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Water Productivity Improvement in Practice

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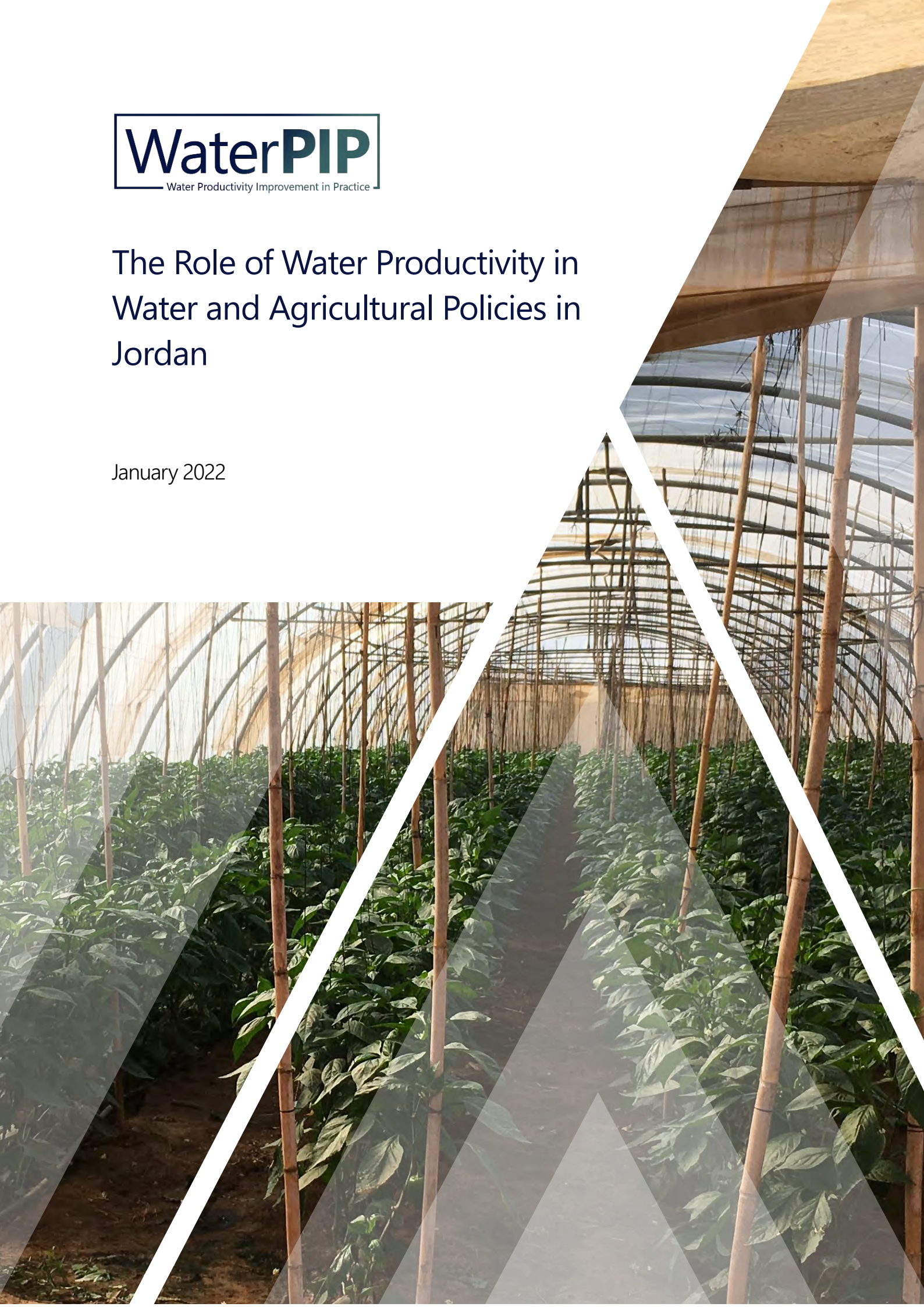
January 2022



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Wageningen University and Research

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Acronyms

AKIS	Agricultural Knowledge and Innovation System
AZB	Amman Zarqa Basin
FNS	Food and Nutrition Security
FTA	Farm Turnout Assemblies
GDP	Gross Domestic Product
GIZ	German Corporation for International Cooperation
JVA	Jordan Valley Authority
KAC	King Abdullah Canal
KTD	King Talal Dam
MENA	Middle East and North Africa
MOA	Ministry of Agriculture
MoEnv	Ministry of Environment
MOF	Ministry of Finance
MOPIC	Ministry of Planning and International Cooperation
MWI	Ministry of Water and Irrigation
NARC	National Agricultural Research Centre
NSAD	National Strategy for Agricultural Development
RSDS	Red Sea Dead Sea
TWW	Treated Waste Water
USAID	United States Agency for International Development
WAJ	Water Authority of Jordan
WFP	World Food Program
WUA	Water User Associations

1 Introduction

Irrigated agriculture is by far the largest water user worldwide, accounting for an estimated 70 percent of total freshwater withdrawals. In many drier countries, agricultural water use accounts for more than 90 percent of total withdrawals (Molden, 2013; Scheierling & Tréguer, 2018). As water becomes increasingly scarce, the management of agricultural water use moves to the centre of water management concerns. The question of how best to adapt agricultural water management is complicated, not least because irrigated agriculture is at the centre of two large and conflicting trends. On the one hand, irrigated agriculture is rapidly expanding with the growing demand for agricultural products. On the other hand, additional demands for irrigation water are increasingly difficult to accommodate in many parts of the world. The growing demand for water from other sectors is further intensifying the competition for water resources. Because water use in irrigated agriculture is seen as having relatively low net economic returns compared with other water uses, other sectors increasingly look to agriculture as a potential source of water. In Jordan, domestic and industrial sector are given priority over agriculture based on the concept of (economic) water productivity, since the net economic returns per unit of water for domestic and industrial sector is significantly higher than that of agriculture (Ministry of Water and Irrigation, 2016b; Ministry of Water and Irrigation, 2016d). As such, agriculture has had to diminish its water share to accommodate the rising urban and industrial demands (Jouhari, 2018; Berg & Al Nimer, 2016). Moreover, since the two priority sectors require good quality water, recent water policies in Jordan are focused on saving higher shares of good quality groundwater resources for domestic and industrial use by shifting the water shares of agriculture to a higher dependency on wastewater reuse.

The most common and widely promoted approach for adapting agricultural water management to the increasing scarcity of water in closed or closing river basins is to focus on improving agricultural water productivity and efficiency—and thus to achieve more crop per drop. Such improvements would allow either higher agricultural production with the same amount of water, or the same amount of agricultural production with less water, resulting in water savings. Water savings from surface water can be reallocated to other higher-value uses, reallocated to irrigate areas that extract groundwater and thus reduce groundwater dependency, or freed up to increase environmental flows. Water savings from groundwater withdraws can directly reduce groundwater exploitation and ensure long-term sustainability. Such groundwater savings are particularly relevant for counties with high dependency on groundwater, such as Jordan. For 2014, around 69% of the overall water use in Jordan was from groundwater[1] (Ministry of Water and Irrigation, 2016d). Groundwater over-exploitation has caused an average drop in groundwater tables of 1 m per year (Goode, 2012, cited in Al Naber & Molle, 2017).

The implicit assumption is that such improvements in water productivity, efficiency and water savings would help address the trade-off between increased agricultural production versus increased economic water productivity in other economic sectors; i.e. economic value per unit of water, and/or environmental sustainability. As a result, many international organizations and national agencies concerned with water management are promoting an increase in agricultural water productivity and water use efficiency as an important policy goal. An example of this is the indicator 6.4.1 of water use efficiency of Sustainable Development Goal (SDG). This indicator focuses on economic value produced per volume of blue water in all economic sectors.

However, regarding agricultural sector, advocating for maximizing agricultural water productivity, increasing agricultural economic water productivity and increasing 'crop per drop' are limiting the complex goals and objectives of agricultural sector while also obscuring complex decision-making processes of

[1] This figure includes the officially recognized unregulated groundwater extractions of 225 Mm^3/year

balancing multiple socio-economic objectives of national development strategies (increasing employment, environmental sustainability, ensuring food security). Moreover, universally applying concepts of water productivity and water use efficiency disregard farm-level decisions and realities of farmers (Boelens & Vos, 2012).

As such, water productivity should move beyond the narrow approach of 'more crop per drop' (Scheierling & Tréguer, 2018). In this context, this policy review aims to shed light into the Jordanian national plans for agricultural water management in relation to water productivity and the related socio-economic objectives of national development that can be met through agricultural water management.

The structure of this policy review is as follows: first, the method used to conduct the policy review is briefly discussed in order to make explicit the boundaries of this analysis (section 2). Following, general background information about Jordan is given (section 3). Next, more specific trends regarding the role of water in agriculture and the economy in Jordan are discussed (section 4). The details of agricultural production are presented in section 5, the main policy targets from the reviewed documents are presented in section 6 and the enabling conditions and challenges of the Jordanian water policies in section 7. The use of the concept of water productivity in the official policies is discussed in section 8. Lastly, conclusions are drawn in section 9.

2 Policy Review Method

This policy review was conducted based on the Framework for Conducting a Policy Review on Agricultural Water Productivity that was developed in the context of the WaterPIP project (Christoforidou, Seijger & Hellegers, 2020). The focus of the framework is to first identify relevant policy document, then to extract policy objectives and targets, wordings and framings used to describe aspects of water productivity, economic water productivity, land productivity, water use, water efficiency. Specific strategies that were targeting the identified objectives were studied and analysed.

Based on the 10-steps of the framework, first the scope of the policy review for Jordan was determined; i.e. understanding what national water and agricultural policies are planning for the productive and efficient water use and how these plans translate into meeting policy objectives. Second, the collection of the policy documents was done from online sources and the network of WaterPIP project. Third, the documents were reviewed, and important aspects given the abovementioned objective were highlighted. Fourth, the main targets and objectives were extracted. Fifth, these targets were compared to identify synergies and conflicts between them. Sixth, scientific literature was briefly reviewed to triangulate the findings so far. Seventh, a first draft working document was created to include the main findings in a one-page document. Eighth, the one-page working document was shared with local experts and feedback was received. Ninth, the feedback was incorporated, and the review was finalized into a policy review report. Lastly, it was discussed within the project team how the findings of this review can be used effectively in the local context.

The main advantage of using the framework is that it provides a quick understanding of the development objectives of the country, making trade-offs related to water productivity explicit. Thus, water productivity is understood and studied in its broader sense. Moreover, the influence of the policy analyst is minimized through triangulation (step 6) and validation (step 8) of the findings.

On the other side, the main limitation of the framework revolves around the decision to review national strategies that, depending on the governance scheme of the country, might not reflect regional and local policies. In the case of Jordan, national agricultural policies were focused on two different regions, the Jordan Valley and the Highlands. However, it is unclear if Jordan has specific regional development strategies. Lastly, official policy documents might contradict realities on the ground, since important issues might be too politically sensitive to be written down.

3 Jordanian Context

Jordan or the Hashemite kingdom of Jordan is an Arab country of the Middle East and North Africa (MENA) region (Figure 3-1). It is located on the east bank of the Jordan river and borders with Israel, Palestine, Syria, Iraq and Saudi Arabia. Jordan has access to the Dead Sea, located southwest of Amman, while in the south, it has access to the Red Sea. The country has a population of 9.5 million people (2015) which is expected to almost double by 2050 (Ministry of Water and Irrigation, 2016a). The majority of people live in the capital city of Amman (42% of the population) while 84% of the population lives in urban areas (Figueroa et al., 2018). The official language is Arabic and the dominant religion is Islam.

Figure 3-1: Jordan Map (Retrieved from: https://www.britannica.com/place/Jordan)

Despite the political instability in other countries of the MENA region (Arab Spring, Syrian civil war and Qatari conflict), Jordan remains politically stable. For this reason, an accelerated influx of refugees has migrated to Jordan, putting extra pressure on the resources and infrastructure of Jordan, increasing the pressure on the domestic water supply. The country has more than 3 million refugees, with the majority coming from Palestine (around 2.2 million) and Syria (1.4 million) (Nuffic, n.d.). Palestinian refugees have been hosted in Jordan since the 1948 Arab-Israeli War (Al-Karablieh & Salman, 2016). Today, most of them have full citizenship[2]. Since the Syrian crisis in 2011, Syrians flee to Jordan to seek asylum. Syrian refugees are mostly working in the informal sector, which represents 44% of total employment in Jordan (Mansour-ille et al., 2018). Syrian refugees are supporting the agricultural sector, mainly in the northern highlands.

[2] https://www.anera.org/where-we-work/jordan/

4 Water, Economy and Agriculture

4.1 Water

Jordan is the second most water scarce country in the world (Jouhari, 2018). The total renewable water resources in Jordan amount to 937 Mm^3, providing 96.58 m^3 per capita per year for 2017, falling below the threshold for severe water scarcity of 500m^3 per capital per year (Aquastat data[3]). Based on the National Water Strategy 2015-2025, water use for 2014 exceeded the renewable water resources by 22%[4]. The total water use for 2014 was 1,197 Mm^3/year, out of which 722.5 Mm^3/year was attributed to agriculture (497.5 Mm^3/year officially allocated from surface water, groundwater and treated wastewater (TWW) while 225 Mm^3/year come from unregulated groundwater extraction), 429 Mm^3/year for municipal and around 39 Mm^3/year for industrial activities (Ministry of Water and Irrigation, 2016b) (Table 4-1). Interestingly, unregulated groundwater use in agriculture is officially recognized and is estimated through remote sensing techniques.

Table 4–1: Water Resources Use in Jordan in Mm^3/year for 2014, Adapted from: Ministry of Water and Irrigation (2016b)[5]

Source	Municipal	Industrial	Irrigation	Livestock	Total
Surface Water	103.8	4.8	143	7	258.6
Groundwater (official)	325	32.2	231.2	0.1	588.5
Groundwater (Renewable)	207.2	19.3	189.4	0.1	419.2
Groundwater (Non-Renewable)	107.2	12.9	41.8	0	162.1
Groundwater (Brackish, Abo Zeighan)	10.2	-	-	-	10.2
Groundwater (unregulated, for irrigation)	-	-	225	-	225
Treated Wastewater	0	2	123.3	0	125
Total	**429**	**39**	**722.5**	**7.1**	**1,197**

Below, the different water sources and economic sectors in relation to Table 4-1 are discussed.

[3] Data from Aquastat for Jordan were downloaded from http://www.fao.org/nr/water/aquastat/data/

[4] Assuming that the renewable water resources for 2014 was the same as the one reported in Aquastat (above) for 2016.

[5] In the official policies, there are different terms used to describe this table (water utilization, water use, water supply). The table refers to water use that is withdrawn or allocated in the different economic sectors. The water consumption; the water that cannot be captured and reused, under each sector is not explicitly stated. To avoid confusion around the terms, in this review, water use refers to water allocation.

Surface water withdrawal accounted for 44% of the total renewable surface water (Aquastat data[6]). The rest of surface water is discharged naturally and might flow towards groundwater recharge and environmental flows while part of it might be illegally used. Surface water is mostly used for agriculture in the Jordan Valley (Jouhari, 2018). To increase the availability of surface water, Jordan constructed dams, expanded the King Abdullah Canal (KAC), invested in rainwater harvesting and adopted pressurized irrigation networks (Jouhari, 2018). Annual precipitation is estimated at 266 mm per year with a spatial variation between different areas (Figure 4-1). The maximum annual precipitation of around 600 mm takes place in the Highlands, in the northwest area.

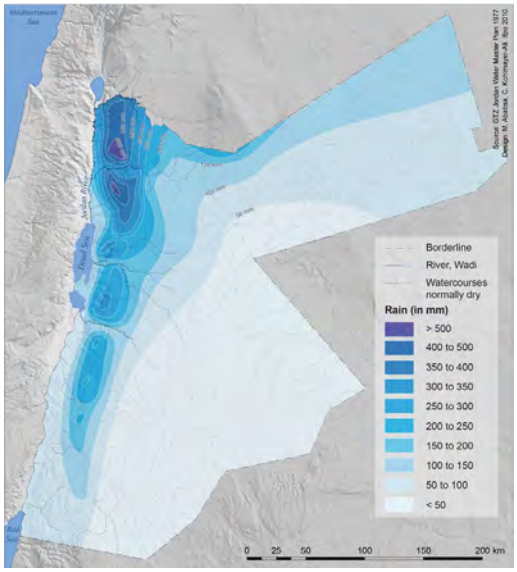

Figure 4-2: Map of Rainfall in Jordan. Retrieved from: https://books.openedition.org/ifpo/4865

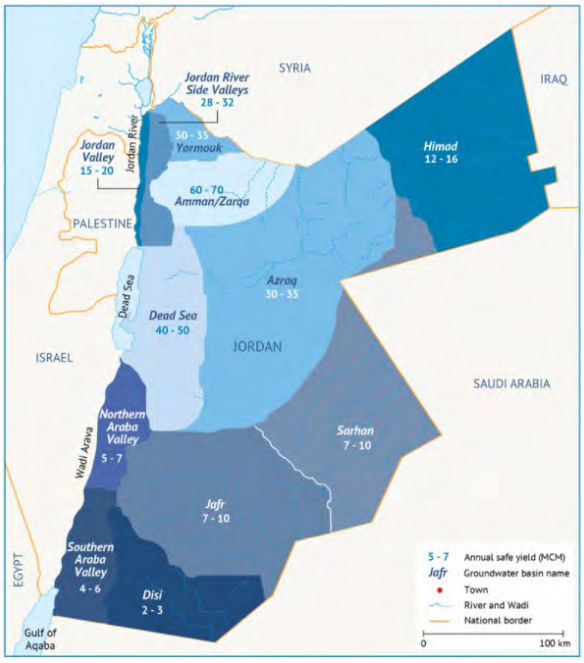

Figure 4-1: Map of Groundwater Basins in Jordan. Retrieved from: https://water.fanack.com/jordan/water-resources/surface-and-groundwater/

Groundwater comes from 12 aquifers (Figure 4-2). Most aquifers in Jordan are being overexploited beyond the safe yields, resulting in decreases of the water table (Al-Shibli et al., 2017). With decreased groundwater table, issues of salination of the groundwater are expected to increase. Currently, issues of groundwater salination are evident mainly in Mafraq. The Disi aquifer (in the south bordering with Saudi Arabia) is the most extracted aquifer (Al-Shibli et al., 2017).

Groundwater, including unregulated extractions, accounted 68% of the overall water use in Jordan (based on Table 4-1). The amount of 225 Mm^3/year of unregulated extraction of groundwater was estimated through remote sensing. Interestingly, the unregulated groundwater extraction is 45% of the water that is officially allocated to agriculture.

Including the unregulated groundwater pumping, 56% of the groundwater is used in agriculture and 40% is used in domestic water supply (based on Table 4-1). Domestic water supply is highly dependent on groundwater as 75% of the domestic water comes from groundwater.

This indicates a clear water competition between the domestic and agricultural sector. This competition is to be resolved by prioritizing domestic water use over agricultural water use, considering the high economic value of domestic water use (Ministry of Water and Irrigation, 2016f) Domestic water demand is expected to increase due to population growth, increasing the total supply of good quality water necessary to meet domestic demand. Water is supplied once or twice a week. During 2014, domestic water supply was designed to provide 126 litres per day per capita, corresponding to 429 Mm^3/year. However, revenue was obtained from 61 litres per capita per day, with some governorates receiving less (Ministry of Water and Irrigation, 2016b). The missing 65 litres per capita per day are the so called non-revenue water (NRW)

[6] Data from Aquastat for Jordan were downloaded from http://www.fao.org/nr/water/aquastat/data/

that is not billed and accounted for and is lost due to illegal use or leakages (Ministry of Water and Irrigation, 2016a).

However, considering the higher economic value of domestic sector over agriculture, it can be argued that domestic water can afford the production of high-cost water and shift towards producing desalinated water. This way good quality water can be spared for agriculture. Even if Jordan aims to increase the desalinated water supplied for domestic uses (see section 6.3), good quality groundwater is still going to be used for the domestic and industrial sector while agriculture is to be supplied TWW.

TWW re-use has been politically supported as a way to adapt to water scarcity. Based on the water budget of 2014, Jordan is re-using 123.3 Mm^3 of TWW, coming from the domestic sector (Table 4-1). Due to the expected population growth and the relatively high connectivity of households to sewage (around 63%), more TWW will become available in the future. As such, TWW reuse is regarded in official policies as a promising source of additional water. However, reworking the official water budget of 2014 (Table 4-1) in terms of water balance in Jordan, an interesting trade-off between TWW re-use in agriculture and non-renewable groundwater extraction appears. Domestic water use is 429 Mm^3 while 201.7 Mm^3 are actually being consumed, as 123.3 Mm^3 are re-captured and allocated to agriculture as TWW re-use. Looking at the amount of non-renewable groundwater that is used in the domestic water supply, this amounted to 107.2 Mm^3. The amount of TWW re-use (123.3 Mm^3) is larger than the domestic non-renewable groundwater extraction (107.2 Mm^3). As such, it is argued that TWW re-use comes at the expense of groundwater recharge (Figure 4-3). In this line, a better understanding of the interactions between surface water (including treated wastewater) and groundwater is necessary for water resource allocation and sustainable groundwater use.

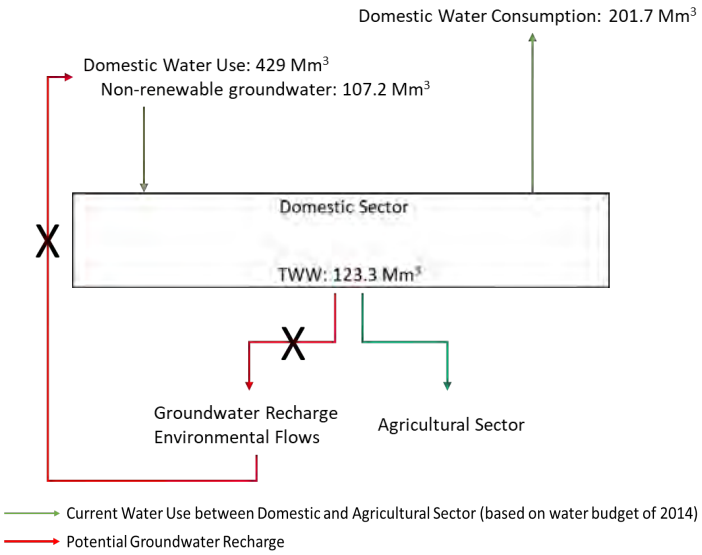

Figure 4-3: Trade-off between TWW re-use in agriculture and non-renewable groundwater extraction

Jordan's has transboundary water resources and thus Jordan's water resources are affected by upstream neighbouring countries. In the south, groundwater is extracted from the Disi aquifer, a transboundary aquifer shared between Jordan and Saudi Arabia. Saudi Arabia extracts around 1.000 Mm^3/year and Jordan extracts 180 Mm^3/year, of which 100 Mm^3/year are transferred through the Disi Water Conveyance Project to Amman for domestic use and the rest is used for irrigation in the city of Aqaba (Muller et al., 2017). The two countries have agreed to maintain a minimum transboundary buffer zone but no restrictions on abstraction volumes are agreed (Muller et al., 2017). In the north, the Yarmouk and the Hasbani rivers enter the country, coming from Syria and Lebanon respectively. Based on the 1987 agreement between Syria and Jordan on the Yarmouk river, a new dam (Al Wahda or Unity dam) was constructed and became operational in 2006. The dam would store Yarmouk water for Jordan after the filling of 26 Syrian dams that are located further upstream. The water stored in the dam has not reached the expected water quantities based on the agreements (Hussein, 2019; Müller et al., 2016). However, due to the Syrian conflict and the decreased irrigated agriculture in Syria, the level of water in the dam has increased over the last years (The World Bank, 2017; Müller et al., 2016). Yarmouk river is the main tributary of the Jordan river. Flows in the Jordan river do not exceed 150 Mm^3/year (Ministry of Water and Irrigation, 2016a). In order to provide potable surface water, Jordan, Israel and the Palestinian Authority agreed on constructing the Red Sea – Dead Sea Water Conveyance (RSDSC) project. Salt water from the Red Sea will be desalinized and provided

to Amman and Israel for domestic consumption while the brine water will be used to increase the water level in the Dead Sea (Rajsekhar & Gorelick, 2017; Alqadi & Kumar, 2014). Jordan expects that the completion of the project will bridge the gap between water demand and water supply, bringing it down from 26% to 6% in 2025 (Ministry of Water and Irrigation, 2016a). The RSDSC project is also in line with the peace treaty that Jordan and Israel signed in 1994. According to this treaty, Israel agreed to transfer 50 Mm^3/year of water to Jordan from the lake Tiberias (Hussein, 2019).

Climate change is an issue that is expected to impact water scarcity and food security in Jordan. For the different basins in Jordan, temperature is expected to increase by 1°C in 2030 and by 2°C in 2050. It is estimated that in the Yarmouk river basin and the south Jordan river basin, 10% and 20% decrease of precipitation will take place in 2030 and 2050 respectively (Al-Bakri et al., 2013). As such, extra pressure on Jordan's water resources should be expected in the future.

4.2 Economy

Jordan is an upper-middle income country[7] which has seen economic growth rates of more than 5%. However, due to the combined effect of the global economic crisis and the political instability in the region, the economy slowed down from 2009 onwards. The annual growth rate between 2000 and 2009 was at 6.5% and decreased to 2.5% in 2016 while Jordan's public debt increased from 65% of the GDP during 2008 to 95% in 2016 (Figueroa et al., 2018). Foreign investments in Jordan decreased after 2008 while exports were also negatively affected by the instability in Syria and Iraq (Leeters & Rikken, 2016). Syria was the main export route serving the Russian and European markets. Additionally, the high dependency of Jordan on Egypt's natural gas to meet its energy requirements severely impacted the country when the Egyptian revolution interrupted the energy supply. All these aspects resulted in an increased youth unemployment, which reached 34% in 2016. Food security was affected by the economic and political crisis but has started to recover since 2015 (Figueroa et al., 2018). The government aims at improving the agricultural sector as it has high potential for job creation for Jordanians and refugees (Figueroa et al., 2018; Groot et al., 2018)

4.3 Agriculture

Agriculture is the largest water user in the country, with a decreased percentage of water official use over the last years, accounting for 64% in 2007 and 51.7% for 2017 (Jouhari, 2018). As seen in Table 4-1 the total official water use between 2007 and 2017 increased from 940 Mm^3/year to 1,054 Mm^3/year. This trend is followed by a redistribution of water from agriculture to domestic uses (i.e. from 30% in 2007 to 44.6% in 2017 for domestic purposes). This can be understood by the influx of refugees and thus the increased domestic water needs. However, these values refer to official water withdrawals, thus unregulated groundwater pumping volumes are not included. Officially recognized volumes of unregulated groundwater withdrawals are only available for 2014. Considering unregulated groundwater as mainly used in agriculture, the percentage of agricultural water use is maintained at around 60% (Table 4-2) In absence of data regarding unregulated groundwater pumping in previous years, it is not possible to conclude on whether actual total agricultural water withdraws are decreasing. Regarding water consumption of each economic sectors, data were not available.

[7] Source: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519

Table 4–2: Total water Withdraws per sector between 2007-2017 (adopted from Jouhari, 2018; Ministry of Water and Irrigation, 2016b; Ministry of Water and Irrigation, 2016c)

	Total Water Withdrawal (Mm^3/year)	Domestic (%)	Agricultural (%)	Industry (%)
2007 [a]	940	30	64	5
2010 [a]	970	34	59	6
2014 [b]	972	44.1	51.2	4
2014 (including unregulated GW) [b]	1,197.1	35.8	60.4	3.3
2017 [a]	1,054	44.6	51.7	3

[a] Jouhari, 2018, [b] Ministry of Water and Irrigation, 2016b; Ministry of Water and Irrigation, 2016c

Agricultural value has been increasing in Jordan over the years while agriculture's contribution to GDP declined between 1950s and 2010s due to increases in other economic sectors (Al Quran, 2019). Based on the National Agricultural Development Strategy 2020-2025 (2020), agriculture directly represents 5.6% of Jordan's GDP while its indirect contribution, including the food-agricultural value chain, it represents 15-20% of the GDP. The food-agricultural value chain employs around 15% of working population of Jordan, with half of women living in rural areas working in the sector. As such, agriculture is an important sector.

Regarding the agricultural area, some contradictory data were found. Based on the data from the World Bank database[8] (Figure 4-4), agricultural land was decreasing between 1994-2007. In 2007, agricultural land reached the lowest point and progressively increased but not enough to reach the level cultivated land of 1994.

Figure 4-4: Agricultural land (km^2) in Jordan (source: The World Bank, retrieved from: https://data.worldbank.org/indicator/AG.LND.AGRI.K2?end=2016&locations=JO&start=1993

[8] Data available until 2016
https://data.worldbank.org/indicator/AG.LND.AGRI.K2?end=2016&locations=JO&start=1993

However, based on the report regarding groundwater resources from IWMI[9] (Al-Karablieh & Salman, 2016), total and irrigated agricultural area has been expanding between 1994 and 2015 (Table 4-4). In 2015, 40% of the total agricultural area was irrigated. As seen in Table 4-4, agriculture in the Jordan Valley is mostly irrigated (99%). Groot et al. (2018) note that the adoption of new technologies in the Valley made this expansion possible. In the Highlands rainfed agriculture is more prominent than irrigated agriculture. However, irrigated agriculture in the Highlands has increased over 80% between 1994 and 2015 (see Table 4-3; Ministry of Water and Irrigation, 2016f). Expansion of agricultural land is only possible under increased agricultural water consumption. Additional water to support this expansion is mainly sourced from unregulated groundwater abstractions.

Table 4–3: Expansion of total and irrigated Agriculture in Jordan between 1994 and 2015 (adapted from: Al-Karablieh & Salman, 2016)

	Total Agricultural Area (Dunums)	Irrigated Agricultural Area (Dunums)*	Non-Irrigated Agricultural Area (Dunums)	Expansion of Total Agricultural Area (%)	Expansion of Irrigated Agricultural Area (%)	Expansion of Non-Irrigated Agricultural Area (%)
Jordan Valley (1994)	276,627	275,101 (99.5%)	1,525 (0.5%)	16.10	15.75	79.08
Jordan Valley (2015)	321,170	318,439 (99.1%)	2,731 (0.9%)			
Highlands (1994)	1,909,741	390,930 (20.5%)	1,518,811 (79.5%)	22.78	83.24	7.22
Highlands (2015)	2,344,794	716,362 (30.5%)	1,628,432 (69.5%)			
Jordan (1994)	2,186,368	666,031 (30.5%)	1,520,337 (69.5%)	21.93	55.37	7.29
Jordan (2015)	2,665,965	1,034,801 (38.8%)	1,631,163 (61.2%)			

* The percentage in the parenthesis indicates the relation between the of irrigated/non-irrigated agricultural area and the total agricultural area for each year.
Note: 1 dunum equals 0.1 hectare.

[9] Original data from Department of Statistics

5 Agricultural Production

The main crops produced in Jordan are horticultural crops like fruits, vegetables and olive trees, which account for 70% of the total harvested area. Tomato production is the leading vegetable for both domestic consumption and exports, accounting for 43.4% of vegetable production (Groot et al., 2018). Dates production, and especially the Medjool variety, are increasing in Jordan. Date palms have the advantage of being saline-tolerant, a characteristic that ensures that brackish groundwater can be used without significant yield reduction. Interestingly, Jordan exports high quality dates and imports low quality dates for local consumption (Fileccia et al., 2015).

Exports involve fruits and vegetables with tomatoes, apricots, cherries, peaches, plums and cucumbers being the most important for the agri-food export value (Fileccia et al., 2015). Despite the relatively high water consumption for the production of these crops, the economic value obtained through their exports is crucial for Jordan's food security. Agricultural exports are important for the country, accounting for 18% of the total value of exports for 2016 (Jordan Investment Commission, 2017). National agricultural production accounts for two times the domestic consumption (Groot et al., 2018). As such, Jordan is self-sufficient in fruits and vegetables. More specifically, during 2009 the estimated self-sufficiency percentage for tomatoes reached 294% (Fileccia et al., 2015). Additionally, during 2017, agricultural exports decreased by 14% due to the closing of routing paths through Syria and Iraq, the halting of exports to Qatar due to political reasons and the chemical residues in Jordan's export products[10].

During the beginning of this century Jordan was a net virtual water importer (Hoekstra & Hung, 2005). This trend is most likely to be the case in recent years as well. Jordan is dependent on staple food imports, consisting of 90% of the country's needs (Salman et al., 2018). Wheat and barley production in the country is limited in rainfed highland. Despite the low self-sufficiency of Jordan in staple crops, the World Food Program (WFP) considers Jordan as a food secure country[11].

Agricultural debate in Jordan is often focused on economic water productivity (JD/m^3 of water). The highest economic water productivity in Jordan is for olive, grape and dates, while tomatoes, cucumbers and sweet peppers follow. Compared to other MENA countries, Jordan scores low in economic water productivity in tomatoes and cucumbers. Groot et al. (2018) assigns these differences to the use of different varieties as well as better water saving and management measures However, considering that management practices can improve water use efficiency; i.e. the amount of water consumed by the plant over the total supplied water, it seems that these estimations of economic water productivity are not based on the water that is actually consumed but rather the water that is applied. Additionally, the low quality of agricultural production in Jordan is also likely to have influenced this low economic water productivity. Jordan's agricultural production is characterized by weak post-harvest management and chemical residues that have resulted in the reputation of Jordan as a supplier of low quality products (Advance Consulting BV & Wageningen University and Research, 2019).

[10] Source: http://www.jordantimes.com/news/local/action-plan-strengthen-resilience-agriculture-sector%E2%80%99

[11] Source: https://www.wfp.org/countries/jordan#:~:text=Jordan%20is%20considered%20a%20food,level%20of%20hunger%20is%20moderate.&text=While%20Jordan%20ranks%20139%2F144,improving%20over%20the%20last%20years.

The main two areas where agricultural activities take place are the Jordan Valley and the Highlands. The **Jordan Valley** is a thin strip of land that is located between the north borders of Jordan with Israel and the Dead Sea (Figure 5-1). The Valley borders on northwest with Israel and Palestine. The Valley is located below mean sea level, along the Jordan river. Vegetables at over 58% (cucumbers, tomatoes and eggplants), citrus orchards at 20%, and field crops (maize, wheat, barley, clover), bananas and dates are cultivated (Berg & Al Nimer, 2016; Groot et al., 2018). In the area, greenhouses and tunnels are used. Agricultural production in the Valley is irrigated (see section 6).

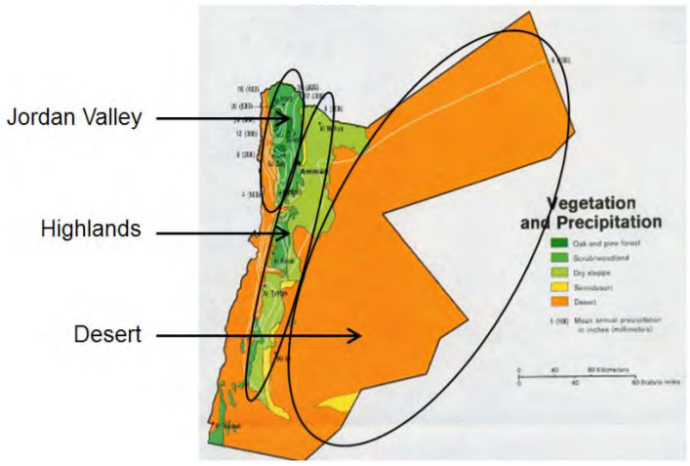

Figure 5-1: Map of Jordan (Source: Leeters & Rikken, 2016)

The Highlands, the other agricultural area of Jordan, refers to the agricultural areas that are located in higher elevation. In general, Jordan is a country with relatively high surface elevation thus the rest of the country can be considered as part of the Highlands. Even if Figure 5-1 indicates that the Highlands refer to the area directly next to the Jordan Valley, in this report, the Highlands refer also to the agricultural lands in the desert areas that have been developed due to the (illegal) groundwater extractions. As seen in Figure 5-2, wells are evident in the northern part of the desert (Yarmouk, Azraq and Amman Zarqa groundwater basin. These groundwater basins are overexploited, making the use of groundwater for agriculture unsustainable (Molle et al., 2017).

The main agricultural products in the highlands in terms of crop quantities are summer vegetables, followed by fruits and field crops. Agriculture in the Highlands is taking place under rainfed and irrigated conditions. Rainfed agriculture is mostly for staple crops such as maize, wheat, barley and legumes (Fileccia et al., 2015). Irrigated agriculture in the Highlands is dependent on groundwater extractions. Irrigation water from groundwater resources is used fruit trees and vegetables. Around 50% of irrigation demand goes to olive cultivations in the Highlands (Sixt et al., 2018).

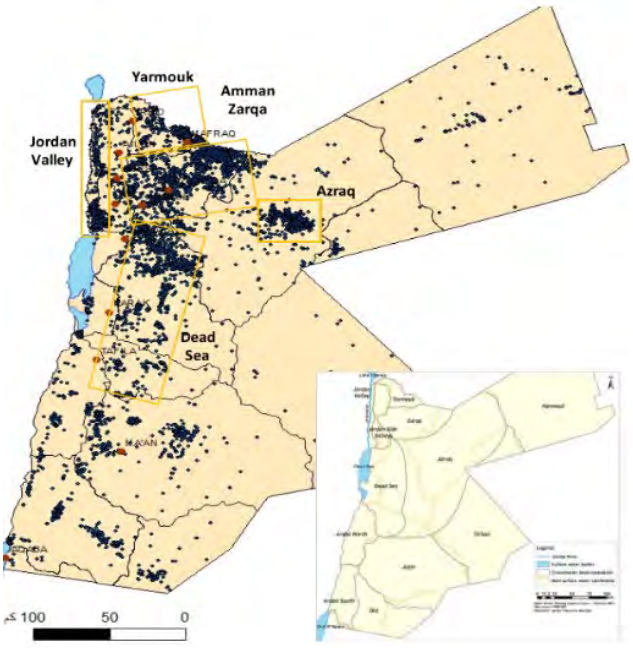

Figure 5-2: Map of wells in the Jordan Valley and the Highlands, (Source: Molle et al., 2017)

Between the two agricultural areas, the Highlands produce the most and occupy the largest area, when compared to the Valley (Fileccia et al., 2015). However, the Valley has higher land productivity in vegetables and fruits than the Highlands (calculations based on Fileccia et al., 2015). Moreover, the Valley is important for the economic value of agricultural production of Jordan. Official policies note that the Valley 'consumes' 35% of the irrigation water, while contributing 70% of the total economic value of agricultural products (Ministry of Water and Irrigation, 2016c). Looking at the official numbers mentioned in the Water Substitution and Reuse policy (Ministry of Water and Irrigation, 2016f),

this distribution of 35% and 65% of water consumption of irrigation water (178.43 Mm^3 in the Valley and 325.22 Mm^3 in the Highlands, in total 503.56 Mm^3)[12] is not including the unregulated groundwater extraction. Additionally, it refers to water use rather than water consumption. Based on the Water Reallocation Policy (Ministry of Water and Irrigation, 2016b) which includes unregulated groundwater extractions, during 2014, 729 Mm^3 was used; 200 Mm^3 in the Valley and 529 Mm^3 the Highlands[13]. Accounting for unregulated extractions, the Valley uses 27% of irrigation water and the Highlands 73%. Table 5–1 provides an overview of the characteristics of the two agricultural regions.

Table 5–1: Characteristics of the Jordan Valley and the Highlands

	Jordan Valley		**Highlands**
Water Source	Surface water (including available TWW) and (some) groundwater		Rainfed – Groundwater Good Quality (better than in Valley) Dams for groundwater recharge
	North Valley	King Abdullah Canal (KAC) from Yarmouk River. Good quality, insufficient quantity Groundwater (brackish) abstraction for irrigation scheduling Quatas[b]	
	Middle and Southern Valley	King Talal Dam (KTD) which collects mixes of TWW and water from KAC[a, b] Poor quality, insufficient quantity [b]	
	Southern Ghors	King Talal Dam (KTD) which collects mixes of TWW and water from KAC[a] Good quality, insufficient quantity Groundwater abstraction of lower water quality [b]	
Irrigation Management	Public Irrigation Scheme, managed by JVA		Private groundwater abstractions
Irrigation Technology	Farm investments on higher water efficiency with localized irrigation, increasing greenhouses (tunnels) and crop substitution with high-value produce [a] Quality seeds, high-yielding varieties, good nutrient management [b] Drip irrigation, other form of localized irrigation and surface irrigation at 81%, 5% and 8% of farmers respectively [b]		Mostly localized irrigation systems [14, d, e]
	Middle and Southern Valley	Drip irrigation (almost universally)[b]	
	Southern Ghors (area close to Dead Sea)		
	Northern Ghors (area close to Dead Sea)	Drip irrigation, sprinkler irrigation and other form of localized irrigation at 51%, 31% and 14% of farmers respectively [b]	
Agricultural Products	Winter vegetables (tomato, eggplant, cucumber, potato and squash), citrus trees, bananas, dates and field crops [b]		Summer vegetables, staple crops (rainfed) and olive trees
Farm Size[d]	1.5-10 ha		15-30 ha
Soil Type	Sandy soil		Clay soil
Agricultural Season	Year round (85% of vegetable production, limited during summer with high temperatures in the Valley)		Summer

[a] Fileccia et al., 2015, [b] Berg & Al Nimer, 2016, [c] Molle et al., 2008, [d] Frenken, 2009, [e] Venot, 2004.

[12] The sum of the total legal water use (503.56 Mm^3) is slightly different from the one of Table 4-2 (497.5 Mm^3) (Ministry of Water and Irrigation, 2016b).

[13] The sum of the total water use (729 Mm^3) is slightly different from the one of Table 4-2 (722.5 Mm^3)(Ministry of Water and Irrigation, 2016b)

[14] The only found sources about the irrigation systems in the highlands are from the past decade. Thus, there is a risk of information being outdated and not describing accurately more recent changes in the Highlands.

6 Agriculture and Water Policies

6.1 National Strategic Development Plan: Jordan 2025, a National Vision and Strategy (2015)

Jordan released its national plan, Jordan 2025: a national vision and strategy. This national strategic development plan lays the guiding principles and targets for the development of Jordan for the near future in all the sectors. The plan mainly targets the 'integrated economic and social framework that will govern the economic and social policies based on providing opportunities for all.' (p 13, Hashemite Kingdom of Jordan, 2015). In general, the vision focuses on the improvement of the living conditions of the Jordanian citizens, setting tangible targets for real economic growth rate, poverty reduction, unemployment reduction and reduction of public debt.

The objectives of the national vision are:

- Improve welfare of citizens, and the basic services provided to them
    - Resource security and sustainability (energy, water and food)
    - Infrastructure facilities
- Create a balanced and stable society with opportunities for all
    - Education
    - Health
    - Employment - Economic participation: women, declining size of work force, youths (15-24), university graduates, foreign workers with great disparity in wages
- Achieve self-reliance and financial stability
- Enhance productivity and competitiveness of Jordanian economy
- Eliminate indiscriminate subsidies and make economy resilient to external shocks

The national plan acknowledges the importance of resource security and management, referring to the water-energy-food nexus, which is central to the country's discourse.

Regarding the Water Sector, the national strategic development plan defines specific priority initiatives as presented in Table 6–1.

Table 6–1: Priority Initiatives for the Water Sector under 'Jordan 2025, a national vision and strategy' policy document (Source: Jouhari, 2018)

Targeted Scenario	Priority Initiatives
Enhancing the efficiency of irrigation systems	Increase the amount of water availability for irrigation in the Jordan Valley
	Develop, rehabilitate and expand irrigation projects
	Implement a strict monitoring program to ensure the quality of water used for agriculture and its compliance with international standards
	Encourage farmers to stop malpractices and increase investment in infrastructure
Expanding sanitation and re-use services	Maintain and rehabilitate drainage system and treatment plants
	Expand sanitation services and establish more sewage networks to serve new areas
	Focus on wastewater treatment and reuse in agriculture
	Contribute to the development of industrial water treatment plants

Regarding the energy sector, the plan notes the high dependency of Jordan to energy imports, since 97% of the country's energy requirements is imported. Jordan aspires to develop local renewable energy sources and implement energy efficiency measures. It is worth noting that energy used for water pumping

in 2014 accounted for 14% of the total energy production in Jordan (total amount of 1,424 GWh) (Ministry of Water and Irrigation, 2016b).

Regarding food security, the plan notes that 81% of food requirements are imported while imported basic food commodities increased. Additionally, the country is exposed to international price fluctuations. In this line, the Jordan vision for 2025 highlights the intention to promote agriculture and work towards increasing the contribution of the agricultural sector to the GDP (from 2.9% in 2013 to 3.4% in 2025) (Hashemite Kingdom of Jordan, 2015). The specific priority initiatives of the Agricultural sector include, among others, i) the promotion of organic agriculture and water efficiency for increased crop production and increased economic return of irrigated products, ii) the implementation of the National strategy for Food Security, iii) the promotion of the 30% shift from open field agriculture to protected agriculture; i.e. greenhouses, in both the Valley and the Highlands and iv) increase the support to existing farmers for increased water efficiency and productivity (Ministry of Environment of Jordan, 2016).

6.2 Institutional Landscape of Agricultural Water

The management of the water sector in Jordan is the responsibility of the Ministry of Water and Irrigation (MWI). The MWI aims to upgrade, develop and regulate the water sector and improve the quality of its services while it is responsible for policy development and strategic planning and monitoring of water and public sewage policies and interventions. The general mandate of the MWI is 'to develop strategies, policies and plans for the water sector' (p. 41, Salman et al., 2018). The ministry works in close collaboration with the other two water entities: the Water Authority of Jordan (WAJ) and the Jordan Valley Authority (JVA).

The **WAJ** is responsible for providing water and sanitation to the country[15]. Other responsibilities involve issuing license and monitoring of the groundwater extraction for agriculture (Al Quran, 2019). WAJ owns the three water utilities companies of Jordan; i.e. the Miyahuna, the Aqaba Water Company and the Yarmouk Water Company. The first two companies are currently managed and operated through public private sector partnerships (PPPs) while the latter is still under the management of WAJ (Al Quran, 2019). This is in line with Jordan's strategic vision (Jordan Vision 2025) which sets the intention for commercializing all water and wastewater utilities through public private sector partnerships (PPP).

The **JVA** is responsible for the socio-economic development of the Jordan Rift Valley and the development and distribution of water among the different economic sectors (power, tourism, agriculture, industry), from the King Abdullah Canal to Farm Turnout Assemblies (FTAs). JVA has developed Water User Associations (WUAs) to stipulate participation and transfer some operational functions of secondary and tertiary irrigation levels to farmers.

Other ministries involved in the water sector and the agricultural water management are the Ministry of Agriculture (**MOA**), the Ministry of Environment (**MoEnv**), the Ministry of Finance (**MOF**) and the Ministry of Planning and International Cooperation (**MOPIC**).

Regarding MOA, responsibilities include the development of the agricultural sector, improvement of water use efficiency at farm-level as well as in-farm issues such as the irrigation systems and cropping patterns (Jouhari, 2018). The general mandate of the MoA is to 'contribute to the achievement of sustainable development ensuing the preservation of the environment and agricultural resources and to promote self-sufficiency and rural development by matching production requirements of the internal markets with those of the external markets' (p. 25, Salman et al., 2018). MOA works in close collaboration with the National Agricultural Research Centre (NARC).

NARC is a research body that conducts applied agricultural research with the goal of improving technologies and facilitate continuous professional development[16]. NARC is responsible for research and

[15] Source: http://www.waj.gov.jo/sites/en-us/default.aspx#

[16] Source: https://menanwc.org/about-network/current-members/national-center-agricultural-research-and-extension-ncare

dissemination of appropriate technologies as well as capacity building for farmers. In this line, NARC proposed to develop a greenhouse as a training centre for capacity building and research in hydroponic technology. Moreover, the centre conducts research on some high value crops (pistachio, figs, palm trees) with the aim to diversify Jordan's agricultural production (Jouhari, 2018).

MoEnv is responsible for the development of policy frameworks that protect the ecosystem, promote a transition to green economy and sustainable development. In particular, MoEnv is responsible for adapting to climate change, which is expected to affect drought occurrence, fluctuation of rainfall and decrease of available water[17].

MOF and MOPIC are responsible for coordination between stakeholders and donors to realize and engage funding for the implementation of sustainable development in agriculture and water management (Jouhari, 2018).

6.3 Policies of the Ministry of Water and Irrigation (MWI)

Based on the national vision, the National Water Strategy 2016-2025 was drafted by the Ministry of Water and Irrigation (MWI). This strategy builds upon the two previous strategies; the 'Jordan Water Strategy and Policies' of 1998 and the 'Water for Life: Jordan's Water Strategy 2008-2022' of 2008. The main objective of the National Water Strategy 2016-2025 is to become more resilient for expected future pressures on the water supply and do business differently and more efficiently.

The National Water Strategy 2016-2025 consist of many different policies (Ministry of Water and Irrigation, 2016a). The policies address water competition over different economic sectors. Domestic water supply is set as a top priority, followed by industry and tourism, followed by agriculture (Water Demand Management Policy, Ministry of Water and Irrigation, 2016d). Official policies aim to reduce the non-revenue water. For the agricultural sector, the Water Demand Management policy aims at maximizing the utilization of available water resources by raising water use efficiency with more efficient irrigation systems, adopting programs that reduce water losses (on-farm and conveyance), expanding water harvesting and appropriate water pricing. Linked to this policy is the policy that aims at substituting surface water used in irrigation and other economic sectors with treated wastewater as much as possible (Water Substitution and Re-use Policy, Ministry of Water and Irrigation, 2016c). Treated wastewater plants in Jordan have been expanded and rehabilitated lately, with GIZ and USAID being involved in these processes. Treated wastewater is considered an additional water resource that is given priority in the agricultural sector for unrestricted irrigation (Ministry of Water and Irrigation, 2016b,c). The increased use of wastewater is expected to free surface and groundwater used by agriculture that can be used for domestic purposes (Water Reallocation Policy, Ministry of Water and Irrigation, 2016b, and Surface Water Utilization Policy, Ministry of Water and Irrigation, 2016e). This way, groundwater use in agriculture is aspired to be reduced and controlled. However, as it was discussed in section 4.1., TWW re-use in agriculture comes at the expense of groundwater resources. Hence, the sustainability of groundwater is under question, despite the Groundwater Sustainability Policy (Ministry of Water and Irrigation, 2016f).

The three main targets of the strategy are: to increasing the water supply in order to meet increasing water demand, increase the domestic water supply and to reduce the groundwater over abstractions (Table 6–2).

[17] Source: https://www.jordanewe.com/about-sector/ministry-environment

Table 6–2: Water sector Indicators and Targets for 2025 (Source: Ministry of Water and Irrigation, 2016a)

Goal	Indicator	2014	2025
Financial Sustainability	Percentage of Operation and Maintenance Coverage	70%	127%
	Government Support (Million JD)	170	180
	Net Debt (Million JD)	1,170	1,200
	Energy Used per Mm^3 billed (KWh/Mm^3/billed)	4.31	3.66
Enhance the service of Water and Wastewater	Percentage of Water Service Coverage	94%	95%
	Percentage of Wastewater Service Coverage	63%	80%
Supply of water to meet the Demand for all uses	Water Share per Capital (L/C/D)	61	105
	Available Water Resources (Mm^3/year)	832	1,341
	Dams Storage Capacity (Mm^3)	325	400
	Percentage of Non-Revenue Water	52%	30%
Water Resources Sustainability and Protection	Percentage of over Abstraction	160%	140%
	Percentage of Protected Resources	35%	60%

As seen in Table 6–2, there are ambitions for substantial increase of the available water resources. The National Water Strategy aspires to increase water resources by 509 Mm^3 between 2014 and 2025 (from 832 to 1,341 Mm^3). Even if this increase refers to 'sustainable water resources' and 'groundwater over-abstractions' are indeed decreasing over the years, the 'non-renewable groundwater resources' are more heavily exploited (see Annex 1). This contradicts the principle of the Environmental Sustainability Policy, as more non-renewable water is being exploited. The total water resources are aspired to increase by 467.5 Mm^3 between 2015-2025 (from 992 to 1,459 Mm^3, including the decreasing 'groundwater over-abstractions'), coming from increases in surface water by 57.5 Mm^3, groundwater extraction by 115 Mm^3, TWW re-use by 130 Mm^3 and desalinated water by 165 Mm^3 between 2016 and 2025 (Table 6–3). Figure 6-1 presents the allocation of different water sources to the different economic sectors.

Table 6–3: Additional Water Supply by 2025, (Source: Ministry of Water and Irrigation, 2016a)

Projects	Additional Water Supply by 2025 (Mm^3)	
RSDSC	85 150	20 Mm^3 to agriculture, Phase 1 Phase 2, total
Multiple projects for Groundwater	115	
Multiple projects for Dams	20.5	
Desalination	15	
Household Water Harvesting	7	
Wadi Arab Water System II (from KAC to the city of Irbid)	30	
TWW	94	to agriculture
Marginal Water	36	partially to agriculture
Total	**467.5**	

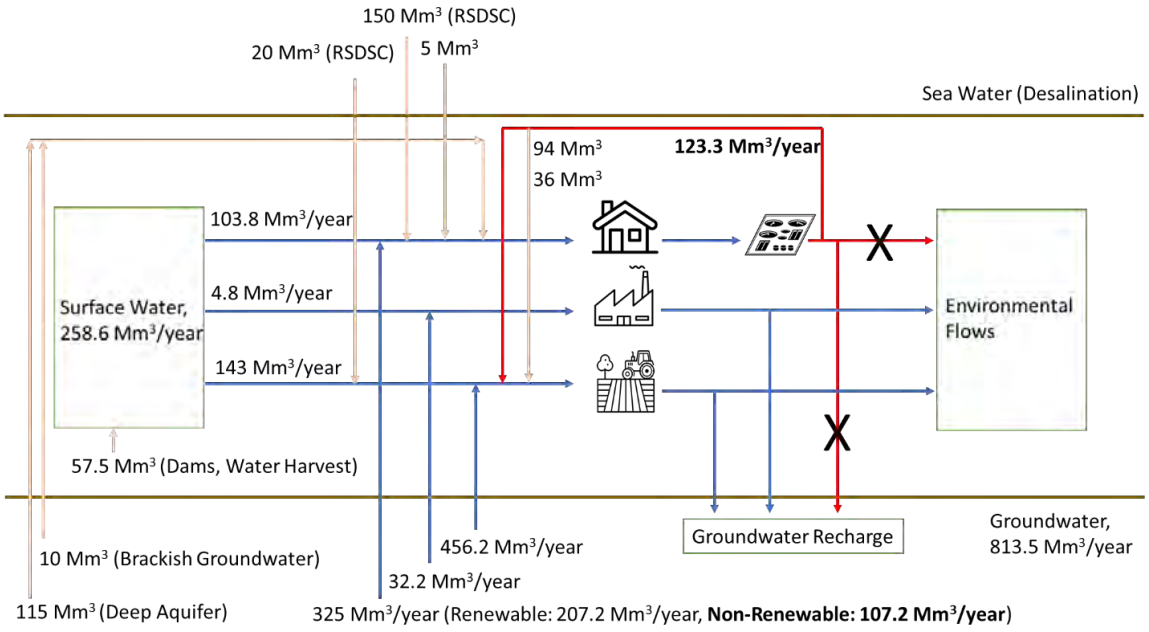

Figure 6-1: Allocation of increased water budget by 2025 to the different economic sectors of Jordan

Despite the concrete targets of Jordan in terms of water sourcing, there are limited information regarding the water balance of the country, raising questions regarding the feasibility of such increases. Jordan's desalination plans are indeed absolute additions to the water balance that can increase the water budget. However, as the water consumption of each sector is not known, the water balance contains major uncertainties, making it virtually impossible to assess the feasibility of proposed policy changes for groundwater extraction, maximizing the utilization of available surface water resources and treated wastewater. Information on the water balance is crucial for the understanding of the interactions between surface water, groundwater and environmental flows. Based on these interactions it can be assessed whether the desired increases of the water budget are sustainable. With the limited data that there are on water consumption levels, the contradiction that is evident between TWW re-use and groundwater extractions was made visible (see section 4.1.). Similar issues might hold true also for the increased availability of surface water. For example, ambitions to increase surface water supply might result in reducing the water available for other non-productive purposes such as groundwater recharge and environmental flows, leading to negative water balance. As such, the ambitions for increasing the water supply seem to be overly ambitious. Especially because there no studies for the water consumption and thus, it is unknown how the water balance will be affected.

Regarding agricultural water policies, an overall cap on irrigation water at 700 Mm³/year has been set (Annex 1). Agricultural water use for 2014 exceeded this cap by 22.5 Mm³/year. As such, water use should be reduced by 22.5 Mm³. Increasing irrigation efficiency by 4-5% already would suffice to meet this small decrease in agricultural water use. Considering that increasing efficiency is another policy goal, higher increases in efficiency are expected. This will result in increasing the water that can be captured and potentially can increase the water consumption in agriculture.

In order to implement this capping policy, appropriate water tariffs are proposed. Pricing of both ground and surface water used for irrigation is seen as a means to promote water efficiency, economic efficient cropping patterns and high economic return (Ministry of Water and Irrigation. 2016b). The Water Demand Management Policy explicitly notes the importance of 'identif[ing] a rational price to guarantee costs recovery, taking into account applying of cost-saving innovations, as prescribed in substitution and re-use policy for Treated wastewater or blended water.' (p. 10, Ministry of Water and Irrigation, 2016d).

Agricultural water pricing in the Jordan Valley is currently maintained at the prices of 1994. The water prices are presented Table 6–4. JVA is responsible for billing and the collection of the fees and for 2010 the

authority collected 75% of billed water charges. Costs of the JVA (including the domestic and industrial sector) are not covered by water prices (Berg & Al Nimer, 2016). For this reason, and in absence of the separate agricultural costs of JVA, it is assumed that current agricultural water prices are not covering the costs.

Table 6–4: Irrigation Water Tariffs in the Jordan Valley (Source: Berg & Al Nimer, 2016).

Volume of Water Consumed (m^3/month)	Current Unit Price (JD/m^3)
0-2,500	0.008
2,501-3,500	0.015
3,501-4,500	0.020
More than 4,500	0.035

Groundwater pricing policies to control the use of groundwater for agricultural purpose have a long history in Jordan. The last decade, much action and interventions in Jordan have focused on controlling groundwater with limited results. Since 1992 Jordan has introduced policies regarding drilling bans to control the number and expansion of well and lay the rules of well drilling and use. In 2002, Jordan decided to legalized illegal well. In 2014, wells that were not legalized recently and were older than 2005 were considered illegal and liable to be backfilled (Molle et al., 2017). Most illegal wells are to be found in areas with unclear land rights, which complicates the legalization of wells. In the Azraq area, where land rights are unclear, drilling illegal wells is still taking place (Al Naber & Molle, 2017). In the Amman Zarqa Basin (AZB), 95% of wells are legalized. Other measures implemented in Jordan to control the abstraction levels are, among others, to create awareness, impose quotas, water metering and water pricing. Water pricing level is based on the type of well; i.e. licensed or well with permit or illegal wells. Another category involved wells in Azraq region. High pricing is implemented in this region due to the shallow nature of the aquifer and the protection of the groundwater for domestic supply. For illegal wells, water prices are extremely high and thus agriculture is only profitable under the use of greenhouses. Despite these new policies, farmers circumvent these measures by rewinding or bypassing the water meters or deepening their well. As such, there is a gap between official policies and actual groundwater use on the ground (Molle et al., 2017). As such, higher water tariffs are no expected to promote efficient use and water savings (Venot & Molle, 2008).

Lastly, agricultural development in the Valley has been given a priority over the Highlands. Policies aim at capping the freshwater water allocated to irrigation in the highlands at current levels and become replaced by treated wastewater (Ministry of Water and Irrigation, 2016b). Contrary, irrigation water in the Jordan Valley is envisioned to be increased (when this would be feasible) with reclaimed non-revenue water, new water sources (desalination) and wastewater (Ministry of Water and Irrigation, 2016b). As discussed above, the use of non-revenue water and TWW use in agriculture might negatively affect the water balance of Jordan.

In the official policies, the prioritization of the Jordan Valley over the irrigated Highlands is justified by the unsustainable and inefficient agriculture in the irrigated Highlands and the high economic value of production in the Valley. The Jordan Valley produces double the value of agricultural products of the Highlands, contributing significantly to food security while consuming less than 40% of the water consumed in the Highlands (Ministry of Water and Irrigation, 2016f). Even through in the Water Substitution and Re-Use policy the term 'water consumed' is used, it is most probable that this refers to water applied since the main policy for the Valley is to increase water productivity through reducing losses and non-beneficial water use. Additionally, shifting to higher-value crops is also envisioned. The main policy for the Highlands is to reduce the use of groundwater resources. In the Groundwater Sustainability Policy, it is indicated that groundwater for irrigation purposes should be given priority in case of i) existing sustainable projects with high capital investments and advanced irrigation methods, ii) poor water quality that does not qualify for municipal use or industrial purposes and ii) supplementary irrigation from groundwater.

6.4 Policies of the Ministry of Agriculture (MOA)

Agriculture and agricultural development is expected to be affected the most from the new water policies. The main body for the development of agriculture is the Ministry of Agriculture (MOA).

During 2001, an advisory committee comprising of five agricultural sub-sectors (rainfed, irrigated in Jordan Valley and the Highlands, animal production and marketing) drafted the National Strategy for Agricultural Development, 2002-2010. This strategy recognized the declining trend in the agricultural sector and noted that agriculture was neglected and perceived as a 'burden on the national economy' (p. 2, Hellaliaghdam et al., 2003). Additionally, it is state that inaccurate data and statistics have created a negative attitude towards agriculture. Similar findings regarding inaccuracies in water budgeting, were reported by Vervelde et al., 2020.

The Ministry of Agriculture (MOA) developed the National Strategy for Agricultural Development (NSAD) 2016-2025[18], in alignment with the Jordan's vision. The goal of the strategy is a 'sustainable development of agricultural resources that will preserve the country's animal and plant biodiversity, favour an investment climate in the sector and create a close link between production and market demand. This objective will result in a reduction of migration from country [countryside] to city and the guarantee of greater food security for the whole country, together with the economic benefits of increased exports.' [19].

During 2020, an updated version of the agricultural strategy of 2016 was released; i.e. National Strategy for Agricultural Development (NSAD) 2020-2025. The ultimate goal of the strategy is to increase economic value obtained from agriculture without increasing water use, through shifts to high-value crops and more water efficient crops. As such, the focus is mostly on water use efficiency gains. In terms of water resources, it is recognized that agricultural sector will have to face the burden of using TWW, with technical and environmental issues as well as human health considerations to be managed.

The main targets of this policy focus on increasing the exports of high-value fruits and vegetables by establishing agricultural export chain, improving the quality of production through better post-harvest management and packaging as well as reducing the costs of exports by 12%. In particular, the costs of air freight are envisioned to reduce and assure better opportunities for the European market. Exports are aspired to constitute 24% of total agricultural production in 2015 (from 18% in 2014). Great attention for exports is paid to date cultivations. As Jordan's date production has increased 1880% during the last 20 years[20], the strategy wants to explore further options in establishing a national fund for dates and register a national brand for Jordanian date products. Other targets involve increasing the efficiency of irrigation water use and increasing the productivity per cubic meter of water, increase the agricultural area using drip irrigation by 0.1% annually, expand support to farmers in order to increase higher productivity and efficiency in existing farms as well as increasing the value of agricultural production by 3% annually. As also mentioned in the national strategic plan of Jordan, there is a target of increasing the contribution of the agricultural sector to the GDP by 0.5% between 2014 and 2025 while also increasing the agricultural GDP growth rate from 18% in 2014 to 24% in 2025. Interestingly, the strategy targets to increase the number of Jordanians working in agricultural sector. Currently, immigrant workers in agricultural sector constitute around 70% of total hired labour.

In the strategy, the challenges that the agricultural sector had gone through during the past years are briefly mentioned. The strategy recognized that after 2014 there was a significant decline on vegetable and fruit exports both to Arab countries as well as EU, as a consequence of the crisis in Syrian and Iraq as well as

[18] FAO brief of the NSAD 2016-2025. The strategy is only available only in Arabic http://www.fao.org/faolex/results/details/en/c/LEX-FAOC166604/

[19] FAO brief of the NSAD 2016-2025. The strategy is only available only in Arabic http://www.fao.org/faolex/results/details/en/c/LEX-FAOC166604/

[20] Authors' calculations based on FAOSTAT data

the Qatari crisis which resulted in the closure of trading routes. The COVID19 pandemic revealed the limited capacity for agricultural cold storage.

7 Enabling Environment and Implementation Challenges

Jordan has recognized the need to manage its water resources more efficiently and productively as seen in the previous sections. Jordan, through different water policies, sets a clear vision for the future of water management. Under water scarcity conditions and the increased competition among sectors, Jordan prioritizes water allocation based on the concept of economic water productivity. As such, domestic and industrial sector are prioritized over agriculture. In terms of water resources, additional desalinated water for mainly domestic purposes is added to the water budget of the country. Jordan aspires to move agricultural water use away from groundwater use and mainly towards TWW. At official level, agricultural groundwater pricing policies have been developed as a means to control the use of groundwater since 1992. However, unregulated groundwater use for irrigation purposes is still taking place in the Highlands, resulting in increased pressure to groundwater resources. Remarkably, Jordan has officially recognized unregulated groundwater use and has included (to some cases) the estimated quantities in the calculations of water use for 2014. This is indicative of Jordan's will to control groundwater and ensure sustainability.

Despite this clear policy choice of prioritizing domestic over agricultural water use, Jordan recognizes the importance of agricultural sector for food security, economic and social prosperity. Jordan's food security depends on agricultural exports and around 90% of its staple food needs are imported (Salman et al., 2018). This renders Jordan highly vulnerable to external markets. Following the years of the Syrian civil war, Jordan experienced decreases in exports due to the closure of exporting routes. In this light, Jordan aims at improving the economic performance of the agricultural sector and targets on increasing the sector's exports, its contribution to the GDP, its value and its growth rates. These increases are expected to materialize through changing to high-value crops, better export market opportunities, improved quality of production and better post-harvest management. Additionally, Jordan acknowledges the great potential of the sector for increasing job opportunities and the importance for woman workers in rural areas. This indicates that Jordan considers agriculture as an important pillar of development for the country.

The question that arises is whether Jordan can boost agricultural sector's development under decreased agricultural water use while simultaneously ensuring that no more water is consumed by agriculture. As agricultural water use is to be capped at 700 Mm^3 and agricultural water use is currently at 725 Mm^3, reductions in water use will need to take place. Efficiency improvements and appropriate pricing are envisioned as a means to reduce water use. A possible efficiency improvement of 3-5% would suffice to reduce agricultural water use under the set cap. However, if greater efficiency improvements take place, more water will be captured and could potentially be used, resulting in higher water consumption. In general, by increasing efficiency of irrigation systems, farm-level water losses are reduced, resulting in more water being available in one place but less being available to another place. As such, these farm-level water losses might be used further downstream for other productive (other farms) or non-productive purposes (environmental flows, groundwater recharge). These productive and non-productive water uses are not taken into consideration as there are no figures on the water balance of the country, which points towards another challenge of the Jordanian policies.

More information regarding the water balance of the country is necessary in order to better understand the interactions between surface water (including treated wastewater) and groundwater. As Jordan provides figures for water use (see Table 4-1), rather than water consumption, non-productive water uses (such as groundwater recharge and/or environmental flows) are not included. This tends to create a sense that the used quantities of water of each sector are consumed. However, this does not hold true. Looking at the domestic water supply (429 Mm^3), around 70% (305.7 Mm^3) seems to be used by the sector while around 30% (123.3 Mm^3) are treated and used in agriculture. Considering that non-renewable groundwater

extraction for domestic sector is 107.2 Mm^3 and that the re-used TWW is 123,3 Mm^3, it can be argued that TWW re-use comes at the expense of groundwater. As such, TWW re-use is not an addition to the water budget but rather an increase in the water consumption of the national water budget for productive uses. The increased consumption will, most probably, have a negative effect in the water balance of the country, as more unsustainable groundwater will be used. Similar issues are arising for the targets regarding maximizing the utilization of available surface water resources. As return flows are not taken into consideration (groundwater recharge, environmental flows), increased consumption of surface water might also affect the water balance of the country. Even if this might have limited importance when wanting to understand the narrative of the overall water policies, water consumption figures are essential for assessing the biophysical water productivity and how proposed interventions are going to influence the water balance of the country. In absence of these figures, the only safe, non-affecting the water balance option for increasing the water budget is through desalination. Jordan has also targets to increase its desalinated water budget.

TWW re-use in agriculture posses challenges regarding related to environmental issues such as soil salinity and health risks. TWW has a low water quality which restricts its reuse, depending on the level of treatment. Also, as issues of soil salinity might arise, agricultural production might be affected, resulting in lower yields and/or lower quality of products. In the context of Jordan, it seems that the two ministries have different aspirations for the use of TWW. MWI advocates for unrestricted use of treated wastewater. MOA has a more hesitant stance, advocating for treated wastewater use in fodder and tree crops to avoid health risks (Al Naber et al., 2019).

Despite the clarity of the policies in terms of vision, policies are scattered in many different documents instead of a comprehensive and holistic strategy. The absence of a comprehensive strategy is also expected to result in difficulties of implementation and monitoring of the policies as well as coordination between different stakeholders and sectors. Previously drafted reports explicitly note that coordination between the different ministries and stakeholders is a challenge in the Jordanian context (Jouhari, 2018; Salman et al., 2018).

In the process of drafting this policy review, the challenge of accurate and reliable data and statistics also appeared relevant. This challenge is stated by the National Strategy for Agricultural Development, 2002-2010 (Hellaliaghdam et al., 2003; Vervelde et al., 2020). As discussed in chapter 4, contradictory data were found regarding the total agricultural area. Moreover, information in the official policy documents was sometimes incosistent as in some cases unregulated groundwater was accounted and in other cases it was not. This made the understanding and cross-checking of the different policy documents challenging.

Lastly, to overcame these challenges in the agricultural sector, the Netherlands is supporting different interventions in Jordan's agriculture. The report of Groot et al. (2018) focused on providing the Embassy a comprehensive programme that supports the horticulture sector in transitioning into a 'sustainable, competitive, inclusive and market-oriented sector' (p. 7). The Embassy of the Kingdom of the Netherlands also sees opportunities in supporting skills and knowledge development in the horticulture sector throught the Agricultural Knowledge and Innovation System (AKIS). As a continuation of the report from Groot et al. (2018), a report for a more detailed proposed application of AKIS was conducted by Sixt & Poppe (2019). Other projects in the Food and Nutrition Security (FNS) by the Dutch Embassy involve the Hydroponic Aquaculture and Employment Development Project (HEAD-Jo), the Pilot project Inclusive Horticulture Value Chain Jordan, the Export Promotion (by the Centre for Promotion of Imports from developing countries, CBI) and the Jordan Food Nutrition and Safety (Pesticides) Program (Nuffic, n.d.).

8 Water Productivity and related indicators

Economic Water Productivity is central to the development policy of Jordan towards 2025. Competition for water among different sectors is to be resolved through prioritizing firstly the domestic water use and then the sector with the higher economic return. However, rationing water provided to agriculture and the other sectors, is expected to be a challenge. Agriculture consumes the greatest amount of water while (directly) contributing the least to the GDP, which can justify providing less water for agriculture. On the other side, Jordan aims to support agricultural development through other non-conventional water sources. Even though these two aspects are not exactly contradictory, in the absence of more clear action plans of the quantity, quality and sources of water, the development of agriculture is uncertain.

9 Conclusions

Based on the analysis conducted for Jordan in the context of the WaterPIP project, the following main conclusion points are noted:

- Jordan has recognized the need for increasing resilience to water scarcity and improving food security by developing the agricultural sector. There seems to be an enabling environment as awareness for these issues is high and reflected in the national water and agricultural policies.
- Jordan water policies prioritize economic sectors based on the concept of economic water productivity. As such, domestic and industrial sectors are prioritized over agriculture.
- Issues of groundwater sustainability are central in national policies. Jordan has clearly shown the political will to control and reduce the issue of (unregulated) groundwater over-abstractions in agriculture. However, how the set policies are going to be implemented on-the-ground is to be seen.
- Jordan aspires to cap agricultural water use and increase agricultural economic output. To achieve this, agricultural development strategies focus on increasing the quality and value of production. However, as agriculture has the least priority for water use, a new major challenge arises for the future to even further reduce water use by agriculture. This is a challenge that should be tackled by the entire agricultural sector.
- There is an apparent competition between groundwater for domestic and agricultural purposes. Around 55% of the groundwater is used in agriculture and 40% is used in domestic water supply while groundwater contributes 75% of domestic water use and 65% to agricultural water use.
- There is a clear policy to move agricultural water use from groundwater towards TWW and domestic water use from groundwater towards surface water, desalinated water and groundwater (in priority). To assess whether such changes on water resource base are viable and sustainable for Jordan, water consumption values are necessary. Without these figures, the only safe, non-affecting the water balance option for increasing the water budget is through desalination. Jordan is indeed having concrete targets for increasing desalinated water.
- Limited analysis of the water balance of Jordan for the interaction between groundwater and TWW re-use (see Figure 6-1) shows that TWW re-use comes at the expense of groundwater sustainability, thus negatively affecting the water balance.
- In terms of agricultural production, the two agricultural areas; i.e. the Jordan Valley and the Highlands, have different challenges and opportunities. Production in the Jordan Valley is mostly focused on vegetables while in the Highlands stone-fruits are cultivated. In terms of water

resources, the Jordan Valley uses mostly surface water while future plans envision increased use of TWW. In the Highlands groundwater is mostly utilized, with substantial unregulated groundwater use. The unregulated groundwater use poses a great challenge for controlling and reducing the groundwater use in the Highlands.

Jordan's resource base is under an extreme strain. As population growth increases, this trend will further exacerbate and the needs for more water and food will also increase. As such, Jordan is faced with a dire situation. In order to adapt to these new trends, Jordan aims at increasing the economic value of agriculture without increasing agricultural water use[21]. Jordan has taken significant steps to achieve this both from improving economic benefits coming from agricultural production as well as capping agricultural water use. However, as the agricultural water source is changing from groundwater to TWW, there is a risk that more water will be consumed by agriculture.

[21] Considering the reduction from 725 Mm^3 to 700 Mm^3 negligible.

10 References

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11 Annex 1

Development of Resources and Projected Demand in Mm^3/year (Source: Ministry of Water and Irrigation, 2016b)

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Groundwater Safe yield	275	275	275	275	275	275	275	275	275	275	275
Non-renewable groundwater	144	145	146	147	178	189	174	240	241	242	243
Groundwater Over Abstraction	160	156	152	148	144	140	136	131	127	122	118
Surface water (Local + Tiberius Lake)	263	265	267	269	271	276	284	293	306	311	329
Treated wastewater	140	140	175	176.6	176.6	181.6	191	191	195	195	235
Additional Resources (Desalination + SWAP)	10	11	12	18	19	20	106	107	108	109	260
Total Resources	**992**	**992**	**1027**	**1034**	**1064**	**1082**	**1165**	**1237**	**1251**	**1253**	**1459**
Sustainable Resources	**832**	**836**	**875**	**886**	**920**	**942**	**1030**	**1106**	**1125**	**1131**	**1341**
Municipal, Industrial, Tourist demands	701	703	712	717	723	730	737	746	755	766	778
Irrigation demand	700	700	700	700	700	700	700	700	700	700	700
Oil shale and Nuclear power demand	-	-	-	25	25	25	48	48	48	70	70
Total demand without irrigations	**701**	**703**	**712**	**742**	**748**	**755**	**785**	**793**	**803**	**836**	**848**
Total Demand	**1,401**	**1,403**	**1,412**	**1,442**	**1,448**	**1,455**	**1,485**	**1,493**	**1,503**	**1,536**	**1,548**
Deficit in MCM/a (with over abstraction)	**(409)**	**(411)**	**(385)**	**(408)**	**(384)**	**(373)**	**(320)**	**(256)**	**(252)**	**(283)**	**(88)**