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Tapped out

The costs of water stress in Jordan

ABOUT THE REPORT

This report was written by Economist Impact and commissioned by the United Nations Children's Fund (UNICEF) Jordan. This research explores the key impacts of water-stress, economy and society in Jordan, through a range of interviews, secondary research and data modelling, and interactive workshops held in Amman (see the full list of participants in the Appendix). This research programme was conducted from August 2021 to May 2022 with the help of various experts in the field. The findings and views expressed do not necessarily reflect the views of the partners and experts.

The report was produced by a team of Economist Impact researchers, writers and editors, including Matus Samel, Dina Alborno, Shivangi Jain, Shreyansh Jain and Saru Gupta.

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RESEARCH OBJECTIVES AND LIMITATIONS:

This report aims to provide a high-level overview of tangible economic and social costs that water stress and scarcity impose on Jordan's population. The research aims to empirically explore and identify relationships between water stress and various socio-economic outcomes to inform a policy and expert discourse and further research. It does not provide a definitive account of the exact cost of and solutions to Jordan's water crisis. The results of the modelling analysis presented in this report should therefore be treated with caution, as indicative of the potential impacts associated with water stress (please see detailed methodology in the Appendix).

One of the key challenges for our research was inadequate availability of historical data, which negatively impacts the robustness of the findings. Due to the limited availability of historic data, as a proxy, our model assesses the relationship between water scarcity and each variable of interest by exploring trends across 83 countries over a time period of up to five years, and then makes inferences for Jordan. However, this approach hinders scaling down the larger model to fit Jordan's needs as we lose out on degrees of freedom due to fewer number of observations. This research provides a high-level overview and a foundation for policy and academic discourse, but further research is needed to develop nuanced, Jordan-specific models. Improving the availability of high-frequency, long time-series data should be one of the key priorities going forward.

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Executive Summary

Jordan, like other countries in the Middle East and North Africa (MENA) region, has a long history of coping with water stress and water-related conflicts. However, in recent years, numerous factors have combined to exacerbate the pressure on its already limited water resources, including demographics, urbanisation and climate change. The resulting water stress increases competition for access to the safe water needed for drinking, sanitation and hygiene, as well as agriculture and industrial processes, undermining social and economic development.

The impacts of climate change and water stress are among the key risks to long-term growth in Jordan, exacerbating an already difficult economic situation the country faces. Jordan's economy has been hit hard by Covid-19, particularly because of its reliance on services and tourism. Unemployment increased sharply to above 25%, with youth unemployment reaching nearly 50%. This reduced household incomes and increased social spending.[1] Public debt reached nearly 109% in 2021, limiting the scope for large-scale public investment.[2]

Nevertheless, the economy performed somewhat better than expected, and also compared to its peers. This was partially a result of the government's timely fiscal and monetary stimuli, support programmes for poor and vulnerable households as well as workers and firms impacted by the crisis. Importantly, the government is also working to address some of its long-term economic challenges. The National Plan for Sustainable Agriculture 2022-25, launched in January, aims to mobilise investment to address water usage and unemployment in the agricultural sector.[3] The government also agreed a deal with USAID for help to finance the construction of a new water pipeline from Israel to Jordan, due to be completed by mid-2023.[4]

However, although the water sector received significant attention from the government and the international community, water-stress challenges remain one of the key risks hampering economic growth in the medium and long term. Building on existing in-depth research (particularly by Yoon et al, the World Bank, UNICEF and USAID)[5], this Economist Impact report provides an

1. World Bank, Jordan's Economic Update, (2021). https://www.worldbank.org/en/country/jordan/publication/economic-update-october-2021
2. Economist Intelligence Unit (EIU), Country report, Jordan, (2021). http://country.eiu.com/article.aspx?articleid=641623047&Country=Jordan&topic=Politics&subtopic=Forecast&subsubtopic=International+relations
3. Ibid.
4. Jordan Time, "USAID announces project to build pipeline to pump additional water from Israel to Jordan", (2021). https://www.jordantimes.com/news/local/usaid-build-new-pipeline-pump-additional-water-israel-jordan
5. Yoon et al, "A coupled human–natural system analysis of freshwater security under climate and population change", (2021). https://www.pnas.org/content/118/14/e2020431118; World Bank, "Water in the Balance", (2020). https://openknowledge.worldbank.org/bitstream/handle/10986/34498/153087.pdf?sequence=1&isAllowed=y; UNICEF, "Running Dry: unprecedented scale and impact of water scarcity in the Middle East and North Africa", (2021). https://www.unicef.org/press-releases/running-dry-unprecedented-scale-and-impact-water-scarcity-middle-east-and-north

overview of the extent of the social and economic costs that water stress imposes on the Jordanian population through three key channels: economic production, human capital and broader social and political stability.

The report aims to explore and quantify the linkages from water stress to economic production (agricultural, manufacturing and services) and human capital (infant mortality, educational attainment and nutrition) based on cross-sectional regression and scenario analysis. The scenario analysis draws on the work of Yoon et al to consider the impacts of water stress in Jordan under three intervention scenarios (no intervention, supply-side intervention, and supply and demand-side interventions) and two water-stress scenarios (worst case and optimistic case, defined based on potential outcomes for climate change, population growth and transboundary flows, amongst others).

The impacts are estimated based on an association exercise to identify the relationship between water stress and socio-economic outcomes utilising cross-country trend data. They should be treated as illustrative of the potential impact under alternative scenarios (see Appendix for detailed methodology). The report also explores qualitative linkages between water stress and social and political dimensions that are difficult to measure, such as migration, gender inequality and political instability. Finally, the report looks at the way forward and discusses potential solutions in the form of key policy options to address water stress in Jordan.

Production

Direct economic dollar value effect of water stress on agriculture, manufacturing and services as a result of limited access to resources for production.

Human capital

Longer-term indirect effects of water stress related to health, nutrition, education and human capital, with consequences for labour productivity, poverty and economic growth.

Society and politics

Spillover effects on communities' stability, prosperity and well-being, particularly through broader demographic and political factors, especially migration, gender inequality and regional political instability.

Key findings include:

Jordan is one of the most water-stressed countries in the world and without significant interventions, the situation is likely to deteriorate further. In Jordan, less than 100 cubic meters of renewable water resources is available per person annually. This is already significantly below the 'absolute water scarcity' threshold of 500 cubic meters.[6,7] The country's renewable water supply currently meets only about two-thirds of the population's water demands, with water-stress levels (defined as water withdrawals as a proportion of available water resources) increasing from 80% to 100% in the last two decades. These underlying trends are likely to continue. A seminal study by Yoon et al expects water-stress levels in Jordan to increase at an average annual rate of 1%-1.5% until 2100, making more than 90% of low income households in Jordan subject to critical water vulnerability.[8] These impacts are particularly devastating in the modelled worst case scenarios of adverse climate change effects, in which surface water inflows could decline by a staggering 60% to 70% by the end of the century.[9]

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Jordan's agricultural production is significantly vulnerable to increasing water stress. Agriculture contributes roughly 5% of Jordan's GDP and employs 3% of its workers, but it consumes more than 50% of the country's freshwater.[10] Increased water stress can lead to crop failure, import dependency and increased costs for consumers and businesses. Based on Yoon et al estimates of increased water stress, our analysis suggests that this could lead to a decrease in agricultural Gross Value Added (GVA) of between 0.8% and 1.2% in 2030, or an annual loss of US$20m to US$29m. This would be reduced in both intervention scenarios. While the direct contribution of the sector to Jordan's economy is relatively limited, its overall contribution is closer to 20-25% of GDP when considering indirect linkages with other parts of the economy.[11] The overall economic impact of water stress is therefore likely to be much larger. A World Bank study estimates that a reduction in water supply and related changes in crop yields induced by climate change could reduce Jordan's GDP by up to 6.8%, equating to US$2.6b in monetary terms.[12]

6. UNICEF, Water Sanitation and Hygiene, https://www.unicef.org/jordan/water-sanitation-and-hygiene
7. Ministry of Water, Facts and Figures, (2017); FAO, Aquastat, (2021).
8. Water-vulnerable households are defined as those using less than 40 litres per capita per day on average in a given year. Yoon et al, "A coupled human–natural system analysis of freshwater security under climate and population change", (2021). https://www.pnas.org/content/118/14/e2020431118
9. Ibid.
10. World Bank, National accounts, (2020).
11. The World Bank, "The role of food and agriculture for job creation and poverty reduction in Jordan and Lebanon", (2018). https://documents1.worldbank.org/curated/ar/325551536597194695/pdf/Agricultural-Sector-Note-Jordan-and-Lebanon.pdf
12. World Bank, "Water in the Balance", (2020). https://openknowledge.worldbank.org/bitstream/handle/10986/34498/153087.pdf?sequence=1&isAllowed=y

Jordan's service sector—the country's key source of employment and economic activity—is also indirectly vulnerable to water stress. Jordan's economy is heavily reliant on the service sector, which accounts for more than 60% of the country's GDP and 73% of total employment.[13] The tourism sector, which directly contributes around 5% of Jordan's GDP, is particularly exposed to water shortages and increases in operational costs in periods of water stress.[14] As a labour-intensive sector, services are reliant on employees' skills and productivity, which can be undermined by long-term water stress. Our analysis suggests that, without any intervention, the expected increase in water stress could decrease the output of the services industry by between 2.8% to 4.1% by 2030. This would represent a loss of service sector GVA of between US$800m and US$1.2bn. Through interventions to enhance water supply and manage water demand, the annual growth in water stress could be minimised, reducing the loss of GVA to between US$400m and US$790m. The large magnitude of impact could be reflective of the high proportion of people employed in this sector and the substantial impacts of increasing water stress on health and well-being, e.g. employee productivity levels.[15]

The potential impacts of water stress on Jordan's manufacturing sector are less clear. Overall, the role of water in industry and manufacturing is less clear-cut and less pressing than in agriculture or the service industry. The industrial sector accounts only for 3% of water consumption in Jordan and this is concentrated in a few large sub-sectors, such as chemicals and packaging, that use significant amounts of water directly in their production processes. But water is also crucial for other industrial processes, such as heating and cooling, transport and cleaning, as well as energy supply.[16,17] Although our analysis did not find a statistically significant relationship between water stress and overall industrial production, increased water stress could lead to a reduction in the water available for production and/or increased costs of production in critical sub-sectors. This could have damaging effects on the economy. The chemical industry, for example, accounts for over a third of Jordan's total exports.[18]

Water stress contributes to Jordan's food security challenges. Food insecurity remains a challenge in Jordan, particularly among vulnerable populations. The prevalence of undernourishment has increased from 5% to 10% since the mid-2000s, while around 53% of Jordanians, and 88% of the

13. World Bank, "Jordan Overview". https://www.worldbank.org/en/country/jordan/overview#1
14. World Travel and Tourism Council, Jordan 2021, (2021). https://wttc.org/Research/Economic-Impact/moduleId/704/itemId/139/controller/DownloadRequest/action/QuickDownload; Ahmed Abu Al Haija, "Jordan: Tourism and conflict with local communities", (2011). https://elevatedestinations.com/wp-content/uploads/2020/01/Jordan-Tourism-and-Conflict-with-Local-Communities.pdf
15. International Labour Organisation (ILO), Employment in services (% of total employment), (2020). https://data.worldbank.org/indicator/SL.SRV.EMPL.ZS?locations=JO
16. McKinsey&Company, "The global corporate water footprint", (2009). https://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/Sustainability/PDFs/Report_Large_Water_Users.aspx
17. Motasem N Saidan, "Estimation of industrial water demand and reclamation in Jordan: A cross-sectional analysis", (2020), Water Resources and Industry. 23. 100129.
18. Oxford Business Group, "Jordanian industry makes progress on phosphate, chemicals and pharmaceuticals".

refugee population remain food-insecure or vulnerable to food insecurity.[19,20] Our analysis shows that increasing levels of water stress are associated with a decline In the adequacy of the average dietary energy supply—a measure of the country's average supply of calories for food consumption as a share of the average dietary energy requirement estimated for its population. Jordan's adequacy of dietary intake ratio declined from 125% in the mid-2000s to just 117%, which is well below the regional average of 125%. Our analysis suggests that without intervention to curb the growth in water stress, this ratio could decrease further, to 115%, increasing the risk that people will face food insecurity and malnutrition. Food insecurity and the resulting risk of under- and malnourishment are key contributors to suboptimal health outcomes, particularly among children.

Reduced water consumption is associated with higher infant mortality. The global health burden associated with inadequate water provision is staggering: lack of access to safe water, sanitation and hygiene (WASH) services causes around 1.6m deaths every year.[21] The World Bank estimates that total economic losses associated with inadequate WASH services amount to US$260bn annually in low- and middle-income countries, roughly equivalent to an average annual loss of 1.5% of the aggregate GDP in those countries.[22] Water stress can be driven by increased water consumption, which in the case of health can lead to positive outcomes. Indeed, access to safe drinking water has been linked to reduced under-five mortality in Jordan.[23] Associating an increase in water stress with increased consumption of water by children, our results show that a 5% increase in water consumption could reduce infant mortality in Jordan from 13.4 deaths per 1,000 to 9.7 deaths per 1,000. Yet despite significant progress achieved in recent decades, only 85% and 82% of Jordanians have access to safely managed drinking water and sanitation services, respectively. Moreover, only 70% of the urban and 20% of the rural population have access to sewage-treated sanitation.[24]

Inadequate water services could undermine educational attainment by Jordanian youth—particularly girls. Water-related illnesses that arise when children do not have access to water at home can stunt growth and decrease capacity for learning. This can force children to remain outside of the classroom and hamper their educational achievements and long-term earning potential.[25] Moreover,

19. Reliefweb, "Jordan Food Security Update - Implications of COVID-19 (July-August 2020)", (2020). https://reliefweb.int/report/jordan/jordan-food-security-update-implications-covid-19-july-august-2020.
20. World Bank Data. https://data.worldbank.org/indicator/SN.ITK.DEFC.ZS?locations=JO
21. Reliefweb, "Jordan Food Security Update - Implications of COVID-19 (July-August 2020)", (2020). https://reliefweb.int/report/jordan/jordan-food-security-update-implications-covid-19-july-august-2020
22. F Tarrass and M Benjelloun, "The effects of water shortages on health and human development", (2012), Perspectives in Public Health 132(5):240-4. https://pubmed.ncbi.nlm.nih.gov/22991372/
23. Cornelia Kaldewei, "Determinants of Infant and Under-Five Mortality – The Case of Jordan", (2010). https://www.un.org/en/development/desa/policy/capacity/country_documents/jordan_desa_mdg4_technote_mar2010.pdf
24. WHO, UNICEF, (2020). https://washdata.org/data/household#!/table?geo0=country&geo1=JOR
25. UNICEF, "Water Security for All", (2021). https://www.unicef.org/media/95241/file/water-security-for-all.pdf

In Jordan, the paucity of women in the labour market underscores the domestic role most women fill: only around 15% of the country's women work, a very low level by global standards.

inadequate water and sanitation facilities in schools negatively impact student enrolment, attendance and performance, particularly for girls.[26] Worryingly, the girls' school attendance rate has been declining in Jordan over the past two decades. For instance, while the female primary school enrolment rate was above 95% in the early 2000s, it declined to just 80% by 2018.[27] While there are various factors that contribute towards the decline, climate change and a lack of sanitation facilities further exacerbate the issue. Our analysis suggests this could decline by an additional percentage point due to increased water stress by 2030.

Women and girls are especially vulnerable to water stress. Women and girls are disproportionately affected by inadequate water access due to their role in domestic activities and the importance of sanitation in dealing with menstruation and pregnancy.[28] In Jordan, the paucity of women in the labour market underscores the domestic role most women fill: only around 15% of the country's women work, a very low level by global standards.[29] UNICEF highlights that women and girls in Jordan may not have a suitable space to manage their menstruation at work, especially if they work in the informal sector. In some cases, they may simply stay home, losing a source of income. There is a lack of conversation and policy building around the WASH needs of women and girls, leading to the disempowerment of girls and negative effects on their education and health.[30]

Water stress can further exacerbate migration pressures. Historically, war and unemployment drive more migration within MENA than water-related events such as drought.[31] However, as the effects of climate change intensify, vulnerabilities and tensions over water resources may rise, leading to cycles of water insecurity and fragility. We are starting to see this happen in the region—displacement in the southern region of Iraq was reportedly caused by water scarcity.[32] Jordan is among the top three recipients of refugees in MENA, and an influx of refugees creates additional stress on areas that are already weak by exacerbating pre-existing political

26. Batool Ghaith, "UNICEF warns of impact of water scarcity on children's well-being", (2021). https://www.jordantimes.com/news/local/unicef-warns-impact-water-scarcity-childrens-well-being
27. EIU analysis using FAO data
28. Palmioli et al, "The gendered impacts of climate change: The Jordan River Basin region and water scarcity". http://www.ra-un.org/uploads/4/7/5/4/47544571/13_osce_the_gendered_impacts_of_climate_change.pdf
29. WeForum, 'Global Gender Gap Report', (2021). https://www3.weforum.org/docs/WEF_GGGR_2021.pdf
30. Sara AlHattab, "Breaking the cycle of silence - menstruation matters", (2019). https://www.unicef.org/jordan/stories/breaking-cycle-silence-menstruation-matters
31. World Bank, 'Ebb and Flow', Volume 2, (2021). https://www.worldbank.org/en/topic/water/publication/ebb-and-flow-water-migration-and-development
32. UNICEF, "Drying Up Their Futures The Impact Of Water Scarcity On Children In The Middle East And North Africa Region", (2020).

and socio-economic stressors. Migration into urban areas will further intensify the pressure on municipal infrastructure and services such as housing, healthcare, education, water and sanitation.[33]

Water stress can further complicate regional cooperation. Political tensions over water resources have a long history in the MENA region. These are less a result of an absolute shortage of water in the region, but rather a lack of cooperation over unequally distributed shared resources. Jordan, a downstream country, obtains 40% of its water from transboundary basins, leaving it heavily dependent on cooperation with its upstream neighbours.[34] Despite years of dialogue and diplomatic efforts, effective cooperation over the management of, and investment into, shared water resources remains elusive, as demonstrated by the cancellation of the long-awaited Red Sea-Dead Sea Canal that was planned as a shared project with Israel.[35] Nevertheless, innovative initiatives, such as the water-energy agreement between Jordan, Israel and the United Arab Emirates (UAE) might pave the way for improved cooperation.[36]

Policy intervention can reduce the increase in water stress and mitigate its most negative effects. Jordan is facing a declining supply of freshwater and ever-growing demand, exacerbated by the fact

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that around 50% of the water supplied is lost due to technical or commercial losses. However, policy choices can influence the extent to which Jordan's water-stress crisis will deteriorate over the coming years, as well as its subsequent impacts on society and the economy. Yoon et al show that supply-side (e.g. new desalination projects, reduced water loss and leakage) and demand-side (e.g. revisions to the water tariff schedule) interventions can significantly minimise growth in water stress and the resulting damages.[37] Our analysis based on these scenarios highlights the effects that this reduction would have on Jordan's economic and social development.

33. World Bank, 'Data for better lives', (2021). https //www.worldbank.org/en/publication/wdr2021
34. Hussam Hussein, "Whose 'reality'? Discourses and hydropolitics along the Yarmouk River", (2017), Contemporary Levant, 2:2, 103-115. https://www.tandfonline.com/doi/full/10.1080/20581831.2017.1379493
35. Times of Israel, (2021). https://www.timesofisrael.com/after-years-of-delays-jordan-said-to-nix-red-sea-dead-sea-canal-with-israel-pa/
36. EIU country report, Jordan, (2021). http://country.eiu.com/article.aspx?articleid=641623047&Country=Jordan&topic=Politics&subtopic=Forecast&subsubtopic=International+relations
37. EIU country report, Jordan, (2021). http://country.eiu.com/article.aspx?articleid=641623047&Country=Jordan&topic=Politics&subtopic=Forecast&subsubtopic=International+relations

In the long-term, Jordan will need to enhance the amount of water that can be supplied to end users. Firstly, around a quarter of the water in the piped network is lost due to technical issues, such as leaks.[38] This is very high and requires improvements in the water supply and storage infrastructure and monitoring. Secondly, desalination presents one of few options to increase the supply of freshwater in Jordan at scale and for the long-term. Recent breakthroughs in sea water desalination technology have reduced the potential desalination costs to less than US$0.60 per cubic meter, making desalination affordable for middle-income economies.[39] Finally, wastewater treatment (WWT) offers an alternative source for Jordan, but currently covers only around 14% of the country's water supply.[40]

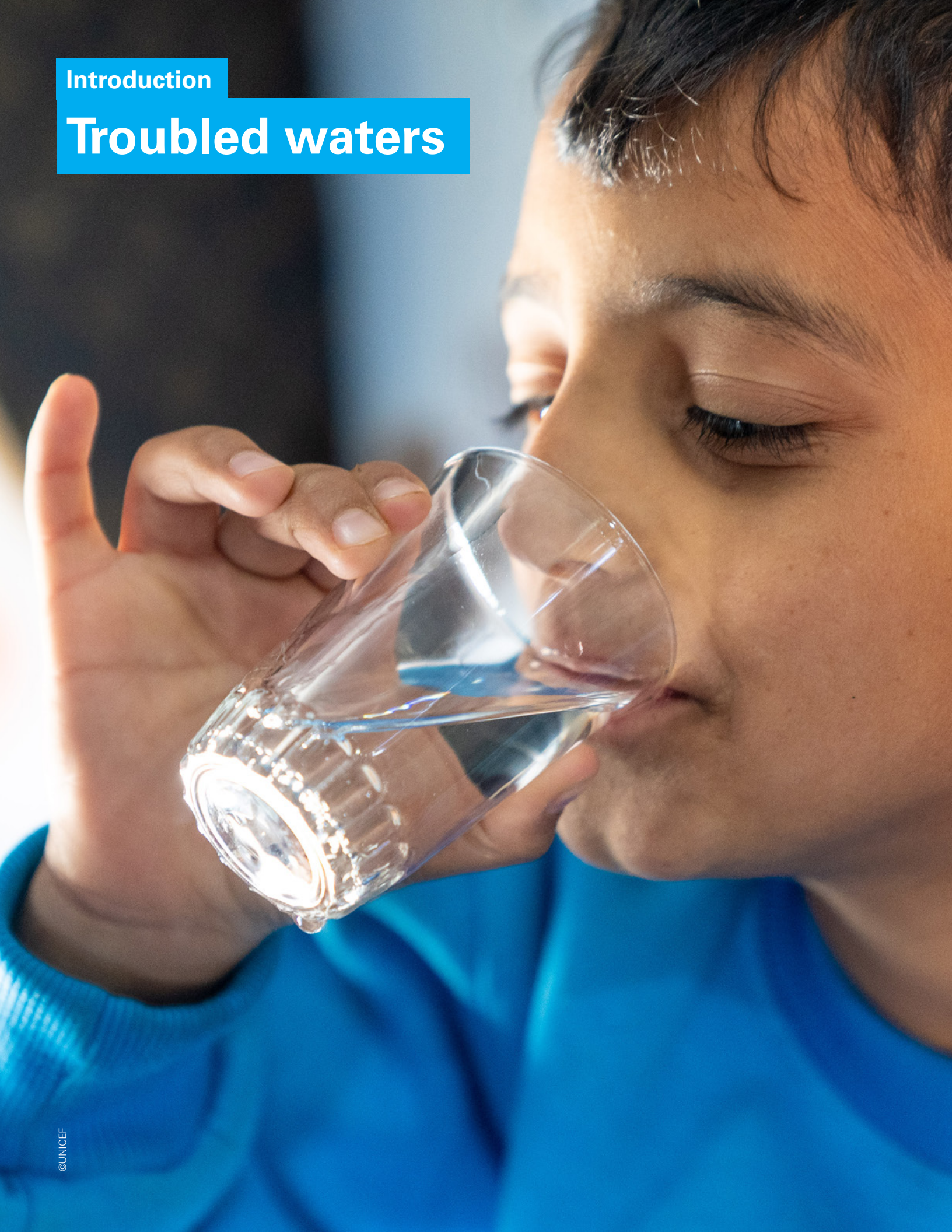
Despite being a water-stressed country, water-use practices in Jordan are not efficient and need to improve. Water use is heavily subsidised in Jordan—47% of the price of domestic water is covered by the government—at an estimated cost of JOD348m (US$490m) in 2017.[41] End-user tariffs are set below the cost of operations, which means that water suppliers run long-term budget deficits, undermining their ability to invest in infrastructure maintenance and development. Improving the subsidy and tariff system should be gradual and will require significant time to be implemented. Supporting adoption of water-efficient practices and technology—especially in agriculture—will be particularly important in the meantime. For domestic consumption, public awareness programmes can help to reduce water waste and encourage use of water alternative sources, such as treated wastewater and harvested rainwater.

Cross-sectoral coordination will be critical. Coordination and joint planning among the key decision makers, including regulators, investors, and users is essential for achieving efficient and sustainable infrastructure development and water allocation. Importantly, the planning should be evidence- and data-based. However, the availability of water data is currently a challenge for researchers, users and policy makers in Jordan. Finally, improved regional cooperation on water resources can help improve Jordan's water situation in the long run.[42]

38. Jordan Water Sector Facts and Figures, (2017)
39. Salameh et al. "Jordan's Water Sector—Alarming Issues and Future", (2021). 10.4236/gep.2021.912007
40. Yoon et al. "A coupled human–natural system analysis of freshwater security under climate and population change", (2021) https://www.pnas.org/content/118/14/e2020431118
41. Jordan Water Sector Facts and Figures, (2017)
42. EcoPeace MENA, "Green Blue Deal", (2020) https://ecopeaceme.org/wp-content/uploads/2021/03/A-Green-Blue-Deal-for-the-Middle-East-EcoPeace.pdf

Introduction

Troubled waters



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Water provides the foundation for life, societal well-being and prosperity, yet too few people are able to access high-quality sources of it. When the demand for water exceeds the available supply, or when poor quality restricts its use, water stress ensues, with cascading consequences: aquifer overexploitation, dry rivers, organic and mineral pollution, saline intrusion and so on. Increased water stress can also fuel competition between different water users and potentially generate negative long-term effects on the sustainability of natural resources and economic and social development. The lack of access to safe and affordable water, sanitation and hygiene (WASH) services has a devastating impact on human health, prosperity and social stability and has thus been recognised by the United Nations as a basic human right.[43]

Globally, the lack of access to basic WASH services contributes to the deaths of an estimated 1,400 children per day.[44] The devastating effects of water scarcity were tragically demonstrated in a refugee camp 70km away from Jordan's capital city of Amman when a parasite in the water supply resulted in the hospitalisation of at least 1,000 residents of Bani Hassan village, including children and the elderly, in 2007.

In 2018, 90% of people in the Iraqi city of Basra, located at the tail end of the famous Tigris and Euphrates rivers, lost access to clean drinking water and more than 100,000 of them ended up being hospitalised with water-borne diseases.[45] These human tragedies also undermine economic development and prosperity, as people miss out on educational and employment opportunities, and suffer from poor health and low productivity. The World Health Organisation (WHO) estimates that every US dollar invested in water and sanitation generates a fourfold return because of higher labour participation and productivity and lower healthcare costs.[46] Yet, according to the UN, over 2bn people live in areas subject to water stress and about 3.4bn people—nearly 45% of the global population—lack access to safely managed sanitation facilities.[47]

The Middle East and North Africa (MENA) region, in particular, faces unprecedented levels of water shortage. Countries in the MENA region are only able to access 1.4% of the world's renewable freshwater while hosting 6.3% of the world's population.[48] Of the 17 most water-stressed countries in the world, 12 are in the MENA region.[49] In 2021, over 90% of

43. UN Water, Human Rights to Water and Sanitation. https://www.unwater.org/water-facts/human-rights/
44. UNICEF, "Diarrhoea remains a leading killer of young children, despite the availability of a simple treatment solution", (2021). https://data.unicef.org/topic/child-health/diarrhoeal-disease/
45. UNICEF, "Multi-Tiered Approaches to Solving the Water Crisis in Basra, Iraq", (2019). https://www.unicef.org/media/91401/file/Multi-Tiered-Approaches-to-Solving-the-Water-Crisis-in-Basra-Iraq.pdf
46. WHO, https://news.un.org/en/story/2014/11/484032-every-dollar-invested-water-sanitation-brings-four-fold-return-costs-un
47. United Nations, 'Water'. https://www.un.org/en/global-issues/water
48. Roudi-Fahimi et al, "Finding the balance: population and water scarcity in the Middle East and North Africa", (2000). https://www.prb.org/resources/finding-the-balance-population-and-water-scarcity-in-the-middle-east-and-north-africa/
49. WRI, "Updated Global Water Risk Atlas Reveals Top Water-Stressed Countries and States", (2019). https://www.wri.org/news/release-updated-global-water-risk-atlas-reveals-top-water-stressed-countries-and-states

children in the region lived in areas of high or extremely high water stress,[50] compared with 20% of children living in such areas globally.[51] Furthermore, over 70% of the region's GDP is generated in areas with high to very high surface water stress, compared with a global average of 22%.[52] Multiple factors—including climate change leading to droughts and floods, low water quality, and poor water management due to weak governance, conflict and violence—drive water stress in the region.[53]

Jordan's water crisis

Jordan is one the most water-stressed countries in the world, ranking fifth globally by one measure.[54] Overall, less than 100 cubic meters of water is available per person annually, which is already significantly below the 500 cubic meters threshold of 'absolute water scarcity', and it is declining further.[55] The country's renewable water supply currently only meets about two-thirds of the population's water demand, with groundwater being used up twice as quickly as it can be recharged and water-stress levels (defined as water withdrawals as a proportion of available water resources) increasing from 80% to 100% in the last two decades.[56] Jordan is one of a few countries in the world (most of them located in the Middle East), where this ratio is above 100% indicating 'critical' levels of water stress.

With less than 100mm of annual average precipitation, Jordan is one of the driest countries in the world.* Climate change is making the region warmer and the supply of freshwater scarcer and more volatile.[57] According to the Global Historical Climatology Network (GHCN), average annual precipitation levels in Jordan have decreased by 2.92 mm/month since 1900.[58] The average local temperature in Jordan has increased rapidly since the 1990s, by 1.5°C–2°C, and it is projected to rise further—potentially by 1.5°C to 3.75°C during the period 2080-2099.[59] The drier and warmer climate will further exacerbate issues related to water stress in Jordan.

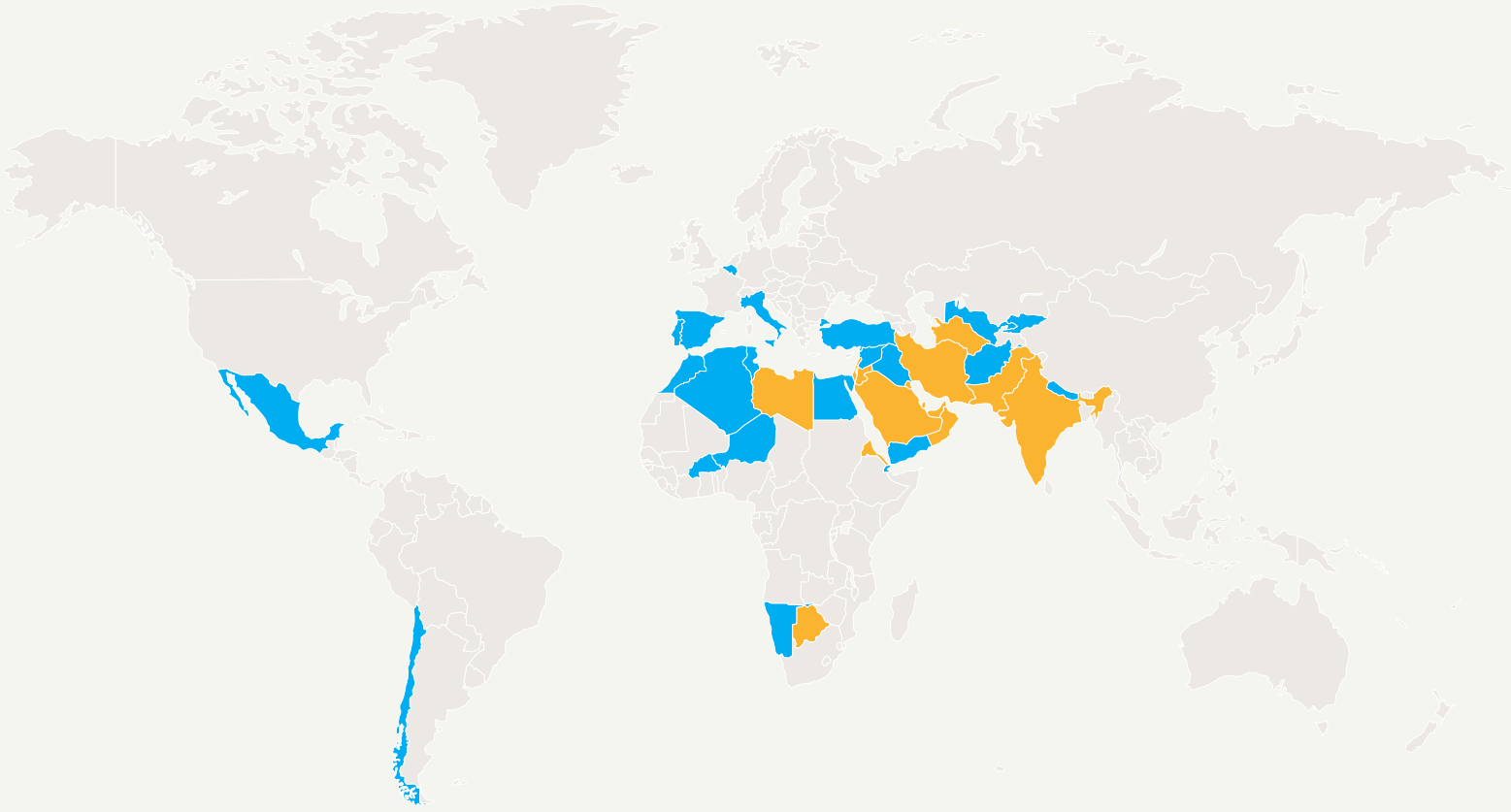
>70%

of the region's GDP is generated in areas with high to very high surface water stress

* Climate Knowledge Portal, (2020). https://climateknowledgeportal.worldbank.org/country/jordan/climate-data-historical

50. UNICEF, "Running Dry: unprecedented scale and impact of water scarcity in the Middle East and North Africa", (2021). https://www.unicef.org/press-releases/running-dry-unprecedented-scale-and-impact-water-scarcity-middle-east-and-north
51. World Bank, Beyond Scarcity Water Security in the Middle East and North Africa, (2017). https://openknowledge.worldbank.org/bitstream/handle/10986/27659/211144ov.pdf?sequence=3&isAllowed=y
52. Ibid.
53. Sopho Kharazi, "Water Stress Poses Greatest Threat to MENA Region", (2018). https://reliefweb.int/report/world/water-stress-poses-greatest-threat-mena-region
54. World Resource Institute (WRI), https://www.wri.org/insights/17-countries-home-one-quarter-worlds-population-face-extremely-high-water-stress
55. Ministry of Water, Facts and Figures, (2017); FAO, Aquastat, (2021).
56. USAID, Jordan Background. https://www.usaid.gov/jordan/water-resources-environment
57. The World Bank, "Water in the Balance", (2020). https://openknowledge.worldbank.org/bitstream/handle/10986/34498/153087.pdf?sequence=1&isAllowed=y
58. World Bank, "Climate Knowledge Portal". https://climateknowledgeportal.worldbank.org/country/jordan/climate-data-historical.
59. Abdulla Fayez, "21st Century Climate Change Projections of Precipitation and Temperature in Jordan", (2020). https://www.sciencedirect.com/science/article/pii/S235197892030809X

Figure 1: Water stress around the world



Extremely high baseline water stress			
1. Qatar	6. Libya	10. United Arab Emirates	14. Pakistan
2. Israel	7. Kuwait	11. San Marino	15. Turkmenistan
3. Lebanon	8. Saudi Arabia	12. Bahrain	16. Oman
4. Iran	9. Eritrea	13. India	17. Botswana
5. Jordan			

High baseline water stress			
18. Chile	25. Uzbekistan	32. Turkey	39. Niger
19. Cyprus	26. Greece	33. Albania	40. Nepal
20. Yemen	27. Afghanistan	34. Armenia	41. Portugal
21. Andorra	28. Spain	35. Burkina Faso	42. Iraq
22. Morocco	29. Algeria	36. Djibouti	43. Egypt
23. Belgium	30. Tunisia	37. Namibia	44. Italy
24. Mexico	31. Syria	38. Kyrguzstan	

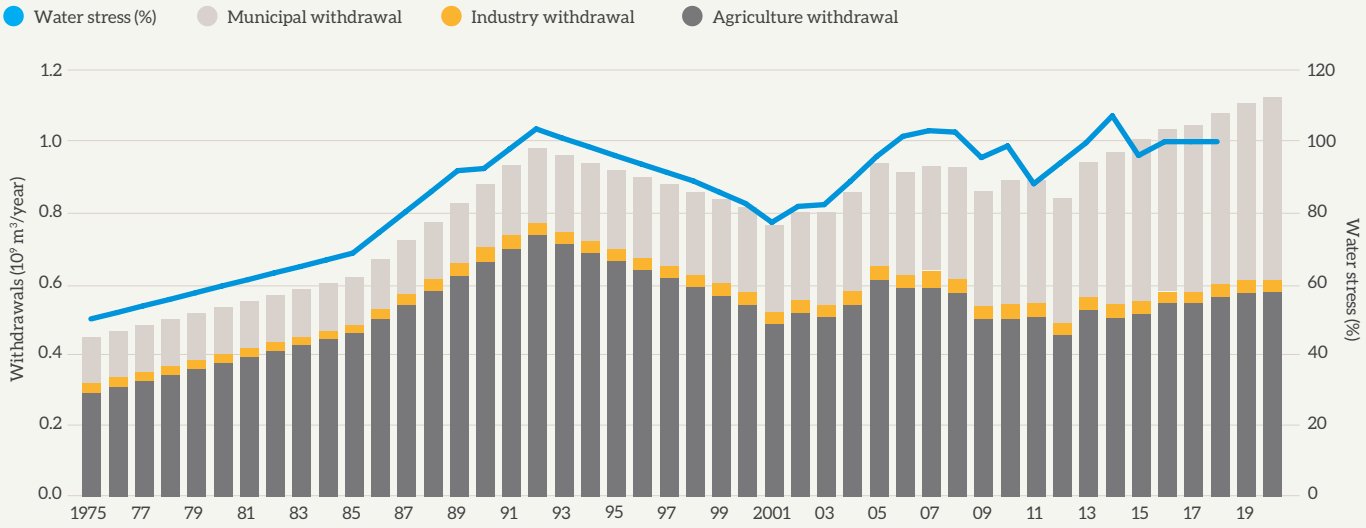
*Baseline water stress measures the ratio between total water withdrawal and available renewable surface water supply

Source: World Resource Institute (WRI)

In recent years, rapid growth in the volume of water used has led to a significant increase in water stress, which is likely to continue. Consumption of water resources—driven by economic development, population growth and migration as well mismanagement and waste due to inadequate maintenance—has increased across all sectors of society.

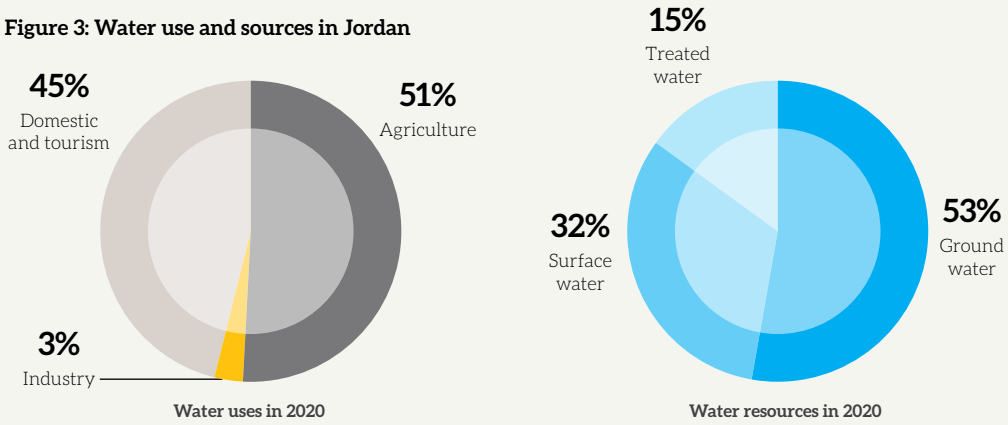
Agriculture has consistently remained the dominant consumer of water, but demand for municipal water has increased sharply over the past three decades (see Figure 2). More than 50% of all water consumed goes to agriculture, while under 45% is directed to domestic use—compared with just under 25% in the late 1990s.

Figure 2: Jordan's water withdrawals by sector (10^9 cubic meters/year) and water stress (% of water withdrawals as a share of available renewable sources)



Source: Aquastat, Food and Agriculture Organization of the United Nations; Jordan Ministry of Water Facts and Figures (2020)

Figure 3: Water use and sources in Jordan



Source: Ministry of Water, 2020

The increased demand for water services has been driven by population growth, rapid urbanisation and improved access, as well as the refugee influx from neighbouring conflict areas.

Exacerbated by low water availability and climate change, Jordan faced one of the worst water shortages in the summer of 2021. A combination of low rainfall, poor planning and increased demand due to the covid-19 pandemic further increased the pressures on available water sources. The situation is likely to deteriorate further. The Kingdom received only around 60% of the usual rainfall during the October 2020 – May 2021 period, while the increased hygiene demands in response to the pandemic increased water use.[60] This has contributed to the dams being filled well below their storage capacity and the country facing a vast 40m cubic meters water deficit.[61] This has already put Jordanian water users under enormous pressure, and the deficit is projected to increase to at least 60m cubic meters in 2022.[62]

The increased demand for water services has been driven by population growth, rapid urbanisation and improved access, as well as the refugee influx from neighbouring conflict areas.[63,64,65] Jordan's population has grown rapidly, and almost exclusively in urban areas in recent decades, reaching just under 11m in 2021, with over 90% living in urban areas. This is a dramatic increase from just 3.5m and 75% urbanisation rate in 1990.[66] In recent years, this has been exacerbated by a significant influx of refugees. As of 2021, Jordan hosts the second highest share of refugees compared to its population in the world, 89 refugees per 1,000 inhabitants.[67]

Access to safely managed drinking water has increased to above 85%, from around 54% in 2000, significantly improving the quality of life of millions of Jordanians.[68] The fact that despite demographic pressures, 98% of metropolitan Amman's residents are connected to the water supply system is a remarkable accomplishment for a low-middle-income country.[69] This has been achieved thanks to significant national and international investment in the country's water infrastructure, particularly pumps and pipelines.[70]

Nevertheless, the water supply network and water sources have been under pressure from rapidly increasing demand and subject to rationing for years. It is estimated that

60. SciDevNet, "Jordan suffers summer of water shortages", (2021). https://www.scidev.net/global/news/jordan-suffers-summer-of-water-shortages/
61. Al-Mamlaka, "The Ministry of Water: 40 million cubic meters of water shortage in Jordan this year", (2021). https://www.almamlakatv.com/news/78966
62. Jordan Times. https://www.jordantimes.com/news/local/kingdoms-drinking-water-consumption-stands-11bcm-deficit-hit-60mcm-2022-%E2%80%94-najjar-0
63. Leen Hajjar, "Jordan's resources 'stretched to the limit' as population doubles", (2016). https://english.alarabiya.net/blog/2016/01/27/Rise-in-Jordan-s-population-a-concern-for-many-
64. UN-Habitat, "Jordan - Urban issues", https://unhabitat.org/jordan-urban-issues
65. ReliefWeb, "Influx of Syrian Refugees in Jordan | Effects on the Water Sector", (2021). https://reliefweb.int/report/jordan/influx-syrian-refugees-jordan-effects-water-sector
66. Alexandra Francis, "Jordan's Refugee Crisis", (2015). https://carnegieendowment.org/2015/09/21/jordan-s-refugee-crisis-pub-61338; United Nations Population Division, "World Urbanisation Prospects", (2021).
67. UNHRC, UNHCR Jordan Factsheet - February 2018, (2018). https://reliefweb.int/report/jordan/unhcr-jordan-factsheet-february-2018
68. JMP, WASH Data, "Jordan". https://washdata.org/data/household#!/table?geo0=country&geo1=JOR
69. Daanish Mustafa and Samer Talozi, "Tankers, Wells, Pipes and Pumps: Agents and Mediators of Water Geographies in Amman, Jordan", (2018), Water Alternatives. 11. 916. https://www.water-alternatives.org/index.php/alldoc/articles/vol11/v11issue3/470-a11-3-23/file
70. Ibid.

Jordan's water reserves can only sustain a population of 3m, as the amount of freshwater per person declined 10-fold since the 1960s and is expected to halve by the end of this century.[71] These underlying trends are likely to continue. A key study conducted by Yoon et al estimates water stress in Jordan to increase at an annual rate of 1%-1.5%.[72]

Shutterstock/Iuliia Khabibullina

The pressure on limited reserves is further undermined by inefficiencies in Jordan's water-distribution system. Around 50% of Jordan's piped supply is lost as Non-Revenue Water (NRW), due to either physical losses (e.g. pipeline leaks) or administrative losses (e.g. water theft, incorrect meter readings or underbilling).[73] Estimates suggest that slightly more than 50% of NRW is attributable to administrative losses and less than 50% to physical losses from the networks.[74] Around 25% of the total water supply is therefore lost due to technical losses, which is still significantly high compared with only 10% in advanced economies.[75]

The transboundary nature of Jordan's water resources also complicates the situation—Jordan is a downstream country that gets 40% of its water from the Sea of Galilee and the Jordan and Yarmouk River basins, which are controlled by Israel and Syria. There are water agreements in place to ensure equitable water allocation, however, these agreements are weak, do not favour Jordan and do not take sudden population spikes into account. The remaining 60% comes from aquifers that are replenished by regular rainfall.[76] As a result, prolonged periods of drought and conflict amongst MENA states often result in disruptions in water supply, hampering overall availability of freshwater in Jordan.[77]

71. Yoon et al, "A coupled human–natural system analysis of freshwater security under climate and population change", (2021). https://www.pnas.org/content/118/14/e2020431118
72. Ibid.
73. Ibid.
74. Ministry of Water, Facts and Figures, (2017).
75. Nadhir Al-Ansari, et al, "Water Supply Network Losses in Jordan", (2014).
76. Osama Al Sharif, "Why Jordan faces a critical water crisis", (2021). https://gulfnews.com/opinion/op-eds/why-jordan-faces-a-critical-water-crisis-1.78685626
77. Yoon et al, "A coupled human–natural system analysis of freshwater security under climate and population change", (2021). https://www.pnas.org/content/118/14/e2020431118

Consequences of water stress

Water stress has become a part of every-day life for many people in Jordan, particularly the most vulnerable. Most regions rely on rooftop water tanks that are replenished once a week for daily domestic freshwater use.[78] It is estimated that on average, households in the capital of Amman receive piped water for only 36 hours per week, with lower-income neighbourhoods receiving as low as 24 hours of municipal supply, while higher-income households receive up to five days of uninterrupted supply per week.[79] Urban users often end up buying expensive water obtained from private wells through both formal and informal markets, which is delivered by tanker trucks.[80] Moreover, Jordanian citizens often question the quality of the water sources they access. In a study conducted in the Al-Mafraq Governorate of Jordan, 43% of respondents have experienced water contamination.[81]

A more recent World Bank study estimates that a reduction in water supply and changes in crop yields induced by climate change could reduce Jordan's GDP by up to 6.8%

Yoon et al estimate that on its current trajectory, 58% of normal-income households (up from 16%) and a staggering 91% of low-income households will be water-vulnerable by 2100.[82] In this scenario, water vulnerability also becomes more unequal, as higher-income households fall below the critical water-use threshold of 40 litres per capita per day for seven consecutive months per year on average, while lower-income households fall below this threshold for 11 consecutive months on average.[83]

However, inadequate supply of and access to high-quality water resources is not only expensive and inconvenient, it also has significant consequences for peoples' health, well-being and prosperity. Water stress, exacerbated by climate change, can hinder economic and social development, spur migration, increase inequalities and even fuel political and social instability.

A World Bank report finds that unless action is taken soon, water will become scarce in regions where it is currently abundant—such as Central Africa and East Asia—and scarcity will greatly worsen in regions where water is already in short supply—such as the Middle East and the Sahel in Africa. These regions could see their economic growth rates decline by as much as 6% of GDP by 2050 due to water-related impacts on agriculture,

78. Interview with Dr Majd Al Naber, November 2021

79. Daanish Mustafa and Samer Talozi, "Tankers, Wells, Pipes and Pumps: Agents and Mediators of Water Geographies in Amman, Jordan", (2018), Water Alternatives. 11. 916. https://www.water-alternatives.org/index.php/alldoc/articles/vol11/v11issue3/470-a11-3-23/file

80. Ibid.

81. Naji K Al-Mefleh, "Water management problems and solutions in a residential community of Al-Mafraq city, Jordan", (2019). https://www.researchgate.net/publication/330099101_Water_management_problems_and_solutions_in_a_residential_community_of_Al-Mafraq_city_Jordan/link/5ca3b057a6fdcc12ee8ece3a/download

82. Water-vulnerable households are defined as those using less than 40 litres per capita per day on average in a given year. Yoon et al, "A coupled human–natural system analysis of freshwater security under climate and population change", (2021). https://www.pnas.org/content/118/14/e2020431118

83. Ibid.

health, and incomes.[84] A more recent World Bank study estimates that a reduction in water supply and changes in crop yields induced by climate change could reduce Jordan's GDP by up to 6.8%.[85]

Water stress in Jordan will likely further undermine economic and social development in the country if it continues to deteriorate. This report explores the tangible social and economic costs that water stress imposes on the country through a series of complex interlinkages across three main pillars: economic production, human capital, and society and politics.

Production

Direct economic dollar value effect of water stress on agriculture, manufacturing and services as a result of limited access to resources for production.

Human capital

Longer-term indirect effects of water stress related to health, nutrition, education and human capital, with consequences for labour productivity, poverty and economic growth.

Society and politics

Spillover effects on communities' stability, prosperity and well-being, particularly through broader demographic and political factors, especially migration, gender inequality and regional political instability.

84. World Bank, "High and Dry: Climate Change, Water, and the Economy", (2016). https://www.worldbank.org/en/topic/water/publication/high-and-dry-climate-change-water-and-the-economy

85. The World Bank, "Water in the Balance", (2020). https://openknowledge.worldbank.org/bitstream/handle/10986/34498/153087.pdf?sequence=1&isAllowed=y

Modelling the impacts of water stress in Jordan

This report draws on findings from statistical analysis that assesses the associations between water stress and economic and social development. Using data from over 80 countries since 2015, it explores the relationship between changes in water-stress levels and the subsequent implications for a range of indicators including:

- Gross value added (GVA) of the agriculture industry
- GVA of the manufacturing industry
- GVA of the services industry
- Undernourishment
- Female enrolment rates in schools
- Infant mortality rates

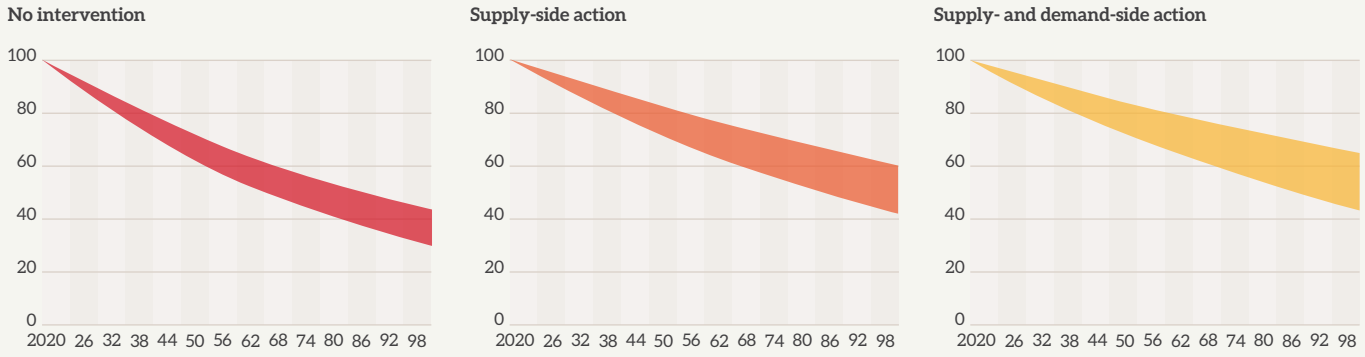
While the analysis does not allow for a causal link to be determined between water stress and these socio-economic indicators, it provides evidence of an association. These cross-country findings provide a basis for understanding the possible impacts for Jordan under a range of hypothetical future scenarios related to water scarcity.

Drawing on the work of Yoon et al[86], the analysis considers the impacts of water stress in Jordan under the following scenarios:

- **No intervention scenario:** Assumes no interventions to address water scarcity in Jordan
- **Supply-side action:** Accounts for planned projects to address issues related to the availability of water including, for example, the Red Sea-Dead Sea desalination project, amongst others
- **Supply- and demand-side action:** In addition to supply-side actions, this scenario also accounts for demand-side measures, including revisions to the water tariff schedule and transferring the groundwater production allocation from the agricultural sector to the municipal sector.

Within each scenario, the range of potential implications for water stress is driven by a number of factors including climate change, population growth, transboundary flows and others (see Figure 4). For further detail on the methodology, please refer to the appendix to this report.

Figure 4: Evolution of water supply in Jordan under hypothetical scenarios, 2020-2100 (cubic meters/capita/year)

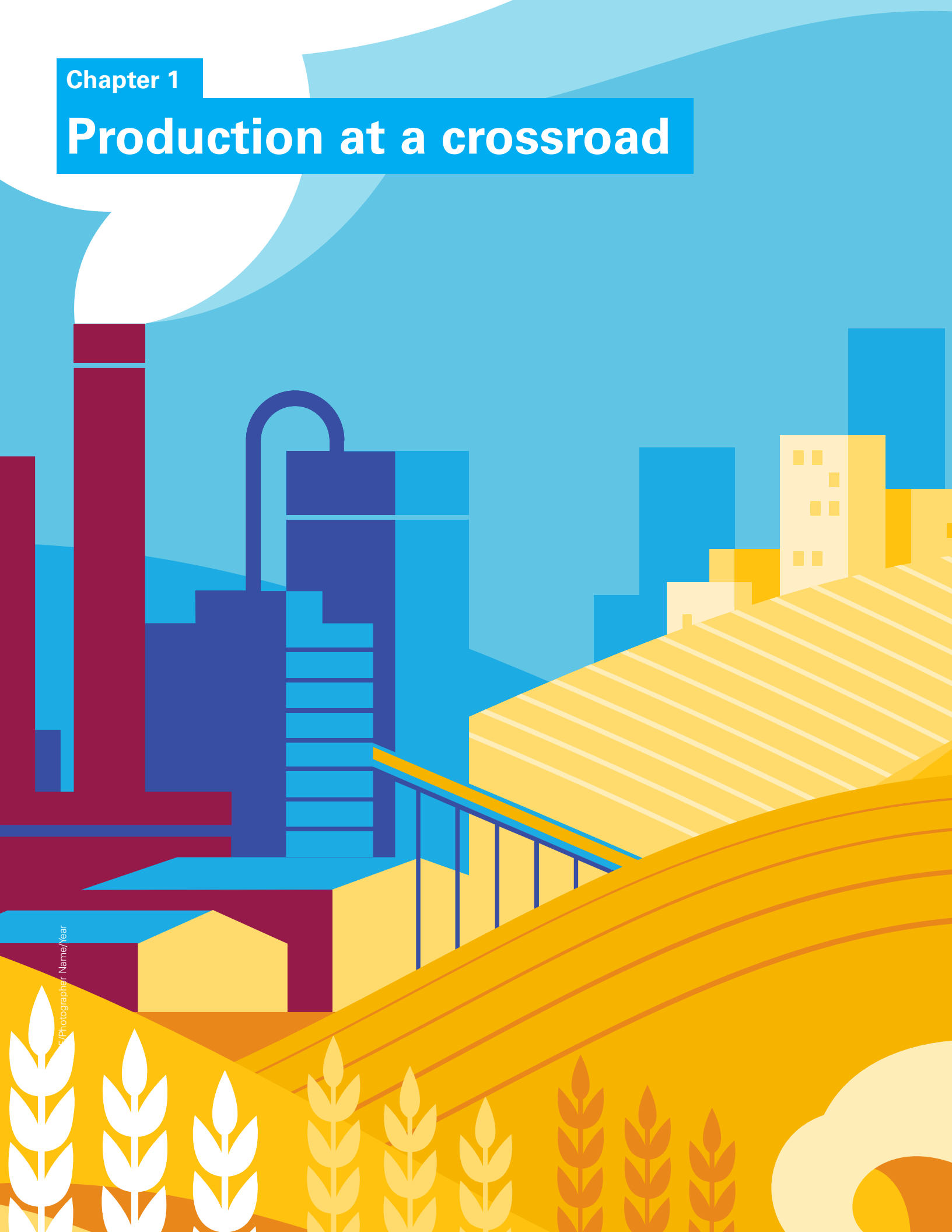


Source: Adapted from Yoon et al (2021)

86. Yoon et al, "A coupled human–natural system analysis of freshwater security under climate and population change", (2021). https://www.pnas.org/content/118/14/e2020431118

Chapter 1

Production at a crossroad



Agriculture: cannot survive without water

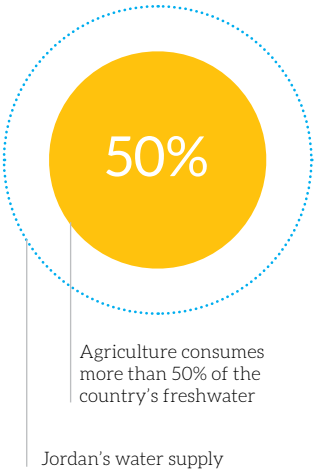
Agriculture contributes roughly 5% to Jordan's GDP and employs 3% of its workers, yet it consumes more than 50% of the country's freshwater.[87] Jordan's agricultural production has increased significantly in both volume and value terms over the years, even as growth in the value added has been outpaced by growth in manufacturing and services, until very recently (see Figure 5).

Nevertheless, Jordan remains a net food importer, particularly of staple foodstuffs, such as wheat, rice, barley and dairy products, while exporting fruits and vegetables, such as tomatoes, dates and citruses.[88] Despite efforts to improve irrigation efficiency and to encourage farmers to grow less water-intensive crops, such as bananas and citruses, water consumption in agricultural practices remains unsustainable.[89] The share of agriculture value added coming from irrigated production has increased from around 35% in the mid 1990s to around 46% in 2016.[90] Just under 70% of crop production is rain-fed, leaving it vulnerable to drought—instances of which have been increasing over the past years— and fluctuations in water supply in a country where 70% of the land receives less than 100mm of rain per year.[91]

Agricultural water-use efficiency (measured as economic output per cubic metre of water used) in Jordan has increased from US$0.5/cubic meters in the early 1990s to almost US$2.0/cubic meters today (see Figure 6). Improved irrigated agricultural water productivity means that the same value of output can be produced using less water.[92] This has mainly been achieved due to investments in water efficiency measures—such as public awareness and support for adoption of new irrigation technology among farmers—and production of higher value-added commodities, such as dates, fruits and vegetables, and poultry meat.[93] However, growth in agricultural production in Jordan means that the sector still consumes a large share of available water resources.[94]

An increase in water stress can significantly damage agricultural production through crop failures, decreased yields and increased costs, undermining overall economic growth. Water stress puts pressure on the amount of water available for irrigation, leading to cost increases, potential crop failure and a reduction in the crops available for export. This can cause losses in jobs like farming, collection and transportation, and ultimately higher prices for consumers and businesses.[95]

Agriculture water consumption



87. World Bank, National accounts, (2020).
88. UN COMTRADE data, (2020).
89. FAO, "Jordan: Water Along the Food Chain," (2015). https://www.fao.org/3/i4608e/i4608e.pdf
90. FAO, Aquastat, (2021).
91. Stanford News, 'Jordan's worsening water crisis', (2021). https://news.stanford.edu/2021/03/29/jordans-worsening-water-crisis-warning-world/
92. Based on data published by the FAO: https://www.fao.org/sustainable-development-goals/indicators/641/en/
93. FAO, "Jordan: Water Along the Food Chain", (2015). https://www.fao.org/3/i4608e/i4608e.pdf
94. Ibid.
95. FAO, "The future of food and agriculture: Trends and Challenges", (2017). http://www.fao.org/3/i6583e/i6583e.pdf

An increase in water stress could decrease the annual agricultural GVA by

0.8%-1.2%

Countries that depend on food imports—Jordan being one of the most cereal-import-dependent countries in the world—are also particularly exposed to potential price increases and balance of payments deterioration.[96]

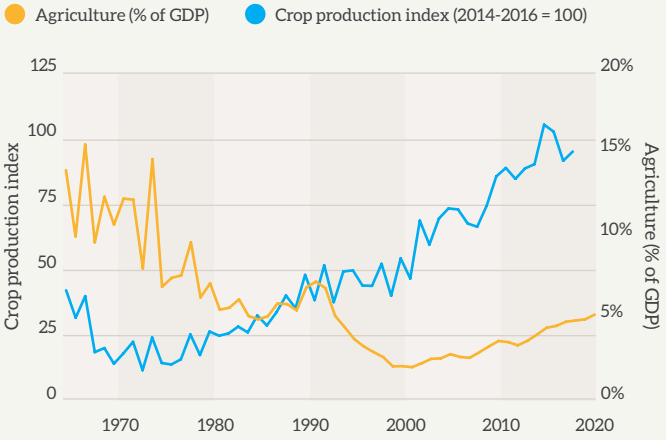
Even a small increase in water stress can therefore have a significant impact on the sector. A seminal World Bank study estimates that a 20% reduction in water supply could potentially inflate crop prices by 2.4%, leading to a number of negative economic spillovers, such as a 6% decline in demand for skilled agricultural labour in the country.[97] This can be particularly impactful for already vulnerable rural areas.[98] Furthermore, a 20% reduction in water supply is estimated to lead to a 5.2% and 5% drop in crop and food supply respectively, which will have spillover effects in terms of labour productivity, nutrition, and other. Overall, a loss of agricultural activities creates a negative feedback to other activities that either provide inputs for agricultural activities or process agricultural products. Overall, the study estimates that with a 20% reduction in water supply, Jordanian GDP could contract up to 6.8% which would equal to a loss of US$2.6bn in monetary terms.

With no intervention to address water challenges, Yoon et al expect water stress in Jordan to increase at an annual rate of 1%-1.5%, depending on population growth, climate change and other factors. Our analysis of the direct association between water-stress changes and the output produced by the agriculture sector shows that, with this rate of increase in water stress, annual agricultural GVA could decrease by 0.8%-1.2% in 2030. However, as outlined above, the spillover effects are likely to be substantial. While agriculture directly accounts for only 5% of Jordan's GDP, its overall contribution is close to 20-25% when considering indirect linkages with other parts of the economy, including the food processing sector.[99] Our projections only capture the direct impact on GVA, not the spillover effects in terms of food processing, food insecurity and other input impacts. Thus, it is likely that an increase in water stress will have serious and significant ramifications for the agricultural sector.

Crucially, with supply-side and demand-side actions, growth in water-stress levels could be reduced, thereby minimising the impact on the agriculture sector. Initiatives to increase water supply could reduce annual growth in water stress to 0.6%-1.1%. With additional actions to increase water supply and simultaneously cut demand, this could reduce further to 0.5%-1%. Reducing water-stress levels could lead to subsequent improvements in the sector's production capacity, and knock-on benefits for the wider economy and society.

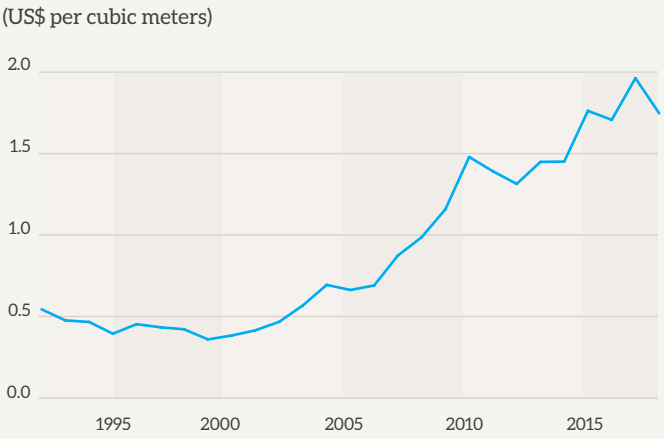
96. The World Bank, "Water in the Balance", (2020). https://openknowledge.worldbank.org/bitstream/handle/10986/34498/153087.pdf?sequence=1&isAllowed=y
97. Ibid.
98. World Bank Data, https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=JO
99. The World Bank, "The role of food and agriculture for job creation and poverty reduction in Jordan and Lebanon", (2018). https://documents1.worldbank.org/curated/ar/325551536597194695/pdf/Agricultural-Sector-Note-Jordan-and-Lebanon.pdf

Figure 5: Jordan's agricultural production



Source: Food and Agriculture Organisation of United Nations (FAO)

Figure 6: Water Use Efficiency in Jordan (US$ per cubic meters)



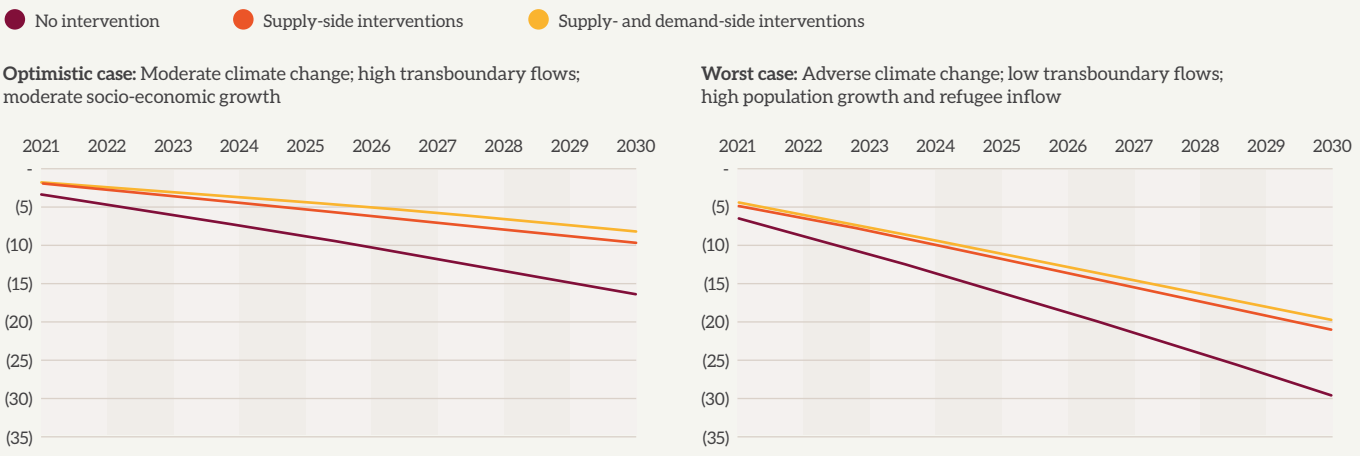
Source: FAO

Impact of water stress on agriculture GVA in 2030

Modelled scenarios		Annual change in (%) water stress	Change in 2030 GVA relative to baseline (%)	Change in 2030 GVA relative to baseline (US$m
No intervention	Optimistic case	+1.0%	-0.8%	-20
	Worst case	+1.5%	-1.2%	-29
Supply-side interventions	Optimistic case	+0.6%	-0.5%	-12
	Worst case	+1.1%	-0.9%	-20
Supply- and demand-side interventions	Optimistic case	+0.5%	-0.4%	-10
	Worst case	+1.0%	-0.8%	-19

Note: These impacts are estimated based on an association exercise to identify the relationship between water stress and socio-economic outcomes. They should be treated as illustrative of the potential impact under alternative scenarios

Figure 7: Change in Jordan's agriculture GVA relative to baseline under alternative scenarios of water scarcity (US$ m)



Source: Economist Impact analysis

Manufacturing: effect less clear, but water still vital

The role of water in industry and manufacturing is less clear-cut and less pressing than in agriculture. However, this could change in the future, particularly in a few critical sub-sectors.

The industrial sector accounts only for 3% of water consumption in Jordan, but uses water as a direct input into products and for a host of processes.[100] For some industries, such as pulp and paper, food and drink, and textiles and apparel, the role of water is clear. But even for those components of the industry sector where water is not a major product input (e.g. assembly lines, construction), it is crucial for industrial processes such as heating and cooling, transport, cleaning, product use and servicing, as well as energy supply.[101,102] Water consumption in Jordan's industrial sector is dominated by a few large sectors, such as chemicals and packaging, which use significant amounts of water in production processes. Increased water stress could lead to a reduction in the water available for production and/or increased costs of production. This could have damaging effects on the overall economy: the chemical industry, for example, accounts for over a third of Jordan's total exports.[103]

Crucially, industrial water use relies heavily on groundwater, which could be used for critical domestic purposes. In fact, over 85% of water used by industry in Jordan comes from underground, while 15% is treated wastewater, compared with over 25% in agriculture.[104]

Our analysis has not found a statistically significant relationship between changes in water supply levels and manufacturing production. This is understandable, given the low direct consumption of water by Jordan's industrial sector, as well as its relatively high capital-intensity.[105] Nevertheless, with expected growth in demand for water by the industrial sector, the effects could become more significant by widening the gap between water supply and water demand.[106] Moreover, water scarcity could affect the sector through indirect channels. In the longer-term, degradation in human capital, for example, due to reduced access to food and water, could have knock-on implications by reducing employee productivity, output, income levels and overall spending.

Water consumption in Jordan's industrial sector is dominated by a few large sectors

100. Ministry of Water, Facts and Figures, (2020); FAO, Aquastat, (2021).
101. McKinsey&Company, "The global corporate water footprint", (2009). https://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/Sustainability/PDFs/Report_Large_Water_Users.aspx
102. Motasem N Saidan, "Estimation of industrial water demand and reclamation in Jordan: A cross-sectional analysis", (2020), Water Resources and Industry, 23, 100129
103. Oxford Business Group, "Jordanian industry makes progress on phosphate, chemicals and pharmaceuticals". https://oxfordbusinessgroup.com/overview/steady-progress-despite-global-economic-headwinds-and-regional-conflicts-many-key-segments-continue
104. Ibid.
105. Saidan et al, "Wastewater reclamation in Major Jordanian industries: a viable component of a circular economy», (2020), Water 12.5 (2020): 1276.
106. Motasem N Saidan, "Estimation of industrial water demand and reclamation in Jordan: A cross-sectional analysis", (2020), Water Resources and Industry, 23, 100129

Water reclamation and reuse could become critical in managing industrial water demand. Investments in technologies like rainwater harvesting and wastewater management and use could reduce the overall water footprint of the manufacturing sector, allowing freshwater to be allocated towards crucial domestic consumption. One study estimates that 38% of the total processed water demand across five key industries—Agriculture and Food, Chemicals, IT, Pharmaceuticals and Packaging—could potentially be reclaimed after on-site treatment of wastewater. This could lead to greater profits for industry as well as substantial reductions in their water footprint.[107]

Services: dependent on reliable and safe water

Jordan's economy is heavily reliant on the service sector, which accounts for more than 60% of the country's GDP.[108] The sector is dominated by government services, finance and real estate, tourism and hospitality, and transport.[109] Water shortages and scarcity could have a significant negative impact on the sector through increased operational costs, greater complexity in supply chains and forced government intervention to divert water resources to other competing sectors and uses.

Shutterstock/Ayman Alakhras

The tourism sector contributed around 5% to Jordan's GDP in 2020, down dramatically from around 16% in 2019. Prior to the pandemic, tourism was estimated to contribute nearly 20% to Jordan's GDP.[110] This significant, but likely temporary shock due to the covid-19 pandemic, has put the industry under a lot of pressure.[111] In the long term, the tourism sector is particularly exposed to water shortages and increases in operational costs in periods of water stress. Indeed, the hospitality sector as a whole frequently falls victim to water shocks in countries around the world.[112] This can especially knock small and medium-sized enterprises.

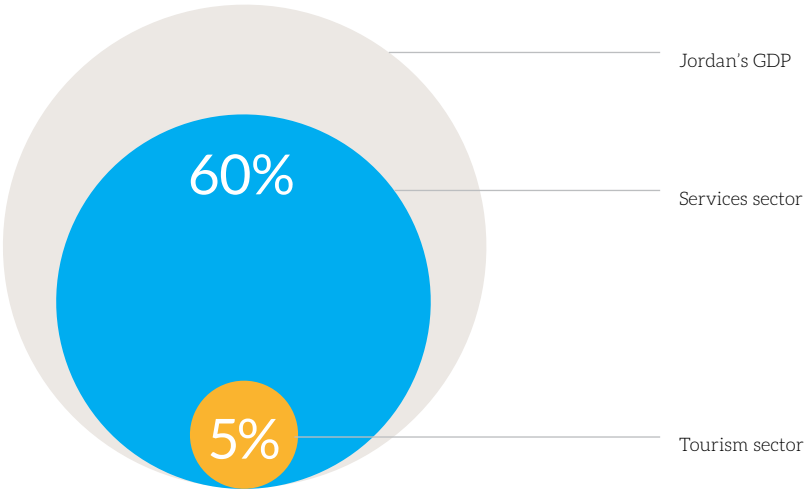
107. Ibid.
108. The Economist Intelligence Unit, (2021); World Bank, "Jordan Overview". https://www.worldbank.org/en/country/jordan/overview#1
109. Jordan Economic Policy Council, "The Jordan Economic Growth Plan 2018 - 2022", (2018). https://www.ssif.gov.jo/UploadFiles/JEGProgramEnglish.pdf
110. World Travel and Tourism Council, Jordan 2021, (2021). https://wttc.org/Research/Economic-Impact/moduleId/704/itemId/139/controller/DownloadRequest/action/QuickDownload; Ahmed Abu Al Haija, "Jordan: Tourism and conflict with local communities" (2011). https://elevatedestinations.com/wp-content/uploads/2020/01/Jordan-Tourism-and-Conflict-with-Local-Communities.pdf
111. ILO, FAO & UNDP, "Impact of COVID-19 on Enterprises in Jordan: One year into the pandemic", (2021). https://reliefweb.int/sites/reliefweb.int/files/resources/ILO%20FAFO%20UNDP%20Covid%20Report%20July%202021.pdf
112. Wires Water, "Tourism, water, and gender"—An international review of an unexplored nexus", (2020). https://wires.onlinelibrary.wiley.com/doi/full/10.1002/wat2.1442

Water woes in the service industry also work their way via indirect channels into broader society. For example, increased water stress during work could be considered an occupational health risk, as it restricts workers' physical functions, capabilities and work capacity, and reduces productivity. As a labour-intensive industry—compared to manufacturing which is typically capital-intensive—services are more reliant on human-capital (i.e. the skills and productivity of employees), which can be weakened by water stress (see Chapter 2 for detailed discussion). The negative impact on income from the inability to work productively due to water stress can also affect the ability of residents to spend on services, with further implications for the output of the industry.

Based on the relationship between increased water stress and service sector GVA, the expected 1%-1.5% rise in water stress could decrease GVA for services in Jordan by anywhere between 2.8% (US$810m), if climate change and population growth is moderate, to up to 4% (US$1.2bn) if climate change and population growth is more aggressive. The large magnitude of impact could be reflective of the high proportion of people employed in the service sector—some 73% of those in employment according to International Labour Organisation (ILO) estimates in 2019—and the substantial impacts on health and well-being from increasing water stress.[113]

With supply-side and demand-side actions to reduce the levels of water stress, the impacts on the services industry could also be reduced. The loss in services GVA could be reduced to US$480m-US$840m under a "supply-side intervention" scenario to increase the availability of water, compared with a "no intervention" scenario, and to US$400m-US$790m with additional action to manage water demand.

The tourism sector contributed around 5% to Jordan's GDP in 2020



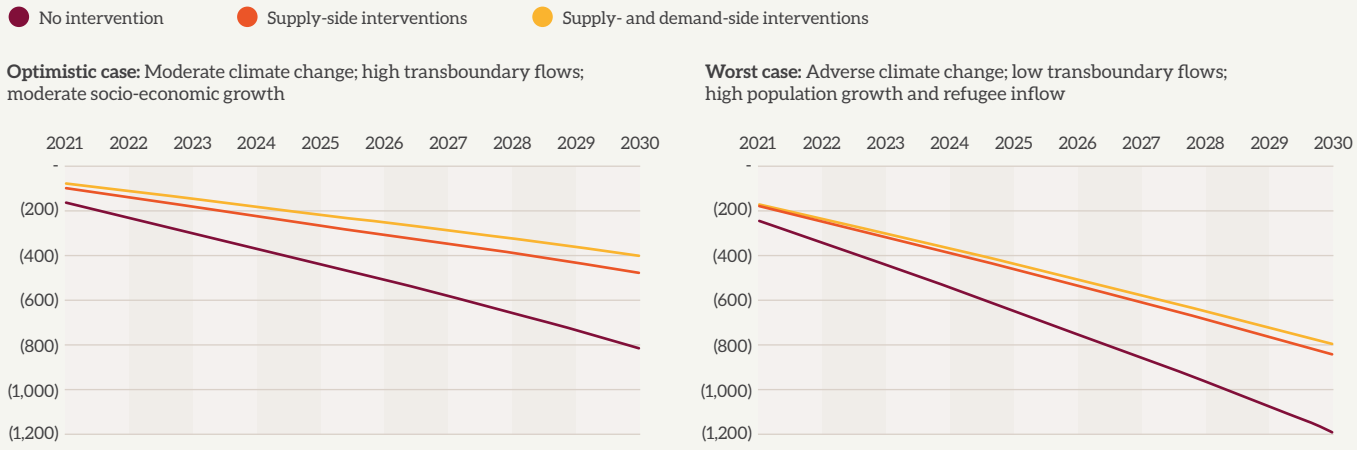
113. International Labour Organisation (ILO), Employment in services (% of total employment), (2020). https://data.worldbank.org/indicator/SL.SRV.EMPL.ZS?locations=JO

Impact of water stress on services GVA in 2030

Modelled scenarios		Annual change in (%) water stress	Change in 2030 GVA relative to baseline (%)	Change in 2030 GVA relative to baseline ((US$m
No intervention	Optimistic case	+1.0%	-2.8%	-810
	Worst case	+1.5%	-4.1%	-1,180
Supply-side interventions	Optimistic case	+0.6%	-1.7%	-480
	Worst case	+1.1%	-2.9%	-840
Supply- and demand-side interventions	Optimistic case	+0.5%	-1.4%	-400
	Worst case	+1.0%	-2.7%	-790

Note: These impacts are estimated based on an association exercise to identify the relationship between water stress and socio-economic outcomes. They should be treated as illustrative of the potential impact under alternative scenarios

Figure 8: Change in Jordan's services GVA relative to baseline under alternative scenarios of water scarcity (US$ m)



Source: Economist Impact analysis

The negative impact on income from the inability to work productively due to water stress can also affect the ability of residents to spend on services, with further .implications for the output of the industry

Chapter 2

Water is essential for human capital

There are longer-term impacts of water stress related to human capital, with consequences for poverty and economic growth. Poor health, nutrition and education lead to weaker immunity and greater susceptibility to illness. This results in an increase in absenteeism at work and school, resulting in a significant drag on overall productivity. As with production, these hits to human capital can also indirectly sap labour productivity, production levels, incomes and overall economic growth.

Food insecurity and undernourishment remain significant in Jordan and can be further exacerbated by water stress and challenges to domestic food production. Jordan has achieved significant progress in providing access to water for domestic consumption, but significant challenges remain in the stability and quality of the service. Children are particularly vulnerable to water-related diseases and malnutrition that can hamper their development, educational and earning potential. For young adults, absenteeism at work and school due to disease and inadequate water, sanitation and hygiene (WASH) facilities limit economic activity and productivity.

Health: a human cost

WASH services are vital to both human and economic development. Overall, the global health burden associated with inadequate water provision is staggering: lack of access to safe drinking water, inadequate sanitation and poor hygiene cause around 1.6m deaths every year.[114] This equates to a child's death every two minutes due to a water-borne cause— from consuming contaminated water to suffering from dehydration due to diarrhoea.[115] Total economic losses associated with inadequate WASH services amount to US$260bn annually in 136 low- and middle-income countries, roughly equivalent to an average annual loss of 1.5% of the aggregate GDP in those countries.[116]

Despite significant progress achieved in recent decades—85% of Jordanians have access to safely managed drinking water compared with around 54% in 2000—most Jordanians still only have intermittent water supply and piped water is often not trusted. According to official estimates, 50% of Jordanians had access to piped water for 24 hours per week or less in 2017.[117] A study conducted in the Al-Mafraq Governorate of Jordan showed that 71% of respondents find the water pumped from the public system to be insufficient, and 40.9% find that water laws and regulations are implemented ineffectively. The study also showed that 85% of respondents are dependent on groundwater wells, and 42.5% of respondents have suffered water contamination.[118] Unsurprisingly, one study found that 43% of the population relies on bottled water.[119]

114. F Tarrass and M Benjelloun, "The effects of water shortages on health and human development", (2012). https://pubmed.ncbi.nlm.nih.gov/22991372/
115. Water.org, 'A Health Crisis'. https://water.org/our-impact/water-crisis/health-crisis/
116. UN Water, "The United Nations World Water Development Report – "Valuing Water" ", (2021). https://unesdoc.unesco.org/ark:/48223/pf0000375724/PDF/375724eng.pdf.multi
117. Ministry of Water, Facts and Figures, (2017).
118. Naji Al-Mefleh, Saad Alayyash & Fatima Khaled, "Water management problems and solutions in a residential community of Al-Mafraq city, Jordan". (2019). https://www.researchgate.net/publication/330099101_Water_management_problems_and_solutions_in_a_residential_community_of_Al-Mafraq_city_Jordan .
119. WHO, "Progress on Drinking Water, Sanitation and Hygiene", (2017). https://www.who.int/mediacentre/news/releases/2017/launch-version-report-jmp-water-sanitation-hygiene.pdf

According to the WHO, in Jordan, the mortality rate attributed to WASH-related diseases is 0.6 per 100,000 people. This is low compared to the global average, but still high relative to advanced economies and some regional peers, such as Turkey, Saudi Arabia, Israel, Oman and the UAE.

Moreover, only 70% of the urban and 20% of the rural population have access to sewage-treated sanitation.[120] Jordan has improved overall access to these vital services, particularly in light of rapid population growth, but there is still significant room for improvement, compared to the best performers in the region, including the UAE, Saudi Arabia and Israel.

Children bear an outsized share of the pain and suffering due to water stress. Their immature immune systems often fail to beat back devastating pathogens that have significant and often irreversible long-term consequences on health and economic outcomes. For instance, exposure to water-borne diseases such as diarrhoea in a child's very early years is associated with greater stunting of growth, lower educational attainment and lower earnings.[121]

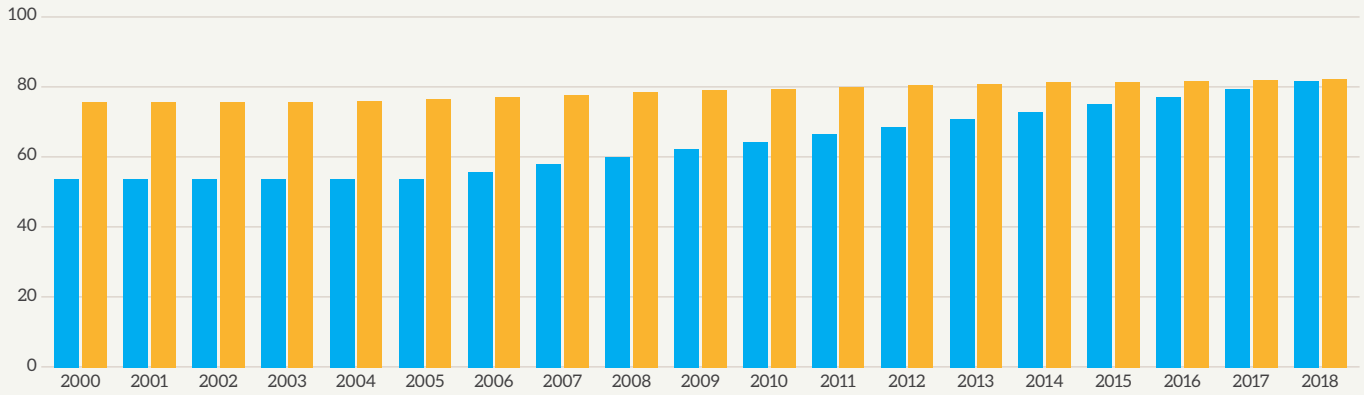
According to the WHO, in Jordan, the mortality rate attributed to WASH-related diseases is 0.6 per 100,000 people. This is low compared to the global average, but still high relative to advanced economies and some regional peers, such as Turkey, Saudi Arabia, Israel, Oman and the UAE.[122] A study in 2012 estimated that despite a significant reduction in recent decades, around 16% of all children in Jordan still experienced diarrhoea.[123] Moreover, the prevalence of diarrhoea was higher in low-income regions and families.

Water stress could be driven by one or a combination of two key factors—an increase in water consumption (i.e. the amount of water withdrawn from available water sources) and/or a decrease in water supply available. In the context of production, discussed in the previous chapter, an increase in water stress mostly limits the resources available for productive activities, creating negative consequences for industries. When it comes to human capital, however, an increase in water stress, driven by an increase in consumption, can produce somewhat counterintuitive impacts and lead to positive effects. In this case, although the additional stress implies less availability of water for other uses, it also means increased availability of clean water for children and adults, thereby reducing the risk of illness and death.[124,125] According to a study by Fink Gunther, in association with the World Bank, access to improved water and sanitation can reduce child mortality by approximately 20% and prevent about 2.2m deaths in children under five across developing countries.[126]

120. WHO, UNICEF (2020), https://washdata.org/data/household#!/table?geo0=country&geo1=JOR.
121. D Almond & J Currie, "Killing Me Softly: The Fetal Origins Hypothesis", (2011), Journal of Economic Perspectives, 25(3):153-172. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4140221/
122. WHO, Wash-related mortality rates by country, https://unstats.un.org/sdgs/dataportal
123. Abdelhakeem Okour, Ziad Al-Ghazawi, Muntaha Gharaibeh, "Diarrhea Among Children and the Household Conditions in a Low-Income Rural Community in the Jordan Valley", (2012), Jordan Medical Journal, 46, 108-117. https://applications.emro.who.int/imemrf/Jordan_Med_J/Jordan_Med_J_2012_46_2_108_117.pdf
124. USAID, "Association Between Maternal, Birth, and Newborn Characteristics and Neonatal Mortality in Five Asian Countries, (2008). http://www.path.org/publications/files/MCHN_dhs_nnm_asian.pdf
125. AE Aiello, EL Larson & R Sedlak, "Hidden heroes of the health revolution Sanitation and personal hygiene", (2009). American Journal of Infection Control, 36, S128–S151.
126. G Fink & I Günther, "Water and Sanitation to Reduce Child Mortality: The Impact and Cost of Water and Sanitation Infrastructure". Development Economics Prospects Group, World Bank; Zurich, Switzerland: 2011.

Figure 9: Access to Water Services in Jordan

Share of population using safely managed water services (%)

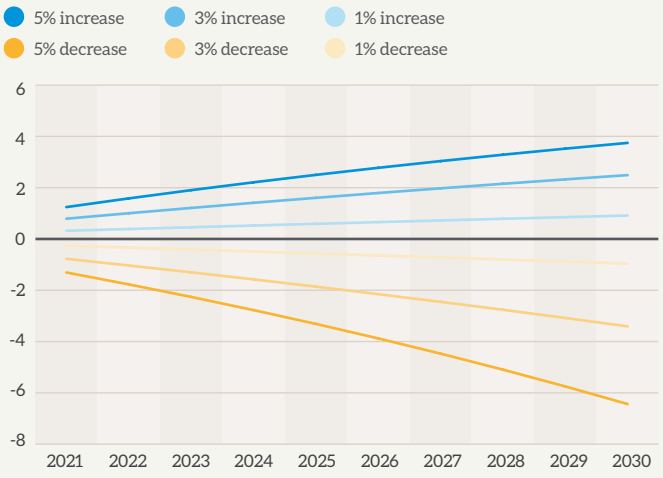


Impact of water stress on infant mortality in 2030

Modelled scenario: Annual change in water consumption (%)	Change in 2030 infant mortality relative to baseline (deaths per 1,000 live births)
-5%	+3.7
-3%	+2.5
-1%	+0.9
+1%	-1.0
+3%	-3.5
+5%	-6.5

Note: These impacts are estimated based on an association exercise to identify the relationship between water stress and socio-economic outcomes. They should be treated as illustrative of the potential impact under alternative scenarios

Figure 10: Change in Jordan's infant mortality rate under alternative scenarios of increased water consumption by children (deaths per 1,000 live births)



Source: Economist Impact analysis

One older study in Jordan found some indications that access to safe drinking water was significantly associated with decreased under-five mortality.[127] Associating an increase in water stress with increased consumption of water by children, our analysis finds that increased water stress can contribute towards reduced infant mortality. In this case, we treat water stress instead as an increase in water consumption to assess the impacts. Our results show that a 3% increase in water consumption could decrease infant mortality from 13.4 deaths per 1,000 to 9.9 deaths per 1,000. On the flipside, a worsening of the current situation in Jordan resulting in a 3% decrease in water consumption could contribute to an increase in infant mortality from 13.4 to nearly 15.9 deaths per 1,000.

127. Cornelia Kaldewei, "Determinants of Infant and Under-Five Mortality – The Case of Jordan", (2010).

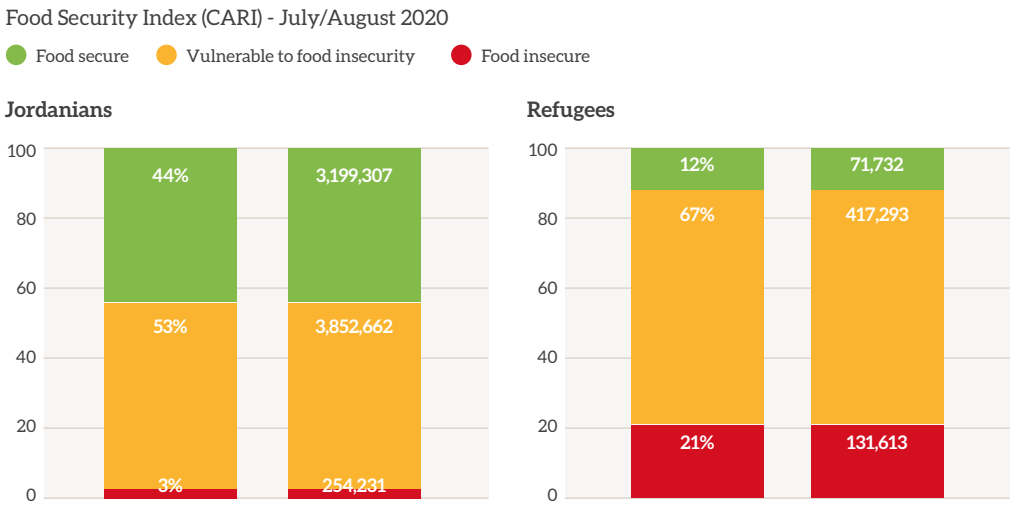
Nutrition: no substitute for clean water

Water is essential for agricultural production. Given the natural aridity of the region, most countries in MENA are increasingly dependent on the efficient use of water resources and conservation practices—consisting primarily of irrigation development and management—for long-term sustainability of food production. In Jordan, the government has worked hard to narrow the gap between food production and food needs over the last three decades, especially in basic foodstuffs. Despite such efforts, the gap has widened, especially for cereals, sugar and animal products, with Jordan growing more dependent on imports.[128]

Food insecurity remains a challenge in the country, particularly among vulnerable populations. The prevalence of undernourishment has increased from 5% to 10% since the mid-2000s, while around 53% of Jordanians (more than 4m people) remain vulnerable to food insecurity.[129,130] In addition, 88% of the refugee population (nearly 550,000 people) find themselves in this situation.

Our analysis shows that increasing levels of water stress are associated with a decline in the adequacy of the average dietary energy supply—a measure of what proportion of a population's nutritional requirements can be covered by the food available in the country.[131] Dietary energy supply is

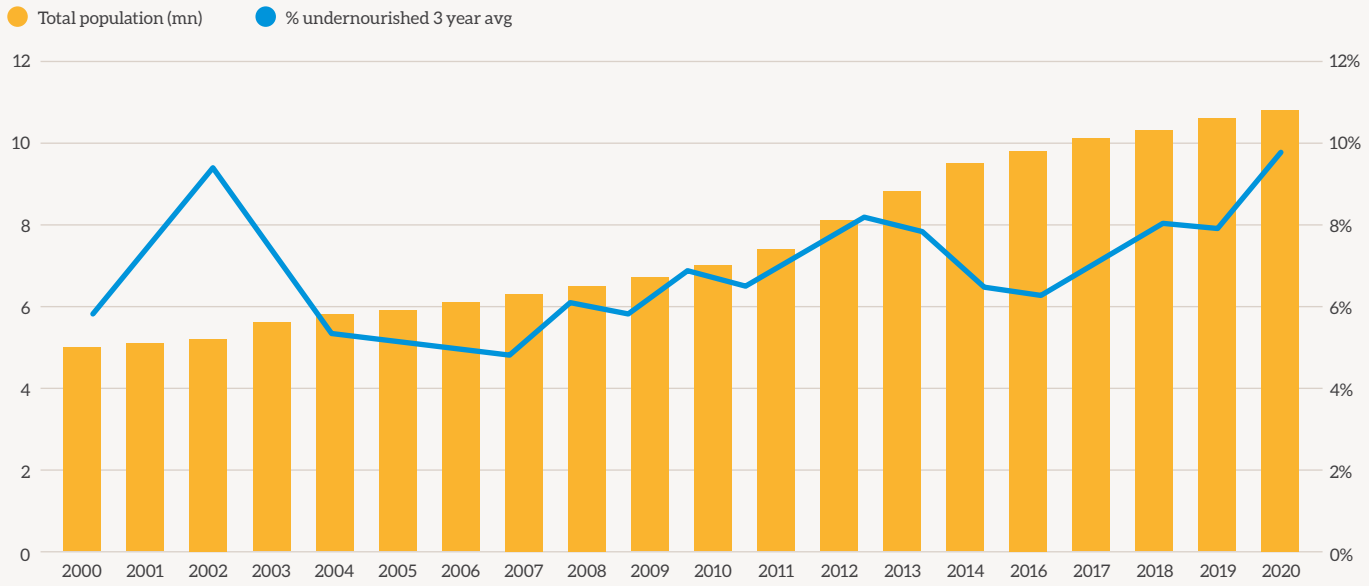
Figure 11: Food insecurity in Jordan



Source: Jordan Food Security Update Implications of COVID-19

128. Bdour et al, "Food Security and its Dependent on Foreign Trade: The Case of Jordan 2001-201", (2014). https://www.researchgate.net/publication/269096555_Food_Security_and_its_Dependent_on_Foreign_Trade_The_Case_of_Jordan_2001-2010
129. World Bank Data. https://data.worldbank.org/indicator/SN.ITK.DEFC.ZS?locations=JO
130. Reliefweb, "Jordan Food Security Update - Implications of COVID-19 (July-August 2020)", (2020). https://reliefweb.int/report/jordan/jordan-food-security-update-implications-covid-19-july-august-2020
131. FAO defines Average Dietary Energy Supply Adequacy (ADESA) as "each country's or region's average supply of calories for food consumption is normalised by the average dietary energy requirement estimated for its population to provide an index of adequacy of the food supply in terms of calories." https://www.fao.org/faostat/en/#data/FS

Figure 12: Undernourished population in Jordan in comparison with total population



closely linked to the water-food nexus. As water-scarcity levels increase, agricultural production decreases leading to a dwindling crop supply. Inadequate food intake has significant negative implications for peoples' health and productivity, and can also cause severe effects on human health in terms of a region's nutritional conditions.[132]

The adequacy measure provides an insight into the nutritional situation in a country. An index of around 100% would mean that food provision would be sufficient only in the case of perfect equality of access to food among its citizens. However, an index score of 100% after accounting for inequalities implies that a very high proportion of people face food vulnerability. Even countries with indexes of up to 115% are hit hard by the scourge of malnutrition.[133] Based on the FAO's adequacy of dietary intake measure, Jordan currently stands at 117%, representing a decline from around 125% in the mid-2000s. This is among the lowest in the region, only outperforming struggling Iraq and Yemen, and lagging behind regional leaders such as Turkey, Israel, Algeria and Tunisia, who achieved adequacy ratios of 156%,154%, 151% and 147% respectively.[134]

An increase in water stress under a "no intervention" scenario could decrease this adequacy ratio to between 114.8% and 115.5%, depending on the degree of climate change and population growth. With interventions to increase water supply, the decline in the adequacy ratio is expected to be capped at 115.4% under the worst case scenario of aggressive climate change and population growth, and at 115.5% if interventions also include demand-side management.

132. IUCN, "Water, energy and food security Nexus in Jordan, Lebanon and Tunisia", (2019). https://portals.iucn.org/library/sites/library/files/documents/2019-039-En.pdf

133. Massimo Livi Bacci, "Understanding Africa's key challenges: Nutrition, Health and Human Capital", https://paper.foodandmigration.com/en/chapters/understanding-africa-s-key-challenges-nutrition/

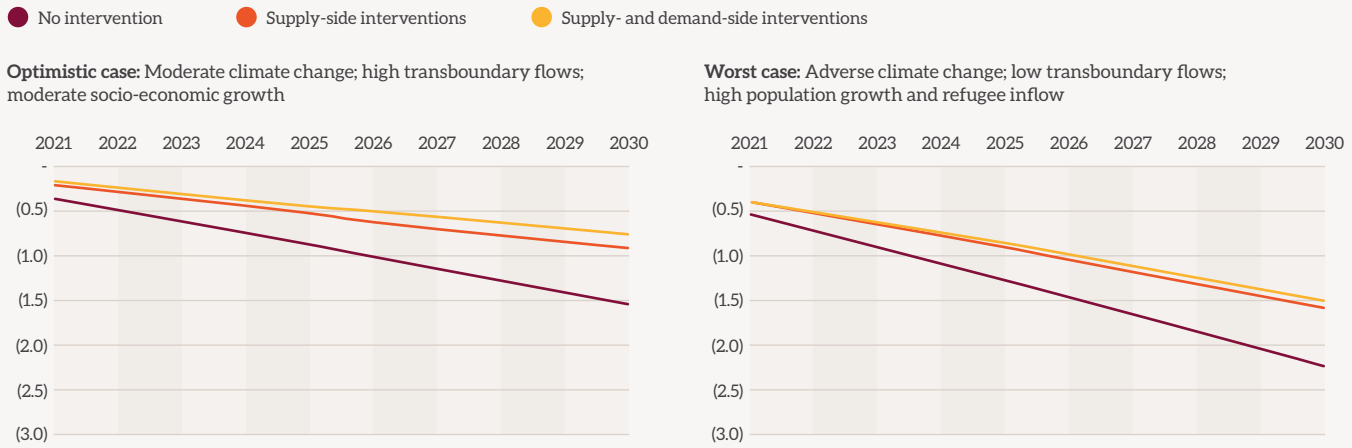
134. FAO, Average dietary energy supply adequacy (%) (3-year average), 2018-2020

Impact of water stress on the adequacy of dietary intake in 2030

Modelled scenarios		Annual change in (%) water stress	Change in 2030 adequacy of dietary intake (relative to baseline (percentage point change
No intervention	Optimistic case	+1.0%	-1.5
	Worst case	+1.5%	-2.2
Supply-side interventions	Optimistic case	+0.6%	-0.9
	Worst case	+1.1%	-1.6
Supply- and demand-side interventions	Optimistic case	+0.5%	-0.8
	Worst case	+1.0%	-1.5

Note: These impacts are estimated based on an association exercise to identify the relationship between water stress and socio-economic outcomes. They should be treated as illustrative of the potential impact under alternative scenarios

Figure 13: Change in Jordan's adequacy of dietary intake under alternative scenarios of increased water consumption by children (percentage point change)

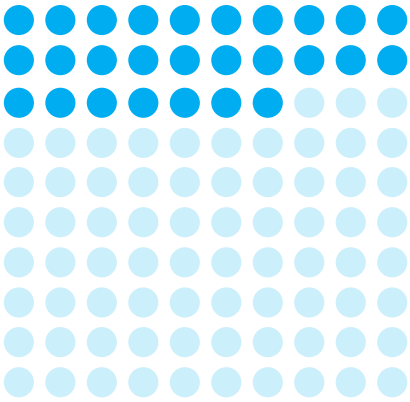


Source: Economist Impact analysis

Based on the FAO's adequacy of dietary intake measure, Jordan currently stands at 117%, representing a decline from around 125% in the mid 2000s

Education: water woes take a toll

Water stress and shortages can lead to worsened educational outcomes. In addition to water-related illnesses that can stunt growth and decrease capacity for learning, when children do not have access to water at home, they are often responsible for collecting it for their families. Sharing the burden with their mothers, children around the world collectively spend 200m hours each day collecting water, taking valuable time away from school.[135] The combination of reduced cognitive capabilities, absenteeism due to illness and prioritisation of water collection duties force children to remain outside of the classroom.[136]



Only about a third of schools in Jordan have access to adequate WASH facilities

The interplay between education and water stress also manifests in other ways. Limited access to water results in children being unable to practice important hygiene behaviour like hand-washing and proper disposal of menstruation products. According to one survey, only 27% of schools in Jordan have adequate WASH facilities, with only 62 out of 164 schools surveyed having separate facilities for boys and girls.[137] According to the Drinking Water, Sanitation, and Hygiene in Schools Baseline Report 2018, Jordan has the second lowest coverage of basic sanitation services in schools in Northern Africa and Western Asia. A 2015 nationwide assessment of public schools found that 57% of schools felt that the frequency of supply and available storage capacities were not sufficient to provide the national minimum of 10 litres of water per student per day.[138] A shortage of water in schools impacts student enrolment and attendance rates, particularly for girls, which have declined significantly in the past two decades.[139,140]

Looking deeper at the implications of water stress for school attendance rates for girls, our analysis explores the association between the two and the consequences for Jordan under alternative pathways of water stress. Currently, 80.7% of infant girls are enrolled in primary schools in Jordan, based on UNESCO data.

135. Water.org, "A Children's and Education Crisis." https://water.org/our-impact/water-crisis/childrens-and-education-crisis/
136. UNICEF, "Water Security for All", (2021). water-security-for-all.pdf (unicef.org)
137. UNICEF, "Wash Emergency Assistance in Jordan Schools". https://data2.unhcr.org/en/documents/download/70854
138. Ministry of Environment, Green Growth Action Plan 2021-2025, (2020) https://gggi.org/site/assets/uploads/2020/10/20022_Jordan_Water_v03_HL_Web.pdf
139. Batool Ghaith, "UNICEF warns of impact of water scarcity on children's well-being", (2021). https://www.jordantimes.com/news/local/unicef-warns-impact-water-scarcity-childrens-well-being
140. EIU analysis using FAO data

©UNICEF

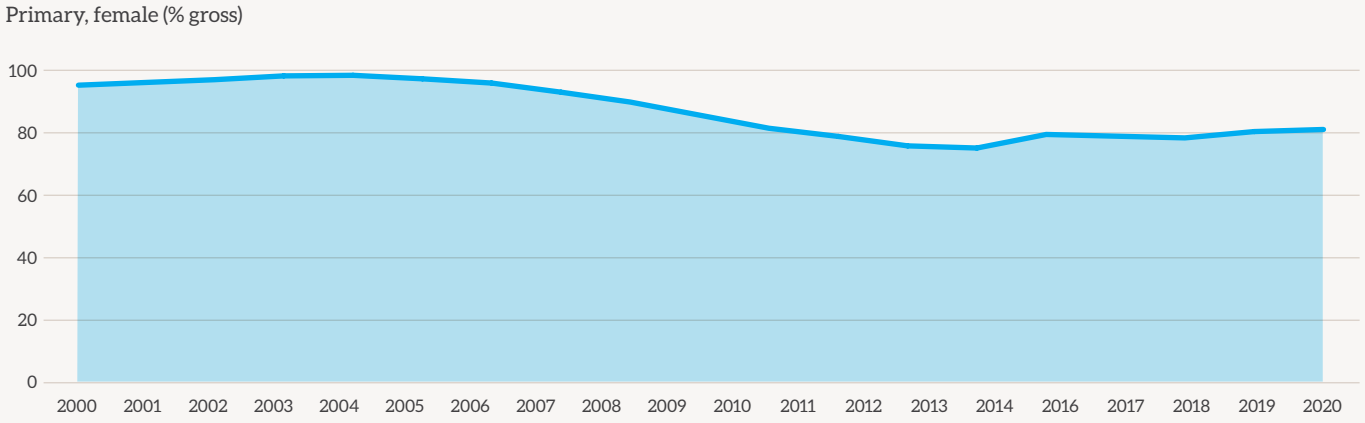
However, with no measures to curb the increase in water stress, this could decline by over one percentage point to 79.6% by 2030. With a combination of interventions to both increase supply and manage demand, and under optimistic assumptions on climate change and population growth, the decline in female enrolment could be lower in magnitude, hitting a minimum of 80.1%.

The impact of water scarcity on education could further exacerbate intra-generational income inequality. In Jordan, water is usually available on average for 24 hours per week in urban areas and less than that in rural areas. The study conducted by Yoon et al also found a decline in economic well-being attributable to changing water use, with higher-income households experiencing an annual welfare loss equivalent to US$340 and lowest-income households experiencing a US$245 loss.[141] This equates to a welfare loss equivalent to 11% of income for the lowest-income households solely attributable to reduced water use.[142] This is a significant loss to low-income families that further undermines their ability to cope with water stress.

141. Welfare loss is measured by consumer surplus, an economic measure of welfare that assesses a buyer's excess benefit from consumption above the payment for a good or service. When the cost of producing a product is more than what people are willing to pay, you have a consumer surplus.

142. Yoon et al, "A coupled human–natural system analysis of freshwater security under climate and population change," (2020). https://www.pnas.org/content/118/14/e2020431118

Figure 14: Primary school enrolment rates for girls in Jordan



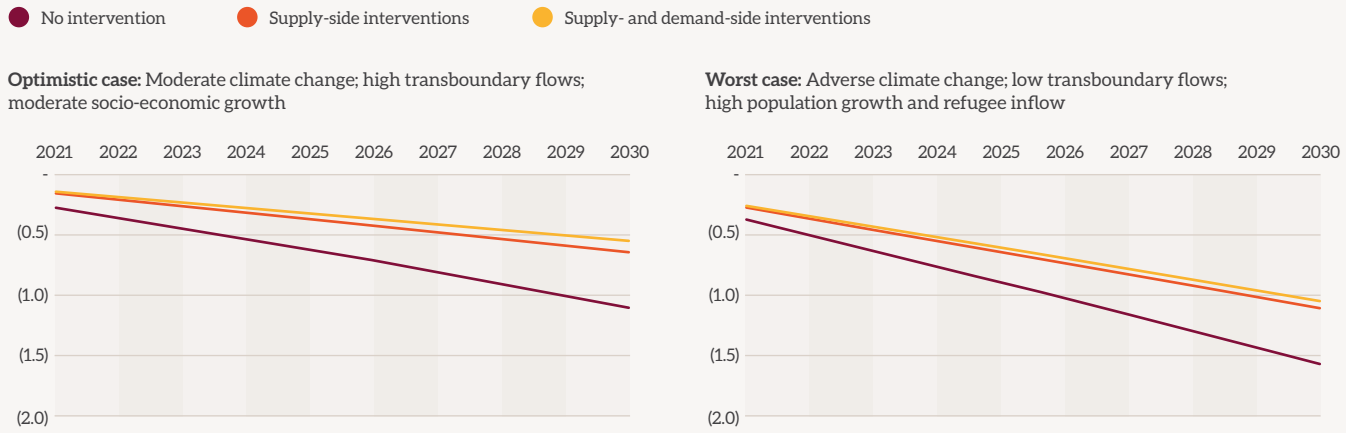
Source: World Bank, UNICEF, The Economist

Impact of water stress on female enrolment in primary school in 2030

Modelled scenarios		Annual change in (%) water stress	Change in 2030 female primary school enrolment relative to baseline (percentage point (change
No intervention	Optimistic case	+1.0%	-1.2
	Worst case	+1.5%	-1.1
Supply-side interventions	Optimistic case	+0.6%	-0.7
	Worst case	+1.1%	-1.3
Supply- and demand-side interventions	Optimistic case	+0.5%	-0.6
	Worst case	+1.0%	-1.2

Note: These impacts are estimated based on an association exercise to identify the relationship between water stress and socio-economic outcomes. They should be treated as illustrative of the potential impact under alternative scenarios

Figure 15: Change in Jordan's female primary school enrolment rate under alternative scenarios of increased water consumption by children (percentage point change)

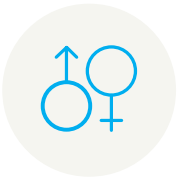


Source: Economist Impact analysis

Chapter 3

Water's essential role in society and politics

While the effects of water stress and scarcity on economic production and people's health and productivity are relatively direct, linkages with other complex social and political areas are more difficult to establish and quantify. Nevertheless, water stress can have significant effects on phenomena, such as migration, gender inequality and political instability, which are crucial for communities' stability, prosperity and well-being. These linkages are particularly important for policymakers and experts to consider due to their politically sensitive nature.



Women and girls are especially vulnerable to water stress

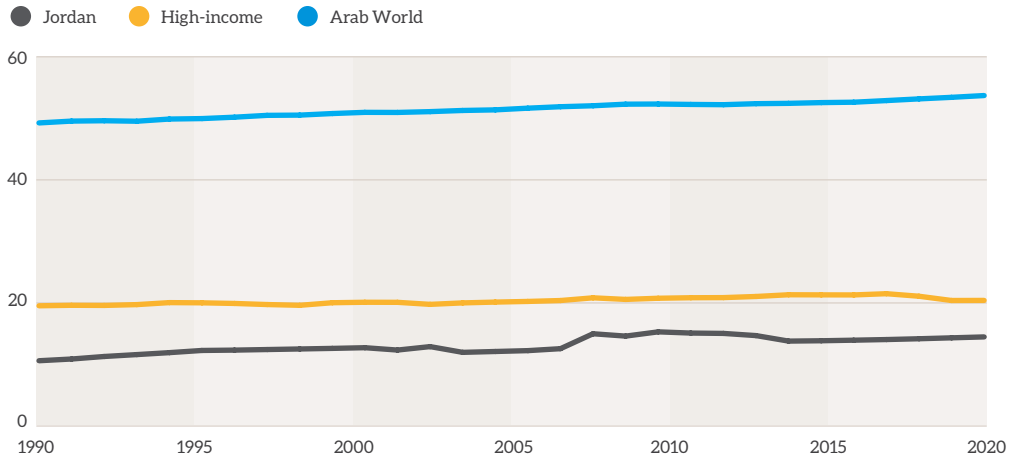
Women and girls are disproportionately affected by inadequate water access due to their role in domestic activities and the importance of sanitation for dealing with menstruation and pregnancy.[143] These gender inequities of water access are evident globally. In 80% of households where water is not readily available, women and girls are responsible for water collection.[144] In Jordan, women are most often the collectors, users and managers of water and play an important role in water-resource management in homes.[145] This is, in part, due to the significant role of women in household management in Jordan—only 15% of the country's women participate in the labour force, a very low level by global standards.[146]

In research conducted by Mercy Corps in Jordan, interviewees reported the difficulties female-headed households face during periods of water shortage. Many rely on private water transported house-to-house by trucks, which are often operated by men. Women seeking water are often vulnerable to "sexploitation" and may not receive fair amounts of water due to cultural reasons.[147] For married women, water shortages can cause friction between couples and women often receive criticism from their husbands when it is time to procure more water for the household.[148] However, women are often left out of decisions regarding how the water is used, leading to a lack of female representation in community-level decision-making, resulting in non-inclusive policies.[149]

Furthermore, inadequate WASH facilities contribute to pushing women and girls out of workplaces and schools. Girls may avoid going to school during their menstrual cycle due to lack of privacy or cleanliness in toilets, or simply due to stigma or cultural taboos, causing absenteeism.[150]

143. Palmioli et al, "The gendered impacts of climate change: The Jordan River Basin region and water scarcity", (2020). http://www.ra-un.org/uploads/4/7/5/4/47544571/13_osce_the_gendered_impacts_of_climate_change.pdf
144. UNICEF, Press Release, (2016). https://www.unicef.org/press-releases/unicef-collecting-water-often-colossal-waste-time-women-and-girls
145. The Millennium Challenge Corporation, 'Water and Women: A Focus on Equality in Jordan', (2014). https://www.mcc.gov/resources/story/story-milestones-winter-2014-water-and-women-in-jordan
146. WeForum, 'Global Gender Gap Report', (2021). https://www3.weforum.org/docs/WEF_GGGR_2021.pdf
147. E Andrew, L Pamioli & C Borges, "The gendered impacts of climate change: The Jordan River Basin region and water scarcity", (2020). https://www.researchgate.net/publication/348550735_The_gendered_impacts_of_climate_change_The_Jordan_River_Basin_region_and_water_scarcity
148. Ibid.
149. Interview with Edoardo Borgomeo, November 2021
150. Ibid.

Figure 16: Female labour force participation (% of female population aged 15+)



Source: International Labour Organisation (ILO)

According to UNICEF, women and girls in Jordan may not have a suitable space to manage their menstruation at work, especially if they work in the informal sector. In some cases, they may simply stay home, losing a source of income.[151] This is a particularly pressing issue in Jordan where participation of girls and women in education and employment is relatively low in the first place. The ILO estimates that around 44% of young women and girls are not in education, employment or training (NEET rate), compared to under 30% of young men and boys. This is among the highest rates in the region.[152] There is a lack of conversation and policy building around hygiene and the menstrual needs of women and girls, further exacerbating the issue of menstrual management. The culture of silence around women's reproductive health issues leads to disempowerment of girls and negatively affects their education and health.[153]

Despite these negative impacts on women, there is still a lack of female representation in water-related policy making. In a study by the Women Studies Unit at the Ministry of Water and Irrigation of Jordan, interviews and surveys were conducted with women and men working in three water entities and three companies undertaking the governance and operation of water and sanitation services. The results of the study reveal the weak representation of women in the sector, with female employees constituting only 11% of the total workforce.[154] Gender disparity is also observed with regard to leadership and supervisory positions, of which only 17.5% are held by women in the Jordanian water sector.[155]

151. Sara AlHattab, "Breaking the cycle of silence - menstruation matters", (2019). https://www.unicef.org/jordan/stories/breaking-cycle-silence-menstruation-matters.
152. ILO, Share of youth not in education, employment or training, (2020).
153. Sara AlHattab, "Breaking the cycle of silence - menstruation matters", (2019). https://www.unicef.org/jordan/stories/breaking-cycle-silence-menstruation-matters.
154. E Andrew, L Pamioli & C Borges, "The gendered impacts of climate change: The Jordan River Basin region and water scarcity", (2020). https://www.researchgate.net/publication/348550735_The_gendered_impacts_of_climate_change_The_Jordan_River_Basin_region_and_water_scarcity
155. USAID, Water Management Initiative, "The Status of Women in Jordan's Water Sector", (2019).

Water stress can accelerate migration

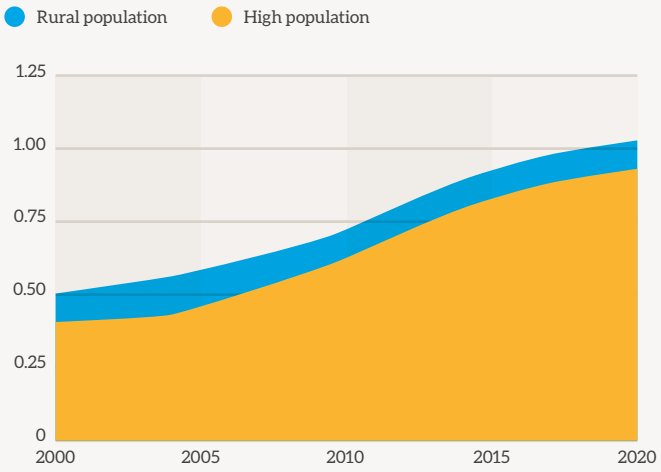
Historically, war and unemployment drive much more cross-border and internal migration within MENA than water-related events such as drought.[156] However, as the effects of climate change intensify, these historical patterns may no longer hold. Climate change is likely to exacerbate vulnerabilities and tensions over water resources, leading to vicious cycles of water insecurity and fragility. We are starting to see evidence of this happening in the region. For instance, the displacement observed in the southern region of Iraq was reportedly caused by water scarcity. When water becomes so scarce that livelihoods are no longer viable, families migrate to urban areas, adding an additional burden to already underserved communities.[157] As instances of drought increase, farmers are facing a higher prevalence of crop failure. This is forcing them to abandon traditional farming and look for other job opportunities. For example, in Najada, a village in Jerash that was once famous for producing olive oil, most inhabitants have abandoned traditional farming and moved to urban areas in search of new sources of income.[158]

Migration into urban areas will further intensify the pressure on municipal infrastructure and services such as housing, healthcare, education, water and sanitation. Most cities in developing countries are not prepared for efficient and sustainable expansion,[159] and Jordan is no exception. Urban planning institutions rarely coordinate development effectively, urban land markets tend to be dysfunctional and zoning and restrictive building regulations limit the size of structures, economic density, and ultimately urban efficiency. Rapid urbanisation and poor urban planning could increase per-capita water consumption and fuel water price inflation, widening the gap between the rich and the poor. This could lead to instances of water hoarding, resulting in heightened social tensions.[160]

Shutterstock/Africa Studio

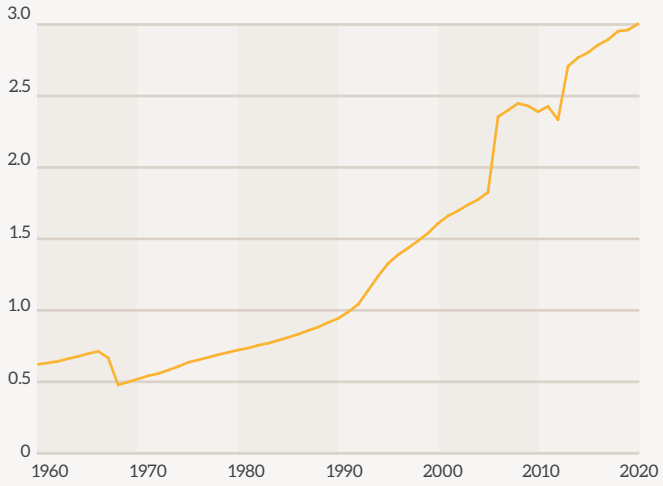
156. World Bank, 'Ebb and Flow', Volume 2, (2021). https://www.worldbank.org/en/topic/water/publication/ebb-and-flow-water-migration-and-development
157. UNICEF, "Drying Up Their Futures The Impact Of Water Scarcity On Children In The Middle East And North Africa Region", (2020).
158. Olive Oil Times, "Jordanian Farmers Expect Fall in Production Due to Drought, Pests", (2021). https://www.oliveoiltimes.com/production/jordan-farmers-expect-fall-in-production/101022
159. World Bank, 'Data for better lives', (2021). https //www.worldbank.org/en/publication/wdr2021
160. A coupled human–natural system analysis of freshwater security under climate and population change.

Figure 17: Rural and Urban population in Jordan



Source: United Nations Population Division's World Urbanisation Prospects (2020)

Figure 18: Refugee population in Jordan (million)



Source: United Nations High Commissioner for Refugees (UNHCR)

Jordan is also particularly exposed to cross-border migration as one of the top three recipients of refugees in MENA. The refugee population in Jordan grew rapidly over the past two decades, reaching 3m people in 2020 (nearly 30% of the country's population).[161] An influx of refugees—especially those from "at risk" communities—creates additional stress on areas that were already weak by exacerbating pre-existing political and socio-economic stressors. For instance, in Jordan, Syrian refugees currently make up nearly 10% of the total population. They often face discrimination, particularly in accessing jobs, housing and education, which increases their vulnerability to food and water insecurity.[162]

Finally, water shocks affect not only the number of people who move, but also the skills they bring with them. Migrants in developing countries who move from rural to urban areas because of drier climate conditions tend to have lower education and productivity levels and face up to a 3.4% wage gap in their host regions compared with typical migrants.[163] Countries with stressed water resources also experience outward migration. However, in this scenario, the population that migrates is usually richer and better educated. Increased demand for municipal services can make cities less attractive to high productivity workers, potentially exacerbating "brain drain" pressures.[164]

161. United Nations High Commissioner for Refugees (UNHCR). https://www.unhcr.org/refugee-statistics/
162. "Influx of Syrian Refugees in Jordan | Effects on the Water Sector". https://reliefweb.int/report/jordan/influx-syrian-refugees-jordan-effects-water-sector#:~:text=Overall%2C%20we%20can%20say%20that,water%20infrastructure%20and%20its%20mismanagement; Dr Ayat Jebril Nashwan and Dr Zeynep Sahin Mencütek, "The employment of Syrians in Jordan: Main trends and challenges", https://www.menasp.com/en/opinion/the-employment-of-syrians-in-jordan-main-trends-and-challenges/
163. World Bank Group, 'Ebb and Flow Volume 1', (2021). https //www.worldbank.org/en/topic/water/publication/ebb-and-flow-water-migration-and-development
164. E Bekaert, I Ruyssen & S Salomone, "Domestic and international migration intentions in response to environmental stress: A global cross-country analysis". (2021). Journal of Demographic Economics, 87(3), 383-436. doi:10.1017/dem.2020.28

Water stress could undermine political cooperation across MENA

A growing body of research highlights the central role of water security in ensuring social and economic development and political stability. Access to adequate water resources is crucial for communities' health, livelihoods, socio-economic development, and ecosystems. Conditions of water insecurity can trigger social tensions and pose a threat both domestically and between states.[165]

Political tensions over water resources have a long history in the MENA region. These are not so much a result of an absolute shortage of water in the region, but rather a lack of cooperation over unequally distributed shared resources. The lack of mutual agreement over water allocation among shared rivers and aquifers adds a layer of complexity and potential conflict to the water-stress situation in the region.

40%

Jordan, a downstream country, obtains 40% of its water from rivers that originate in Syria and Israel

Jordan and Israel are both situated along the Jordan and Yarmouk Rivers, which are both part of the Jordan River system. The Jordan River flows downstream through Israel where it forms a border with Jordan south of the Sea of Galilee. The Yarmouk River, meanwhile, originates in Syria and forms the border between Jordan and Israel, before joining the Jordan River downstream of the Sea of Galilee. Jordan, a downstream country, obtains 40% of its water from these basins, leaving it heavily dependent on cooperation with its upstream neighbours.[166]

Following the 1948 war that put Israel against its Arab neighbours, all countries located along the Jordan River system began unilateral water-development plans. Jordan and Syria reached a bilateral agreement in 1953 over the management of the Yarmouk River without specifying clear water allocation between the countries. They also agreed to construct several dams along the Yarmouk River to store irrigation water and generate hydropower.[167] The first draft of the agreement went through many changes, and it was only in 2003 that Jordan and Syria agreed to build a dam at the border between Syria and Jordan—construction started in 2004. Yet evidence shows that since 1954, Syria has only cooperated "intermittently" with Jordan—when it was in its interest—and there have been several treaty violations.[168] In 2012, Jordan's water minister officially called on Syria "to end violations of water-sharing agreements".[169] Given that in 1994 Jordan committed to releasing some water from the Yarmouk River to Israel each year, such violations increase pre-existing water stresses in Jordan. However, a seminal study, conducted by Dr Samer Talozi explains that there have been no treaty violations by Syria, as the treaties, when drafted, did not favour Jordan. The study explored declining water levels in the Yarmouk River Basin through modelling and remote-sensing techniques.

165. Open Rivers, (2018). https://editions.lib.umn.edu/openrivers/article/the-work-of-ecopeace-middle-east/
166. Osama Al Sharif, "Why Jordan faces a critical water crisis", (2021). https://gulfnews.com/opinion/op-eds/why-jordan-faces-a-critical-water-crisis-1.78685626
167. Climate Diplomacy, "Jordan and Syria". https://climate-diplomacy.org/case-studies/yarmouk-river-tensions-and-cooperation-between-syria-and-jordan
168. Climate Diplomacy, "Yarmouk River: Tensions and cooperation between Syria and Jordan". https://climate-diplomacy.org/case-studies/yarmouk-river-tensions-and-cooperation-between-syria-and-jordan
169. NCR Trade, (2014). https://www.nccr-trade.org/

Political tensions over water resources have a long history in the MENA region. These are not so much a result of an absolute shortage of water in the region, but rather a lack of cooperation over unequally distributed shared resources.

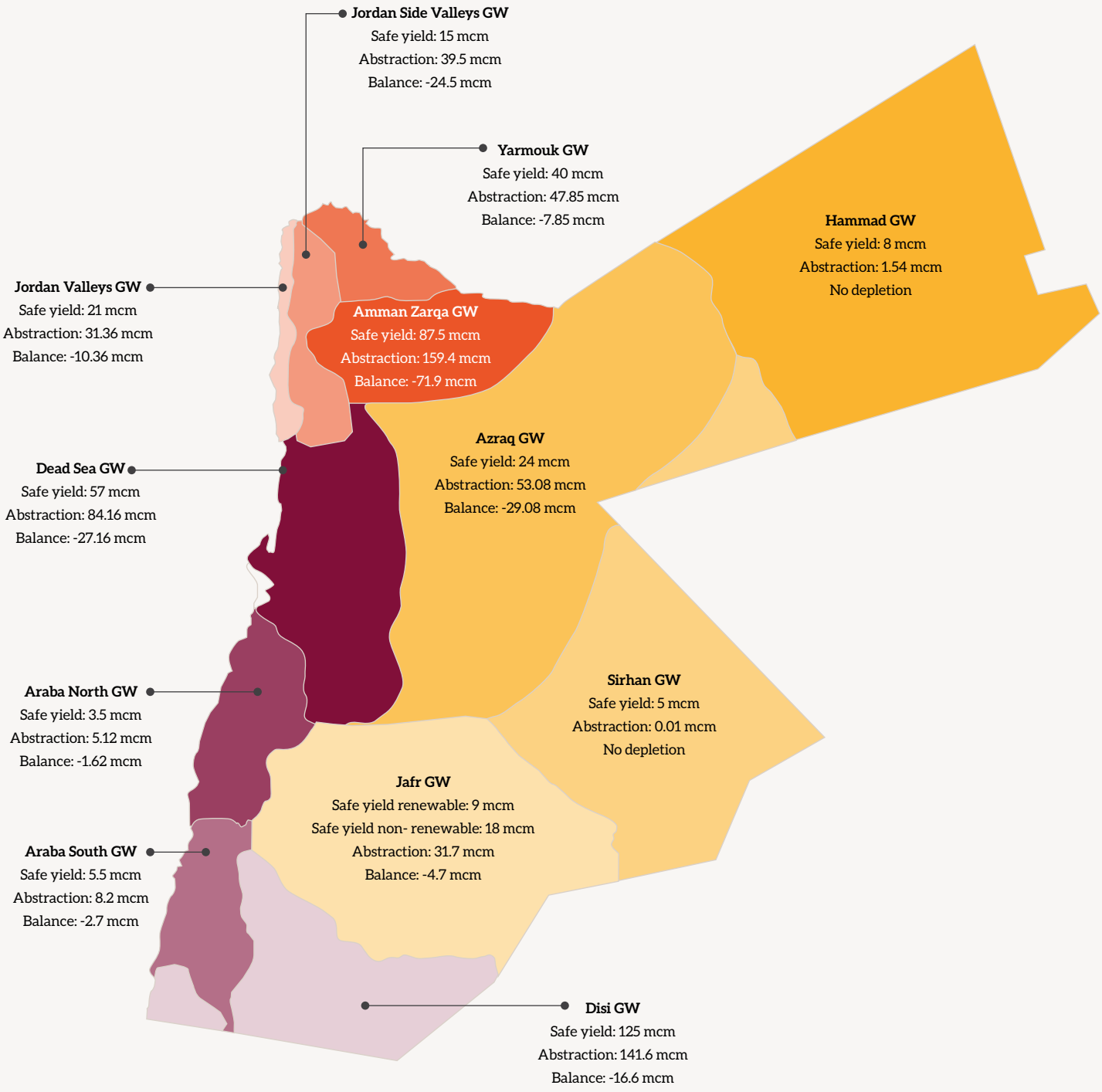
He concluded that (1) the unilateral construction of dams that are not listed in the 1987 agreement between Syria and Jordan seem to have had a limited impact on the flow regime changes; (2) a 36% precipitation decrease since the first half of the 20th century has partly led to the river flow decline, highlighting that climate change is a major contributor to the drying basin; and (3) groundwater over-abstraction by Syrian highland farmers can explain most of the decrease in Yarmouk River flows.[170]

Another important project to bring freshwater to Jordan was started in 2015. Jordan's water and irrigation minister and Israel's regional co-operation minister signed a contract to start construction on a canal linking the Dead Sea, the Red Sea and desalination facilities. Concerns about environmental problems in the Dead Sea—water levels have been falling each year—and water over usage led to the proposal of a Red-Dead canal to address these issues in 2005. The canal was intended to bring potable water to southern Israel, Jordan and the Palestinian Authority and to establish a desalination facility in Jordan. However, the project led to a furious uproar due to environmental concerns, including the risk of groundwater contamination, re-establishment of stratification conditions, seasonal precipitation of chemicals, and the growth of microorganisms in the Dead Sea.[171] After many years of talks, the project was nixed in 2021, with the Jordanian government stating that there was no real intent on the Israeli side to take it forward.[172]

Even though historic trends show that cooperation amongst neighbouring states in MENA is uneasy at best, scholars claim that as water-stress levels increase, countries will become more cooperative. For instance, in November 2021, under US auspices, Israel, Jordan and the UAE signed a declaration of intent calling for the development of 600MW of renewable power in Jordan for export to Israel in exchange for 200m cubic meters per year of desalinated water.[173,174]

170. Avisse et al, "Quantitative Assessment Of Contested Water Uses And Management In The Conflict-Torn Yarmouk Basin", (2020). Journal of Water Resources Planning and Management. 146. 10.1061/(ASCE)WR.1943-5452.0001240.
171. Anas Nawafleh, "Techno-Economic Feasibility Study of a Hypersaline Pressure-Retarded Osmosis Power Plants: Dead Sea–Red Sea Conveyor", (2018). https://www.researchgate.net/publication/328927425_Techno-Economic_Feasibility_Study_of_a_Hypersaline_Pressure-Retarded_Osmosis_Power_Plants_Dead_Sea-Red_Sea_Conveyor
172. Times of Israel, (2021). https://www.timesofisrael.com/after-years-of-delays-jordan-said-to-nix-red-sea-dead-sea-canal-with-israel-pa/
173. EIU country report, Jordan, (2021). http://country.eiu.com/article.aspx?articleid=641623047&Country=Jordan&topic=Politics&subtopic=Forecast&subsubtopic=International+relations
174. Middle East Eye, "Jordan and Israel sign US-brokered water-for-energy deal", (2021). https://www.middleeasteye.net/news/israel-jordan-sign-uae-brokered-deal-to-swap-solar-energy-and-water

Figure 19: Water basins and aquifers in Jordan



Source: Jordan Water Sector Facts and Figures (2020)

Chapter 4

The path towards a more sustainable future

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Water stress is a reality in Jordan. Groundwater resources have been overused for decades, and it is estimated that the country's groundwater is being consumed twice as quickly as it can replenish.[175] Jordan is highly supply-constrained, but rapidly increased demand and significant wastage have been the main drivers behind the worsening water stress in recent years. With the interplay of a multitude of factors, there is no standalone fix.

Jordan has been implementing various measures geared towards alleviating water stress. These include attempts to increase water availability through the desalination of seawater and the building of dams, and efforts to reduce water consumption by fortifying public water supply networks. But water-stress levels are at an all-time-high.

To effectively address the challenges Jordan faces and ensure a more sustainable water future, it must implement short-term, demand-side interventions to reduce and improve the efficiency of consumption and longer-term, supply-side policy reforms to increase water availability. However, efforts to combat water stress face financial and governance challenges. Supply-side interventions like desalination, rehabilitating the water networks, rainwater harvesting and wastewater management are often met with high upfront costs and ongoing costs (energy required, abstraction and maintenance) that act as a deterrent to implementing these interventions. Improving business-cases and looking at converting these interventions to for-profit models might attract private players to invest, lowering the overall cost to the state. On the other hand, challenges around demand-side interventions come from a lack of awareness and incentives to reduce water consumption. This requires significant investment, but crucially, coordination and collaboration among key domestic stakeholders, neighbouring countries, and the international donor community.

Groundwater resources have been overused for decades, and it is estimated that the country's groundwater is being consumed twice as quickly as it can replenish.

Water supply

Increasing the amount of freshwater available to users in Jordan is crucial to address the water crisis in the country in the long-term. Freshwater resources are currently being used at an unsustainable pace. Firstly, Jordan loses a significant amount of its already limited water supply due to leaks and inefficient water distribution infrastructure. Fortifying the network and reducing non-revenue water loss should be an immediate priority. Investments in wastewater treatment and rainwater harvesting plants could ease the pressure on existing surface and groundwater resources. Finally, development of desalination plants could increase the overall water supply by significant amounts, and will be critical in the long term.

175. USAID, "Strengthening Water Security in Jordan", (2021). https://www.usaid.gov/jordan/water-resources-environment

Reducing losses through improved water system

Jordan's water distribution system is inefficient. Over half of its already-limited piped water supply is lost as "non-revenue water" due to leaks, water theft, incorrect meter readings and under-billing. The interrupted water supply also imposes significant costs on Jordanian citizens, as they are forced to invest in purchasing, installing and maintaining pumping and storage facilities and purchasing expensive water from alternative sources.[176] This has a critical impact on the everyday lives of Jordanian citizens. Various interventions could boost reliability and efficiency, including better management and upgrading of public water networks, strengthening water sector regulations, introducing rapid leak detection and implementing smart metering.

Jordan is already taking steps in this regard. The country's National Water Strategy 2016-2025 identifies projects that contribute to a resilient water sector as a key priority. In December 2020, the European Investment Bank (EIB) granted the government of Jordan a loan of €260m (US$280m) to support the country's priority water sector investments, including efforts to construct, upgrade and improve water supply facilities across the country.[177] Such measures will help to reduce leakages, but more needs to be done, particularly at the local level.

Furthermore, the Green Growth Action Plan 2021-2025 aims to create a sustainable environment by reducing leakages in the public network: the government's Structural Benchmark Plan—a sovereign debt-reduction plan—aims to improve operation and maintenance cost recovery in the water sector by 2021. The government is working with utilities to identify leakages in physical infrastructure more quickly through the use of technologies such as the Supervisory Control and Data Acquisition (SCADA) and leak detection systems. The Water Authority of Jordan (WAJ) is also working to improve enforcement regimes around illegal water extraction, working with communities to quickly identify and stop water theft.[178]

However, more needs to be done to achieve further improvements. For instance, in 2020, the emirate of Dubai in the UAE replaced all mechanical water meters with smart meters that provide users with real-time data. The aim was to help consumers improve management of their water consumption.[179] As part of the upgrade, customers receive alerts if there is a sudden increase in water consumption that might be indicative of water leakage. In addition, artificial intelligence is used to remotely monitor Dubai's water network in real-time. The results of these initiatives are promising. In 2020, the emirate's water network losses fell to just 5%, a low figure globally, and down from 42% in 1988.[180] There is potential for cities in Jordan to pilot similar schemes, which help to ensure accurate meter readings and consumer billing, in a bid to reduce levels of "non-revenue water". This, however, would require a longer-term process implemented gradually.

176. Salameh et al. "Jordan's Water Sector—Alarming Issues and Future", (2021). 10.4236/gep.2021.912007

177. European Investment Bank, "Jordan: EIB supports priority water sector investments", (2020). https://www.eib.org/en/press/all/2020-333-jordan-eib-supports-priority-water-sector-investments

Case study: Dubai's smart metering system

In 2014, Dubai Electricity and Water Association (DEWA) launched the first phase of the Supervisory Control and Data Acquisition (SCADA) centre for water transmission at DEWA's Sustainable Building in Al Quoz. The project aimed to monitor Dubai's water network in real-time through smart devices. Initially, the project was limited to transmission pipelines, pumping stations and reservoirs but this was expanded to include water distribution pipelines and other parts of the transmission network in 2020.

As a part of the project, all mechanical meters were replaced by smart meters, and DEWA started operating the Smart Meters Analysis and Diagnosis Centre. This allows DEWA to improve meter readings, identify and rectify defects in the water network, and reduce the time needed to fix problems.[181]

Smart meters also empower consumers to rationalise their own water consumption through a host of programmes aimed at encouraging rational water usage. Another programme helps consumers identify and fix leakages on their own, making the overall process more efficient. This has reduced the number of field visits by DEWA technicians by 56% and reduced the time taken to fix interruptions by 43%.[182]

DEWA has also developed a hydrogen project that uses Artificial Intelligence (AI) and Deep Learning to remotely monitor and control the water network in Dubai, eliminating the need for human intervention to fix pipes. Since its inception, Hydronet has saved AED5.3m (US$1.44m) annually.[183]

178. Ministry of Environment, "Green Growth National Action Plan 2021-2025", (2020). https://gggi.org/site/assets/uploads/2020/10/20022_Jordan_Water_v03_HL_Web.pdf
179. Government of Dubai, "DEWA's smart programmes increase conservation and water network efficiency", (2021). https://www.dewa.gov.ae/en/about-us/media-publications/latest-news/2021/05/conservation-and-water-network-efficiency
180. Ibid.
181. ITP, "DEWA's smart systems help Dubai residents save AED420 million in water losses", (2022). https://www.itp.net/business/dewa-smart-meters-save-water-losses
182. Government of Dubai, "DEWA's smart programmes increase conservation and water network efficiency", (2021). https://www.dewa.gov.ae/en/about-us/media-publications/latest-news/2021/05/conservation-and-water-network-efficiency
183. Ibid.

Desalination

Jordan is a naturally arid country, and one of the key long-term solutions to Jordan's water scarcity is augmenting water supply through desalination through which water can be brought in from the Red Sea to Amman and various other governorates. Desalination is increasingly being used to provide potable water across the globe, and presents a few options to increase the supply of freshwater in Jordan at scale and for the long-term.

Recent improvements in seawater desalination technology have reduced potential desalination costs to less than US$0.60/cubic meters, making desalination affordable for middle income economies.[184] However, despite the improvements in technology, large-scale desalination projects require significant capital investment to build and operate the facility. Moreover, the desalination process is highly energy intensive. This is particularly challenging since Jordan's energy system is currently heavily reliant on imported fossil fuels. As declining technology prices mean renewables become more mainstream, powering the desalination and water conveyance process using renewable energy is an opportunity for Jordan.[185]

The planned National Water Carrier Project—bringing up to 300m cubic meters of desalinated water annually from Aqaba to Amman—is a significant and ambitious project.[186] It will be critical that the project ensures financing through a public–private partnership (PPP) format, limits environmental impacts and is delivered on time and on budget. However, the long timeframe needed to build desalination plants means that other faster-acting measures are needed in the interim. Other initiatives to increase supply are also needed to complement the outputs from these plants.[187]

Declining technology prices mean renewables become more mainstream, powering the desalination and water conveyance process using renewable energy is an opportunity for Jordan.

184. Salameh et al. "Jordan's Water Sector—Alarming Issues and Future", (2021). 10.4236/gep.2021.912007
185. Ministry of Environment, 'Green Growth National Action Plan 2021-2025', (2020). https://gggi.org/site/assets/uploads/2020/10/20022_Jordan_Water_v03_HL_Web.pdf
186. Jordan Times, "Water Ministry finalises tender documents for National Water Carrier Project — Najjar", (2022). https://www.jordantimes.com/news/local/water-ministry-finalises-tender-documents-national-water-carrier-project-%E2%80%94-najjar
187. Ministry of Environment, 'Green Growth National Action Plan 2021-2025', (2020). https://gggi.org/site/assets/uploads/2020/10/20022_Jordan_Water_v03_HL_Web.pdf

Case study: Desalination in Saudi Arabia

Water consumption and supply in Saudi Arabia is characterised by elevated demand juxtaposed with semi-arid lands, limited natural water resources, a rapid increase in population and unsustainable growth in water demand. Further, there are low incentives to curb water demand: water costs are high but tariffs are low in comparison, and there is limited private sector participation in the Kingdom's water sector.[188]

To bridge the demand and supply gap, the Kingdom has invested heavily in desalination plants. Currently, Saudi Arabia is the world's largest producer of desalinated water, and its plants are vital to easing a chronic water shortage that has reached acute levels. Of the country's GDP, 65% is from activities exposed to risks from water shortages, while 64% of the population is vulnerable to water shortages.[189]

Desalinated water makes up half of the Kingdom's overall water consumption.[190] A large contributing factor to this is the Kingdom's broader privatisation plans for Saudi Arabia—in 2016, the Kingdom announced plans to increase the private sector's role to meet growing socio-economic and urbanisation demand. This was followed by the creation of the National Centre for Privatisation and PPP (NCP) in the following year. The NCP's core competencies include advising various sectors on privatisation, establishing regulations and developing public information and marketing campaigns to promote privatisation. According to sources, the Kingdom states that privatisation will lead to an increase in the efficiency of operational processes, redress technical gaps, and localise technology and technical expertise".[191]

Due to the large costs involved, desalination is covered under this mandate. In January 2021, the Saline Water Conversion Corporation (SWCC) invited consortiums to bid for a 60% stake in the Ras Al-Khair power and desalination plant—the largest desalination plant in Saudi Arabia.[192] In terms of desalinated water in the Kingdom, the private sector produces 38%, while 62% is produced by the SWCC, which is responsible for water desalination, power generation and water transmission in the Kingdom. The provision of desalination plants has alleviated much stress from the water sector.[193]

188. Konrad-Adenauer-Stiftung, Regional Study: "Desalination as an alternative to alleviate water scarcity and a climate change adaptation option in the MENA region," (2020). "https://www.kas.de/documents/264147/264196/kas_remena_studie_meerwasserentsalzung_web.pdf
189. The New York Times, "The World Can Make More Water From the Sea, but at What Cost?" (2019). https://www.nytimes.com/2019/10/22/climate/desalination-water-climate-change.html
190. Ibid.
191. The Euro-Gulf Information Centre, "Behind the Privatisation Drive in Saudi Arabia". egic.info/behind-privatisation-drive-saudi-arabia
192. Ibid.
193. Konrad-Adenauer-Stiftung, Regional Study: "Desalination as an alternative to alleviate water scarcity and a climate change adaptation option in the MENA region," (2020). "https://www.kas.de/documents/264147/264196/kas_remena_studie_meerwasserentsalzung_web.pdf

Wastewater treatment and reuse

To bridge the gap between water resources and demand, Jordan could increase water availability by treating municipal wastewater and reusing it for agricultural purposes. Such treatment is cheaper than desalination and wastewater can be treated to a high quality. Several studies have shown the impact of wastewater recycling on water availability as it can reduce the demand-supply gap by as much as 48%, significantly improving water availability.[194] Furthermore, wastewater treatment (WWT) also confers environmental and ecological benefits. It enables the conservation and preservation of existing water sources by rechannelling wastewater to treatment plants that would otherwise have been dumped into water bodies.

In 2020, re-used treated wastewater accounted for only 15% of the total water resource available in Jordan.

Yet treatment levels remain low in Jordan. In 2017, re-used treated wastewater accounted for only 15% of the total water resource available in Jordan. Challenges include the low acceptance of treated wastewater by users and the significant capital investments needed to set up WWT plants. Substituting groundwater and surface water used in agriculture and industry with treated wastewater would release additional freshwater for potable use, helping to depress the supply gap.[195]

The Jordanian government aims to develop and expand the capacities of wastewater treatment plants at Aqaba, Madaba and Burkish to increase the volume of reclaimed water for agricultural use, thus redirecting potable water currently used for irrigation to domestic uses to alleviate the water supply deficit.[196] However, more can be done, particularly to encourage the adoption and use of treated water. For instance, the Abu Dhabi Department of Energy launched a Recycled Water Policy in 2019 that seeks to ensure optimal use of recycled water in the emirates by mandating distribution companies to develop recycled water safety plans to the point of delivery to end-users and to perform sampling at various zones through the Emirate.[197]

194. Ministry of Environment, 'Green Growth National Action Plan 2021-2025', (2020). https://gggi.org/site/assets/uploads/2020/10/20022_Jordan_Water_v03_HL_Web.pdf
195. Jordan Water, Facts and Figures, (2017).
196. Ministry of Environment, 'Green Growth National Action Plan 2021-2025', (2020). https://gggi.org/site/assets/uploads/2020/10/20022_Jordan_Water_v03_HL_Web.pdf
197. Aqua Tech, Water reuse in Abu Dhabi, (2020). https://www.aquatechtrade.com/news/water-reuse/water-reuse-increases-in-abu-dhabi-after-policy/

Case Study: Public–Private Partnership for Decentralised, Small-Scale Sewage Treatment Plants, New Delhi

Delhi has been facing acute water shortages for the past decade due to increasing pollution, urbanisation and heat. Low levels of precipitation in recent years have significantly exacerbated the problem. It is estimated that Delhi is facing an acute water shortage of over 190m litres per day.[198] Before 2016, only 40% of the wastewater in Delhi was treated with the rest directed to the Yamuna river, further increasing water pollution levels.

In 2016, the New Delhi Municipal Corporation (NDMC) decided to install small-scale, decentralised Sewage Treatment Plants (STPs) around the city to treat sewage locally and reuse the treated water for horticulture, which is quite prevalent in the city. These projects were also promoted under the Delhi Smart City project.[198]

The NDMC did not issue a standard contract wherein the service provider was paid to build and operate the STP. Rather, it issued a PPP agreement stating that the NDMC would provide space to build the STP and then buy the treated sewage from Vision Earthcare, a private power engineering company based in India, once it meets the required standards.

The PPP model, according to research, has been extremely beneficial and has proven to be better than publicly funded plants. An Asian Development Bank report notes that this can be attributed to the fact that private players focus on profit, hence allowing them to build the plant leveraging business expertise. Whereas, for the NDMC, outsourcing meant that they did not have to invest a large amount of capital for construction.[200]

By engaging private players and ensuring 100% treatment and reuse of wastewater, the NDMC has seen an increase in wastewater treatment. However, during implementation of the plant, gaps were identified with a significant number of households still not connected to the sewage system. More recently, the government has committed that by June 2022, all eligible households will be given sewage connections.[201]

198. Asian Development Bank Institute, "Decentralized Wastewater and Fecal Sludge Management: Case Studies from India", (2020). https://www.adb.org/sites/default/files/publication/634586/adbi-cs2020-2.pdf

199. South Asia Network on Dams, Rivers and People, "Decentralized STPs in the Delhi Capital Region", (2017). https://sandrp.in/2017/09/23/decentralized-stps-in-the-delhi-capital-region/

200. Asian Development Bank Institute, "Decentralized Wastewater and Fecal Sludge Management: Case Studies from India", (2020). https://www.adb.org/sites/default/files/publication/634586/adbi-cs2020-2.pdf

201. Times of India, "Cleaner Yamuna: Delhi Jal Board identifies 109 colonies for laying sewer pipelines", (2022). https://timesofindia.indiatimes.com/city/delhi/cleaner-yamuna-djb-identifies-109-colonies-for-laying-sewer-pipelines/articleshow/89355655.cms

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Rainwater Harvesting

An alternative option that offers substantial potential to increase available water supply is to expand national awareness and access to rainwater harvesting (RWH) to augment the network's supply. More than 90% of rainwater in Jordan is lost to evaporation or run-off. RWH is a lower-cost, sustainable approach to diversify both agricultural and municipal water supply. RWH is also one of the cheapest and greenest ways to augment the water supply, since there are few costs associated with transportation and energy.[202]

The main barriers to expanding both urban and rural RWH are lack of awareness, low implementation rates and access to finance. However, under the Green Growth Action Plan 2021-2025, the Government of Jordan is expected to set up a financing facility to support projects that augment rural and urban water supply. The facility will work in collaboration with the Ministry of Water and Irrigation, Ministry of Agriculture and municipal governments to identify and develop projects. Currently, public awareness about RWH is relatively low, even though households and businesses are increasingly comfortable with rooftop solar for water heating and management of rooftop water tanks. Efforts should be made to raise public awareness and increase adoption of RWH.

202. Ministry of Environment, "Green Growth National Action Plan 2021-2025", (2020). https://gggi.org/site/assets/uploads/2020/10/20022_Jordan_Water_v03_HL_Web.pdf

Case study: Australia's rainwater harvesting systems

The climate in Australia is extremely dry—the annual rainfall is around 470mm compared with the global average of 990mm—yet it is one of the highest drinking water consumers in the world.[203] High demand for water, frequent droughts and a rapidly increasing urban population has created additional pressure on the water table. A rainwater management system was part of the Integrated Water Cycle Management Programme in the water reforms that started in 1994.[204] Since then, rainwater harvesting (RWH) has been a vital part of Australia's water ecosystem.

Currently, Australia has one of the highest levels of RWH system implementation. Rainwater harvesting provides an estimated 274bn litres annually. According to the Australian Bureau of Statistics (ABS) one in four, or 26% of Australian houses have a rainwater tank. The uptake has been incentivised by significant rebates offered to households. The ABS estimates rainwater provides 177bn litres (9%) of residential water in Australia worth A$540m (US$388m).[205] Research has estimated that rainwater harvesting and water efficient appliances in Sydney alone saved 90bn litres in 2016, equivalent to the entire capacity of the A$1.8bn (US$1.29bn) Sydney desalination plant.[206] The success observed in Australia demonstrates the effectiveness of combating long spells of droughts through RWH implementation.

Success in Australia is promising for developing countries, like Jordan, which have inadequate water supply for drinking and sanitation and an unreliable centralised water supply systems. RWH systems can treat and store water that could bridge the gap between demand and supply. Despite being extremely effective, RWH can still be expensive. Governorates or housing communities could build larger RWH systems to serve the community, and this could be financed via PPPs. In Jordan, RWH systems could be extremely beneficial in areas that currently receive higher rainfall or are projected to have an increase in precipitation due to climate change.

203. Select Water Tanks, "'"Rainwater Harvesting Australia". https://www.selectwatertanks.com.au/rainwater-harvesting-australia/
204. EWRA, "Integrated Water Management Cycle: An Australian Perspective," (2006). https://www.ewra.net/ew/pdf/EW_2006_15-16_03.pdf
205. Rainwater Harvesting Australia, "Irrigation Australia - Rainwater Harvesting Website". https://rainwaterharvesting.org.au
206. Ibid.

Water use

Augmenting water supply is a long-term process that requires significant time and capital investment. However, in the short-term, Jordan could implement measures to limit excessive and wasteful water use practices. Of Jordan's 12 groundwater basins, ten are being pumped at a deficit—an unsustainable position. To help limit such overexploitation, Jordan could introduce policies that improve water-use efficiency, raise public awareness and incentivise and encourage more efficient water use and behaviour.

Improving water-use efficiency

Water use is heavily subsidised in Jordan—47% of the price of domestic water is covered by the government, at an estimated cost of JD348m (US$490m) in 2017.[207] Agricultural water users face even lower tariffs and despite increases in recent years, as well as clear efforts to improve enforcement, revenues have not been able to cover the cost of operations.[208,209] This means that key utilities, such as the Water Authority of Jordan (WAJ) and the Jordan Valley Authority (JVA) run long-term budget deficits, undermining their ability to invest in infrastructure maintenance and development. This contributes to leakages and very high technical losses of water.[210] Moreover, inadequate monitoring and enforcement lead to high rates of under-billing and theft.

Households pay low flat rates even though water costs account for only a small proportion of their budgets. However, the volumetric block system (with low- and high-use determining amounts billed) has benefited wealthy, small-family households using less water while poorer large households using more water receive a lower subsidy. The continuation of subsidies and distorted incentives thus worked against efforts to improve end-use efficiency, reduce waste and increase conservation. Instead, distorted allocations contribute to growing water stress.[211]

Improving the subsidy and tariff system should be gradual and part of a comprehensive reform. As such, it will require significant time to be implemented. Until this situation can be addressed in the medium to long term, measures to improve water efficiency—particularly in agriculture—will be critical. Water-use efficiency can improve significantly through rehabilitation of the physical network, installation of metering devices, a re-orientation towards less water-intensive production and capacity building for local water users.

207. Jordan Water, Facts and Figures, (2017).

208. T Liptrot and H Hussein, "Between regulation and targeted expropriation: Rural-to-urban groundwater reallocation in Jordan." (2020). https://www.water-alternatives.org/index.php/alldoc/articles/vol13/v13issue3/599-a13-3-17/file;

209. Klassert et al, "Increasing Block Tariffs in an Arid Developing Country: A Discrete/Continuous Choice Model of Residential Water Demand in Jordan", (2018). https://doi.org/10.3390/w10030248

210. Ibid.

211. Ibid.

Case study: Santiago's tariff reforms in the 1980s

Water tariffs are an important economic and financial instrument that help to minimise investment costs by managing demand and generating revenues to cover expenditure associated with the provision of services.[212]

In the 1980s, the Chilean water sector went through several reforms that included a revision of the tariff structure: the tariff increment system was changed from ad hoc increases set by the Ministry of Economy (issued as Presidential decrees) within a ceiling (no more than 10% return on fixed assets to tariffs indexed to inflation) and adjusted every five years according to a formula based on marginal costs.

A new tariff formula was introduced gradually from 1990 to 1995 starting with a 30% real increase in 1990.[213] The new tariff system was implemented to tackle the financial losses incurred by the water management authority (EMOS) due to low tariffs. According to a World Bank report, EMOS' rate of return on total assets in 1989 was only 2.7%. The financial losses had further implications on the water network system—the facilities were old and in need of repair and replacement by 1990. For example, it had collection and treatment works dating back to 1917 and 20% of its network of pipes exceeded their usable life of 30 years. The new tariff aimed to bridge some of the financial gap and allow reinvestment into the water network, reducing water losses due to infrastructural issues.

The reforms led to higher water prices and substantial efficiency gains, even though concerns were raised over the affordability of water and sanitation services for low-income households. To address equity issues, the government introduced an individual means-tested water consumption subsidy in the early 1990s. The subsidy covers 25%-85% a household's basic water and sewerage consumption costs (up to 15 cubic meters a month), with all consumption beyond this limit charged at the full price. The subsidy is targeted towards households unable to purchase the basic water needs, roughly defined as households for which the WSS bill constitutes more than 5% of their monthly income.

The separation of water use into two distinct goods—basic needs and optional consumption—allowed the government to provide a water subsidy to low-income households that is independent of water consumption beyond the basic needs.

The current tariffs in Chile are high compared to the rest of Latin America, and some regional tariffs in Chile are almost double. In the north, reflecting water scarcity and in the far south, possibly reflecting difficult conditions for providing water supply and sewerage to users.[214] In 2016, Chile achieved universal levels of coverage in water, sewerage and wastewater treatment in urban areas.[215]

Despite the fact that there was political uncertainty around increasing water tariffs, the success story from Santiago is extremely important for arid developing nations. Similar to Chile, there is an imperative need to rehabilitate the water network in Jordan. Increasing tariffs in conjunction with subsidies to ensure that the most vulnerable populations are not unfairly burdened, might be the way forward for the Water Authority to recover some of the losses it faces due to metering, leaks and non-revenue water.

212. Ibid.
213. The World Bank Development Research Group, "Reforming the Urban Water System in Santiago Chile", (2020). https://openknowledge.worldbank.org/bitstream/handle/10986/22314/WPS2294.pdf?sequence=2&isAllowed=y
214. Ibid.
215. Ferro et al, "Technical efficiency in Chile's water and sanitation providers", (2016) https://www.sciencedirect.com/science/article/abs/pii/S0957178715300631#

Public Awareness and behavioural change

Despite the urgency of the water crisis in Jordan, many end users are still engaged in wasteful water practices. This is particularly the case for traditional farming and irrigation practices, but also in domestic use.

For instance, while drip irrigation is the dominant system used in the Jordan Valley, studies have indicated that around 30% of farmers still prefer to use traditional approaches, such as water-intensive surface irrigation. The use of modern production and irrigation technologies is dependent on financial realities and farmer knowledge. This means improving engagement and awareness with water users directly is critical, as is addressing water affordability and access to finance for water-efficient technologies. Improving water efficiency in agriculture, through promoting the practice of drip irrigation and the use of treated wastewater, could potentially reduce water consumption by up to 168m cubic meters per year in Jordan. Further aligning water-sector practices and agricultural trade policies to promote strategic import substitution of water-intensive crops could save an additional 52.5m cubic meters per year.[216]

Investment in mainstreaming educational programmes that focus on appraising the public about ground realities and promoting water conservation are the need of the hour. One of the objectives of the Green Growth National Plan 2021-2025 is to create awareness amongst citizens and decision makers about the current water situation. This includes encouraging the public to use more sustainable water alternatives like treated wastewater and harvested rainwater. The Ministry of Water and Irrigation (MWI) promotes water awareness campaigns to shape water users' habits and perspectives on water through various channels. For instance, the MWI, in collaboration with the Ministry of Education, disseminated information on water scarcity in Jordan through textbooks to raise awareness about water challenges and shape students' behaviour.[217]

Some countries in the MENA region have made information sharing a priority. In Egypt, the Ministry of Water Resources and Irrigation, with support from the EU Water Stars project, runs an annual competition that aims to raise awareness among farmers of the importance of adopting modern, water-saving irrigation methods.[218] The winner shares the modern techniques they have adopted, and the water savings they have made as a result, with fellow farmers during a knowledge-sharing session organised by the ministry. Such initiatives could be replicated and expanded in Jordan to raise awareness of the benefits of modern systems and encourage their adoption.

216. Ministry of Environment, "Green Growth National Action Plan 2021-2025", (2020). https://gggi.org/site/assets/uploads/2020/10/20022_Jordan_Water_v03_HL_Web.pdf

217. Benedict and Hussein, "An Analysis of Water Awareness Campaign Messaging in the Case of Jordan: Water Conservation for State Security", (2019).

218. Niras, "As ambassadors for modern irrigation, innovative farmers raise awareness about the importance of food and water security in Egypt", (2021). https://www.niras.com/news/eu-water-stars-project-water-conservation-competition/

Case study: Israel's public awareness campaigns

Israel has very similar groundwater realities to Jordan. The environment in Israel is arid, and is characterised by overconsumption. However, despite this, Israel ranks high globally in terms of water efficiency.[219] According to a researcher, this is due to impeccable water management systems.[220]

A key pillar in water management is curbing public water demand through interventions and awareness campaigns. Started in the midst of consecutive droughts in the 2000s, the Israeli Water Authority launched several campaigns via TV, radio and the internet to apprise citizens of the water crisis and urge people to be mindful of their water usage. The campaigns were targeted at different age groups and communities. For example, one campaign was aimed at nurturing water-conscious habits in children through a series of cartoon television programmes that spoke about the importance of saving water, creating longer-term impacts and raising more water-sustainable adults.

In 2008, the Water Authority initiated a major water conservation campaign that promoted the installation of water-saving devices (bathrooms, toilets, kitchens), reaching 55% of all households and all public buildings and government offices. In parallel, a media awareness campaign was implemented over an 18-month period from 2008 to 2010 to educate consumers about water use. The main motto of the campaign was: "the basis for change is public acceptance," and it was structured around a combination of education and media activities, carefully targeted to the various segments of the population. Clear targets and objectives were set for the campaign, and its implementation was accompanied by ongoing polls and focus groups to monitor the impact, allowing changes and adaptations to achieve optimal results.[221]

Another significant awareness campaign was launched in 2009 that featured Israeli celebrities speaking about the declining water levels and the importance of consuming water in moderation. As the celebrities spoke, their facial features began to crack and peel, highlighting the drying Sea of Galilee. This campaign led to an 18% reduction in water consumption in urban areas.[222]

219. The Jerusalem Post, "Is Israel's scarcity of water a blessing in disguise?" (2021). jpost.com/jpost-tech/is-israels-scarcity-of-water-a-blessing-in-disguise-654578
220. Ibid.
221. World Bank, Water Management in Israel, (2017). https://documents1.worldbank.org/curated/en/657531504204943236/pdf/Water-management-in-Israel-key-innovations-and-lessons-learned-for-water-scarce-countries.pdf
222. Zenger, "No Drought About It: How Israel Used Innovation To Beat Its Water Crisis", (2022). zenger.news/2022/05/02/no-drought-about-it-how-israel-used-innovation-to-beat-its-water-crisis/

Enabling environment

Currently, long-term planning for the future of water resources in Jordan is hampered by a lack of effective coordination among all key stakeholders. Inclusive joint planning, and evidence-based decision-making are essential for developing the right investment and management strategies and priorities to addressing the water crisis in Jordan in the long-term. These should include all relevant stakeholders, from water users to investors and donors, and be informed by high-quality data and climate change considerations. Furthermore, due to its position as a downstream country, Jordan is reliant on collaboration with its neighbours or providing sufficient supply. The existing arrangements have not been effective or suitable, and have not taken the growing Jordanian population into account. Improved cross-border collaboration will therefore be key for addressing Jordan's water challenges in the long term.

Joint planning

The water network in Jordan currently lacks coordination amongst key actors, as well as proper inclusion of users and vulnerable groups. Better coordination between policymakers, the private sector, the general public and, crucially, the international community is required. Improved data and information sharing and incorporation of climate-change factors into planning and decision-making processes is critical. Joint planning will help decision makers introduce policies that are forward looking and in keeping with the current ground-realities. Greater inclusion of the private sector will be important for long-term financial sustainability of the water system. Furthermore, higher representation of women and other vulnerable populations would help strengthen interventions.

Streamlining coordination between key actors and institutions through integrated, evidence-based national water planning will be key. This is critical not only for efficient allocation of the necessary investment, but also for its long-term sustainability in the face of worsening climate change. Climate modelling and planning should be at the very heart of this. This has already been recognised, and Jordan's Economic Green Growth National Action Plan 2021-2025 aims to enhance cooperation and coordination amongst different ministries. The plan outlines four steps to achieve this: (1) Consolidating governance bodies where overlap exists, removing duplicate committees or governance units for the same issues; (2) Upholding the highest standards of transparency and knowledge exchange, committing to sharing information as needed and following standard procedures for policy and project development; (3) Hosting regular, inclusive sector-level donor and development partner consultations, and more frequent public-private-civil society dialogues on key policies and investments; (4) Conducting more public outreach and awareness of government successes and lessons learned.[223] Moreover, under the National Water Strategy, the Ministry of Water and Irrigation (MWI) promotes staff exchanges and sharing of experiences as additional learning opportunities for all levels, leading to enhanced capacity building in Jordan's water management sector.[224] The USAID's Water Management Initiative (WMI) also featured knowledge-sharing workshops on how to reduce non-revenue water in Jordan.[225]

223. Ministry of Environment, "Green Growth National Action Plan 2021-2025", (2020). https://gggi.org/site/assets/uploads/2020/10/20022_Jordan_Water_v03_HL_Web.pdf

Case Study: The Murray-Darling Basin Commission – Australia

The Murray-Darling Basin Commission was established in 1992 as an inter-governmental organisation whose main role is to coordinate the management of natural resources across state borders within the Murray-Darling Basin. The main aim of the Commission is to achieve sustainable use of water, land and other environmental resources of the Basin. The Murray-Darling Basin Authority (MDBA) undertakes activities that support the sustainable and integrated management of the water resources of the Murray-Darling Basin in a way that best meets the social, economic and environmental needs of the Basin and its communities.[226]

The Commission also advises the Murray-Darling Basin Ministerial Council on environmental management issues throughout the Murray-Darling Basin, and administers a Natural Resources Management Strategy in the basin. The Commission office employs technical and support staff in the areas of river management, natural resources, finance, administration and communications. The office undertakes close consultation with both State and Commonwealth agencies and is also responsible for the financial management of all activities shared between the four governments under the Murray-Darling Basin Agreement. All member governments refer to the Commission for comment on any development proposal or change in water management policy that could have adverse effects on the water quality or quantity in the Murray River. Under the Commission, there are more than 20 working groups with experts drawn from government departments, universities, private organisations and community organisations.[226]

The Commission has a centralised website that houses all the data, key updates and news relating to the Basin. The website also has school resources in the form of fun activities designed for kids aimed at encouraging sustainable use of water, agriculture and the environment.[227]

224. Lund and Kiewg, "Water governance in Jordan: Managing a scarce resource", (2019). https://projekter.aau.dk/projekter/files/307171370/Kieweg__Lund___Water_governance_in_Jordan___Managing_a_scarce_resource.pdf
225. USAID, "Mid-term Evaluation: USAID/Jordan Water Management Initiative", (2018). https://www.globalwaters.org/sites/default/files/jordan-wmi-midterm-evaluation.pdf
226. Murray-Darling Basin Authority, "About Us". mdba.gov.au/annual-reports/annual-report-2014-15/about-mdba/about-us
227. Ibid.

Improved quality and accessibility of data for water resources planning and supply

For the Jordanian Government and researchers to arrive at more well-informed solutions, they need to be able to access data to monitor water leakages and trends over time. Currently, hydrological and other data required for water resources and supply planning is not readily available, and is often behind paywalls. Hydrological data is crucial to prepare and plan for extreme events by identifying where risks are highest. Day-to-day hydrological data can also be used to better manage and distribute Jordan's water resources, identify leakages and illicit water connections.

Academics and researchers also state that their efforts to map Jordan's past, present and future water situation is undermined by the relative lack of data and resources available to develop the needed information and data.[229] The channels for sharing and disseminating data and information among the key actors, including ministries are currently lacking.

The government has recognised the need to improve its data collecting capacity, and has taken steps to build capacity. According to the Green Growth National Action Plan 2021-2025, the MWI and WAJ will work together to implement an updated Geographic Information System (GIS) for newly constructed/rehabilitated water networks that could monitor and store data for more informed policy making. Further, the plan aims to implement a Joint Work Programme (JWP) model, which would serve as a much-needed strategic planning tool.[230]

Academics and researchers also state that their efforts to map Jordan's past, present and future water situation is undermined by the relative lack of data and resources available to develop the needed information and data.

In the long-run, advanced and distributed technology, including Internet of Things (IoT) and Supervisory Control and Data Acquisition (SCADA) systems offer an opportunity to collect, monitor and manage data efficiently. Remote sensing can be used on water network pipes to detect physical leaks. This information can then be sent to the relevant authorities, reducing response time and increasing decision support. Further, IoT can be used to create a data repository that can be used for evidence-based policy interventions.

228. Murray-Darling Basin Authority, "Education". https://www.mdba.gov.au/education
229. Whiteman, "A land without water: the scramble to stop Jordan from running dry", (2019). https://www.nature.com/articles/d41586-019-02600-w
230. Ministry of Environment, "Green Growth National Action Plan 2021-2025", (2020). https://gggi.org/site/assets/uploads/2020/10/20022_Jordan_Water_v03_HL_Web.pdf
231. Olson and Radosevich, "Existing And Emerging Basin Arrangements In Asia: Mekong River Commission Case Study", (1999). http://web.worldbank.org/archive/website00660/WEB/PDF/MEKGONGR.PDF
232. Ibid.
230. MRC Data Portal. https://portal.mrcmekong.org/home
234. MRC, "Greater transparency in data sharing and cooperation will improve management of the Mekong River, says MRC", (2020). mrcmekong.org/news-and-events/news/greater-transparency-in-data-sharing-and-cooperation-will-improve-management-of-the-mekong-river-says-mrc/

Case study: Using transboundary data sharing to build trust – The Mekong River

The Mekong River is shared between Myanmar, Laos, Thailand, Cambodia and Vietnam. To optimise use, the four member countries, with the aid of the United Nations, set up the Mekong River Commission (MRC) to work towards sustainable transboundary water sharing amongst the member states. The Agreement represents a milestone in international water resource management treaties due to its emphasis on joint development, ecological protection, and a dynamic process of water allocation.[231] A key aspect of the MRC is transboundary hydrological data sharing amongst the member countries, enabling them to meet the MRC's vision.

The MRC was formed in the aftermath of the second world war while the United Nations' Economic Commission for Asia and the Far East (ECAFE) investigated the potential for integrated development in the lower Mekong basin. The Mekong Agreement represents a "constitution" for a framework of cooperation. It focuses on fundamental issues, such as general principles, areas of functional responsibility, decision-making procedures, eligibility and organisational structure. The committee was set up on five pillars: (1) The principle of international waters; (2) Principle of reasonable and equitable utilisation; (3) Obligation to not cause significant harm; (4) Principle of notification and negotiations on planned measures; and (5) Duty to cooperate.[232] These five principles ensure that the transboundary nature of the Mekong River fosters trust-building and peace. The committee also produces, shares and recommends water policies through a data portal that is open and accessible to all.

Information sharing is at the core of MRC's mission. In 2001, ministerial delegates of the MRC Council adopted a set of procedural rules on multilateral data sharing among the four members known as the "Procedures for Data and Information Exchange and Sharing," (PDIES). PDIES provided a framework for the member states to share and exchange data for joint management of the shared water resources in the region. For example, the MRC, through the use of PDIES, is able to provide real-time water-level information and better flood forecasting. PDIES has also enabled constant water quality, fisheries, and water sedimentation-level monitoring.[233] In recent years, the MRC has initiated programmes to increase data transparency and accessibility to improve overall management.[234]

In transboundary contexts, data sharing is considered to be a means of building trust between riparian countries and thus a contributor to long-term commitment and strong international cooperation. The MRC can be considered a leader in transboundary water management. According to studies, the MRC has "gathered and processed substantial amounts of data on the river and its basin, obtained through cooperation by all member states", even under difficult circumstances like war and political suspicion.

Resource cooperation amongst neighbours

In the long-term, there is a need to improve trust and collaboration over management of shared water resources between countries in the region. This is especially important given the transboundary nature of most of the water bodies present in Jordan. As in other basins globally, basin governance for the Jordan River is challenged by concerns for establishing and maintaining national sovereignty, misperceptions of benefits and risks of cooperation and inadequate technical capacities.[235]

Regular joint benefit assessments can serve as an important entry point to establish or deepen cooperation and advance governance solutions as described in this paper. The benefit assessment will provide new information to riparian states regarding the type and magnitude of potential benefits while informing the governance functions needed by joint bodies to maximise the potential benefits, including those initially less apparent.[236]

Jordan could also work towards a Water-Energy Nexus (WEN) with neighbouring countries.[237] The WEN is designed to create a regional desalinated water–solar energy community among Jordan, Israel and Palestine that would result in healthy and sustainable regional cooperation. As a relatively large country, with landmass on which to build expansive solar power plants, Jordan is in a strong position to negotiate resource-based agreements. In November 2021, Jordan, Israel and the UAE signed a water-for-renewable-energy declaration of intent. Under the agreement, the UAE would build a solar energy farm in Jordan capable of producing 600MW of renewable power annually, which Jordan would send to Israel in exchange for 200cubic meters of desalinated water.[238]

Similar initiatives, if successfully implemented, could serve as a basis for improved trust and expanded cooperation in other crucial areas.

Conclusion

Policy choices can influence the extent to which Jordan's water-stress crisis escalates over the coming years, as well as its subsequent impacts on society and the economy. Yoon et al show that supply-side (e.g. desalination projects, reduced water loss and leakage) and demand-side interventions (e.g. revision to the water-tariff schedule) can significantly mitigate increases in water stress and the resulting damages.[32]

The interventions need to be aimed at increasing water supply, optimising water use and creating an enabling environment that is conducive to efficient investment and water use.

235. Stockholm International Water Institute, "Governance structures for transboundary water management in the Jordan Basin", (2015). https://siwi.org/wp-content/uploads/2016/08/partner-publication-basin-structure-twm-web.pdf
236. Ibid.
237. EcoPeace MENA, "Green Blue Deal", (2020). https://ecopeaceme.org/wp-content/uploads/2021/03/A-Green-Blue-Deal-for-the-Middle-East-EcoPeace.pdf
238. Mohammed Mahmoud, "Exploring the feasibility of the Jordan-Israel energy and water deal", (2021). https://www.mei.edu/publications/exploring-feasibility-jordan-israel-energy-and-water-deal

Case study: Formation of the International Sava River Basin Commission (ISRBC)

After the dissolution of the Socialist Federal Republic of Yugoslavia in the early 1990s, the importance of the Sava River, as a transboundary water source became apparent. In 2001, Bosnia and Herzegovina, the Federal Republic of Yugoslavia, the Republic of Croatia and the Republic of Slovenia, entered the Sava River Basin Initiative, aimed at cooperation for sustainable basin-wide water resource management. The main objective was to establish an appropriate institutional framework for transboundary cooperation that ensures sustainable use, protection and management of the water resources in the Sava River Basin and thus enables "better life conditions and raising the standard of the population in the region".[239]

The ISRBC is the joint institution established with the international legal capacity necessary to exercise its functions, e.g. the implementation of the Framework Agreement on the Sava River Basin (FASRB). The commission is founded on three mutually agreed goals: (1) Establishment of an international regime; (2) Establishment of sustainable water management; and (3) Undertaking measures to prevent or limit hazards. The commission works to share resources across the region, like risk management plans, river information services, monitoring and forecasting weather and flood patterns, and creating early warning systems. The ISRBC also works on the preparation and realisation of development programmes and other strategic documents, carrying out and coordinating the preparation of studies and projects.[240]

Having a centralised body to govern activities around a transboundary water resource allows for quicker and more comprehensive decision-making. Post-conflict cooperation built around vital natural resources further fosters trust amongst neighbouring countries, paving the way for collaboration in different areas.

239. International Sava River Basin Commission, "History of Cooperation". https://www.savacommission.org/about-us/history-of-cooperation/235

240. EEA, "National and regional story (Bosnia and Herzegovina) - The Sava River Basin Initiative", (2020). https://www.eea.europa.eu/soer/2010/countries/ba/national-and-regional-story-bosnia

Appendix: Methodology

The quantitative analytical findings presented in this report assess the impact of alternative scenarios of water stress in Jordan. The analysis uses a two-stage approach:

1. **Regression analysis:** First, a series of regression models were designed that test the strength of the relationship between water-stress levels and a range of socio-economic variables across countries.
2. **Scenario analysis:** The findings from the regression analysis were applied to the context of Jordan, assessing the implications of alternative future trends in water-stress levels on socio-economic outcomes for the country.

This appendix outlines the methodology used in each stage of the analysis.

Regression analysis

The first stage of the analysis uses an econometric modelling approach to understand the strength and direction of the relationship between water stress and key socio-economic variables, including:

- **Economic indicators:** The analysis assesses impacts of water stress on the gross value added (GVA) of the agricultural, manufacturing and service sectors of the economy.
- **Social indicators:** The analysis assesses impacts of water stress on indicators that reflect effects on health and education, including undernourishment, infant mortality and female enrolment in education.

For the purposes of this analysis, water stress is defined as the ratio of water withdrawal to water availability—higher levels of water stress can therefore be the result of either increasing rates of withdrawal, decreasing levels of availability or a combination of both.

The use of an econometric modelling approach allows for the effect of water stress on selected variables to be isolated from the impacts of other contributing factors (to a certain extent) through the use of control variables. Although the models seek to control for other factors that cause variation in the selected variables, it should be noted that there is always a degree of variation that cannot be fully captured or explained.

A panel regression approach was used in building the models. This approach assesses the relationship between water scarcity and each variable of interest by exploring trends across countries (for 83 countries) over a time period of up to five years. In an ideal world, the regression model would cover a wider time period to fully capture the impacts of fluctuations in water scarcity levels and the knock-on impacts on socio-economic variables. In its most basic form, the panel regression models used in this analysis assume the following relationship between variables:

$$y_{(i,t)} = \alpha_i + \beta WAT_{(i,t)} + \gamma x_{(i,t)} + \delta_t + \varepsilon_{(i,t)}$$

where $y_{(i,t)}$ is the socio-economic variable of interest (for example, infant mortality) for country i at time t, α_i is a country-specific intercept, $WAT_{(i,t)}$ is a measure of water scarcity, $x_{(i,t)}$ is a vector of controls, δ_t is a time-period-specific intercept and $\varepsilon_{(i,t)}$ is an error term capturing other factors influencing the variable of interest that are not explicitly captured in the model. In this model framework, the coefficient β provides an estimate of the relationship between water stress and the variable of interest.

A total of six regression models were built, each focusing on a different variable of interest. For each model, alternative model specifications were tested to identify the model with the best fit. The table on page 72 summarises each model by outlining the variable of interest (the dependent variable), the variables that contribute to fluctuations in the variable of interest (the independent variables) and the key data sources.

Scenario analysis

The findings from the regression analysis described above provided a quantified association between a change in water-stress levels and the selected socio-economic variables based on historic trends. For example, by assessing the trends across countries and over time and by controlling for other confounding factors, the model identifies the average expected percentage impact of a 1% change in water-stress levels on each variable.

These identified relationships were then used in scenario analyses to forecast the impacts of changes in water-stress levels in Jordan up to 2030. To do this, a baseline forecast was developed for each socio-economic variable by assuming that water-stress levels in Jordan remain the same as current levels. Forecasts for each variable under the baseline scenario were obtained through existing projections for economic and demographic growth in Jordan.

The analysis then considered the deviation from the baseline for each indicator under alternative scenarios. We considered three potential scenarios, drawing on the research of Yoon et al:[241]

- **No intervention:** Assumes no additional interventions to address water scarcity in Jordan.
- **Supply-side action:** Accounts for planned projects to address issues related to the availability of water including, for example, the Red Sea-Dead Sea desalination phase 1 (80m cubic meters / year) and phase 2 (150 MCM/year), all other planned water supply projects (132m cubic meters / year) and physical NRW reduction (50% of current losses).
- **Supply- and demand-side action:** In addition to supply-side actions, this more aggressive scenario also accounts for demand-side measures including revisions to the water tariff schedule and transfers of groundwater production from the agricultural sector to the municipal sector.

241. Yoon et al, "A coupled human–natural system analysis of freshwater security under climate and population change", (2021). https://www.pnas.org/content/118/14/e2020431118

Table: Model specifications

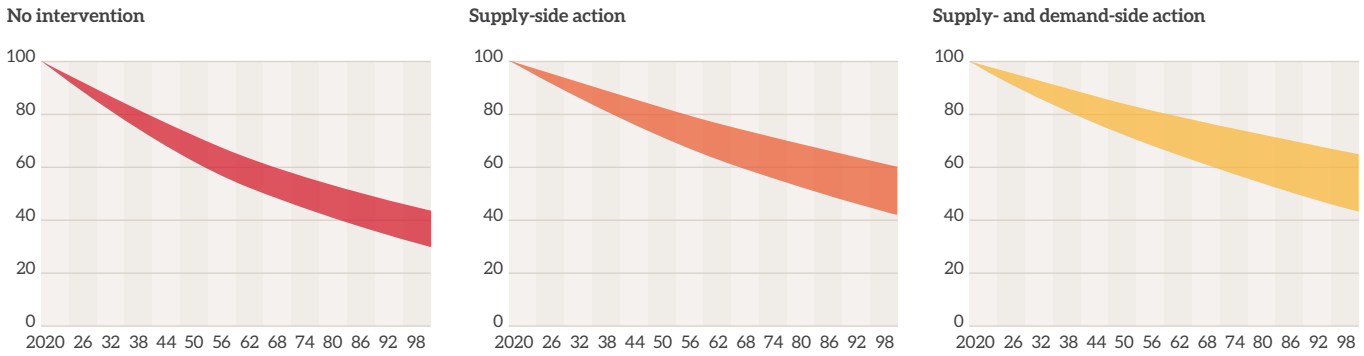
No.	Socio-economic impact variable	Independent variables	Data sources
1	Agriculture GVA per capita	**Water stress:** Key variable of interest, which can impact agriculture GVA directly (reducing available inputs for production) and indirectly (e.g. through labour (productivity impacts **Personal disposable income (relative to GDP):** Can affect demand for agricultural produce **Regulatory quality:** Acts as a proxy for institutional quality, which can affect ease of doing business **Percentage of land area used for agriculture:** Input to production, therefore directly affects output levels	World Bank, FAO, EIU
2	Manufacturing GVA per capita	**Water stress:** Key variable of interest, which can affect manufacturing GVA directly and indirectly **Gross domestic energy consumption:** Provides a proxy for changes in population demographics, affecting demand for manufacturing **Political stability:** Acts as a proxy for institutional quality, which can affect ease of doing business **Real gross fixed investment (relative to GDP):** Input to production through investments in capital, which can directly affect output levels	World Bank, FAO, EIU
3	Services GVA per capita	**Water stress:** Key variable of interest, which can affect services GVA directly and indirectly **Real GDP per capita:** Acts as a proxy for the general economic welfare of the population and the ability to spend on services **Real government consumption:** Reflects changes in government-generated demand for domestic services **Control of corruption:** Acts as a proxy for institutional quality, which can affect ease of doing business	World Bank, FAO, EIU
4	Undernourishment (measured based on three-year average dietary energy supply (adequacy	**Water stress:** Key variable of interest which can affect nourishment levels through changes to the agricultural sector, with knock-on implications for access to food **Real GDP per capita:** Acts as a proxy for the economic welfare of the population and the ability to afford sufficient nutritional intake **Political stability:** Acts as a proxy for institutional quality, which can affect agricultural production and nutritional intake **Rural population share:** Acts as a proxy for the economic welfare of the population and the ability to access and afford sufficient nutritional intake	FAO, EIU
5	Female enrolment	**Water stress:** Key variable of interest, which can affect female enrolment in schools (through a number of channels (discussed in report **Personal disposable income (relative to GDP):** Acts as a proxy for economic welfare, which can affect decisions to enrol children, particularly girls, in education **Control of corruption:** Acts as a proxy for institutional quality, which can affect the enforcement of education policies **Unemployment rate:** Acts as a proxy for economic welfare, which can affect decisions to enrol children in education	WHO, UNICEF, EIU
6	Infant mortality	**Water stress:** Key variable of interest, which can affect infant mortality through a (number of channels (discussed in report **Real gross fixed investment per capita:** Reflects investment in infrastructure, sanitation, etc, with implications for health and mortality **Regulatory quality:** Acts as a proxy for institutional quality, which can affect enforcement of health policies **Proportion of population using safely managed sanitation services:** Can affect infant health with direct implications for mortality rates	WHO, UNICEF, EIU

Within each scenario, water-stress levels were determined by a number of assumptions with regards to economic and social development. We considered the upper and lower ends of these assumptions to provide a full range of the potential levels of water stress expected in each scenario. Yoon et al use the following assumptions to derive these upper- and lower-end estimates:

- **Lower-end water stress (optimistic case):** The optimistic case for each scenario assumes a moderate degree of climate change, high levels of transboundary flows, moderate socio-economic growth and stable crop prices.
- **Upper-end water stress (worst case):** The worst case assumes adverse climate change, low levels of transboundary flows, high levels of population growth, growth in the refugee population and increasing crop prices.

The diagram below indicates how expected levels of water stress vary between the upper- and lower-end estimates under each of the hypothetical scenarios.

Figure: Evolution of water supply in Jordan under hypothetical scenarios, 2020-2100 (cubic meters/capita/year)



Source: Adapted from Yoon et al (2021)

Using the Yoon et al scenarios on water stress in Jordan, we estimated an average annual change in water-stress levels. This was combined with the findings from the regression analysis to estimate levels of change in each indicator corresponding to each scenario.

The baseline forecasts for each variable were then compared to these alternative scenarios, in which all variables remain the same with the exception of water-stress levels, which are lower than in the baseline. The difference in outcomes between the baseline and scenario forecasts provided an estimate of the impact of changes in water-stress levels in Jordan.

Model limitations

Empirical approaches to testing the relationships between different variables based on observational data face a number of limitations and challenges. Such models rely on simplifying assumptions, which has implications for the estimated relationships. The results of the modelling analysis presented in this report should therefore be treated with caution, as indicative of the potential impacts associated with water stress.

A key limitation of the regression models used in this analysis is the lack of data. The robustness of the findings is limited by the availability and quality of data. The preferred approach to the modelling exercise would be to assess the specific implications of changes in water scarcity in Jordan. However, this assessment would require high frequency, long time-series data, which is not readily available. As the next best alternative, therefore, the model assesses the implications of changes in water scarcity across a range of countries and then applies the average findings to Jordan.

Poor availability of historical data hinders scaling down the larger model to fit Jordan's needs as we lose out on degrees of freedom due to the low number of observations. Furthermore, given the limited availability of historic data, the models built for this analysis are not able to comprehensively assess effects of small variations in water scarcity, which may take time to feed through into socio-economic variables, such as output impacts or impacts on health and education. As a result, the significance of the models and the probability with which they identify a true relationship between water stress and the variables tested is lower than would be desired.

As a result of these limitations to the modelling exercise, the findings from the analysis should not by any means be seen as evidence of a causal link between water stress and socio-economic outcomes. Instead, the findings should be treated as purely indicative of the potential impacts associated with changes in water-stress levels. The collection and availability of more frequent data on water withdrawals and availability would enable more granular analysis of this topic in the future.

Appendix: Workshop Attendees

Table: List of participants at the UNICEF / E consultation roundtable in Amman, April 2022

Abdulrahmad Sultan	Ecopeace Middle East
Abeer Alassaf	Water authority of Jordan
Ahmad Al Barmawi	Ministry of Health
Alham al Shurafar	CAN
Ashraf Edabat	Ministry of Environment
Ayman Shafi	Civil Status and Passports Dept
Belal El Hanbaly	Ministry of Water and Irrigation
Cindiya Siva	Act against Hunger
Deema Abuthiab	UN-HABITAT
Elias Batbouta	Act Against Hunger
Emad Al Karablieh	University of Jordan
Emelie Karre	UNICEF
Eyad Batarseh	
Hala Abdelhadi	UNICEF
Hana'a Mhiesen	Water Authority of Jordan
Haya Taweel	Hashemite University
Haytham Shqerat	
Hazim Nazal	European Commission
Hisham Almaharmeh	Ministry of Water and Irrigation
Hussein Al Kayyali	Ministry of Water and Irrigation
Ibrahim AlKilani	Ecopeace Middle East
Jamal Abu - Ashour	Jordan University of Science and Technology - JUST
Jamal Hammad	Ministry of Health
Jose Gesti	Sanitation and Water for All
Laurene Goublet	World food Program
Lubna Hamdi	Orient

Maha Al Zubi	International Water Management Institute - IWMI
Mahmoud Abuhussein	Higher Council of Science and Technology - HEST
Majeda Al Azzeh	World Health Organisation
Manal Al Deeerani	Ministry of Water and Irrigation
Manal Shehadeh	DCA/NCA
Mohammad Altaweil	WVI
Mohammad Shakkour	World Health Organisation
Muna Al Shunnaq	Ministry of Water and Irrigation
Nadia Al Assaf	Ministry of Health
Nour Alghazo	Ministry of Environment
Noura Alshraa	Ministry of Environment
Nowar Sabeel	Ecopeace Middle East
Pierre-Yves Pitteloud	Embassy of Switzerland
Qasem Al Ayoubi	WV
Ra'ed Ghazal	Ministry of Water and Irrigation
Razan Al Roud	Ministry of Water and Irrigation
Reema Majed	Ministry of Water and Irrigation
Salam Ababneh	Ministry of Water and Irrigation
Saleh Sadeq	Action Against Hunger
Samar Taha	World Food Program
Suad Asad	Water authority of Jordan
Sufyan Batayneh	Water Authority of Jordan
Talal Judeh	Ministry of Agriculture
Zaid Al Ghazawi	Jordan University of Science Technology - JUST
Zaid Shawabkeh	Act Alliance

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UNICEF Jordan
+962 (6) 550 2400
https://www.unicef.org/jordan/contact-us