Food and Agriculture Organization of the United Nations

# An assessment of policies, institutions and regulations for water harvesting, solar energy, and groundwater in Jordan

## A review and gap analysis

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# Acronyms and abbreviations

| | |
|---|---|
| **AgWA** | Agricultural Water for Africa |
| **AWM** | Agriculture Water Management |
| **BRP** | Badia Restoration Program |
| **CEGCO** | Central Electricity Gen. Co |
| **DoS** | Department of Statistics |
| **EDCO** | Electricity Distribution Company |
| **EMRC** | Jordanian Energy and Minerals Regulatory Commission |
| **GDP** | Gross Domestic Product |
| **GEL** | General Electricity Law |
| **HEIS** | Households Expenditures and Income Survey |
| **IDECO** | Irbid District Distribution Company |
| **IPP** | Independent Power Producers |
| **IWRM** | Integrated Water Resource Management |
| **JEPCO** | Jordan Electric Power Company |
| **JOD** | Jordanian Dinars |
| **JVA** | Jordan Valley Authority |
| **KAC** | King Abdullah Canal |
| **MCM** | Million Cubic Meters |
| **MEMR** | Ministry of Energy and Mineral Resources |
| **MoA** | Ministry of Agriculture |
| **MWI** | Ministry of Water and Irrigation |
| **NEPCO** | National Electric Power Company |

| | |
|---|---|
| **NGO** | Non-Governmental Organization |
| **NWMP** | National Water Master Plan |
| **PVP** | Photovoltaic Pumping |
| **SDGs** | Sustainable Development Goals |
| **SEPCO** | Samra Electricity Power Company |
| **WAJ** | Water Authority of Jordan |
| **WFP** | World Food Program |
| **WSP** | Waste Stabilization Ponds |

# Focus and scope of this report

This report constitutes part of the project GCP/JOR/018/SWI: "Reduce vulnerability in Jordan in the context of water scarcity and increasing food/energy demand" project, funded by the Swiss Agency for Development and Corporation (SDC).

Water scarcity has long been a major challenge in Jordan due to limited available water resources, waste disposal issues, inadequate infrastructures and feeble enforcement of regulations. Furthermore, the expected rise in population growth and refugee influx will likely aggravate Jordan's water crisis in the near future. The rationale of this project is to, therefore, reduce vulnerability of the rural Jordanian and the disadvantaged communities in the context of water scarcity for agriculture, increased demand for food and livelihood provision from growing populations, and rising energy demand. To this end, the project pilots a three-pronged, community-based approach, combining water harvesting, conjunctive use of groundwater and surface water, and solar power for lifting irrigation water.

The purpose of the three-pronged approach is to increase sustainability and management efficiency in the use of agricultural water resources in rural areas. Water harvesting allows the capture of resources that otherwise would have evaporated. The resulting impounded surface water serves as both a source of water for rural communities and as a source of groundwater recharge through percolation and seepage. Conjunctive use of groundwater and the captured surface water ensures the reliability of water supply for rural communities and lessens the dependence on groundwater alone. The conjunctive use of groundwater and surface water, thus, reduces groundwater over-exploitation. Moreover, solar-powered irrigation then provides a sustainable source of energy for lifting water. Finally, the partial mounting of solar panels over the water harvesting structure shelters the surface of the water from sunlight and wind thereby introducing efficiency gains as evaporation is reduced.

The objective of this report is to address project output 4: "Prepared appropriate long-term policy, regulatory and institutional frameworks to facilitate the adoption and scale-up of the three-pronged approach and integrate it within national food-water-energy related policies/ strategies and programmes", activity 1: "Review and evaluate previous strategies related to individual components of three-pronged approach in the region".

The report constitutes a review of the key institutional actors, regulatory frameworks and policies in the water harvesting, solar energy and ground water sectors, and an analysis of the corresponding policy and institutional gaps.

Section 1

# Water resources

Photo: © Maher Salman

Jordan is among the ten most water stressed countries in the world. It has an estimated renewable water resources base of around 780 million $m^3$, of which 275 million $m^3$ is groundwater, with the remainder coming from surface water sources such as the Yarmouk River and runoff stored in Wadis. There is also approximately 116 million $m^3$/year available from treated wastewater, which is stored inside Wadi dams and then used for irrigation in the Jordan Valley (FAO, 2013).

Water scarcity is driven primarily by the arid to semi-arid climatic regime – 92 percent of the country receives average precipitation of less than 200 mm/year (MWI, 2016a) – and by the population boost experienced in recent decades as a result of both natural growth and immigration/refugee intake.

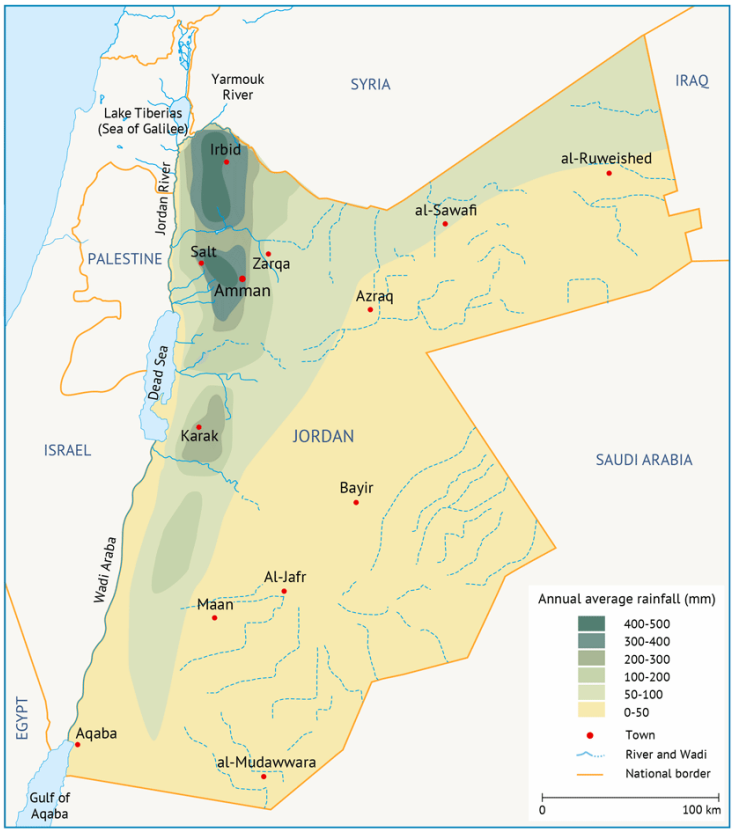
The 2014/2015 average annual rainfall volume was 8 884 MCM (MWI, 2015). Reports show that in the past several decades, the rainfall volume has decreased by up to 20% (Table 1), mostly due to the effects of climate change.

**Table 1:** Rainfall volumes 2005-2015

| Year | Rainfall Volume (MCM) | Long-term average (MCM) | Deviation from Long-term average |
|---|---|---|---|
| 2004/2005 | 9 304 | 8 352 | 952 |
| 2005/2006 | 6 258 | 8 322 | -2 064 |
| 2006/2007 | 7 683 | 8 313 | -630 |
| 2007/2008 | 5 194 | 8 269 | -3 075 |
| 2008/2009 | 6 379 | 8 243 | -1 864 |
| 2009/2010 | 8 728 | 8 249 | 479 |
| 2010/2011 | 6 477 | 8 225 | -1 748 |
| 2011/2012 | 5 943 | 8 195 | -2 252 |
| 2012/2013 | 8 120 | 8 194 | -74 |
| 2013/2014 | 7 228 | 8 181 | -953 |
| 2014/2015 | 8 884 | 8 191 | 693 |

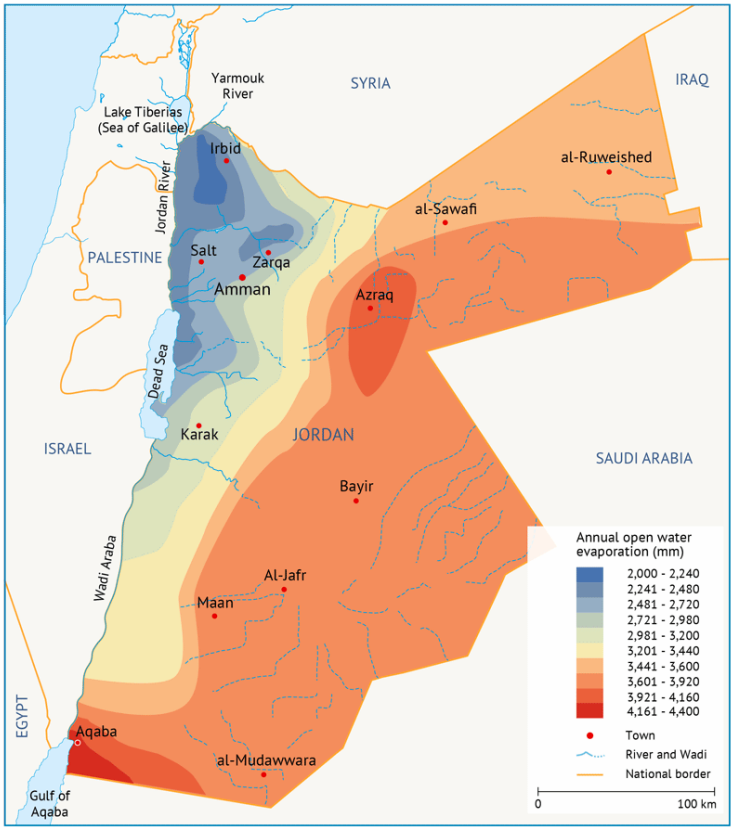
*Source: MWI, 2015*

**Figure 1:** Annual average rainfall




*Source: Fanack after MWI, 2015*

**Figure 2:** Annual open water evaporation




*Source: Fanack after MWI, 2015*

At present, total water use exceeds the renewable supply, with the balance being met mostly by groundwater over abstraction and reclaimed wastewater, and to a lesser extent by small-scale desalination.

In 2015, the Ministry of Water and Irrigation (MWI) estimated water availability to be 1 008 million cubic meters (MCM), and water demand 1 222 MCM with a deficit of 214 MCM as illustrated in Table 2.

**Table 2:** Development of resources and demands in MCM

| Indicator | 2015 | 2020 | 2025 |
|---|---|---|---|
| Groundwater safe yield | 275 | 275 | 275 |
| Non-renewable groundwater | 144 | 189* | 243** |
| Groundwater over abstraction | 160 | 140 | 118 |
| Surface water (Local + Tiberius Lake) | 263 | 276 | 329 |
| Treated wastewater | 140 | 181,6 | 235 |
| Additional resources (Desalination + SWAP) | 10 | 20*** | 260 |
| Total resources | 992 | 1 082 | 1 459 |
| Sustainable resources | 832 | 942 | 1 341 |
| Municipal, industrial, tourism demands | 701 | 730 | 778 |
| Irrigation demand | 700 | 700 | 700 |
| Oil shale and nuclear power demand | – | 25 | 70 |
| Total demand without irrigations | 701 | 755 | 848 |
| Total Demand | 1 401 | 1 455 | 1 548 |
| Deficit in MCM/a (with over abstraction) | (409) | (373) | (88) |

*Source: MWI, 2016a*

Jordan's water deficit is projected to become even more severe in the near future. Assuming that renewable supplies were to remain constant, increases in demand are projected to lead to a fall in per capita water availability to 90 $m^3$ by 2025. However, climate models for the region predict a decrease in winter rainfall and an increase in mean annual temperature (FAO, 2013), which will reduce the renewable water supply and further exacerbate water scarcity. The high rates of groundwater over-abstraction cannot be sustained either, as pumping costs and salinity levels will continue to increase (FAO, 2013).

The severe water shortages likely to be faced by Jordan require a comprehensive approach to managing both water supply and water demand. While the national government has placed a priority on meeting domestic water needs, the importance of the agricultural sector to rural employment necessitates a considered approach to improving agricultural water security. Augmenting the water supply for agriculture can make an important contribution to achieving this. Large-scale seawater desalination has been promoted as the long-term solution to Jordan's water scarcity problems, but the cost involved does not make this a viable

option for supporting agriculture. Alternative lower-cost approaches are needed to diversify agricultural water supply.

## Surface water

Surface water resources are unevenly distributed among 15 basins. River flows have a large seasonal and annual variation. The largest source of external surface water is the Yarmouk River, which enters from the Syrian Arab Republic, then joins the Jordan River. The natural annual flow of the Yarmouk River is an estimated 400 MCM. Currently, however, the total actual flow is much lower. The Yarmouk River is the main source of water for the King Abdullah Canal (KAC) and is, thus, considered the backbone of development in the Jordan Valley. The current flow from the Yarmouk River to KAC is around 135.15 MCM per year. Other surface water sources are side Wadis, mainly the Zarqa River, controlled by the King Talal dam, where water flows from the dam to KAC for irrigation. There are also ten small side Wadis that flow from the mountains to the Jordan Valley. Dams on each Wadi store water from runoff in the winter for flows to the Jordan Valley for irrigation in the summer. The total capacity of the dams is around 375 MCM (FAO, 2013).

## Groundwater

Jordan's groundwater is distributed across 12 major basins, ten of which are renewable groundwater basins and two, in the southeast, are fossil groundwater aquifers. Total internal renewable groundwater resources are an estimated 275 MCM/year (FAO, 2013).

Groundwater resources are mainly concentrated in the Yarmouk, Amman–Zarqa and Dead Sea basins. Currently most groundwater is exploited at maximum capacity, in some cases beyond safe yield. Of the twelve-groundwater basins, six are overexploited, four are balanced, and two are underexploited (Hammad and Sarhan). Overexploitation of groundwater resources has degraded water quality and reduced exploitable quantities, resulting in the abandonment of many municipal and irrigation water-well fields, such as in the area of Dhuleil.

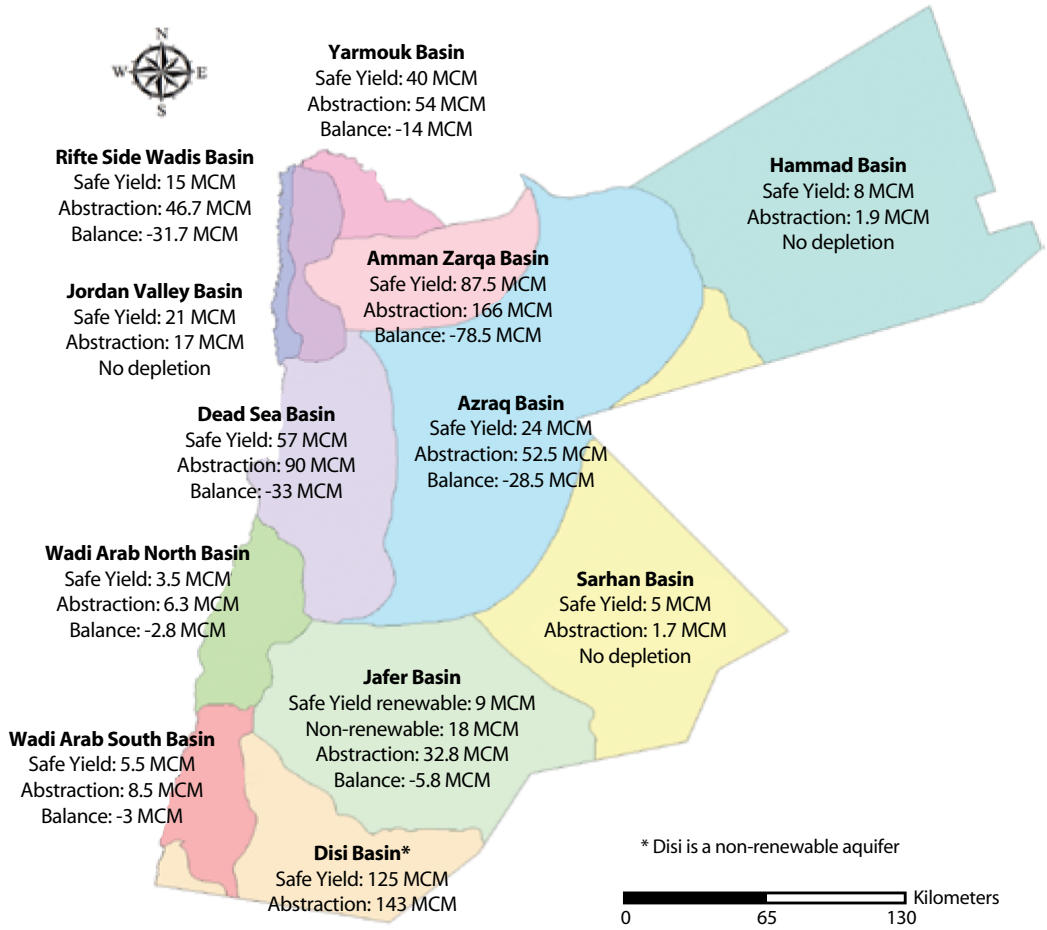
The main non-renewable exploited aquifer is the Disi aquifer (sandstone fossil) in southern Jordan, with an estimated safe yield of 125 MCM/year for 50 years. Other non-renewable water resources are found in the Jafer basin, for which the annual safe yield is 18 MCM. The Water Authority of Jordan (WAJ) estimates that the total safe yield of fossil groundwater is 143 MCM/year for 50 years. In 2007 water withdrawal was 940 MCM with 64 percent diverted to agriculture, 30 to domestic use, 5 to industrial use and 1 percent to the tourism industry. In 2010 water withdrawal was 970 MCM with 59 percent destined to agriculture, 34 percent to domestic use, 6 percent to industrial use and 1 percent to tourism.

During periods of water shortage strict measures are taken such as rationing water allocations, and reducing or banning the cultivation of irrigated summer vegetables.

## Wastewater

Wastewater in Jordan can be defined as very concentrated with high salinity. The high strength is due to the low per capita consumption of water, due to shortages in water resources. The

**Figure 3:** Groundwater basins




*Source: MWI, 2015*

high salinity of wastewater is caused by the high salinity of domestic drinking water. This is exacerbated by the use of Waste Stabilization Ponds (WSP) that have high evaporation rates, especially during the summer season. Wastewater reaching the wastewater treatment plans have insignificant levels of heavy metals and toxic organic compounds due to the low level of industrial discharges to the wastewater treatment plans. In fact, only 10 percent of the biological load of wastewater comes from industrial waste, thus, Jordan's wastewater is low in heavy metals and toxic organic compounds (Nsheiwat, 2007).

In the year 2000, there were 17 treatment plants in operation in Jordan. Out of these, 6 plants used WSP, one used an aerated pond, while the remaining 10 plants used activated sludge or attached growth processes or a combination of both. At that time, WSP treated about 85 percent of collected wastewater in Jordan (about 80 MCM per year) (Ammary, 2005). In 2015, the number of treatment plants reached 32 and the volume of treated wastewater was 147 MCM (MWI, 2015).

The plant at As-Samra alone is the largest treatment plant in Jordan. The As-Samra plant began operating in 1985, and is located about 30 km northeast of Amman receiving wastewater from Amman, Zarqa, and Russaifa. The plant is based on a wastewater stabilization pond system. The collected effluent is then treated to secondary treatment levels. The treated effluent is

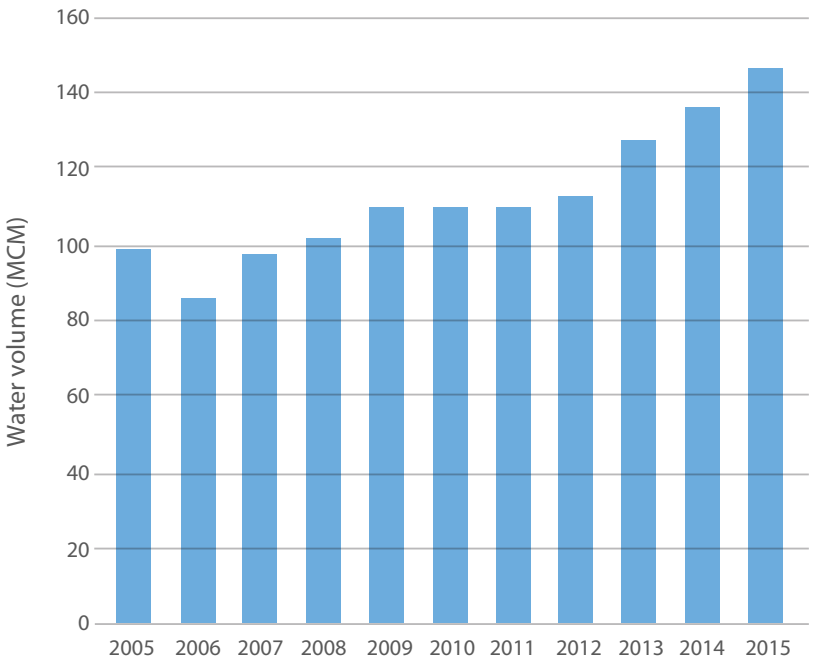
**Table 3:** Groundwater abstraction for 2015 in MCM

| Groundwater Basin | | Safe Yield | Abstraction | Deficit |
|---|---|---|---|---|
| Disi | | 125 | 143 | |
| Amman-Zarqa | | 87.5 | 166 | -78.5 |
| Yarmouk | | 40 | 54 | -14 |
| Jordan Side Valley | | 15 | 46.7 | -31.7 |
| Azraq | | 24 | 52.5 | -28.5 |
| Jafer | Renewable | 9 | 35 | -29 |
| | Non-Renewable | 18 | 1.7 | |
| Jordan Valley | | 21 | 17 | 4 |
| Dead Sea | | 57 | 90 | -33 |
| Araba South | | 5.5 | 8.5 | -3 |
| Hammad | | 8 | 1.9 | 6.1 |
| Sirhan | | 5 | 1.7 | 3.3 |
| Araba North | | 3.5 | 6.3 | -2.8 |

*Source: MWI, 2015*

**Figure 4:** Treated wastewater volume (MCM) 2005-2015

| Year | Treated Wastewater |
|---|---|
| 2005 | 99 |
| 2006 | 86 |
| 2007 | 98 |
| 2008 | 102 |
| 2009 | 110 |
| 2010 | 110 |
| 2011 | 110 |
| 2012 | 113 |
| 2013 | 128 |
| 2014 | 137 |
| 2015 | 147 |




*Source: MWI, 2015*

**Table 4:** Wastewater treatment plants, 2015

| No. | WWTP Name | Design Capacity | Daily Influent CM/day | Technology | Operation Year | BODS Design |
|---|---|---|---|---|---|---|
| 1 | Aqaba-Natural | 9000 | 6699 | Waste Stab Ponds | 1987 | 900 |
| 2 | Aqaba-Mechanical | 12000 | 12475 | Activated Sludge | 2005 | 420 |
| 3 | Baqa | 14900 | 11862 | Trickling Filter | 1987 | 800 |
| 4 | Fuheis | 2400 | 2719 | Activated Sludge | 1997 | 995 |
| 5 | Irbid Center | 11023 | 8143 | Trickling Filter + Activated Sludge | 1987 | 800 |
| 6 | Jerash-East | 9000 | | Activated Sludge | 1983 | 1090 |
| 7 | Karak | 5500 | 1408 | Activated Sludge | 1988 | 800 |
| 8 | Kufranja | 9000 | 2506 | Trickling Filter + Activated Sludge | 1989 | 850 |
| 9 | Madaba | 7600 | 6557 | Activated Sludge | 1989 | 950 |
| 10 | Mafraq | 6050 | 3557 | Waste Stab Ponds | 1988 | 825 |
| 11 | Ma'an | 5772 | 2288 | Activated Sludge | 1989 | 700 |
| 12 | Abu Nuseir | 4000 | 3201 | Activated Sludge | 1986 | 1100 |
| 13 | Ramtha | 7400 | 4743 | Activated Sludge | 1987 | 1000 |
| 14 | Salt | 7700 | 7407 | Activated Sludge | 1981 | 1090 |
| 15 | Tafila | 7500 | 1450 | Trickling Filter | 1988 | 1050 |
| 16 | Wadi Arab | 21023 | 12880 | Activated Sludge | 1999 | 995 |
| 17 | Wadi Hassan | 1600 | 1594 | Activated Sludge | 2001 | 800 |
| 18 | Wadi Mousa | 3400 | 2628 | Activated Sludge | 2000 | 800 |
| 19 | Wadi Esseir | 4000 | 5040 | Oxidation Ditch | 1997 | 780 |
| 20 | Ekedar | 4000 | 1918 | Waste Stab Ponds | 2005 | 1500 |
| 21 | Lajoon | 1000 | 595 | Waste Stab Ponds | 2005 | 1500 |
| 22 | Tal Mantah | 400 | 358 | Trickling Filter + Activated Sludge | 2005 | 2000 |
| 23 | Jiza | 4000 | 773 | Activated Sludge | 2008 | 800 |
| 24 | Samra | 360000 | 294862 | Activated Sludge | 2008, 1984 | 650 |
| 25 | Meyrad | 10000 | 6268 | Activated Sludge | 2011 | 800 |
| 26 | Shobak | 350 | 92 | Waste Stab Ponds | 2010 | 1850 |
| 27 | Mansorah | 50 | 15 | Waste Stab Ponds | 2010 | |
| 28 | South Amman | 52000 | 5436 | Activated Sludge | 2015 | 750 |
| 29 | Mutah and Adnaniyyah | 7060 | 1228 | Activated Sludge | 2014 | |
| 30 | Shallaleh | 13750 | 6070 | Activated Sludge | 2014 | 762 |
| 31 | North Shouna | 1200 | 777 | Waste Stab Ponds | 2015 | 1200 |
| 32 | Zaatari | 3500 | 964 | Trickling Filter + Activated Sludge | 2015 | 1130 |
| Total | | 606178 | 416513 | | | |

*Source: MWI, 2015*

then discharged into Wadi Zarqa to join the runoff of this Wadi. These effluents are captured at the King Talal Dam and its associated reservoir. Water from this dam is used for irrigation mainly in the Jordan Valley. As of September 2006, the average total flow into the As-Samra plant was about 294 862 m3/day (MWI, 2015). Future plans at As-Samra focus on generating their own electrical power through establishing digesters that produce biogas using sludge produced from the treatment process. The treated wastewater is intended to be used mainly for irrigation.

## Key water policy developments

The management of the water sector in Jordan is shaped by three main strategy documents. The first one was adopted in 1998 under the name of "Jordan Water Strategy and Policies"; this was followed by "Water for Life; Jordan Water Strategy 2008-2022" and "National Water Strategy 2016-2025".

The first sector strategy (1998) was associated with policies including groundwater, water utilities, wastewater reuse and management, and irrigation. An investment program and action plan was developed for the years 1997-2010, updated in 2002 and extended until 2011. The said investment program was completely implemented except for the Red-Dead project, which will be realized in 2021, for a total value of about three billion USD (MWI Strategy, 2015). Amendments to the legislation were also implemented, including Article 28 of WAJ law, to allow for private sector participation (2002), and the Groundwater Bylaw aiming at protection of groundwater resources (2002). The National Water Master Plan (NWMP) was put into operation in 2004.

The second strategy document, "Water for Life; Jordan Water Strategy 2008-2022", sets the pace for Jordan's efforts until 2022. The strategy stresses the need to exploit the full potential of surface water and groundwater at a reasonable level, using lower quality water and brackish water for irrigated agriculture and desalinated seawater as an additional resource for towns, industrial and commercial use.

The "National Water Strategy 2016-2025" builds on the previous two strategic documents and is in alignment with the royal initiative for economic change in all sectors that was formulated in 2015 in the document "Jordan 2025, A National Vision and Strategy". This strategy incorporates provisions for climate change, water-energy-food nexus, sustainability of overexploited groundwater resources, the adoption of new technologies and techniques available including decentralized wastewater management, and reuse of treated wastewater. It incorporates more decentralization, commercialization and consolidation of water and wastewater services as well as increasing private sector participation. It also considers the Sustainable Development Goals (SDGs) and the recently developed sector policies and it builds on the new developments in the sector. These include the implementation of the approved Action Plan to Reduce Water Sector Losses in 2013, the progress in strategic projects (e.g. Nuclear Power plan, Oil-shale and Red–Dead conveyance), the increased demand resulting from the pressure of Syrian refugees on water resources, the higher cost of production, specifically the effect of electricity and fuel increased prices and the fiscal strain affecting the service delivery.

Section 2

# Agriculture

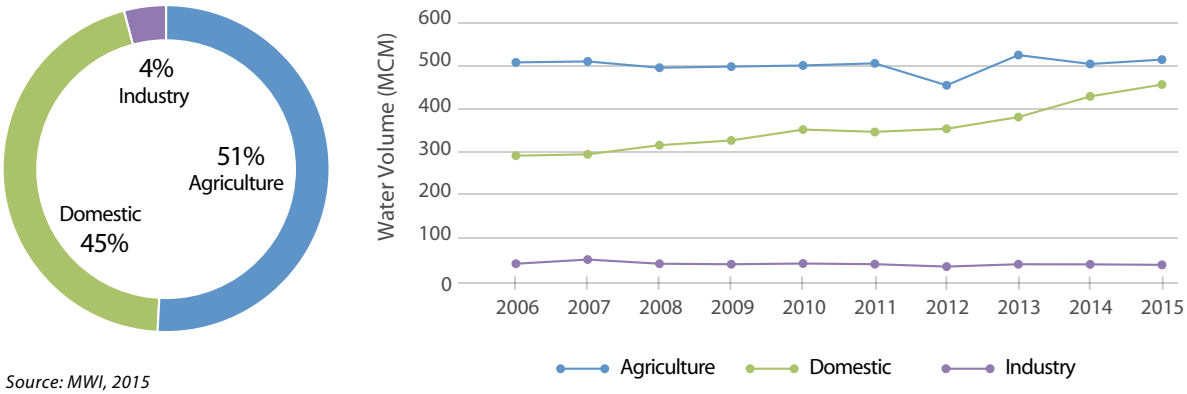
Photo: ©FAO/Khalil Mazraawi

Agricultural land is limited to 10.9 percent of the total land area in Jordan (Worldstat, 2007). Of this, the cultivated area represents 3.6 percent of the total land (Aquastat, 2014). In 2011, the total rainfed and irrigated cultivated area was an estimated 100 000 ha. However, in any given year, half of rainfed land is left fallow because of fluctuating and unevenly distributed rainfall.

## Irrigated agriculture

Although the agricultural sector contributed 4.2 percent to the gross domestic product (GDP) in 2015 in Jordan (World Bank, 2015), it required large volumes of water, accounting for 51 percent of total national water need, as showed in Figure 5. Farmers irrigate less than 10 percent of the total agricultural land and only 5 percent of the land receives enough rainfall to support cultivation.

**Figure 5:** Water uses for different sectors

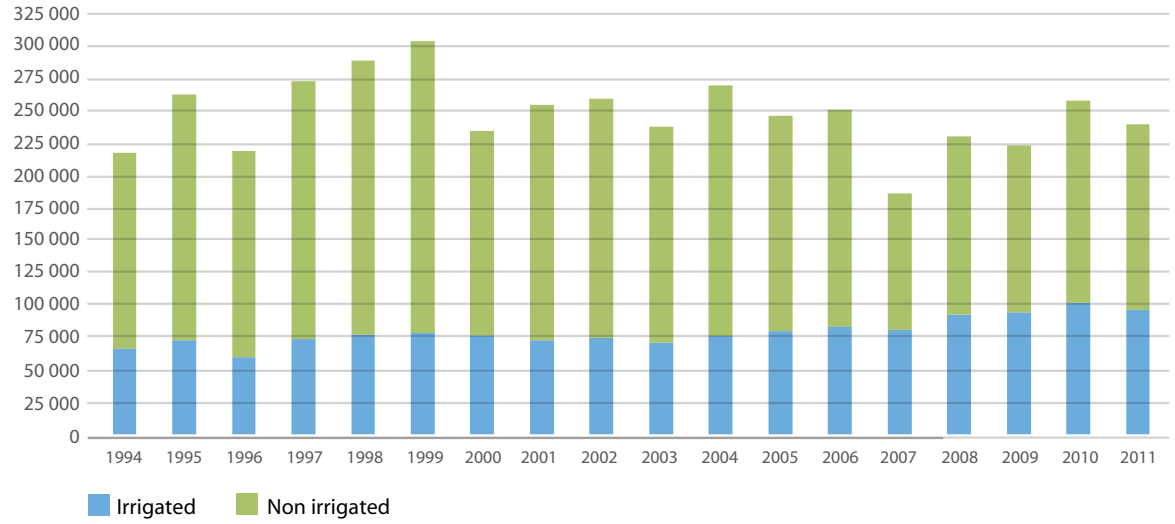



*Source: MWI, 2015*

Due to water scarcity in Jordan, the government has attempted to ration the use of water and allocate scarce water resources to competing uses, thus, reducing the water allocated to irrigation.

While the area of land cultivated in Jordan has shown some variation over recent years, the percentage of cultivated land that is irrigated has seen an increasing trend – from 30 percent in the early 1990s, to around 40 percent from 2008 onwards (Figure 6).

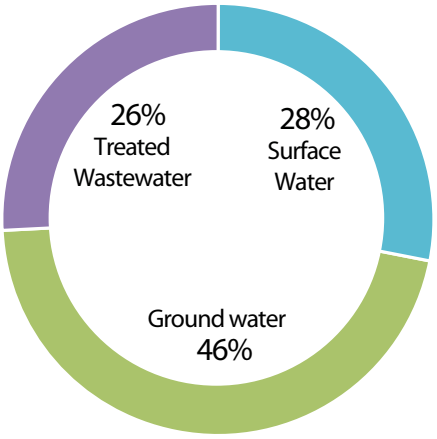
**Figure 6:** Cultivated land in Jordan (hectares)




*Source: FAO, 2016*

This is due to an increasing proportion of cultivated land being used for vegetables and fruit trees. This increase in irrigation is founded on increasingly unsustainable groundwater abstraction: a large proportion of irrigated land (around 46 percent in 2015) uses water abstracted from wells; other important sources include dams and the King Abdallah Canal (28 percent) and the remaining land is irrigated using treated wastewater (FAO, 2013).

**Figure 7:** Water resources for irrigation




*Source: MWI, 2015*

Jordan is one of the smallest and poorest economies in the Middle East with a GDP of US$ 37 517 billion in 2015. Agriculture accounted for 4.2 percent of the GDP in 2015, whereas in 1965 it accounted for 15.4 percent (World Bank, 2015). The contribution of agriculture to GDP has declined from 9.7 percent in 1978 to 2.3 percent in 2008 (FAO, 2013). The proportion of the economically active population working in agriculture is also declining (standing at 2 percent in 2011) (FAO, 2013).

Most irrigated agriculture is located in the Jordan Valley, the majority of which uses water transported via the King Abdallah Canal. Some areas in the south of the Valley are irrigated with groundwater. Most of the cultivated crops are vegetables and fruit trees, including citrus and bananas (UNDP, 2013; MWI, 2014).

In the northern part of the Valley, wheat is typically grown on stony soils and depends largely on supplementary irrigation by sprinklers during the yield formation (UNDP, 2013).

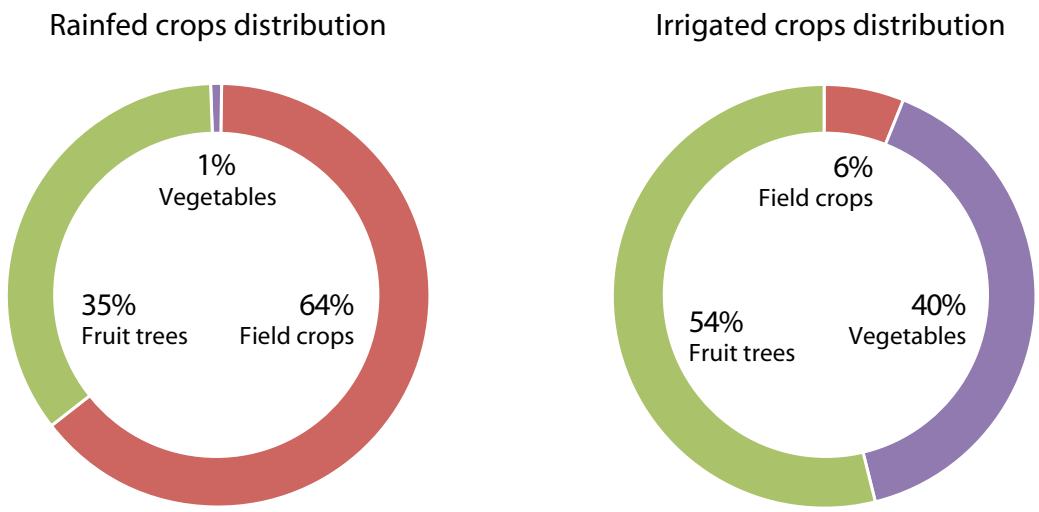
In the Disi and Mudawwara areas, deep groundwater is used to irrigate wheat, forage plants, and potatoes. Irrigated agriculture is also present in the basalt plateau soils of northern Jordan such as in Mafraq Governorate. In these areas, the abstraction of groundwater resources has expanded rapidly into the steppe zone, often for the production of fruit crops.

Other irrigated areas are found mostly in the south and south east of Amman in the upper Dead Sea groundwater basin. In many of the valleys leading from the highlands to the Rift Valley, springs are used to irrigate fruit and vegetables. There are only limited alluvial areas in many of the valleys and, increasingly, water is pumped to small, gently sloping land at considerable heights above the streambed. This kind of production can be seen in Wadi Al Mujib and Wadi Al Hass (MWI, 2014).

Data for the last three decades show an increase of irrigated land area and areas planted with permanent crops while rainfed agriculture is practiced mainly in the highlands. Figure 6 shows the distribution of rainfed and irrigated cultivated area. Field crops include cereals, pulses, fodder representing 38 percent, fruit 44 percent, and vegetables 18 percent.

Fruit trees, vegetables and field crops represent 54, 40 and 6 percent respectively of harvested irrigated area; and 35, 1 and 64 percent respectively of the harvested rainfed area (Figure 8).

**Figure 8:** Rainfed and irrigated crop distribution (%)




*Source: FAO, 2013*

Based on figures published by the Department of Statistics, the total cultivated area (rainfed and irrigated) increased from 0.187 in 2007 to 0.22 million ha in 2009, as shown in Table 5. Even though the cultivated area increased by 12 percent between 2007 and 2009, agricultural production fell by 10 percent to 2.15 million tonnes, of which 71 percent vegetables, 19 percent tree-crop fruit and 10 percent field crops, which are consumed locally and exported to neighbouring countries.

**Table 5:** Area of cultivated agricultural land

| Crops | Area (ha) in 2007 | Area (ha) in 2009 |
|---|---|---|
| Vegetables | 33 477 | 41 179 |
| Field crops | 72 406 | 100 755 |
| Fruits | 81 305 | 82 256 |
| Total | 187 188 | 224 191 |

*Source: FAO, 2013*

Despite the central role agriculture plays in the economy, the sector continues to face the following major challenges:

- Climate: drought, fluctuating rainfall and hot winds are the main difficulties affecting rainfed agriculture.
- Water-related challenges: limited available water resources, overexploitation of groundwater, and silting of dams where water is stored in the winter season.
- Fragmentation of farm holdings.
- Erosion of topsoil on steep slopes.
- Marketing: markets are restricted because of the instability of open markets in the Gulf Region. The competitiveness of Jordanian products on world markets also increases pressure on the agriculture sector and farmers.
- Limited storage capacity and lack of post-harvest services that negatively impact the sector's ability to fulfil market needs.

## Water harvesting

'Water harvesting' is defined as the process of concentrating precipitation through runoff and storage for productive use. Jordan is characteristic of the Near East region in that rainfall is not only low, but also erratic. In any given year, half of potentially cultivable land is left fallow because of fluctuating and unevenly distributed rainfall. That rain which does fall is mostly lost in evaporation and unutilised runoff (which in turn often causes erosion), leaving frequent dry periods during the growing season (FAO, 2016). This creates difficulties in sustaining crops, pasture and livestock. In such a climate, water harvesting is an appropriate option for augmenting the available water supply to allow for supplemental irrigation (when rainfall fails to provide sufficient moisture for normal plant growth).

By concentrating rainfall runoff in the winter and during storms, water harvesting structures can increase the amount of supplemental irrigation available per unit of cropping area – thereby increasing and stabilizing production. These structures, such as small check dams, pools and bunds, can also provide a source of drinking water for livestock, potentially throughout the year, and may also support small-scale home gardens for household income generation. Water harvesting is therefore a way to improve water security for vulnerable farmers in a high-risk climate. Water harvesting may also help to reduce the pressure currently exerted on Jordan's aquifers, and could contribute to improved groundwater recharge rates, by concentrating water in a way that allows more infiltration before the water is ultimately used or evaporates.

The importance of water harvesting has been recognized by the Government of Jordan in its Water Strategy for 2008 to 2022, Water for Life, which describes several goals and actions aimed at addressing the water supply-demand imbalance. With respect to irrigation water, a specific goal is included to 'promote the use of rainfall harvesting methods in irrigation'. Water harvesting also plays an important role in the planned activities under the 2006 National Strategy and Action Plan to Combat Desertification.

Research undertaken by FAO (FAO, 2016) indicates that there are 250 existing water harvesting structures in Jordan as of October 2013, with a further 112 structures under construction or planned for construction (Table 6). The design capacity of these structures is shown in Table 7, while the map with their distribution is shown in Figure 9. Most water harvesting capacity is found in small dams, with small contributions from ponds and pools[1]. The use of these structures varies, with dams typically being used for irrigation while ponds and pools are used for both irrigation and livestock. The largest proportion of the existing capacity in water harvesting is found in the northeastern governorate of Al-Mafraq (67 percent), as well as in Karak and Ma'an (10 percent each).

**Table 6:** Number of water harvesting structures in Jordan, October 2013

| Existing | On-going | Future | projects | Total | Percentage of total |
|---|---|---|---|---|---|
| Dams | 56 | 6 | 29 | 91 | 25.10 |
| Ponds | 129 | 31 | 46 | 206 | 56.90 |
| Pools | 65 | - | - | 65 | 18 |
| Total | 250 | 37 | 75 | 362 | |

*Source: FAO, 2016*

**Table 7:** Construction capacity of water harvesting structures in Jordan, October 2013 (1000 $m^{3)}$

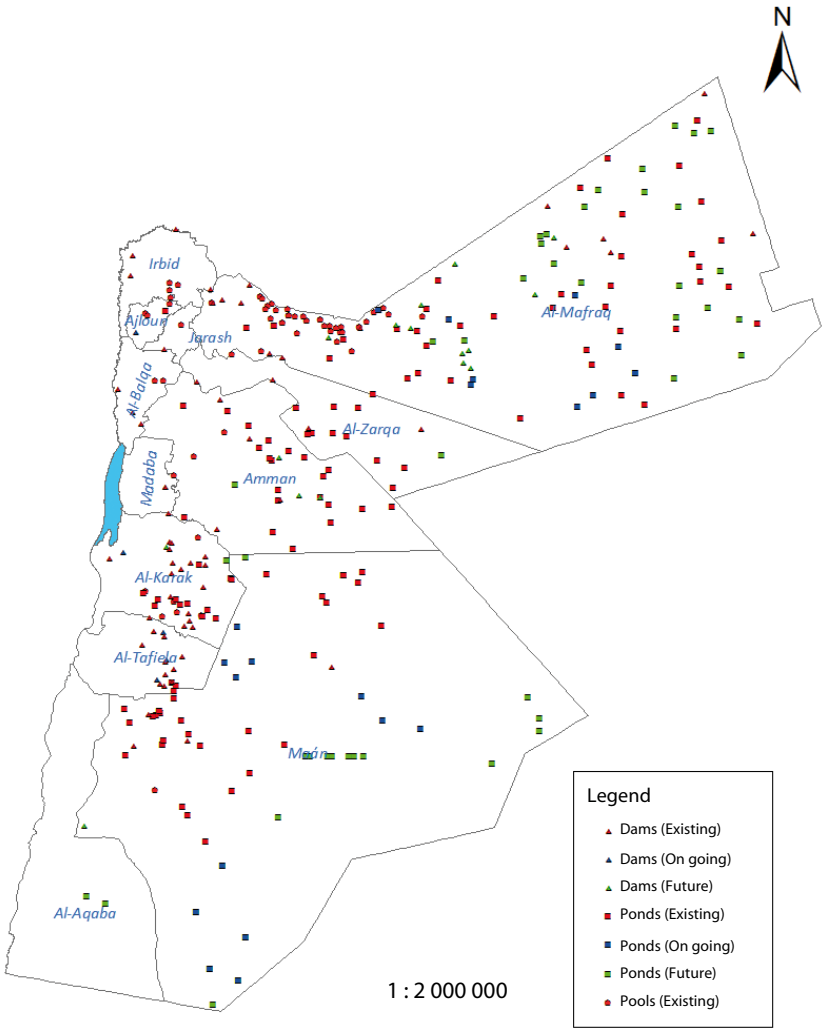
| Existing | On-going | Future | projects | Total | Percentage of total |
|---|---|---|---|---|---|
| Dams | 95 297 | 9 060 | 10 755 | 115 112 | 84.00% |
| Ponds | 15 190 | 2 625 | 3 880 | 21 695 | 15.80% |
| Pools | 268 | 0 | 0 | 268 | 0.20% |
| Total | 110 755 | 11 685 | 14 635 | 137 075 | |

*Source: FAO, 2016*
*Note: the capacity of dams excludes existing large dams situated on rivers*

The capacity of water harvesting structures (Table 7) can be compared to the total amount of water resources available in Jordan, to show the potential contribution of water harvesting to national water supply. The annual renewable water supply is shown in Table 8 below. Due to the difficulties in obtaining information on the actual volume of water in existing water harvesting structures, this can for now only be compared to the total construction capacity (110 755 $m^3$ for existing water harvesting structures).

[1] The Government of Jordan customarily defines these structures by their capacity: pools hold less than 50,000 $m^3$; ponds hold 50,000–200,000 $m^3$; and dams hold more than 200,000 $m^3$.

**Figure 9:** Water harvesting sites in Jordan, October 2013




*Source: FAO, 2013*

**Table 8:** Annual renewable water resources in Jordan, 2011 (1000 $m^3$)

| | Natural | Actual |
|---|---|---|
| Renewable surface water | 1 155 000 | 650 000 |
| Renewable groundwater | 720 000 | 540 000 |
| Total renewable water resources | 1 622 000 | 937 000 |

*Source: FAO, 2016*

## Food security

Despite the limited economic and natural resources and the country's sensitive location, Jordan's economy has benefited from tangible growth over the last decade at an average of 7 percent mainly triggered by the economic reform process adopted in the early 1990s. As a consequence, the country was able to achieve progress in the fields of socio-economic development, food security, education and poverty alleviation.

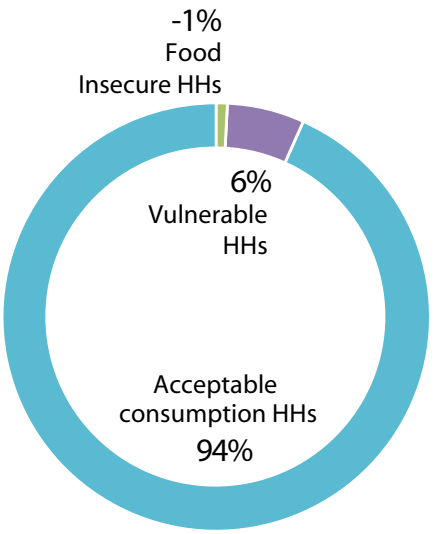
Nevertheless, poverty continues to be a challenging issue, with 14 percent of Jordan's population falling below the poverty line of 680 Jordanian Diners (JOD) (US$960) per person per annum (WFP, 2017). The incidence of poverty and food insecurity is much higher in the rural population. This constitutes more than 40 percent of the population in five governorates of Jordan, namely Mafraq, Jarash, Madaba, Karak, and Maan. In these areas, those working in the agricultural sector are poorer than those employed in other sectors. Small farmers, especially in the rain-fed highland areas that are subject to fluctuating rainfall and droughts, and households depending on small herds of sheep or goats as their main income source, may be the poorest in the country (Agriculture Policies & International Cooperation Department, 2004). In addition, over 90 percent of cereal needs are imported, making the country vulnerable to international food price rises (WFP, 2017).

**Table 9:** Food availability and utilization indicators

| Indicator | Data | Source |
|---|---|---|
| Prevalence of undernourishment (% of population) | 5 | World Bank, 2015 |
| Number of people undernourished (millions) (3-year average) | 0.3 | FAO, 2000-2002 |
| Average protein supply (g/capita/day) (3-year average) | 82 | FAO, 2009-2011 |
| Average dietary energy supply adequacy (%) (3-year average) | 137 | FAO, 2013-2015 |
| Percentage of children under 5 years of age who are underweight (%) | 3 | FAO, 2012 |

Between 2013 and 2014, the Jordan Department of Statistics (DoS) and the World Food Program (WFP) implemented a survey to assess the food security status in Jordan (WFP and DoS, 2014). This survey was conducted in conjunction with the Households Expenditures and Income Survey (HEIS) and covered all the districts in the Kingdom's 12 governorates. Survey results indicate that 6 212 households in Jordan are food insecure, compared with 3 887 households in 2010, i.e., 0.5 percent of all households in the Kingdom, against 5.7 percent of households that are vulnerable to food insecurity. Households whose food consumption is acceptable account for 93.8 percent of the total (Figure 10).

**Figure 10:** Relative Distribution of Households by Average Food Consumption, 2013




*Source: DoS, 2016*

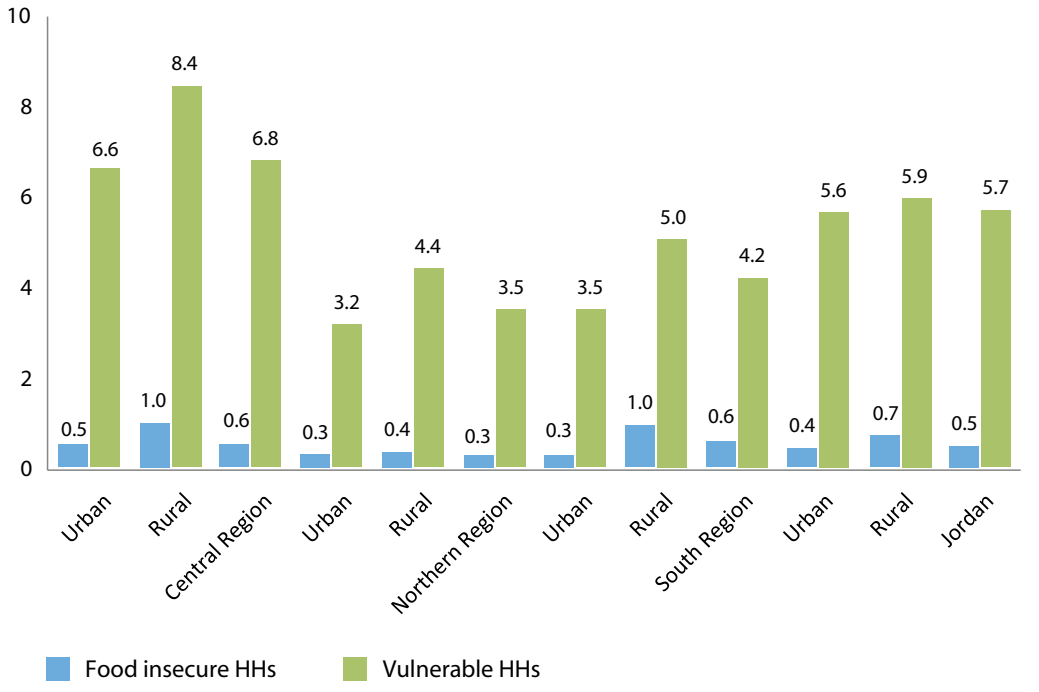
*Note: Low food consumption households (insecure Households); 2. Critical food consumption households (Households vulnerable towards food insecurity); 3. Acceptable food consumption households (Food Secure Households)*

The survey revealed that all households, irrespective of their food consumption category, consume cereals and starches (including wheat, the different kinds of bread and rice, burghul,

couscous, macaroni, potatoes and roots) on daily basis. This group is followed by the sugars and oils groups, which are consumed 6 days a week. The findings reveal a clear difference in the consumption pattern of some food groups by food insecure households, compared with food secure households, especially in terms of the meat and poultry group, the dairy products group and the fruits group. While food secure households consume meat around 6 days a week, food insecure households consume this group only two days a week on average.

Figure 11 shows that 0.5 percent and 0.6 percent of households in central and southern regions respectively are food insecure, while only 0.3 percent of households in the northern region are food insecure. In addition, the highest percentage of households that are vulnerable to food insecurity is found in the central region (6.8 percent), followed by the southern region (4.2 percent). These findings also reveal that food insecurity is almost negligent in urban areas across all regions, while it reaches 1 percent in rural areas in central and southern regions.

**Figure 11:** Percentage of food insecure and food vulnerable households, by urban and rural area and region, Jordan




*Source: WFP and DoS, 2016*

Section 3

# Energy

Photo: ©FAO/Horst Wagner

## Supply and demand

In Jordan, energy supply poses a difficult challenge because of the lack of local energy resources and the increasing need for energy for social and economic development. It is, therefore, expected that energy demand will increase by 3 percent annually. In 2008, the energy bill was more than 800 million JOD (JOD1 = US$1.4 07.2012), representing 13 percent of the GDP, which is around 45 percent of the value of exported goods.

Annual electricity consumption per capita in Jordan rose to 25 percent between 2001 and 2011, from 1 280 to 1 598 kWh and reached 2 483 kWh by 2015. However, primary energy intensity has decreased by 18 percentage points over the past decade, from 266 to 217 kg of oil.

The volume of electricity generated in 2015 reached 18 911 GWh registering a growth of 1 percent from 2014 while the electricity consumed for the same period reached 16 173 GWh recording a growth of approximately 5 percent with respect to 2014 (MEMR, 2015).

However, the peak load of the electricity system has recorded 3 300 MW in 2015 pointing to a growth of 9 percent compared to 2014 (MEMR, 2015).

**Table 10:** Energy supply (Thousand tonnes of oil equivalent 'ktoe' on a net calorific value basis, 2014)

| | Coal and peat | Crude oil | Oil products | Natural gas | Nuclear | Hydro | Geothermal, solar, etc. | Other* | Total |
|---|---|---|---|---|---|---|---|---|---|
| Production | 0 | 1 | 0 | 97 | 0 | 5 | 152 | 5 | 261 |
| Imports | 361 | 3 224 | 4 552 | 203 | 0 | 0 | 0 | 38 | 8 379 |
| Exports | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -6 | -6 |
| International Marine Bunkers | 0 | 0 | -2 | 0 | 0 | 0 | 0 | 0 | -2 |
| International Aviation Bunkers | 0 | 0 | -339 | 0 | 0 | 0 | 0 | 0 | -339 |
| Stock changes | 0 | -46 | -67 | 0 | 0 | 0 | 0 | 0 | -113 |
| Total Primary Energy Supply (TPFS) | 361 | 3 179 | 4 143 | 301 | 0 | 5 | 152 | 38 | 8 180 |

**Other includes: Biofuels and waste, Electricity, and Heat*

*Source: International Energy Agency, 2014*

## Renewable energy resources in water pumping and agriculture

Jordan has abundant potential for solar energy production. Solar photovoltaic technology can produce power at a fixed low rate of 0.6 US$/kWh for a period of 20 years. This is lower than the cost of power produced by conventional plants. Therefore, solar energy provides an opportunity to lower pumping costs in the water sector. Furthermore, due to the decentralized nature of solar energy technologies, small off-grid solutions can be developed for remote isolated regions, mainly for water harvesting projects.

Water pumping represents 15 percent of overall electricity consumption and has a tariff of 0.08 US$/kWh. The economics of photovoltaic pumping (PVP) systems for irrigation depends on numerous factors. In general, PV pumps for irrigation can only be operated cost-efficiently under the following conditions:

- To reduce the energy requirements of PVP irrigation systems water-conserving and energy-saving micro-irrigation techniques have to be applied.
- High rates of system utilization are necessary to achieve economic viability of PVP irrigation systems.
- PVP systems are limited to irrigate permanent crops and continuous crop rotation in arid climates.
- High value-added cash crops like fruits, vegetables and spices should be given preference to recoup the high initial investment.
- Low-interest loans should be available for the same reason.
- PVP irrigation systems require a careful planning of the crop schedule and require advanced knowledge and skills to be efficiently managed.

## Water-energy-agriculture nexus

Limited resources and increasing demand underscore the need for integrated approaches in policy and project development to identify both trade-offs and synergies between water, agriculture and energy sectors.

Most of Jordan's water use is in agriculture, while agricultural contribution to GDP and total employment in this sector is less than 5 percent. Additionally, water supply accounts for 25 percent of Jordan's total electricity demand (Hoff, 2011). Besides food imports, the focus of Jordan's water strategy is on large-scale supply-side infrastructure projects, including fossil groundwater transfer from the Disi aquifer and the Red Sea to the Dead Sea combined with desalination.

Given Jordan's high water prices and the large costs and energy demands associated with new infrastructural projects, conventional supply-side water management is reaching its limit. Potential options for water demand management have not yet been implemented. Such demand management options include greater reliance on food imports (with associated virtual water imports); reducing water loss in urban systems, currently accounting for 50 percent of the total volume of urban water use (Potter and Darmame, 2010); substituting freshwater use in agriculture with treated wastewater; increasing energy efficiency in the water sector; energy recovery from waste.

Jordan's National Water Strategy also explicitly supports the goals of increasing the energy use efficiency of its water supply and wastewater treatment, and using alternative energy to meet 20% of energy demand for water pumping (MWI 2008).

Section 4

# Governance analysis: a methodological note

Photo: © Yanal Obeidat

**Mapping excercise**
Systematic overview of institutions, policy framework and legal and regulatory framework

**Gap analysis matrix**
Policy & regulatory needs not matched by an appropriate and effective governance response

The objective of this assessment is to review the institutional arrangements, legal frameworks and policies in the three sectors of water harvesting, groundwater and solar energy and to identify the existing gaps. The proposed assessment methodology draws from a number of studies and methodological papers designed for the assessment of agricultural water management within the Agricultural Water for Africa (AgWA) framework (FAO and AgWA, 2014) as well as the OECD Multi-level Governance Framework tool (Charbit, 2011; OECD, 2011).

The methodology comprises of two steps:

- Mapping exercise: Systematic review of policies, law, regulations, and institutional frameworks in a specific context.
- Gap analysis matrix: Assessing and visualizing the policy, institutional and regulatory needs that are not matched by appropriate and effective governance responses.

Each of the steps is illustrated below.

## Mapping exercise

The mapping exercise is based on the methodology outlined in the "Tool for institutional and policy evidence-based analysis of agriculture water management (AWM) at country level" developed by FAO in 2009 within the context of the AgWA Partnership. The mapping exercise allows the identification of:

- Institutions
- Laws and regulations
- Policies

### *Institution mapping*

Institutions and actors involved in the regulation and management of a pre-defined sector of the economy are identified at national, provincial and local level. Their respective mandates and coverage can be mapped using the following dimensions:

- Geographical level: presence and influence at the national, regional, provincial, district or village level.
- Nature of the institutions: public or private, for or non-for-profit; formal or informal.
- Mandate: brief description of the key objectives and goals of each institutions. A mission statement can be a good description of the institution's mandate.
- Functions: key tasks conducted by each institution to fulfil its mandate.

### *Regulatory and Legal Mapping*

Laws and regulations in the chosen sector of the economy are identified through a literature review. Each can be described using the following dimensions:

- Specific targets: each of the specific objectives that the law or regulation aims at attaining (e.g. promote renewable energy sources or increase transparency in budget management).
- Measures implemented to attain said targets: these measures can include setting up institutions, mandating participation, devolving or centralizing responsibilities etc.

### *Policy Mapping*

Finally, the policy environment in the chosen sector of the economy can be mapped by identifying all relevant policies (that might also go beyond the single sector to highlight complementarities or overlaps) and describing each of them through the following aspects:

- Specific objectives: each of the specific objectives that the policy or regulation aims at attaining (e.g. economic allocation of water resources or provide sufficient water of good quality to all citizens).
- Measures implemented to attain said objectives: these can be management, administrative, budgetary, capacity building, and accountability measures.

## Gap analysis matrix

The analysis of gaps in the policies and strategies in a pre-defined sector is guided by the OECD Multi-level Governance Framework Tool. This can be used to identify the main multi-level governance challenges in the water sector and the policy instruments that governments use to overcome them (OECD, 2011a). The Framework is structured around seven types of gap, as indicated in Table 11.

This methodology has been widely applied in areas beyond the governance of water resources, to include studies on innovation, public investment, or fiscal governance mechanisms (OECD 2007; OECD, 2009, OECD, 2011b).

A gap is identified when there is a policy need not matched by an appropriate and effective governance response. The gap could take the form, for example, of partial implementation of existing strategies, lack of law or regulatory provisions, poor coordination among various levels of governance, lack of governmental commitment to a specific action (deemed as necessary by stakeholders).

The identification of gaps is carried out through an iterative process that involved desk research, consultation with key sector experts and wider stakeholders' engagement. The gaps were, in fact, at first defined by a small pool of sectoral experts, then brought to a wide group of stakeholders including representatives of the key governmental institutions involved in water and energy management, representatives of research organizations, representatives of civil society and donor organizations. Each gap was discussed in depth and stakeholder's' comments and suggestions were then incorporated to complete and strengthen the gap analysis matrix.

**Table 11:** OECD Multi-Level Governance Framework

| | | |
|---|---|---|
| **Administrative gap** | Geographical "mismatch" between hydrological and administrative boundaries. This can be at the origin of resource and supply gaps. | Need for instruments to reach effective size and appropriate scale. |
| **Information gap** | Asymmetries of information (quantity, quality, type) between different stakeholders involved in water policy, either voluntary or not. | Need for instruments for revealing and sharing information. |
| **Legal and Policy gap** | Sectoral fragmentation of water-related tasks across ministries and agencies and/or lack of appropriate regulation. | Need for mechanisms to create multidimensional/ systemic approaches, and to exercise political leadership and commitment. |
| **Capacity gap** | Insufficient scientific, technical, infrastructural capacity of local actors to design and implement water policies (size and quality of infrastructure, etc.) as well as relevant strategies. | Need for instruments to build local capacity. |
| **Funding gap** | Unstable or insufficient revenues undermining effective implementation of water responsibilities at sub-national level, cross-sectoral policies, and investments requested. | Need for shared financing mechanisms. |
| **Objective gap** | Different rationales creating obstacles for adopting convergent targets, especially in case of motivational gap (referring to the problems reducing the political will to engage substantially in organising the water sector). | Need for instruments to align objectives. |
| **Accountability gap** | Difficulty ensuring the transparency of practices across the different constituencies, mainly due to insufficient users' commitment' lack of concern, awareness and participation. | Need for institutional quality instruments. |

Section 5

# Water harvesting: Institutions, laws, and policies

Photo: © Motasem Abukhalaf

## Institutions

The key actors involved in Jordan's water harvesting sector are presented in Table 12. The table provides a synopsis of all institutions involved in the policy, regulation, distribution and administration. The table also provides concise information on the mandate of each institution as well as its key functions.

**Table 12:** Institutions' mapping

| Institutions/Actors | Geographical level/Nature | Mandate | Functions |
|---|---|---|---|
| *Ministry of Water and Irrigation* | National | Develop strategies, policies and plans for the water sector. Operates through the WAJ and the JVA. The MWI has the role of collecting information about the water sector through these institutions and use it in an optimal manner in the management of water resources, to ensure provision of water to users from various sectors. | Site selection, resource allocation, referral tender, follow-up tender, receipt of tender and post-implementation follow-up for water harvesting projects in all areas.<br>Technical support for water harvesting projects in Badia by developing water harvesting schemes. |
| *Ministry of Agriculture (MoA)* | National | Authority created 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. | Site Selection, project studies, resource allocation, referral tender, follow-up tender, receipt of tender, post-implementation follow-up for water harvesting projects in the areas 300 m above sea level in the north Jordan and 500 m above sea level in the south of Jordan (these areas include Badia). |

| | | | |
|---|---|---|---|
| *Ministry of Environment* | National | Improve and maintain the quality of the Jordanian environment and conservation of natural resources; contribute to the achievement of sustainable development through the preparation and development of policies, strategies, legislation and monitoring programs and the introduction of environmental concepts into national development plans. | Development and implementation of policies, strategies and legislation for the conservation and protection of the environment; supervision and enforcement of legislation; planning and development of awareness-raising programs and activities. |
| *Jordan Valley Authority (JVA)* | Jordan Valley and the area 300 m above sea level in the north of Jordan and 500 m above sea level in the south of Jordan | Comprehensive development of the Jordan Valley. | Full management of the valley, including construction, installation and maintenance of the infrastructures; building and maintenance of the dams in the highlands. |

Institutions can also be visually mapped using the structure given in Table 13 showing that the water harvesting sector appears to be managed though institutions acting at the national, regional and provincial level and across the three key functions of administration, policy and regulation.

**Table 13:** Institutions' mandates and geographical level

| | Policy | Administration | Regulation |
|---|---|---|---|
| *National* | MWI, MoA, Ministry of Environment | MWI | MoA, MWI |
| *Regional* | MW, MoA, Ministry of Environment | JVA in MWI within its mandate area, Directorate of water harvesting in MoA | MoA, MWI |
| *Provincial* | Field Directorates | Field Directorates of JVA and MoA | MoA, MWI |

## Laws and regulations

The key laws and regulations in the water harvesting sector are presented in Table 14.

**Table 14:** Laws and regulations

| Primary Legislation / Main Objective | Specific Targets | Measures to attain targets |
|---|---|---|
| Jordan Valley Development Law as amended by the Law No. (30) in the year 2001 | Describes the institutions' responsibilities according to geographic location. | Set special instructions for the implementation of the law related to water harvesting. |
| Agriculture Law No. (13) for the year 2015 | Increase the production of food and foodstuffs; use of natural and agricultural resources without damaging the environment; create suitable conditions for investing in agricultural sectors and rural development; increase the production capacity; increase farmer's incomes and improve their lifestyle; improve the use of irrigation waters; face animal and plant diseases; carry out scientific research and desertification control; and encourage agricultural cooperative work and agricultural cooperative associations. | Set special instructions for the implementation of the law in relation to water harvesting. |

## Policies and strategies

The key policies in the water harvesting sector are presented in Table 15.

**Table 15:** Policies and strategies

| Policy | Specific Objectives | Measures to attain objectives |
|---|---|---|
| Surface Water Utilization Policy | Achieve maximum utilization and optimum use of surface water, its protection, its management, and propose measures needed towards successfully integrating all its components | Establish an integrated development and conservation program to increase surface water development |
| | | Adopt supply-enhancing measures, including surface and subsurface storage, minimizing losses by surface evaporation and seepage, soil and water programs, and protecting surface water supplies from pollution |
| | | Maximize the use of surface water to the greatest extent possible by increasing the storage capacity of dams, construction of new dams, and investment in rainwater harvesting in remote areas and from rooftops |
| National Water Strategy 2016-2025 | Provisions for climate change | Measures shall be taken into account for extreme events such as higher temperatures, reduced rainfall and declining river flows |
| | Focus on water economics and financing | Increase private sector participation |
| | Provisions for water-energy nexus | Decrease water pumping cost in mandated area |
| | Management of sustainable wastewater | Protect, conserve and recover available water lost due to inefficiency and misuse |
| | | More decentralization, commercialization and consolidation of water and wastewater services |
| | Increased needs for utilization of surface water in municipal supply | Enhance enforcement of bylaws and regulations, protect water resources and catchment areas, automation of water resource monitoring system |
| | | Supply-enhancing measures shall be adopted, including surface and subsurface storage, minimizing losses by surface evaporation and seepage, soil and water programs, and protecting surface water supplies from pollution |

| | | |
|---|---|---|
| National Water Strategy 2016-2025 (continued) | Development of water sources | New water source options including harvesting water, brackish and seawater desalination, increased storage of water runoff, artificial recharge |
| | | A comprehensive monitoring and assessment program for surface water quantity, quality uses and protection shall be in place in order to enhance surface water resources |
| | | An integrated development and conservation program shall be established to increase surface water development in Jordan, including the development of sustainable management plans for surface system in the Jordan Valley |
| | | A three-year plan shall be formulated for the development of surface water resources. A parallel investment plan shall accompany the development plan |
| | | Land use in all catchments and sub-catchments shall be subject to permitting in cooperation with ministries and municipalities such that the generation of sediments potentially transported by rainwater is minimized |
| | | Storage of dams shall be enhanced by removing/managing sediments already accumulated over the years, and by minimizing losses due to evaporation |
| | | If expropriation of established users' rights on springs is foreseen for the public good, such expropriation shall be based on clear high priority need and against fair compensation |
| | | Cooperation with concerned authorities and other governmental bodies shall be undertaken to ensure that restrictions imposed on protection zones are implemented and enforced |
| | | Interactive use of multiple resources (especially groundwater and surface water) with different qualities shall be targeted to maximize the usable flows, and maximize the net benefit from the use of a unit flow of water |
| | Sediment management | Sedimentation caused by soil erosion shall be minimized by delineating bare soil areas on slopping terrains and planting them |
| | Enhance quality of water | Protection zones for all drinking water sources shall be delineated and monitored |
| | | Springs and the existing water supply infrastructure shall be rehabilitated to achieve improved protection of water resources from pollution, to facilitate discharge and/or enhance recharge |
| National Strategy for Agricultural Development 2016-2025 | Maintain soil capabilities | Introduction of water harvesting techniques in pasture lands |
| | | Creation of water harvesting techniques at the level of large watersheds (pools, dams) |
| | | Implementation of rainwater harvesting techniques at the level of small watersheds (contour lines and half-circles) |

| | | |
|---|---|---|
| National Strategy for Agricultural Development 2016-2025 (continued) | Improve the efficiency of irrigation water use | The development of plant varieties, horticultural and pastoral crops of high productivity under drought conditions |
| | | Implementation of technologies for the deployment of water and soil conservation |
| | | Rehabilitation and maintenance of water sources and springs |
| | | Maintenance and lining of irrigation canals |
| | | Introduce water harvesting techniques in the pastoral lands |
| | | Creation of water harvesting techniques at the level of large watersheds (pools, dams) |
| | | Implementation technologies for rainwater harvesting techniques at the level of small watersheds (contour lines and half-circles) |
| | | Improving irrigation water drainage networks in the Jordan Valley |
| | | Improving the management of irrigation water supply |
| | | Improving the irrigation water demand management |
| | | Projects for the construction of Ibn-Hammad Valley Dams, Wadi Husban, and ramp Al-Wehdeh Dam |
| | Improve the quality of irrigation water | National project to monitor water quality remotely |
| | | Monitoring of soil and groundwater contamination |
| | | Rehabilitation of Zarqa basin Project |
| | | Protection of valley banks |
| | | Rehabilitation of artesian wells in the Badia |
| | | Raising and rehabilitation of dams distributed all over the Badia |
| | | Re-thinking of mixed ratios of irrigation water to improve the quality |
| | Reduction of regulation infringements on the surface and underground water resources | Stopping infringement on the sources and water lines |
| | | Monitoring of construction permits of artesian wells and taking the legal right to action |
| | Protect the Jordanian Badia | Implementation of the deployment of water and soil conservation techniques |
| | | Creation of dams and pools in the Badia, rehabilitation of artesian wells and improvement of water quality |
| | | Studies and surveys on land use in the Badia area that are rehabilitated |

| | | |
|---|---|---|
| National Strategy for Agricultural Development 2016-2025 (continued) | Promote the establishment of water harvesting means to develop pastures in the Badia | Introduction of water harvesting techniques in the Badia lands |
| | | Creation of dams and pools in the Badia |
| | | Creation of water harvesting techniques at the level of large watersheds (pools, dams) |
| | | Implementation of technologies for rainwater harvesting at the level of small waterfalls (contour lines and half-circles) |
| | | Rehabilitation of artesian wells in the Badia and improvement of water quality |
| | | Creation of dams and pools in Tafila Governorate |
| Environment Strategy 2014-2016 | Protect the environment and its sustainability | Natural resources and land reuse |
| | | Improving the management of natural reserves and preparing a master plan for land use |
| | | Drafting a long-term comprehensive policy to combat desertification and incorporating it into national policies for sustainable development |
| | | Including enhancing policies for water and monitoring programs |
| | Improve management of natural resources | Badia Restoration Program (BRP) Environmental Compensation Program |

## Gap analysis

The application of the Framework approach to water harvesting policies in Jordan allows identification of the degree to which coordination and implementation is compromised within the country. Through the development of the gap analysis matrix, various types of gap were critically addressed and possible solutions to bridge gaps were proposed.

**Table 16:** Gap Analysis Matrix

| | Question/Problem | Status | Proposed Action/Recommendation |
|---|---|---|---|
| Administrative Gap | Creation of a body that supervises the management of water harvesting facilities after implementation | Partially achieved: there is coordination during the planning of the project, but there is no body supervising the operation & maintenance phase | Water Harvesting Directorate and MoA have a clear mandate on planning water harvesting infrastructures, including tasks such as defining the size of the water harvesting schemes, their locations, and understanding the impacts of each of such infrastructures. Encourage a specific institution (or department within existing institution) to participate in the planning and implementation phase of the water harvesting project so that it can supervise the project after its implementation. |
| | Coordinated and integrated planning of water harvesting infrastructures | Currently an excessive reliance on a top-down approach to planning water harvesting infrastructure is recorded | Engage the communities, including non-governmental organizations (NGOs), in planning water harvesting infrastructures. |

| | | | |
|---|---|---|---|
| Legal/Policy Gap | Integration of water harvesting policies with specific policies to increase agricultural production and water efficiency | Gap in integration of agricultural production policies with water harvesting efforts led to loss of agricultural production and inefficient use of water | Integration of agricultural production policies, water harvesting policies and rural development policies to target water use to the most water efficient and economically relevant activities with a view towards the sustainability of the agricultural system and restoration of the Badia ecosystem. |
| | Water harvesting in Badia should help rural development | Water harvesting measures are currently being implemented in areas far away from the population centers | Need for water harvesting projects to be implemented near community areas through coordination between institutions involved in the Badia such as The Hashemite Fund for Badia Development and civil society organizations, as well as the implementing agencies of the water harvesting policies in the Badia. |
| | Maintenance of dams and ponds excavated in Badia | No policies within the current budgets of the MWI and MOA include the necessary activities to maintain water harvesting facilities and make them sustainable | Need for policies and programs to ensure the maintenance and sustainability of water harvesting facilities projects. |
| | Lack of water harvesting policy | The MoA has adopted water harvesting policies but they are limited to increasing the harvested volume of water (maybe because of insufficient financial resources). There is no clear understanding of the benefits that might spur from the water harvesting policies | Need to build an integrated and comprehensive strategy for water harvesting in Badia focused on efficient utilization of available resources to improve the livelihood of the population, especially vulnerable groups and rural women. |
| Objective gap | Scarce attention to water harvesting in the Badia | Focus on national strategy for water policies sustaining and providing water for drinking, irrigation, domestic uses and other economic sectors rather than on water harvesting policies | National strategy for water harvesting in Badia involving government partners, NGOs and local community to include a comprehensive policy framework relating to water harvesting. Focus on clearly setting priorities and implementation of water harvesting facilities over the long term as well as rural development policies in Badia based on water harvesting policies. |
| | Conflicting priorities and competition among ministries in charge of water management | Current competition for financial resources between ministries and different priorities lead to inefficiency in the planning and management of water harvesting | Re-prioritize water harvesting within the government agenda with a specific accent on ensuring the sustainability of water harvesting infrastructures. |
| Information gap | Cooperation among stakeholders | There are no frameworks for cooperation among stakeholders in water harvesting projects to regulate water use and to maintain these facilities | Need for coordination between government agencies and civil society to review the policies and mechanisms and adjust them to meet the challenges faced during the implementation of policies |
| | Biophysical database for planning and monitoring water harvesting structures | Projects are planned on a case-by-case basis and there is no database to support planning, monitoring and management of infrastructures | Build a comprehensive database for water harvesting to include biophysical studies, socio-economic studies, hydrologic and technical studies. |
| Funding Gap | Funding water harvesting in the Badia, particularly with respect to maintenance of infrastructures | The attention to water harvesting means in Badia (earth dams and excavations) is very weak. This is the responsibility of the MoA, but its investment does not exceed 0.2% of its financial budget | Considering that over 50% of the benefits of Badia restoration are environmental, not directly for the farmer, MoA should increase its budget allocation to water harvesting measures or raise funding from international donors. Increase funding for water harvesting should be integrated in the national budget. |

| | | | |
|---|---|---|---|
| Capacity Gap | The policy instruments do not include studies that deal with the universality of the Badia region | No policy instruments that include studies dealing with the universality of the Badia region. This could lead to a misallocation of financial resources in the implementation of policies related to water harvesting | Need to include studies that deal with the universality of the Badia region. |
| | Hydrological studies that measure the flow of water in valleys would help in the long-term planning to develop surface water resources | Several hydrological studies have been conducted but were not implemented due to funding issues | Cooperation and coordination between the government and international and local institutions to prioritize the implementation of water harvesting policy tools, so to maximize the impact of water harvesting policies in Badia and to optimally allocate the resources for the implementation of this policy. |
| | Infrastructures are of paramount importance to exploit harvested water | No provision of technology alternatives to address the lack of infrastructures to the water harvesting programs and projects | Coordination with the relevant institutions, such as the Royal Scientific Association, and the private sector when adopting water harvesting policies in Badia. |
| | Capacity building on planning, constructing and managing water harvesting structures | Insufficient qualified personnel to carry out water harvesting engineering works; institutions have a knowledge gap in terms of climate change, water harvesting, food security, including high-tech tools, remote sensing and GIS | Need to build capacity of the ministries to ensure that staff acquires the technical ability to conduct rigorous work in water harvesting. Ensure that training is directed towards advanced technological methods and tools. |
| Accountability Gap | Clear monitoring system to supervise the planning, implementation and operation and maintenance phases of the policies and programs | There is a special directorate in the MoA and in the MWI that supervise the planning and implementation phases of water harvesting projects, but there are no entities in either Ministry responsible for the operation and maintenance phase | Need to establish a monitoring unit specialized in water harvesting with special system in the MoA and in the MWI. |

As it appears from the gap analysis summarised in Table 16, the current national water policy framework does not fully address the strategies related to the water harvesting sector and there are unclear and overlapping mandates. It is, therefore, essential to build a comprehensive water harvesting policy framework that focuses both on improving the efficiency in the utilization of available resources and on overcoming the lack of integration between the agricultural production policies and the water harvesting efforts. This framework could ultimately guarantee higher agricultural production, better water efficiency, and more sustainable rural development.

From a capacity perspective, the preparation of such framework will require both a thorough review of the current hydrological studies to take informed, evidence-driven decisions on the location, size, and impacts of water harvesting infrastructures, as well as the coordination with the relevant scientific institution to find the most effective technology provision. This preliminary step would help maximize the impact of the water harvesting policies.

From an administrative point of view, it is necessary to encourage better coordination between the institutions currently in charge of water harvesting projects and to allow for a stronger participation of community members, especially during the planning phase, to ensure that the population's best interests are guaranteed. It is also crucial to re-define the institutional framework by appointing a body responsible for the supervision of the operation and maintenance of water harvesting infrastructures.

Section 6

# Energy and agriculture: Institutions, laws, and policies

Photo: © Yanal Obeidat

## Institutions

The key actors involved in the energy sector are presented in Table 17. The table provides a synopsis of all institutions involved in the policy, regulation, distribution, administration, and power generation spheres in Jordan. The table also provides summary information on the mandate of each institution as well as its key functions.

**Table 17:** Institutions' mapping

| Institutions /actors | Geographical level/nature | Mandate | Functions |
|---|---|---|---|
| *Ministry of Energy and Mineral Resources (MEMR)* | National, public | Umbrella institution responsible for the implementation of the law together with the Energy and Minerals Regulatory Commission and power utility companies. | Identify a list of Renewable Energy Development Zones.<br>Issue calls for proposals to implement renewable energy projects.<br>Supervise the establishment of these projects. |
| *Jordanian Energy and Minerals Regulatory Commission (EMRC)* | National, public | Regulatory body working under the umbrella of MEMR. Responsible for granting licenses for energy projects, issuing directives and orders, establishing and emending grid codes and power tariffs. | Implement the General Electricity Law (GEL No. 64–2002).<br>Generate and update the reference price list.<br>Issue licenses after signing of project agreements. |
| *National Electricity Power Company* | National, public | Power Transmission | Power system safe and economic operations (System Operator).<br>Construct, own and maintain the transmission system (Transmission Network Owner).<br>Plan and develop the power system.<br>Purchase electricity from different sources and sell it to distribution companies (Single Buyer).<br>Procure the required fuel for power plant operation.<br>Import and export electricity with neighboring countries.<br>Contract the new generation capacity to meet the future demand. |

| | | | |
|---|---|---|---|
| *Independent Power Producers (IPP)* | Regional, Private | Responsible for power generation segments and plants to supply electricity to the transmission grid. | Responsible for power generation in coordination with the National Electric Power Company (NEPCO).<br>The companies included here are:<br>1. Amman East Power Company (370MW)<br>2. Qatrana Power Company (373MW)<br>3. IPP3 (600MW)<br>4. IPP$ (250MW) |
| *Central Electricity Gen. Co (CEGCO)* | National, Private | Power generation | Power generation. CEGCO owns 1555 MW generation capacity i.e. 49% of total installed capacity in Jordan. |
| *Samra Electricity Power Company (SEPCO)* | National, Private | Power generation | Power generation. SEPCO owns 888 MW generation capacity i.e. 28% of total installed capacity in Jordan. |
| *Jordan Electric Power Company (JEPCO)* | Regional, Private | Distribute electricity in the central part of Jordan. | Responsible for power distribution network in the central part of Jordan, mainly in Amman and Zarqa cities, and for any renewable energy connection to its distribution network. |
| *Irbid District Distribution Company (IDECO)* | Regional, Private | Distribute electricity in the northern part of Jordan. | Responsible for power distribution network in the northern part of Jordan, mainly in Irbid and Mafraq cities and, for any renewable energy connection to its distribution network. |
| *Electricity Distribution Company (EDCO)* | Regional, Private | Distribute electricity in the southern part of Jordan. | Responsible for power distribution network in the southern part of Jordan, mainly in Karak, Maan and Aqaba cities, and for any renewable energy connection to its distribution network. |

Institutions can also be visually mapped using the structure suggested in Table 18. As the table illustrates, the governance of the energy sector is considerably centralized in its policy and administrative dimensions where institutions operate at the national and regional level only. Service deliver, instead, appears to be rather decentralized as the electricity distribution companies operate from the national to the village level.

**Table 18:** Institutions' mandates and geographical level

| | Policy | Administration/Regulation | Service delivery |
|---|---|---|---|
| *National* | MEMR | EMRC, NEPCO | CEGCO, SEPCO, NEPCO, IPPs |
| *Regional* | | EMRC, NEPCO | SEPCO, JEPCO, IDECO, EDCO |
| *Provincial* | | | JEPCO, IDECO, EDCO |
| *District* | | | JEPCO, IDECO, EDCO |
| *Commune* | | | JEPCO, IDECO, EDCO |
| *Village* | | | JEPCO, IDECO, EDCO |

## Laws and regulations

The General Electricity Law (GEL No. 64–2002) governs the power sector in Jordan. This law was established by the EMRC to foster the development of IPP projects in Jordan, with a view to the eventual establishment of a competitive power market, subject to regulation by an independent Electricity Sector Regulatory Commission. The first independent power project in Jordan was signed in February 2007 when a 25-year term power purchase agreement was signed with AES Corporation and Mitsui & Co. for a 370-megawatt project known as Amman East.

According to EMRC, the General Electricity Law (GEL) plays the main role in the Jordanian electricity sector regulatory frameworks, mainly for:

- Issuing Licenses: Generation, transmission, distribution, system operation and bulk supply
- Issuing sector regulation (code, orders, directives)
- Determining electricity tariffs and connection charges
- Participating in setting the technical and environmental standards
- Recommendations (to MEMR) to advance to a more competitive electricity market

The law has been in full legal force since 2003, and it governs the operation of the power generation and distribution companies in Jordan, as well as the Jordanian Energy and Minerals Regulatory Commission.

Besides this law, MEMR is regulated by five main laws:

- General Electricity law
- Nuclear safety and security law
- Conserving energy law
- Natural resources affairs law
- Renewable energy and energy efficiency law

The Renewable Energy & Energy Efficiency Law aims to provide the government with suitable tools to reach the National Energy Efficiency Strategy targets and governs the implementation of all renewable energy projects and activities in Jordan. This became a permanent law on 12 April 2012.

It also was the first law in the region and enabled investors to identify and develop grid connected electricity projects through the unsolicited or direct proposal submission. In addition, it allowed the erection of renewable energy projects for own power use, i.e. by net-metering and wheeling mechanisms.

According to the law, MEMR is the umbrella institution responsible for the implementation of the regulation together with EMRC and power utilities. MEMR should identify a list of Renewable Energy Development Zones, issue calls for proposals to implement renewable energy projects and supervise the establishment of these projects. This has been effectively

implemented so far and three different Requests for Proposals were issued by MEMR in the last few years.

Furthermore, NEPCO is expected to purchase the entire amount of electricity produced by private producers and provide grid access to each individual renewable energy project.

Apart from large projects that must be bid by competitive tender, any individual has the right to submit a proposal to the Ministry directly in order to develop a site for renewable energy. A direct proposal must satisfy certain conditions and a development plan must be submitted outlining the preliminary design, initial financing plan and contribution of local content to the facility, supplies, construction and operation. A fixed price tariff must be proposed, and it must fall within a set of guidelines, called the "reference price list" that has been established by the EMRC.

If a project is accepted, then negotiations of the project agreements follow. The EMRC issues a generating license after the project agreements have been signed and the electricity generated can be sold to the national utility, NEPCO, or to holders of retail supply licenses.

One of the most attractive and important amendments of the Renewable Energy and Energy Efficiency Law is its tax incentives regime: a bylaw was issued on tax exemptions for renewable energy, energy efficiency systems and equipment imported from abroad.

## Policies and strategies

Jordan imports about 97 percent of its primary energy from abroad (MEMR Annual report 2015). These imports are a major factor behind its significant trade deficit. Giving that the demand for energy is projected to increase drastically, the government has laid out an ambitious energy strategy that encompasses harnessing the potential of renewable energy and shale oil resources.

The National Energy Strategy was drafted in 2007 by Jordan's MEMR as a roadmap for Jordan's energy development until 2020. The strategy shall transform the national electricity mix through several different resources to reduce risks to energy security caused by import dependency and to turn Jordan into a largely self-sufficient country. According to the strategy, 2020 is the deadline for this overhaul.

According to MEMR, the strategy has the following targets:

1. Diversifying the energy resources in the country.
2. Increasing the share of the local energy in the energy mix.
3. Reducing the dependency on imported oil.
4. Enhancing environmental protection.

These goals can be achieved through:

1. Maximizing the utilization of domestic resources (oil shale, natural gas, etc.)

2. Expanding the development of renewable energy projects.

3. Generating electricity from nuclear energy.

The utilization of renewable energy resources has a great focus within the National Energy Strategy given the great potential for development of renewables, with particular emphasis on solar and wind energy. The strategy sets a target of 10 percent renewable energy input into the energy mix by 2020. It is very likely that this target shall be exceeded due to the large momentum of constructing large and medium scale solar energy projects, mainly due to market driven factors.

In addition, the renewable energy market has greatly expanded because of the favourable legal framework established by the Renewable Energy and Energy Efficiency Law passed in 2012 and amended in 2014.

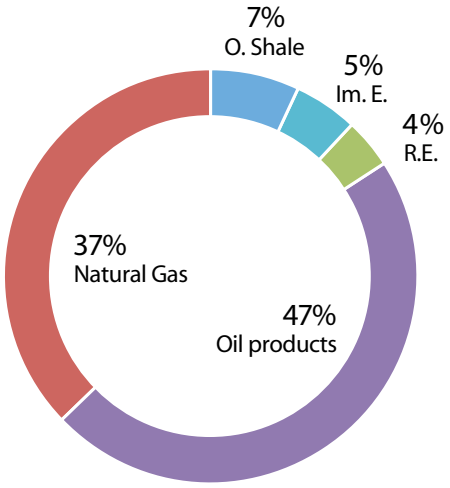
The energy mix strategy developed for years 2017, 2020 and 2025 is illustrated in figures (12, 13 and 14) to the right.

## Gap analysis

Similarly, the gap analysis matrix methodology is applied to identify weaknesses in the current policy, regulatory and institutional provisions of the energy sector. It is also to suggest a preliminary set of possible solutions to the identified gaps.

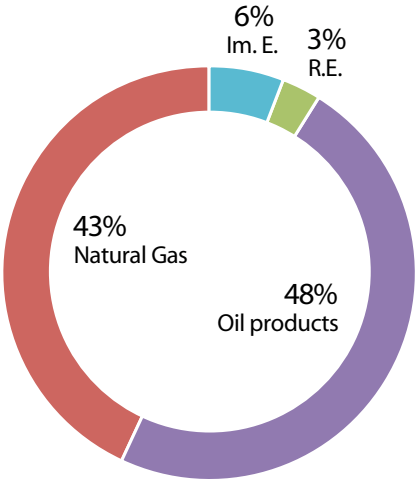
The National Energy Strategy, which was drafted by the MEMR as a roadmap for Jordan's energy development until 2020, focuses on the objective of transforming the national electricity mix through several different resources to reduce risks to energy security caused by import dependency. While this represents a very challenging and ambitious goal, a new demand-side water management policy is becoming increasingly necessary to promote the use of alternative water and energy sources. This strategy should incorporate provisions aimed at tackling the double subsidization of water pumping (through electricity and water prices) to promote water conservation, and at encouraging the use of new technologies for local brackish water and the adoption of different irrigation technologies which would result in yield gains and water savings.

**Figure 12:** Energy Mix 2015



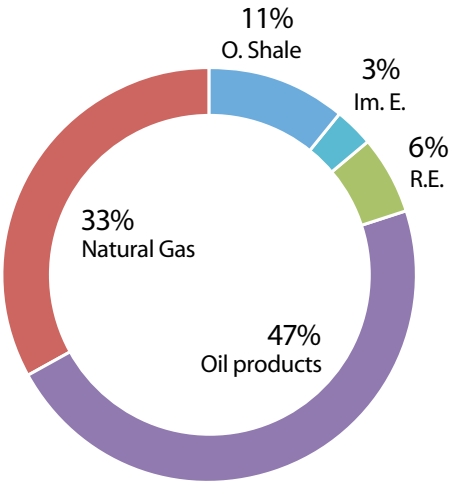

*Source: MOMR, 2007*

**Figure 13:** Energy Mix 2017




*Source: MOMR, 2007*

**Figure 14:** Energy Mix 2020




*Source: MOMR, 2007*

**Table 19:** Gap Analysis Matrix

| Gap | Question/ Problem | Status | Proposed Action/ Recommendation |
|---|---|---|---|
| Administrative Gap | Different water costs based on geographical location.<br>The cost of transferring 1 $m^3$ of water to Amman for example is between 0.6 – 1.2 JOD depending on the source basin. On the other hand, the cost of transferring water to the near lands is negligible.<br>This directly affects the cost of producing different kinds of crops. | Partially achieved. The government took good steps to harmonize water costs but it has no clear mandate and there is no explicit requirement to give priority to the water-energy-food nexus. | Integrate land-water planning strategy.<br>Utilize the landscape near the water sources to minimize the cost of producing crops.<br>Change the water tariff to take into consideration the cost of water transportation. |
| Legal/Policy Gap | Clear regulation that controls the interaction between the (surface and ground) water, energy and agriculture sectors. | No clear regulations to control the water-energy and agriculture interaction. | A collaborative strategy and regulation should be set to determine trade-offs and synergies that meet demand, without compromising sustainability. |
| | Clear regulation in water pumping using renewable resources or provision of incentives. | No regulation exists. | Clear regulation should be set to encourage using renewable energy for water pumping without neglecting incentives like customs and tax exemptions |
| | Clear regulation for off-grid energy using renewable resources. | No regulation exists. | Clear regulation should be included because off-grid systems are the most adequate for pumping water. |
| | Fragmentation of water and energy tasks across different levels of governance (local versus national). | The water and energy sectors in Jordan are scattered among several ministries, authorities, public and private companies. | Elaborate a communication plan amongst regulatory bodies to regulate these sectors.<br>Increase involvement of these bodies in the planning and policies development. |
| | New incentive system to encourage the adoption of the new photovoltaic technology. | No regulation exists that encourages the use of the new photovoltaic technology. | Elaborate an incentive system that could work both at individual farmer level as well as at the association level to lead to improvement of rural households' livelihoods as well as sustainable energy production.<br>Adopt incentives to target users of photovoltaic systems, e.g. tax exemption. |
| Objective gap | New demand-side water management strategy to promote use of alternative water and energy sources. | Partially implemented: MoA is mandated to work on on-farm water management and technology adoption; brackish water use has been explored but it is a costly venture. An improved management of energy demand has not yet been implemented. | Tackle double subsidization of water pumping (through electricity price and water price) to encourage water conservation.<br>Encourage use of wastewater and grey water.<br>Set new technologies for using local brackish water.<br>Adoption of different irrigation technologies which results in yield gains and water savings.<br>Water harvesting has to be better represented in policies and infrastructure. |
| Information gap | Embrace evidence-based policy making, including the use of research studies conducted on the water, energy and agricultural sectors. | Not yet implemented: the researches and studies stay on paper or do not have appropriate implementation. | Promote regular roundtables between policy-makers and key research institutions in the country to foster dialogue around policy gaps and improvements in the energy and agriculture sectors. Focus research on the water-energy-food nexus. |

| | | | |
|---|---|---|---|
| | Analytical reports based on previous strategies and policies to point out weak points and recommendations. | There are no analytical reports or SWOT analyses concerning previous policies and strategies that could be used when setting the strategic plans and policies. | Regularly perform a (and monitor progress in) gap analysis for the water, energy, and agricultural strategies and policies.<br>Produce a comprehensive report and action plan for the existing policies and strategies in the term of water-energy-agriculture interactions is an urgent issue.<br>Elaborate a response strategy plan to meet the additional energy and food required in urban areas as a result of refugees' needs through renewable energy solutions. |
| Funding gap | Insufficient or unstable revenues to implement water policies across ministries and levels of government. | Insufficient funds to implement the strategic plan projects. | Mobilize funds from other countries or funding agencies.<br>Receive support from private sector and stakeholders. |
| | Insufficient credit for farmers. | There is no credit program for farmers. | Establish a credit program for farmers directed towards the adoption of water-saving technologies and practices. |
| Capacity gap | Insufficient technical and/or scientific expertise and infrastructure for designing and implementing water policies. | Limited number of technical expertise in water-food-energy policies. | Establishment of university programmes in this field.<br>Capacity building for the existing technical staff. |
| Accountability gap | Issues with transparency, integrity and ability to monitor investments in the water sector. | Progress has been made: Policy makers have started to be transparent with the public yet there is still mistrust towards the government bodies. | Increase communication channels between policy makers and society.<br>Disseminate information on achievements with regards to the strategic plan. |

From a legal standpoint, the Jordanian electricity sector is regulated by a set of well-defined laws governing the operation of the power generation and distribution companies and the implementation of all renewable energy projects and activities. However, the current regulatory framework fails to address some key elements, particularly the water-energy-agriculture nexus and the use of renewable energy sources in irrigation. Indeed, a collaborative strategy addressing the water, energy and agriculture interaction should be included to determine trade-offs and synergies to meet the energy demand, without compromising sustainability. In addition, clear regulations should be adopted to encourage using renewable energy for water pumping and to promote the use of off-grid systems that are regarded as the most adequate for pumping water. Moreover, an incentive system should be introduced to encourage the adoption of the new photovoltaic technology; this would lead to sustainable energy production as well as the improvement of rural households' livelihoods.

Finally, it is essential to promote regular roundtables between policy-makers and key research institutions in the country to foster dialogue around policy gaps and improvements in the energy and agriculture sectors, with a specific focus on the water-energy-food nexus.

Section 7

# Groundwater: Institutions, laws, and policies


Photo: © Google

## Institutions

While there is no specific institution responsible for the overall management of groundwater resources, Table 20 provides an overview of the key mandates and functions of the institutions involved in the policy and legal structuring of the groundwater sector.

**Table 20:** Institutions' mapping

| Institutions | Geographical level/Nature | Mandate | Functions |
|---|---|---|---|
| *Ministry of Water and Irrigation* | National | To develop strategies, policies and plans for the water sector. Operates through the WAJ and the JVA. | Responsible for the overall monitoring of the water sector, water supply and wastewater system and related projects, planning and management, the formulation of national water strategies and policies, research and development, information systems and procurement of financial resources. Its role also includes the provision of centralized water-related data, standardization and consolidation of data. The MWI is responsible for the monitoring wells only with respect to maintenance and construction. |
| *Water Authority of Jordan* | Jordan Rift Valley (North and South of the Dead Sea). | Mandated to plan, design, construct, operate and maintain irrigation projects, dams and hydroelectric power stations in the Valley. | Responsible for the socio-economic development of the Jordan Rift Valley (North and South of the Dead Sea), including water resources development, management, distribution of irrigation water, land reclamation and development, tourism development and environmental improvement and protection. The WAJ is responsible for all wells other than monitoring wells with respect to maintenance and construction. The WAJ operates through three autonomous water companies: Miyahuna, Yarmouk Water Company and Aqaba Water Company. |
| *Jordan Valley Authority* | Jordan Valley and the area 300 m above sea level in the north of Jordan and 500 m above sea level in the south of Jordan. | The development of water resources of the Jordan Valley and their utilization for purposes of irrigated agriculture, domestic and municipal uses, industry, hydropower generation and other beneficial uses. | Responsible for all activities within JVA boundaries including water, irrigation, construction work, etc. |

## Laws and regulations

The key laws and regulations in the groundwater sector can be mapped as represented in Table 21.

**Table 21:** Laws and regulations

| Primary Legislation / Main Objective | Specific Targets | Measures to attain targets |
|---|---|---|
| By-law No. 85/2002 - Underground water | To control over-drafting of groundwater, illegal well drilling, provide for substantive penalties for illegal use and motivate farmers to use brackish groundwater in irrigation. | In case of water pollution or over-abstraction the Water Authority has the duty to stop the source of pollution or over-pumping (Art 16).<br>The distance between wells cannot be less than 1,000m (Art 25).<br>A maximum amount of withdrawals is set for each well (Art 29).<br>A tariff is set in the regulation for water abstracted over and above the permitted annual abstraction rate. |
| JVA law no. 19 of 1988 | To develop the water resources of the valley and manage their exploitation for different purposes, including irrigated agriculture and domestic use, as well as protect and preserve these resources | The Jordan Valley Authority has the power to implement any projects in the Valley, including: (a) developing water resources of the Valley; (b) carrying out hydrological, hydro-geologic and geological studies for evaluating the water resources in the Valley; (c) planning, designing, constructing and maintaining irrigation projects; (d) organizing and directing the construction of private and public wells. |

# Policies and strategies

The key policies in the groundwater sector can be mapped as represented in Table 22.

**Table 22:** Policies and strategies

| Policy | Specific Objectives | Measures to attain objectives |
|---|---|---|
| National Water Strategy 2016-2025 | Adopt Integrated Water Resources Management (IWRM) to ensure that national water resources management is based on the principles of sustainable use, economic efficiency and social equity. | Restructure the water sector, in the medium-term, by carrying out institutional and economic reforms in the sector aimed at increasing efficiency, functionality and accountability of roles to cover governance, regulation, supply development, transmission, distribution and advisory services. |
| | | Increase the participation and enhance the knowledge of all the stakeholders (including private sector); enhance public awareness on water scarcity, and in particular, on the costs incurred in water abstraction, treatment, transmission and maintenance of the water supply infrastructure. |
| | | Improve the infrastructure of water services and revise costs. |
| | | Introduce technological improvements to optimize water usage and reduce wastage. |
| | | MoA will work together with MWI and JVA to reduce inefficient agricultural practices and introduce improved ones by shifting to more water-efficient crops to optimize yield per M3 of water used. |
| | Achieve higher water productivity and, in particular:<br>• Improve the efficiency of bulk irrigation water delivery and on-farm irrigation systems in the JV<br>• Increase the water quality from treatment plants destined for agricultural use to ensure food safety<br>• Reduce groundwater use for agriculture in the highlands to reach safe yield levels (from about 588 mcm in 2014 to 118 mcm in 2025)<br>• Strengthen the enforcement of existing regulations. | Increase water supply for agriculture through substitution of fresh water from surface and groundwater sources with treated wastewater from wastewater treatment plants. |
| | | Introduce appropriate water service incentives and costs to promote water efficiency in irrigation and discourage the planting of crops with high water requirements. |
| | | Promote the adoption of alternative technologies – such as rainwater harvesting – to increase water supply. |
| | | Take the climate change risks into account in planning technical water sector policies, strategies, action plans and investment. |
| | Enhance water and climate change adaptation and, in particular:<br>• Build the adaptive capacity of communities and institutions;<br>• Increase the resilience of natural ecosystems, water and agricultural resources to climate change. | Introduce proactive and preventive water adaptation approaches to protect the limited water resources. |
| | | Build technical capabilities within MWI to access financing sources available for climate adaptation measures. |
| | | Theoretical investigation and field operations in the form of drilling, sampling and logging shall be conducted continually. |

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| 2016 Groundwater Sustainability Policy | Resource exploration and assessment | Theoretical investigation and field operations in the form of drilling, sampling and logging shall be conducted continually. |
| | | Assessment and re-assessment of the sustainable yields of groundwater reservoirs shall be made in light of the accumulation of data and information. |
| | | A comprehensive program to assess the potential of brackish groundwater shall be conducted. |
| | | Implementation of groundwater exploration will be conducted by MWI/WAJ personnel as a priority. |
| | Monitoring | A network of observation wells shall be installed in each of the groundwater reservoirs or parts thereof for the purpose of monitoring the conditions and performance of the reservoirs in response to development and abstraction. MWI/WAJ shall evaluate, update and redesign the groundwater-monitoring plan to cover all aquifers with emphasis on the over-exploited and polluted aquifers. |
| | Resource Protection, Sustainability, and Quality Control | Conflicts arising out of urbanization shall be addressed, and mitigation measures specified for the urban planners to have them included in the urban planning process. |
| | | Recharge areas shall be protected against pollution caused by whatever means including solid and liquid waste disposal, mining, landfills, brine disposal, agricultural inputs and the like. |
| | | Drilling of wells and abstraction of groundwater from them shall be prohibited without a drilling license and an abstraction permit issued by WAJ. |
| | | Withdrawal from wells shall not exceed the abstraction permit rate under penalty of substantial fines and / or revoking the abstraction permit and the closure of the well. Over-abstraction from aquifers shall be reduced to sustainable levels in accordance with a time-phased plan. |
| | | Development of groundwater reservoirs shall be commenced only after careful studies are made of the potential of each, and observation wells installed in carefully chosen locations to monitor the reservoir during exploitation. |
| | | Development of deep groundwater aquifers shall be carefully made. Abstraction from them shall be gradual with periodic assessment of quality and quantity. |
| | | Natural rainwater and treated effluent of wastewater are considered primary sources for artificial recharge. |
| | Priority of Allocation | Priority of allocation of groundwater use shall be given to municipal and industrial uses, to educational institutes and to tourism. These purposes are deemed to have the higher returns in economic and social terms. |
| | | Priority shall also be given to the sustainability of existing irrigated agriculture where high capital investment had been made. In particular, trees irrigated from groundwater shall continue to receive an amount sufficient for their sustainability with the use of advanced irrigation methods. |
| | | Priority shall be given to the use in irrigated agriculture of the reservoirs whose water quality does not qualify them for use in municipal and industrial purposes. |
| | | Priority for use in agriculture shall also be given to the cases where supplementary irrigation from the groundwater reservoir is possible. |

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| | Regulation and Control | Campaigns shall be waged against illegal drilling of tube wells, and wells thus drilled shall be stopped, rigs confiscated and legal action taken against violators. |
| | | Comprehensive groundwater basin management plan for each aquifer shall be developed as part of the National Water Master Plan. |
| | | Prohibition of well licensing for agricultural purposes will be sustained. Only high priority purposes shall be entertained for licensing. |
| | | Fees and charges will be used as an instrument to control ground-water over-pumping. |
| | | Cooperation with concerned authorities and other governmental bodies shall be undertaken to ensure that restrictions of protection zones are implemented and enforced (MoMa, LUA committees, RDEP/Rangers, etc.) |
| | Legislation and Institutional Arrangements | Effective laws shall be reviewed from time to time with the intention of updating their provisions to match the requirements of changing times. By-laws issued under the applicable laws shall also be updated to serve the purpose of performance efficiency. Institutional set-up shall be reviewed in parallel, updated, adjusted or restructured to improve performance. |
| | | Close cooperation will be maintained with the other organizations whose activities may directly impact the performance in the water sector. |
| | | A study and research activity shall be entrusted with a specialized unit within MWI. The unit will be entrusted with technology transfer responsibilities. |
| | | The campaign undertaken by MWI in August 2013, in enforcing bylaw 85(2002) and its amendments shall be sustained. |
| | | Abstraction from all groundwater wells shall be metered, and monitoring of abstraction shall be made periodically to assure conformity with the provisions of the abstraction permits. |
| | Shared Groundwater Resources | Efforts shall be made and sustained to establish Jordan's rights in shared groundwater resources through international agreements. |
| | | Cooperation with neighboring countries for the optimal and sustainable use and management of the shared groundwater resources, shall be sought. |
| | | Shared basins shall be managed based on an integrated water resource management (IWRM) approach not foregoing the need for regional cooperation to develop contingencies for droughts and impact of climate change. |
| | | International and regional cooperation shall be pursued in the fields of research, development and technology transfer in ground-water exploration, management, quality control, and economics shall be promoted. Exchange of information and experience shall be maintained with regional and international parties. |
| | Public Awareness | MWI/WAJ in cooperation with other concerned agencies shall maintain a program to educate farmers on the importance of groundwater protection and shall promote technology transfer related to groundwater use in irrigation. |
| | | Cooperation with other concerned agencies shall be maintained to encourage the reuse of groundwater for beneficial purposes. |

| | | |
|---|---|---|
| Irrigation Water Policy, 1998 | Sustainability of Irrigated Agriculture | No diversion of surface or ground water to other uses other than agriculture shall be allowed without providing a replacement source fit for agricultural use unrestricted by health and public health considerations, and unduly hampered by chemical constraints. |
| | | Sustainability of agriculture shall be compromised only if it threatens the sustainability of use of ground water resources. Potential pollution of underlying aquifers or the depletion thereof are among the reasons that can prompt such compromise. |
| | | Surface and ground water shall be protected against pollution which degrades water quality, is hazardous to the environmental integrity of soils, or can endanger animal health, particularly livestock. In this regard, the adoption of biological control methods shall be promoted in lieu of the use of pesticides. Where desalination of brackish water is practiced, particular attention will be paid to the disposal of brine especially when such practice is done within the catchments area of dams. |
| | | Close coordination shall be maintained with the MoA and its research and development arm and with other related institutions with the aim of enhancing on-farm irrigation efficiencies and maximizing the agricultural output of a unit of land area per unit flow of surface and ground waters. |

## Gap analysis

The application of the Framework approach to the case of groundwater policies in Jordan allows identifying the degree to which coordination and implementation of such policies is compromised within the country. Through the development of the gap analysis matrix, it is possible to list and critically address various types of gaps occurring in the groundwater policies and regulations and their implementation. The approach also allows suggesting possible solutions to the identified gaps.

**Table 23:** Policies and strategies

| Gap | Question/Problem | Status | Proposed Action/ Recommendation |
|---|---|---|---|
| *Administrative Gap* | Unclear mandates related to the groundwater resources management | Mandates and responsibilities regarding the management of groundwater resources show some overlap between WAJ and MWI. | Clearly define in the 2016 Groundwater Sustainability Policy the unique institution mandated for the groundwater management and specify the information sharing mechanisms with the other relevant institutions. |
| *Legal/Policy Gap* | A groundwater extraction by-law in 2002 began imposing abstraction tariffs and requiring well registration and monitoring, but has not slowed extraction rates | External factors such as market competition and increasing energy costs appear to be pushing highlands agricultural users towards adoption of higher efficiency irrigation methods, but this trend seems to be offset by the use of groundwater to increase the value of land for speculative real estate investment, notably in the planting of low-value olive trees. | Tariff increases, shifting water use to higher value crops and more efficient production technologies. |
| | Unclear framework to use groundwater in a more productive way | Progress is very slow and a clear policy on the topic does not exist. | Focus the policy on increasing water productivity (producing more with less water).<br>Adopt incentives to advance technologies by subsidizing the technology that uses water rather than water itself. |

| | | | |
|---|---|---|---|
| *Objective Gap* | The Irrigation Water Policy ensures that protection of groundwater resources takes priority over the sustainability of agriculture. The policy encourages coordination between MoA and MWI | Coordination between the two ministries has not materialized. | Strengthen coordination between MoA and MWI and clarify mandates to ensure effectiveness of their actions. |
| | Contradiction between goal to decrease groundwater abstractions and strong subsidization of water pumping | Double subsidization of water pumping, first on electricity price, second is water price.<br>Lack of firmness in enforcing groundwater abstraction limits. | Realign objectives and mandates to ensure a gradual reduction of the groundwater extraction rate to meet the renewable safe yield. |
| | No clear link between the energy and groundwater sectors | No clear policy encouraging the establishment of an interconnection between the two sectors. | Implement policy connecting the groundwater and energy sectors. |
| *Information Gap* | Technology transfer (e.g. higher agricultural yields, more advanced technologies, pressurized pipelines, genetically engineered plant varieties) and adoption and transfer at the farm level is insufficient | Private sector, farmers and universities are ahead of government in using modern tools and technology transfer in irrigated agriculture. The process of adopting technology transfer is slow. An indicator for success requires baseline survey every five years. Two baseline surveys were conducted in 1986 and 1994 and indicated slow progress in this regard. However, a significant progress has been achieved since then with the implementation of USAID sponsored programs. | Establish a national information management system for irrigation that includes groundwater.<br>Foster technology transfer, particularly on monitoring and control of aquifers, though collaborations with the private sectors and academia. |
| *Funding Gap* | Lack of ability to timely collect fees from groundwater users | Fees from the majority of wells used for agriculture purposes are not collected. Without fees coming back into the sector from users, the country will be subsidizing water in perpetuity. Actions are being taken to ensure payment of the fines. | Strengthen fee collection capacity through full enforcement of bylaw 85. Strengthen collaboration among water authorities and clarify mandates related to fee collection. |
| | Funding focuses on traditional technologies | Funding patterns have not yet shifted in favor of new technologies. | Encourage more funding for micro-projects to replace old-fashioned technologies with new, water-saving technologies. |
| | Lack of funding for solar water lifting systems | Progress is very slow. | Encourage funding to solar water lifting systems. |
| *Capacity Gap* | No involvement of end users, farmers and livestock holders to raise awareness on better water use practices | Progress is slow. | Organize more workshops for end users, also in remote areas, to raise awareness. |
| *Accountability Gap* | Excessive illegal water pumping and inability to effectively monitor abstraction and punish overuse | Illegal wells still pump water daily in Jordan, which stresses the country's aquifers. | Enhance enforcement of the groundwater pumping regulations and the related limits. Strengthen monitoring of abstractions. |
| | Groundwater user association | No association exists. | Establish groundwater user associations to oversee management at catchment level of groundwater resources. |

The Ministry of Water and Irrigation has outlined all provisions related to the groundwater sector in the Jordan's Water Strategy 2008-2022, the 2016 Groundwater Sustainability Policy and the Irrigation Water Policy. While these strategies provide a comprehensive framework, it is necessary to point out some important aspects that are not fully tackled and, thus, require to be addressed further. Indeed, while the policy framework asks for a reduction of the groundwater abstractions it also provides strong subsidization of water pumping. This contradiction needs to be resolved by realigning objectives and mandates to ensure a gradual reduction of the groundwater extraction rate to meet the renewable safe yield. In addition, no policy currently exists pertaining the increased productivity of groundwater use. Hence, a provision should be included to incentivize the advancement of technologies by subsidizing the technology that uses water rather than water itself.

As part of the regulatory framework, a groundwater extraction by-law in 2002 began imposing abstraction tariffs and requiring well registration and monitoring to control over-drafting of groundwater and illegal well drilling. However, because this bylaw has failed to slow down the extraction rates, it becomes necessary to encourage stricter enforcement of groundwater abstraction limits, strengthen the fee collection capacity, increase tariffs, and shift water use to higher value crops and more efficient production technologies.

# Conclusions and way forward


Photo: © Yanal Obeidat

The governance analysis presented in this report satisfies a key objective of the project "Reduce vulnerability in Jordan in the context of water scarcity and increasing food/energy demand", funded by the Swiss Agency for Development and Corporation (SDC).

The project pilots a three-pronged, community-based approach, combining water harvesting, conjunctive use of groundwater and surface water, and solar power for lifting irrigation water. The governance of the three sectors involved in the project, namely energy, water harvesting, and groundwater shows strengths, weaknesses and a number of critical gaps that have been systematically addressed in this report.

The methodology used for this assessment draws from a number of studies and methodological papers designed for the evaluation of agricultural water management. It is a two-step approach that consists of a mapping exercise and a gap analysis matrix. The mapping exercises includes a review of policies, laws, regulations, and institutional frameworks in a specific context, while the gap analysis helps assessing and visualizing the policy, institutional, and regulatory needs that are not matched by appropriate and effective governance responses.

The governance of water harvesting is critical in Jordan and its importance has been specifically recognized by the Government of Jordan in its Water Strategy for 2008 to 2022, Water for Life, which describes a number of goals and actions aimed to tackle the water supply-demand imbalance. It is shown, though, that the current water policy framework dos not fully address the challenges (and opportunities) of the water harvesting sector. Policy makers are urged to focus on the creation of a comprehensive policy framework for water harvesting to promote the more efficient use of water resources as well as to better integrate agricultural production policies with the water harvesting efforts.

The preparation and adoption of such framework will require the coordination with the relevant scientific and research institution to explore the most efficient options and ensure evidence-driven decision making. The new policy framework should also focus on an improved coordination among the institutions currently in charge of water harvesting projects and on a stronger participation of the community in decisions related to water harvesting.

With its National Energy Strategy, the government of Jordan has set an important objective of transforming the national electricity mix by 2020 through several different resources

to reduce risks to energy security caused by import dependency and to turn Jordan into a largely self-sufficient country. To achieve this goal it is recommended to adopt a new demand-side water management policy in order to promote the use of alternative water and energy sources. One of the key issues to be addressed with this strategy is streamlining the double subsidization of water pumping through electricity and water prices to promote water conservation. While the Jordanian electricity sector is regulated by a set of well-defined laws, the current regulatory framework fails to address the water-energy-agriculture nexus and the use of renewable energy sources in irrigation. It is recommended to adopt regulations specifically addressing the water, energy and agriculture interaction encouraging the use of renewable energy for water pumping, possibly though a clear inventive system.

The groundwater sector strategies are clearly outlines in Jordan's Water Strategy 2008-2022, the 2016 Groundwater Sustainability Policy and the Irrigation Water Policy. Nonetheless, the current strategic framework embeds conflicting objectives as, on the one side, it aims at reducing groundwater withdrawals, but on the other side, it also provides for strongly subsidized water pumping. Resolving this contradiction should be a priority task and policy objectives and institutional mandates should be realigned to ensure a gradual reduction of the groundwater extraction rate to meet the renewable safe yield. Despite the groundwater extraction by-law that imposes abstraction tariffs and requires well registration and monitoring to control over-drafting of groundwater, extraction rates have not slowed down. It is therefore recommended to strengthen the enforcement of groundwater abstraction limits together with a gradual shift to higher value crops and more efficient production technologies.

The objective of the assessment presented in this report was to review the institutional arrangements, legal frameworks and policies in the three sectors of water harvesting, groundwater and solar energy and to identify the existing gaps. While the gaps have been identified through a layered participatory approach, the next step is to identify a set of clear actions required to fill the gaps. This process will involve several steps including **better understanding the root causes** of each of the gaps analyzed, **develop a comprehensive database of possible actions or policy solutions** to be potentially adopted to close the gaps, and **perform, in a participatory fashion, a tradeoff analysis** among the possible solutions (whenever alternative options are available). The outcome of these additional steps will be a **clear action matrix** that will support the **prioritization** of actions, programmes and projects in the domains of groundwater, water harvesting and energy in Jordan.

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