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UNIVERSITY & RESEARCH

Confronting the challenges of water scarcity in Jordan;
Seeking viable, sustainable, and prosperous options for Agriculture & Water in 2050

Policy Recommendations Report

Final report - 14/10/2022

Water Resources Management Group

Acknowledgements

The project 'Confronting the challenges of water scarcity in Jordan' aims to seek viable, sustainable and prosperous options for agriculture and water in 2050 by bringing different stakeholders together to discuss and explore future options. This would not have been possible without the engaged participation of the different stakeholders, ranging from ministers, ministerial officials, the international donor community, regional authorities, farmers and the private sector. Thus, we would like to sincerely thank all participants of the workshops for sharing their extensive knowledge and experiences.

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Table of Contents

Introduction

For decades Jordan has been rapidly abstracting its groundwater resources in favour of domestic, industrial, but mainly agricultural purposes, while exceeding the yearly groundwater recharge. This has left vast areas of the main overlying aquifer already unsaturated, forcing both private and public well owners to drill deeper and deeper wells in a destructive race to the bottom (BGR & MWI, 2019). In total, up to 40% of Jordan's groundwater system is at risk of depletion by 2030 if current pumping rates continue (Mercy Corps, 2014). The water crisis in Jordan is further exacerbated by a continuous population growth and a changing climate, which will hit the Mediterranean disproportionally hard (Leal Filho & Manolas, 2022). Thus, as freshwater supplies have to be increasingly replaced by desalinated brackish or saline water and even treated wastewater, Jordan will sooner than later have to fully adhere to the Arabic saying: *"Any water in the desert will do"*, if it is to meet all its demands in a sustainable manner.

This is a very inconvenient truth, but one that has to be faced by all Jordanians to collectively seek for viable, sustainable and prosperous options in all demand sectors: agriculture, industry, and domestic. As the largest demand sector with the lowest economic return on water used, agriculture will face the biggest challenges to sustainably meet its needs in 2050. Thus, the main goal of the project conducted by the Water Resources Management (WRM) group from Wageningen University & Research with support from RVO and the Embassy of the Kingdom of the Netherlands (EKN), was the following:

Finding viable, sustainable, and prosperous options for Agriculture & Water in 2050

A distinction is made between options to achieve this goal in the 'Jordan Valley' and the 'Highlands', with the Jordan Valley representing the valley itself plus the Southern Ghors and Wadi Araba and the Highlands representing the rest of Jordan, as shown in Figure 1.

In each region a venue was selected to host a series of three workshops. These workshops focussed on facilitating dialogues for a wide array of regional stakeholders. Firstly, to discuss current water challenges and agricultural policies and their implications on the ground, secondly to collectively face the inconvenient truth of water scarcity in Jordan and thirdly to draw and discuss recommendations for agriculture and water to provide a water- and socio-economically secure future for the next generation.

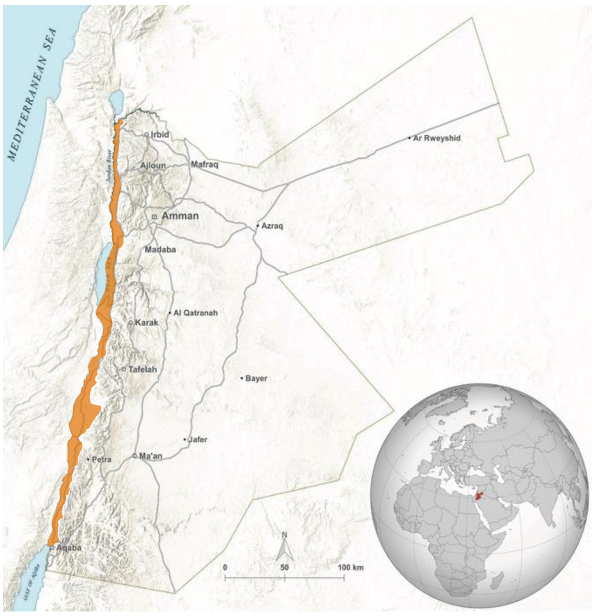

Figure 1: The Hashemite Kingdom of Jordan, divided into the 'Jordan Valley' and the 'Highlands' (BGR & MWI, 2019)

This report is part of a threefold dossier on reporting on the outcomes of the project. The dossier includes i) the **policy recommendations report** (i.e., this report), reflecting on recommendations discussed during the workshops, ii) the **technical background report**, where technical information is provided about the recommendations and the assumptions and sources used from the WUR team during the workshops, and iii) the **workshop report**, reporting on the discussions of the workshops. The presentations given by the WUR team during the workshops are provided in the supplementary documents.

This report provides recommendations with the aim of closing the water supply-demand gap. Based on the sustainable water supply and increasing demand for 2050 and the principles of water allocation for Jordan, water supply and agriculture will have vast implications to face in the future. This report outlines these implications and the ensuing recommendations on how to address these implications. The implications and recommendation stem from the policy dialogues held in February and March and may serve to identify and check policy priority areas in which stakeholder efforts might be concentrated.

This report starts from discussing the water supply-demand gap for 2050 and the current principles of water allocation (chapter 1). Second, the implications of closing the water supply-demand gap for the water and energy sector are discussed (chapter 2). Third, the implications and related recommendations for the agricultural sector are examined (chapter 3). Last, the importance of data availability and accessibility is explored (chapter 4).

1. The 2050 Water Balance: coping with a substantive water supply – demand gap

The water balance outlook for Jordan is characterised by a growing disparity between an exponentially growing demand for domestic and industrial water, and a climate driven growth in agricultural demand, on the one hand; and a starkly delimited, and partially climate reduced, availability of renewable water supply on the other hand (see technical background report). By 2050, projections put this disparity at: 808 (domestic) + 220 (industrial) + 973 (agriculture) = 2001 MCM demand, and a mere 246 (fresh surface water) + 234 (fresh groundwater) = 480 MCM renewable water supply, indicating a structural freshwater shortage of 1521 MCM per year.

To narrow this gap, it is thus inevitable to seek and develop supply augmentation sources. In this policy dialogues, we have discussed two supply augmentation options and the maximisation of water re-use, as already foreseen and contemplated within current government policies. These are: 300 MCM of desalinated Red Sea water; 200 MCM of fresh (or desalinated) water from bilateral trade agreements (e.g., water-energy deals); and, maximum reutilisation of about 800 MCM treated wastewater, from both domestic and industrial use. If all these supply augmentation options materialize, the water balance of Jordan towards 2050 will show a gap of 221 MCM, which is considered an optimistic scenario of development[1].

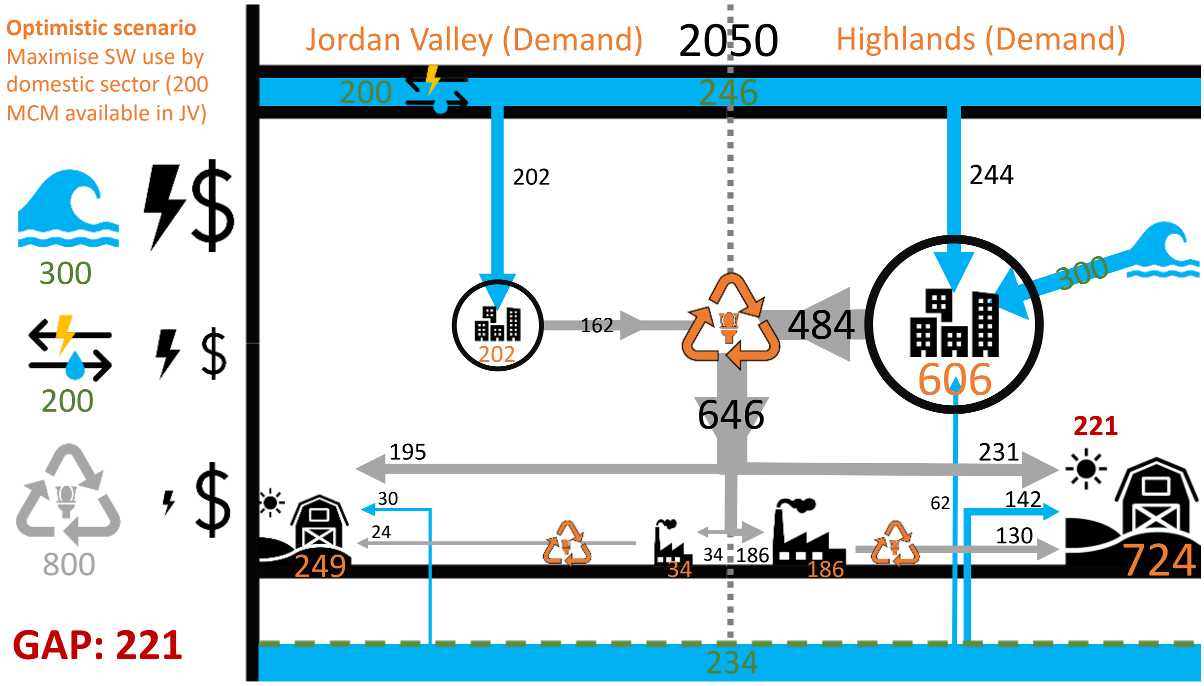

Figure 2: Optimistic scenario of the water budget and beneficiaries in 2050

[1] Optimistic in that this scenario relies on the completion of the huge infrastructure investments and developments by 2050 required to secure the supply augmentation options and efficient TWW, as well as the energy supply to run these systems. The technical background provides further outlines of pessimistic outlooks in which parts of these supply augmentation options are not realized in time, and what these imply in terms of an increased supply gap.

As outlined in Figure 2 of the optimistic scenario for the 2050 water balance, the full utilisation and optimisation of these supply augmentation options has far fetching implications for the water supply and agricultural sectors, whilst still not able to fully close the water supply gap, as agriculture remains to face a water supply gap of 221 MCM per year.

1.1 Principles of water allocation

Given the projected water scarcity situation for 2050, the principles of water allocation uniformly applied in this water dialogue have been: i) prioritisation of domestic water supply from available freshwater supplies; ii) maximisation of treated wastewater (TWW) use, set at potentially 80 per cent of domestic and 70 per cent of industrial water supply, to meet agricultural and industrial water demands. In the optimistic outlook all available renewable freshwater resources (480 MCM) and the full supply augmentation options (300 MCM desalinated Red Sea and 200 MCM bilateral trade deals) are utilised. This implies that: i) TWW capacity will need to increase to 800 MCM a year; ii) industry and agriculture will need to shift (entirely and/or primarily) from freshwater to TWW supply; and iii) a water supply gap of 221 MCM per year will remain which will need to be accommodated by agriculture through diminished demands.

Though 2050 may still be seemingly far away and uncertain, the implications for the water supply and agriculture sectors make clear that the closing of the water supply gap will require huge investments in infrastructure and energy and in transforming the wastewater and agriculture sectors. Such investments and developments will take time to develop, procure and implement. Given the scale of investments and transformation required, 28 years suddenly does not seem such a long lead time. With these implications and recommendations, we do not seek, or pretend, to be complete or resolving of the daunting task ahead. Merely, they may serve to identify and check policy priority areas in which a concerted effort of stakeholders may help to reach an attainable goal of reducing the future water supply gap in Jordan to 221 MCM per year.

From an agricultural perspective this seems imperative, as any failure to achieve the ambitious targets set for supply augmentation and water reutilisation (i.e., shortfalls) will inevitably be passed on to the agricultural sector in the form of more water supply reductions. If the water supply gap is not closed, as is currently the case, agricultural supplies will continue to depend on over-abstraction of groundwater resources (i.e., abstraction beyond renewable supply (at ca. 621 MCM per year in 2016)). With current rates, both non-renewable and renewable groundwater reserves will be depleted to such an extent by 2050 that the economic feasibility of extracting groundwater for agricultural use will become highly questionable. As outlined in the supporting documents, this may amount to a water supply gap/reduction of 421 and 721 MCM for the realistic and pessimistic outlook. In both cases, any future for agriculture will be bleak.

2. Implications for the Water & Energy Sector

In the most optimistic outlook, meeting the rising demands from domestic water supply will require acquiring an additional 500 MCM of desalinated water supply (200 MCM through bilateral energy-water deals, 300 MCM from the Red Sea). All of this additional water and the limited available renewable supply of freshwater resources (246 MCM from the surface water and 234 MCM from groundwater resources) will be needed to satisfy the increased demand from urban and industrial water supply. This has implications for the allocation and routing of water flows and return flows in the Jordan water balance:

- Industrial water supply will have to be satisfied by TWW from domestic water supply; exceptions may need to be applied for food industries to be supplied by freshwater.
- TWW capacity and efficiency will have to increase manifold – in terms of treated volume, and in terms of efficiency (assumed to be 80% for each treatment cycle).
- This increased dependency on TWW to satisfy demands requires large and concerted investments in water supply and treatment capacity and infrastructure: the volume of water captured, treated and re-distributed needs to increase from 136 MCM in 2016 to 800 MCM by 2050; the efficiency rate of re-capturing domestic water use in treatment needs to increase from 30 per cent in 2016 to 80 per cent in 2050, requiring high investments and efficiencies in the urban water supply & effluent network. Any shortfall in meeting these targets will affect the critical and delimited TWW supply rates for industrial and agricultural use.
- Agricultural water use in the Jordan Valley and in the Highlands will substantially, if not entirely, shift to TWW as the principal or only supply of water, which requires re-assessing of the rules and regulations for TWW use in agriculture.
- Agricultural water use in the Highlands and Jordan Valley will still have to be reduced by 221 MCM as not all demands can be met.
- The economic costs of water supply will increase manifold. The combined cost of desalination, conveyance, and treatment for agricultural water supply flows of TWW will amount to at least US$ 3.38 per m^3 [2]. These costs will have to be borne by the domestic, industrial, and agricultural sectors together, but inevitably signify a structural and significant price hike for agricultural water use (not in the least as a deterrent for overutilisation).
- The energy requirements for this water supply system will increase tremendously. Rough and conservative estimates indicate an additional 2,100 to 4,400 GW capacity needed to power the TWW plants, desalinate the Red Sea water, and pump up the water 900 m onto the highlands. Not accounting for additional requirements of groundwater extraction and transportation, this amounts to an increase of 10-25 per cent of current national capacity. This will require dedicated planning and investment in solar (and other renewables) power plants capacity, power grid and power storage to provide for:

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[2] 3.38 $/$m^3$ is derived as: 0.79 $/$m^3$ for desalinization costs (Advisan, N.D) + 9 * $0.06 = 0.54$/m^3 for lifting water over 900 m height from Read sea to Aman, + 4.5 * 0.05 = 0.23$/$m^3$ to transport water over 450 km from Red Sea to Aman (Zhou and Tol, 2005) + 1.82$/$m^3$ to cover operation, maintenance and investment costs of TWW (Ali Kashani et al., 2021).

- 300-500 MCM per year desalination;
- Conveyance of water over large distances and heights (450 km over 900 m height for the National Water Carrier);
- Treatment of wastewater (800 MCM per year), and its conveyance to and from TWW plants;
- Groundwater pumping from declined/declining aquifers;
- Energy recouperation potential as TWW from highlands may be diverted to the Jordan Valley.

- Agricultural water use will structurally shift to TWW, which will have implications for its sustainable and economic use – e.g., quality, salinity, and costs.
- As Jordan is forced to play a zero-sum game regarding its water resources, rainwater harvesting of renewable water resources at a certain location means that it cannot be used at another location, effectively making this approach a matter or water reallocation rather than a matter of supply augmentation.

3. Implications & recommendations for the Agricultural Sector

The water balance outlook for Jordan in 2050, as presented above, has far reaching implications for the agricultural sector: i) agriculture will need to nearly entirely shift to TWW as its only source of irrigation water; ii) economic costs of building and operating energy dependent water supply systems increase the pressure on the agricultural sector to focus on high economic value produce; and iii) not all future demands from agriculture can be met, and thus, they have to be reduced by at least 23 per cent in the most optimistic outlook. These three implications point towards three distinct sets of recommendations, namely i) completing the shift from freshwater to TWW, ii) enhancing the economic value of agriculture, and iii) reducing agricultural water demand.

i. Completing the shift from freshwater to TWW

To meet the projected growth in urban water supply, delimited renewable freshwater resources (both surface and groundwater) will need to be prioritised and diverted to urban water supply. This implies that agriculture will need to shift towards TWW nearly entirely, and that urban water use will need to be recaptured and recycled at 80% efficiency to provide agriculture with an alternative source of water. Though successfully and progressively initiated over the past decades, with 111 MCM of TWW applied in agriculture by 2016, the complete shift required from freshwater to TWW supply in agriculture as foreseen for 2050, raises several issues that will need to be addressed:

- Rules and regulations, as well as operation & monitoring, for wastewater treatment and use need to be assured to be set according to quality standards that comply with international and national standards for re-use in agriculture – farmers need to be assured and guaranteed in the TWW supply dependency.
- Standards for quality, use and handling, as well as consumer handling, of TWW use in agriculture need to be set and upgraded across all agricultural consumables (raw &

cooked, vegetables & fruits), assuring TWW quality aligns with use and consumption. This requires certification (regulation & monitoring) of TWW effluent, and possibly upgrading of TWW levels to higher standards, to allow and enable TWW utilisation across all crops (as opposed to the present exclusion of most vegetables).

- To safeguard farmers, and enable high value agriculture development, certification & quality assurance of TWW irrigated produce across national and international market chains should be developed and invested in.
- Investment in, and development of, TWW plants and capacity (an increase is required from the present 136 MCM to 800 MCM by 2050) should be paired to the development of TWW irrigation facilities and schemes. This can be applied as a mechanism to gradually and stepwise shift agriculture from freshwater (surface or groundwater) to TWW and a gradual phasing out of freshwater use in agriculture. Decentralised and/or semi-centralized wastewater treatment and regional irrigation development may then be used to reduce the use and re-use cycle and distance (and thereby infrastructure and energy costs), as well as assure a regional spread in irrigation development. Irrigation modernisation and automation developments (for instance for the King Abdullah Canal, see technical background report) should anticipate and account for the future shifts to TWW.
- To harness the potential benefits of TWW use in agriculture (i.e., minimisation of fertiliser use), TWW monitoring of nutrient loads and optimisation of fertigation (fertiliser application in irrigation water) should become integral to, and explicitly targeted in, any future TWW-irrigation developments.
- The increase of TWW capacity also implies an increase in the efficiency of industrial and agricultural processing effluent, which currently still finds its way into the 'blended' surface water. In particular, effluent capture and treatment from dairy and olive processing needs to increase. Investments in process technology that may reduce the treatment load of processing effluent may help to achieve this.
- A differential wastewater treatment strategy may be defined and adopted to lower the costs of wastewater treatment and, allow for treatment to differential degrees of quality that are suitable for safe use in differential classes of crops and produce.
- A wastewater treatment and utilization strategy in agriculture will need to take into account the salinity standards, and safe use of saline water in agriculture – this may require differential treatment standards for different applications for soils and crops.

Freshwater exceptions

As indicated in the optimistic outlook scenario 2050, the availability of fresh groundwater resources for use in agriculture and industries are extremely delimited (174 MCM in total for Jordan Valley, Highlands and industries). Presently, rules and regulations governing TWW use in agriculture and salinity of water (recorded at 800 PPM in blended water in the Valley) prevent the utilisation of TWW in certain crops (e.g., vegetables & strawberries for TWW, and citrus for salinity). For food and beverage industries, restrictions on TWW use apply as well. Given the extreme limitations of freshwater availability for industries and agriculture in the future, allocation of these rare resources can be addressed by:

- A prioritisation strategy for crops and industries, that specifies both crops and areas, as well as industry and output, to allocate these extremely delimited freshwater resources for agriculture and industries. This should also provide a guarantee for investors.
- Conduct wastewater treatment at higher standards of quality and adapt rules & regulations accordingly (see TWW recommendations), to allow a larger segment of crops and industries to be served by TWW (at safe and good quality levels) and reduce these sectors' pressure on the delimited freshwater sources.

Salinity management

With moderate salinity already an issue in some areas, and for some crops, and a progressive shift towards TWW use, soil salinity may be expected to become more of an issue for agriculture (dependent on the level of wastewater treatment). Increased capacity of the sector to cope with salinity – through salt tolera nt crops & varieties, and sustainable management of the salt balance in the soil – might help alleviate its pressure on the freshwater resources base and the (salinity) quality standards for wastewater treatment. This may warrant the establishment of a dedicated investment, research and breeding program for salt tolerant crops and varieties, and services and extension sector dedicated to the sustainable management of salinity. The latter dedicated to the irrigation scheduling for the salt leaching fraction and the avoidance of salt accumulation in the soil.

ii. Enhancing the socio-economic value of agriculture

Enhancing the socio-economic value of agriculture, both in terms of GDP (absolute if not in percentage) and jobs, is a prerequisite if agriculture is to contribute its share to: i) bearing the increasing costs of the water supply system; and ii) provide for economic food security. Technically, it may be relatively simple to identify and cater for potentially high value crops and produce (e.g., vegetables, fruits, and dates), but as experience has shown over the last decade (re. fresh export to the Gulf), developing and securing a market (segment) is, and will remain, a challenge. Increasingly, the successful securing of a high-value market segment, requires the concerted effort and integration of private and public parties across the vertical and horizontal value chain. Delivery of specified volumes, at dedicated times of assured quality and uniformity, increasingly dominate the agricultural (high value) markets, that impose organisation and integration of the value chain across: production planning and organisation (cooperation & coordination among farmers (and water suppliers)); quality control and certification; packaging, handling and (cold) storage; branding & marketing; transport and logistics; financing, and R&D. Fostering and securing high value market shares thus require investments and development of capacity across the horizontal and vertical value chains, in which public institutions may foster private investment. This requires a concerted public-private effort across the domains of agriculture, finance, economic development, transport etc.

To enhance the value of agriculture, value chain development (horizontal and vertical) around specific crops and produce, that tackle both the agricultural technicalities of producing the demanded crops/produce at desired volume, time and certified quality, as well servicing producers and product handlers (logistics of packaging, branding/marketing, transport and storage, processing etc) will need to be targeted explicitly as an integrated effort. A dedicated (interdepartmental) government programme, with private sector inclusion, could target the development of high(er) value agricultural value chains, that are specified per crop and produce, and targeted to specified market segments. The programme needs to assure that:

- A variety of crops and produces is linked to different market segments. This may provide (spatial) variability for production across the Jordan Valley (see Figure 7 in workshop reporting) and Highlands and increase resilience of Jordan against market shocks.
- Discerns and targets explicitly domestic and export markets, and its specific requirements vis-à-vis volume, timing, and quality.
- Explores explicitly the increasing market opportunities for high(er) value ecological produce – e.g., rainfed olive oil, traditional grains, etc.
- Is explicit in fostering and developing the required and specified services; for producers in providing the required volumes at the specified times and certified quality, as for handlers in processing produce from farm to market.

Efficiency gains within the value chain can be expected to overall improve the agricultural sector's productivity in reducing (post) harvest losses.

iii. Reducing agricultural water demand

As the optimistic outlook scenario for 2050 shows, not all projected agricultural water demand can be met, and a water supply gap of 221 MCM remains. This implies that agricultural water use in 2050 should not surpass 752 MCM per year. This is 81 MCM lower than the agricultural water use in 2016. By 2050 there is thus no room to accommodate for any increases in agricultural water demand, not even those induced by climate change (e.g., hotter climate and lower and more erratic rainfall). In other words, agricultural water use needs to be restricted and reduced, and at the same time made more efficient and (economic) productive. This imposes challenges for the agricultural sector in accommodating these efficiencies and reductions at production level, whilst assuring that any savings achieved at farm level are transferred to proportionate gains in the water balance.

Efficiency gains = reduction in water supply

Within the field of irrigation efficiency gains are widely pursued with transformations from surface to drip irrigation, and conversion of open channels to closed piped water systems, or from open field to greenhouse systems. Typically, efficiency gains of 30-40 per cent in water use are deemed feasible and realisable. Although realisable at field level, these efficiency gains will have no impact on the water balance as long as they are not accompanied by an equivalent reduction in water supply (e.g., pass the saving on to the water supply system). In practice this is often neglected (Perry, 2007), with the result that efficiency gains at farm level serve to appropriate water that was not consumed in the past and returned to the hydrological system for increased production (either through intensification or expansion) at farm level (see technical background report). Thus, to all purpose and effect, increasing the water consumption and demand of agriculture without returning savings to the water supply system. An effect that has also been discernible in the Jordan Valley, where water consumption of agriculture has increased by 30-40 per cent over the last decades, coinciding with the period of massive transition towards drip irrigation (see technical background report). To help resolve the water balance gap at country level, any (technological) increase in water use efficiency needs to be accompanied by an equivalent reduction in water supply in agriculture (e.g., 20% increase in efficiency = 20% reduction in supply). Only in this manner water savings can be effectively passed on to the water supply system, where they can be used for water (re)allocation to other use(r)s. Any failure to recoup these efficiency gains in the water supply system will inevitably lead to an increase in agricultural water use and demand (either through intensification or expansion) and result in a widening of the water supply gap.

Shifting to higher water efficient crops

Given the scarcity of water and arid conditions, a shift in cropping choices and patterns towards water efficient crops represents a sensible, win-win option, if these crops are also of high value. To establish this shift, a dedicated strategy and cropping plan for higher value agricultural crops & high-tech agriculture ($/m^3) should be developed, supported by a high value agriculture investment facility. One type of crop that could be considered are CAM crops. Agricultural crops can be classified in three types of photosynthetic pathways that define their rate of biomass production to water consumed (transpiration). Most common crops fall under the type C-3 (wheat) or C-4 (maize), but the most efficient CAM type of crops are the not so widespread arid-adapted plants – pineapple, aloe vera and agave, being the commercially, most commonly applied. With the potential to combine high(er) value agricultural output with less water consumption, these crop-types (and produce) represent a smart response strategy. As with the principles of water use efficiency, care should be taken to replace higher water consuming areas with lower consuming areas and reduce supply according to reduction in consumption to make effective use of water savings in resolving the water supply gap.

Rainfed crop breeding

With the impact of climate change the increasing vagaries of the climate (e.g., temperature extremes, variability and intensity of rainfall and droughts) increasingly affect the rainfed crop yields in particular the Highlands. With the onset of modern and commercial high yielding varieties, the sensitivity of modern varieties to climatic extremes has tended to increase. As the climatic extremes are set to increase (in both scope and frequency), and the availability of irrigation water to compensate for these (e.g., drought) is extremely delimited, a dedicated

R&D program for climate robust rainfed crop varieties and cropping patterns may be warranted. The basis for this lies in the nurturing and developing of the traditional varieties (e.g., olive, wheat/cereal, peas) that show more robustness to climatic extremes (re. this year's cold spell), and the past and on-going work of ICARDA in this field. Whereby it should be noted that these traditional varieties, though lower yielding per ha, may fetch higher prices on specialty markets (equating or exceeding the value of commercial varieties). This warrants specific focus in the value chain development, to be paired with such a rainfed R&D program.

Deficit & supplementary irrigation

With a projected supply gap of 221 MCM and a required corresponding reduction of agricultural water demand, making the most productive use of delimited irrigation water availability would be a logical strategy to apply. Depending on crop (cereals, fruits, or fresh vegetables) and produce (table olives or olive oil), as well as crop variety, the optimum yield to water consumption ratio often falls below the maximum yield per ha. Deficit irrigation is the practice to purposefully water stress the crop to that extent that it does not reach its maximum yield per ha but, obtains its maximum ratio of yield to water use. Supplementary irrigation is the practice of supplying essentially rainfed grown crops with a small and targeted additional irrigation amount to secure optimal yields in times of rainfall shortfalls – whereby the small additional irrigation water applied yields the highest return to water, when compared to fully irrigated crops.

Whereas sensible as a water optimisation strategy, these practices are difficult to realise and regulate in practice:

- Deficit & supplementary irrigation require intimate knowledge of the specific crop yield to water response mechanisms to determine the optimal quantity and timing of irrigation, as well a reliable water supply system so that water can be applied when critically needed.
- Water optimisation, as a strategy, only applies when water is scarcer than land at the farm level. In practice this may mean a water supply cap (m^3 per ha/farm) has to be applied to induce farmers into water optimisation rather than yield maximisation.

Regulation and enforcement of groundwater abstraction

As the optimistic outlook for 2050 results in a 221 MCM water supply gap for agriculture, this implies agriculture will need to reduce its water demand and consumption. This is no easy task to accomplish without economic pain. This also implies that additional increases in agricultural water use and demand (as occurred over the last decade) should be avoided at all costs. Avoiding doing so will have two economic repercussions:

- Any future reductions in agriculture and agricultural water use will be politically and economically more difficult and costly to achieve (e.g., closing a gap of 350 instead of 221 MCM);
- The higher and longer the over-abstraction of groundwater resources continues (abstraction above renewable supply), will reduce the buffer capacity of fossil groundwater resources to cope with future climate shocks, variability in surface water

supply or delays in completing the supply augmentation options; and, increase the economic costs of groundwater abstraction as aquifer levels continue to drop.

To avoid this from happening, a stricter regulation and subsequent enforcement of groundwater abstraction by agriculture is required.

Fallow for value programme

Considering the water scarcity and the low profitability during the summer season, a programme that focuses on compensating Jordan Valley farmers to leave the land fallow during summer would result in reducing the agricultural water demand.

4. Integrated Planning and Governance

Given the tightness of the water balance for Jordan, and the concerted efforts that are required across the water supply, water treatment, agriculture, industries, energy, and environment sectors, to align their future water use and interdependencies to minimise the remaining water gap, an integrated and joint planning and policy making is of critical importance. Realising this optimistic scenario in time will require integrated planning and policy making across the sectors and ministries; aligning sectoral developments, impacts and interdependencies, as well as sequencing and timing of investments and developments (e.g. irrigation modernisation dependent of TWW, needs to align with increased TWW capacity, increased energy supply, and development of regulations and standards and market developments…). To facilitate this process, it is recommended to:

- Establish an integrated planning and policy entity at the highest level of government and policy making to take charge of, and facilitate, the integrated planning across ministries and sectors and safeguard a long-term vision and a coordinated planning including a roadmap. This roadmap is to lie out the strategy towards an envisioned situation of Jordan's water resources, in e.g. 2050, that all ministries and potentially private actors should adhere to and connect their policies with.
- Strengthen the capacity of government and regulation institutions in integrated planning and empower institution to enforce regulations (strengthen & establish cooperation between Water resources planning committee and Agricultural High Value crop planning committee?);
- Continue with the policy dialogue as an integrated planning process that facilitates integrated planning, engages and aligns stakeholders across sectors, and fosters continued analysis of the complex interactions towards establishment of a roadmap for policy implementation.

5. Data availability and accessibility

Given the scale and complexity of the water balance in Jordan, and its multiple cycles of water re-use and reallocation, issues always arise around data availability and accuracy. Especially complex is the congruent distinction and assessment of water available, water applied, water consumed (evapotranspirated) and return flows to surface and groundwater resources. Gaining insights in and more accurate quantifications of these complex hydrological flows may be a continuous quest.

We have taken care to base our analysis and scenario on the, to our knowledge, best public available data and sources. These are referred to in the technical background report, and as such up to scrutiny and critique. No doubt, discussions may abound on the sources used and the numbers derived. Though welcomed and appreciated as a means to gain a better grip and understanding of the complex hydrology and water balance of Jordan, it may also form a risk if it distracts the discussion from the daunting task and challenge ahead of us to seek the means to close the future water gap in Jordan.

However, as the water balance situation in Jordan becomes tighter and more precarious by the year, there is certainly a need and demand for a more comprehensive public database on water flows and availability to assist monitoring and planning, water allocation and distribution, and water quality control and certification. Investment in a public database, with real-time monitoring (discharge rates, water quality, water distribution, water consumption) and forecasting (weather, crop water requirements, agronomic services) would thus be welcomed. This may form a critical information base for both water managers and farmers to base their management decisions and attain higher degrees of efficiency and productivity as targeted, whilst assuring all priority demands are met.