



Briefing Paper



ODI Global

Climate risks to Syria's urban water and sanitation systems

Sarah Opitz-Stapleton, Magda Nassef, Jim Jarvie, Basile Maupu-Estupina, Camille Laville, Yue Cao and Mauricio Vazquez

April 2026

Key messages

Syria already faced a significant national water deficit before the conflict, and now faces compounding pressures from damaged infrastructure, declining water supplies and rising demand driven by population return and economic recovery.

Climate change is intensifying water scarcity through higher temperatures, droughts and increasing aridity, while also degrading water quality and placing additional strain on drinking water and sanitation systems.

A shift toward integrated water resource management is critical: combining demand reduction (particularly in agriculture), infrastructure rehabilitation, water reuse and strengthened governance, alongside regional cooperation on transboundary water resources.

Without climate risk-informed, system-wide planning, Syria risks deepening water insecurity, increasing waterborne disease and contamination risks, and locking in costly maladaptive investments that undermine long-term recovery and stability.



ODI Global, 4 Millbank, London SW1P 3JA, UK

© ODI Global 2026

ISSN 0140-8682

The research for this report was completed in December 2025.

This material has been funded by the UK government; however, the views expressed do not necessarily reflect the UK government's official policies.

The designations employed and presented in this report do not imply the expression of any opinion whatsoever on the part of the authors or the UK government concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Readers are encouraged to reproduce material for their own publications, as long as they are not being sold commercially. ODI Global requests due acknowledgement and a copy of the publication. For online use, we ask readers to link to the original resource on the ODI Global website.

Views and opinions expressed in this publication are the responsibility of the author(s) and should in no way be attributed to the institutions to which they are affiliated or to ODI Global.

This work is licensed under CC BY-NC-ND 4.0.

How to cite: Opitz-Stapleton, S., Nassef, M., Jarvie, J., Maupu-Estupina, B., Laville, C., Cao, Y. and Vazquez, M. (2026) 'Climate risks to Syria's urban water and sanitation systems.' ODI Global Briefing Paper. London: ODI Global (<https://doi.org/10.61755/LWFL5905>)

Acknowledgements

About this publication

This briefing paper is published through the Pioneering a Holistic approach to Energy and Nature-based Options in MENA for Long-term stability (PHENOMENAL) programme, which is supported by the United Kingdom's Foreign, Commonwealth and Development Office (FCDO).

The authors are grateful to Mauricio Vazquez, Guy Jobbins, Christopher Kidner, Hiam Alashkar, Ruba Al Zubi and Andrew Lucas for their inputs and review of the briefs. We also thank Ruby Cowling for copyediting and Valerie Geiger for figure design and typesetting.

About the authors

Sarah Opitz-Stapleton

Sarah Opitz-Stapleton is a Senior Research Associate with the Global Risks and Resilience Programme at ODI Global

Magda Nassef

Magda Nassef is an independent consultant

Jim Jarvie

Jim Jarvie is an independent consultant

Basile Maupu-Estupina

Basile Maupu-Estupina is an independent consultant

Camille Laville

Camille Laville is a Research Fellow with the Global Risks and Resilience Programme at ODI Global

Yue Cao

Yue Cao is a Research Associate with the Global Risks and Resilience Programme at ODI Global

Mauricio Vazquez

Mauricio Vazquez is Head of Policy with the Global Risks and Resilience Programme at ODI Global

Contents

Acknowledgements / i

—

Display items / iii

—

Abbreviations and acronyms / iv

—

Major river basins and climate zones mentioned in this briefing paper / 1

—

1 Introduction / 2

—

2 Considerations and opportunities / 4

Consideration 1. Transboundary and regional cooperation / 4

Consideration 2. Governance, decentralisation and community engagement / 5

Consideration 3. Agriculture and water resource management / 6

Consideration 4. Water supply and infrastructure / 6

Consideration 5. Technical and environmental cross-cutting issues / 7

—

3 Risks to Syria's urban water and sanitation / 8

Current state of the system and rehabilitation efforts / 8

Scenarios for future urban water demand / 12

Future climate risks / 16

—

4 Suggested strategic direction and priority investments / 25

Agricultural considerations / 26

Decentralised governance approaches / 27

Negotiations on transboundary waters / 28

Increased monitoring of quantity and quality: surface, groundwater

and water delivery networks and automated weather stations / 29

—

References / 31

Display items

Boxes

Box 1 Snapshot of socio-economic conditions post-Assad / 2

Box 2 Estimating Syria's population to 2045 / 14

Box 3 Climate change projections / 16

Tables

Table 1 Estimated water demand, renewable supply and deficits in the 2000s / 9

Table 2 Climate trends 1979–2024 and impacts on urban water security / 18

Figures

Figure 1 Syria municipal water demand-growth scenarios: domestic and industrial / 15

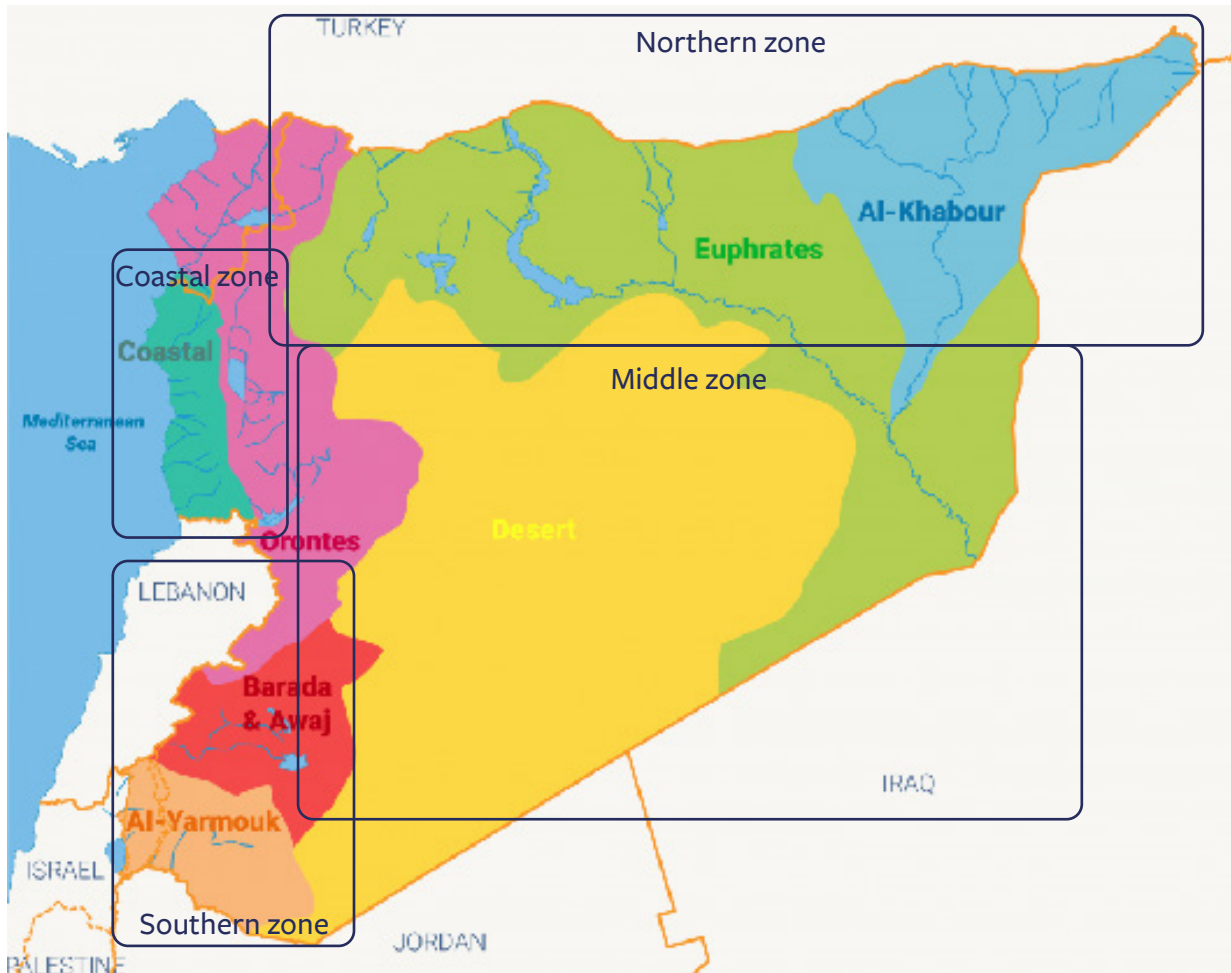
Figure 2 Projected changes in precipitation / 19

Figure 3 Projected changes in aridity / 20

Abbreviations and acronyms

BCM	billion cubic metres
ENSO	El Niño Southern Oscillation
GDP	gross domestic product
IDP	internally displaced person
PDO	Pacific Decadal Oscillation
SSPs	Shared Socioeconomic Pathways
SST	sea surface temperature
TFR	total fertility rate
Tmax	maximum temperature
Tmin	minimum temperature
WASH	water, sanitation and hygiene

Major river basins and climate zones mentioned in this briefing paper



Source: Fanack.com

1 Introduction

Prior to the conflict, Syria was already facing an annual net national water deficit of -0.7 to -3.4 billion m^3 (BCM). The Al Khabour, Orontes, and Barada and Awaj basins had the highest deficits; these are where major population centres are located or where irrigated agriculture is intensive (such as in Al Khabour). Estimates suggest that annual per-capita renewable water availability fell from over $5,500 m^3$ in 1950 (Al-Charideh and Kattaa, 2016) to approximately $808 m^3$ by 2012 (Daher, 2022). Population return, growth and economic shifts will shape domestic demand in the future, even as climate change and diversions by neighbouring countries impact supply. How Syria reconstructs its urban water and sanitation sector and manages urban and agricultural demand¹ will shape its water, food and energy security for decades to come.

Box 1 Snapshot of socioeconomic conditions post-Assad

In the decade up to 2011, agriculture, oil and gas production, a growing industrial sector with small to large enterprises, and increasing trade (including oil exports) were Syria's dominant economic sectors. Gross domestic product (GDP), driven primarily by growth in non-fossil fuel sectors, grew at an annual average of 4.3%. However, the economic growth did not translate to prosperity for all; the overall poverty rate was 33.6% and higher in rural areas, particularly in the northeast.

The conflict led to a severe economic downturn post-2011. Oil, export and foreign exchange revenues decreased significantly, while government debt for military expenditures rose. The destruction and damage of transport, electricity, water and other infrastructure; loss of key sector inputs (such as fertiliser for agriculture); and the migration and internal displacement of over half the population (some 14 million) have left Syria in a dire economic situation. International sanctions and asset freezing contributed to the economic decline. The 2023 earthquake further damaged infrastructure in Aleppo, Idlib and Latakia governorates, while the COVID-19 pandemic, regional instability, and ongoing internal pockets of conflict continue to have socioeconomic impacts. GDP in 2025 is estimated to be less than half of pre-conflict levels; inflation is high and ~90% of the population are living in poverty.

Sources: World Bank (2017); UNDP (2025).

1 This briefing paper does not extensively cover the rural water sector – that is, drinking water and sanitation for rural households and irrigation for agriculture. The rural water sector requires significant additional analysis.

This briefing paper presents key findings from a semi-quantitative climate risk assessment of Syria's key lifeline infrastructure – specifically electricity ([briefing paper 1](#)) and urban drinking water and sanitation ([briefing paper 2](#)) – to support the country's reconstruction efforts. Focusing on the reconstruction of urban drinking water and sanitation systems (WASH), the briefing paper first presents some considerations and opportunities for Syria to adapt urban WASH infrastructure to climate change. The considerations and opportunities are grounded in a snapshot of future demand considerations, plausible national socioeconomic development trajectories, and future climate risks to the sector through the 2030s (the period 2021–2050) in consideration of initial reconstruction plans.

Together with the companion briefing paper on the electricity sector, this paper will be complemented by a more detailed technical report outlining the analytical framework, data and methodologies used (including multi-model climate projections and qualitative analysis), and underlying assumptions. This brief is organised as follows:

2. Considerations and opportunities
3. Risks to Syria's urban water and sanitation
 - Current state of the system and rehabilitation efforts
 - Scenarios for future urban water demand
 - Future climate risks
4. Suggested strategic direction and priority investments

2 Considerations and opportunities

There are key elements to consider when addressing the critical water management challenges facing Syria as it emerges from conflict. These include damaged water and electricity infrastructure; unregulated groundwater extraction; declining water supplies exacerbated by climate change and upstream restrictions; soil and water contamination from conflict-related pollutants and agricultural, industrial and other pollutants; and a shortage of technical expertise. Syria's dependence on transboundary water flows from Türkiye, coupled with outdated bilateral agreements, adds complexity. A decentralisation of water management in urban settings during the conflict has created inefficient, uncoordinated systems. Rising demand from population growth and refugee returns, and increasing temperatures and drought frequency due to climate change, compound these pressures.

Complementary opportunities for more water-efficient and less polluting urban drinking water, wastewater and stormwater treatment systems – and for better management – span multiple dimensions. Regionally, Syria can re-engage with its neighbours to develop basin-wide management strategies that enhance data sharing, joint decision making, and mutual trust and resilience. Domestically, a hybrid governance model combining decentralised service delivery with strong national oversight could legitimise community-led initiatives while ensuring quality control, equitable water access, and coordination around water conservation and management.

Agriculture consumes most water supply despite damaged irrigation systems. Economic diversification, improved efficiency of irrigation practices, shifts to less water-intensive crops and enhancing water-efficient food processing could reduce demand. Infrastructure priorities in the WASH sector could include rehabilitating existing systems to reduce leaks, followed by climate change risk-informed longer-term investments in wastewater treatment, desalination, more renewable energy deployments and groundwater recharge. Addressing cross-cutting technical constraints could include measures such as surface and groundwater monitoring and a strengthened network of automated weather and hydrological stations, basin-scale climate risk assessments of the water–energy–food nexus, improved pollution control coupled with public health monitoring, and the training and recruitment of skilled professionals.

Consideration 1. Transboundary and regional cooperation

Syria relies on water flowing from Türkiye and, in turn, has upstream control over water flowing to Jordan and Iraq. Yet the Euphrates, Tigris, and Orontes basins are governed by international agreements that are a collection of outdated, bilateral agreements.

Opportunity

As Syria recovers from conflict, there is an opportunity to re-engage in dialogue with neighbouring countries to develop inclusive, basin-level integrated water management strategies

that incorporate climate and environmental risk assessment. An integrated water management approach at the basin scale could shift negotiations from a fundamental focus on volumetric flow to cooperative management of resources, strengthening regional cooperation and mutual resilience. The Regional Conference on the WEFE Nexus in February 2026, with technical follow-ups in August 2026, offers an opportunity for regional governments to engage around mutual regional climate adaptation in transboundary river and aquifer water management.

Enhanced data sharing, integrated basin planning incorporating climate and environmental risk assessment, and a strengthened monitoring network, including automated weather stations, river gauges and satellite-based groundwater monitoring, can support more informed negotiations and resource management.

Consideration 2. Governance, decentralisation and community engagement

During conflict, centralised water management gave way to various public and private controls over more localised systems, including wells, water tankers and community supplies. These are uncoordinated and inefficient, and do not provide value for money.

Opportunity

While inefficient without central coordination, regulation, and quality control, there is an opportunity to negotiate a hybrid model that combines decentralised service delivery with strong national coordination and oversight.

National oversight might include identifying, bringing together and coordinating current public and private urban water supply, so that people can make informed decisions about where to best access safe water; monitoring supply and system efficiency; harmonising costs and tariffs to ensure equitable access; licensing local water extraction and distribution networks to curtail overuse of limited supply; providing additional strategic infrastructure; and ensuring quality control.

Legitimising water user associations and creating empowered local groundwater councils working in different contexts across Syria would present a chance to develop trust, adaptive capacity, and locally co-designed solutions to problems in the water sector. An opportunity would also arise for the government to ensure that resuscitating the country's water sector emphasises coordination among ministries and other institutions, stepping away from the obstructive inter-departmental competition that existed previously.

Consideration 3. Agriculture and water resource management

Agriculture consumes most of Syria's water supply and is constrained by damaged irrigation and electricity infrastructure. Groundwater extraction is unregulated. Supply is declining due to decades of over-extraction and is likely to decline further, given the impact of climate change and restrictions on water flow upstream of Syria.

Opportunity

The government could consider economic diversification away from agriculture over coming decades, to prioritise water demand for other sectors. Policies aimed at improving agricultural practices could be considered, including incentivising irrigation conservation technologies; scaling the reuse of wastewater near urban centres (provided effective treatment is established/re-established); improving farmers' access to groundwater data and education around water supply sustainability; shifting to crops with reduced water needs; and importing water-intensive agricultural commodities.

Consideration 4. Water supply and infrastructure

Syria faces rising water demand with a growing population and the return of refugees and internally displaced people post-conflict. This rise is happening in a context of damaged and destroyed infrastructure, strained aquifers, and reduced transboundary flows. Climate change will further reduce water quality and supplies.

Opportunity

Rehabilitation of infrastructure, rather than large-scale new construction, may be the most feasible near-term strategy. Priorities include pipe leak reduction for water conservation, including real-time performance monitoring; strategic solar/hybrid-powered pumping within aquifer recharge limits; and building redundancy to increase resilience in WASH systems.

In the longer term, targeted water conservation measures could be introduced and investments in supply management could be made to complement rehabilitation. Approaches could include adapting the wastewater sector to include stormwater separation and groundwater recharge; developing wetlands for wastewater collection and treatment in urban and rural areas; shading canals with mounted solar photovoltaic panels to reduce evaporation; establishing desalination plants for coastal regions; and carrying out climate and environmental risk-informed feasibility studies of potential inter-basin transfers of water. Syria recently announced the signing of an agreement with a Saudi partnership to construct coastal desalination plants and water transmission pipelines to bring water from the coastal regions to Damascus (Levant 24, 2026). Reducing climate change risks can help safeguard reconstruction investments from debt and other financial vulnerabilities created by maladaptive decisions.

Consideration 5. Technical and environmental cross-cutting issues

Warming temperatures, droughts, and contamination risks from fertilisers, conflict-related pollutants and oil spills reduce water and soil quality. Climate change will continue to worsen some of these parameters. There is a shortage of technical experts, due to many having left during the conflict and the lack of capacity to train a new cadre of workers during the violence.

Opportunity

Syria can adapt and begin to manage constraints through measures including better wastewater treatment; regulating agricultural inputs; managing contamination from conflict-related chemicals and oil spills; upgrading pipe materials and pipe burial depths; and protecting smaller surface reservoirs and open conveyance canals from evaporation through shading by solar photovoltaic installations.

Public health risk can be mitigated through measures such as monitoring for toxic cyanobacterial blooms and eutrophication in reservoirs, lakes, and other surface waters; water quality testing at sources and at multiple points throughout municipal distribution networks; helping farmers make better choices about fertilisers; and regulating industry to control pollution.

Within the education sector, efforts could focus on training skilled professionals to design, construct, operate, and monitor water and wastewater systems across Syria's diverse contexts.

3 Risks to Syria's urban water and sanitation

Climate change, population and economic growth need to be accounted for in the reconstruction and expansion of Syria's urban drinking water and sanitation systems. Some climate change risks can be avoided or reduced by combining climate resilience measures in WASH infrastructure reconstruction and development. This section highlights these risks.

Current state of the system and rehabilitation efforts

Water demand and supply estimates

In 2010, the Syrian population was estimated at 22.5 million; following the outbreak of conflict in 2011, an estimated 6.3 million became refugees abroad and a further 7.4 million were internally displaced (World Bank, 2025). Pre-conflict, nearly 56% of the population lived in cities and ~30% in towns (UNDESA, 2025). The most densely populated cities were Damascus, Aleppo, Homs and Hama.

Water demand, including irrigation for agriculture, fluctuated prior to the conflict. Municipal demand – encompassing both domestic and industrial demand – grew and was greatest in Aleppo governorate (23% of demand), followed by Damascus (17%) and peri-urban Damascus (11%), which together constituted 50% of Syria's urban demand and highlighted the concentration of population, commerce, and industry in these governorates (JICA, 2008). Annual per-capita domestic urban demand, excluding industrial demand, in 2010 is estimated to have been 46.0–65.7 m³ (Daher, 2022; FAO Aquastat, 2025).² Pre-conflict, officially 98% of the urban population received piped water, but with regular shortages and rationing, particularly in summer (Mourad and Berndtsson, 2012). There are data limitations in the assumptions around municipal water demand and supply.

2 Excludes industrial users not connected to public supply

Table 1 Estimated water demand, renewable supply and deficits in the 2000s³

Basin	Governorates	2000s total demand	% domestic + industrial use	Estimated renewable water supply*	Estimated deficit
Al Yarmouk	Daraa; Quneitra; As-Suweyda	0.36 to 0.42	42%	0.27 to 0.58	0 to -0.08
Barada & Awaj	Damascus (including peri-urban)	1.05 to 1.34	36%	0.84 to 1.28	-0.14 to -0.21
Coastal	Latakia; Tartous	0.70 to 0.72	24%	1.17 to 4.16	0.46 to 0.62 (surplus)
Desert	Eastern Homs, parts of Hama	0.17 to 0.33	31%	0.07 to 0.37	0 to 0.05 (surplus)
Euphrates	Aleppo; Deir ez-Zor; Raqqa	7.06 to 7.68	9%	7.93 to 9.98	1.03 to 1.84 (surplus)
Al Khabour	Al Hasakha	4.23 to 4.81	3%	1.37 to 2.73	-1.79 to -2.08
Orontes	Hama; Homs; Idlib	2.22 to 2.73	20%	1.83 to 2.87	-0.3 to -0.9
Syria-wide		16.0 to 20.9	12%	14.2 to 18.1	-0.7 to -4.9

Note: * includes estimated renewable surface water, groundwater and reclaimed water from different periods. Units are in billion m³/year (BCM) for demand (irrigation, domestic and industry), supply and estimated deficit.

Over the past decades, Syria's renewable freshwater availability has declined dramatically due to irrigation, population growth and upstream diversions by Türkiye and uncoordinated diversions within Syria. Demand has fluctuated with drought conditions; groundwater pumping for irrigation and urban use accelerated during drought and further strained supplies. Historical estimated water deficit between the late 1990s and 2010 ranged from between -0.7 and -3.4 BCM per year. The multi-year drought of 2006–2010, coupled with economic restructuring measures, contributed to an estimated 40,000–60,000 of already economically stressed rural households from Al Hasakah, Deir ez-Zor, Raqqa and Aleppo governorates relocating to urban areas, which rapidly increased urban water demand and strain on WASH infrastructure (Solh, 2010; Eklund et al., 2022). Current (2025/2026) demand and supply measurements are lacking, in part due to reduced monitoring capacities and destruction of infrastructure during the conflict.

3 Bazza and Najib, 2003; Kaisi, Yasser and Mahrouseh, 2005; JICA, 2008; Mourad and Berndtsson, 2012; Fanack Water, 2025; all used various government data sources at different points in time between the late 1990s and up until the conflict. Datasets are inconsistent. We therefore present ranges from multiple datasets.

Syria's freshwater supplies comprise seven major river basins (see map on page 1) and multiple aquifers, some of which are shallow and connected with the rivers (particularly in the Orontes and Euphrates basins). Of Syria's river water, 50%–70% is transboundary; the Euphrates originates in Türkiye and supplies roughly 50% of Syria's renewable water. The Turkish Southeast Anatolia Project has led to the construction of dams on both the Euphrates and the Tigris, including the Karakaya and Ataturk dams. Despite agreements in which Syria's expected delivery was to be 210 m³/s from Türkiye – a total of 500 m³/s was agreed to be split 42% to Syria and 58% to Iraq – only 200–300 m³/s in total for both Syria and Iraq has recently been flowing from Türkiye (ESCWA, 2013; Daher, 2022).

Pre-conflict groundwater supplies were estimated at ~2.0–6.2 BCM but had been declining rapidly due to decades of over-pumping for agriculture. Beginning in the 1960s, the government instituted policies encouraging irrigated agricultural expansion for food self-sufficiency and subsidised diesel for groundwater pumps (Aw-Hassan et al., 2014). There were an estimated 229,800 wells for irrigation in 2010 and 57% of these were unlicensed (Arraf, 2016). Satellite-derived GRACE measurements indicate nationwide groundwater storage losses of approximately –6.0 to –7.15 mm/year for the period 2002–2022 (Xanke and Liesch, 2022). Some multi-country aquifer complexes have higher than national-average declines; the transboundary Tigris–Euphrates aquifer complex shows declines of –11 to –21 mm/year between 2003 and 2017 in the Syria portion (Rateb and Kuo, 2019).

The Aleppo, Raqqa and Deir ez-Zor governorates heavily rely on surface water from the Euphrates for urban supplies. Damascus and surrounds, Lattakia, Tartous, Idlib, Daraa, Quneitra, and Suweyda are highly dependent on groundwater for municipal use, while Homs, Hama, and Al Hasakah utilise both sources (Al-Charideh and Kattaa, 2016). Declines in groundwater tables have significant implications for future water security, as only 7% are renewable (in deeper aquifers underlying Lattakia, Tartous and Quneitra) and 11% are semi-renewable (in deeper aquifers underlying Homs and Damascus, and parts of Hama, Idlib, Aleppo and Daraa) (ibid.). Even where the aquifers are (semi-) renewable, over-extraction is often dropping water levels faster than recharge; for instance, the Fige Spring supplying Damascus has begun drying out during spring and summer due to intensive pumping in the catchment (Kattan, 2006; ESCWA, 2013).

Since the conflict's widespread destruction of water infrastructure and interruption of services, well owners have been prioritising selling water for domestic purposes rather than for agriculture, particularly in areas with IDP camps. Well owners described their motivations as including high demand for drinking water, higher prices for drinking water, and more guaranteed profits, given the reduced sustainability of the irrigation sector (Atik et al., 2024).

The state of urban water and sanitation services and infrastructure

Syria depended on a combined sewage and stormwater collection system, with most wastewater transferred by gravity through the sewerage network. In 2010, around 89% of the urban population were connected to sewerage networks (Daher, 2022; Fanack Water, 2025).

Sewage treatment plants, however, only served major cities (GCF, 2023) as domestic and industrial wastewater treatment were relatively new state-provided services, assigned high priority in the government's Tenth Five-Year Plan (2006–2010) (GTZ, 2010). To reach about 75% of the population, the Ministry of Housing and Construction had planned to construct between 320 and 345 wastewater treatment plants throughout the country, half of which were to be built in Rural Damascus, Lattakia and Homs governorates (Daher, 2022). The sewage network in many municipalities was constructed of concrete and was prone to deterioration, leakage and cross-contamination of the water supply. Pre-conflict assessments had recommended replacing the concrete sewerage network (JICA, 2008).

Since the conflict, WASH infrastructure across Syria has suffered extensive damage from hostilities, limited or no maintenance, an absence of technical staff, and electricity shortages. Post-conflict, two thirds of water treatment plants, half of pumping stations, one third of water towers, a quarter of sewage treatment plants, and a sixth of wells are estimated to have been damaged (UNICEF, 2022). A 2022 World Bank assessment for 14 of Syria's major cities notes that the damage to WASH facilities constitutes 3.5% of total physical infrastructure damage in Syria, equating to between \$125 million and \$380 million in costs. This, however, does not include damage to piped networks for water distribution, drainage, and sewage, because it was not possible to assess such sub-surface infrastructure through satellite observations. Estimates indicate that 50% of WASH systems do not function (or do not function properly), with over 80% of water supply systems in the northeast currently non-functional, mainly due to extensive damage to the electricity infrastructure necessary for water treatment and conveyance (ICRC, 2021; Crisis Analysis Syria, 2025).

While many urban households received piped water before the conflict, rates of water loss were between 19% and 40% due to illegal tapping of pipes, faulty water metering and logistical challenges (GTZ, 2010). Potable water has become scarce in all 14 cities surveyed by the World Bank (2022), with as little as one day's supply per week. In many places, public system water provision relies on pumps, yet unreliable electricity supplies and conflict-related damage to public wells and water towers hamper delivery. Where public infrastructure fails to meet domestic water needs, households frequently rely on water trucking and private wells (World Bank, 2022; Atik et al., 2025; Crisis Analysis Syria, 2025). By 2022, 47% of Syrians relied on often untreated alternatives to piped water, up from 37% the previous year (UNOCHA, 2022b; GCF, 2023). More than 50% of the population across the north relied on water tankers, rising to 70% for co-located IDP camps (UNOCHA, 2022b; 2022a) (the government announced the intent to have all IDP camps closed by end 2026). These percentages fluctuate from year to year.

Household reliance on water tankers is not without issue. Private water tankers are sourcing from wells and by tapping into municipal pipes, triggering further infrastructure damage and increasing water losses in the remaining system. Rising diesel prices and demand are driving up water prices – both from the remaining quasi-functioning municipal distribution networks and from tankers – and households are spending a significant portion of their incomes on water purchases. As a result,

some households have resorted to digging their own wells. Shifts from centralised networks to decentralised wells and tankers has increased rates of waterborne disease, as these may draw from untreated and polluted wells or mains, such as in parts of Aleppo (Tabor et al., 2023).

Scenarios for future urban water demand

Future urban water demand and where it is concentrated over the coming two decades is contingent upon a number of factors, including: (1) rate of refugee return and to where; (2) rate of IDP return and to where; (3) total fertility and mortality rates; (4) abilities to restore critical transport, electricity and water infrastructure; which in turn influence (5) economic recovery and diversification.

Potential urban future demand will depend on the diversification directions Syria's economy takes. As climate change and depleted groundwater resources make it difficult for water-intensive agriculture to be viable, economic shifts to a more industrial and service-based economy may be necessary and will shape municipal water demand and centres of demand. Other factors – such as how the local authority sources water, the percentage of households purchasing from private water tankers, and how many industries are connected to municipal supplies or have dug their own wells – will also influence overall municipal demand in the coming decades.

We developed several demand scenarios out to 2045 accounting for the factors above (excluding specifics on areas of return). Total municipal demand is defined here as: (1) annual quantity of water withdrawn by the public distribution network, which can include industries, plus (2) the annual quantity of self-supplied water (not connected to public distribution networks) withdrawn for industrial uses, including water for cooling of thermal plants, but not hydropower.⁴ Our primary municipal demand scenarios are as follows (see also Box 2):

- **City neutral demand-growth:** an urban population of 29.2 million by 2045, assuming demand remains similar to the historical annual average municipal per-capita demand, which between 2000 and 2022 was 102.9 m³.
- **City high demand-growth:** an urban population of 32.5 million by 2045, assuming demand remains similar to the historical annual average municipal per-capita demand, which between 2000 and 2022 was 102.9 m³.

The mean urban population projection from these two scenarios (30.8 million by 2045) was then further applied to demand scenarios conditioned by recent urban water-demand trends in neighbouring countries.⁵

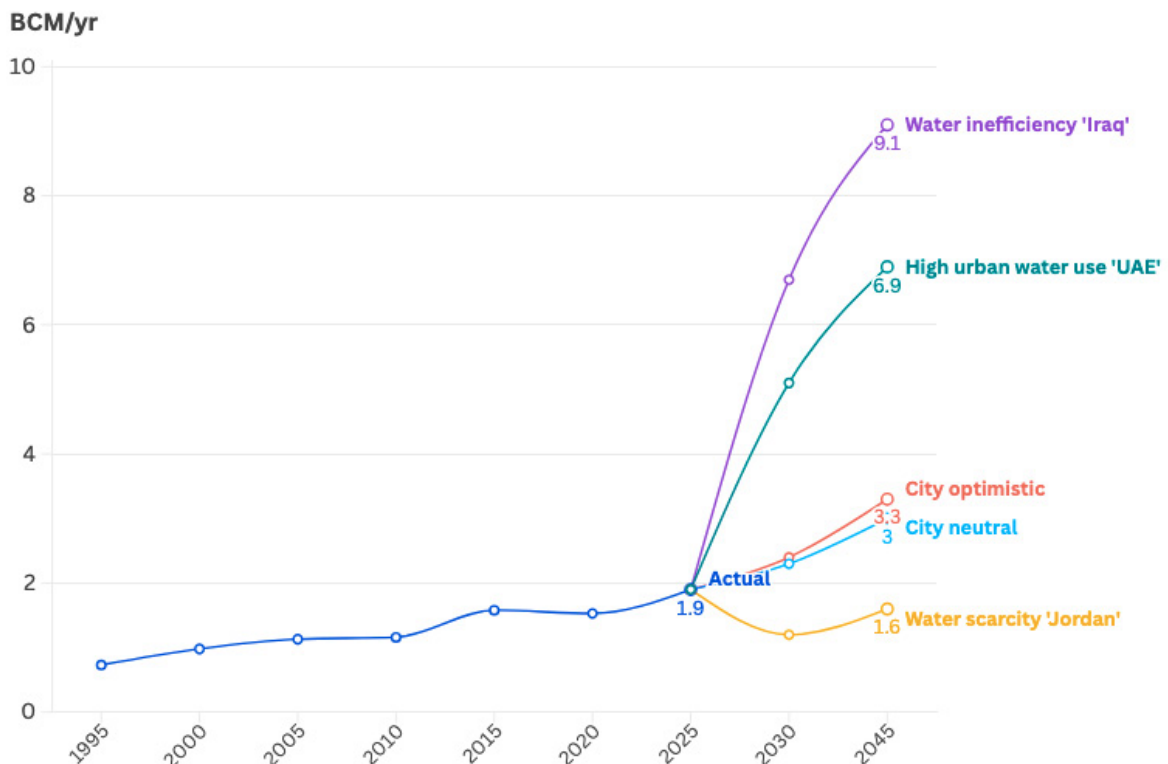
4 Adapted from FAO AQUASTAT Glossary (2020)

5 These countries face considerable supply constraints and difficulties in demand management. Syria shares similarities.

- **Water scarcity ('Jordan') scenario:** reliance on food imports (limited agriculture), high groundwater depletion and desalination for supplies – resulting in significant deficits (World Bank, 2023). Annual average per-capita municipal demand 2000–2022 was 51.3 m³.
- **High urban water use ('UAE') scenario:** significant services and industry; reliant on food imports (Alsharhan and Rizk, 2020). Desalination for some urban areas. Annual average per-capita municipal demand 2000–2022 was 224.0 m³.
- **Water inefficiency ('Iraq') scenario:** Municipal demand shaped by water inefficiencies, with few conservation and re-use measures, and water inequities (Al-Hudaib et al., 2025). Annual average per-capita municipal demand 2000–2022 was 294.6 m³.

In all scenarios (Figure 1), except for the 'Jordan' water scarcity scenario, municipal demand (including industries not connected to the piped network) increases by 2045. In scenarios 1, 2, 4 and 5, increasing municipal demand is projected to require between 17% and 64% of pre-conflict estimated renewable water supply. However, if serious supply constraints emerge, Syria could find itself in a municipal demand situation like Jordan's. A water scarcity situation would imply less available supply than the pre-conflict period.

Figure 1 Syria municipal water demand-growth scenarios: domestic and industrial



Source: authors

Basin- and national-scale coupled surface and groundwater supply-and-demand modelling, incorporating climate change projections, is necessary for developing more detailed scenarios that could better inform water management at the national and local levels. However, even without hydrological modelling, pre-conflict conditions indicated water deficits. These will be extended in the future. Without significant water savings in agriculture and municipal conservation, severe water scarcity could emerge for the country even without accounting for climate change-induced reductions in supply.

The extent of municipal demand will be shaped by restoration efforts to repair pipe networks (and reduce system losses); the reintegration of private tankers and households into the network; and economic activities. An expansion of service and industry could attract more people to urban areas, particularly if a return to agriculture remains unfeasible in some areas over the next 5–10 years. Water conservation and re-use measures will also influence demand. While municipal water demand is high in the United Arab Emirates, desalination, water reuse, tariffs and a degree of conservation have kept its demand lower than that of Iraq's municipal demand over the past two decades.

These municipal demand scenarios do not account for the potential future directions of irrigation demand, which will affect water availability for municipal supplies. Over the short term, there may be a preference to increase agricultural production to reduce food imports and return displaced rural families to their livelihoods. However, given the serious depletion of groundwater in many basins – due to decades of unregulated pumping and surface extractions within Syria, as well as groundwater pumping and extractions of transboundary countries – and increasing aridity and temperatures under climate change, a return to historical levels of water-inefficient agriculture is unlikely to be viable for the future.

The demand scenarios also do not account for how quickly the electricity generation and transmission system is restored and expanded, or the degree to which thermal power (currently reliant on a mixture of oil and natural gas-fired turbines) is offset by renewables over coming decades. Electricity supply and prices will influence water pumping and delivery prices, in turn influencing demand (and inequities in accessing water and sanitation).

Box 2 Estimating Syria's population to 2045

As of 2024, Syria's remaining population is estimated at 24.7 million, with a median Total Fertility Rate (TFR) of 2.7 children per woman. The return of over 6.2 million refugees will depend on security, and on the political and economic stability of Syria and of neighbouring countries to which many refugees fled. Of the estimated 1.5 million refugees who had returned as of March 2026, nearly 84% returned to place of origin (UNHCR, 2026).

Starting with this baseline, we developed three different scenarios of population out to 2045. TFR and mortality rate projections were extracted from UNDESA projections and combined different scenarios of refugees returning to place of origin. The pessimistic scenario assumes persistent conflict (higher mortality rates) and slow return (5% to 20% of refugees). The neutral scenario takes a stable TFR, moderate reductions in mortality rates and refugee return of 20%–40%. The optimistic scenario assumes a temporary TFR rebound (largely in urban areas) for the next five years before declining, mortality reductions, and a return of 50%–70% of refugees.

The technical report accompanying these two policy briefing papers describes the methodologies, data sources and background for the population projections, climate projections, urban water demand scenarios and water sector risks analysis.

Source: authors, derived from the accompanying Technical Report (Opitz-Stapleton et al., 2026)

Future climate risks

Risks to Syria's municipal water and sanitation security over the coming decades are estimated using the demand scenarios and climate change projections from multiple climate models.

Box 3 Climate change projections

Syria has approximately four major precipitation zones: (1) Coastal zone – governorates of Latakia and Tartus; (2) Northern zone – part of Hama governorate, Idlib, Aleppo, Raqqa and Al-Hasakah governorates; (3) Middle zone – eastern portions of Hama and Rural Damascus governorates, Damascus and Homs governorates, much of Deir ez-Zor; and (4) Southern zone – western portion of Rural Damascus, Quneitra, Daraa and Suweyda governorates. The Ministry of Agriculture uses five zones, but for the purpose of the climate modelling, we use four.

Historical climate data from gridded global datasets were analysed for trends. Climate projections from seven CMIP6 general circulation models from the IPCC 6th Assessment were bias-corrected and downscaled to find potential future changes in mean seasonal precipitation; in maximum and minimum temperature; and in temperature and precipitation extremes such as cooling degree days and heat waves. Future projections for three periods (2030s: 2021–2050, 2050s: 2041–2070 and 2070s: 2061–2090) and two climate change scenarios: SSP2–4.5 (likely given current global emission pledges) and SSP5–8.5 (a more extreme scenario, and less likely) were used for this risk assessment.

Due to lack of data and time constraints, a climate risk assessment using a coupled groundwater–surface water hydrological model was not possible for this study.

Source: authors, derived from the accompanying Technical Report (Opitz-Stapleton et al., 2026)

Climate trends and climate change projections⁶

Between 1979 and 2024, climate change has already demonstrably increased temperatures throughout Syria and is having impacts on municipal drinking water and sanitation security and hydropower (Table 2).

Temperatures are projected to increase significantly in the future due to climate change in both scenarios SSP2–4.5 and SSP5–8.5. Increases in Tmax and Tmin (maximum and minimum daily temperatures) in all seasons are likely over coming decades due to climate change. For instance, countrywide Tmax increases of 1.3°–1.9°C above the 1980–2010 historical averages are

⁶ Source: authors, derived from the accompanying Technical Report as well as Richardson et al. (2021); and SMHI and ESCWA (2021).

projected by the 2030s under SSP2–4.5; by the 2050s, Tmax increases of 1.8°–2.4°C are possible. The global greenhouse gas emissions scenario matters for the severity of climate change outcomes. Under the high-emissions scenario SSP5–8.5, increases in Tmax are more severe in the 2050s (2.5°–3.2°C) than under the lower-emissions scenario.

There is less agreement among the climate models about projected changes in winter precipitation and precipitation extremes (Figure 2). Potential decreases begin emerging around 2050 according to the multi-model projections, with the Coastal and Southern zones (particularly higher elevations) likely to experience more significant decreases than other areas under SSP5–8.5. Projected decreases under SSP2–4.5 are of a lesser magnitude than under the higher-emissions scenario. By the medium (~2041–2070) to late (~2061–2100) terms, more climate models from multiple studies agree on mean annual precipitation declines for the Coastal and Northern zones, particularly for the high-emissions scenarios of SSP5–8.5 and RCP 8.5 (SMHI and ESCWA, 2021; Hamed et al., 2022; Zittis et al., 2022; IPCC, 2023a; 2023b; Naaouf and Torma, 2023). There is less agreement on the direction and amount of change for the Middle zone of the country (higher model uncertainty) over the medium term, with some models indicating none to a potentially small increase in precipitation during the September–November season and others indicating decreases (SMHI and ESCWA, 2021; Naaouf and Torma, 2023).⁷ By the late term, most models begin to converge in agreement on decreases over most of the country.

Precipitation variability will continue to be high year-to-year and on multidecadal scales. The likelihood of multi-year meteorological droughts (precipitation deficits) and heavy winter flooding will continue to be influenced by the El Niño Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO) and other large-scale climate patterns. The climate science community is actively working to improve climate models' skill in simulating these large-scale patterns, which may assist in decreasing uncertainties in precipitation projections for Syria and globally (Ma et al., 2023; Jacobson and Seager, 2025). Atmospheric rivers, such as the one in late March 2019 that induced significant flooding, may increase in frequency and intensity under climate change (Zhang et al., 2024; Pathak et al., 2025). Additionally, rates of aridity and evapotranspiration will continue to increase due to temperature increases – thus contributing to more hydrological, agricultural and socioeconomic droughts.

Most zones of the country will experience various degrees of increasing aridity during the winter (December–February, not shown) and spring (March–May, in Figure 3). This includes the Aleppo governorate, where Lake Tabqa and the Tishreen, Al-Thawrah/Tabaqa and Freedom/Baath hydroelectric power plants are located. The frequency and intensity of

⁷ In the past few decades, a small increase in September–November precipitation over the eastern areas of the Middle zone and central areas of the Northern zone has been observed. Due to hot temperatures, the small increase has little impact on overall water availability over this desert region. Furthermore, the fall increases are offset by decreases in December–February amounts, contributing to an overall statistically significant decline in total annual precipitation.

hydrological, agricultural and socioeconomic droughts will increase with hotter temperatures and more heat waves. With increasing aridity and hotter temperatures projected not only for Syria, but for the Arabian Peninsula as a whole (Zhao et al., 2023; Abadi et al., 2025; Tamimi et al., 2025), the frequency and intensity of dust storms is likely to increase in the future.

Table 2 Climate trends 1979–2024 and impacts on urban water security

Observed climate changes	Impacts on urban water security (pre-conflict)
Maximum daily temperatures (Tmax)	
<ul style="list-style-type: none"> ● increase of 0.3°–0.4°C/decade during December–February ● increase of 0.40°–0.57°C/decade during March–May ● by the 2030s, average annual Tmax may be 1.3°–1.9°C higher than historical averages ● by the 2050s, it may be 1.8°–2.4°C warmer 	<ul style="list-style-type: none"> ● increasing water demand and higher rates of ground-water pumping ● increasing evaporation from surface water supplies (rivers, lakes and reservoirs) and shallow aquifers
Heat waves (days above 35°C)	
<ul style="list-style-type: none"> ● increasing by 4.7–8.9 days/decade; largest increases across Southern zone 	<ul style="list-style-type: none"> ● additional strain on low-efficiency thermal power plants, contributing to generation losses and load shedding which impact delivery of municipal water ● increased evaporation from surface and shallow aquifer supplies ● strain on shallow water delivery and sanitation conveyance pipe network ● strain on water pumping infrastructure
Aridity⁸	
<ul style="list-style-type: none"> ● has been worsening in the Middle and Northern zones during the March–May period ● in the future, likely to worsen across all zones during March–May and, by 2041–2070, during December–February as well 	<ul style="list-style-type: none"> ● increased water supply–demand deficit, contributing to increased extraction from semi- and non-renewable aquifers for agriculture and some municipal supply ● worsening local air pollution as households deploy diesel generators for domestic electricity needs, including for water pumping if restoration of electricity and municipal water infrastructure is slow
Variable precipitation⁹	
<ul style="list-style-type: none"> ● below-average winter rains since early 1990s, tied with cycle of the PDO and climate change ● multi-year droughts: 2006–2011 and 2020–2024, linked with moderate to strong multi-year La Niña events, PDO and climate change 	<ul style="list-style-type: none"> ● decreasing river flows in the Euphrates (also due to upstream diversions by Türkiye), Orontes, Al-Kabir al-Shamali rivers and other surface water sources ● decreased recharge to renewable groundwater resources ● increased evaporation of surface and shallow ground-water sources (due to both hotter temperatures and less winter precipitation)

Source: authors' analysis. See the technical report for details.

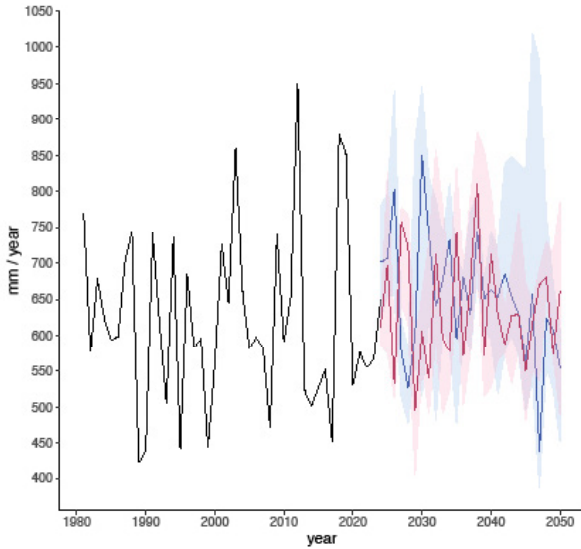
8 The De Martonne Aridity Index is an older aridity–humidity index relying only on precipitation and temperature variables. Due to data constraints, projections of changing evapotranspiration were not possible and projections of the Standardised Precipitation Evapotranspiration Index (SPEI) were not calculated.

9 Sources: Hoerling et al., 2012; ACSAD and ESCWA, 2021; Otto et al., 2023; and the authors.

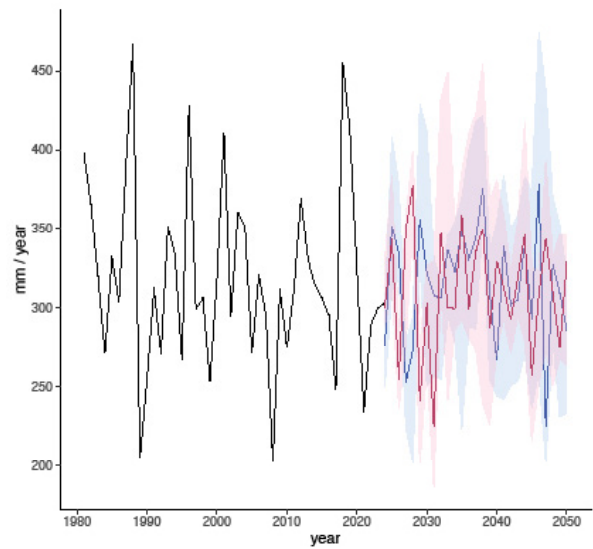
Figure 2 Projected changes in precipitation

Zone-average annual total precipitation

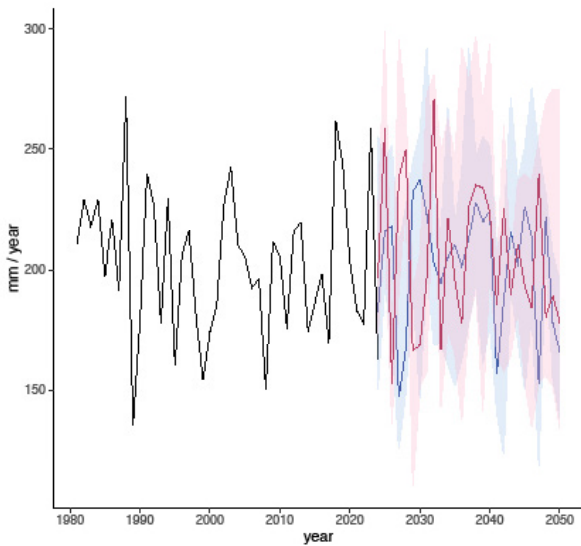
Coastal zone



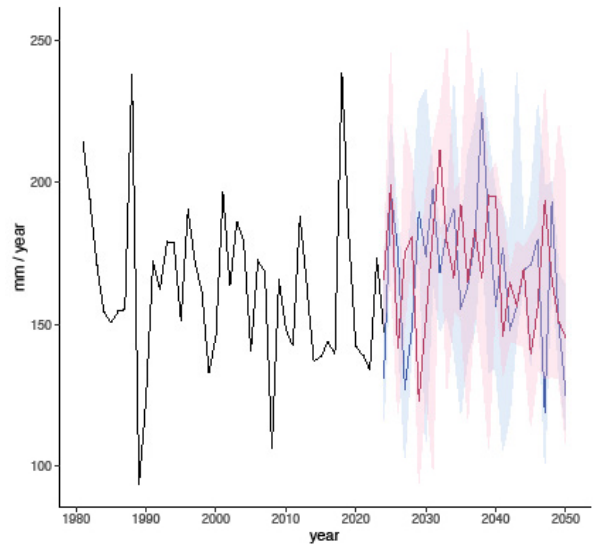
Northern zone



Southern zone

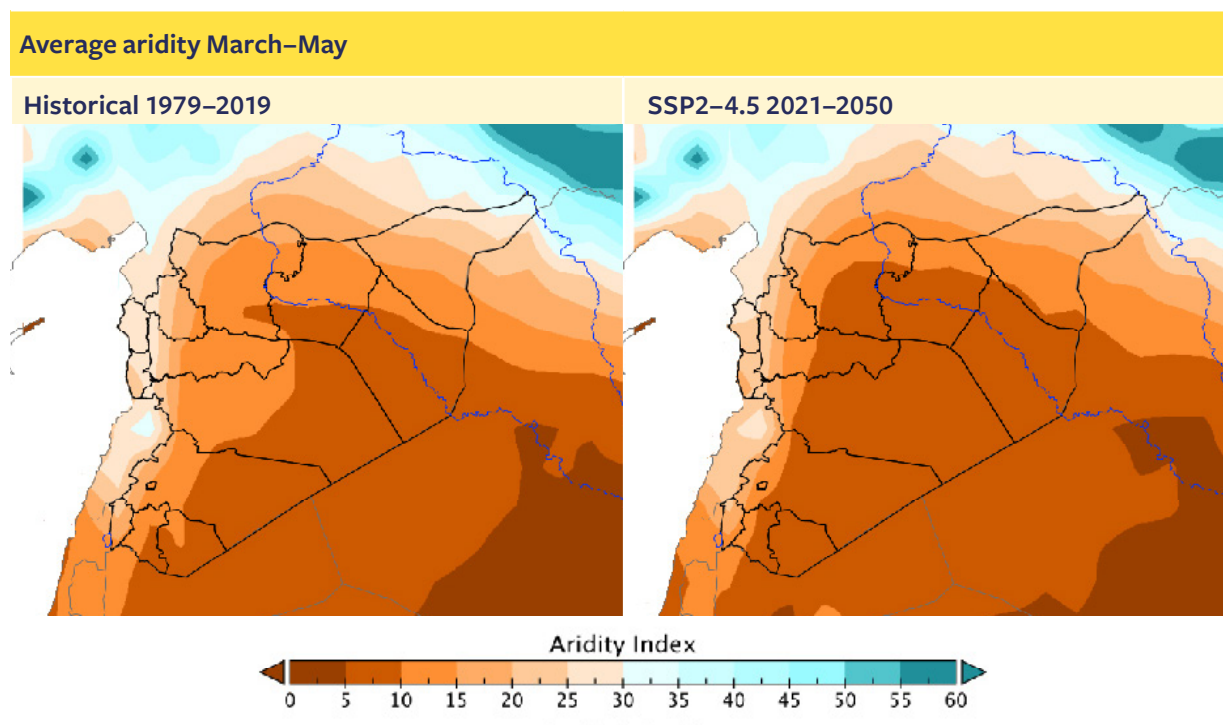


Middle zone



Note: historical (black line) 1981–2024 and multi-model projected 2025–2050: SSP2–4.5 (blue line median, blue area spread P25–P75) SSP5–8.5 (red line median, pink area spread P25–P75)

Source: authors

Figure 3 Projected changes in aridity¹⁰

Source: authors

Climate change risks

Water quality risks

Sea level rise and saltwater intrusion of coastal aquifers – municipal water sources

for Lattakia and Tartous governorates – are likely. While sea level rise projections along the Syrian and Lebanese coasts indicate possible small increases of 2–7 cm by the end of the century (Vecchio et al., 2024; Parras-Berrocal et al., 2025), the shallow aquifers in the coastal governorates are already experiencing saline intrusion. Pre-conflict well monitoring indicated saline intrusion at various points along Syrian coastal aquifers (Abou Zakhem and Hafez, 2003; Allow, 2011; Faour and Fayad, 2014). Depending on coastal slope and rates of groundwater pumping, a small increase in mean sea level will likely enhance salinity. Higher salinity brings the added risk of more rapid corrosion of drinking water and wastewater treatment infrastructure. Hotter sea surface temperatures also present water quality and water–energy infrastructure risks.

With the growing risk of dust storms in the Tigris and Euphrates basins (ESCWA, 2017) the water quality of surface supplies and shallow aquifers will be negatively impacted.

Syria has nine main lakes and between 150 and 166 dams (Bazza and Najib, 2003; Aw-Hassan

¹⁰ De Martonne Aridity Index (calculated): a value <10 is arid; 10–20 is semi-arid; 20–24 is Mediterranean; 24–28 is semi-humid. Values above 28 indicate more humid climates. By the 2030s, the areal extent affected by aridity during March–May is projected to increase for most zones.

et al., 2014; Mourad and Alshihabi, 2016; Fanack Water, 2025b). Beyond fine dust deposition and the increased sedimentation of lakes and reservoirs, what the dust storms convey also threatens water quality. The movement of soil particles that are contaminated – with agricultural, industrial, oil and gas pollution (historical and current) and chemicals from the conflict – are leading to increased pollutant loading in both surface and groundwater supplies (Al-Charideh and Hasan, 2013; Abou Zakhem and Hafez, 2015; Aldeeb et al., 2020). Nitrate pollution from fertiliser application is of particular concern in multiple irrigated areas, exceeding 50 mg/L in drinking water. The sources of such pollutants vary by area within Syria and point to the need for re-establishing water quality monitoring, prioritising environmental remediation in areas with significant conflict contamination, and gradually working to bring industrial contaminant discharge treatment procedures, wastewater treatment and agricultural capacity building online.

Hotter temperatures, heat waves and growing aridity will further concentrate pollutants in shallow groundwater and surface water supplies. Hotter temperatures in the absence of strengthened pollution discharge controls will lead to harmful algal blooms, eutrophication and bacterial overgrowth in reservoirs and open water conveyance canals due to warmer water temperatures and nutrient loading from polluted runoff (Gobler, 2020; Zhan et al., 2022; Shiwen et al., 2024). Bacterial and algal growth related to untreated sewage and industrial discharge, and irrigation, has already been noted at various points along the Tishreen Dam system supplying Lattakia, for example (Mahmoud and Khudair, 2023). Monitoring for toxic cyanobacterial blooms and eutrophication in reservoirs and lakes, open conveyance canals, and shallow groundwater to reduce risk of urban supply contamination is also necessary. Bacterial loads, turbidity and total dissolved solids also spike following heavy rainfall and flood events, which could increase in frequency due to climate change.

Over the next few decades, significant risks to Syrian soil, air and water quality that require urgent remediation include contamination from dense munitions – including potential depleted uranium from ammunitions – and chemical weapons use; and damage to oil and gas infrastructure and industrial facilities (Fares and Fares, 2018; Zwijnenburg and Shi, 2020; Gaafar, 2021; Robinson and Baade, 2021; Stall et al., 2022; Schellens et al., 2024). Oil pollution and related by-products from damaged infrastructure in the Rmeilan oil fields along the Al Khabour basin in Hasakah city, and the bombing of Homs oil refineries, for instance, are documented incidences of water contamination (Zwijnenburg and Shi, 2020; Schellens et al., 2024). Flooding, drought and extreme heat have the potential to exacerbate water and soil quality risks. Prioritising clean-up from the conflict will assist in protecting water quality.

Infrastructure risks

Temperature increases, as well as more droughts and flooding, present additional risks to Syria's damaged drinking water and wastewater treatment and conveyance infrastructure (and to electricity infrastructure, as covered in the [electricity briefing paper](#)). Within water mains, for example, increasing temperatures can facilitate the growth of biofilms, bacteriological-fungal pathogens, and precipitates of various mineral and chemical compounds.

Shallow neighbourhood delivery pipes with smaller conveyance volumes, particularly those with low water pressure, are more exposed to heating than deeper, higher flow pipes. The WHO recommends that water temperatures in pipes should not continuously exceed 25°C to avoid overgrowth of pathogens (World Health Organization, 2017). Load shedding during heat waves and/or droughts may present additional challenges to water conveyance and increase the risk of exceeding recommended temperature thresholds. Additionally, disinfectants like chlorine can degrade faster in warmer temperatures, and unhealthy levels of disinfection byproducts can form. This might require increased use of disinfectant and/or alternative disinfectant modalities to maintain residual disinfection levels at distant points throughout the distribution network.

Heat stress damage in shallow water mains and pipes to neighbourhoods is an additional risk. The rate of pipe expansion and contraction with heat is dependent on pipe and connector composition. The distribution system may simultaneously face stress due to soil compaction and deformation in drought conditions. Older cast iron mains that are still functional should be monitored over the coming decades and gradually replaced, as they become brittle with age and are more prone to leakage from repeated heat waves. Monitoring for pipe deformation and damage will be crucial for detecting leaks early and reducing water loss.

Beyond droughts, heavy flood events will continue to pose risks to drinking water and sanitation systems. Flooding may induce shifting in soils and substrates, causing pipes to move and break. It also presents the risk of drinking water and wastewater treatment plant damage and can temporarily reduce capacities to provide safe drinking water. Heavy rainfall and flooding have the potential to overwhelm Syria's remaining combined stormwater and sewage system and lead to spreading of sewage and cross-contamination of damaged drinking water pipes. System volumetric capacity increases in the joint stormwater and sewage network, along with stormwater retention areas and floodplain restoration where possible, may reduce flood damage.

Supply and demand management risks

The continued variability in winter precipitation, with the potential for multi-year droughts associated with persistent La Niña conditions and multidecadal conditions in the Pacific, along with hotter temperatures will further constrain surface and shallow groundwater supplies. Post-2050, declines in total annual rainfall are projected for most of the country. Recharge rates of renewable and semi-renewable aquifers will be reduced, and river runoff could reduce 15% or more (IPCC, 2023a; 2023b). Even as climate change constrains supplies, demand will increase due to population growth alone. Food and electricity supplies – inherently linked with water – will also have to grow with population, and demand scenarios for these will be linked with the socio-economic trajectories Syria takes between now and 2045 (and beyond). Climate-resilient, low-carbon integrated food–energy–water resource management approaches on the basin scale – including those that are transboundary – are needed to protect and conserve linked surface and groundwater supplies in a hotter and more arid future.

Evaporative losses will increase for surface supplies during a longer hot season. Syria has multiple smaller, mostly agricultural reservoirs and lakes, as well as large reservoirs such as Lake Assad. In 2005, one study estimated annual evaporative losses at Lake Assad to range from 1.9–2.2 BCM or 20%–23% of actual reservoir capacity (Kattan, 2008); temperatures are hotter than in 2005 and actual evaporative losses are likely higher. For example, in other semi-arid and arid regions, evaporative losses are estimated to equate to between 27% (Spain) and 53% (Texas) of total water demand (Martínez Alvarez et al., 2008; Zhang et al., 2017); this is between 38% and over half of total water storage capacity (Zhang et al., 2017; Aminzadeh et al., 2024). There is the risk that Lake Beyşehir in Türkiye could dry out completely due to the combination of higher evaporative losses, reduced inflows and extractions (IPCC, 2023b); Syrian lakes and dams could face a similar future. The construction of further reservoirs as supply buffers might not be desirable given increased evaporation and reduced inflows from rivers and shallow aquifers. Instead, water conservation measures to reduce domestic, industrial and irrigation demand could be given priority.

4 Suggested strategic direction and priority investments

With increasing climate constraints on already limited supplies, demand management will be of increasing importance. As Syria moves forward in its post-conflict recovery, the demand for water will continue to grow with population increases and the return of people to places of origin in Syria. Groundwater extraction, particularly to try to restore agriculture, could limit municipal water supply options over the coming decades, potentially leading to severe future water deficits. Reducing agricultural consumption through a portfolio of water conservation techniques and economic diversification could enhance municipal supply. The government has announced such objectives in its Syrian Agricultural Strategy 2026–2030 (Ministry of Agriculture, 2026). However, concurrent urban water conservation and reuse measures will also be critical.

Syria has already demonstrated leadership and innovation under extraordinary constraints, prioritising the restoration of critical networks, adapting pumping stations along the Euphrates to lower water levels, and enhancing water delivery through tankers and additional wells, as observed in Aleppo and Hama (World Bank, 2022). For example, Aleppo's local council replaced sewerage lines and delivered tanker water to areas not connected to the network. In Idlib the water administration continues to dig wells and repair water and wastewater lines in different parts of the city. Power shortages, a leading cause of drinking water conveyance failures, are being addressed through solar and hybrid energy systems in over a quarter of operational water systems in northwest Syria (UNOCHA, 2022a).

Recognising the state of the country's existing infrastructure and the challenges posed by overdrawn aquifers and uncertain transboundary flows, the current focus on rehabilitating and enhancing existing systems is both practical and sustainable. Prioritising clean-up of ordnances and chemicals from the conflict, and oil- and gas-related spills where such infrastructure was targeted, can help protect water quality. These efforts highlight the value of rehabilitation, maintenance, and strategic upgrades to adapt infrastructure to material and technical capacity limited conditions, with improving existing systems offering the potential for increased efficiency and resilience. However, targeted new investments and planning for municipal drinking, wastewater and stormwater systems expansion are needed, as rehabilitation will not be sufficient to meet future demand.

Reducing drinking water system losses is critical. Repairing leaks to reduce losses and installing monitors along pipe networks to detect leaks in real time will become of increasing importance due to likely declines in supply availability. It is likely that private water tankers will continue to operate for the next few years, providing services until households can be reconnected to municipal supplies. Without engaging the private water tankers, continued tapping into municipal

lines will increase water losses and water insecurity for all. Raqqa, Idlib, and Daraa may be cities of immediate priority, as they are the least serviced and currently most affected by conflict, social unrest and riots (World Bank, 2022).

Other measures could include separating combined wastewater networks in higher-rainfall coastal areas to enable stormwater capture as a supplementary supply source (Faour and Fayad, 2014)¹¹ and using pervious concrete for stormwater networks to reduce surface runoff and recharge groundwater during winter storms (Ferdowsi et al., 2024). Desalination plants for the coastal governorates of Lattakia and Tartous could be considered, particularly due to increasing saline intrusion into coastal aquifers. Plants that depend on mixed thermal-solar or solar generation are an option (Sawah and Slepnev, 2023). Depending on financing, later phasing could then consider inter-basin transfers from the coastal areas to municipalities in Aleppo and Idlib, for example. However, desalination and pumping for inter-basin transfers require a rehabilitated and strengthened electricity generation and transmission sector, as well as consideration of groundwater recharge and environmental flows.

When restoring piped water distribution networks, deeper burial of water mains could be considered to reduce risks of prolonged warmer water temperatures and pipe damage due to soil expansion and contraction. There are trade-offs in considering pipe depth in earthquake-prone areas in Coastal, northern and Southern governorates. Pipes branching from the mains might be replaced with plastic (e.g. PVC), which is more flexible under higher rates of soil stress/strain, but which cannot handle high water pressures. Deeper burial of mains and branches can also reduce the risk of damage during flood events and potentially reduce the incidences of tapping into lines that create significant leaks and water losses.

Increasing infrastructure resiliency against climate extremes, such as heavy flooding or drought, also should be considered. Measures could include ensuring redundancy in the WASH sector to enable quick replacement when one facility is down (Salimi and Al-Ghamdi, 2020). Other options include low-cost, nature-based solutions, such as constructed wetlands for wastewater disposal and treatment, which can complement other investments in rural areas and small towns (JICA, 2008).

Agricultural considerations

In agriculture – by far the largest user of water – documented practices are also converging toward restraint on withdrawals. Given damage to infrastructure, significant shifts towards rainfed agriculture were observed during the conflict years (Daher, 2022) including the diversion of irrigation water to drinking supply. In Raqqa, for example, the local irrigation office reduced irrigation deliveries from the Balikh Canal in 2021 to secure drinking water reserves (Crisis Analysis Syria, 2025). Farmers have also increasingly shifted, where possible, to drip irrigation to

¹¹ This should, however, be done with an eye to using the stormwater for groundwater recharge.

conserve water (ibid.), while wastewater reuse – while only a small fraction of water supply – was already in place prior to the conflict (Mourad and Berndtsson, 2012).

Providing subsidies and encouraging markets for water conservation and agro-ecological techniques and technologies, coupled with integrated water management training through agricultural extension and farmer cooperatives, could also enhance more conservation in agriculture. Promotion of less water-intensive crop varieties, and assistance on updating cropping calendars and planting cycles to accommodate hotter temperatures and shifting precipitation can also reduce water use and enhance food security. The Ministry of Agriculture has announced several agricultural water management activities in its latest agricultural strategy (2026); such activities will be carried out in conjunction with the Water Resources Authority.

Installation of small, solar-powered wastewater treatment plants in underserved rural areas can provide multiple benefits including reduced effluent discharge, decreases in waterborne disease and the provision of some irrigation water. Elsewhere, solar pumping is already being adopted to reduce dependence on costly diesel generators (Crisis Analysis Syria, 2025). However, without coordinated water management, and monitoring wells to provide publicly accessible information on water table decline, this runs the risk of further increasing groundwater exploitation and accelerating depletion. Other options for reducing evaporative losses could include mulching, reduced/zero tillage, suspended covers and/or deployment of solar photovoltaics to shade canals and smaller water irrigation dams.

A policy strategy could consolidate such adaptations by continuing to promote treated wastewater reuse for irrigation near cities; to incentivise efficient irrigation and water-conservative crops; to increase farmer awareness of water table depths through open data of well monitoring; and to utilise renewable energy solutions. However, over the longer term, a transition to a lower dependency on agriculture, importation of water-intensive crops and more economic diversification might be necessary for water and food security. It is also important to work with farmers around the appropriate application of fertilisers, pesticides and other agriculture inputs (and with industries on waste deposition) to reduce contamination of surface and shallow groundwater supplies.

Adjustments in agricultural policy may also be prudent. Given anticipated declines in available water, integrating ‘virtual water’ strategies, including importing water-intensive crops and livestock while conserving domestic water, may help balance agricultural water needs with urban and industrial water demands, following models applied in other Gulf States and Middle Eastern economies (Salimi and Al-Ghamdi, 2020).

Decentralised governance approaches

Institutionally, and in the urban water sector specifically, Syria might continue to pursue what its experience during conflict has already revealed: that resilience in the sector can be supported by

diversification and decentralisation, but sustainability in supply and quality management, as well as assessment of climate and environmental risks along the food–energy–water nexus, requires central coordination and oversight. The new Ministry of Energy and Water Resources, which now houses the Directorate of Irrigation and Drainage, Drinking Water Directorate, Sanitation Directorate and Directorate of International Waters and Dams could consider integrated water management approaches, and work with local water user associations. The Ministry should also coordinate with the Ministry of Local Administration and Environment, which has the mandates for climate and environmental management functions, and the Ministry of Agriculture.

Observed shifts towards decentralisation prior to and during the conflict have highlighted the central role end users can play in water supply and management. Supporting ongoing community efforts, for instance by establishing or strengthening water user associations and local groundwater management councils, could give communities authority under state regulatory oversight (Bazza and Najib, 2003; Atik et al., 2024; 2025). Strengthening community engagement may enhance relationships between authorities and local communities, particularly in early post-conflict stages where trust building is essential.

Syria's authorities might strengthen demonstrated gains while addressing the challenges through a hybrid system: embedding neighbourhood wells, public water points, rainwater harvesting, and small-scale treatment within a nationally regulated framework for licensing, quality control, and monitoring and data sharing. Important steps toward improving and protecting water quality for the future could include gradually phasing in farmer training around agricultural inputs to reduce their use, and greater controls over industrial (including oil and gas) waste discharges and handling.

Negotiations on transboundary waters

Syria's shared water basins – including the Euphrates, Tigris, and Orontes – call for a holistic, basin-wide and transboundary approach to Syria's recovery strategy, as upstream decisions in shared basins determine downstream survival. Existing agreements remain bilateral and do not involve all riparian countries. They focus on surface water while overlooking groundwater and baseflow contributions, leaving regional aquifers effectively ungoverned. The overall ecosystems are ignored. The urgency of addressing this challenge is heightened by climate change, with medium- to long-term effects intensifying water scarcity and variability. Embracing regional cooperative water sharing – including, for example, joint decision making on flow timing management during drought – alongside improved demand management by all riparian countries offers greater benefits than a continued emphasis on volumetric allocations alone.

The current state of affairs calls for negotiations that move beyond discussion of volumetric allocations and towards a form of cooperative and holistic integrated basin management that emphasises water demand, quality, and climate and environmental risk management. As Syria's

authorities become established in their national role, a good moment presents itself to turn a new page on international negotiations.

Increased monitoring of quantity and quality: surface, groundwater and water delivery networks and automated weather stations

Enhanced surface, groundwater and drinking water and wastewater conveyance monitoring is a key enabler for informed decision making and negotiation. Continued monitoring of water quality and quantity are necessary for the country to plan for a future with a higher population, warmer temperatures and more aridity, and different economic trajectories. (Re-)installation and expansion of the number of monitoring wells, river gauges, automated weather stations and pressure monitors throughout piped networks should be prioritised.

Given the difficulties of in-situ groundwater measurements, particularly as insecurity continues to remain a factor, the satellite-based groundwater monitoring datasets from GRACE-FO and its planned 2028 successor GRACE-C can play a role in monitoring groundwater storage changes and deficits. Satellite data is reliable but needs to be calibrated with in-situ measurements, which might be taken through drone surveys.

Climate risk assessments for linked water and electricity infrastructure need to consider growing populations, and economic, natural resource and basic services demands, as well as typical inclusions of shifting climate hazards and climate financing appetites.

During the reconstruction and expansion of critical infrastructure – including irrigation schemes, reservoirs, municipal drinking water and wastewater systems, and energy infrastructure – Syria needs to anticipate and account for population growth and mobility, shifting economic demand, and cross-border natural resource management implications well into the 2050s. A focus on water security to realise socioeconomic recovery and development must account for climate change. In some locations, certain types of infrastructure, including large-scale irrigation schemes to promote water-intensive crops, may not be viable by the late 2030s due to climate change and might not be prioritised for reconstruction.

Climate risk assessment should be included within a Social and Environmental Impact Assessment (SEIA) framework, and this requires using projections from multiple climate models to inform reconstruction efforts. Updated basin-scale coupled groundwater–surface hydrologic models (ideally transboundary models) utilising multi-model climate change projections should be used to guide the expansion of water infrastructure and to balance anticipated agricultural and urban demands against supply constraints. An open-source coupled ground- and surface water model such as GSFLOW or SWAT-MODFLOW, in combination with crop-water models such as AquaCrop-OS, can assist in water management decision making across the food–water–energy nexus. The climate projections and these models will then be ideally updated every five to seven years as climate modelling experiments evolve for the IPCC Assessments, the government

plans new socioeconomic objectives and scenarios, and the effects of population growth and economic diversification become more visible.

However, climate risk assessment needs to be extended beyond specific infrastructure and be conducted both at the basin scale and with a climate risk-management lens within urban planning. Whether urbanisation brings more risks than opportunities for Syria will depend heavily on how it manages urban growth, land-use planning, building codes, transportation, and the provision of water, sanitation, electricity, healthcare and education services. As these cities grow, there is the potential to lock in climate risks and maladaptation, particularly in water, sanitation, transportation, energy and building infrastructure.

Finally, how to finance infrastructure repairs, and/or total loss in the event of more extreme climate events, must be a key consideration of infrastructure feasibility studies. Unless climate risk assessment is a fundamental part of feasibility and SEIA, and of the construction and maintenance of infrastructure, the risks of stranded assets, debt default, maladaptation and further environmental and supply degradation may be high. The companion briefing paper on climate risks to Syria's electricity system provides further discussion on finance-climate risks and stranded assets. A similar analysis of financial-climate risks to water infrastructure is also urged.

References

- Abadi, A.R.S., Hamzeh, N.H., Kaskaoutis, D.G. et al.** (2025) 'Future projections of dust storm dynamics and sources in the Middle East: insights from CMIP6 models' *Atmospheric Pollution Research* [Preprint] (<https://doi.org/10.1016/j.apr.2025.102775>).
- Abou Zakhem, B. and Hafez, R.** (2003) *Environmental isotope study of seawater intrusion in the coastal aquifer (Syria)*. AECS-G\FRSR 285. Damascus: Syrian Arab Republic Atomic Energy Commission, pp. 1329–1339 (<http://link.springer.com/10.1007/s00254-006-0431-x>).
- Abou Zakhem, B. and Hafez, R.** (2015) 'Hydrochemical, isotopic and statistical characteristics of groundwater nitrate pollution in Damascus Oasis (Syria)' *Environmental Earth Sciences* 74(4): 2781–2797 (<https://doi.org/10.1007/s12665-015-4258-1>).
- ACSAD and ESCWA** (2021) *Impact of climate change on shared water resources in the Euphrates basin*. RICCAR Technical Report E/ESCWA/CL1.CCS/2021/RICCAR/TechnicalReport.11. Beirut, Lebanon.
- Al-Charideh, A. and Hasan, A.** (2013) 'Use of isotopic tracers to characterize the interaction of water components and nitrate contamination in the arid Rasafeh area (Syria)' *Environmental Earth Sciences* 70(1): 71–82 (<https://doi.org/10.1007/s12665-012-2104-2>).
- Al-Charideh, A. and Kattaa, B.** (2016) 'Isotope hydrology of deep groundwater in Syria: renewable and non-renewable groundwater and paleoclimate impact' *Hydrogeology Journal* 24(1): 79–98 (<https://doi.org/10.1007/s10040-015-1324-4>).
- Aldeeb, S., Abdallah, I. and Mohammad, A.** (2020) 'The pollution of groundwater with nitrogen fertilizers in Al-Mazraa, Homs, Syria' *Association of Arab Universities Journal of Engineering Sciences* 27(4): 121–130 (<https://jaaru.org/index.php/auisseng/article/view/450>).
- Al-Hudaib, H., Adamo, N., Bene, K. et al.** (2025) 'Application of decision support systems to water management: the case of Iraq' *Water* 17(12): 1748 (<https://doi.org/10.3390/w17121748>).
- Allow, K.A.** (2011) 'Seawater intrusion in Syrian coastal aquifers, past, present and future, case study' *Arabian Journal of Geosciences* 4(3–4): 645–653 (<https://doi.org/10.1007/s12517-010-0261-8>).
- Alsharhan, A. and Rizk, Z.** (2020) 'Water resources and water demands in the UAE' in *Water resources and integrated management of the United Arab Emirates*. Cham: Springer Nature (World Water Resources) (https://doi.org/10.1007/978-3-030-31684-6_27).
- Aminzadeh, M., Friedrich, N., Narayanaswamy, S. et al.** (2024) 'Evaporation loss from small agricultural reservoirs in a warming climate: an overlooked component of water accounting' *Earth's Future* 12(1): e2023EF004050 (<https://doi.org/10.1029/2023EF004050>).
- Arraf, F.** (2016) 'The agricultural sector and its impact on Syria's water basins between 1980–2010' *European Journal of Geography* 7(3): 25–40 (<https://www.eurogeojournal.eu/index.php/egj/article/view/387>).
- Atik, O., Kadour, A., Mahmoud, I. et al.** (2024) 'Irrigation water in northwest Syria: impact of the recent crisis and drought' *Water* 16(21): 3101 (<https://doi.org/10.3390/w16213101>).
- Atik, O., Alkaddour, A., Mahmoud, I. et al.** (2025) 'Potable water under pressure: effects of the Syrian crisis and recent drought on northwest Syria' *Journal of Water Resource and Protection* 17(01): 1–13 (<https://doi.org/10.4236/jwarp.2025.171001>).

- Aw-Hassan, A., Rida, F., Telleria, R. and Bruggeman, A.** (2014) 'The impact of food and agricultural policies on groundwater use in Syria' *Journal of Hydrology* 513: 204–215 (<https://doi.org/10.1016/j.jhydrol.2014.03.043>).
- Bazza, M. and Najib, R.** (2003) 'Towards improved water demand management in agriculture in the Syrian Arab Republic' in *First National Symposium on Management and Rationalization of Water Resources Use in Agriculture*. Damascus: FAO.
- Crisis Analysis Syria** (2025) 'Ebb and flow: water insecurity and its cascading impacts in northeast Syria'.
- Daher, J.** (2022) *Water scarcity, mismanagement and pollution in Syria*. EUI Middle East Directions.
- Eklund, L., Theisen, O.M., Baumann, M. et al.** (2022) 'Societal drought vulnerability and the Syrian climate–conflict nexus are better explained by agriculture than meteorology' *Communications Earth & Environment* 3(1): 85 (<https://doi.org/10.1038/s43247-022-00405-w>).
- ESCWA** (2013) *Inventory of shared water resources in Western Asia*. GENERAL E/ESCWA/SDPD/2013/Inventory. Beirut, Lebanon.
- ESCWA** (2017) *Arab climate change assessment report: main report*. E/ESCWA/SDPD/2017/RICCAR/Report. Beirut, Lebanon.
- Fanack Water** (2025) *Water use in Syria* (<https://water.fanack.com/syria/water-use/>).
- Fanack Water** (2026) *Water resources in Syria* (<https://water.fanack.com/syria/water-resources/>).
- Faour, G. and Fayad, A.** (2014) 'Water environment in the coastal basins of Syria – assessing the impacts of the war' *Environmental Processes* 1(4): 533–552 (<https://doi.org/10.1007/s40710-014-0043-5>).
- Fares, J. and Fares, Y.** (2018) 'Cluster munitions: military use and civilian health hazards' *Bulletin of the World Health Organization* 96(8): 584–585 (<https://doi.org/10.2471/BLT.17.202481>).
- Ferdowsi, A., Piadeh, F., Behzadian, K. et al.** (2024) 'Urban water infrastructure: a critical review on climate change impacts and adaptation strategies' *Urban Climate* 58: 102132 (<https://doi.org/10.1016/j.uclim.2024.102132>).
- Gaafar, R.** (2021) The environmental impact of Syria's conflict: a preliminary survey of issues. *Arab Reform Initiative* (<https://www.arab-reform.net/publication/the-environmental-impact-of-syrias-conflict-a-preliminary-survey-of-issues/>).
- GCF** (2023) *Strengthening the capacity of the water, sanitation and hygiene (WASH) sector to assess and address the impacts of climate change on the provision of water and sanitation services and to build the project pipeline for water and sanitation projects in the Syrian Arab Republic*. Readiness Proposal. Green Climate Fund (<https://www.greenclimate.fund/sites/default/files/document/syria-unicef-readinessproposal-cover.pdf>).
- Gobler, C.J.** (2020) 'Climate change and harmful algal blooms: insights and perspectives' *Harmful Algae* 91: 101731 (<https://doi.org/10.1016/j.hal.2019.101731>).
- GTZ** (2010) *Managing water for sustainable development. Modernisation of the Syrian water sector* (https://www.nationsonline.org/pdf_files/Syria-Managing-Water-for-Sustainable-Development.pdf).
- Hamed, M.M., Nashwan, M.S., Shiru, M.S. and Shahid, S.** (2022) 'Comparison between CMIP5 and CMIP6 models over MENA region using historical simulations and future projections' *Sustainability* 14(16): 10375 (<https://doi.org/10.3390/su141610375>).

- Hoerling, M., Eischeid, J., Perlwitz, J. et al.** (2012) 'On the increased frequency of Mediterranean drought' *Journal of Climate* 25(6): 2146–2161 (<https://doi.org/10.1175/JCLI-D-11-00296.1>).
- ICRC** (2021) 'Syria water crisis: up to 40% less drinking water after 10 years of war'. Article, 10 January (<https://www.icrc.org/en/document/syria-water-crisis-after-10-years-war>).
- IPCC** (2023a) *Climate change 2021 – the physical science basis: Working Group I contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press (<https://doi.org/10.1017/9781009157896>).
- IPCC** (2023b) *Climate change 2022 – impacts, adaptation and vulnerability: Working Group II contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press (<https://doi.org/10.1017/9781009325844>).
- Jacobson, T.W.-P. and Seager, R.** (2025) 'Pacific decadal variability and its hydroclimate teleconnections in CMIP6 models' *Journal of Climate* 38: 5103–5127 (<https://doi.org/10.1175/JCLI-D-24-0616.1>).
- JICA** (2008) *The study on urban planning for sustainable development of Damascus metropolitan area in the Syrian Arab Republic*.
- Kaisi, A., Yasser, M. and Mahrouseh, Y.** (2005) 'Irrigation system performance: Syrian country report' in Lamaddalena et al. (eds) *Irrigation systems performance*. Bari: CIHEAM, pp. 179–192.
- Kattan, Z.** (2006) 'Characterization of surface water and groundwater in the Damascus Ghatta basin: hydrochemical and environmental isotopes approaches' *Environmental Geology* 51(2): 173–201 (<https://doi.org/10.1007/s00254-006-0316-z>).
- Kattan, Z.** (2008) 'Estimation of evaporation and irrigation return flow in arid zones using stable isotope ratios and chloride mass-balance analysis: case of the Euphrates River, Syria' *Journal of Arid Environments* 72(5): 730–747 (<https://doi.org/10.1016/j.jaridenv.2007.10.011>).
- Levant 24** (2026) 'Syria launches strategic plan to confront water scarcity'. Article, 9 February (<https://levant24.com/news/2026/02/syria-launches-strategic-plan-to-confront-water-scarcity/>).
- Ma, Y., Yuan, N., Dong, T. and Dong, W.** (2023) 'On the Pacific Decadal Oscillation simulations in CMIP6 models: a new testbed from climate network analysis' *Asia-Pacific Journal of Atmospheric Sciences* 59(1): 17–28 (<https://doi.org/10.1007/s13143-022-00286-1>).
- Mahmoud, A. and Khudair, M.** (2023) 'Evaluation of Al Kabeer Al Shamali river's water suitability for drinking, based on modelling and pseudomonas aeruginosa detection, Syria' *Journal of Life Science and Applied Research* 4(1): 9–29.
- Martínez Alvarez, V., González-Real, M., Baille, A., et al.** (2008) 'Regional assessment of evaporation from agricultural irrigation reservoirs in a semiarid climate' *Agricultural Water Management* 95(9): 1056–1066 (<https://doi.org/10.1016/j.agwat.2008.04.003>).
- Ministry of Agriculture** (2026) *The Syrian Agricultural Strategy 2026–2030*. Damascus: Government of Syria.
- Mourad, K.A. and Alshihabi, O.** (2016) 'Assessment of future Syrian water resources supply and demand by the WEAP model' *Hydrological Sciences Journal* 61(2): 393–401 (<https://doi.org/10.1080/02626667.2014.999779>).
- Mourad, K.A. and Berndtsson, R.** (2012) 'Water status in the Syrian water basins' *Open Journal of Modern Hydrology* 2(1): 15–20 (<https://doi.org/10.4236/ojmh.2012.21003>).

- Naaouf, N. and Torma, C.Z.** (2023) 'Climate of Syria based on Cordex simulations: present and future' *Earth Systems and Environment* 7(3): 679–697 (<https://doi.org/10.1007/s41748-023-00351-3>).
- Opitz-Stapleton, S., Nassef, M., Laville, C. et al.** (2026) *Background analysis to climate risks to Syria's electricity and urban water sectors*. ODI Global Technical Paper. London: ODI Global.
- Otto, F.E.L., Clarke, B., Rahimi, M. et al.** (2023) *Human-induced climate change compounded by socio-economic water stressors increased severity of drought in Syria, Iraq and Iran*. *World Weather Attribution* (<https://doi.org/10.25561/107370>).
- Parras-Berrocal, I.M., Waldman, R., Gonzalez, N.M. et al.** (2025) 'Regionalized Mediterranean relative sea level projections under high-emission regional climate scenarios' *Environmental Research Letters* 20(11): 114068 (<https://doi.org/10.1088/1748-9326/ae15a5>).
- Pathak, R., Dasari, H.P., Ashok, K. and Hoteit, I.** (2025) 'Dynamics of intensification of extreme precipitation events over the Arabian Peninsula derived from CMIP6 simulations' *MPI Climate and Atmospheric Science* 8(1): 126 (<https://doi.org/10.1038/s41612-025-01016-w>).
- Rateb, A. and Kuo, C.-Y.** (2019) 'Quantifying vertical deformation in the Tigris–Euphrates basin due to the groundwater abstraction: insights from GRACE and Sentinel-1 satellites' *Water* 11(8): 1658 (<https://doi.org/10.3390/w11081658>).
- Richardson, K., Doherty, A., Osborne, R. et al.** (2021) *Climate risk report for the Middle East and North Africa (MENA) region*. Met Office, ODI Global, FCDO.
- Robinson, J. and Baade, C.** (2021) 'Measuring explosive munitions use with open-source data: a new tool for enhancing humanitarian mine action' *The Journal of Conventional Weapons Destruction* 25(1) (<https://commons.lib.jmu.edu/cisr-journal/vol25/iss1/24>).
- Salimi, M. and Al-Ghamdi, S.G.** (2020) 'Climate change impacts on critical urban infrastructure and urban resiliency strategies for the Middle East' *Sustainable Cities and Society* 54: 101948 (<https://doi.org/10.1016/j.scs.2019.101948>).
- Sawah, M.M. and Slepnev, P.** (2023) 'Challenges and development perspectives of water supply system in Syrian governorates' *E3S Web of Conferences* 460: 08016 (<https://doi.org/10.1051/e3sconf/202346008016>).
- Schellens, M., Ozdemir, A., Greenwood, M. et al.** (2024) *Thirst for peace: war and water security challenges along the Orontes river in Syria*. Utrecht: PAX.
- Shiwen, H., Yunlin, Z., Na, L. et al.** (2024) 'Summer heatwaves promote harmful algal blooms in the Fuchunjiang Reservoir, an important drinking water source' *Journal of Environmental Management* 359 (<https://doi.org/10.1016/j.jenvman.2024.121056>).
- SMHI and ESCWA** (2021) *Future climate projections for the Mashreq region: summary outcomes*. RICCAR Technical Report. E/ESCWA/CL1.CCS/2021/RICCAR/TECHNICAL REPORT.7/REV.1. Beirut, Lebanon.
- Solh, M.** (2010) 'Tackling the drought in Syria'. *Nature Middle East*, 27 September (<https://doi.org/10.1038/nmiddleeast.2010.206>).
- Stall, H., Hudson, J., Leendertse, E. et al.** (2022) 'Mapping unexploded ordnance in Syria: harnessing the power of open-source information' *The Journal of Conventional Weapons Destruction* 26(1) (<https://commons.lib.jmu.edu/cisr-journal/vol26/iss1/10>).

- Tabor, R., Almhawish, N., Aladhan, I. et al.** (2023) 'Disruption to water supply and waterborne communicable diseases in northeast Syria: a spatiotemporal analysis' *Conflict and Health* 17(1): 4 (<https://doi.org/10.1186/s13031-023-00502-3>).
- Tamimi, M.F., Abanumay, F.A., Hamad, A.G. et al.** (2025) 'Probabilistic modeling of sandstorm frequency and socioeconomic impacts in arid environments under a high-emission warming scenario' *Results in Engineering* 28: 107313 (<https://doi.org/10.1016/j.rineng.2025.107313>).
- UNDESA** (2025) 'World Urbanization Prospects 2025. Country profiles: Syrian Arab Republic' (<https://population.un.org/wup/countryprofiles?country=Syrian%20Arab%20Republic&mainCategory=Countries%20and%20Aggregates&subCategory=Urbanization%20-%20International%20definition>)
- UNHCR** (2026) Comprehensive Overview of Refugee Returns Dashboard: Syrian Arab Republic (as of 19 March 2026). UNHCR
- UNDP** (2025) *The impact of the conflict in Syria: a devastated economy, pervasive poverty and challenging road ahead to social and economic recovery*. UNDP Report (<https://reliefweb.int/node/4134554>).
- UNICEF** (2022) *Whole of Syria water, sanitation and hygiene (WASH) response*. UNICEF.
- UNOCHA** (2022a) *Critical response and funding requirements: response to the water crisis in Syria*. UNOCHA Report (www.unocha.org/publications/report/syrian-arab-republic/critical-response-and-funding-requirements-response-water-crisis-syria-august-2022).
- UNOCHA** (2022b) Humanitarian needs overview Syria. UNOCHA Report (www.unocha.org/publications/report/syrian-arab-republic/2022-humanitarian-needs-overview-syrian-arab-republic-february-2022).
- Vecchio, A., Anzidei, M. and Serpelloni, E.** (2024) 'Sea level rise projections up to 2150 in the northern Mediterranean coasts' *Environmental Research Letters* 19(1): 014050 (<https://doi.org/10.1088/1748-9326/ad127e>).
- World Bank** (2017) *The toll of war. The economic and social consequences of the conflict in Syria*. Washington, DC: World Bank Group (<https://www.worldbank.org/en/country/syria/publication/the-toll-of-war-the-economic-and-social-consequences-of-the-conflict-in-syria>).
- World Bank** (2022) *Syria Joint Damage Assessment of selected cities*. Washington DC: World Bank Group.
- World Bank** (2023) *Jordan water sector efficiency project* (<http://documents.worldbank.org/curated/en/099051523092517483>).
- World Bank** (2025) 'Syrian Arab Republic: macro poverty outlook 2025'. Washington DC: Poverty and Economic Policy Global Departments, World Bank (<https://thedocs.worldbank.org/en/doc/65cf93926fdb3ea23b72f277fc249a72-0500042021/related/mpo-syr.pdf>).
- World Health Organization** (ed.) (2017) *Guidelines for drinking water quality*. Fourth edition incorporating the first addendum. Geneva: World Health Organization.
- Xanke, J. and Liesch, T.** (2022) 'Quantification and possible causes of declining groundwater resources in the Euro-Mediterranean region from 2003 to 2020' *Hydrogeology Journal* 30(2): 379–400 (<https://doi.org/10.1007/s10040-021-02448-3>).
- Zhan, Q., Teurlincx, S., van Herpen, F. et al.** (2022) 'Towards climate-robust water quality management: testing the efficacy of different eutrophication control measures during a heatwave in an urban canal' *Science of The Total Environment* 828: 154421 (<https://doi.org/10.1016/j.scitotenv.2022.154421>).

- Zhang, H., Gorelick, S.M., Zimba, P.V. and Zhang, X.** (2017) 'A remote sensing method for estimating regional reservoir area and evaporative loss' *Journal of Hydrology* 555: 213–227 (<https://doi.org/10.1016/j.jhydrol.2017.10.007>).
- Zhang, L., Zhao, Y., Cheng, T.F. and Lu, M.** (2024) 'Future changes in global atmospheric rivers projected by CMIP6 models' *Journal of Geophysical Research: Atmospheres* 129(3): e2023JD039359 (<https://doi.org/10.1029/2023JD039359>).
- Zhao, Y., Yue, X., Cao, Y. et al.** (2023) 'Multi-model ensemble projection of the global dust cycle by the end of 21st century using the Coupled Model Intercomparison Project version 6 data' *Atmospheric Chemistry and Physics* 23(13): 7823–7838 (<https://doi.org/10.5194/acp-23-7823-2023>).
- Zittis, G. et al.** (2022) 'Climate change and weather extremes in the Eastern Mediterranean and Middle East' *Reviews of Geophysics* 60(3) (<https://doi.org/10.1029/2021rg000762>).
- Zwijenburg, W. and Shi, Y.** (2020) *A river of death: how oil pollution is impacting health and livelihoods in conflict-affected northeast Syria*. Utrecht: PAX (<https://paxforpeace.nl/publications/a-river-of-death/>).



ODI Global

ODI Global advises leaders on driving positive change. We turn bold ideas, evidence, and broad expertise into actionable strategies for a more resilient, just and equitable future.

ODI Global

4 Millbank,
London SW1P 3JA, UK

+44 (0)20 7922 0300
info@odi.org

odi.org
www.linkedin.com/company/odi/
bsky.app/profile/odi.global
