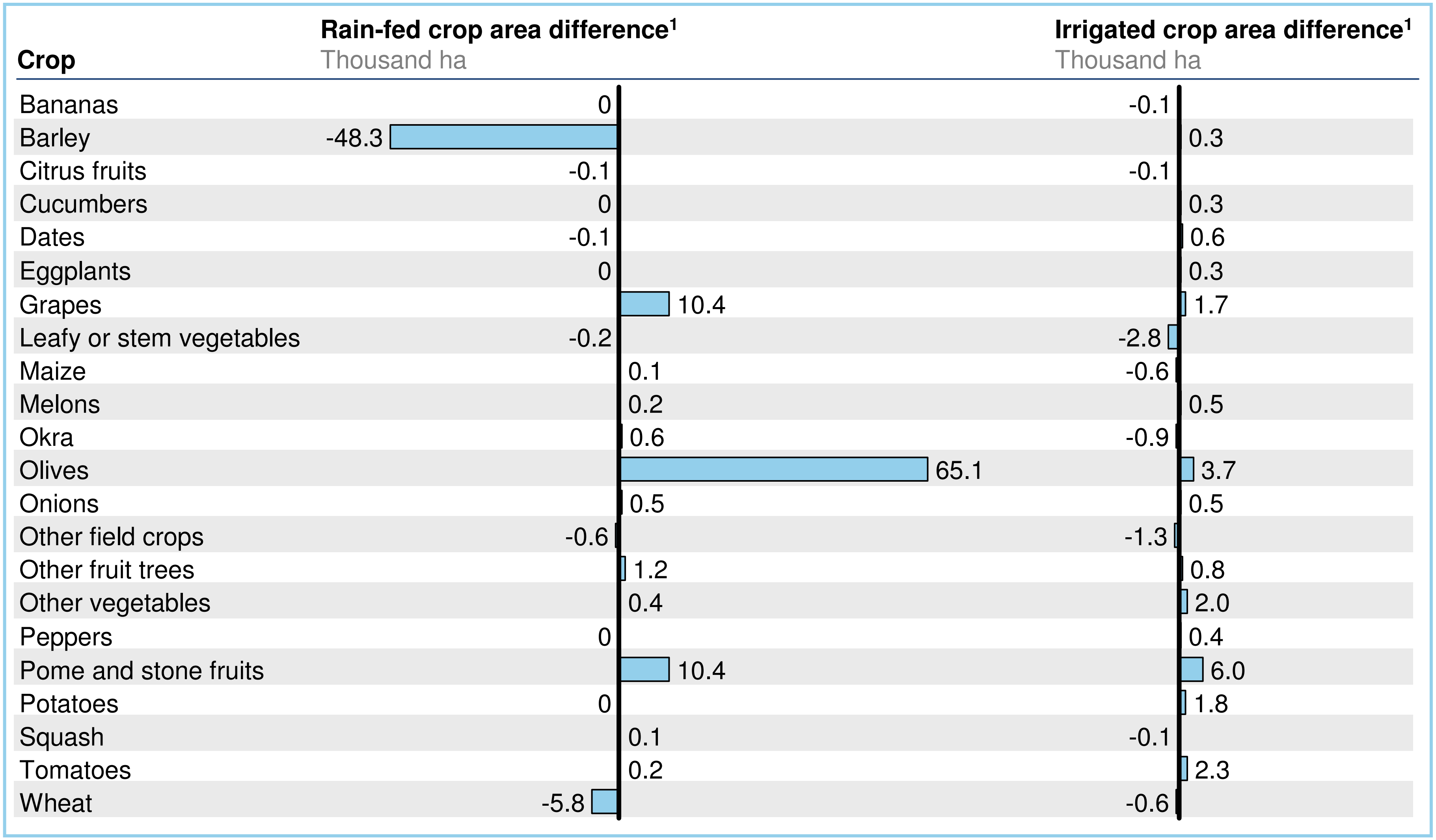
A Cultivated area is available by region

Cultivated area, thousand hectares



SOURCE: Ministry of Agriculture statistics 2009; Department of Statistics 2006-2009

A Some differences in crop area data exist between Department of Statistics and Ministry of Agriculture, mainly in rain-fed areas

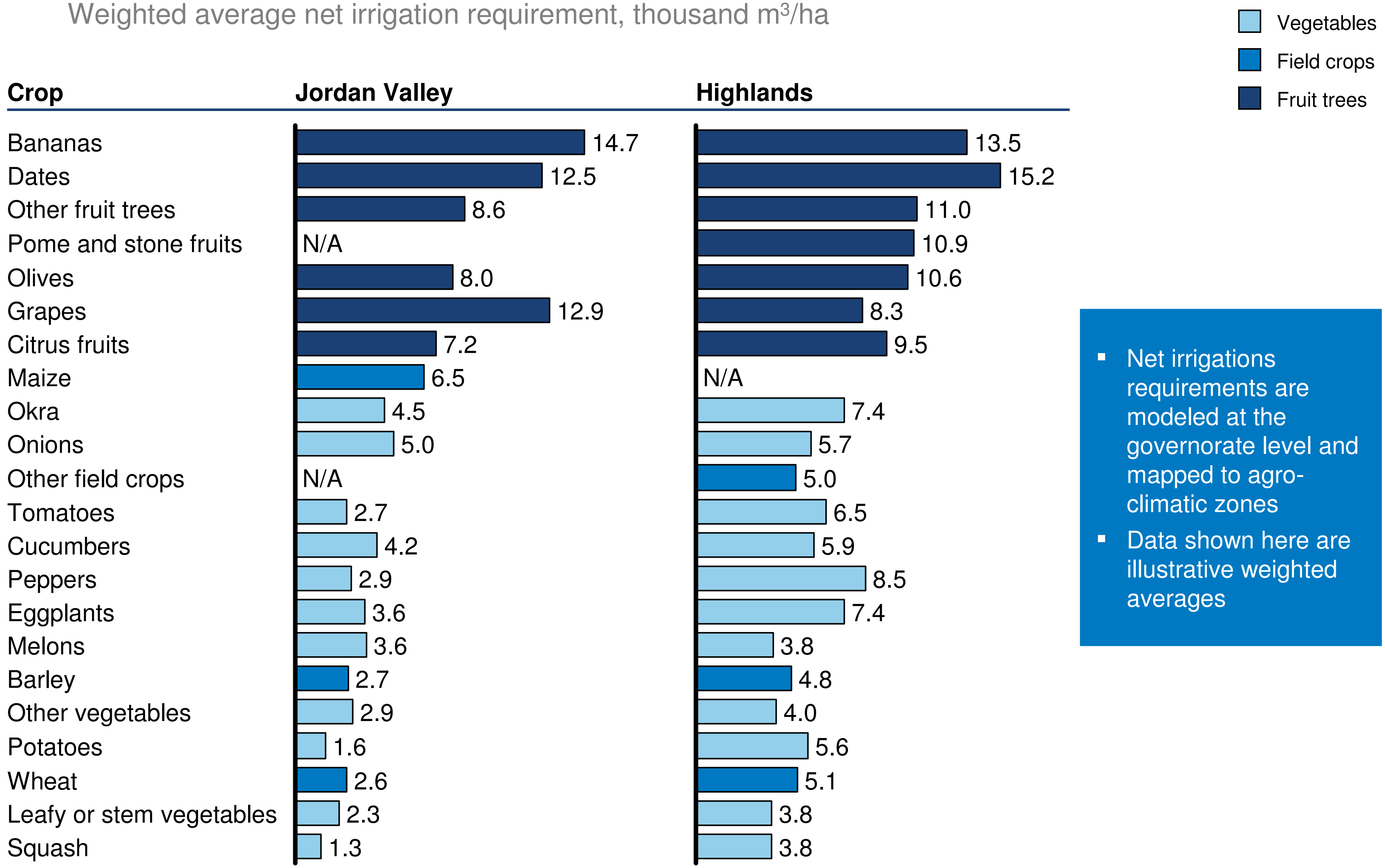


1 Crop area reported by Ministry of Agriculture minus crop area reported by Department of Statistics

SOURCE: Ministry of Agriculture - 2009; Department of Statistics - 2009; Agricultural Census - 2007; team analysis

B Net irrigation requirements are detailed by crop and region

Weighted average net irrigation requirement, thousand m³/ha

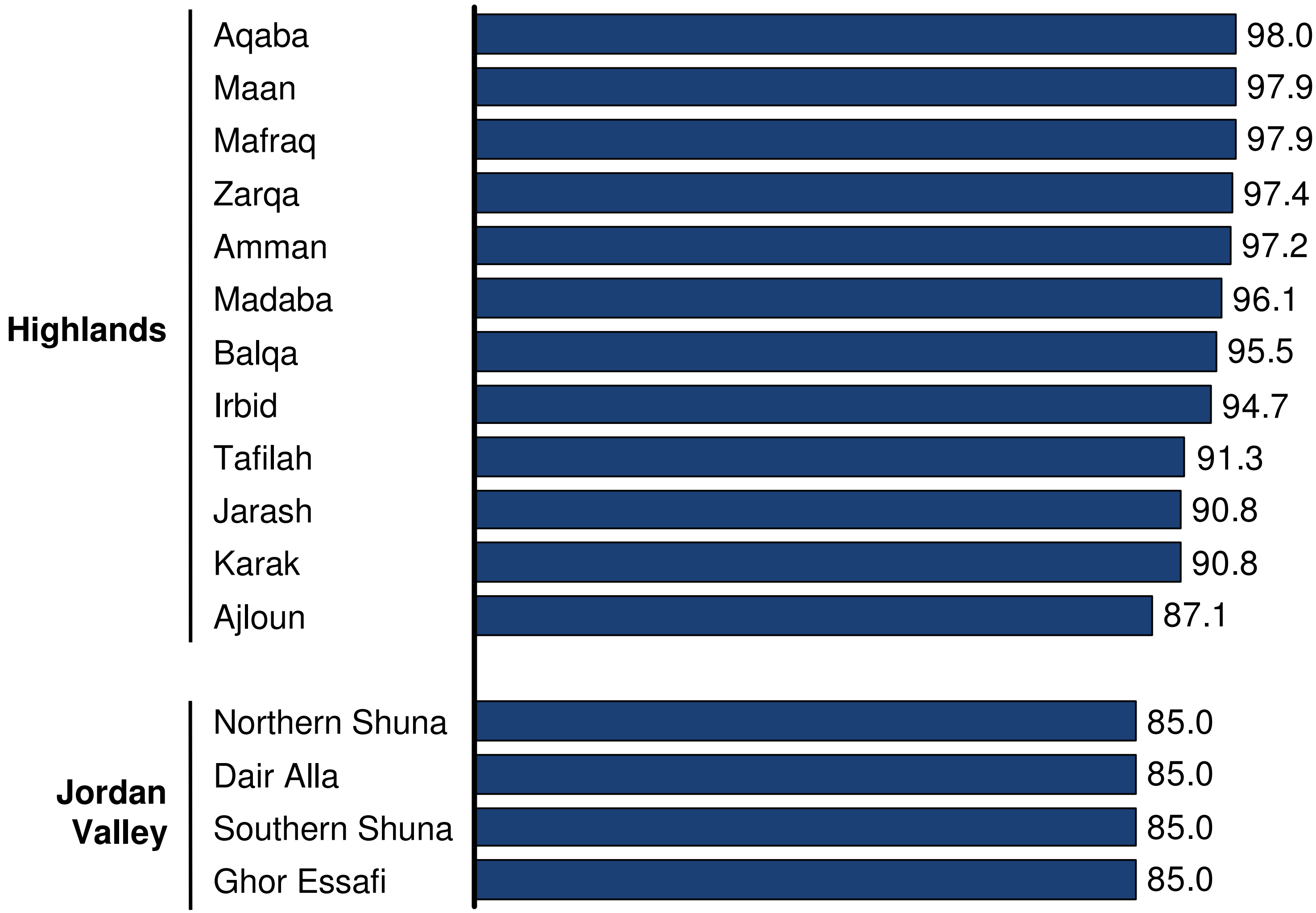


- Net irrigations requirements are modeled at the governorate level and mapped to agro-climatic zones
- Data shown here are illustrative weighted averages

SOURCE: NWMP; team analysis

C Conveyance efficiency varies by region

Average conveyance efficiency, %

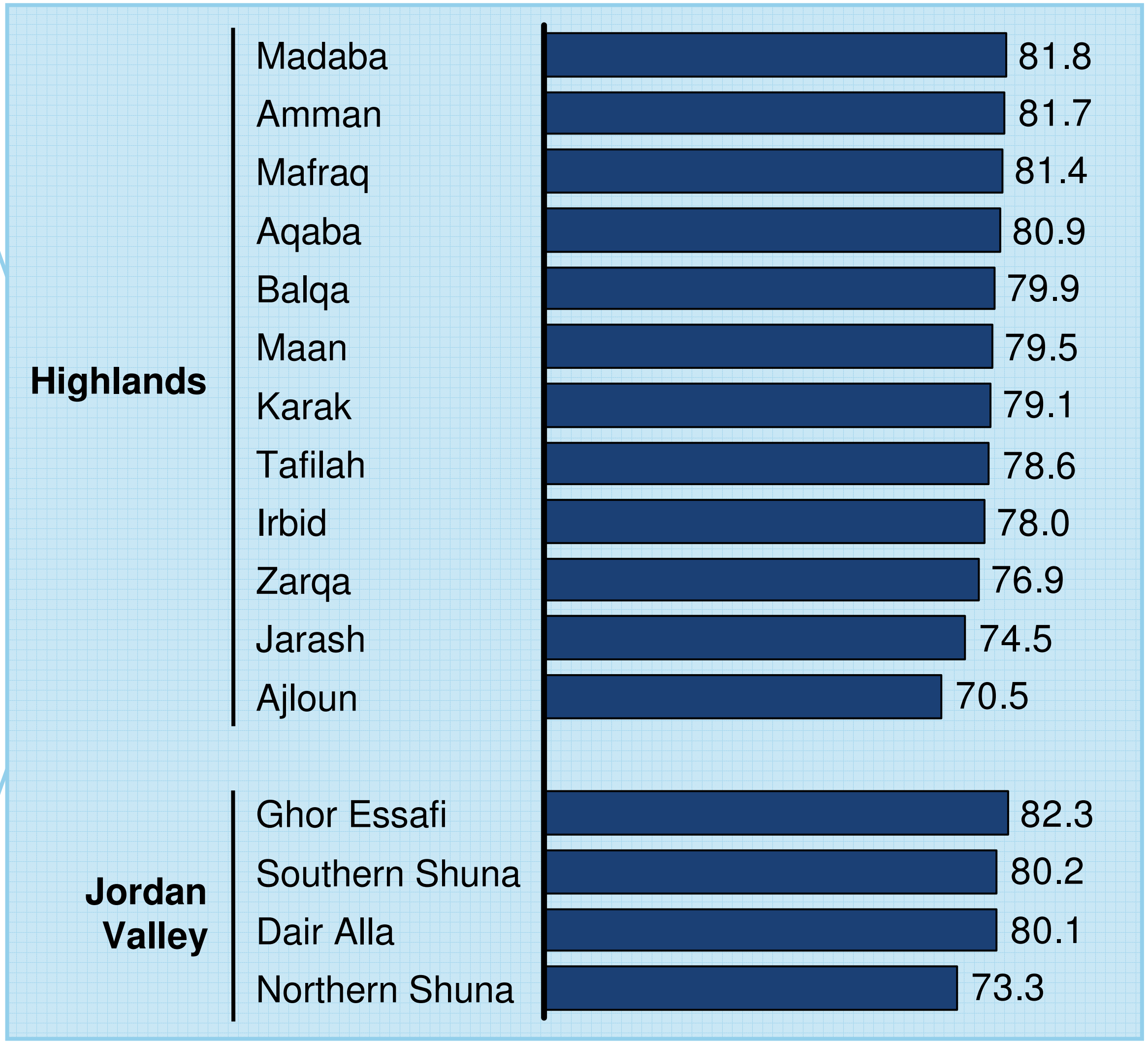


SOURCE: NWMP; team analysis

D Irrigation system efficiency depends on irrigation method

Weighted average irrigation efficiency, %

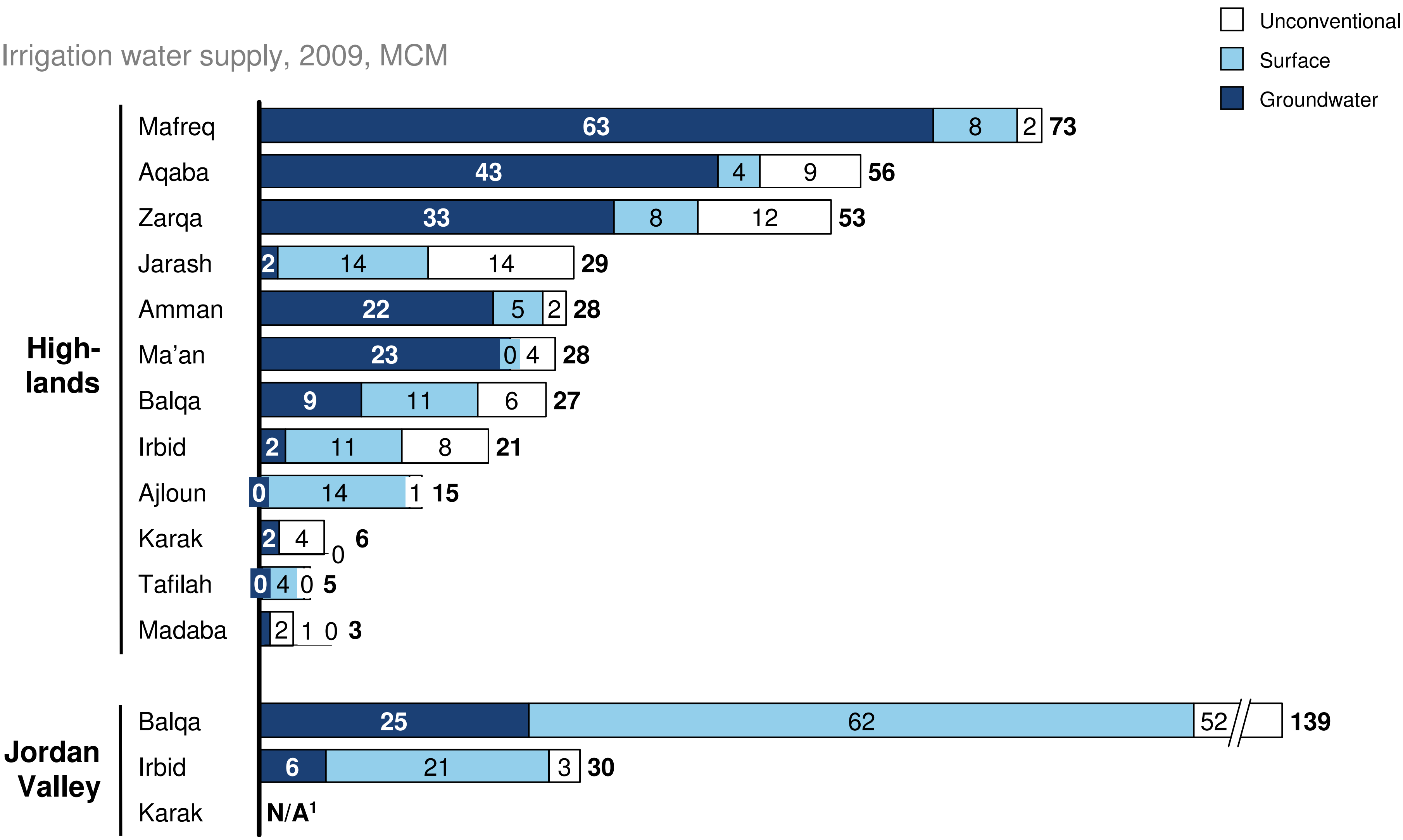
- Irrigation efficiency for each governorate is a weighted average which depends on:
  - **Irrigation method used**
    - Drip: 84%
    - Sprinkler: 75%
    - Surface: 60%
  - **Prevalence of each irrigation system per crop** (e.g. onions use 28% drip, 43% sprinkler, and 29% surface)
  - **Prevalence of each irrigation system per region** (e.g. Irbid uses 67% drip, 8% sprinkler, and 25% surface)



SOURCE: NWMP; Department of Statistics; team analysis

Current irrigation water supply totals 510 MCM

Irrigation water supply, 2009, MCM



1 Supply data for this area to be confirmed

SOURCE: WIS; WAJ; JVA; team analysis

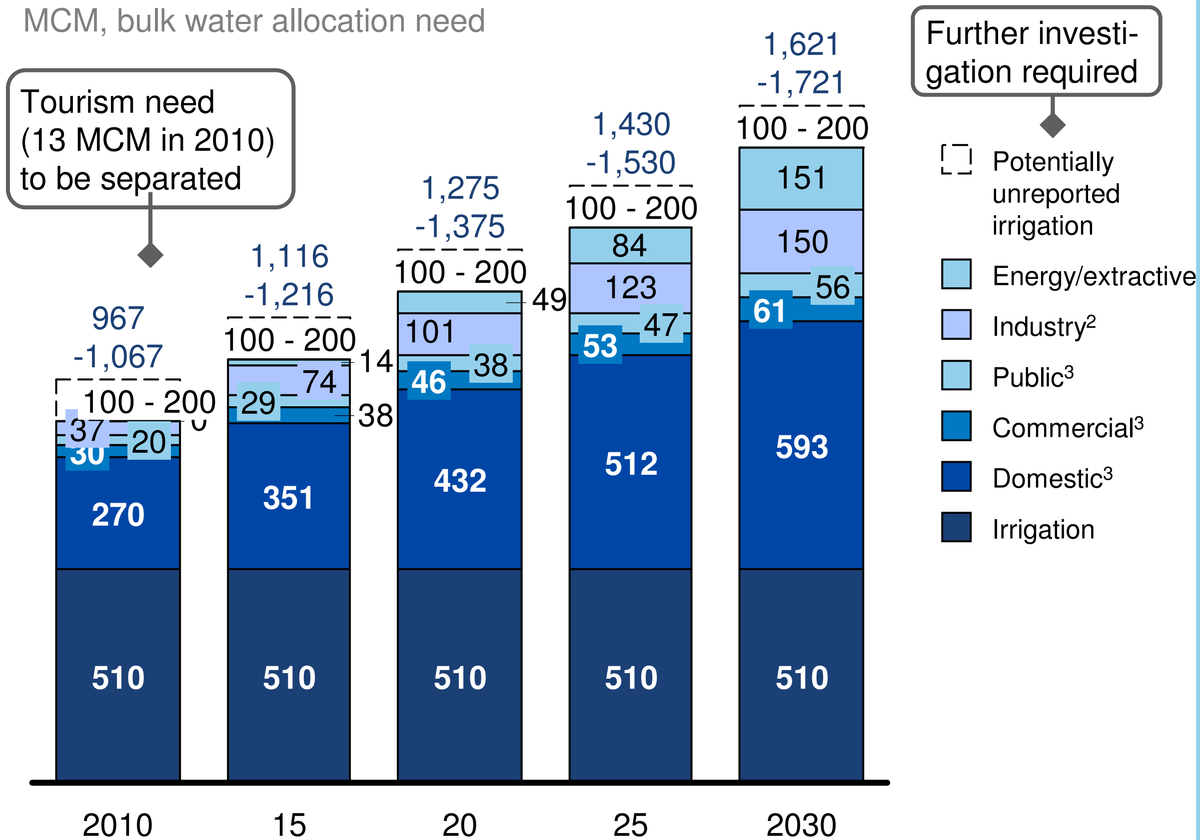
The current allocation policy will keep agricultural water allocation constant at current levels

Allocation policy decisions

- **Agriculture**
  - Focus on the use of treated waste water
  - Limit supply to current water consumption by driving efficiency and crop mix changes
- **Domestic supply**
  - Limit to
    - 120 l/p/d in Amman
    - 100 l/p/d in other cities
    - 80 l/p/d in rural areas

Water allocation need

MCM, bulk water allocation need



1 Higher end of water demand range included for energy/fuel mining 2 Industry water demand projected indicatively in line with National Agenda growth targets 3 Municipal demand projected for 2030 – assumed constant growth rate for 2015, 2020, 2025

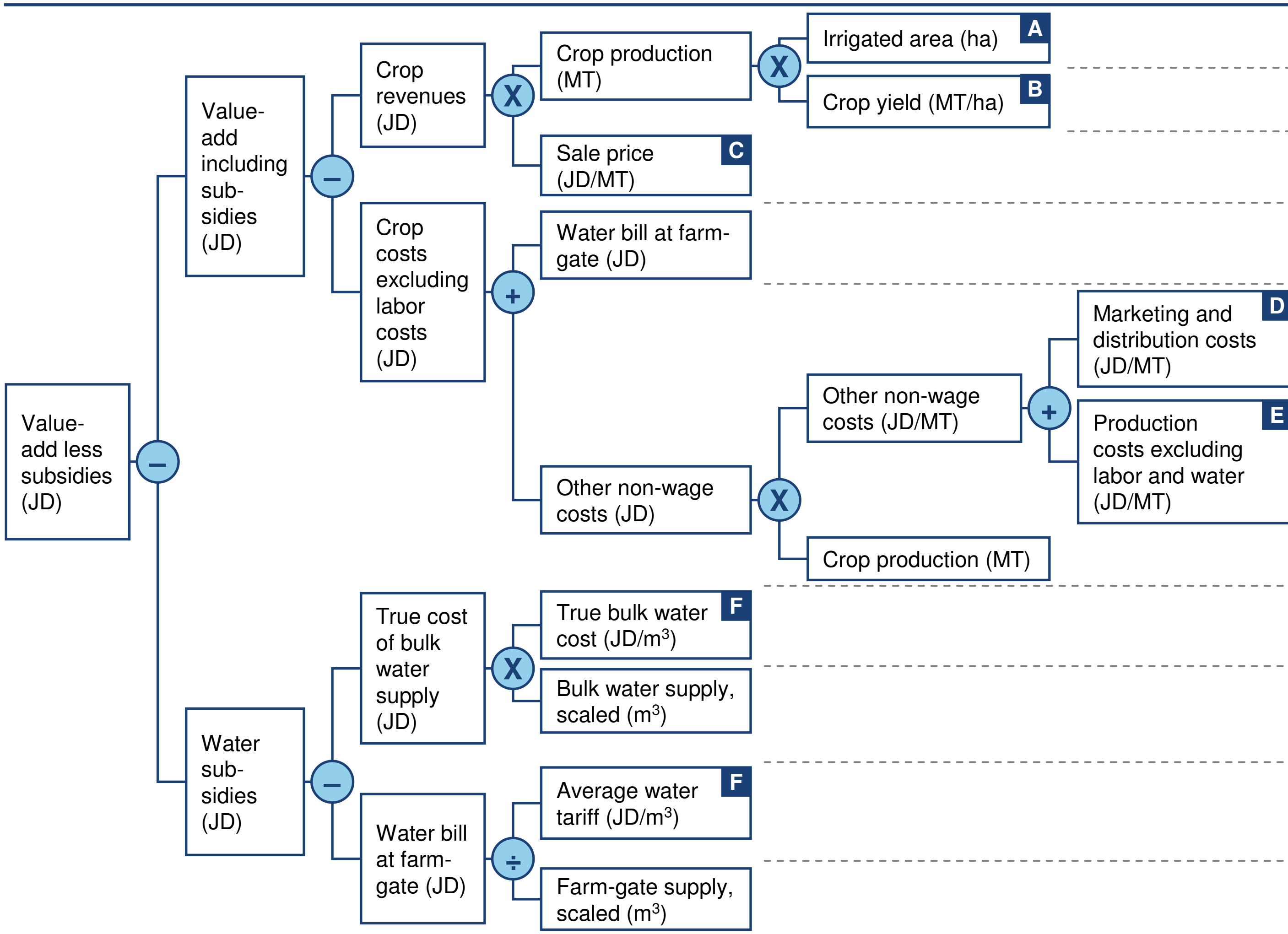
SOURCE: MWI; WAJ; JVA; Ministry of Agriculture; DOS; HIS Global Insight; Ministry of Industry; MEMR; JAEC; NRA; team analysis

Appendix 2 – Agricultural use

- Agricultural aspirations and targets
- Unconstrained demand vs allocation
- **Agricultural water productivity**
- Economic choices
- Technical solutions

Value-add is defined as profits plus wages less subsidies

Calculation method for irrigated value-add



Data sources

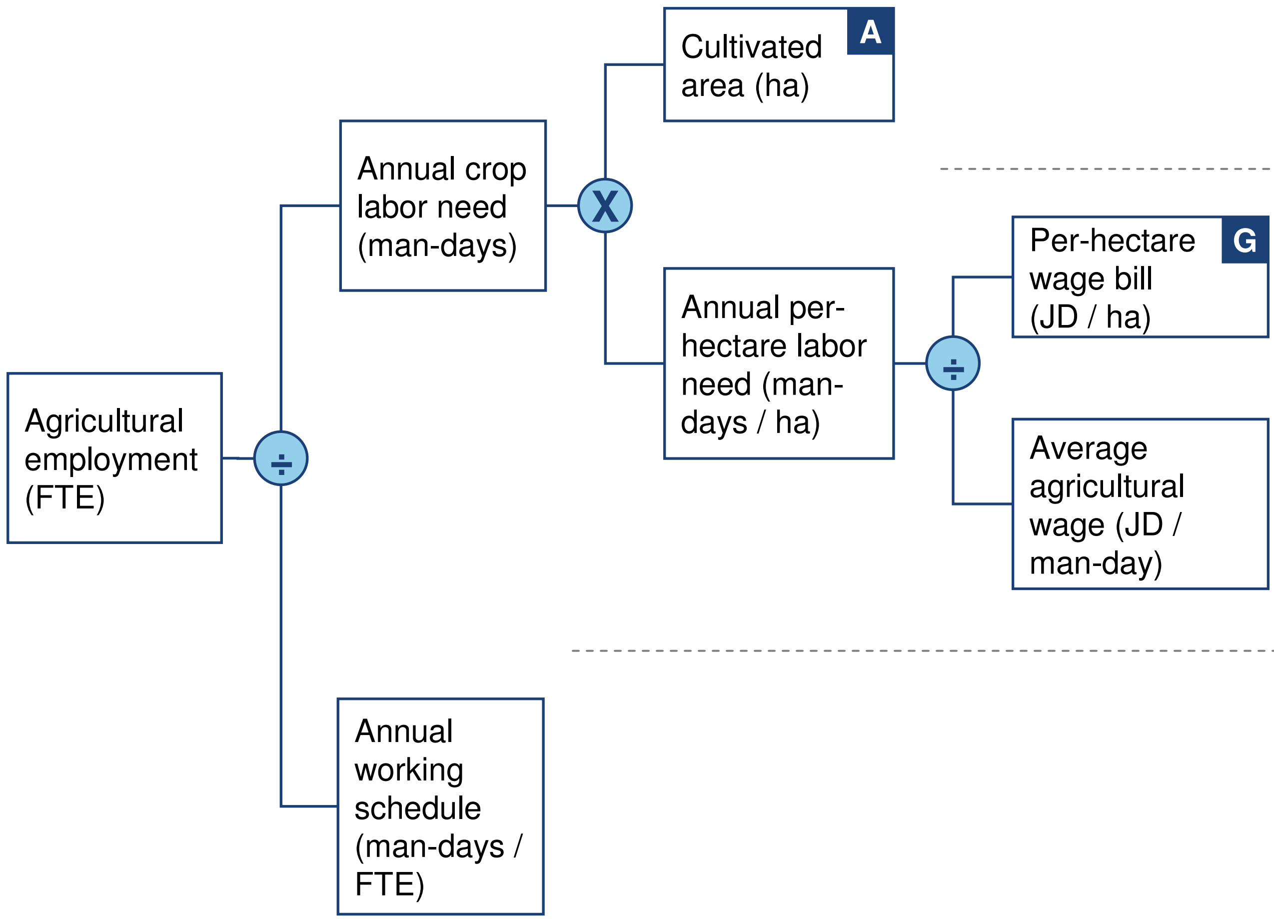
- Ministry of Agriculture statistics (2009)
- Ministry of Agriculture statistics (2009)
- Dept of Statistics (2006-2009)
- UN COMTRADE (2009)
- As calculated below
- Dept of Statistics (2006-2009)
- Agricultural Credit Corporation cost guide (2005)
- Dept of Statistics (2006-2009)
- MoA (2009) for crop yield data
- As calculated above
- Team analysis – calculated by source and use of supply
- Team analysis – calculation of irrigation demand, scaled to current supply
- IWMI – Venot (2007)
- MWI – Well abstraction and billing data (2006-2009)
- Team analysis – calculation of irrigation demand, scaled to current supply

Where possible, estimates calculated by governorate, crop, and exported crops vs. local consumption

SOURCE: Team analysis

Employment was calculated based on labor costs for different crops

Calculation method for irrigation demand



Data sources

- Ministry of Agriculture statistics (2009)

- Agricultural Credit Corporation Agricultural Cost Guide (2005)

- Assumption of 12 JD per day, based on Interviews with:
  – Ministry of Agriculture
  – Agricultural Credit Corporation

- Assumption on available working days of an agricultural laborer, based on:
  – 46 weeks per year
  – 6 days per week

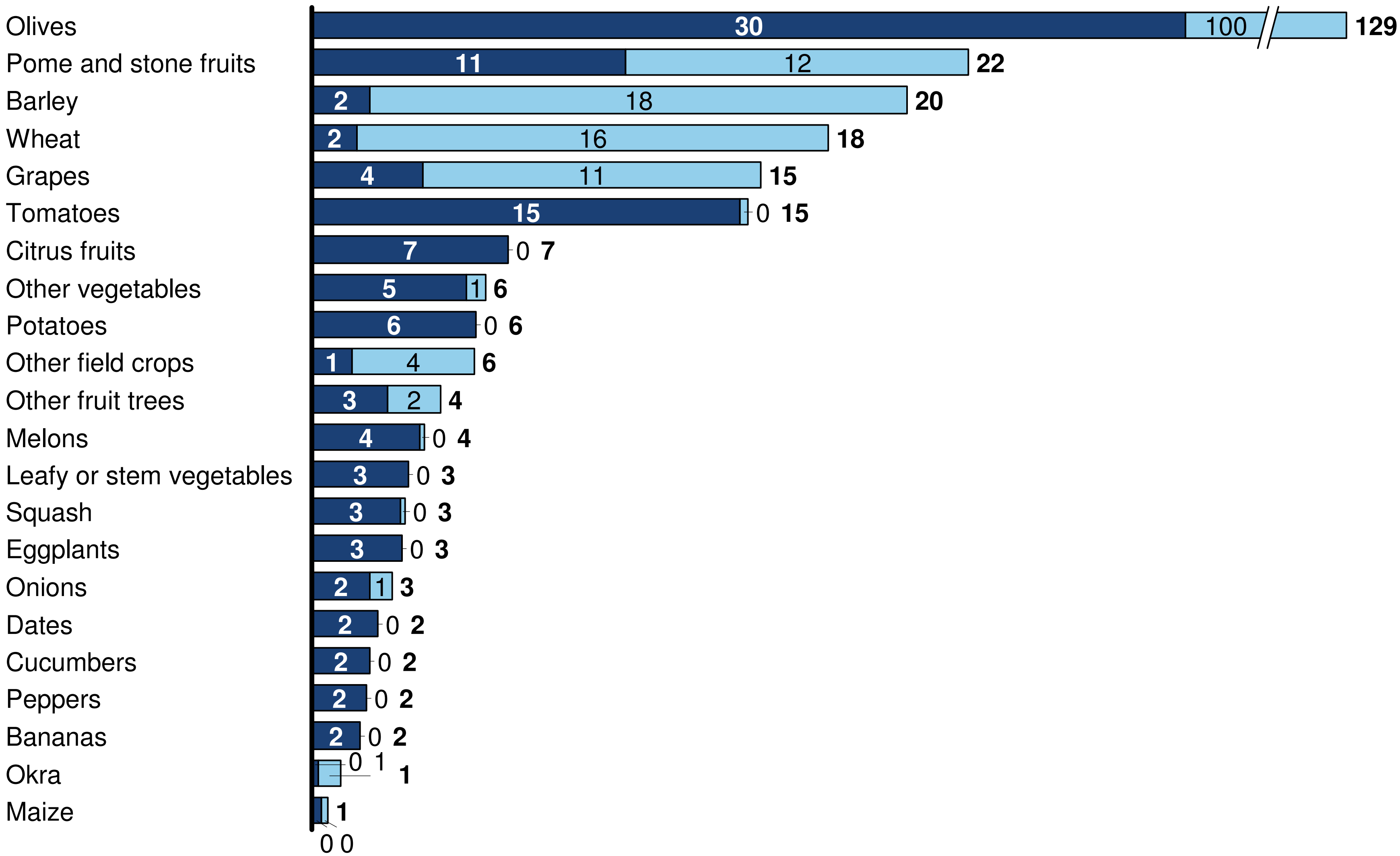
Estimates were calculated by governorate and by crop, where possible

SOURCE: Team analysis

A Cultivated area is available by crop

Cultivated area, thousand hectares

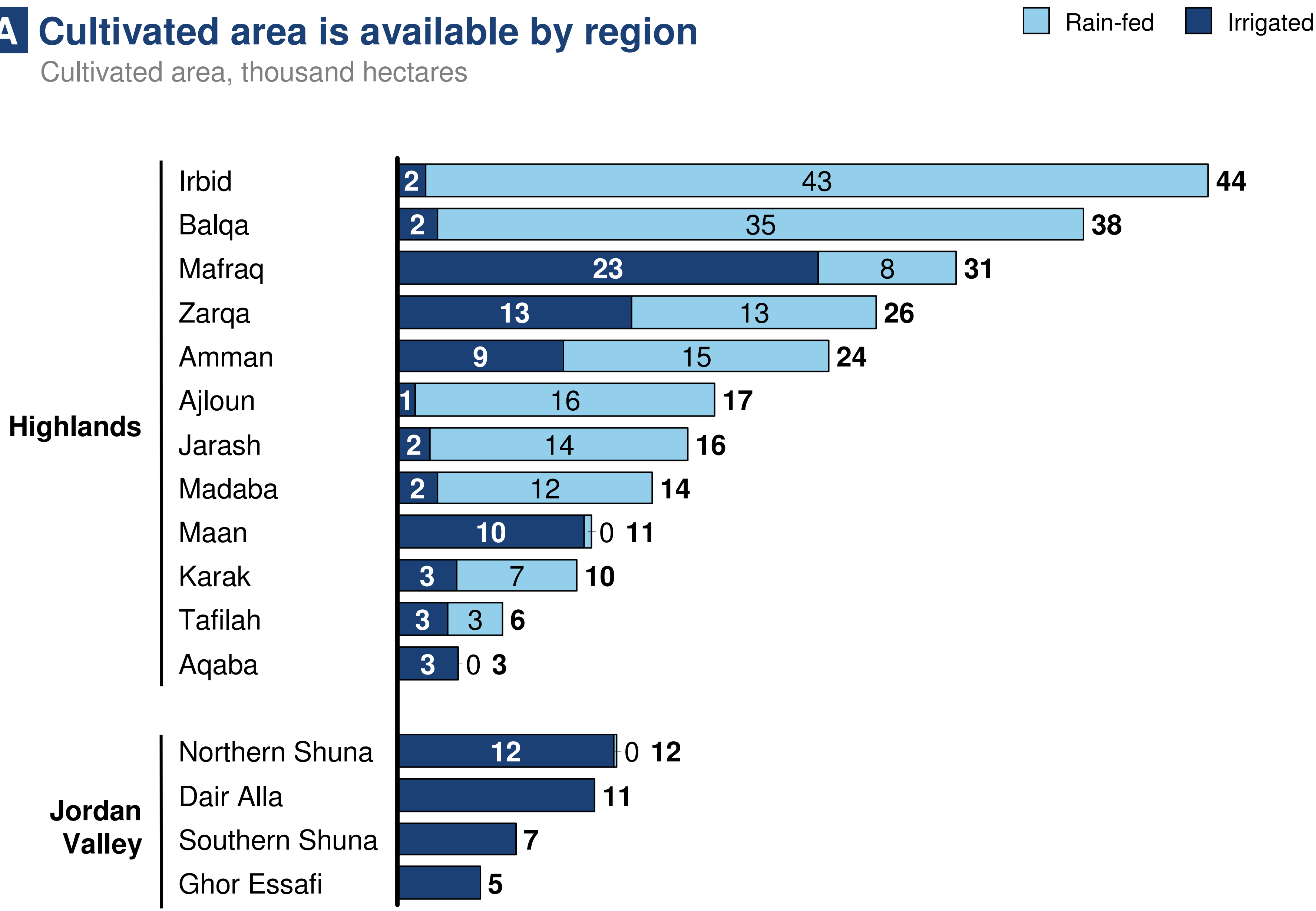
Rain-fed Irrigated



SOURCE: Ministry of Agriculture statistics 2009; Department of Statistics 2006-2009

A Cultivated area is available by region

Cultivated area, thousand hectares

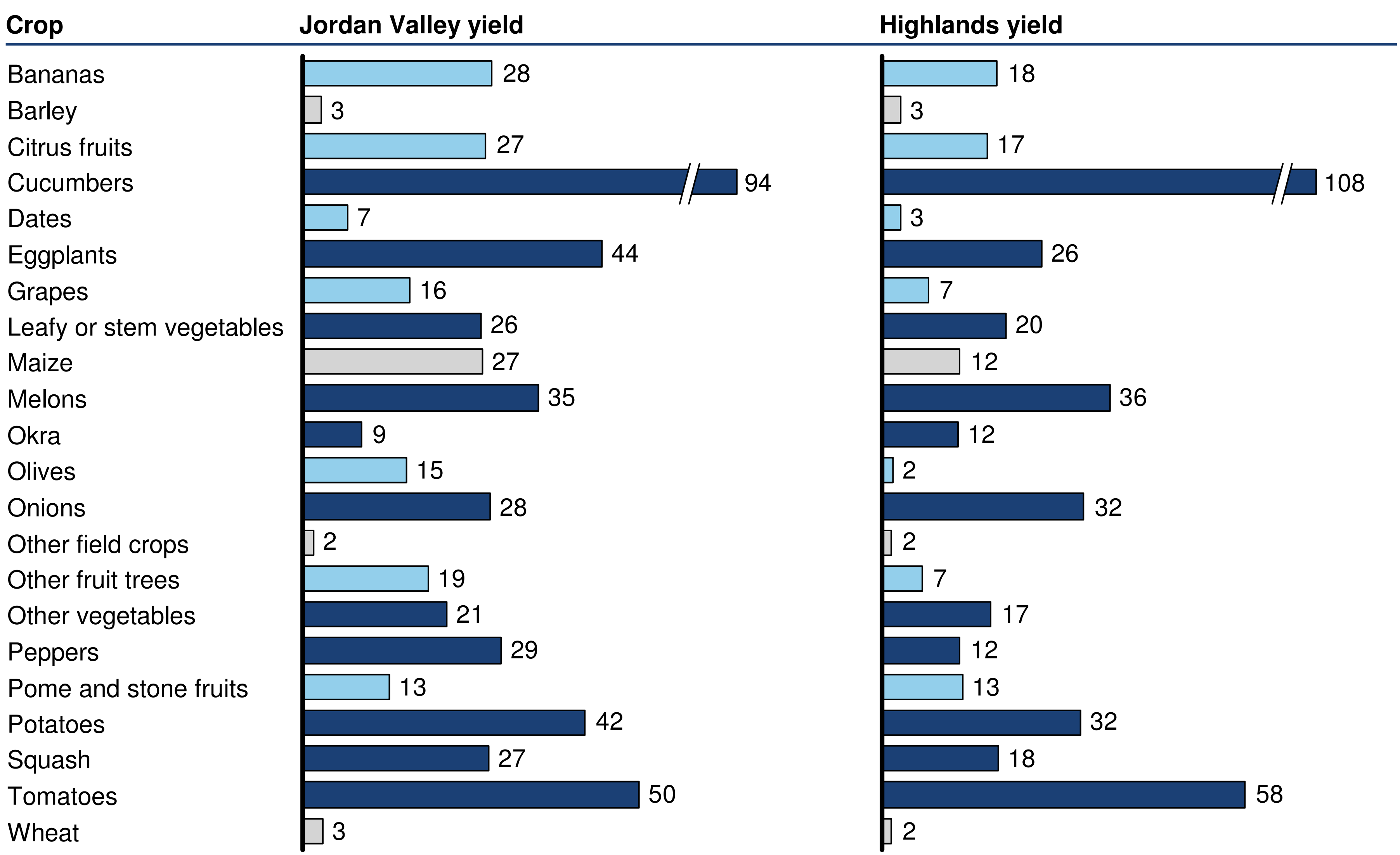


SOURCE: Ministry of Agriculture statistics 2009; Department of Statistics 2006-2009

B Crop yield for irrigated cultivation

Metric tons / ha

Field crops
Fruit trees
Vegetables

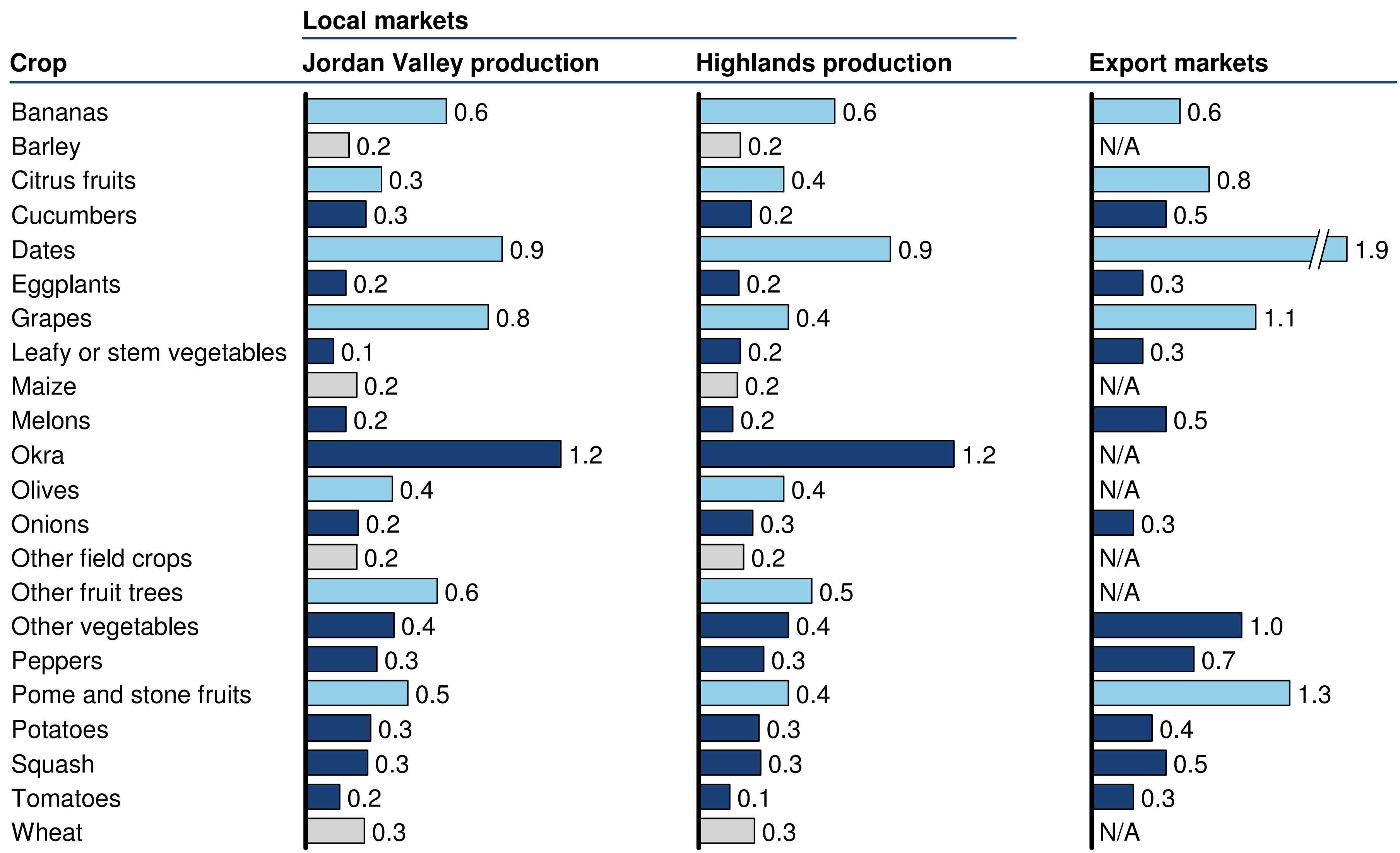


SOURCE: Ministry of Agriculture statistics 2009; team analysis

C Prices vary according to where the crop is sold

JD thousands / metric ton

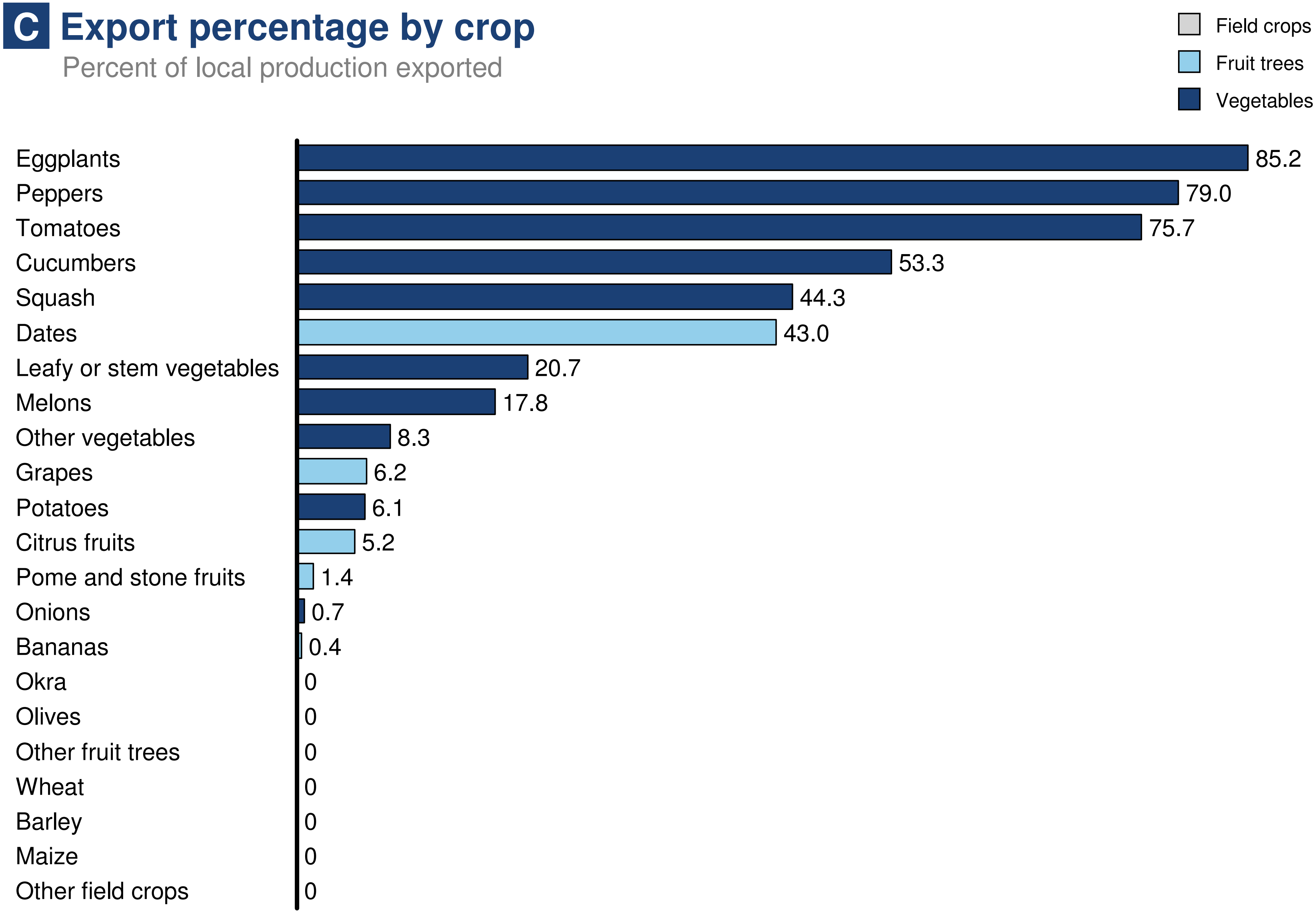
Field crops
Fruit trees
Vegetables



SOURCE: Department of Statistics 2006-2009; UN COMTRADE 2009; team analysis

C Export percentage by crop

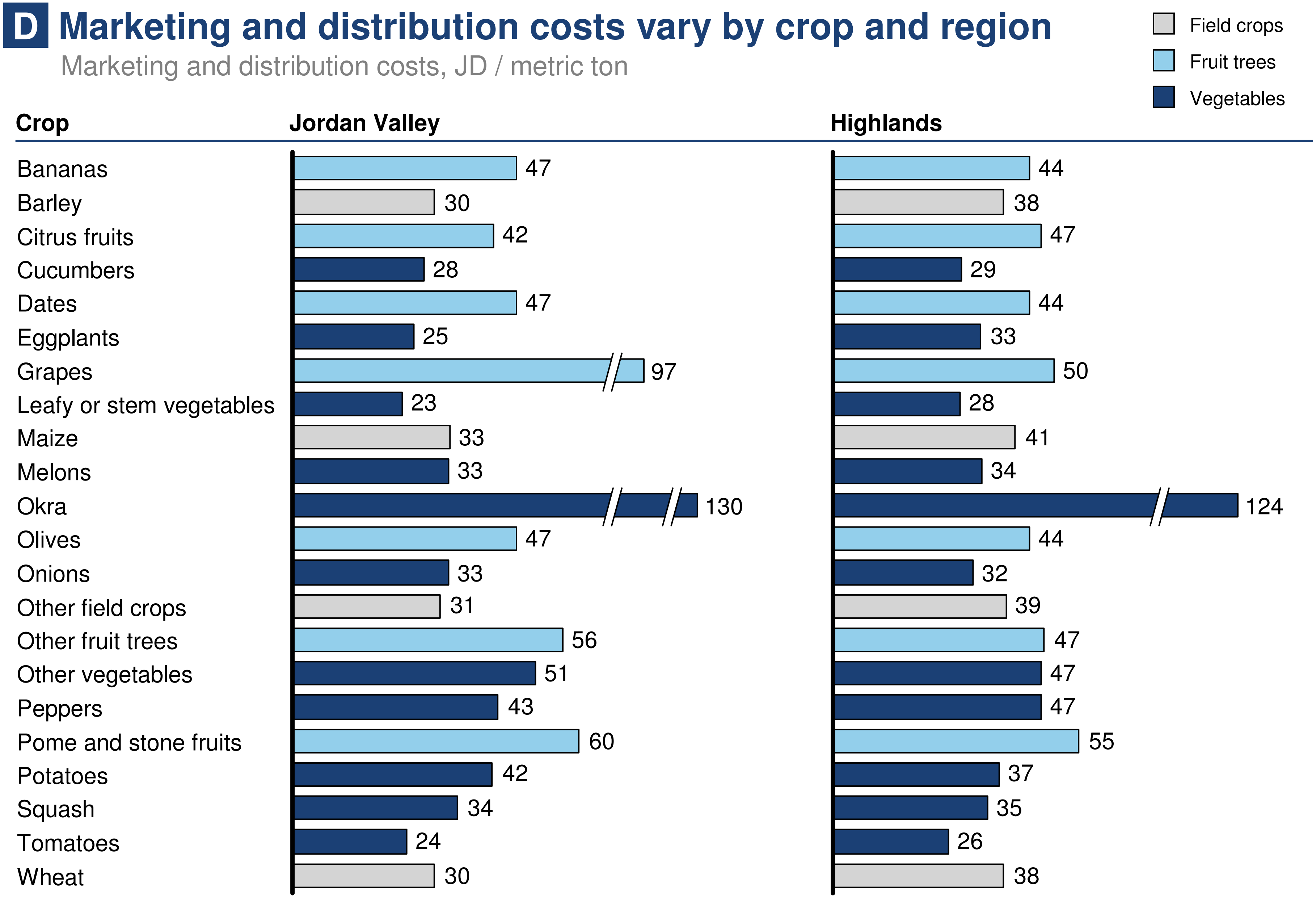
Percent of local production exported



SOURCE: Department of Statistics (2009); UN COMTRADE (2009); team analysis

D Marketing and distribution costs vary by crop and region

Marketing and distribution costs, JD / metric ton

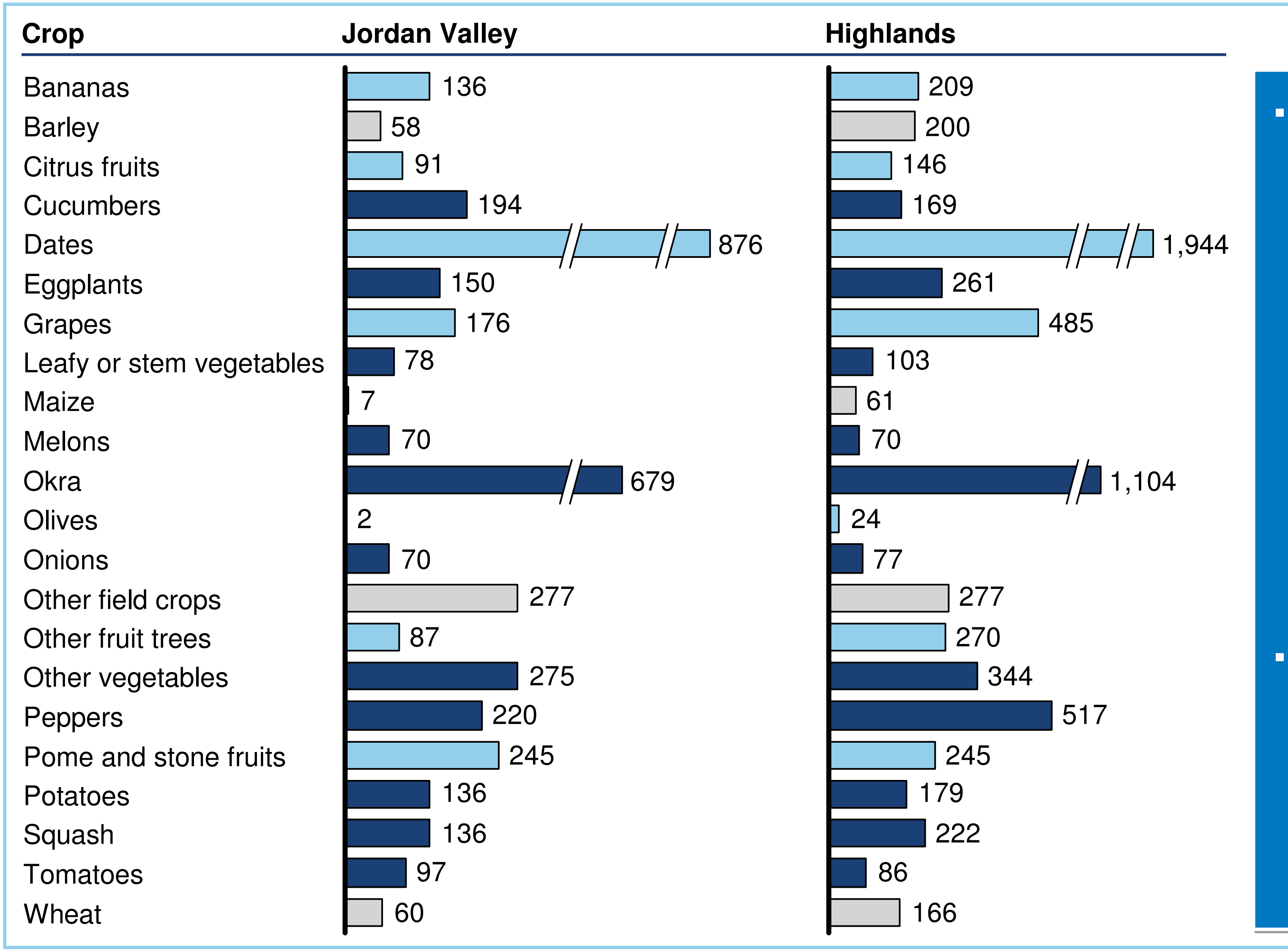


SOURCE: Department of Statistics (2009); UN COMTRADE (2009); team analysis

E Production costs vary by crop and region

Production costs, JD / metric ton

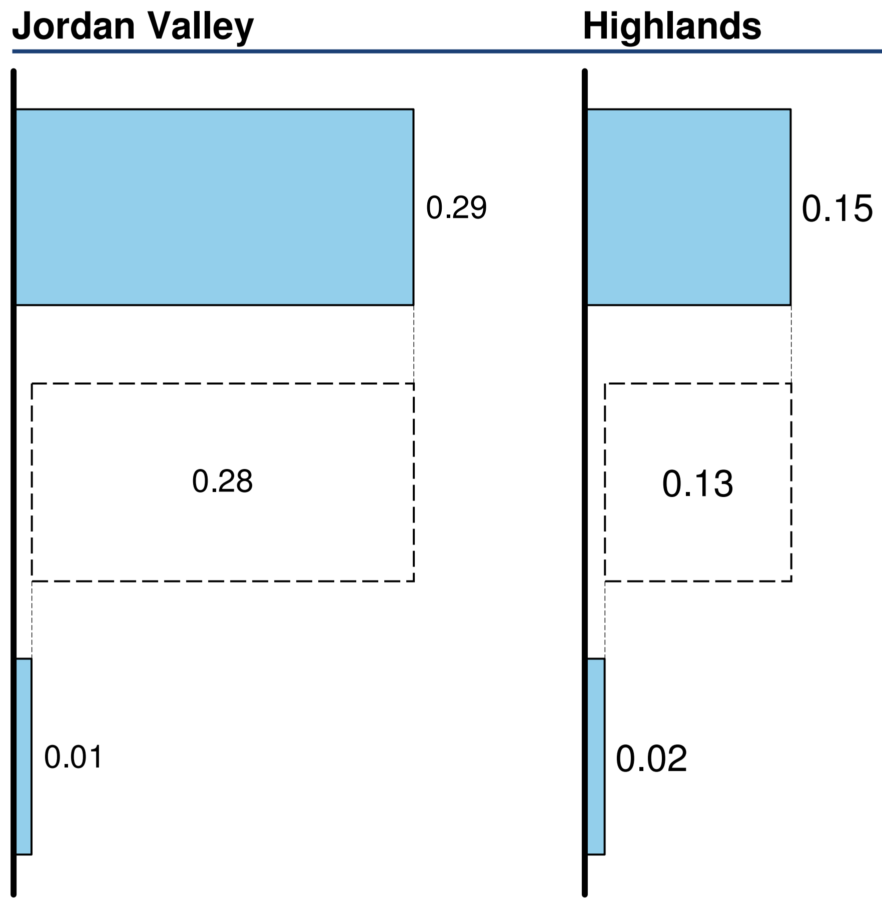
Field crops
Fruit trees
Vegetables



- Production costs account for:
  - Percentage of cultivation under different formats (e.g. covered vs. open field)
  - Differences in age of trees
  - Increases in input prices (e.g. fertilizers)
- **Variation in production costs** per metric ton are driven by **differences in crop yield** between crops and regions

SOURCE: Agricultural Credit Corporation cost guide (2005); Department of Statistics (2006-2009); team analysis

F Cost of supply and average water bill per cubic meter vary by region



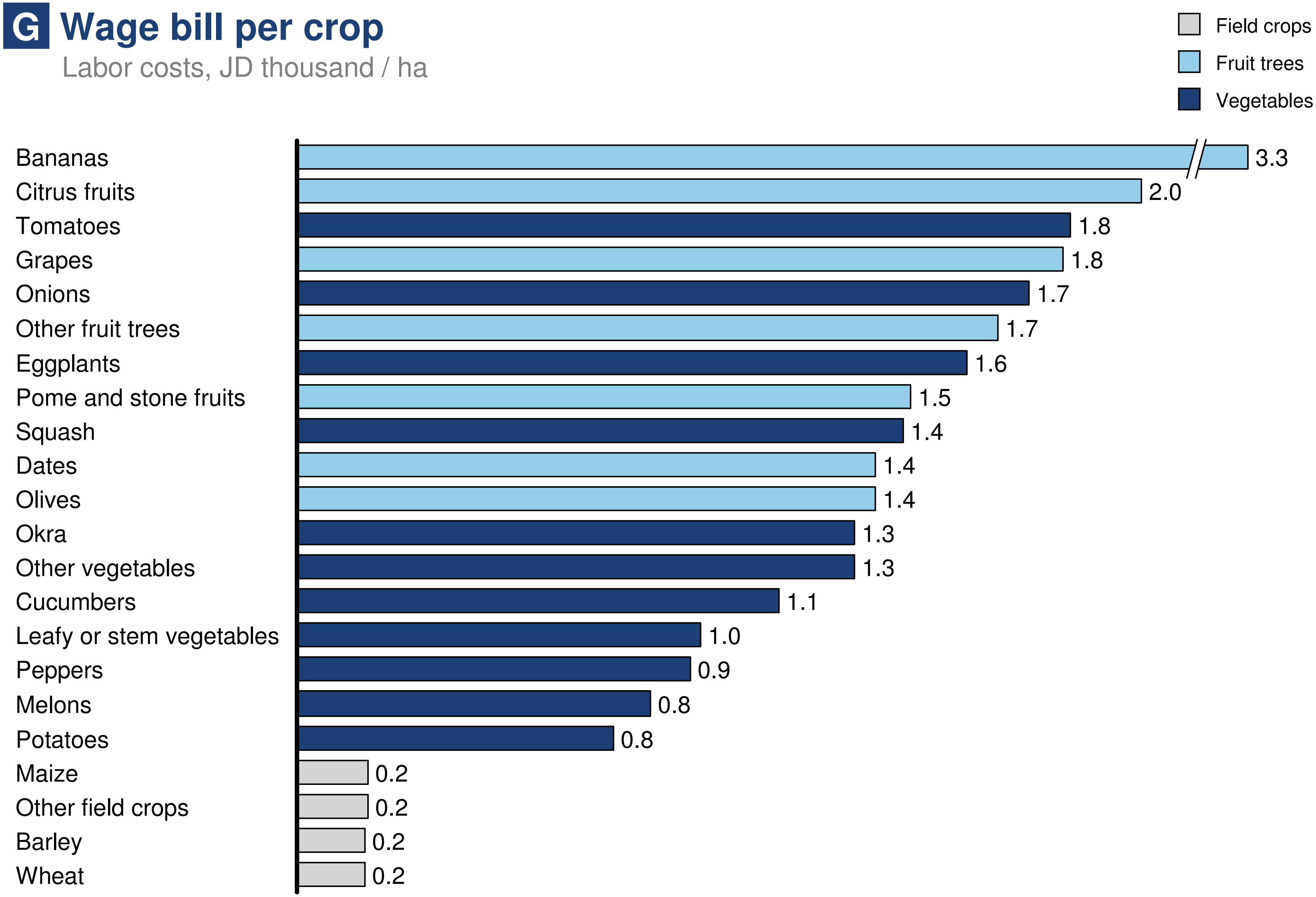
	Jordan Valley	Highlands	Source
True cost of bulk supply[1] JD/m³	0.29	0.15	▪ Analysis based on financial statements of water-supplying institutions
Approximate subsidy[2] JD/m³	0.28	0.13	▪ Difference between bulk cost and farm-gate bills (in total, not on a per-cubic meter basis)
Average bill for farm-gate supply[3] JD/m³	0.01	0.02	▪ Jordan Valley: Venot paper (2007) calculates weighted average price ▪ Highlands: MWI ground-water data on volumes and amounts billed

1 Bulk-level supply, including volume that will be lost due to efficiency losses; includes energy costs
2 Value shown is approximate because the calculated subsidy in the model also accounts for system efficiency losses
3 Average price paid for water by farmers, for both groundwater and surface supply

SOURCE: MWI groundwater statistics (2006-2009); Venot (2007) Appendix 6; team analysis

G Wage bill per crop

Labor costs, JD thousand / ha

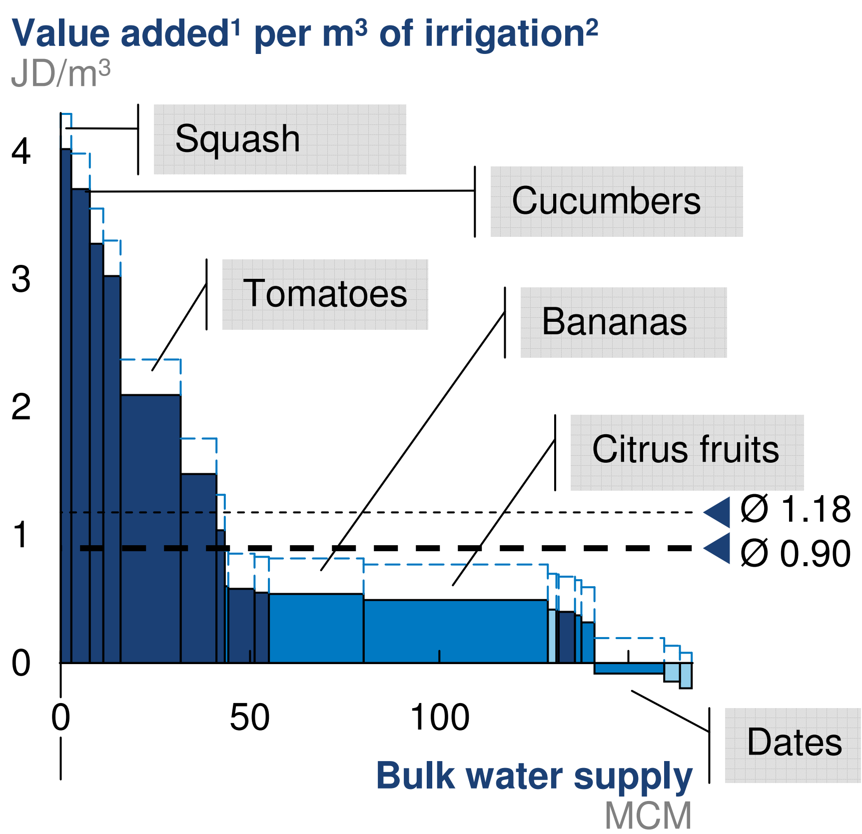


SOURCE: Agricultural Credit Corporation – Agricultural Cost Guide (2005)

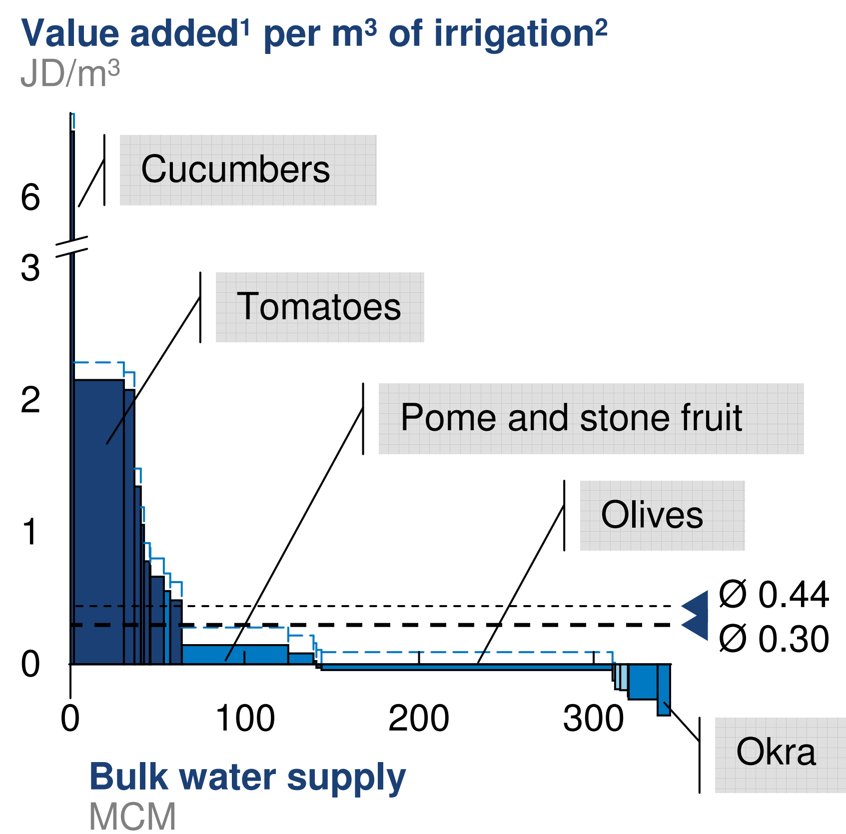
Variation in value-add between crops and regions suggests potential to improve agricultural economics through optimized crop mix

Subsidized average | Unsubsidized average | Subsidy | Field crops | Fruit trees | Vegetables

The Jordan Valley is relatively productive but has a large share of low productivity crops



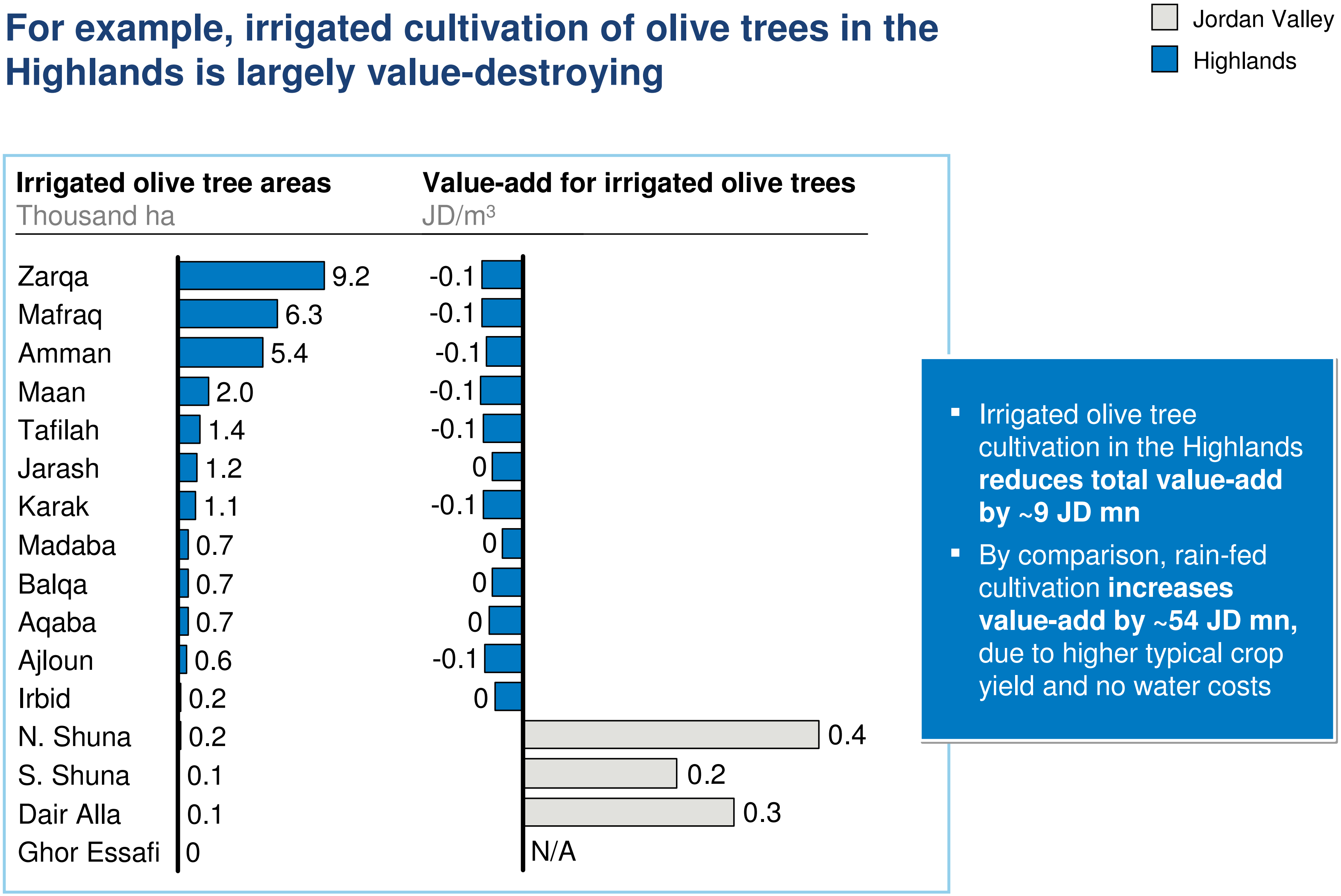
In the Highlands, the low productivity of certain fruit trees is a particular challenge



1 Value-added defined as profits plus wages from agriculture   2 Bulk water supply – includes water lost through distribution

SOURCE: Ministry of Agriculture; Department of Statistics; Agricultural Credit Corporation; team analysis

For example, irrigated cultivation of olive trees in the Highlands is largely value-destroying



- Irrigated olive tree cultivation in the Highlands **reduces total value-add by ~9 JD mn**
- By comparison, rain-fed cultivation **increases value-add by ~54 JD mn,** due to higher typical crop yield and no water costs

SOURCE: Ministry of Agriculture; Department of Statistics; Agricultural Credit Corporation; team analysis

Appendix 2 – Agricultural use

- Agricultural aspirations and targets
- Unconstrained demand vs allocation
- Agricultural water productivity
- **Economic choices**
- Technical solutions

Each scenario has been defined to understand the changes needed to achieve a particular in agriculture

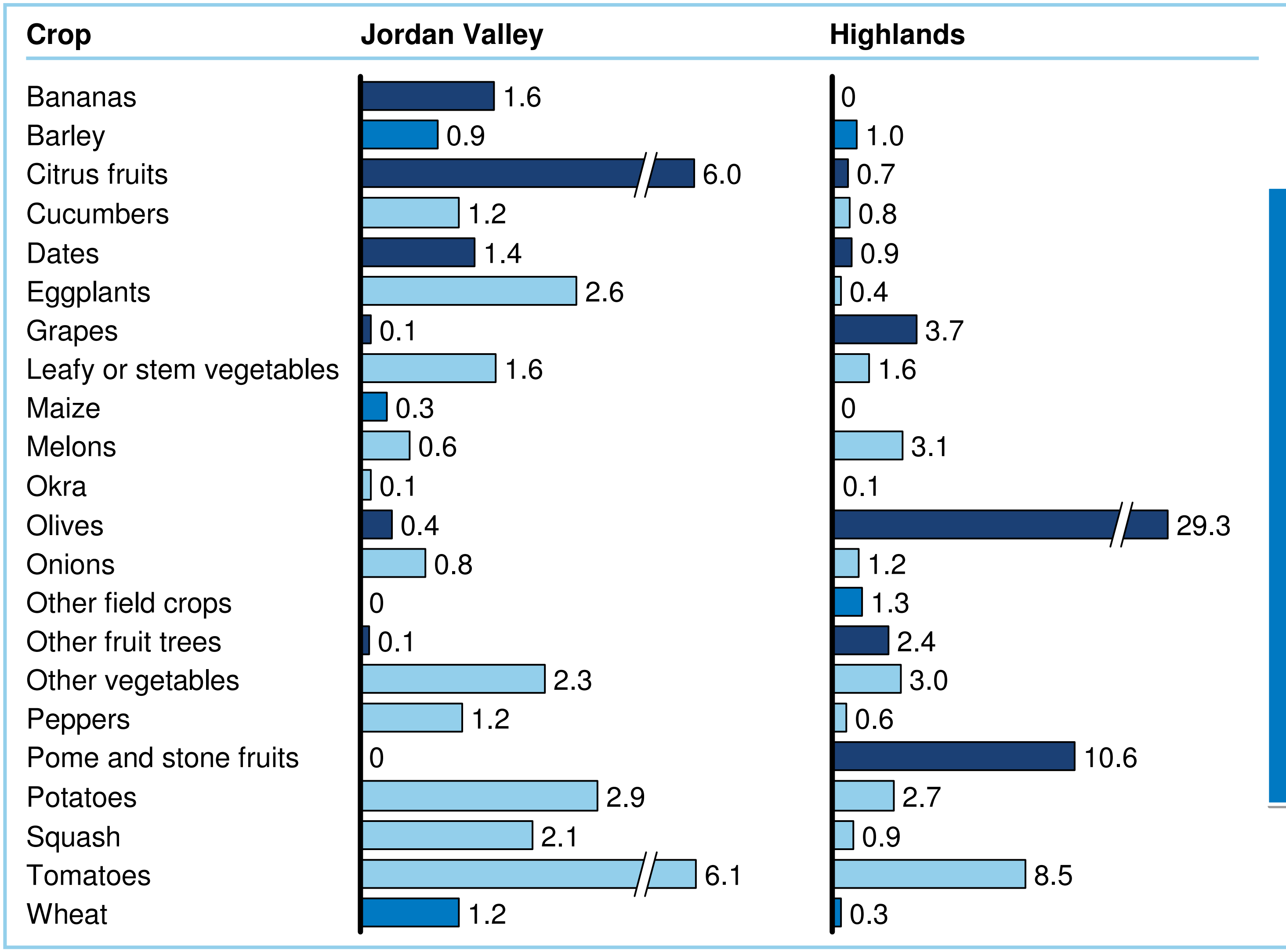
Scenario	Intended outcome	Key changes
A BAU agriculture	▪ Continuation of current agriculture ▪ Establish a baseline two which the outcomes of other scenarios can be compared	▪ Crop mix is unchanged ▪ Water allocation is unchanged ▪ Cultivated area is unchanged
B High-value agriculture	▪ Achieving better use of current agricultural water allocation, i.e. generating additional value and employment from the same water	▪ Shift to crops which are high-value and labor-intensive on a **per-cubic meter basis** ▪ Water allocation is modestly higher ▪ Irrigated area is expanded
C Basic water reduction	▪ Producing water savings of 50 MCM in agriculture while maintaining current acreage, to be applied towards closing the national water gap	▪ Shift to crops which are high-value / low-water on a **per-hectare basis** ▪ Water allocation is modestly higher ▪ Cultivated area is unchanged
D Low-water agriculture	▪ Producing water savings of 100 MCM in agriculture while maintaining current acreage, similarly to Scenario C but to a greater extent	▪ Shift to crops which are high-value / low-water on a **per-hectare basis** ▪ Water allocation is modestly higher ▪ Cultivated area is unchanged

SOURCE: Team analysis

A Business-as-usual scenario keeps current crop mix

2009 irrigated areas, thousand ha

Vegetables
Field crops
Fruit trees



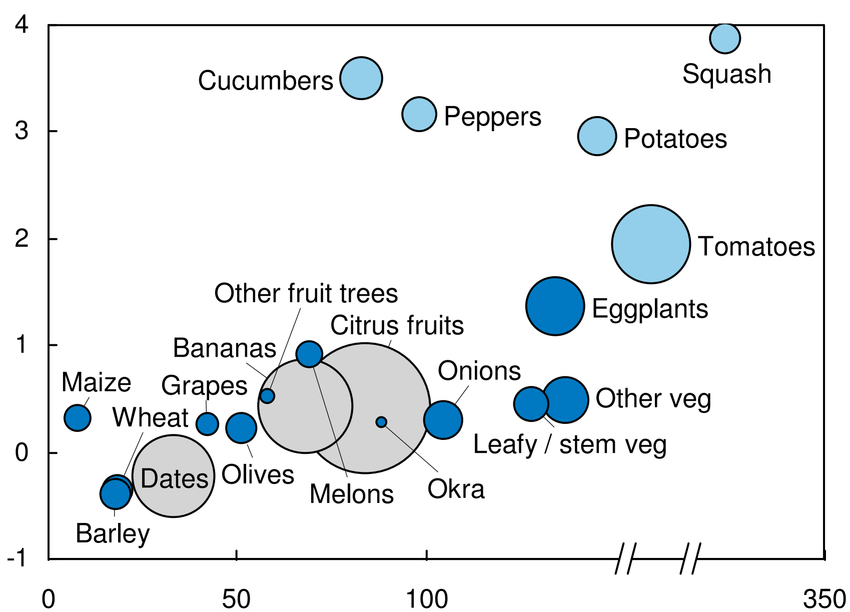
- BAU scenario used to establish a baseline for current agricultural outcomes
- Crop mix changes in all other scenarios use the BAU scenario as a starting point
- Water savings are accomplished in the BAU scenario only through technical solutions

SOURCE: Ministry of Agriculture 2009 statistics; team analysis

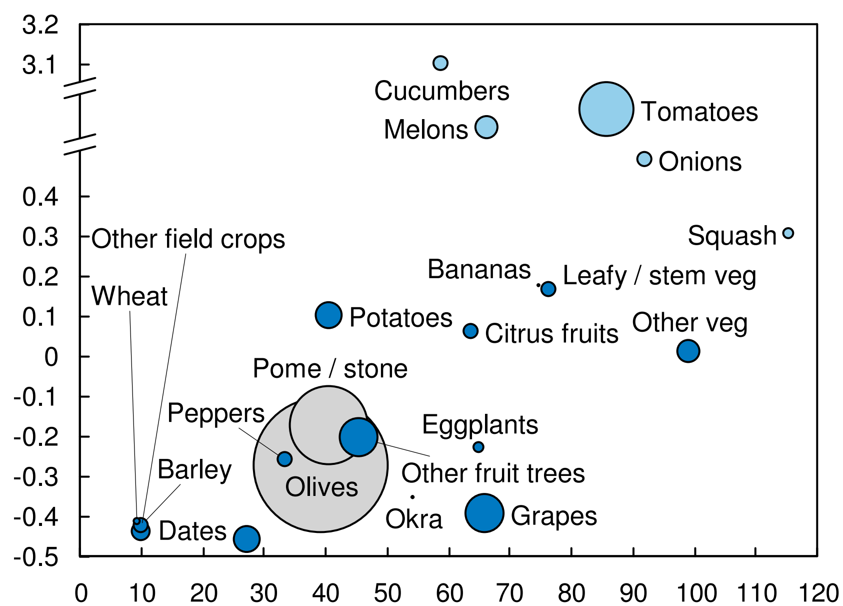
B Scenario B focuses on crop mix changes which maximize value-add per cubic meter

- Area decreased
- No change
- Area increased
- Current water (MCM)

Jordan Valley



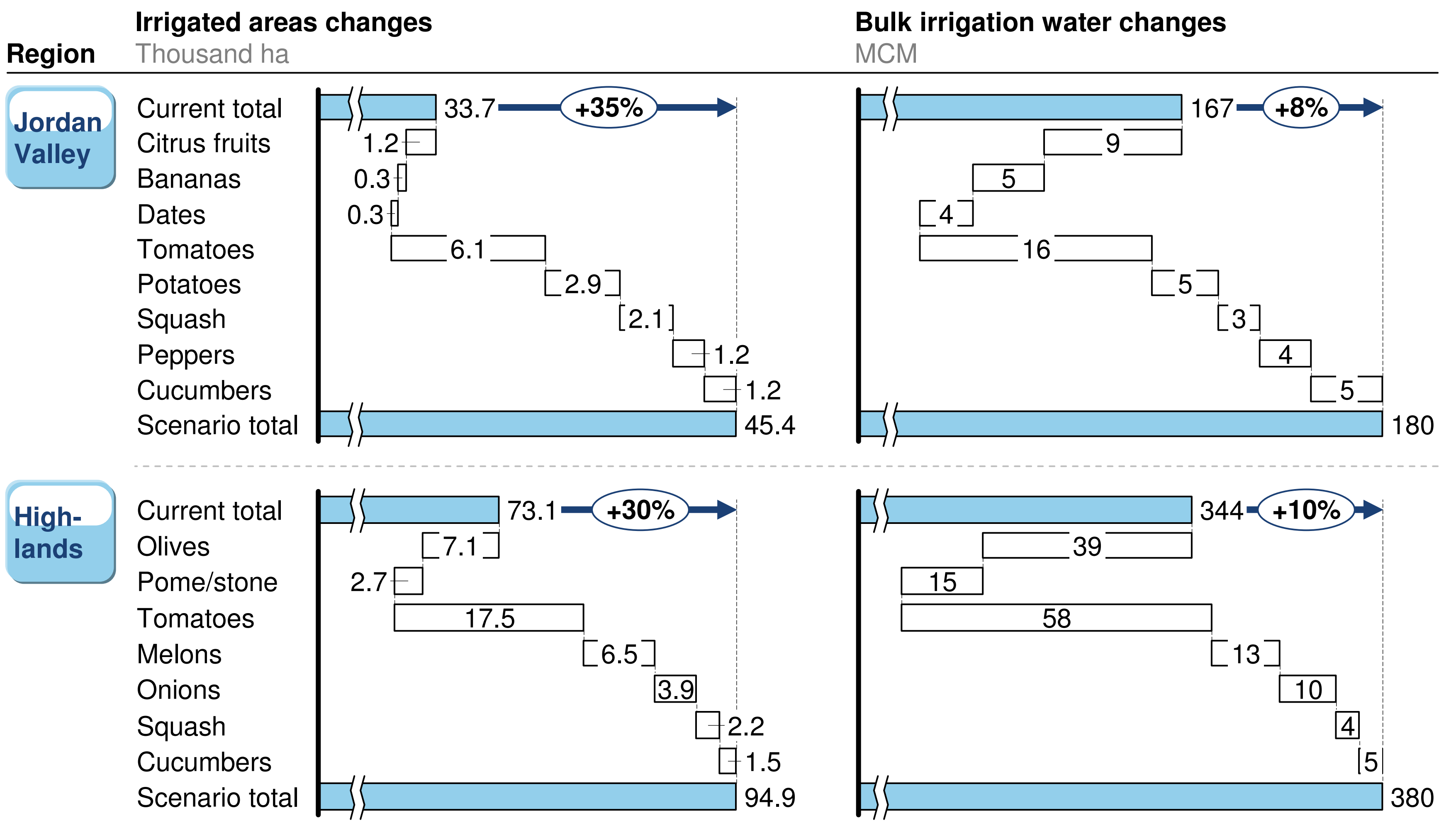
Highlands



- Principal crop changes in Scenario B **reallocate water** from trees to vegetables, and using the water savings to expand area under irrigated cultivation
- Objective of Scenario B is to increase value-add and employment with a modest increase in water requirement, which can be reversed with higher water efficiency and productivity through technical solutions

1 Sum of profits and wages from irrigated cultivation   2 Jobs in areas under irrigated cultivation
3 Irrigation water at the plant level, excluding leaching and efficiency losses
SOURCE: Ministry of Agriculture; NWMP; Department of Statistics; team analysis

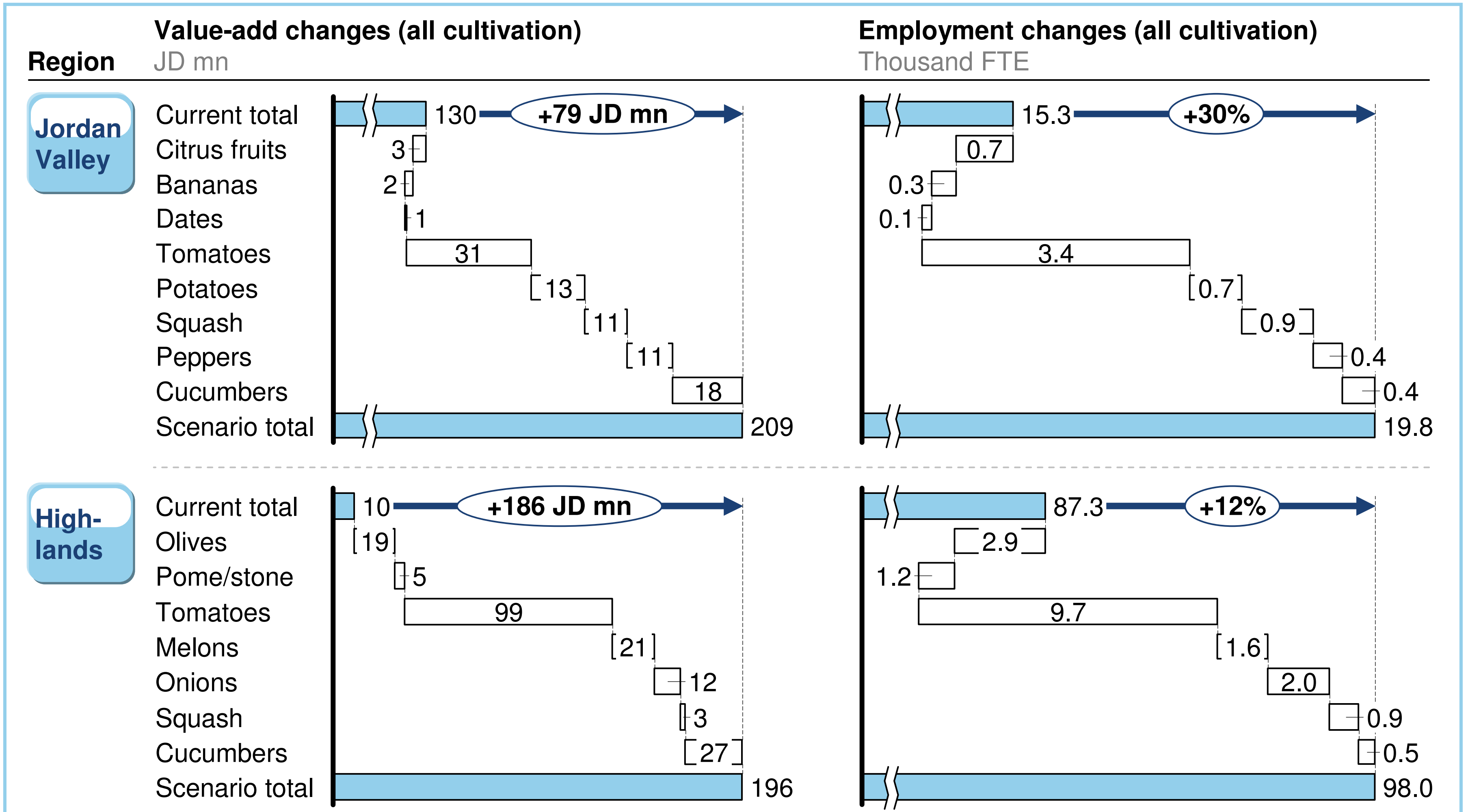
B In scenario B, crop mix changes expand irrigated area by ~30% with only ~10% additional water requirement



With the right crop mix changes and an additional 50 MCM, possible to irrigate 33 thousand more hectares, an area equivalent to current Jordan Valley

SOURCE: Ministry of Agriculture; NWMP; Department of Statistics; team analysis

B Expansion of irrigated land increases value-add by ~190% and employment by ~15 thousand FTE



Large gains in value-add are due to reduction in irrigated cultivation of crops with negative value-add per cubic meter

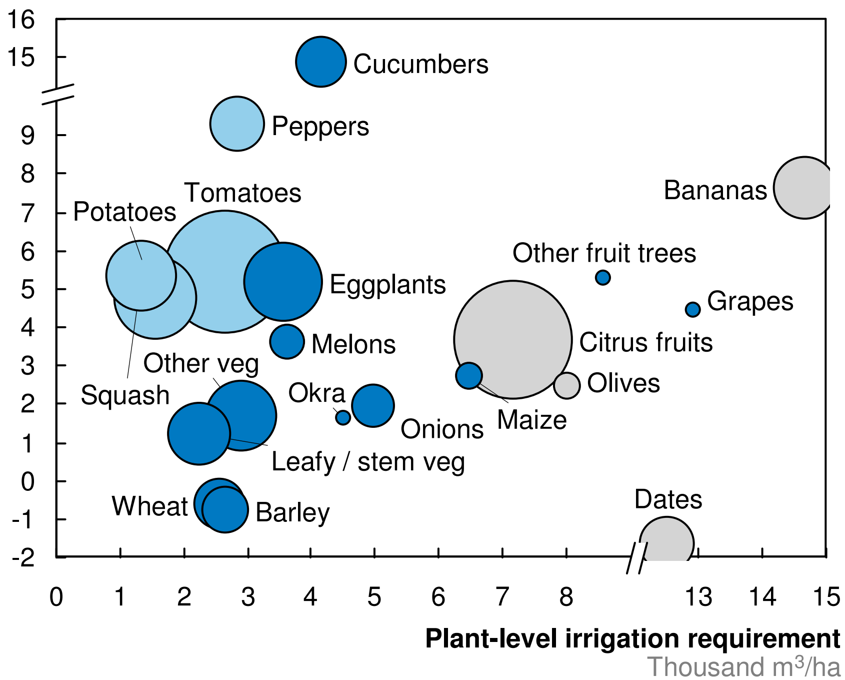
SOURCE: Ministry of Agriculture; NWMP; Department of Statistics; team analysis

CD Scenarios C and D shift crops to save water on a per-hectare basis

Area decreased
No change
Area increased
Current area (ha)

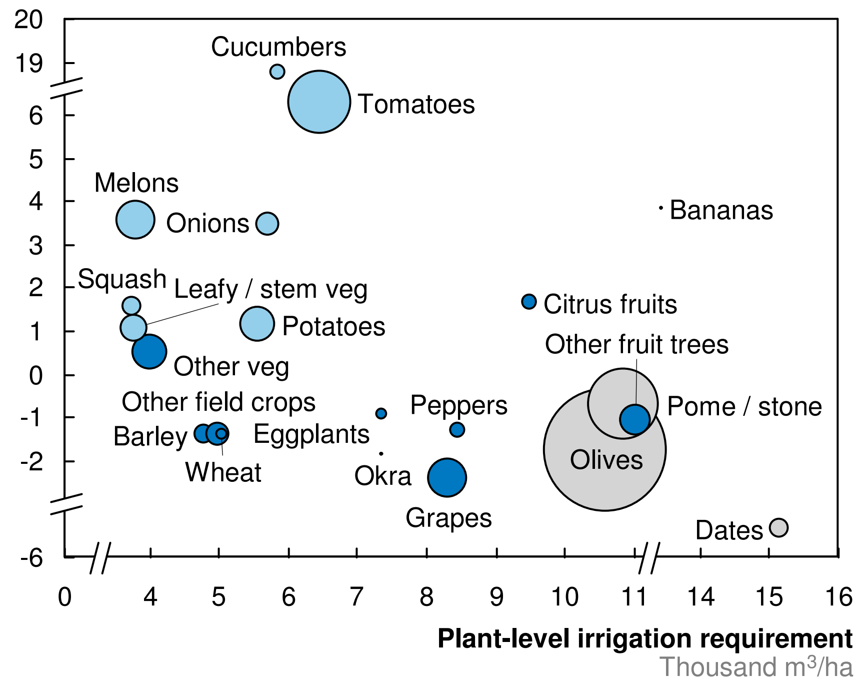
Jordan Valley

Per-hectare value-add[1], irrigated cultivation
Thousand JD/ha



Highlands

Per-hectare value-add[1], irrigated cultivation
Thousand JD/ha

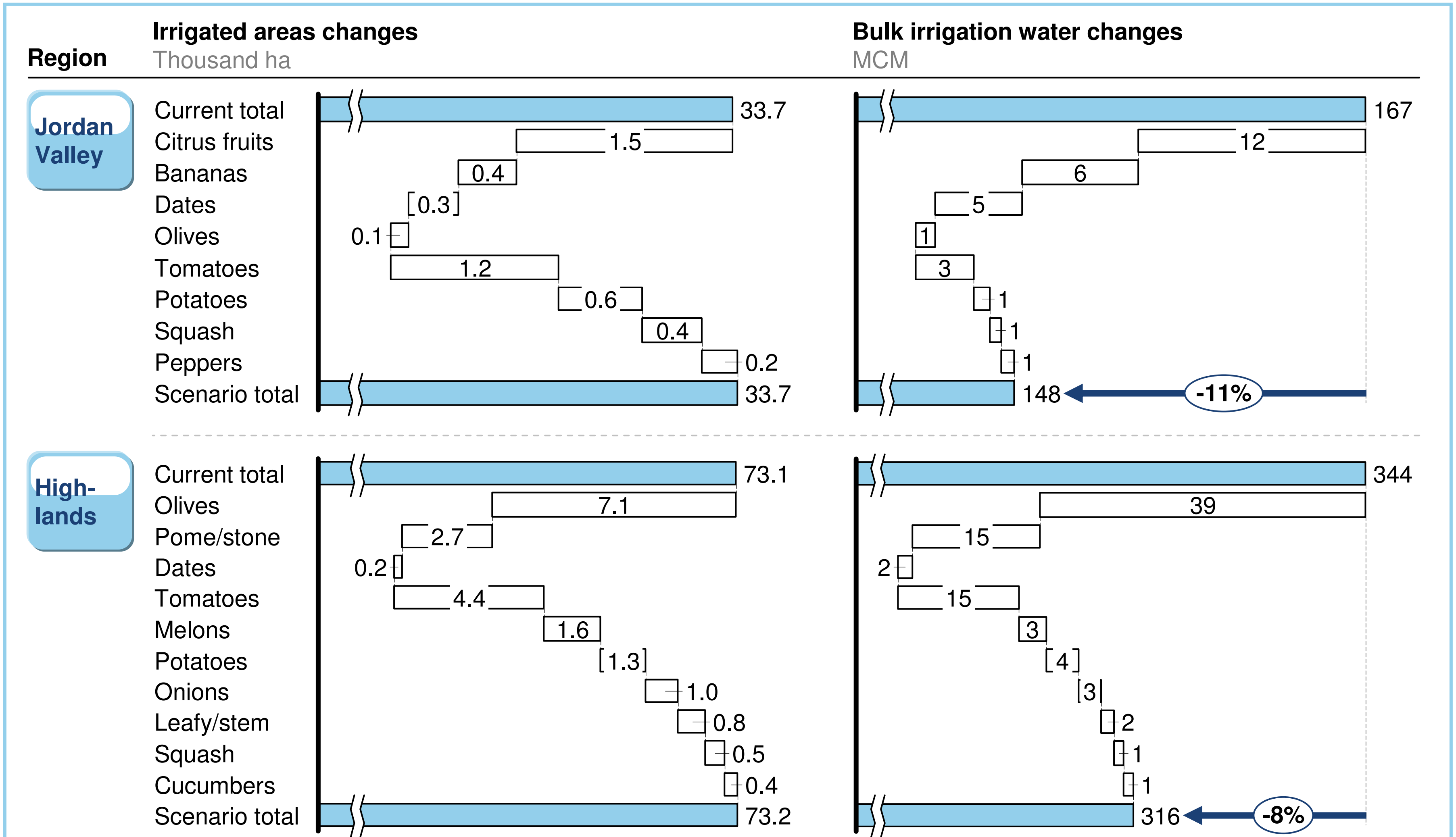


- Principal crop changes in scenarios C and D involve **reallocating land** from fruit trees to high-value, low-water vegetables, **reducing water intensity per hectare**
- Scenarios C and D differ only in the **extent** to which crop mix change is implemented
  - Scenario C aims to reduce water requirement by ~**50 MCM**
  - Scenario D aims to reduce water requirement by ~**100 MCM**

1 Sum of profits and wages from irrigated cultivation

SOURCE: Ministry of Agriculture; NWMP; Department of Statistics; team analysis

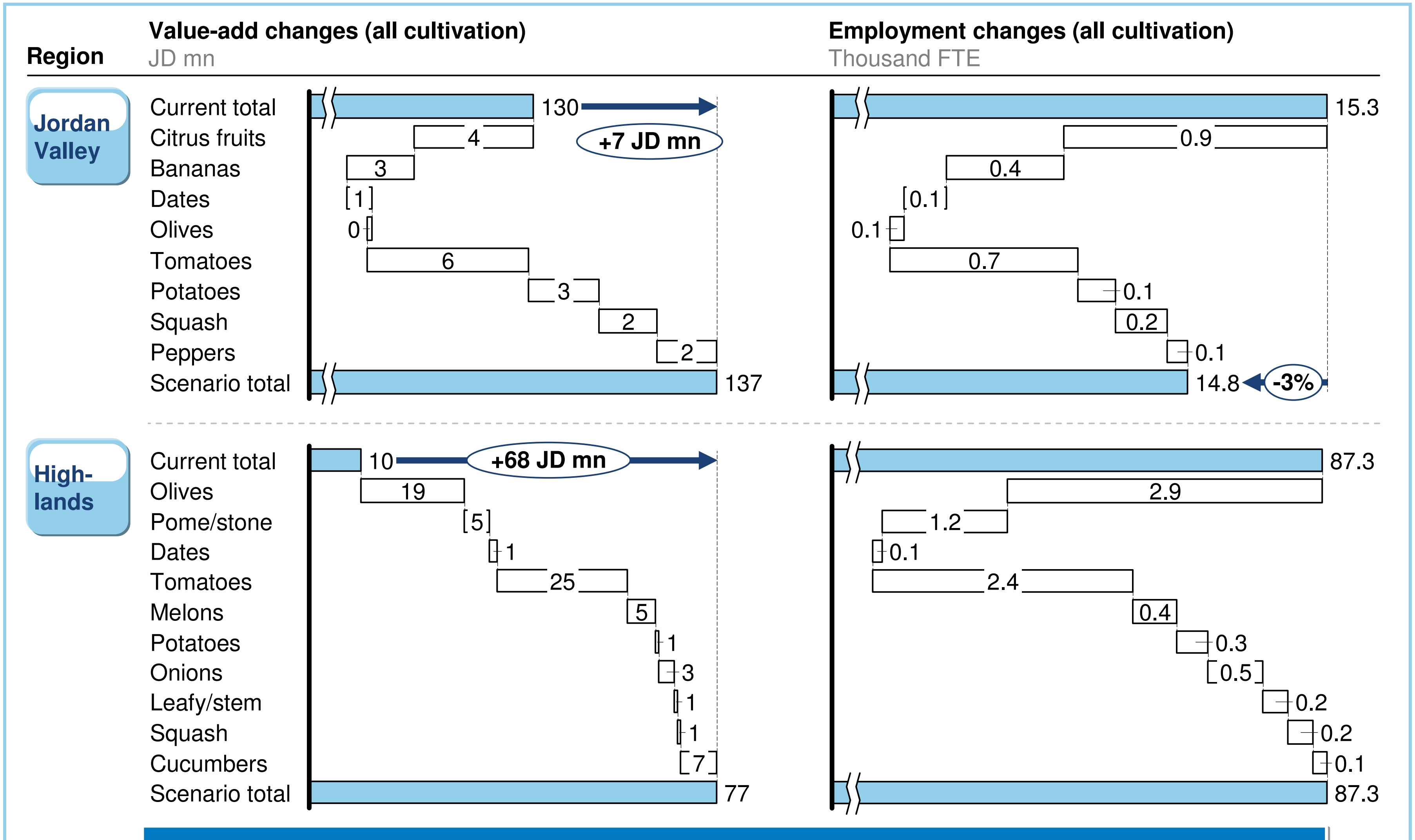
C In scenario C, crop mix changes reduce water requirement by ~50 MCM while keeping cultivated areas constant



Water savings through crop mix changes in scenario C represent ~9% of current bulk irrigation allocation

SOURCE: Ministry of Agriculture; NWMP; Department of Statistics; team analysis

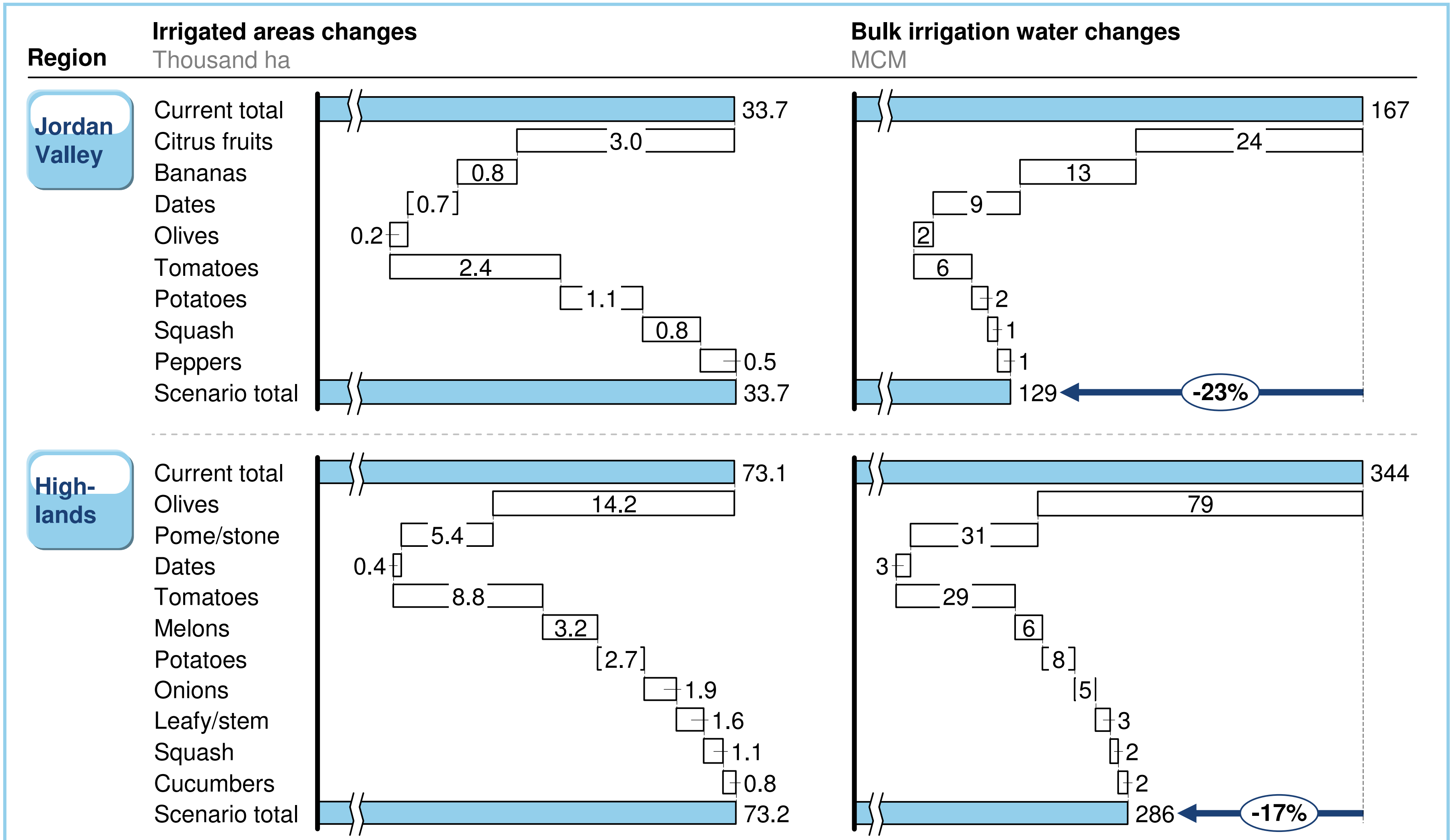
C Crop mix changes increase value-add by ~50% but reduce overall agricultural employment slightly



Increased value-add partially due to reduction in cultivation of crops with negative value-add per cubic meter

SOURCE: Ministry of Agriculture; NWMP; Department of Statistics; team analysis

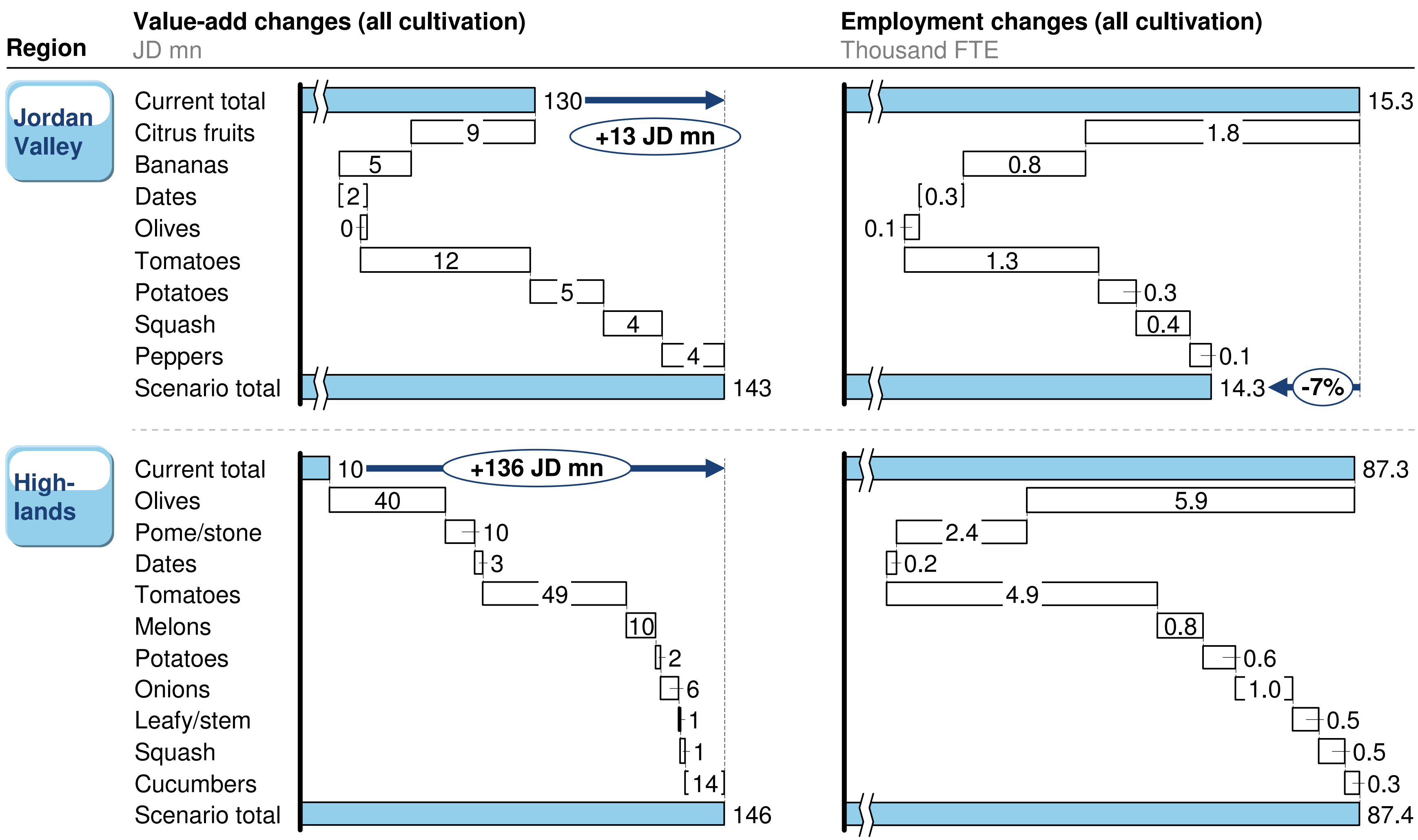
D In scenario D, crop mix changes reduce water requirement by ~100 MCM while keeping cultivated areas constant



Water savings through crop mix changes in scenario C represent ~19% of current bulk irrigation allocation

SOURCE: Ministry of Agriculture; NWMP; Department of Statistics; team analysis

D Crop mix changes roughly double value-add but reduce overall Jordan Valley agricultural employment by 7%

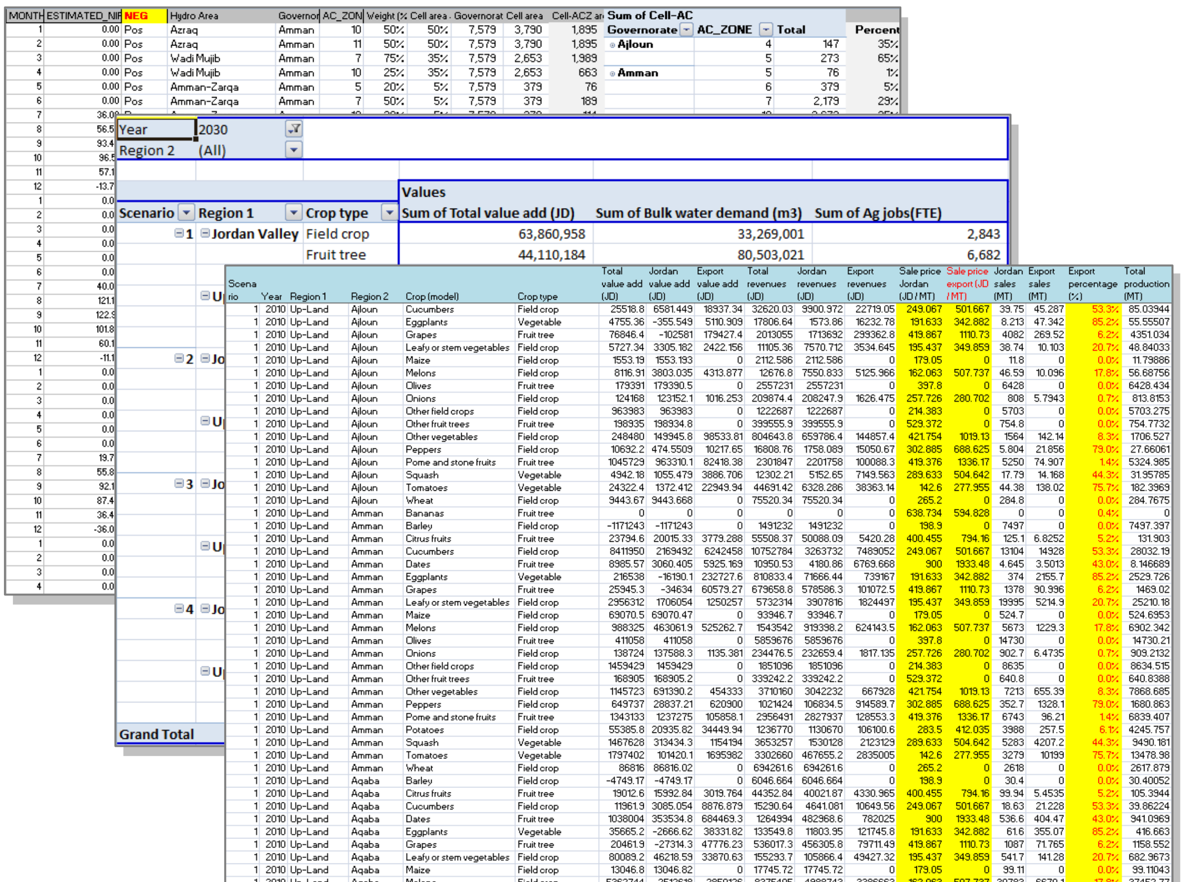


Increased value-add partially due to reduction in cultivation of crops with negative value-add per cubic meter

SOURCE: Ministry of Agriculture; NWMP; Department of Statistics; team analysis

Economic scenarios for agriculture and their outcomes were explored through a purpose-built model

Screenshots of economic model



Model variables include:

- Irrigation requirements by crop, agro-climatic zone, governorate, irrigation system, etc.
- Historical crop production statistics by governorate
- Rain-fed vs. irrigated hectare statistics, by crop and region
- Local prices for agricultural products by crop and region
- Distribution and market costs by crop and region
- Export volumes and prices
- Per-hectare production costs by crop (e.g. cost of fertilizers, seeds, pesticides, etc.)
- Per-hectare labor requirements

SOURCE: Team analysis

The alternative crop mix scenarios can influence water demand and create additional value

Potentially unreported irrigation[1]

Scenario	Description	Water requirement[2] MCM
a BAU agriculture	▪ Agriculture required to meet production targets according to **current plans, crop mix and agricultural techniques**	510 ?
b High-value agriculture	▪ Alternative crop mix which keeps current supply but expands irrigated land, by **shifting water supply** from water-intensive trees to high-value, low-water vegetables	550 ?
c Basic water reduction	▪ Alternative crop mix which maintains current cultivated area but reduces overall irrigation demand by **shifting agricultural land** from **25%** of fruit trees to high-value, low-water vegetables	450 ?
d Low-water agriculture	▪ Alternative crop mix which maintains current cultivated area but reduces overall irrigation demand by **shifting agricultural land** from **50%** of fruit trees to high-value, low-water vegetables	400 ?

1 Irrigation in the Highlands which is not reported

2 Water requirement at a bulk level, before technical efficiency / productivity solutions

SOURCE: Ministry of Agriculture; Department of Statistics; NWMP; team analysis

Appendix 2 – Agricultural use

- Agricultural aspirations and targets
- Unconstrained demand vs allocation
- Agricultural water productivity
- Economic choices
- **Technical solutions**

There are a number of technical solutions in agriculture which can increase water availability

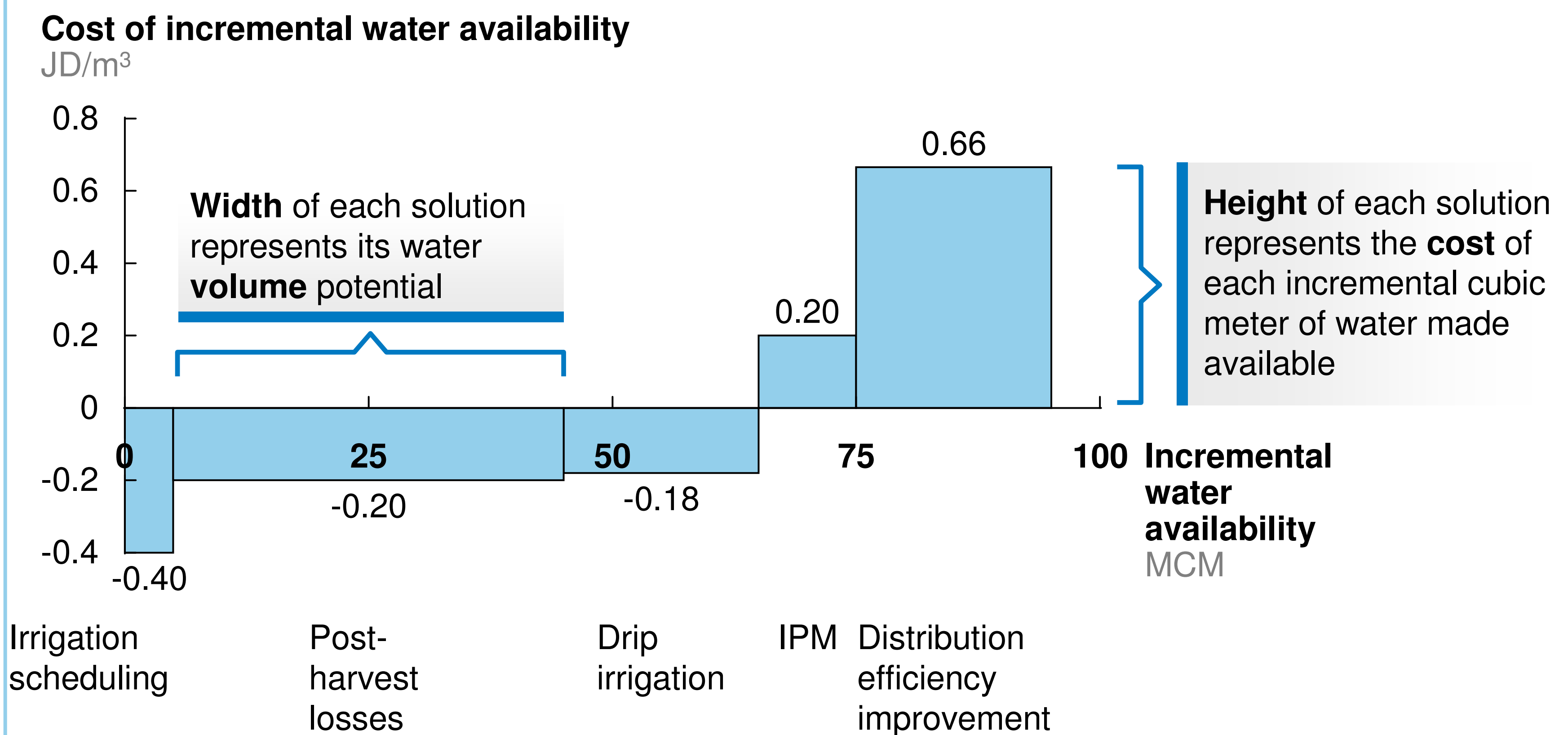
Solution	Description	
1 Drip irrigation	▪ Implement high-efficiency irrigation system	**Water efficiency** solutions aim to **reduce water losses** at different stages of the irrigation system
2 Sprinkler irrigation	▪ Implement high-efficiency irrigation system	
3 Conveyance efficiency	▪ Improve efficiency of distribution network	
4 Irrigation scheduling	▪ Irrigation timed to meet plant requirements	
5 Optimum tillage	▪ Reduce tillage for better moisture retention	**Crop productivity** solutions aim to **increase per-hectare crop yield, allowing reductions in cultivated area** while maintaining or increasing crop production
6 Improve fertilizer balance	▪ Match fertilizer balance to soil needs	
7 Increase fertilizers	▪ Increase usage of fertilizers	
8 Improved seed	▪ Use best available germplasm	
9 Seed engineering	▪ Develop crop varieties suited for Jordan	
10 Pest control	▪ Use integrated pest management techniques	
11 Post-harvest losses	▪ Reduce losses in distribution and marketing	

SOURCE: 2030 Water Resources Group

We use cost curves as an analytical tool to help assess the water potential and costs of these technical solutions

ILLUSTRATIVE

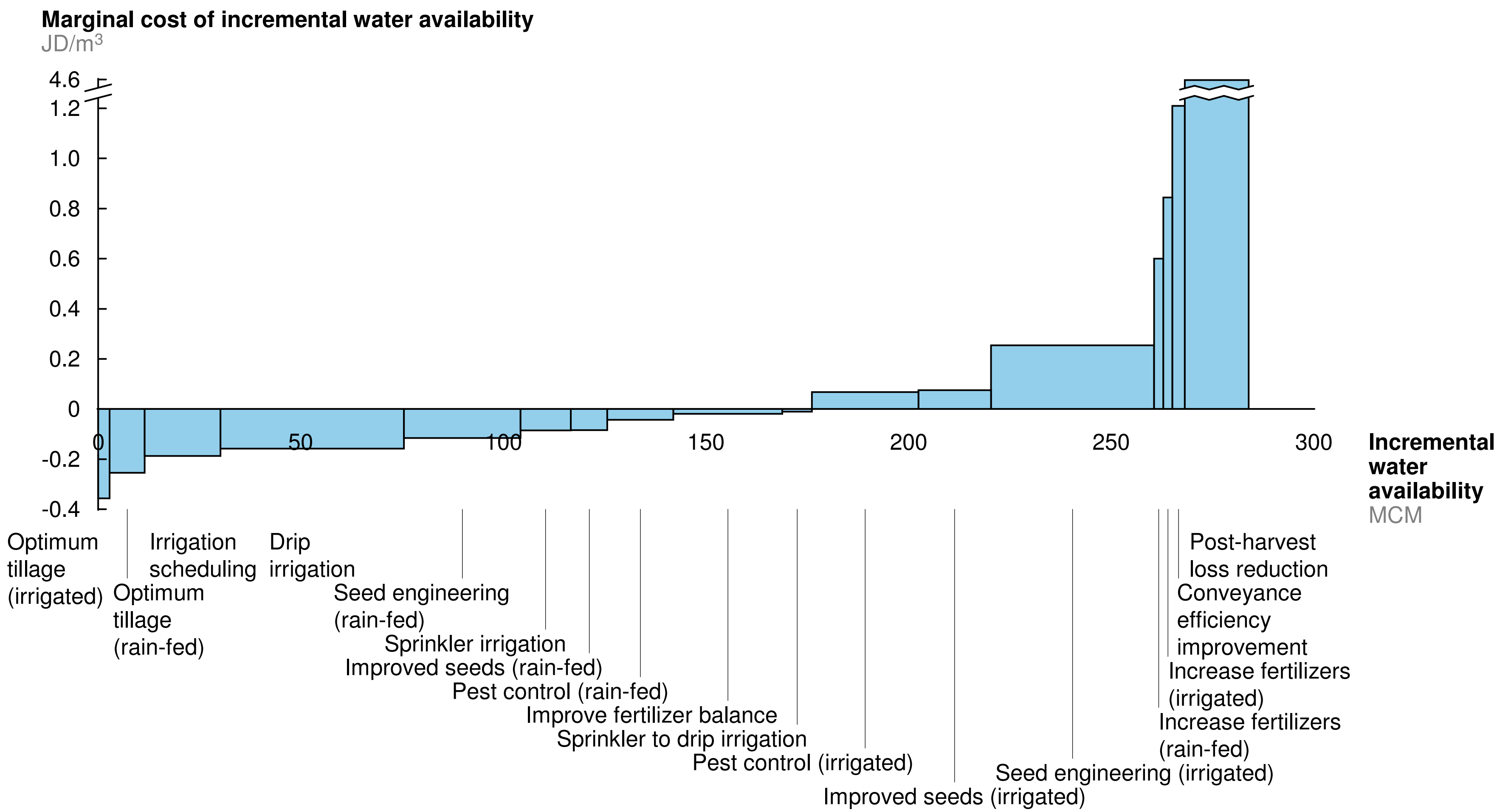
Example cost curve



SOURCE: Team analysis

In the BAU scenario, agricultural technical solutions can increase water availability by up to ~280 MCM

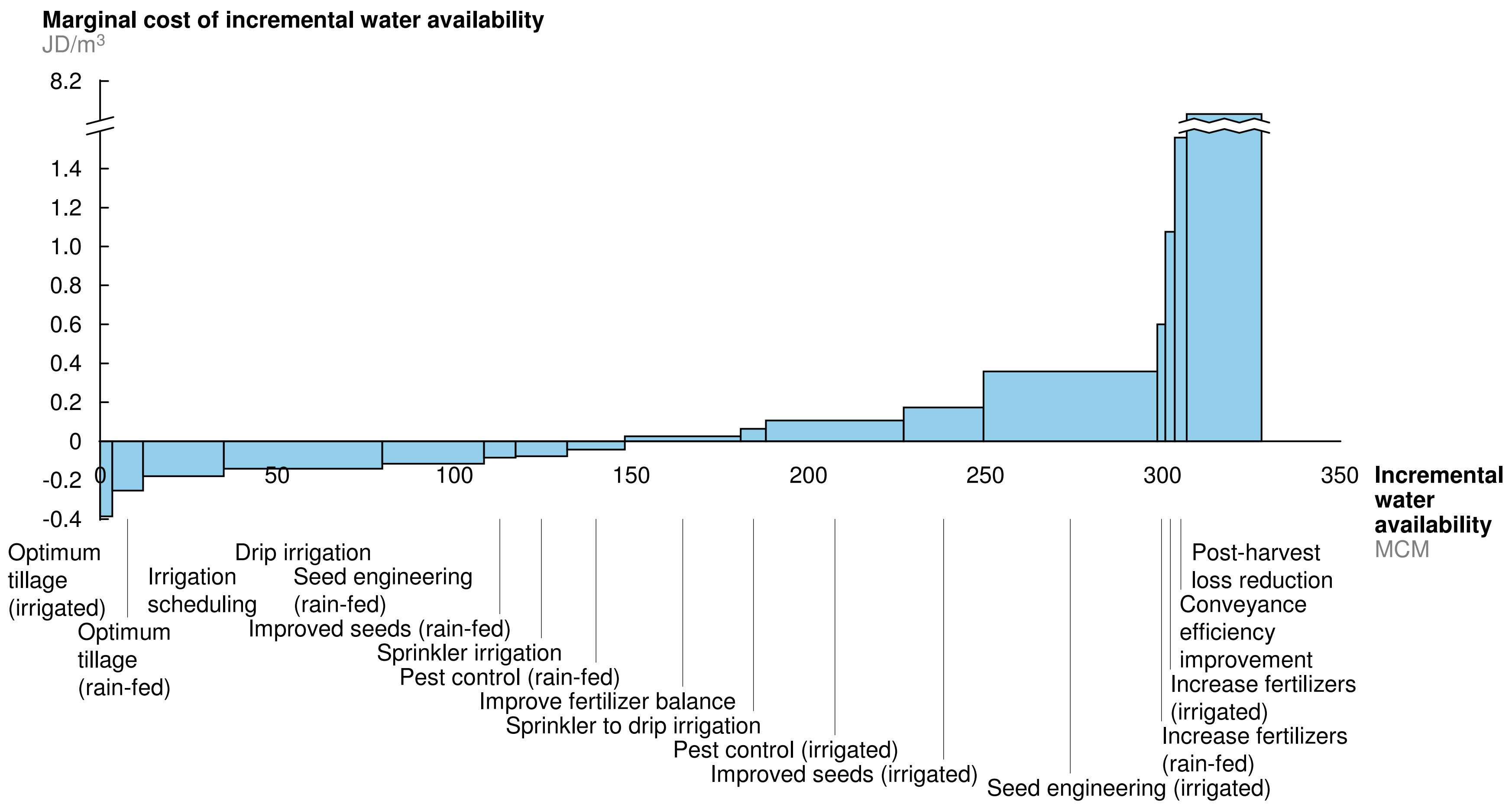
Cost curve of technical solutions in agriculture under BAU scenario



SOURCE: Team analysis

In the high-value scenario, agricultural technical solutions can increase water availability by up to ~325 MCM

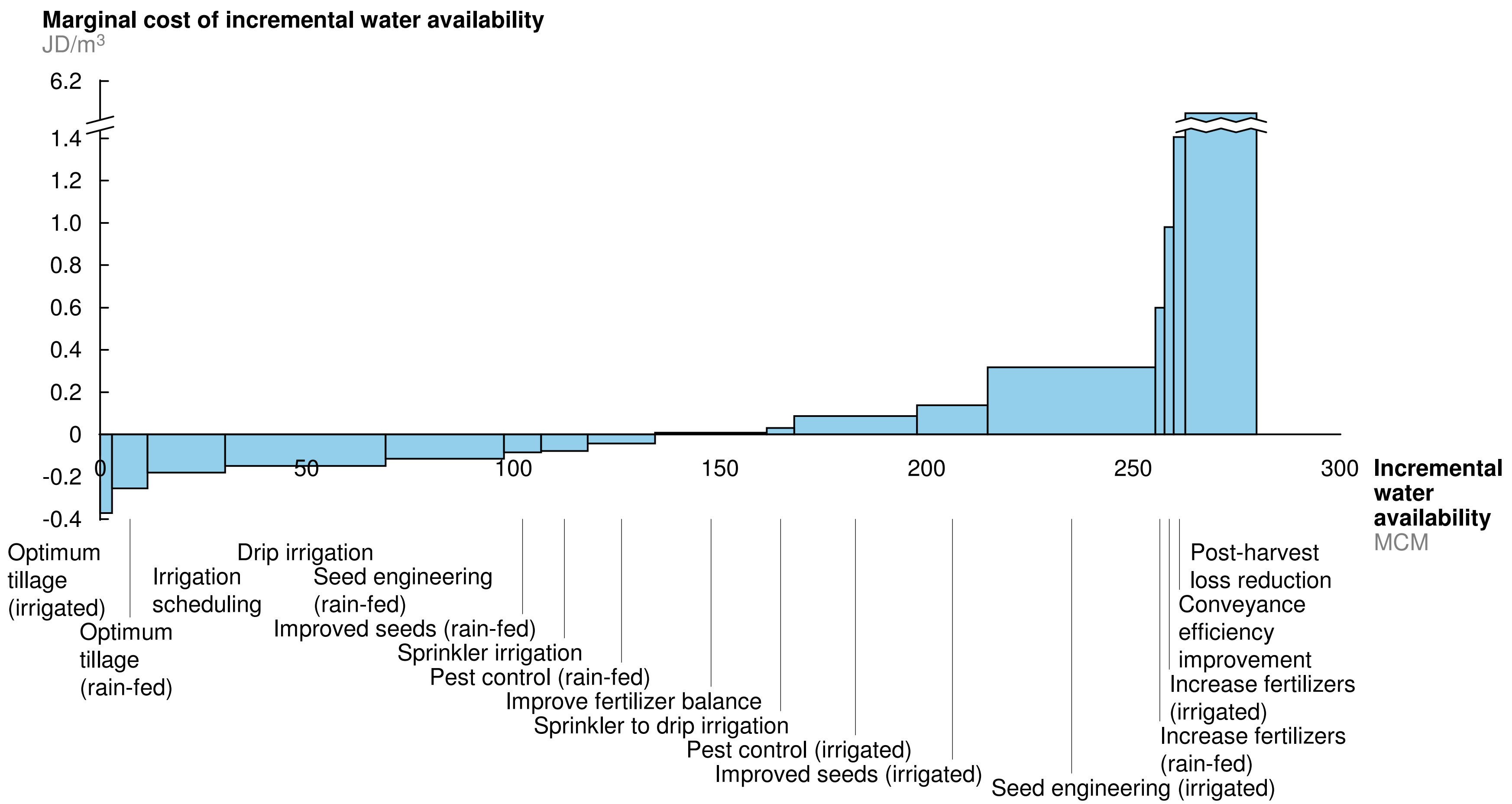
Cost curve of technical solutions in agriculture under high-value scenario



SOURCE: Team analysis

In the basic water reduction scenario, agricultural technical solutions can increase water availability by up to ~275 MCM

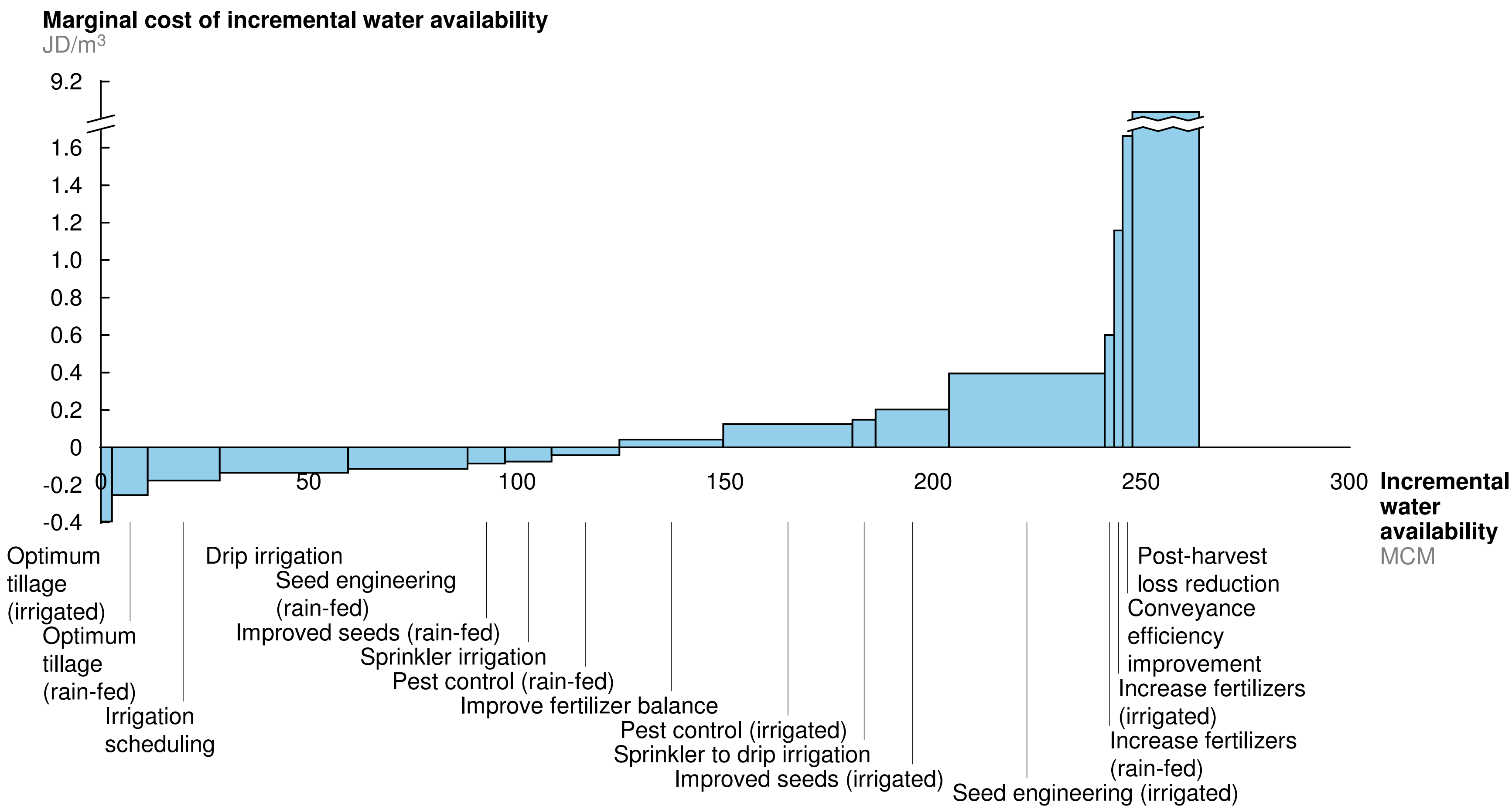
Cost curve of technical solutions in agriculture under basic water reduction scenario



SOURCE: Team analysis

In the low-water scenario, agricultural technical solutions can increase water availability by up to ~260 MCM

Cost curve of technical solutions in agriculture under low-water agriculture scenario



SOURCE: Team analysis

Multiple workshops were held to collect and verify data used to calculate cost and volume of each solution

Volume variables

Cost variables

Data required	Unit	Description
Irrigation water savings	%	▪ Percent of irrigation water that will be saved if the solution is implemented
Yield improvement	%	▪ Percent increase in the per-hectare yield (kg/ha) if the solution is implemented
Current implementation	%	▪ Percent of cultivated area that has already implemented the solution
Potential 2030 implementation	%	▪ Percent of cultivated area that could realistically implement the solution by 2030
Maximum conveyance efficiency	%	▪ Maximum possible efficiency in the distribution system
Crop losses per hectare	%	▪ Percent of crop yield which is typically lost between harvest and sale to consumer
Crop loss reduction	%	▪ Percent of the post-harvest crop loss that can be avoided with the solution (i.e. transportation)
Current OPEX per hectare	JD/ha	▪ Current yearly per-hectare operational expenses
OPEX per hectare after solution	JD/ha	▪ Yearly per-hectare operational expenses after implementing the solution
Up-front CAPEX required	JD/ha	▪ Per-hectare capital investment cost to implement the solution
Interest rate	%	▪ Interest rate used to annualize capital costs; should reflect risk of investing in solution
Asset lifetime	Years	▪ Useful lifetime of assets acquired through up-front capital investments

Data were collected through workshops and interviews held with represen-tatives from :

- Jordan Valley Authority
- Ministry of Agriculture

SOURCE: 2030 Water Resources Group

1 Technical solution: Drip irrigation

Drip irrigation: Water application through low-pressure tubing dispensing water in smaller quantities than other irrigation techniques (e.g. surface, sprinkler)

Volume variables

Data required	Unit	Current input
Irrigation water savings	%	10 to 28
Yield improvement	%	0 to 40
Current implementation	%	30 to 90
Potential 2030 implementation	%	90
Maximum conveyance efficiency	%	N/A
Crop losses per hectare	%	N/A
Crop loss reduction	%	N/A

Cost variables

Data required	Unit	Current input
Change in OPEX per hectare	JD/ha	-20 to -100
Up-front CAPEX required	JD/ha	1,500
Interest rate	%	15
Asset lifetime	Yrs	7

Notes on current inputs

- Current implementation of drip irrigation varies by region (e.g. 40% in Irbid, 90% in Amman, etc.)
- Reduction in OPEX per hectare varies by crop (e.g. high for vegetables and fruits, low for field crops)
- Reduction in OPEX per hectare driven by savings in water, energy, fertilizers, etc.

SOURCE: Workshop (3/9/2011); expert interviews; NWMP; Ministry of Agriculture; Department of Statistics; team analysis

2 Technical solution: Sprinkler irrigation

Sprinkler irrigation: Water application by spraying water in the air; increases irrigation efficiency with reduced evaporation and improved yield

Volume variables

Data required	Unit	Current input
Irrigation water savings	%	20
Yield improvement	%	0 to 40
Current implementation	%	3 to 30
Potential 2030 implementation	%	7 to 45
Maximum conveyance efficiency	%	N/A
Crop losses per hectare	%	N/A
Crop loss reduction	%	N/A

Cost variables

Data required	Unit	Current input
Change in OPEX per hectare	JD/ha	-10 to +20
Up-front CAPEX required	JD/ha	1,000
Interest rate	%	15
Asset lifetime	Yrs	10

Notes on current inputs

- Current implementation varies by region (e.g. 3% in Madaba, 33% in Ma'an, etc.)
- Change in OPEX per hectare varies by crop (e.g. reduction for vegetables, increase for fruit trees)

SOURCE: Workshop (3/9/2011); expert interviews; NWMP; Ministry of Agriculture; Department of Statistics; team analysis

3 Technical solution: Conveyance efficiency

Conveyance efficiency: Measures to reduce water losses in the irrigation water distribution system (e.g. canal lining, replacing canals with closed pipes, etc.)

Volume variables

Data required	Unit	Current input
Irrigation water savings	%	N/A
Yield improvement	%	N/A
Current implementation	%	60 to 90
Potential 2030 implementation	%	90 to 95
Maximum conveyance efficiency	%	90
Crop losses per hectare	%	N/A
Crop loss reduction	%	N/A

Cost variables

Data required	Unit	Current input
Change in OPEX per hectare	JD/ha	-130
Up-front CAPEX required	JD/ha	3,300
Interest rate	%	15
Asset lifetime	Yrs	30

SOURCE: Workshop (3/9/2011); expert interviews; NWMP; Ministry of Agriculture; Department of Statistics; team analysis

4 Technical solution: Irrigation scheduling

Irrigation scheduling: Avoid over-irrigation by scheduling irrigation volume and timing to match changing plant requirements

Volume variables

Data required	Unit	Current input
Irrigation water savings	%	12
Yield improvement	%	10
Current implementation	%	1
Potential 2030 implementation	%	20
Maximum conveyance efficiency	%	N/A
Crop losses per hectare	%	N/A
Crop loss reduction	%	N/A

Cost variables

Data required	Unit	Current input
Change in OPEX per hectare	JD/ha	-4 to -20
Up-front CAPEX required	JD/ha	150
Interest rate	%	15
Asset lifetime	Yrs	10

Notes on current inputs

- Reduction in OPEX per hectare is greatest for fruit trees due to greater water-saving potential

SOURCE: Workshop (3/9/2011); expert interviews; NWMP; Ministry of Agriculture; Department of Statistics; team analysis

5 Technical solution: Optimum tillage

Optimum tillage: Techniques to reduce tillage to retain soil moisture, and laser land levelling to reduce runoff and better drain lands

Volume variables

Data required	Unit	Current input
Irrigation water savings	%	4
Yield improvement	%	0
Current implementation	%	0
Potential 2030 implementation	%	10
Maximum conveyance efficiency	%	N/A
Crop losses per hectare	%	N/A
Crop loss reduction	%	N/A

Cost variables

Data required	Unit	Current input
Change in OPEX per hectare	JD/ha	-100
Up-front CAPEX required	JD/ha	470
Interest rate	%	15
Asset lifetime	Yrs	14

Notes on current inputs

- Solution not applied to tree crops
- Reductions in OPEX due to water savings and reduced costs associated with tillage

SOURCE: Workshop (3/9/2011); expert interviews; NWMP; Ministry of Agriculture; Department of Statistics; team analysis

6 Technical solution: Improve fertilizer balance

Improve fertilizer balance: Improve optimal mineral balance to improve mineral absorption and supply sufficient micro-nutrients

Volume variables

Data required	Unit	Current input
Irrigation water savings	%	N/A
Yield improvement	%	15
Current implementation	%	20
Potential 2030 implementation	%	60
Maximum conveyance efficiency	%	N/A
Crop losses per hectare	%	N/A
Crop loss reduction	%	N/A

Cost variables

Data required	Unit	Current input
Change in OPEX per hectare	JD/ha	+5 to +50
Up-front CAPEX required	JD/ha	470
Interest rate	%	15
Asset lifetime	Yrs	14

Notes on current inputs

- Increase in OPEX varies according to crop type; field crops have the lowest increase

SOURCE: Workshop (3/9/2011); expert interviews; NWMP; Ministry of Agriculture; Department of Statistics; team analysis

7 Technical solution: Increase fertilizers

Increase fertilizers: Increase fertilizer use to reduce mineral exhaustion and increase crop yield

Volume variables

Data required	Unit	Current input
Irrigation water savings	%	N/A
Yield improvement	%	10
Current implementation	%	95
Potential 2030 implementation	%	100
Maximum conveyance efficiency	%	N/A
Crop losses per hectare	%	N/A
Crop loss reduction	%	N/A

Cost variables

Data required	Unit	Current input
Change in OPEX per hectare	JD/ha	+150 to +500
Up-front CAPEX required	JD/ha	N/A
Interest rate	%	15
Asset lifetime	Yrs	N/A

Notes on current inputs

- Increase in OPEX varies according to crop type; field crops have the lowest increase, fruit trees the highest
- Relatively modest increase in implementation is due to over-fertilization concerns

SOURCE: Workshop (3/9/2011); expert interviews; NWMP; Ministry of Agriculture; Department of Statistics; team analysis

8 Technical solution: Improved seed

Improved seed: Increase average yield potential by using the best available seed varieties

Volume variables

Data required	Unit	Current input
Irrigation water savings	%	N/A
Yield improvement	%	30
Current implementation	%	30 to 60
Potential 2030 implementation	%	80 to 90
Maximum conveyance efficiency	%	N/A
Crop losses per hectare	%	N/A
Crop loss reduction	%	N/A

Cost variables

Data required	Unit	Current input
Change in OPEX per hectare	JD/ha	+300 to +950
Up-front CAPEX required	JD/ha	N/A
Interest rate	%	15
Asset lifetime	Yrs	N/A

Notes on current inputs

- Solution applies mainly to vegetable and field crops, with some applicability to trees
- Current implementation varies by crop; low implementation for tree crops and relatively higher implementation for other crops

SOURCE: Workshop (3/9/2011); expert interviews; NWMP; Ministry of Agriculture; Department of Statistics; team analysis

9 Technical solution: Seed engineering

Seed engineering: Development and adoption of varieties that enable higher crop yields; includes both conventional breeding and genetic engineering

Volume variables

Data required	Unit	Current input
Irrigation water savings	%	N/A
Yield improvement	%	30
Current implementation	%	20
Potential 2030 implementation	%	50
Maximum conveyance efficiency	%	N/A
Crop losses per hectare	%	N/A
Crop loss reduction	%	N/A

Cost variables

Data required	Unit	Current input
Change in OPEX per hectare	JD/ha	+250 to +650
Up-front CAPEX required	JD/ha	N/A
Interest rate	%	15
Asset lifetime	Yrs	N/A

Notes on current inputs

- Increase in OPEX varies according to crop type; fruit trees have the lowest increase due to less frequent planting

SOURCE: Workshop (3/9/2011); expert interviews; NWMP; Ministry of Agriculture; Department of Statistics; team analysis

10 Technical solution: Pest control

Pest control: Reduce the use of pesticides while at the same time managing pest populations at an acceptable level through Integrated Pest Management techniques (IPM)

Volume variables

Data required	Unit	Current input
Irrigation water savings	%	N/A
Yield improvement	%	15-50
Current implementation	%	30 to 80
Potential 2030 implementation	%	50 to 90
Maximum conveyance efficiency	%	N/A
Crop losses per hectare	%	N/A
Crop loss reduction	%	N/A

Cost variables

Data required	Unit	Current input
Change in OPEX per hectare	JD/ha	+30 to +500
Up-front CAPEX required	JD/ha	N/A
Interest rate	%	15
Asset lifetime	Yrs	N/A

Notes on current inputs

- Increase in OPEX varies according to crop type; fruit trees have the highest increase and field crops the lowest
- Current and future implementation varies by region, with higher percentages assumed for the Jordan Valley

SOURCE: Workshop (3/9/2011); expert interviews; NWMP; Ministry of Agriculture; Department of Statistics; team analysis

11 Technical solution: Post-harvest losses

Post-harvest losses: Prevent post-harvest crop losses during storage and transportation through measures such as building better storage and improving transportation efficiency

Volume variables

Data required	Unit	Current input
Irrigation water savings	%	N/A
Yield improvement	%	N/A
Current implementation	%	20 to 40
Potential 2030 implementation	%	60 to 80
Maximum conveyance efficiency	%	N/A
Crop losses per hectare	%	20
Crop loss reduction	%	50

Cost variables

Data required	Unit	Current input
Change in OPEX per hectare	JD/kg	+0.10
Up-front CAPEX required	JD/ha	TBC
Interest rate	%	15
Asset lifetime	Yrs	TBC

Notes on current inputs

- Solution not applied to field crops
- Current and future implementation varies by region, with higher percentages assumed for the Jordan Valley

SOURCE: Workshop (3/9/2011); expert interviews; NWMP; Ministry of Agriculture; Department of Statistics; team analysis

Assessing difficulty of implementation provides a framework for prioritizing technical solutions

○ Low challenge
◑ Moderate challenge
● High challenge

	Solution	Challenge type: Financial	Technology & capability	Structural & organizational	Social & behavioral	Overall implementation challenge
1	Drip irrigation	●	○	○	○	◔
2	Sprinkler irrigation	●	◑	○	○	◔
3	Conveyance efficiency	●	◑	○	○	◔
4	Irrigation scheduling	●	●	◑	◑	◕
5	Optimum tillage	●	●	◑	●	●
6	Improve fertilizer balance	◑	○	○	○	○
7	Increase fertilizer	◑	○	○	○	○
8	Improved seed	◑	○	◑	○	◔
9	Seed engineering	●	●	◑	◑	◕
10	Pest control	◑	◑	◑	◑	◑
11	Post-harvest losses	◑	◑	◑	◑	◑

SOURCE: Workshop (3/9/2011); team analysis

Appendix 3 – Energy use

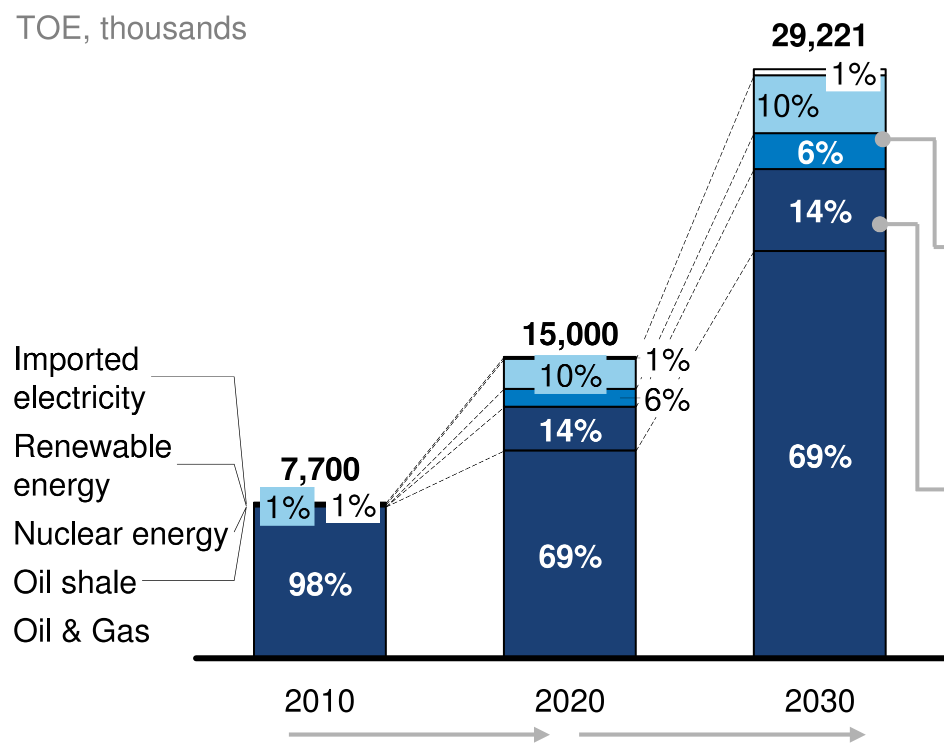
- **Energy growth plans**
- Water requirements for energy
- Water efficiency solutions

Jordan's primary energy demand is expected to triple by 2030 which the country plans to meet by extending power generation and mining capacity

Energy sector 2020/30

- The **National Energy Strategy** targets at meeting 15mn TOE by 2020
- The energy mix is envisioned to shift towards local sources like nuclear/uranium, renewables and oil shale
- Based on these targets the **energy sector is assumed to grow further at a continuous rate** with a similar mix

Primary energy mix 2009 - 2030



Source

National Energy Strategy 2007, Ministry of Energy Annual Report

Assumption: Same growth rate as for 2010-20; stable energy mix

A Power generation

- Nuclear – 4 GW
- Oil shale – 700 MW
- Solar – 300 - 600 MW

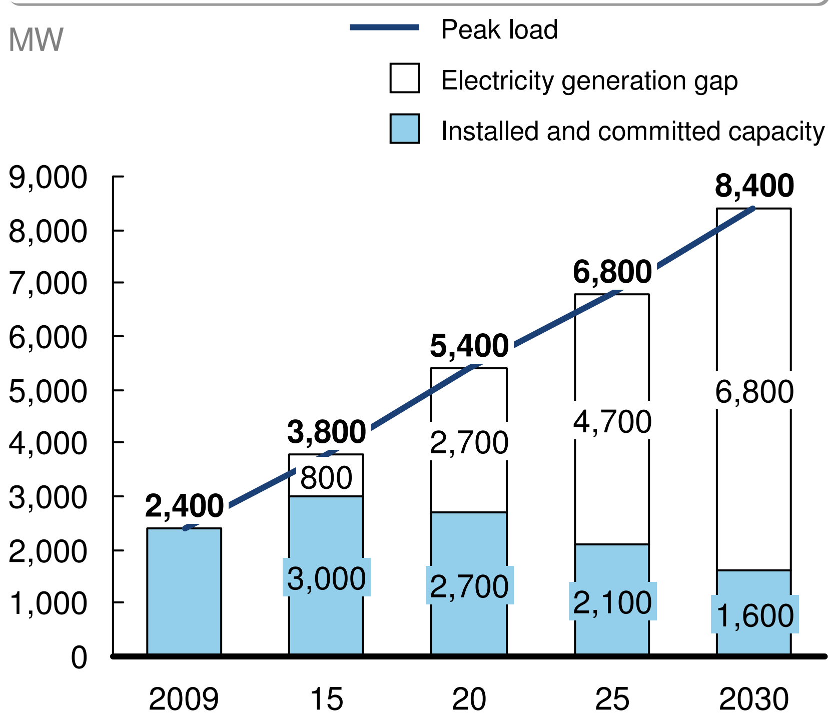
B Energy resource mining

- Uranium – 1,300 tons
- Oil shale – 15m barrel

SOURCE: National Energy Strategy; MEMR; press research; team analysis

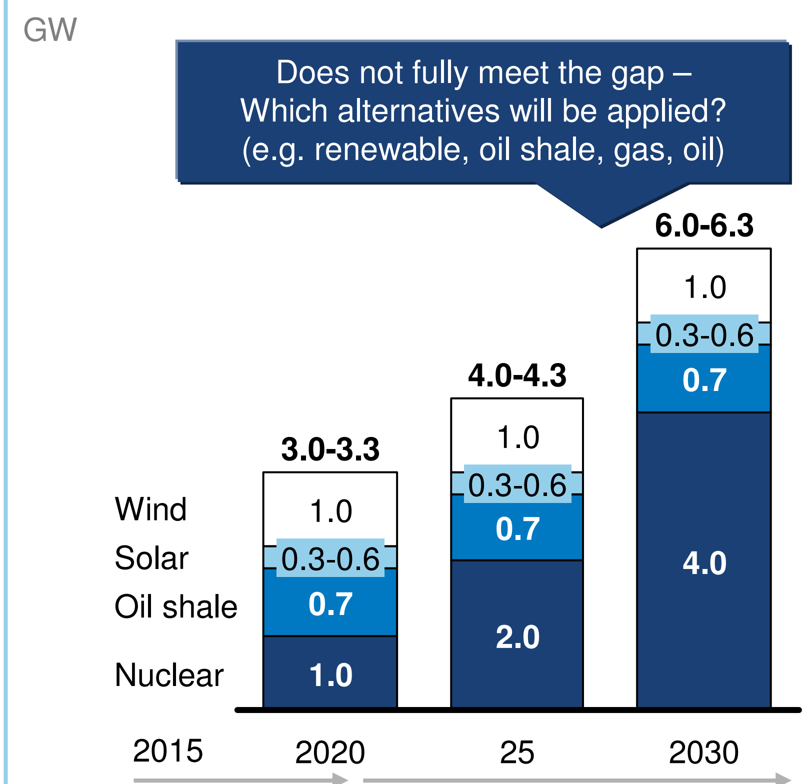
Jordan plans to meet the 6,800 MW power generation gap by 2030 with a mix of nuclear, oil shale, and renewable technologies

Power generation demand 2010 - 2030[1]



Key assumptions
- GDP growth 6%
- Population growth 1.4% p.a.

Planned build-out of capacity



Source National Energy Strategy 2007, MEMR, MWI — JAEC, MEMR, NRA

1 Indicative figures based on demand graph of JAEC (Jordan Atomic Energy Commission)

SOURCE: JAEC; MEMR; NRA

Appendix 3 – Energy use

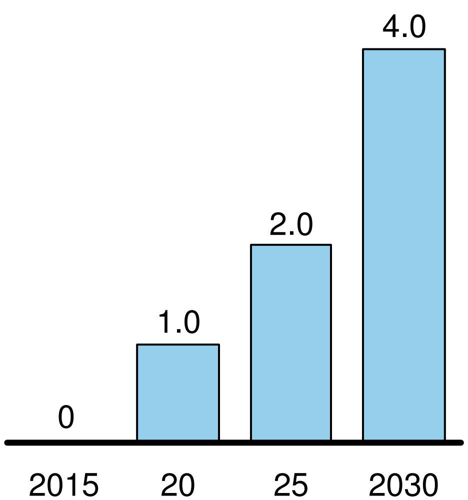
- Energy growth plans
- **Water requirements for energy**
- Water efficiency solutions

Nuclear: Different options currently discussed – preferred option is a mechanical tower located in As-Samra requiring up to 30 MCM of water

Preferred option

Nuclear build-out plan

GW



Cooling options and water estimates

MCM, water demand per 1 GW installed capacity running at ~90% availability

Location	Technology	Water MCM	Own power MW
As-Samra (desert area, treated waste water available)	**Mechanical tower** (waste water)	22-30 +0.8 (freshwater)	8
	Natural draft (groundwater)	> 30 +0.8 (freshwater)	2
Aqaba (seashore)	**Desalinated water**	60 - 70	8
	Natural draft (seawater)	>100	2

SOURCE: JAEC; MWI; team analysis

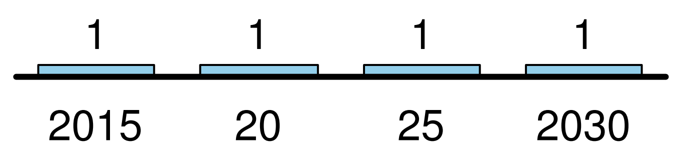
Oil shale: Current plans are highly water efficient implying a low water requirement of 1 MCM per year

Current plans for power generation of oil shale require 1 MCM of water per year

Current plans

- 700 MW oil shale power generation capacity planned besides oil shale extraction plans
- Technology planned to be highly water-efficient requiring 1 MCM per year as per NRA information

Estimated water requirement



SOURCE: NRA

120

Solar: Different technological options exist using up to $3m^3/MWh$

ESTIMATES

Technology		Water usage Cubic meter/MWh	Description
	Water-cooled parabolic trough	3.0	▪ Cooling to condense steam provided via water cooling, air cooling, or a combination ▪ Mirror cleaning
	Water recirculation power tower	2.4	
	Hybrid (water/air)-cooled parabolic trough	1.0	
	Air-cooled power tower	0.3	
	Air-cooled parabolic trough	0.3	
	PV	0.1	▪ Mirror or lense cleaning
	Dish Stirling	0.1	

Air cooling create efficiency losses estimated at 2%-9% for parabolic trough and at 5% for power tower

Sources: U.S. Department of Energy; expert interviews; team analysis

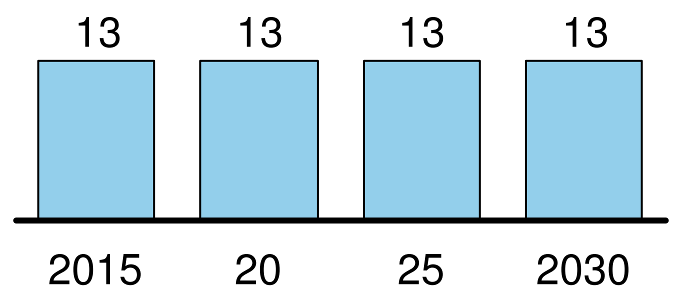
In order to make use of local energy sources, Jordan plans to build mining capacity of 2,000 tons for Uranium and 15m barrel for Oil shale

Jordan has identified local energy resources for mining requiring 30 MCM of water by 2030

Current plans / Estimated water requirement

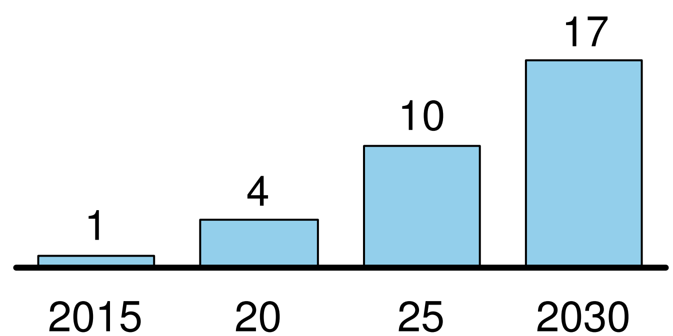
Uranium

- Extraction of 20,000 tons of uranium over 15 years
- Utilization for refinement abroad and export
- Key investor: AREVA



Oil shale

- Extraction of up to 40,000 BPD (15m barrel per year)
- Utilization for export and as a substitute for oil import
- Key investors: Kerak International Oil, Oiil Shale Energy Jordan (JOSE), INCOSIN BVI, Petrobras



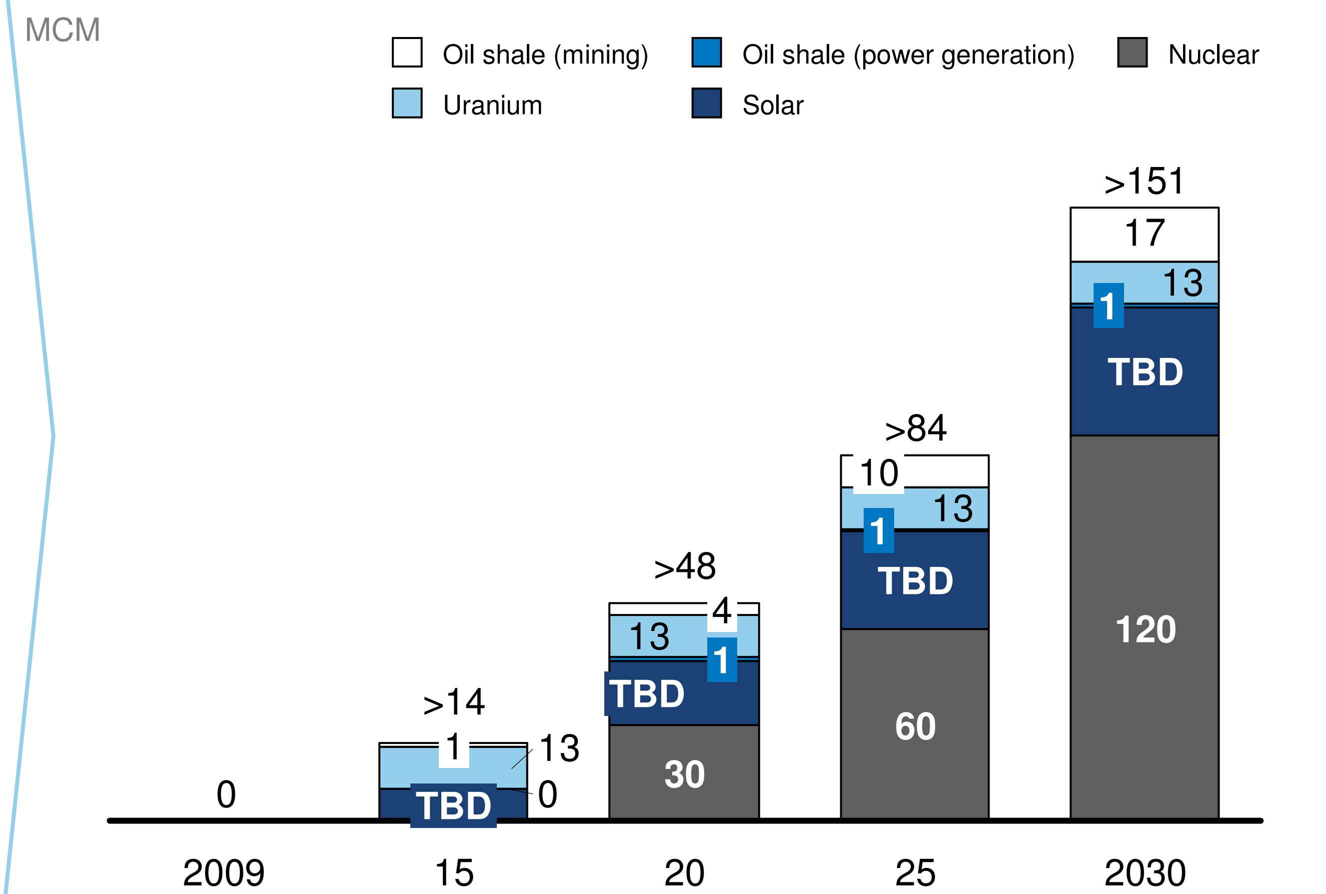
SOURCE: JAEC; NRA

These plans will require >150 MCM of water by 2030 especially driven by the water requirements of nuclear technology

Water requirements

- **Nuclear & Uranium:** Estimates by MEMR (Top range of 30 MCM per GW in preferred option)
- **Solar:** TBD
- **Oil shale (power generation):** Estimate by NRA (1 MCM)
- **Uranium:** Estimate by JAEC (13 MCM)
- **Oil shale (mining):** Estimate by NRA (growth 1-17 MCM)

Water demand from power generation and energy resource mining



1 Range depending on location and technology applied for nuclear power plants as well as source for estimate

SOURCE: MEMR; MWI; expert discussions; team analysis

123

Appendix 3 – Energy demand

- Energy growth plans
- Water requirements for energy
- **Water efficiency solutions**

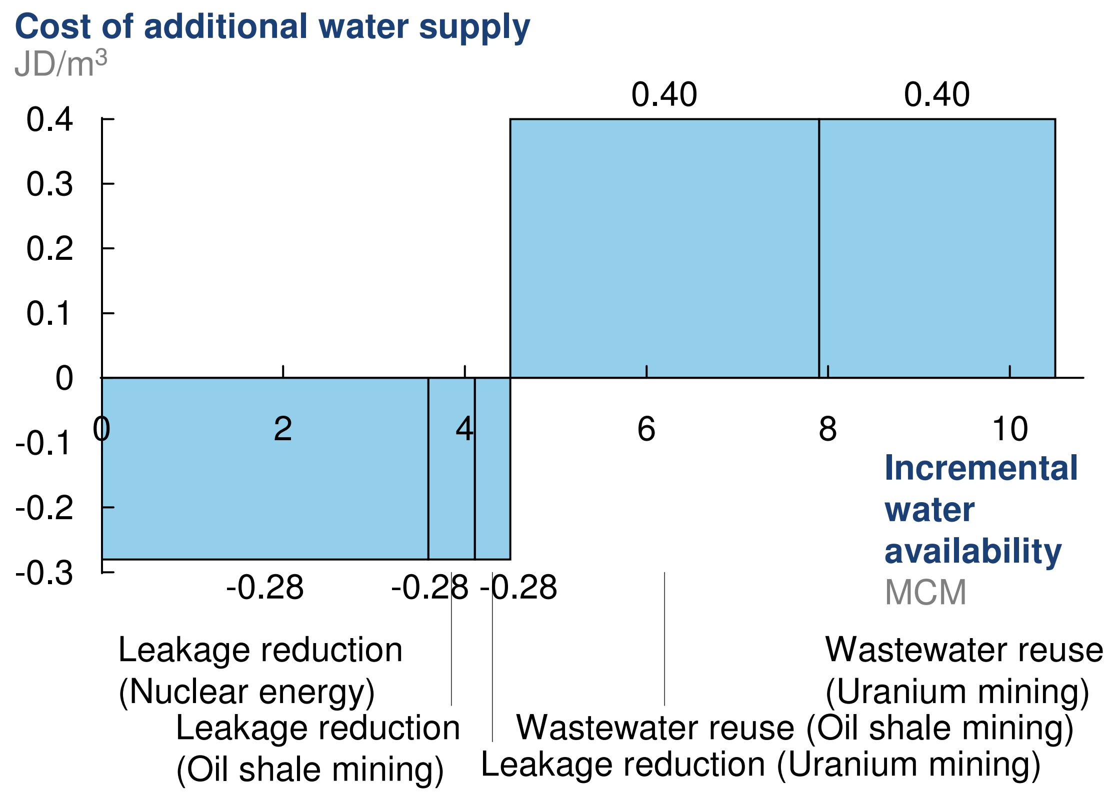
Jordan could reduce energy water requirements by making water a key selection criterion for technology and introducing water efficiency solutions

Water as a key selection criterion for technology in energy

- **Constantly review current energy plans** based on water requirements as they develop further in the bidding and evaluation process
- Make water a **key decision criterion for any new energy plans** and technologies to be introduced (e.g. solar power)

Initial water-efficiency solutions in power generation and energy resource mining

PRELIMINARY ESTIMATES - TO BE VERIFIED



SOURCE: MWI, WAJ, JVA, team analysis

Initial energy cost curve in detail

	Solution	Potential water saving Percent	 MCM	Cost JD/m³	Comment
Leakage reduction	Nuclear	3%	3.6	-0.28	▪ Potential water saving: 50% of total benchmark potential of 6% can be realized ▪ Cost: 0.35 JD/m³ cost of water and 0.07 JD/m³ cost of leakage reduction
	Oil shale mining	3%	0.5	-0.28	
	Uranium mining	3%	0.4	-0.28	
Wastewater-reuse	Oil shale mining	20%	3.4	0.40	▪ Potential water saving: 100% of total benchmark potential of 20% can be realized ▪ Cost: 0.35 JD/m³ cost of water and 0.75 JD/m³ cost of waste water treatment (Benchmark: new, small-scale waste water treatment facilities built by WAJ)
	Uranium mining	20%	2.6	0.40	

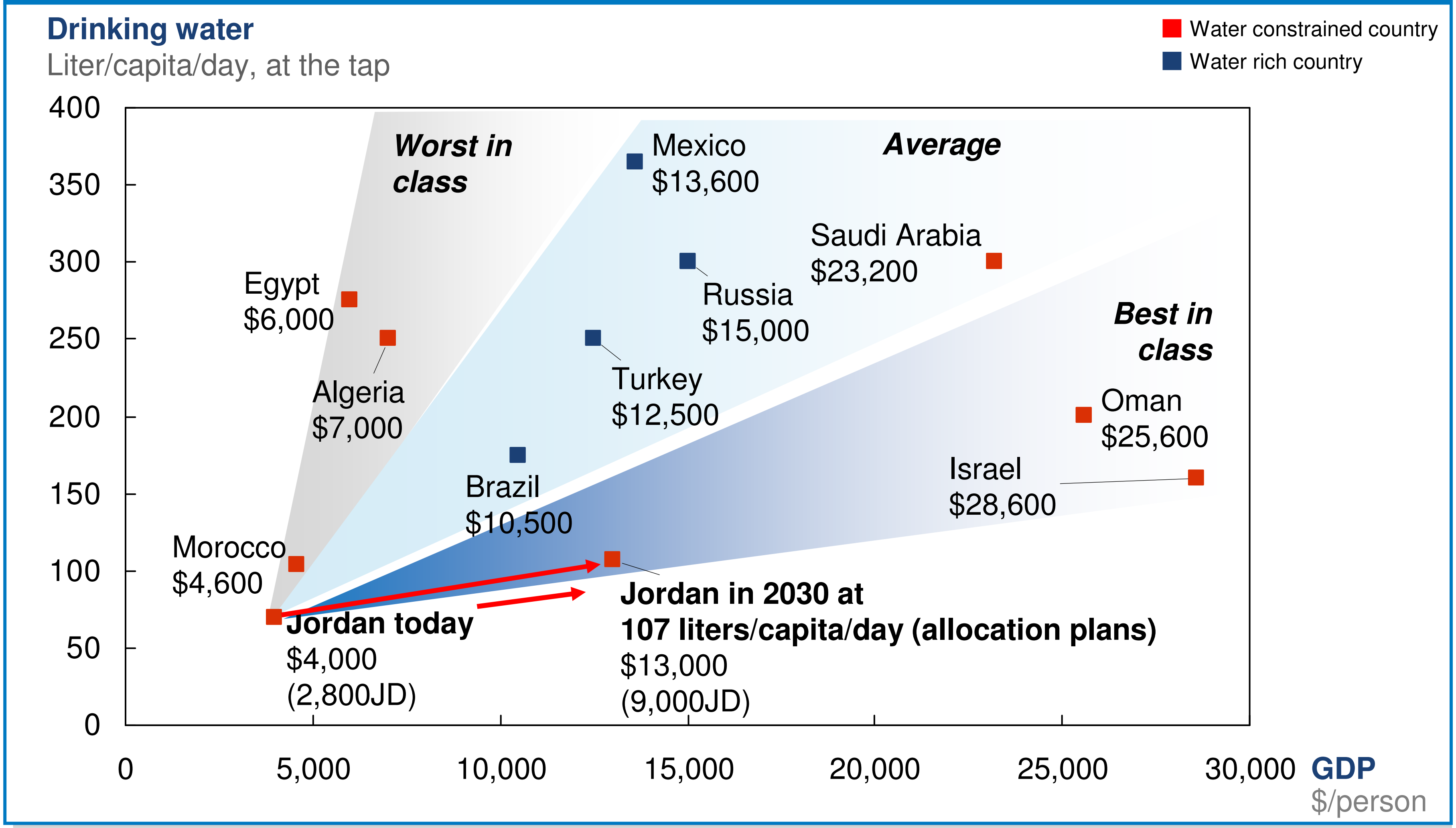
SOURCE: WRG benchmark; team analysis

Appendix 4 – Municipal use

- **Current municipal use**
- Future municipal requirements
- Municipal efficiency solutions

Jordan aspires to significantly increase the per capita water supply in its cities by 2030

Residential water and GDP per capita for sample of countries in 2009

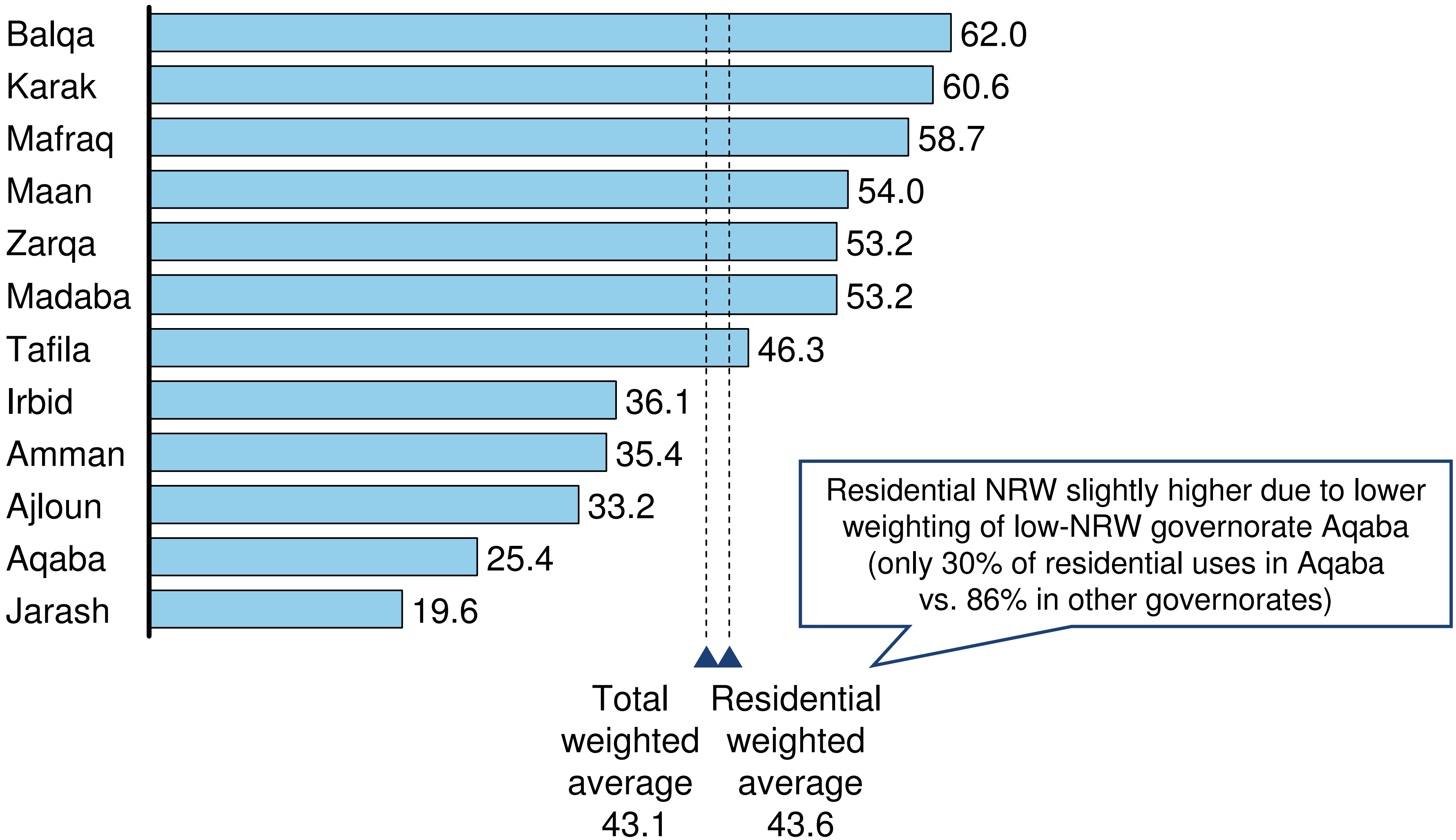


* To be determined through cost curve analysis

SOURCE: IMF, Economist Intelligence Unit, UNDP HDR Report 2006, team analysis

NRW in municipal systems on average at 43% – ranges from ~20% to as high as ~60% in some governorates

Percent



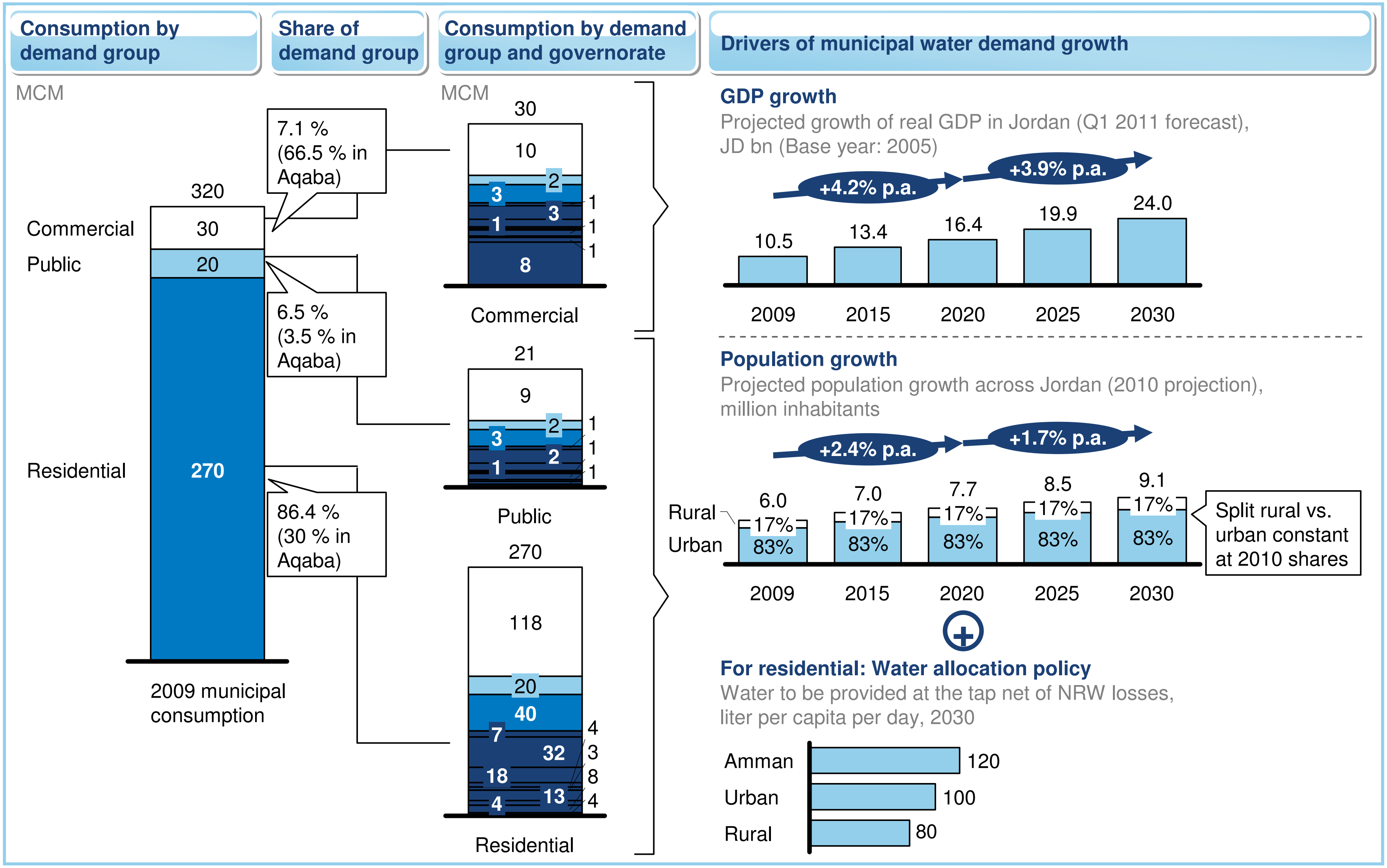
SOURCE: Assessment of water use and efficiency in the Hashemite Kingdom of Jordan (September 2010); IDARA; team analysis

Appendix 4 – Municipal use

- Current municipal use
- **Future municipal requirements**
- Municipal efficiency solutions

Municipal water demand is projected based on GDP and population growth as well as the water allocation policy

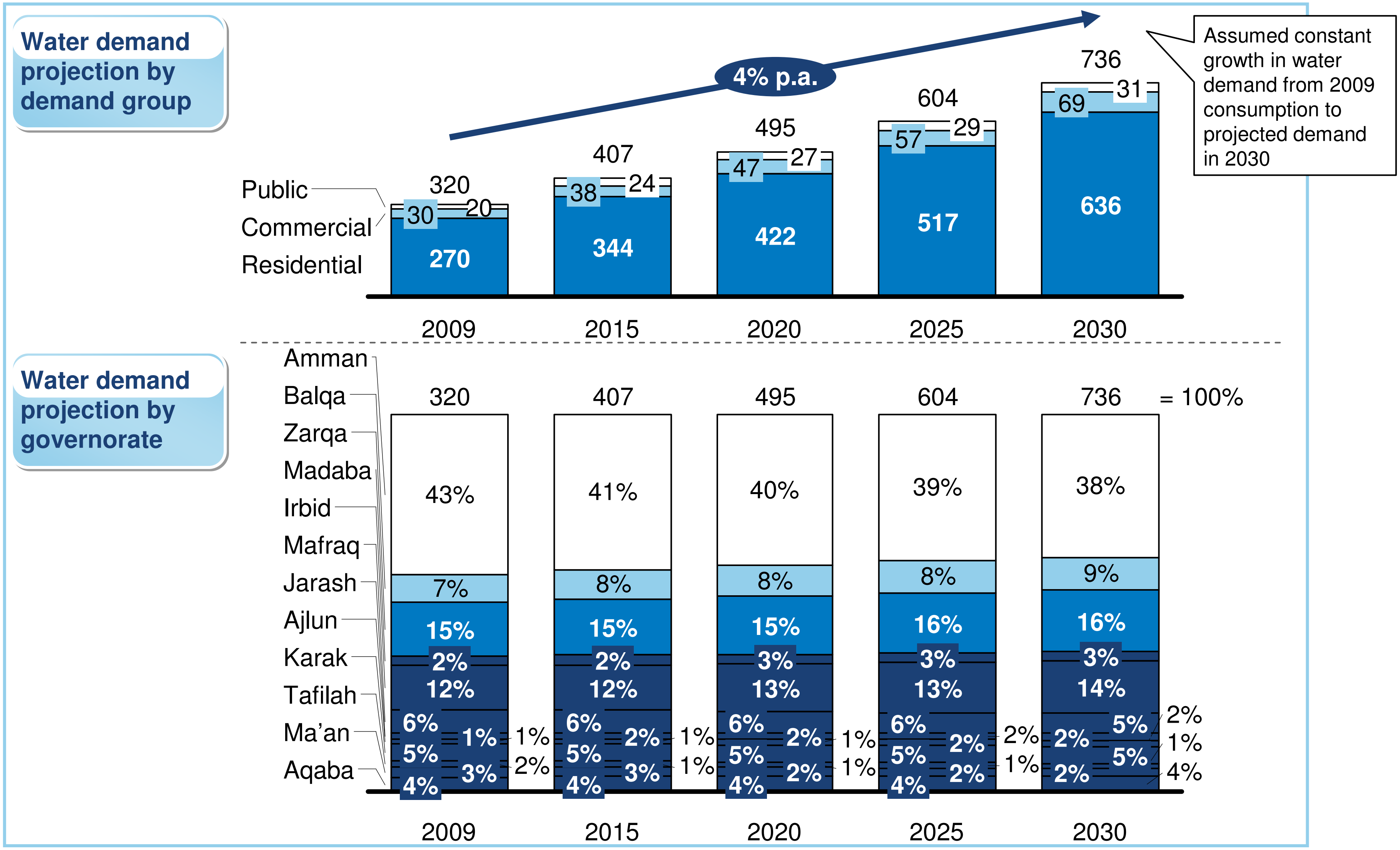
Amman | Irbid | Karak
Balqa | Mafraq | Tafilah
Zarqa | Jarash | Ma'an
Madaba | Ajlun | Aqaba



SOURCE: MWI; WAJ; IDARA; DOS; IHS Global Insight; team analysis

Municipal water demand in 2030 is projected at ~740 MCM, which implies an annual growth rate of 4% based on water consumption in 2009

MCM



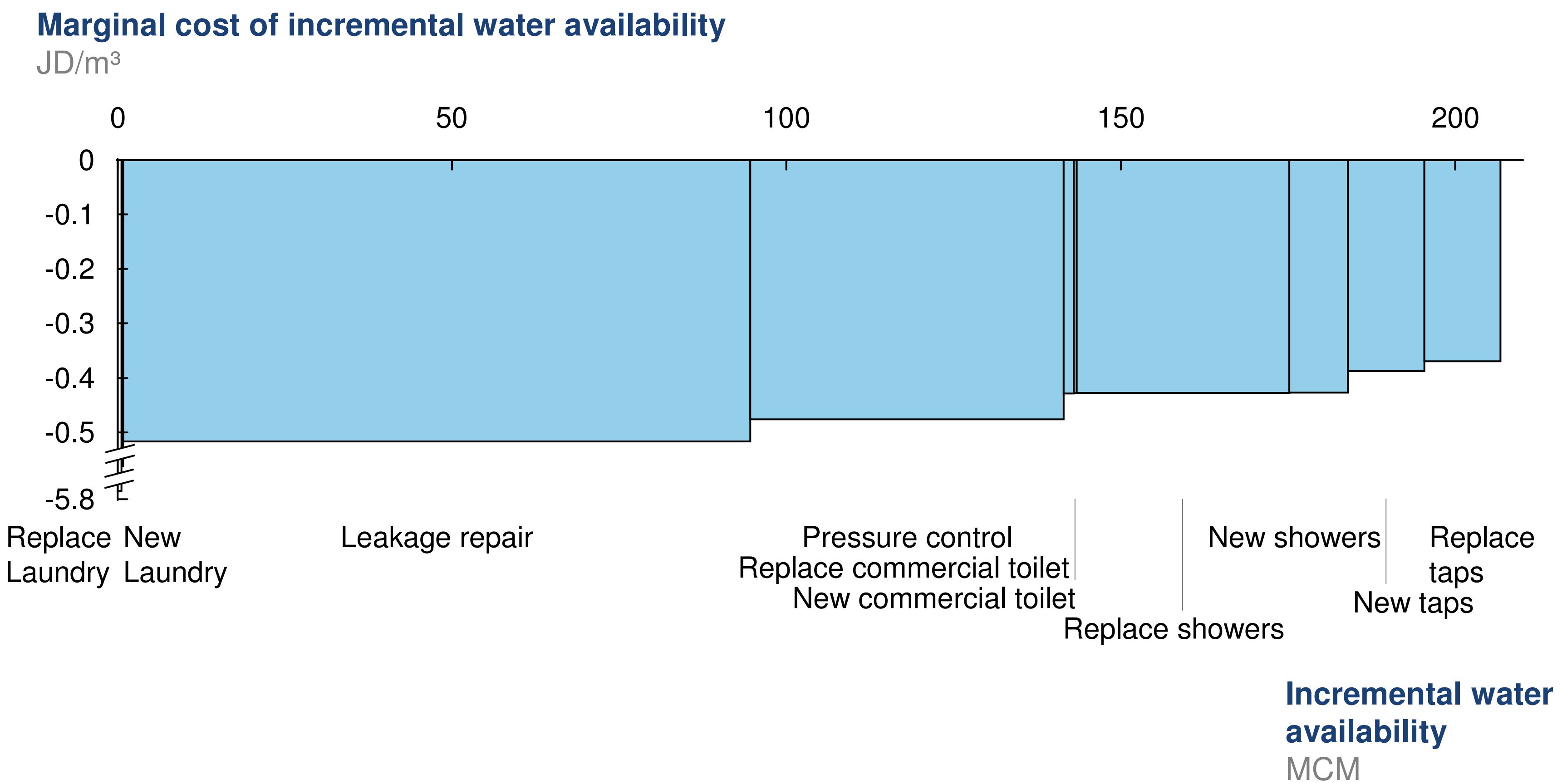
SOURCE: Team analysis

Appendix 4 – Municipal use

- Current municipal use
- Future municipal requirements
- **Municipal efficiency solutions**

Jordan can explore and chose among the most cost effective options for closing the gap between sustainable supply and unconstrained demand

Jordan's cost curve options for closing its 2030 supply demand gap



SOURCE: WAJ, MWI, IDARA, Jordan Department of Statistics, 2030 Water Resources Group, team analysis

Some of these measure are currently being addressed by MWI

	Lever	Applied already	Status
End user effici-ency meas ures	▪ Retrofit domestic toilet	✔	▪ Involves installing a water saving device in existing toilets ▪ Currently being implemented by Miyahuna and Al-Yarmouk water companies ▪ Expected to save 8MCM for Miyahuna and 2MCM for Al Yarmouk over 20 years ▪ Expected lifetime savings of JD2.7m for Miyahuna andJD0.3m for Al-Yarmouk
	▪ Retrofit commercial toilet	✔	▪ Involves installing a water saving device in existing toilets ▪ Currently being implemented by Miyahuna and Al-Yarmouk water companies ▪ Expected to save 5.3MCM for Miyahuna and 0.7MCM for Al Yarmouk over 20 years ▪ Expected lifetime savings of JD1.8m for Miyahuna andJD0.12m for Al-Yarmouk
	▪ Retrofit faucets and showers	✔	▪ Involves installing a water saving device in existing toilets ▪ Currently being implemented by Miyahuna and Al-Yarmouk water companies ▪ Expected to save 28.7MCM for Miyahuna and 17.3MCM for Al Yarmouk over 20 years ▪ Expected lifetime savings of JD9.4m for Miyahuna andJD3.1m for Al-Yarmouk
NRW redu-ction meas ures	▪ Leakage repair	✔	▪ Amman implemented a $350M project from 1999-2009 ▪ This reduced NRW from ~50% to 35% ▪ It involved pipe refurbishment as well as improved administration ▪ It is an expensive lever but has potential to save substantial amounts of water ▪ The further you try to reduce NRW, the more expensive this lever becomes (i.e. going from 35% NRW to 20% is much more expensive than going from 50% to 35%

SOURCE: IDARA – “Water Efficiency Plan – Miyahuna, Al Yarmouk”, 2030 Water Resources Group

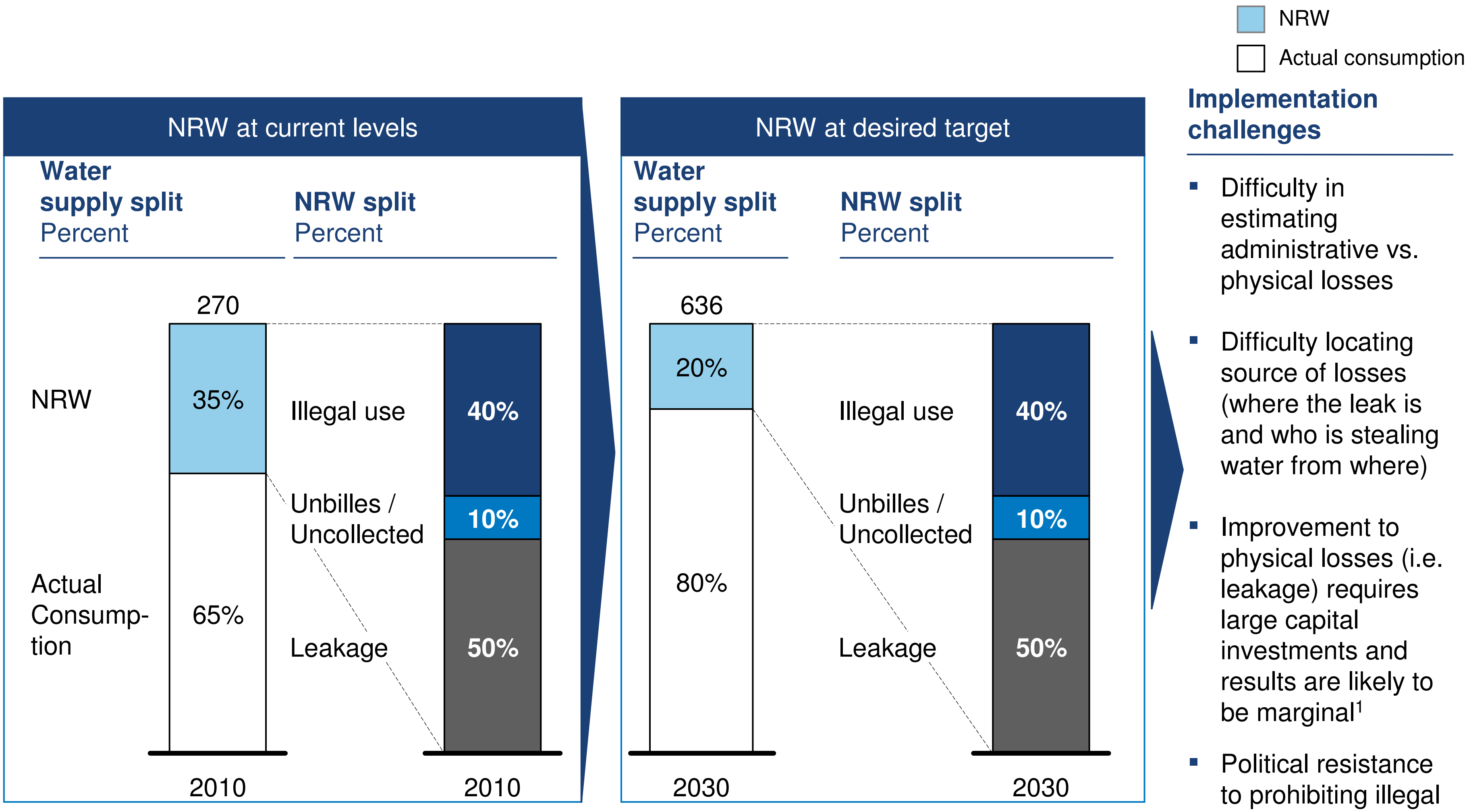
Some measures not currently explored have potential to be addressed

	Lever	Applied already	Status
End user effici-ency meas ures	New toilets	✗	▪ Can be implemented by requiring all new toilets on the market to meet efficiency standards ▪ Assuming avg. life of toilet is 15 years, by 2030 ~all toilets installed would be efficient
	New faucets & showers	✗	▪ Can be implemented by requiring that all new faucets and showers available on the market meet efficiency standards ▪ Assuming average life of showerheads and faucets to be 15 years, by 2030 ~all showers and faucets installed in Jordan would be efficient
	Laundry machine efficiency	✗	▪ Has not been explored because has been difficult to measure exact portion of population with automatic laundry machines and therefore amount of water used ▪ Can be implemented by requiring that all laundry machines on market meet certain efficiency standards and providing incentives to acquire such machines
	Replace manual dishwashing	✗	▪ This lever has potential, but based on interviews claim is that most people use domestic help to do their dishwashing and if financial means were available would prefer paying for domestic help instead of for a new dishwasher ▪ However, it could still be implemented by requiring that all dishwashers on market meet certain efficiency standards and providing incentives to acquire such machines
	Domestic & commercial leaks	✗	▪ According to IDARA sources, leaks on domestic/commercial premises account for ~3% of total use which is very small. ▪ This lever, however can be implemented by raising customer awareness leading to repairing them in time
NRW redu-ction meas ures	Pressure control	✗	▪ Excessive pressure increases leakages and current rationing increase pressure in the networks. Supplying water regularly can reduce pressure to the accepted level of 2.5-7.0 bars and thereby reduce leakage ▪ This lever would require supplying water consistently instead of rationing to avoid placing intense pressure on pipes when water is supplied
	Greywater reuse	✓	▪ This lever has been applied on a small scale in the Dead Sea Spa Hotel. Idea gaining acceptance in Jordan and can be used to improve water usage ▪ Greywater reuse can allow each drop of water to be used 3 times

SOURCE: IDARA – "Water Efficiency Plan – Miyahuna, Al Yarmouk", 2030 Water Resources Group

Reaching national agenda NRW target poses a challenge for Jordan

MCM



Implementation challenges

- Difficulty in estimating administrative vs. physical losses
- Difficulty locating source of losses (where the leak is and who is stealing water from where)
- Improvement to physical losses (i.e. leakage) requires large capital investments and results are likely to be marginal[1]
- Political resistance to prohibiting illegal use – “how can we arrest half the population of certain areas?[2]”

1 According to experts 18% leakage (50% of 35%) is quite good and difficult to improve drastically
2 Comments made often by people interviewd in Miyahuna, MWI, and WAJ

SOURCE: MWI, WAJ, team analysis

Countries around the world suffer from NRW and take actions to reduce it

Country name	NRW status description
UK	▪ Leakage in England & Wales fell from a peak of 5.112 million m³/d in 1994-95 to 3.291 million m³/d in 2008-09 (from 31% to 23%). Since 2000, leakage remained at between 22-23% of total input.
Malaysia	▪ Refurbishment of water distribution networks• : RM 1.48 billion has been allocated for the refurbishment of the distribution network, with a target to reduce non-revenue water from 38% in 2005 to 30% by 2010.
China	▪ Water supply: Achieve an urban water supply coverage rate of at least 95%, and add 40 million m³/d to the water supply capacity. Urban water supply pipes that are more than 50 years old should be rehabilitated, and the average urban leakage rates should be kept below 15%. The estimated budget for these water supply issues is CNY 200 billion
Chile	▪ In general, the Chilean water network experiences 34% of water loss, which is twice the efficiency rate defined by the Regulator Agency.

SOURCE: GWI

NRW Case example 1: Malaysian State of Selangor

Initial situation	In 1997 NRW was estimated at 40%, with leakage estimated at 25%. A severe water crisis was the trigger for the government to start dealing with the water infrastructure issue
Actions taken	A joint venture between a local company and an international player submitted a proposal to reduce NRW by a fixed amount. The consortium had the freedom to choose the zones within the network to implement its NRW reduction strategy. **Phase 1** of the program was an 18-months pilot phase and the agreed loss reduction was 18,540 m^3 per day. The target was exceeded and 20,898 m^3 per day were saved (equally split between physical and commercial losses). 29 district metered areas (DMAs) were established **Phase 2** started in 2000 and the target was to reduce NRW by 198,900 m^3 a day over a period of 9 years. Reduction of NRW is paired with the maintenance of reduced levels of NRW in all zones (phase 1 + phase 2) until the end of the contract
Final result	Results after 6 years ▪ 222 DMAs have been established ▪ 11,000 leaks repaired ▪ Widespread installation of pressure-reducing valves ▪ 119,000 meters have been replaced ▪ Physical loss reduction of 117,000 m^3 per day ▪ Commercial loss reduction of 50,000 m^3 per day ▪ NRW at ~ 17%

SOURCE: The Challenge of Reducing Non-Revenue Water (NRW) in Developing Countries (The World Bank Group)

NRW Case example 2: Bangkok

Initial situation	In 1997 NRW reached its peak value of 42%. In 1999 a reduction in the system capacity to 4 million m^3 was accompanied by a reduction of NRW to 1.5 Mn m^3 e.g. 38%
Actions taken	The Metropolitan Waterworks Authority awarded two contract to two private companies with the target to improve the NRW percentage in 3 of the 14 service branches of the MWA. The contract started in 2000 and had a duration of 4 years. The contractors had the freedom to decide out to organize the leakage reduction activity with the only constraint to use local firms.
Final result	▪ Physical losses have been reduced by 165,000 m^3 a day ▪ NRW is at 30%

SOURCE: The Challenge of Reducing Non-Revenue Water (NRW) in Developing Countries (The World Bank Group)

NRW Case example 3: Gaza

Initial situation	In 1996 NRW is Gaza was at 53%. Key components were: physical (leakages, blocked meters, non-accurate meters, illegal connections), commercial (inefficient meter reading and data entry errors) and institutional (not metered buildings)
Actions taken	The key elements of the management program were the following: ▪ Physical component – Conduct a leak detection survey, build a local team for leakage detection and train technicians to repair bursts – Identify blocked meters and define a strategy to replace them – Ensure proper working of existing meters and supply municipalities with new or repaired meters for replacing old ones – Identify illegal connections and regularize them ▪ Commercial component – Incentivize meters' readers against their performance – Establish a team to audit inconsistent bills ▪ Institutional component – Install meters to the majority of public buildings
Final result	▪ The non revenue water in Gaza was cut to 30% by 2000

SOURCE: World Bank website

Lever description (1/2)

Lever	Description	Volume (MCM)	Marginal cost(JD/m^3)	Required investment (JDm)
New domestic toilet	Installation of new water saving dual-flush toilets	14.0	-0.35	46.0
New commercial toilet	Installation of new water saving dual-flush toilets	0.9	-0.51	1.0
Retrofit domestic toilet	Installation of toilet trim flushing device in existing toilets	27.8	-0.34	93.9
Waterless urinals	Installation of toilet trim flushing device in existing toilets	4.2	-0.55	2.2
New showers	Installation of new water-efficient showerheads with aerators and pressure controllers to keep the water flow at desired levels	13.4	-0.46	23.0
Retrofit showers	Installation of aerators and pressure controllers in existing showers to keep the water flow at desired levels	27.3	-0.46	46.9
New faucets	Installation of new water-efficient faucets with aerators and pressure controllers to keep the water flow at desired levels	18.4	-0.43	41.0
Retrofit faucets	Installation of aerators and pressure controllers in existing faucets to keep the water flow at desired levels	18.4	-0.41	46.0

SOURCE: WAJ, MWI, IDARA, Jordan Department of Statistics, 2030 Water Resources Group

Lever description (2/2)

Lever	Description	Volume (MCM)	Marginal cost(JD/m^3)	Required investment (JDm)
New laundry machines	Adoption of new efficient laundry machines	0.4	-4.35	52.0
Replace laundry machines	Replacing existing laundry machines with newer efficient models	0.5	-7.69	106.1
Replace manual dishwashing	Using dishwasher instead of using a faucet to wash dishes	1.4	13.86	221.0
Domestic leaks	Reduction of leaks in household connections and pipes	12.1	2.03	431.1
Commercial leaks	Reduction of leaks within commercial and public premises	2.0	1.04	45.1
Leakage repair	Reduction of water lost through leak detection and repair in water distribution networks as well as improving administration to reduce administrative losses	84.6	-0.41	250.0
Pressure control	Reduction of water lost through close monitoring and pressure control in municipal networks	84.6	-0.41	250.0
Greywater reuse	Reuse of treated municipal and industrial wastewater as municipal public, industrial cooling water, etc.	26.0	0.33	324.2

SOURCE: WAJ, MWI, IDARA, Jordan Department of Statistics, 2030 Water Resources Group

Key assumptions for municipal levers volume

Lever	Key assumptions - Data	Rationale/Source
▪ Retrofit toilets (domestic)	▪ A water saving device can reduce liters per flush from 7.5 to 4.8 ▪ People flush the toilet on average 3 times per day ▪ In business-as-usual scenario penetration of these devices remains at 5% but in optimal situation penetration reaches 100% in 2030	▪ IDARA ▪ Water Management Demand Unit ▪ Water Management Demand Unit
▪ Retrofit toilets (commercial)	▪ A water saving device can reduce liters per flush from 7.5 to 4.8 ▪ People flush the toilet on average 3 times per day ▪ In business-as-usual scenario penetration of these devices remains at 5% but in optimal situation penetration reaches 100% in 2030 ▪ Approximately 57% of population is of working age (i.e. frequents commercial locations)	▪ IDARA ▪ Water Management Demand Unit ▪ Water Management Demand Unit ▪ Department of statistics
▪ New toilets (Domestic)	▪ New efficient toilets use 4.8 liters per flush ▪ People flush the toilet on average 3 times per day ▪ In business-as-usual scenario penetration of these devices remains at 5% but in optimal situation penetration reaches 100% in 2030	▪ IDARA and local vendors ▪ Water Management Demand Unit ▪ Water Management Demand Unit
▪ New toilets (Commercial)	▪ New efficient toilets use 4.8 liters per flush ▪ People flush the toilet on average 3 times per day ▪ In business-as-usual scenario penetration of these devices remains at 5% but in optimal situation penetration reaches 100% in 2030 ▪ Approximately 57% of population is of working age (i.e. frequents commercial locations)	▪ IDARA and local vendors ▪ Water Management Demand Unit ▪ Water Management Demand Unit ▪ Department of statistics
▪ Replace laundry machines	▪ An efficient laundry machines consumes ~45liters of water per load ▪ 95% of households have a laundry machine ▪ Of thos 95% only 30% have automatic laundry machines ▪ In business-as-usual scenario penetration of these machines among replaced remains at 5% but in optimal situation penetration reaches 100% in 2030	▪ Water Management Demand Unit ▪ Jordan Department of Statistics ▪ Water Management Demand Unit ▪ Water Management Demand Unit

SOURCE: WAJ, MWI, IDARA, Jordan Department of Statistics, 2030 Water Resources Group

Key assumptions for municipal levers volume (continued)

Lever	Key assumptions - Data	Rationale/Source
Buy new laundry machines	An efficient laundry machines consumes ~45liters of water per load	Water Management Demand Unit
	95% of households have a laundry machine	Jordan Department of Statistics
	Of thos 95% only 30% have automatic laundry machines	Water Management Demand Unit
	In business-as-usual scenario penetration of new devices remains at 5% but in optimal situation penetration reaches 100% in 2030	Water Management Demand Unit
Replace dishwashing	Approximately 5% of the population has dishwasher and remainder use foreign manual labor	Water Management Demand Unit
	Approximately 50% of current faucet use goes to washing dishes and declines to ~30% with use of dishwasher	Water Management Demand Unit
	In business-as-usual scenario penetration of new devices remains at 5% but in optimal situation penetration reaches 20% in 2030	Water Management Demand Unit
Replace showers	A water saving device can improve shower efficiency by 20%	IDARA
	Showers consume ~15 liters per minutes	Water Management Demand Unit
	Depending on class on governorate, people spend on average 5 minutes per day in the shower	Team analysis
	In business-as-usual scenario penetration of new devices remains at 5% but in optimal situation penetration reaches 100% in 2030	Water Management Demand Unit
Buy new showers	A new efficient shower will use 20% less water	IDARA
	Showers consume ~15 liters per minutes	Water Management Demand Unit
	Depending on class on governorate, people spend on average 5 minutes per day in the shower	Team analysis
	In business-as-usual scenario penetration of new devices remains at 5% but in optimal situation penetration reaches 100% in 2030	Water Management Demand Unit

SOURCE: WAJ, MWI, IDARA, Jordan Department of Statistics, 2030 Water Resources Group

Key assumptions for municipal levers volume (continued)

Lever	Key assumptions - Data	Rationale/Source
▪ Replace taps	▪ A water saving device can improve tap efficiency by 30% ▪ Taps consume ~10 liters per minutes ▪ Depending on class on governorate, people spend on average 6 minutes per day using the faucet ▪ In business-as-usual scenario penetration of new devices remains at 5% but in optimal situation penetration reaches 100% in 2030	▪ IDARA ▪ Water Management Demand Unit ▪ Team analysis ▪ Water Management Demand Unit
▪ Buy new taps	▪ Efficient taps use 30% less water than normal taps ▪ Taps consume ~10 liters per minutes ▪ Depending on class on governorate, people spend on average 6 minutes per day using the faucet ▪ In business-as-usual scenario penetration of new devices remains at 5% but in optimal situation penetration reaches 100% in 2030	▪ IDARA ▪ Water Management Demand Unit ▪ Team analysis ▪ Water Management Demand Unit
▪ Domestic leaks	▪ Leaks in houses are assumed to be 3% of total use ▪ Correct measures taken can reduce this by ~23% in ideal scenario and 10% in business-as-usual scenario ▪ This percentage is very small and not likely to make big difference	▪ IDARA ▪ Global benchmarks ▪ Water Management Demand Unit
▪ Commercial leaks	▪ Leaks in houses are assumed to be 3% of total use ▪ Correct measures taken can reduce this by ~23% in ideal scenario and 10% in business-as-usual scenario ▪ This percentage is very small and not likely to make big difference	▪ IDARA ▪ Global benchmarks ▪ Water Management Demand Unit

SOURCE: WAJ, MWI, IDARA, Jordan Department of Statistics, 2030 Water Resources Group

Key assumptions for municipal levers volume (continued)

Lever	Key assumptions - Data	Rationale/Source
▪ Moisture retention	▪ Approximately 50% of high income population has a garden	▪ Team analysis
	▪ Each garden consumes approximately $52m^3$ each year	▪ Global benchmarks
	▪ Using material to retain moisture can save up to 30% more water	▪ Global benchmarks
	▪ This will have a very small effect on increasing supply in jordan and even in optimal scenario it will only reach 30% penetration	▪ Water Management Demand Unit
▪ Leakage repair / ▪ Pressure control	▪ Losses were assumed on governorate-level as per demand calculations and include both admin and physical losses	▪ Ministry of Water and Irrigation
	▪ In the optimal scenario these losses could be reduced to 20% in every governorate by reducing physical losses	▪ IDARA
	▪ As an initial assumption 50% of losses can be reduced through leakage repairs and 50% though pressure control	▪ Team analysis
▪ Greywater reuse	▪ Each drop can be used 3 times based on experience in Dead Sea Spa	▪ Water Management Demand Unit
	▪ In optimal scenario penetration can reach 30%	▪ Water Management Demand Unit
	▪ When this was applied in Mexico, $7m^3$ were saved per person per year	▪ Global benchmarks

SOURCE: WAJ, MWI, IDARA, Jordan Department of Statistics, 2030 Water Resources Group

Key assumptions for supply lever cost

Lever	Key assumptions - Data	Rationale/Source
▪ Retrofit toilets (domestic)	▪ Capex – 15JD ▪ Asset lifetime – 15 years ▪ Discount rate – 12%	▪ IDARA ▪ Team analysis/methodology ▪ Team analysis/methodology
▪ Retrofit toilets (commercial)	▪ Capex – 15JD ▪ Asset lifetime – 15 years ▪ Discount rate – 12%	▪ IDARA ▪ Team analysis/methodology ▪ Team analysis/methodology
▪ New toilets (Domestic)	▪ Capex increase from standard to efficient toilet – 25JD ▪ Asset lifetime – 15 years ▪ Discount rate – 12%	▪ Local vendors ▪ Team analysis/methodology ▪ Team analysis/methodology
▪ New toilets (Commercial)	▪ Capex increase from standard to efficient toilet – 25JD ▪ Asset lifetime – 15 years ▪ Discount rate – 12%	▪ Local vendors ▪ Team analysis/methodology ▪ Team analysis/methodology
▪ Waterless urinals	▪ Capex per urinal – 75JD ▪ Asset lifetime – 15 years ▪ Discount rate – 12%	▪ Team analysis ▪ Team analysis/methodology ▪ Team analysis/methodology
▪ Replace laundry machines	▪ Capex increase from standard to efficient laundry machine – 565JD ▪ Asset lifetime – 15 years ▪ Discount rate – 12%	▪ Local vendors ▪ Team analysis/methodology ▪ Team analysis/methodology
▪ Buy new laundry machines	▪ Capex increase from standard to efficient laundry machine – 565JD ▪ Asset lifetime – 15 years ▪ Discount rate – 12%	▪ Local vendors ▪ Team analysis/methodology ▪ Team analysis/methodology
▪ Replace dishwashing	▪ Capex for efficient washing machine – 485JD ▪ Asset lifetime – 15 years ▪ Discount rate – 12%	▪ Local vendors ▪ Team analysis/methodology ▪ Team analysis/methodology
▪ Replace showers	▪ Capex – 15JD ▪ Asset lifetime – 15 years ▪ Discount rate – 12%	▪ IDARA ▪ Team analysis/methodology ▪ Team analysis/methodology

SOURCE: WAJ, MWI, IDARA, Jordan Department of Statistics, 2030 Water Resources Group

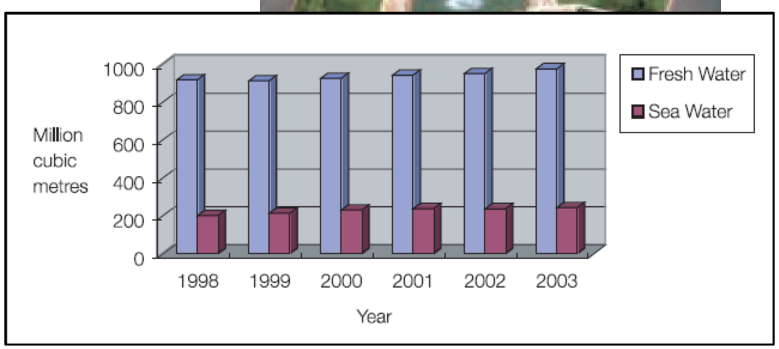
Key assumptions for supply lever cost

Lever	Key assumptions - Data	Rationale/Source
Buy new showers	Capex increase – 15JD Asset lifetime – 15 years Discount rate – 12%	IDARA Team analysis/methodology Team analysis/methodology
Replace taps	Capex increase from standard to efficient toilet – 25JD Asset lifetime – 15 years Discount rate – 12%	Local vendors Team analysis/methodology Team analysis/methodology
Buy new taps	Capex increase from standard to efficient toilet – 25JD Asset lifetime – 15 years Discount rate – 12%	Local vendors Team analysis/methodology Team analysis/methodology
Domestic leaks	Capex per urinal – 75JD Asset lifetime – 15 years Discount rate – 12%	Team analysis Team analysis/methodology Team analysis/methodology
Commercial leaks	Capex increase from standard to efficient laundry machine – 565JD Asset lifetime – 15 years Discount rate – 12%	Local vendors Team analysis/methodology Team analysis/methodology
Moisture retention	Capex increase from standard to efficient laundry machine – 565JD Asset lifetime – 15 years Discount rate – 12%	Local vendors Team analysis/methodology Team analysis/methodology
Leakage repair Pressure control	Total investment cost of JD 250-500m over 20 years at 250-500 JD/m^3/day – 50% of investment cost assumed for leakage repair, 50% for pressure control Asset lifetime – 10 years Discount rate – 12%	World Bank benchmark, team analysis Team analysis/methodology Team analysis/methodology
Greywater reuse	Capex – 224JD / household Asset lifetime – 15 years Discount rate – 12%	Global benchmarks Team analysis/methodology Team analysis/methodology

SOURCE: WAJ, MWI, IDARA, Jordan Department of Statistics, 2030 Water Resources Group

Other technologies for future consideration could further reduce Jordan's water consumption (1/3)

Seawater dual piping system

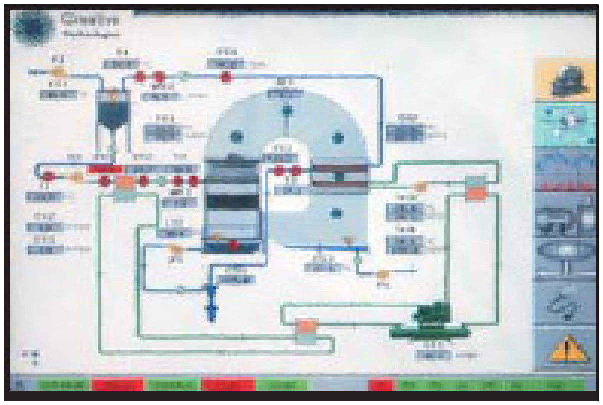


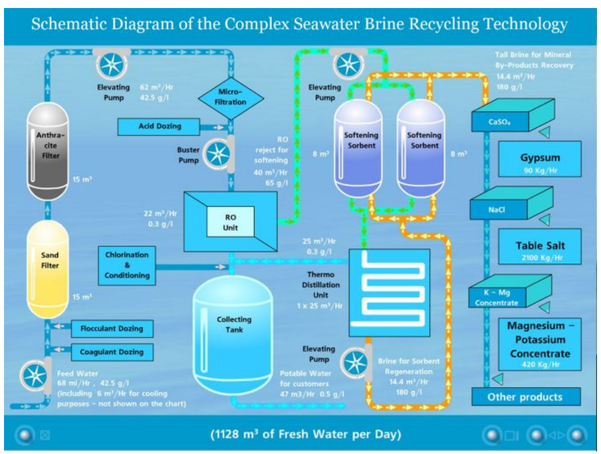
- Hong Kong has used seawater as a substitute to freshwater for toilet flushing since the late 1960s – a response to the chronic 1962-3 drought
- 37 seawater pumping stations and a separate reticulation network have been constructed
- Today, all densely populated areas of Hong Kong are covered by the system – 80% of Hong Kong's population uses seawater for toilet flushes
- In 2003, seawater accounted for 15% of total water supply (241 mcm per year) which translated to a saving of HK$700 million
- The most recent expansion, to cover the more sparsely populated northern districts, incurred a capex of $54 m, has annual operating costs of $3.7m and covers 22% of Hong Kong's population
- Hong Kong Water Supplies Department is now considering using seawater for cooling seafront commercial buildings
- While Hong Kong is still the only city in the world using seawater flushing at a city-scale, nearby Shenzhen is considering adopting a similar system

Source: GCC water economics team, team analysis

Other technologies for future consideration could further reduce Jordan's water consumption (2/3)

Zero water discharge schemes





Technology for waste water free production

- Water from production processes is distilled to only leave solid by-products
- E.g., use contaminated water for heating processes and capture the distilled condensate

Zero discharge for desalination

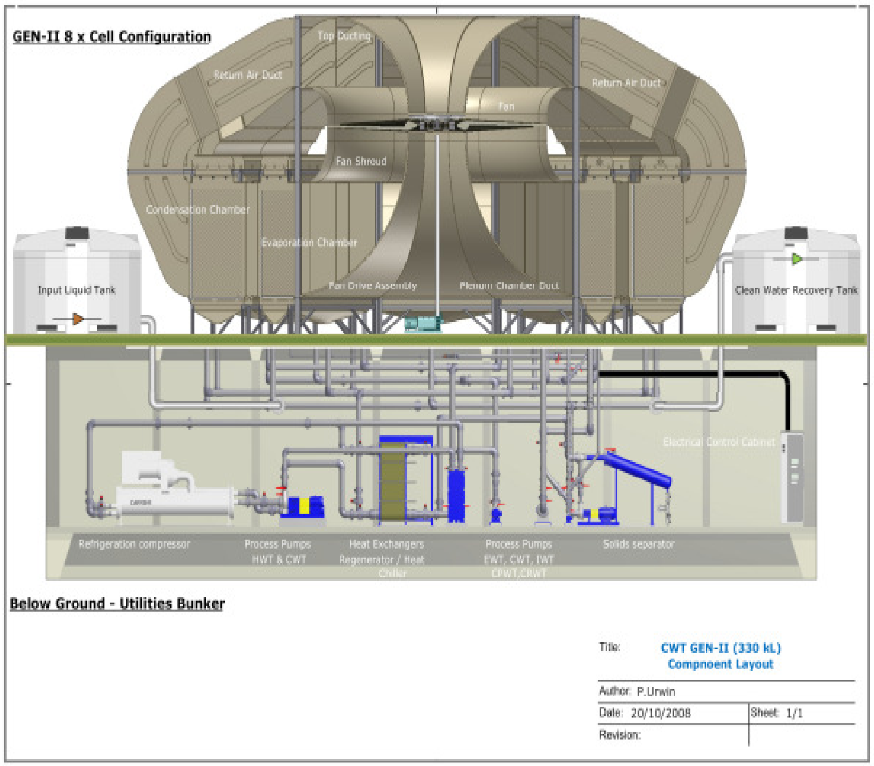
- Amount of drinking water produced from same quantity of seawater increases
- Technologies explored to recycle brines with receiving high-quality drinking water and minerals, such as table salt, magnesium chloride, magnesium-sulphate, potassium chloride, gypsum and other more valuable minerals such as lithium

Source: Creative Technologies, I.E.S. seawater brine recycling

Other technologies for future consideration could further reduce Jordan’s water consumption (3/3)

Creative Water Technologies zero liquid discharge desalination unit

Schematic of CWT gen II unit



Impact

- CWT separates waste water from industrial, cooling and desalination processes into usable water[1] and valuable substances (such as salt - 12 ton/day NaCl in a 40kL RO slurry)
- Delivers water recovery through a distillation process in which a warm “carrier” air stream which is humidified with warmed wastewater and then cooled to evaporate the wastewater
- Uses waste heat and cooling from industrial processes

1 If applied to desalination process, drinking water quality is produced, in other processes irrigation, and flushing water; for input waters with high biological contaminants appropriate disinfection process may be required

Source: Nakheel; Creative Water Technologies

Appendix 5 – Scenario comparisons

Scenarios for Jordanian agriculture were evaluated against criteria relevant to National Agenda objectives

Evaluation criteria	Definition	Rationale	National agenda impact
1 **Value added**[1] JD/m^3	▪ Sum of profits to farmers and wages to agricultural labourers	▪ Key measure of productive water use in agriculture	▪ Relates to 2017 target for agricultural output per cubic meter (5 JD/m^3)
2 **Employment** FTE thousands	▪ Number of full-time-equivalent jobs involved in crop production	▪ Provides an indication of social implications of each scenario	▪ Contributes to achieving overall 2017 unemployment target (6.8%)
3 **Capital requirement** JD mn	▪ Total cost of technical cost-curve solutions needed to close 2030 water gap	▪ Shows effect of crop mix choices on the public and private cost of closing Jordan's water gap	▪ Impacts 2017 goals for: – Overall budget surplus (1.8% of GDP) – Overall public debt (36% of GDP)

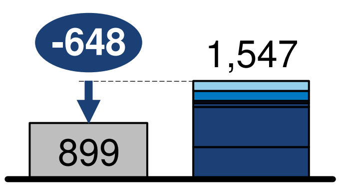
SOURCE: National agenda; team analysis

3 Capital requirement is the sum of investment needed to implement technical solutions and close the water gap

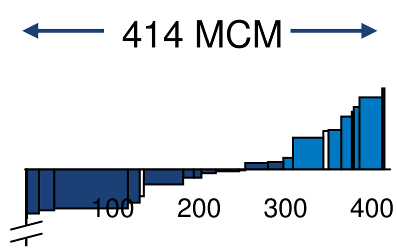
ILLUSTRATIVE

Original water gap	"Must-do" solutions	Remaining water gap	"Optional" solutions
▪ Each scenario has a national water gap that must be closed ▪ Capital expenditure is needed to implement the technical solutions which can close the water gap	▪ "Must-do" levers can cover part of the total water gap ▪ Up-front investment for the "must-do" levers is summed up as part of the overall capital requirement for each scenario	▪ After "must-do" initiatives have been implemented, there still remains a portion of the water gap which requires additional investment to close	▪ Some "optional" levers are needed to close the remaining gap ▪ Lowest-cost "optional" levers are selected until gap is closed ▪ Up-front investment for selected levers is added to overall capital requirement

Availability gap
MCM



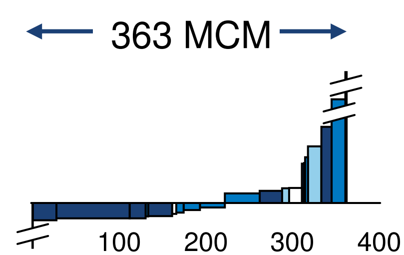
"Must do" solutions



Remaining gap
MCM

234

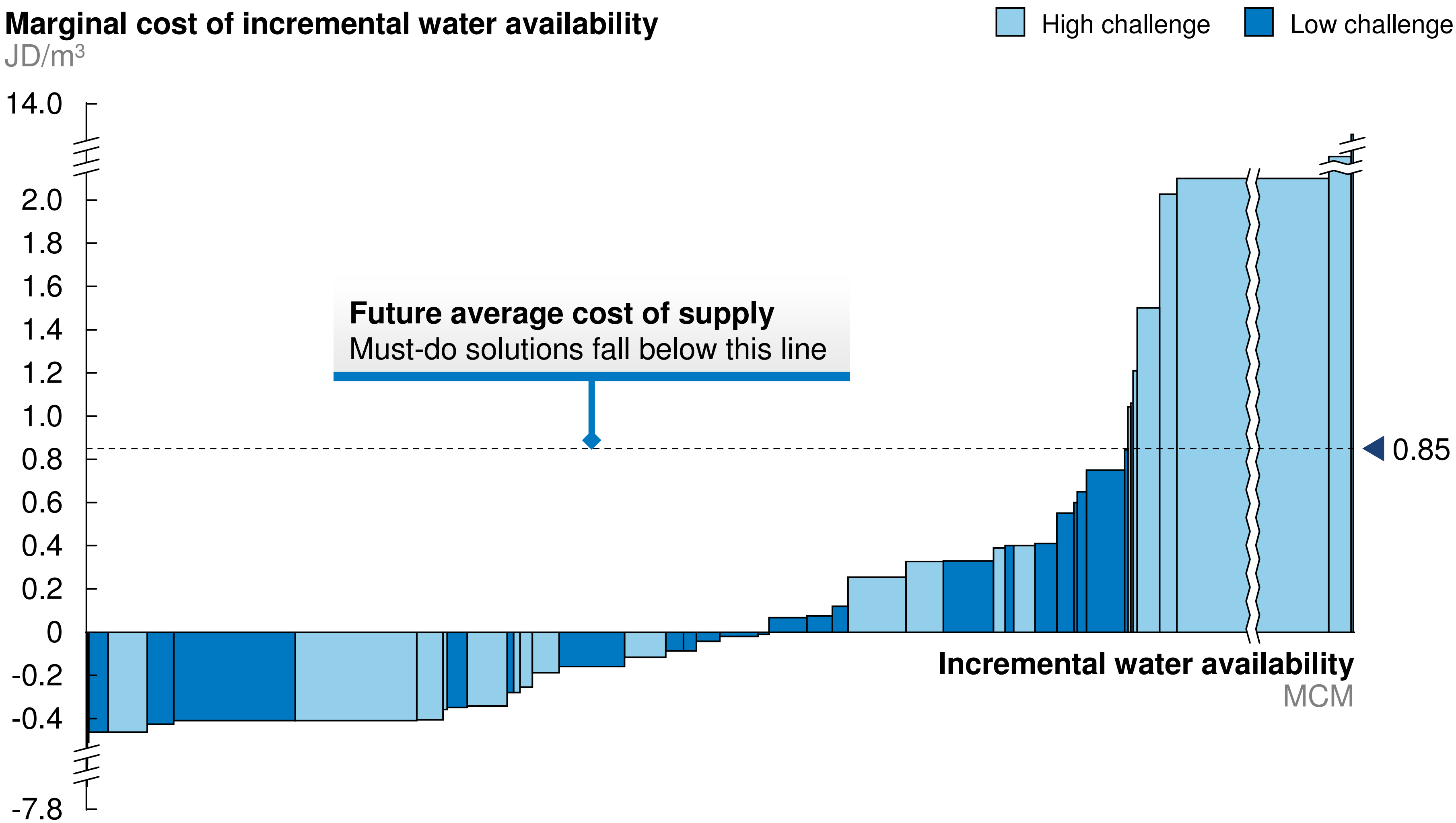
"Optional" solutions



SOURCE: Team analysis

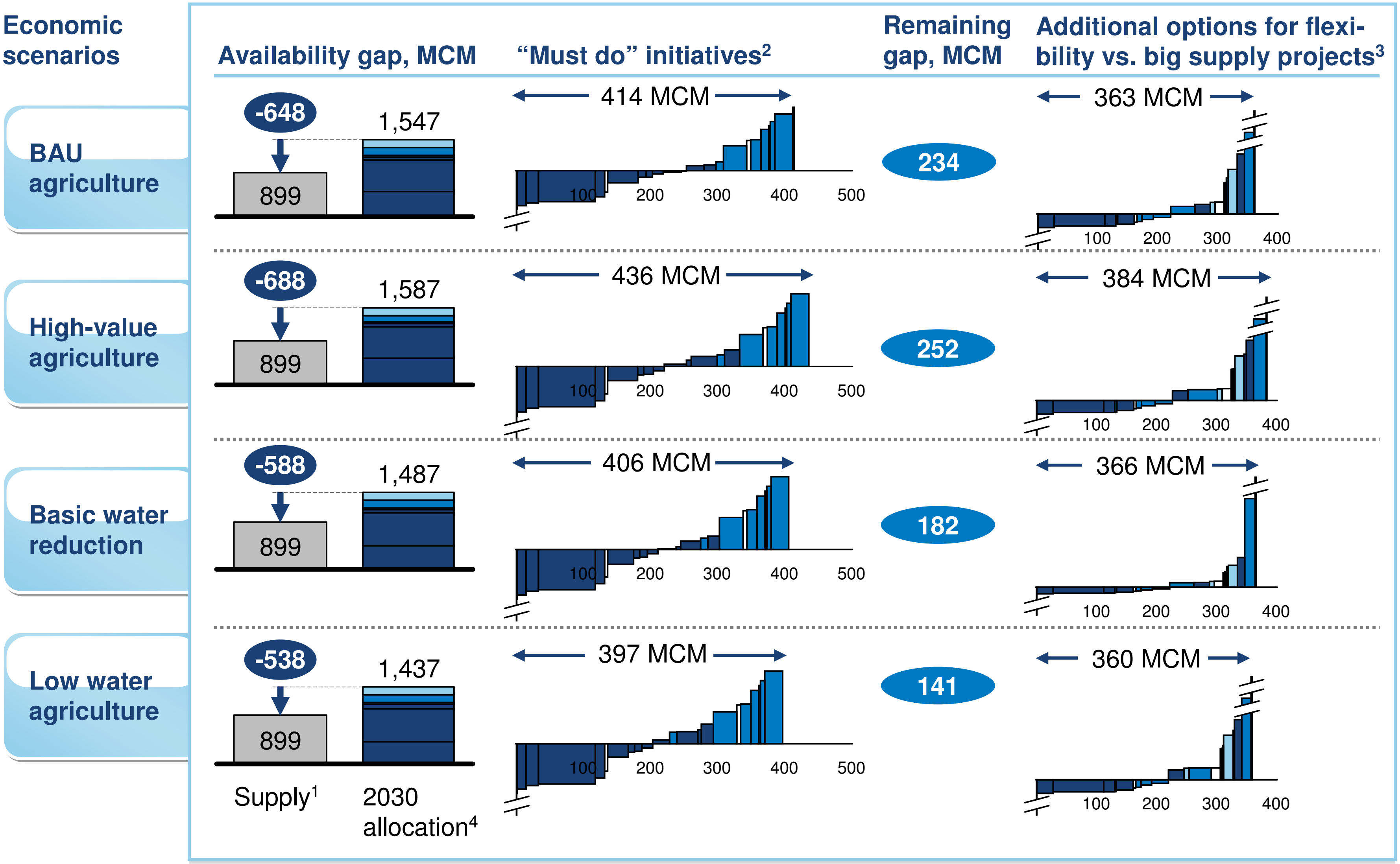
3 Must-do solutions have both low implementation challenge and marginal cost less than future average cost of supply

ILLUSTRATIVE



SOURCE: Technical solution workshops; team analysis

Each economic choice in agriculture provides flexibility on difficult options to close the national water gap



1 Financed, accessible, safe-yield supply in 2030
2 Low challenge solutions below current water cost
3 Solutions that are difficult to implement but can provide flexibility regarding timing of supply mega-projects, e.g. JRSP
4 Based on demand projections and allocation policies

SOURCE: Team analysis