War and Water Security Challenges
along the Orontes River in Syria

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Colofon

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Syrians for Truth and Justice (STJ) monitors, exposes, and documents human rights violations across Syria, regardless of the affiliation of the victims or perpetrators.
See also stj-sy.org/en.

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Cover photo: A view of a tent camp, located near the Orontes River, is seen after the river›s water level rose following heavy rain in Idlib, Syria on January 29, 2021, worrying residents of the camp. Credit: Muhammed Said via Anadolu Images.

Executive Summary

The Asi River, also known as the Orontes (نهر العاصي in Arabic), runs through western Syria, where it serves as a vital artery for the country's agriculture and industry. Although Syria has suffered from a water crisis even before the popular uprising in 2011, the subsequent armed conflict has had major consequences for the country's water resources and their management.

Despite this, water security issues in the Orontes Basin are less known than those of the country's other major river, the Euphrates, owing to the limited access for international media, UN support, and civil society organisations in both the regime- and rebel-held parts of the basin. This PAX water security report aims to build an evidence base of the various ways in which the conflict has degraded the availability and quality of water resources over the past decade, in combination with the intensifying effects of climate change. It thereby aims to raise awareness of how the water crisis has negatively impacted local and regional ecosystems, as well as livelihoods and overall health both in local communities and among internally displaced persons (IDPs) in the region. This report will help to better inform humanitarian policies to respond to critical water insecurity issues in Syria.

The main findings of the report concern the conflict- and climate-related causes and consequences of the decline in water quality and quantity in the basin, as well as their ensuing impacts on local demographics. Deteriorating water quality, quantity, and accessibility have led to public health crises, agricultural decline, and ecosystem degradation in the area, negatively impacting people and communities in the basin. The basin's already strained water resources are exacerbated by the effects of pollution, overuse of water sources, inadequate infrastructure, poor governance, climate change, and conflict-related damages. Communities in the basin are experiencing serious health risks as a result, including the outbreak of communicable diseases; food insecurity due to agricultural water shortages and population decline; and the destruction of precious ecosystems.

The Syrian conflict has had a large impact on industrial facilities such as fertiliser factories, oil refineries, cement and steel factories, electrical power plants, sugar factories, olive oil presses, and chemical and pharmaceutical plants. The conflict has resulted in intense environmental damage through the forced shutdown of operations at industrial facilities; the breakdown of environmental protection standards, compliance, and enforcement; the inhibiting of industrial renewal; and the uncontrolled increase in mineral extraction. Moreover, the acute and chronic exposure to toxic remnants of war, e.g. in unexploded ordnance (UXO), propellants of rockets and missiles, and the chemical components of explosives, also pose concerning public health and environmental risks. The pollution and contamination of water and soil by oil and fuel leaks, industrial wastewater, phosphogypsum residues, heavy metals, algae blooms from fertiliser waste discharge, and toxic remnants of war (TRW) impacts the entire length of the river as it flows northward, destroying aquatic life and making the river unusable for human consumption or agriculture.

Due to its position as a key strategic region in the Syrian conflict, the Orontes Basin has seen a surge in the militarisation of water resources. Public water infrastructure has become a deliberate target of competing factions seeking to interrupt water supplies and expand their territorial control, with targets including wells, pumping stations, water treatment plants, and irrigation networks. Nearly two-thirds of water treatment plants, half of all pumping stations, and one-third of water towers in the basin are estimated to have been damaged, while water stations and water services personnel have been both directly and indirectly targeted.

Water quality across Syria has severely deteriorated since the armed conflict began in 2011, owing to both direct damages to water treatment facilities as well as a collapse in governance, with an estimated one-third of all Syrian water treatment and sewage systems no longer functioning. A lack of wastewater treatment has serious implications not only for sanitation and the physical and mental health of the basin's residents, but also for irrigation practices, safe food production, and the livelihoods of tens of thousands of farmers dependent on uncontaminated water. The destruction of water resources and distribution systems, increased migration, drought, and power shortages are all contributing factors to the severe disruption of access to safe drinking water. The resulting surge in uncoordinated private well drilling as a coping mechanism has exacerbated the decline in both the quantity and quality of groundwater. Moreover, the resulting reliance on expensive and often untreated drinking water from trucks, private well owners, and bottled water companies poses heavy financial burdens and health risks to local communities.

Another major stressor on water infrastructure is conflict-related population displacement. Syria has the second-largest population of internally displaced persons (IDPs) worldwide, with the northern part of the Orontes Basin bearing the brunt of this displacement crisis. Consequently, residents of northern Syria face extreme difficulties in gaining access to clean and affordable water, especially IDPs, who often lack functioning showers and latrines and acquire water from water trucking services with few assurances about the safety of the often-untreated water, resulting in the spread of infectious diseases.

In addition, the Orontes Basin is experiencing significant challenges to water availability, exacerbated by climate change and conflict. While surface water levels have increased in the southern (upstream) part of the basin and declined in the northern (downstream) portion, there has been an overall net increase. The pre-conflict years of drought and climate change-induced high evapotranspiration can partially explain this net increase, but they cannot explain the stark differences between north and south basin water surface levels. It is therefore likely that differences in water management and usage, including upstream damming and irrigation, are responsible. This mismanagement is occurring due to conflict-related damage and looting; a loss of maintenance personnel; and the uncoordinated and uneven establishment of new irrigation infrastructure. Consequently, the Orontes Basin has seen an overall net loss of around 130,000 ha (15.4%) of agricultural lands over the last thirteen years of armed conflict.

Moreover, groundwater reserves, which saw temporary replenishment at the start of the conflict, are now severely depleted due to the intensified and uncontrolled drilling of new groundwater wells. This has led to an estimated groundwater storage loss of around 2,250,000 litres/ha of land in the Syrian part of the basin between spring 2012 and spring 2023.

Flooding and the devastating February 2023 earthquake have each taken a serious toll on communities in the Orontes Basin, killing and injuring civilians, damaging infrastructure, and harming agriculture. The basin's failing flood protection infrastructure, a result of conflict- and earthquake-related damages, has negatively impacted IDPs in particular, many of whom live in camps along the banks of the Orontes River.

Based on this report, PAX calls upon regional actors to treat water insecurity as a priority, in order to prevent further damage to water resources and infrastructure. At the same time, PAX urges the international community to help address these challenges around water insecurity in the Orontes Basin, including the reinvigoration of negotiations towards a political transition. Only when inclusive and genuine negotiations resume towards a political solution of the Syrian conflict can work begin on the provision of clean and adequate water resources in the Orontes Basin. As such, PAX recommends that the international community:

1. Provide humanitarian aid and improve the standards and implementation of wastewater management and sanitation services. This could begin with household water quality testing and filtering kits but should aim at an integrated water management plan, including IDP camps and informal settlements.

2. Provide financial and technical support for the reconstruction of the Orontes' critical water infrastructure and management, adapted to a changing climate. This encompasses public irrigation, drinking water infrastructure, and wastewater treatment plants. Amid the complexities in regional governance and sensitive political landscape, one possibility could be the introduction of an independent technical assistance project focused on infrastructure.

3. Provide expertise on the development of a local/regional framework to regulate and strengthen standards of water management, including water treatment, groundwater pumping, and wastewater discharge from households, IDP camps, input-intensive agriculture, and industrial facilities (such as factories and olive oil presses). The design and monitoring of this framework and these standards should include input from local communities to enable better management of water resources through community-based mechanisms, ensuring that the needs and concerns of local communities inhabiting the Orontes Basin are adequately addressed.

4. Provide financial and technical support towards climate-resilient agriculture in the Orontes Basin. This should focus on water conservation and climate-resilient farming practices.

5. Provide financial and training support to regional researchers and organisations to establish rigorous sampling and research on toxicity levels in soil, surface water, and groundwater in areas of damaged industrial facilities and intense munitions use. This would help eliminate risks to nearby communities and their supportive ecosystems.

6. Set up an early warning system throughout the Orontes River basin to monitor flood and drought risks. This should include regular measurements of groundwater and surface water streamflow parameters of the basin, as well as regular rainfall observation, dam integrity measurements, hydrological models for storms and dam failure, flood risk maps, and communication and response systems in case of drought and flood alerts.

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Introduction

Syria has suffered from a water crisis since long before its nationwide popular uprising began in 2011. Long-term mismanagement of Syria's water resources by the Syrian regime has been ongoing for decades.

By 2015, Syria was ranked 25th on the list of countries expected to face extreme water stress by 2040.[1] The past thirteen years of armed conflict have had further major consequences for the country's water resources and management.

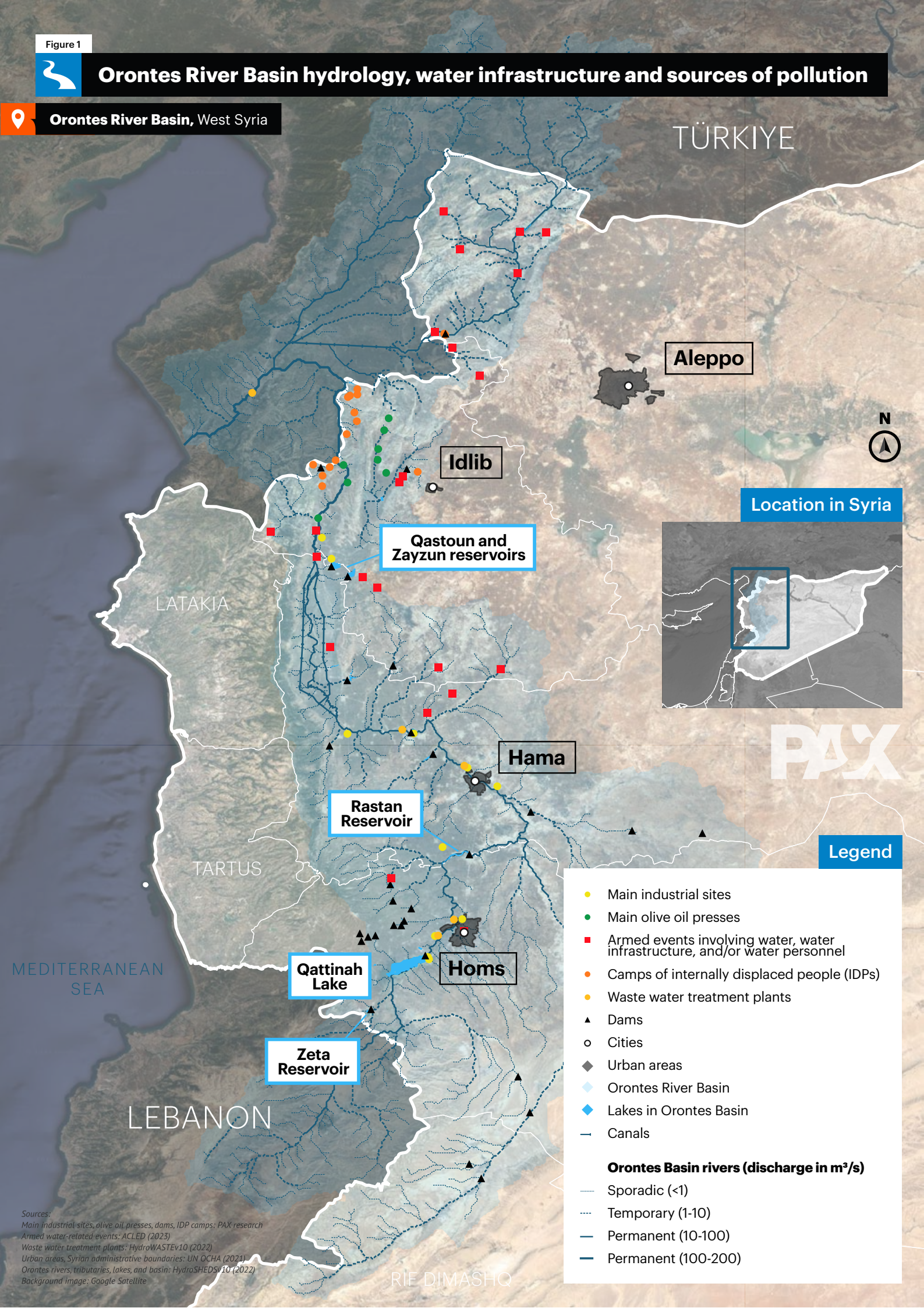
Water infrastructure has been either deliberately destroyed by Syrian government forces (as well as their allies, such as Russia), or damaged during armed conflict with insurgent groups. In many areas, the lack of governance has led to a decline in water quality control, irrigation, and wider water infrastructure maintenance. This has resulted in serious and wide-ranging consequences for public health, livelihoods, and the environment, the effects of which will continue to be felt by future generations in Syria. The vulnerability of Syria's national water resources has led the various conflict parties to militarise water and water infrastructure for strategic purposes since 2011. Weak water governance, mismanagement, and a lack of prioritisation have seriously impacted water quality in Syria. The water security challenges that Syria faces are compounded by the ever-intensifying effects of climate change, such as limited rainfall and low water flows, and the blocking of rivers and water flows. This has led to serious water shortages for millions of people and is particularly problematic for a largely arid country with a hot climate, where livelihoods depend on rivers to a great extent.

While issues around water insecurity in eastern Syria have been frequently reported on by humanitarian organisations and think tanks,[2] covered by international media,[3] and are even discussed in the UN Security Council,[4] the water security situation in western Syria remains less known due to limited access for international media to regime and rebel-held areas. Investigations by local media and reports on social media are helpful to better understand the many water stressors impacting lives, livelihoods, and ecosystems in these areas. As such, the Asi (نهر العاصي) or Orontes River, which plays a vital role in the country's agriculture and industry, is a particularly interesting case for study. The Orontes River Basin accounts for 14% of Syria's total water supply and nearly 13% of all water used in agriculture nationwide. The river originates from artesian wells in the mountains in Lebanon and flows

Figure 1

Orontes River Basin hydrology, water infrastructure and sources of pollution

Orontes River Basin, West Syria

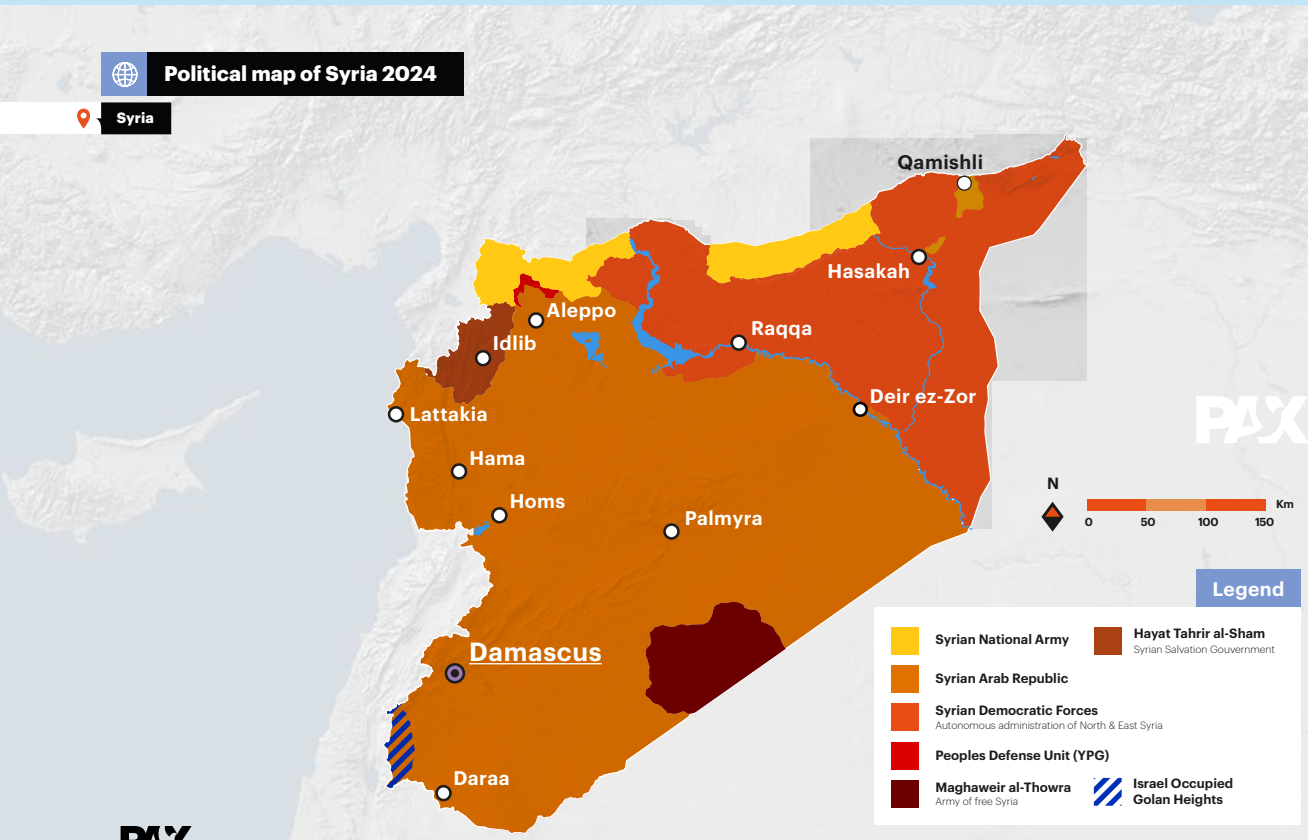


Sources:
Main industrial sites, olive oil presses, dams, IDP camps: PAX research
Armed water-related events: ACLED (2023)
Waste water treatment plants: HydroWASTEv10 (2022)
Urban areas, Syrian administrative boundaries: UN OCHA (2021)
Orontes rivers, tributaries, lakes, and basin: HydroSHEDSv10 (2022)
Background image: Google Satellite

north through the Syrian governorates of Homs, Hama, and Idlib into Türkiye, stretching over 325 km into Syria (see Figure 1).[5] In between, dozens of larger and smaller dams and canals have been built to irrigate the land, boosting local agricultural production.[6] The region's major industrial sites and water treatment facilities are located close to the riverbanks, dumping their wastewater directly into the river due to the breakdown in governance and law enforcement. To the north, in Aleppo governorate, the Afrin River is the largest tributary of the Orontes Basin, flowing down from Türkiye through northern Syria before moving back into Türkiye on the west coast, where it joins the Karasu Stream near Antakya. A bit further downstream in Türkiye, the Karasu Stream joins the Orontes River and then enters the Mediterranean south of Samandağ. The Orontes River partly runs through opposition-held areas in Idlib, where frequent water incidents have been reported. In 2014, pro-government and opposition forces each controlled about 40% of the Orontes Basin, while active conflict zones in the centre and south of the basin accounted for the remaining 20%.[7] Today, the Orontes Basin is largely controlled by pro-government forces, while a small area in the northern part of the basin remains under opposition control (see Figure 2).[8] Developments around the Orontes River Basin are thus indicative of a complex interplay between water resources, armed conflict, and climate change. This PAX water security report provides an overview of water security issues in the entire Basin of the Orontes River, including in Idlib and northern Aleppo governorate. It aims to build an evidence base and raise awareness of the negative impacts of conflict-related water resource degradation – both in availability and quality – on aquatic life, biodiversity, and the livelihoods and health of local communities and internally displaced persons (IDPs) in the region. By exploring in-depth the various ways through which water resources in western Syria have been affected by conflict, this study provides insights and recommendations for the international community, including governments, development agencies, humanitarian organisations, and peacebuilding actors working in Syria, to address the challenges around water insecurity in the Orontes Basin to improve water access, water management, and sanitation services for affected communities. The report also concludes with highlighting the need for the international community to reinvigorate negotiations towards a political transition, something which is crucial to prevent the further degradation of water resources and restore environmental governance in the region.

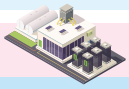
In order to provide these insights and recommendations, the report will begin by outlining the methodology used. This is followed by an overview of the main consequences and challenges of water insecurity facing communities in the Orontes Basin. Subsequently, the report delves into specific water-related stressors contributing to water insecurity in western Syria before ending with the main takeaways and concrete recommendations.

▼ Figure 2. Approximate areas of influence and territorial control in the Syrian Arab Republic, as of December 2023. Source: UN Geospatial.[9]



Data and Methodology

This research is grounded within a mix of data sources and methods to analyse the water security situation in an integrated manner, following methodological guidance developed by UNEP, the EU, and Adelphi.[10] This includes (1) an extensive literature review to identify water security incidents; (2) a geospatial analysis of available open-source data on the water situation in Syria; and (3) testimonies and pictures from a range of community members spread out over the Syrian part of the Orontes River Basin. Comparing the overlap between these three types of information sources, i.e. triangulation, ensures that knowledge gaps are reduced, statements are verified, and quantitative observations can be causally interpreted through narratives.

Section and subsection	Data source	Analytics and methods applied
 **INDUSTRIAL FACILITIES**		
Surface water pollution	Sentinel-2, level 2A surface reflectance [11]	Water quality indicators for concentration of Chlorophyll a
Informal quarries	MAXAR, Airbus, Sentinel-2, CNES, and Landsat [12]	Visual interpretation, cross verification with open-source material
 **MILITARISING WATER AND WATER INFRASTRUCTURE**		
Conflict events	Armed Conflict Location & Event Data Project (ACLED)[13]	Filters for Orontes region and water-related events
Chemical weapons use	Nowhere to Hide dataset: Chemical Weapons in Syria [14]	Summing the amount of attacks
 **INTERNAL DISPLACEMENT AND LIMITS TO CLEAN WATER**		
	IDP camps: US DoS[15] and Maxar through Google Earth pro IDP presence: UNHCR[16] Returnees: UNOCHA[17]	Filters for Orontes region and water-related events
 **SHRINKING WATER AVAILABILITY**		
Observed historical climate: temperature and precipitation	Climatic Research Unit gridded Time Series (CRU TS) Monthly High-Resolution Gridded Multivariate Climate Dataset - version 4 [18]	Aggregated mean values annually and per Syrian governorate through the World Bank Climate Change Knowledge Portal
Projected future climate: temperature and precipitation	Coupled Intercomparison Project Phase 6 (CMIP6)[19]	Aggregated mean values annually and per Syrian governorate through the World Bank Climate Change Knowledge Portal
Surface water extent	JRC and UNEP Global Surface Water Data [20]	Yearly water classification history, version 1.4
Agricultural land use	Combination of Landsat, Sentinel-1, and Sentinel-2	Land abandonment and recultivation analysis through time-series analysis of annual crop and tree crop extent [21]
 **GROUNDWATER**		
	NASA GRACE and GRACE-FO	Monthly and yearly aggregated changes in ground-water storage in the Syrian part of the Orontes Basin [22]
 **FLOODING**		
	Aqueduct Floods Hazard Maps, Inundation Depth In Metres For Coastal And Riverine Floods, Version 2[23]	Developed flood baseline and projection maps with recurrence periods of 10 years and 25 years. For the flood projection maps of 2050, an RCP 8.5 scenario (pessimistic climate change scenario) and the GFDL-ESM2M climate model were used.

▲ Table 1. Geospatial data sources and analytics applied per (sub)section of this report's research.

▲ Phosphate factory at Homs Lake in March 2021. Source: MAXAR

Broad Literature Research to Gather Water Security Incidents

The literature research for this report aimed to list water security incidents from the beginning of the Syrian revolution up to the end of 2023. Information on such incidents was gathered from news articles and social media posts, as well as reports by local civil society organisations and international organisations. Academic research articles were mainly used for background information on larger trends in water security in the basin.

Additionally, a search for such incidents was conducted in the Armed Conflict Location & Event Data Project (ACLED), which has tracked violent conflict events in Syria from 2017 onwards.[24] By filtering through the armed conflict incidents' descriptions for mentions of "water" within the study region, 29 conflict events resulting in severe water-related damages were identified in the Orontes Basin between January 2017 and December 2023.

Geospatial Analysis

Analysis of available geospatial data, often derived from remote sensing, provided significant information on the landscape-wide effects of the Syrian conflict on water. Table 1 presents the details of the geospatial data sources and methodologies applied.

Testimonies

Ten testimonies were gathered by Syrians for Truth and Justice (STJ) from a range of community members spread out over the Syrian part of the Orontes River Basin. The interview participants were diverse in terms of their location in the basin (upstream/downstream, close to/far from the river), livelihood practices, gender, and age. A semi-structured interview guide was developed to better understand the water security situation in the Orontes Basin (see Appendix 1), specified for the context of this report based on insights from UNEP's integrated analysis tool for climate-related security risks.[25] The guiding questions for the testimonies primarily consisted of open-ended questions and were only loosely followed to ensure respondents had the opportunity to bring up their main water-related concerns. An inductive and deductive thematic content analysis of the interviews was conducted, in which common themes, anecdotes, and narratives were identified. These anecdotes were then compared with the above-mentioned alternatively collected data to provide a more complete picture of the situation on the ground, to corroborate alternatively-sourced information, and to provide insight into potentially overlooked topics of interest or concern.

Main Impacts of Water Insecurity Faced by the Communities of the Orontes Basin

The following chapter outlines the consequences of water insecurity faced by the communities living in the Orontes Basin, primarily regarding public health, agriculture, and the natural environment. The Orontes Basin's already strained water resources have been exacerbated by the effects of pollution, the overuse of water sources, inadequate infrastructure, poor governance, climate change, and conflict-related damages. Deteriorating water quality, quantity, and accessibility have led to public health crises, agricultural decline, and ecosystem degradation, with their ensuing impacts on the people and communities of the basin.

Public Health

Water access is essential for Syrian communities to provide drinking water, hygiene, livelihoods, and healthy ecosystems. Before the armed conflict, Syria's ground and surface water quality was already low, a result of pollution and the absence of treatment plants in much of the Orontes Basin. Groundwater is the main source of drinking water in the region, dependent on 1,500 wells feeding rural networks. Overuse and illegal water pumping have had serious negative consequences for the quality and quantity of groundwater levels in northwest Syria, particularly in Homs, Aleppo, and Idlib.Conflict-linked damage to the water networks, power cuts, and failing governance has caused a massive decline in drinking water access for households since the start of the armed conflict. A lack of water security continues to pose serious health risks, particularly in non-regime-controlled areas, where outbreaks of cholera and other communicable diseases due to a lack of access to clean water continue to impact communities. These impacts are felt more acutely due to ongoing climate change-linked droughts, making water access even more unreliable for millions of people. People living in formal and informal IDP settlements are bearing the brunt of the water crisis, with limited water for drinking and showering, as well as lacking operational wastewater networks, severely increasing the risks for communicable diseases, a trend which is worsening by the year.[26]

A male activist from a village near Idlib city, who has been living across the border in Türkiye, corroborated this trend, stating that "diseases caused by water are widespread. Cases of cholera have exceeded 2,000 in northern Syria, according to what I have heard from doctors. Cases of severe diarrhoea are caused by unsterilised water coming through the water network, sourced from underground wells or tanks."

Agriculture and Food Security

As previously mentioned, the use of water for agricultural purposes in the Orontes Basin is significant, with the main agricultural areas located in Al-Ghab Valley and Idlib governorate.[27] Before the armed conflict, agricultural areas in the Orontes Basin provided over 25% of Syria's crop production, including wheat, cotton, sugar beets, sesame, vegetables, apricots, and apples.[28] Despite this, the area was already struggling with water shortages from illegal well drilling and mismanagement of water governance, worsened by droughts and cuts in fuel subsidies.[29] This led to agricultural decline and elevated food prices, which in turn resulted in mass poverty, fuelling protests. The UN Food and Agriculture Organization (FAO) reported below-average harvests in the region 2021 and 2022, despite generally favourable sowing conditions. High costs of inputs further hinder agricultural production.[30]

Climate change-induced droughts and erratic weather patterns have also impacted agricultural production across Syria, including the Orontes Basin and Aleppo province.[31] The World Food Program (WFP) estimates that due to the conflict, 70% of Syria's population faces severe food insecurity and requires food assistance.[32] Between 2011 and 2014, estimates show that at least 2/3s of the population have fled the Orontes Basin area, resulting in a decline of 70% in agricultural production, while Idlib and Aleppo governorates have seen a massive influx of IDPs fleeing violence and persecution.[33] Importantly, the UN and its partners are working in northern Syria to alleviate the impacts of the water crisis, including water infrastructure rehabilitation efforts.[34] However, while these efforts appear promising, larger questions loom regarding the future of sustainable water governance and climate adaptation under a regime that lacks both the means and the will to address them.

This is a worrisome trend for residents, including a male retiree located northwest of Jisr al-Shughour in Idlib province. He observed that "with time, groundwater [resources] will end and we will be in a real crisis without water. Agriculture dwindles as wells dry up."

Natural Ecosystems

The northwestern part of Syria struggles with serious degradation of the natural environment, worsened by the armed conflict and climate change. Prior to the uprising, natural ecosystems were already burdened, linked with industrial pollution and the overuse of groundwater. The Orontes Basin has several protected areas, according to the Syrian government›s submission to the UN Convention on Biological Diversity.[35] These include several unique wetlands that host migratory birds, while Aleppo province has few remaining natural forests, all of which have seen severe deforestation (as documented by PAX).[36] Industrial activities along the Orontes riverside, a lack of proper wastewater facilities, and the large-scale displacement of communities continue to affect water quality and the region's precious ecosystems.

When asked about the current protections for water resources, a field researcher from a village close to the Turkish border identified two main areas of concern, and suggested: “preventing the digging of new underground wells and preventing the diversion of sewage water towards the Orontes River, which destroys agriculture and destroys fish ponds and the fish of the Orontes River.”

Following the above-described concerns for public health, agriculture, food security, and nature in the Orontes Basin, the next chapters will provide an in-depth assessment of specific water stressors contributing to these challenges and how more than a decade of conflict has aggravated each water stressor.

▼ Syrian farmers harvesting a field irrigated from the canal into which water was recently pumped from the Balaa Dam, that had fallen out of service for 12 years after the war broke out, in the northwestern Idlib province on May 22, 2024. Source: Omar Haj Kadour / AFP

Industrial Pollution of Water Resources

Following the construction of a state-run sugar plant and an oil refinery in the Homs governorate in 1948 and 1957, respectively, the Orontes Basin became one of Syria's first industrialised areas. The 1960s saw rapid growth in the national industrial sector. The 1990s saw an expansion of industrialisation nationwide - particularly in the cities of Homs, Hama, and Idlib, with the opening of private factories including chemical and pharmaceutical plants. These critical industrial sites, including fertiliser factories, oil refineries, cement and steel factories, electrical power plants, and sugar factories have played an essential role in developing Syria's economy for a growing population, especially in the Orontes Basin.[37]

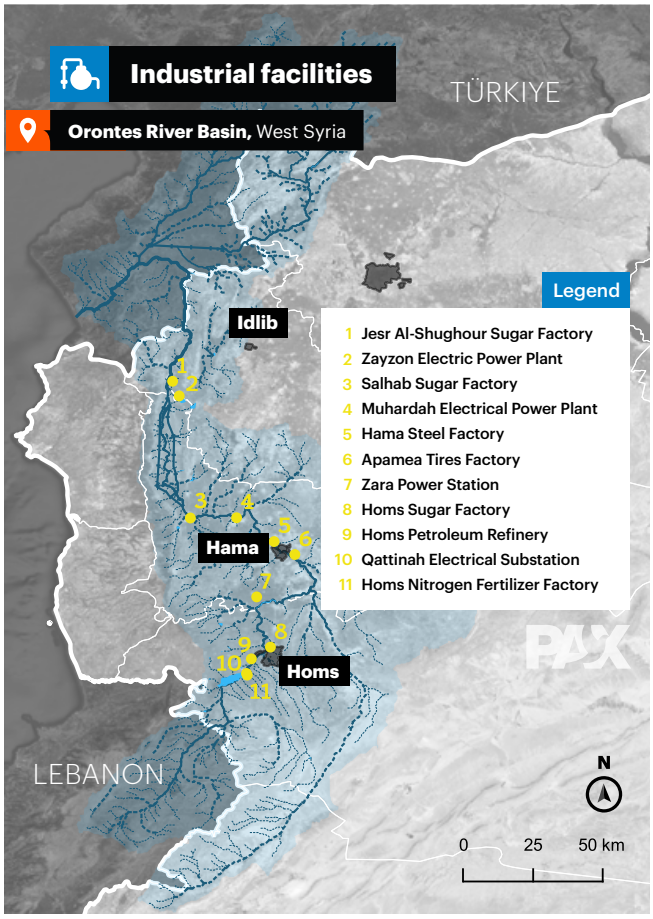
A wide range of reports and research papers have described the environmental risks of these factories to the Orontes River long before the start of the conflict in 2011.[38] The dangers arise primarily from weak and outdated operating policies, factory regulations not adhering to modern environmental standards, and corruption in the public industrial sector. As a result, high levels of dangerous industrial activity, coupled with the environmental impacts of regional agriculture, have led to considerable deterioration in the quality of water in the river basin.[39]

Such deterioration is well-known among local community members and has since been compounded by the effects of the conflict. A female high school teacher from northwest of Jisr al-Shughour said that "the water of the Orontes River is not suitable for drinking. This is what I know, even from the time of the Syrian regime's control, because the water of the sugar factory located in Jisr al-Shughour (which was destroyed by a Russian airstrike) was diverted to it, which led to this water being unfit for drinking and unsuitable for agriculture."

During the armed conflict, as violence intensified across the country, numerous factories were knocked out of operation due direct and indirect damage. Other factories, while still functioning, lacked manpower and specialists. On the other hand, continued industrial production is a priority for local parties to the conflict to sustain their war economies, regardless of the consequences. In other words, the environmental impact is the last priority for conflict actors.

To understand the internal geopolitics of the river and its stakeholders, it is important to highlight that the river flows from south to north. The impact of discharged waste and contamination from certain facilities therefore appears in other locations on the river further north. The regime controls all factories in the southern part of the basin, from the point where the river enters Syria (from Lebanon) up until the Salhab sugar factory in northern Hama province.

Figure 3. Overview of the eleven main industrial facilities along the banks of the Orontes Basin. Source: manual mapping from literature review.

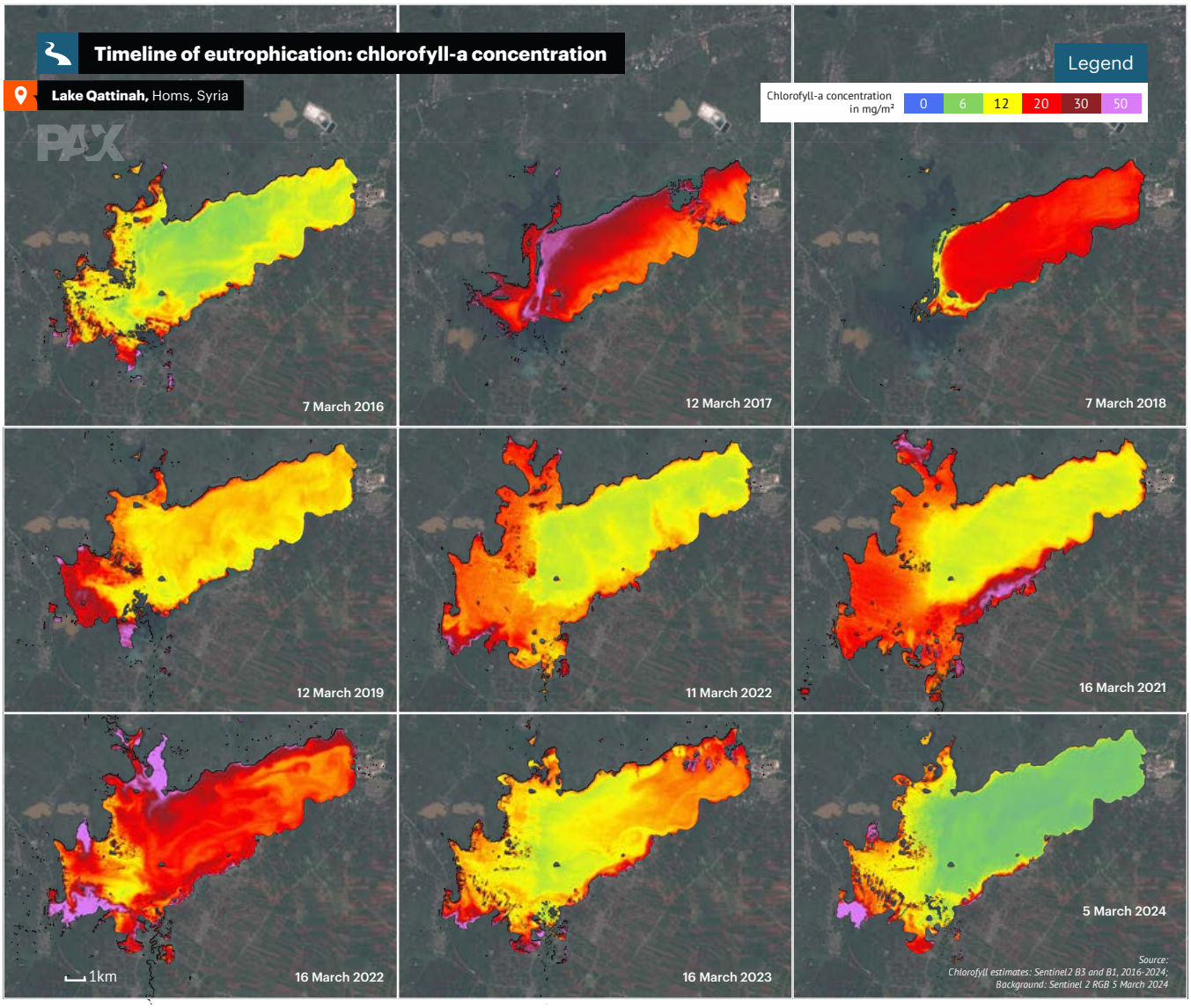


There are at least eleven relevant factories along the Orontes River (see Figure 3), ranging from small to large-sized factories, and administratively affiliated to the three main governorates through which the river flows: namely, Homs, Hama, and Idlib. Most of the factories in the Idlib governorate are out of operation, due to either looting or direct targeting (such as the looting of the electrical power plant in Zayzoun and the targeting of the sugar factory in Jisr al-Shughour).[40] As such, this report examines the environmental impacts of factories along the river and highlights two key polluting industrial facilities in the cities of Hama and Homs, contributing to the degradation of the river: the nitrogen fertiliser factory in the Homs, and the Salhab sugar factory in Hama.

Homs Industrial Pollution Sources

As the third-largest city in Syria and first-largest in the Syrian share of the Orontes River, Homs has and continues to experience its share of destruction and suffering. Due to the strategic central location of the city and its proximity to the coast, several critical industrial facilities have been constructed on the banks of the Orontes since the 1950s. Homs is home to a fertiliser factory and the Qattinah electrical substation, both located along the river. There are two other important industrial sites in the city: the Homs oil refinery to the city's west, and the Homs sugar factory to the north.

The first petroleum refinery in Syria was established in 1959 in Homs, on the western bank of the Orontes River. The refinery has been targeted several times



▲ Figure 4. Map timeline of pollution events in Lake Qattinah between 2016 and 2024: chlorophyll-a (eutrophication). Source: Sentinel-2, level 2A surface reflectance.[41]

during the present armed conflict. Leakages and spills have caused several fires inside the facility, while discharge from the refinery containing untreated oil and petroleum residue has negatively affected soil and water resources.[42] A few kilometres to the north, wastewater from the sugar factory is discharged without proper treatment into the Orontes River. This sugar factory, built in 1948, has been out of operation for several years due to the decline in availability of sugar beets, but it occasionally operates with limited capacity when sugar beets are locally available.[43]

Local reporting and research provide useful guidance into the main sources of pollution in Homs.[44] The General Fertilisers Company (GFC) factory is located 10 km west of Homs city, on the Homs (or Qattinah) Lake.[45] The lake is a natural reservoir on the Orontes that dates back to the Roman era. A remote water quality assessment and satellite imagery indicate that the disruption and continuation of operations during the conflict are related to spatial and temporal algae concentrations in the lake (Figure 4).[46] 2017 and 2022 stand out from other years with chlorophyll-a concentrations over 50 mg/m3, indicating a major growth of algae in the lake. The formation of algae in the lake, especially close to the factory, is caused by high nutrient concentrations in the water, also called eutrophication, resulting from discharge such as nitrate and phosphate from the fertiliser factory. Nutrient-rich water leads to an algae bloom, overconsuming the oxygen in the water and leading to a phenomenon known as hypoxia, a lack of oxygen in the water. This results in a severe degradation of the river's ecosystem by depriving aquatic flora and fauna of critical oxygen.[47]

Another environmental threat from the factory is phosphogypsum, one of the major byproducts of the phosphate fertiliser industry. Phosphogypsum is stored in large stacks to the west of Homs city. Surrounding ecosystems (soil, plant, water, and air) may become contaminated if phosphogypsum is stored in the open-air stacks and exposed to the natural elements such as wind and rain.[48] Additionally, residues and minerals, including fluorine, iron, lead, and mercury, seep out from the factory, first into the soil and then into the groundwater. This contamination has resulted in hundreds of hectares being affected, land which was previously used to grow wheat, barley, peas, and beans and is now unfit for agricultural use.[49]

Local communities around the lake are aware of the impacts on their water, soil, and physical health. Local media has reported that inhabitants of the village of Qattinah, located near the factory, are suffering from its emissions. The village doctor was quoted as reporting that the most common diseases among Qattinah's inhabitants include ailments of the upper and lower respiratory tract, cancer, congenital anomalies, infertility, and allergic skin diseases.[50]

In 2018, the Russian company StroyTransGaz signed an investment contract with the GFC. The contract stipulated that the shares of the GFC will be split, with 35% held by the Syrian government and 65% by StroyTransGaz, with a duration of at least 25 to 40 years. This was followed by the mass layoff of hundreds of factory employees amidst increasing local concerns about what the future would bring.[51]

Hama's Input-Intensive Agriculture, Fossil Fuel-Based Electrical Power Plant, and Steel and Rubber Industries

The city of Hama is located on the banks of the Orontes River, roughly 46 km north of Homs city. Recent decades have seen the intensification of agriculture and rapid growth of the city's population and industrial activity, particularly metallurgical and chemical. These developments have put significant pressure on local soil and water resources and led to contamination, mainly due to agricultural practices in the area, such as the intensive use of fertilisers, pesticides, and wastewater for irrigation. In addition, the close proximity of concentrated industrial areas to villages and agricultural zones has likely increased the concentration of pollutants.[52]

A 2019 study on soil quality in the Hama floodplain identified high concentrations of heavy metals like copper and cadmium in water and soil samples. These concentrations were particularly high near the steel factory in the north of the city and the rubber tyre factory in the city's east, posing a serious environmental risk to local ecosystems and populations.[53]

Another source of contamination comes from the Muhardah electrical power plant near the Muhardah dam, north of Hama city. Thermal pollution occurs during the cooling of fossil fuel-powered steam turbines when boiling water (used in the cooling process and containing fuel residues) is discharged directly into the river, without proper treatment. The high temperature of the wastewater decreases oxygen levels, killing animals and plants in the river.[54]

The Tal Salhab Sugar Factory

The regime-owned Tal Salhab sugar factory is located in the village of Tal Salhab, 35 km northwest of Hama city at the southern end of Al-Ghab Plain. The factory was inactive from 2014 until 2022, owing to low sugar beet production (used in the factory's operations). When the factory resumed production in July 2022, the Orontes River's fish population was severely affected, dropping precipitously after recovering during eight years with no factory-produced pollutants in the river. Many fishermen and locals who rely on the river for their livelihoods were negatively affected by the decreased fish population.[55]

The factory's waste products contain chemicals and oils, toxic substances which form a layer that floats on the surface of the water. This layer lowers the oxygen content of the river, poisoning and suffocating much of the river's ecosystem. High quantities of nitrate, magnesium, calcium, sulphates, and chloride are also present in the waste from the sugar factory. These substances alter the temperature, pH level, and oxygen level of the water.[56] This practice has affected not only the aquatic life of the river, but also the crops that depend on it for irrigation. The damage has reportedly hit corn production especially hard, while also damaging the cultivation of eggplant, pepper, cowpea, and bean crops.[57] Three water samples from three different locations in the Al-Ghab Plain were collected by the Syrian Water Resources Platform and the ACU (Assistance Coordination Unit) and have been tested for their physical and chemical properties. The tests confirmed that biological contamination, including ammonia and phosphates, increases closer to the sugar factory.[58]

Many factories and power plants are located near the Orontes River, as they require large quantities of water for their manufacturing processes. When water mixes with toxins or chemicals released from industrial activity, marine ecosystems and the health of those who depend on the water for food, drinking, or irrigation is affected. Armed conflict has further exacerbated the situation in Syria, with the country's industrial sector suffering from a lack of strict policies, manpower, and specialists. Additionally, economic crisis, lack of capital, and heavy international sanctions have affected local factories' abilities to properly treat wastewater by forcing facilities to use outdated technologies and machinery which produce more pollutants than their modern counterparts.

▼ Fishermen catch live fish as dead fish float in the Orontes River, in the central Hama province, on August 3, 2022, poisoned by chemicals dumped in the river by the Tal Salhab sugar factory. Source: Omar Haj Kadour / AFP

Olive Oil Presses

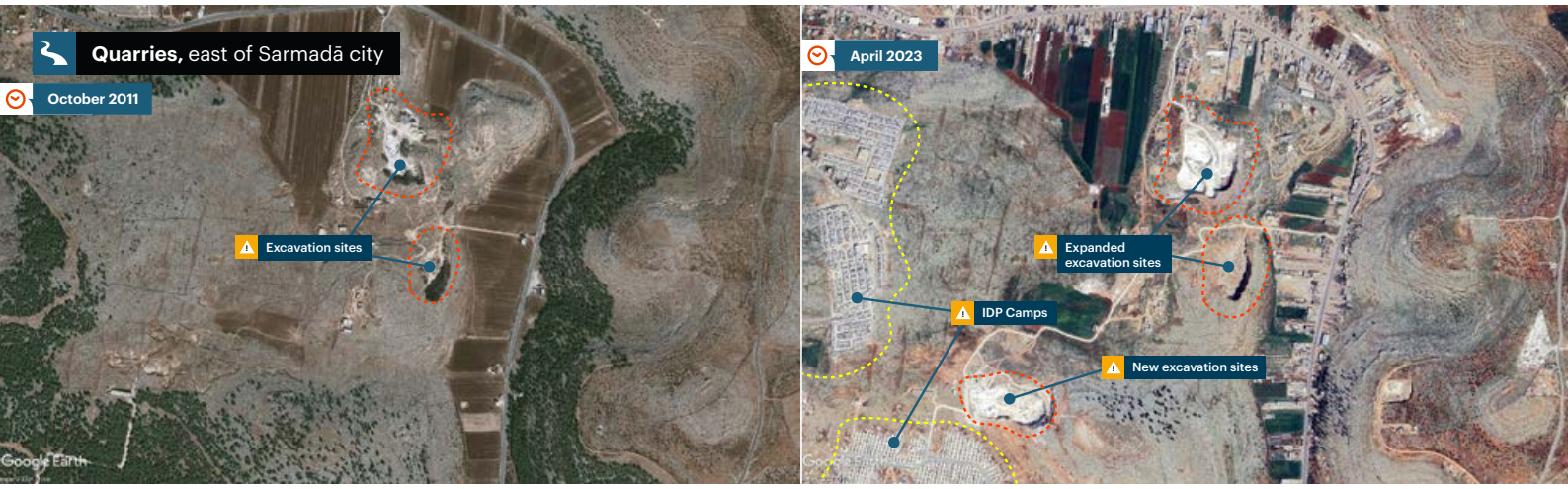
Olives are the most ancient agricultural product in Syria. There is a natural abundance of olive trees in the country's north and northwest regions, stretching back thousands of years. Before the present conflict, the number of olive trees in Syria was approximately 80 million.[59] Around 50 olive presses exist in Idlib province, in the town of Jisr al-Shughour and surrounding villages (Kafr Takharim, Armanaz, Bireh Armanaz, Meles, and Sheikh Yusuf). These olive presses are indirectly connected to the Orontes River through canals that were previously used for irrigation but are now used to discharge wastewater and remnants of the presses at several locations, including the mouth of the White River (a tributary of the Orontes River) and the waterfall in Ain al-Zarqa.[60] As a result of this pollution, thousands of fish either became diseased or died, with a major negative impact on the livelihoods of local fishermen.[61] According to a male media activist living in a village close to the Turkish border, "…cases of poisoning occurred in the eleventh month of 2022 due to the diversion of oil press water into the Orontes River, which led to the death of many fish and the people."

Increases in Informal Quarries

Reconstruction efforts and increases in natural resource extraction have already resulted in a surge of quarries in northern Syria to produce cement and extract limestone, marble, granite, and other materials. Using satellite imagery, PAX was able to identify 19 new quarries and resource extraction sites and 95 quarries that have expanded since the beginning of the conflict in 2011 (see Figures 5 and 6 for examples). 46 quarries were identified as remaining unchanged since 2011, with only two quarries decreasing in size since that time. Reports indicate that illegal quarries could soon become a major issue in Syria, if they are not already.[62] In other conflict-affected countries such as Lebanon, which also witnessed large-scale urban destruction from intense fighting because of the civil war, there was an increase in the number of illegal quarries to contribute to rebuilding damaged and destroyed infrastructure, with much of the extracted material also being exported to Syria for similar purposes. This increase in both formal and informal quarries has had

▼ Water Pollution of the Orontes River after the waste of olive presses was dumped in the Al-Roj Plain area in the Idlib countryside, November 23, 2022. Source: Enab Baladi / Mohammed Naasan Dabal.

severe negative consequences on the environment and local groundwater, an indicator of what could happen in Syria as well.[63] The development of new quarries, particularly informal ones that haphazardly pop up in often undesirable locations, can lead to the increased water turbidity from released rock particles entering underground water supplies and an increased likelihood of landslides and soil loss, negatively impacting the environment and surrounding communities. More attention should be given to the growing number of formal and informal quarries in Syria and their subsequent environmental impacts. Local communities in Idlib have raised concerns over the public health risks and negative environmental effects of these quarries.[64] Of particular concern is the overuse of groundwater for mining activities to suppress the large amounts of dust produced in the process.[65]



▲ Figure 5. New and expanded quarries east of the city of Sarmadā between 2011 and 2023. These excavation sites are located beside IDP camps that emerged in 2021 and have been growing ever since. Source: Maxar Technologies through Google Earth.

▲ Figute 6. New quarries located in the Harem district of the Idlib governorate (image on the left is 2010, on the right is 2024). Source: Maxar Technologies through Google Earth.

Contamination From Toxic Remnants of War

Thirteen years of fighting in Syria have seen widespread use of explosive weapons, including artillery, mortars, rockets, missiles, and air-dropped bombs. The intense usage of a wide variety of explosive weapons and other munitions has resulted in the wide distribution of unexploded ordnance (UXO), as well as munitions remnants such as residues from explosives, also known as energetic materials, and heavy metals deposited in the soil across Syria.[66]

These toxic remnants of war pose well-documented public health and environmental risks,[67] including acute exposure to military toxins in solid and liquid propellants (found in rockets and missiles)[68] and chronic exposure to explosive materials such as trinitrotoluene (TNT), cyclonite, RDX (1,3,5-trinitro-1,3,5-triazine), nitro-glycerine (NG), and octogen (HMX),[69] essential components in munitions and propellants. The leaching of pollutants from UXO, failed detonations, or fully detonated explosions can result in the contamination of soil and water sources and form pathways of exposure for civilians.[70] Current discussions in the U.S. around the remediation of firing ranges highlight the risk to nearby communities from munitions contamination.[71] Sampling studies in Syria could be particularly helpful in areas of intense munitions in order to ensure there are no risks of soil and groundwater contamination, contamination, either from shelling or UXO clearance activities.

The Orontes Basin has also been the site of chemical weapons attacks. Between 2012 and 2019, it was found that there had been 47 chlorine gas attacks in 15 villages in the Idlib governorate; 39 chlorine attacks and one sarin gas attack in 11 villages in the Hama governorate; and eight chlorine attacks and one BZ[72] attack in six villages in the Homs governorate.[73] PAX reached out to chemical weapons experts and reviewed literature to identify potential long-term environmental risks and based on the answers and research concluded that there is not any significant soil and water pollution from chemical attacks.[74]

Militarisation of Water Resources

The Orontes River Basin is a key strategic region in the ongoing Syrian conflict due to its economic productivity, owing to its prosperous agricultural and industrial sectors. The city of Homs has been particularly affected by the conflict. Rural areas, especially those with large irrigation networks such as the Rastan and Al-Ghab Plains, have also been the scenes of heavy fighting and bombardment, particularly with the creation of military zones in the Al-Qusayr and Qattinah districts. Public water infrastructure has thus been a main and deliberate target in military operations as competing factions seek to disrupt their opponents' water resources, including wells, pumping stations, water treatment plants, and irrigation networks, to gain territorial control.[75]

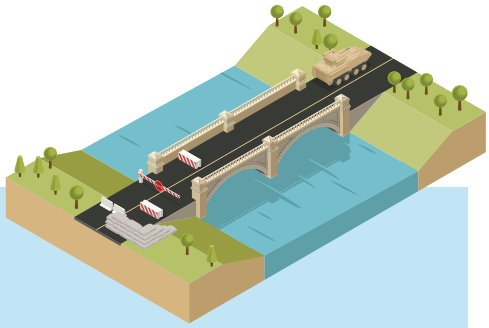
A media activist who lives to the west of Idlib city, on the Turkish border, corroborated this, stating:

> "There was an irrigation project established by the Syrian government, in the neighbourhood of [the town of] Darkush, but it was vandalised and looted, and if it returns, it will bring great prosperity to the region. I will not mention who did it either. The neighbouring village is supplied with hot sulphurous water. Unfortunately, due to the lack of water, this water is also used for drinking and causes many diseases. Its smell disappears because it is drawn from a spring into homes."

The Seventh Conference on "Supporting the Future of Syria and the Region" (Brussels VII), hosted in June 2023, estimated that "[n]early two-thirds of water treatment plants, half of all pumping stations and one-third of water towers [in Syria] have been damaged in the conflict".[76] The Armed Conflict Location & Event Data Project (ACLED) has tracked violent conflict events in Syria from 2017 onwards.[77] Below, is a summarised overview of 29 conflict events tracked by ACLED that resulted in severe water-related damages in the Orontes Basin between January 2017 and December 2023.

Five water stations were damaged in large-scale bombing of the towns they were located in, while at least seven water stations have been deliberately targeted and destroyed in the Orontes Basin since 2017. It is not often clear from the ACLED descriptions whether a given incident involved a water well, water network pumping station, water tower, or wastewater treatment plant. One water management office of the Syrian Salvation Government was targeted and damaged in the town of Khan Shaykun by artillery shelling from 40 rockets. The ACLED database includes three reports of the targeted destruction of water trucks and four reports on the targeting and destruction of water tanks. Three incidents where water services personnel were harmed were identified: one water company employee was assaulted and injured by National Police Forces, three labourers were seriously injured by a landmine when digging a water well, and one employee of a local council's water service was targeted and killed by a regime sniper. At least three protests broke out in the region among displaced people demanding a fair share of water.

Transboundary River Management



As with most transboundary rivers in the region, there is no overall water management agreement between the Orontes' three riparian countries (Lebanon, Syria, and Türkiye), from the river's source to its mouth. Since August 1994, there has been a bilateral water-sharing agreement between Lebanon and Syria, limiting Lebanon's withdrawal to approximately 20% of the river's water flow and prohibiting the drilling of new wells in the Orontes' catchment.[78] There is no bilateral water management agreement between Syria and Türkiye, only a 2009 memorandum of understanding on the planned construction of the "Asi Friendship Dam," set to be built where the Orontes forms the border between the two countries. The Friendship Dam, however, did not progress further than the first celebratory foundational stones in February 2011 due to the outbreak of violent conflict and political differences.[79]

The lack of a trilateral basin-wide agreement over the Orontes, the non-cooperation between Syria and Türkiye, and the bilateral agreement limiting Lebanese water use largely benefits the Orontes region in Syria, unlike the Euphrates Basin in the country's east. The situation demonstrates the regional pre-conflict political influence of Syria, but more than a decade of armed conflict, including shifting territorial control in the basin among various groups, has diminished the Syrian regime's formerly strong (hydro)political position in the Orontes Basin.[80] It remains unclear how the armed conflict has influenced Türkiye and Lebanon's use of the Orontes and what the prospects for joint transboundary river management are.

A female field researcher from a Syrian village near the Turkish border mentioned the "ongoing conflict between Türkiye and the Syrian regime. The regime draws water from Homs and Hama towards agricultural areas, and Türkiye withdraws water from Hatay towards agricultural areas, which reduces the percentage of water that reaches Idlib and its countryside."

One of the three protests erupted into clashes, resulting in one civilian casualty. In 2017, two bodies of kidnapped men were found in a water well south of Morek city in the Hama governorate and two others were found in a well in Jisr al-Shughour in Idlib.

While this section shows the broad picture of the militarisation of water resources in the Syrian conflict, it is far from complete. This overview does not capture the earlier years of the conflict, nor does it address events such as the January 2022 Russian attacks on the Arshani water station, west of Idlib city, which deprived around a quarter of a million people in Idlib of their main water source.[81] Moreover, most qualified water services staff had fled the area, resulting in a lack of maintenance and management for the existing water infrastructure for over a decade to date. Functioning water infrastructure is still needed for basic quality of life purposes if refugees and IDPs are to one day return.

▼ Severe damage to Al-Arshani water station caused by Russian airstrikes in northwestern Idlib on January 2, 2022. Source: Saed al Fin Ziadan via SNHR

Disrupted Water Access and Treatment

Prior to the conflict, the majority of rural and urban communities in Syria were connected to the public water supply system and between 92-98% of rural and urban Syrian populations had reliable access to clean water.[82] Yet mismanagement and lack of oversight have led to overuse and the pollution of ground and surface water sources from wastewater linked with household, industrial, and agricultural use.[83]

During the first 10 years of conflict in Syria, household access to water decreased by up to 40%, with half of the country's sanitation systems becoming nonfunctional.[84] Direct damage to pumping stations, pipelines, and water treatment facilities, the collapse of governance, and increases in both migration and drought have collectively disrupted water access and treatment.[85] Moreover, severe electricity shortages have further exacerbated the scarcity of clean water, as both production and distribution depend on electricity-fuelled pumping systems.[86] Estimates provided by humanitarian groups indicate that nearly two-thirds of water treatment plants, half of all pumping stations, and one-third of the water towers in Syria have been damaged during the armed conflict..[87]

Collapse of Wastewater Treatment

The armed conflict has put restraints on the ability of the government and de facto authorities in rebel-controlled areas to effect proper wastewater management, owing to the direct targeting of wastewater plants and the absence of regulations, with half of the country's sewage systems now being out of order and an estimated 70% of sewage discharge left untreated on a national level.[88]

One citizen described the mismanagement in his village: "The Syrian regime diverted sewage water from a number of villages and towns [north of Idlib] to the Orontes River, which is about 8 km away from us, so it has become undrinkable."

In contrast, another citizen in a village just 40 km south attributes improved management to the Syrian regime:

"Water quality during the time of the Syrian regime was better due to water treatment and adding chlorine to the water, but now, we are provided with insufficient water that is also untreated and not chlorinated... There are no high health standards imposed by the Salvation Government on drinking water. The government's main concern regarding water is collecting taxes, as there is no regulatory authority."

In Idlib, there are major problems with untreated wastewater coming from Idlib city being dumped into a canal that flows past several IDP settlements before ending in the Rouhin Reservoir. This body of water has a storage capacity of two million cubic metres and is situated near one of the major drinking water extraction wells, providing water to nearby villages and IDP camp sites. Research and sampling carried out by local NGOs in collaboration with media investigations indicates that the groundwater is heavily contaminated from untreated wastewater, endangering water security for nearly one million people in Idlib, particularly vulnerable displaced populations.[89]

This contamination endangers the livelihoods of tens of thousands of farmers dependent on wastewater access for agricultural purposes. There are already wider problems from agricultural use of wastewater, as this comes with public health risks from contaminated crops being sold and consumed on markets while containing bacteria such as E. coli.[90] Local reports indicate that old wells are becoming contaminated with wastewater[91] and that there is a spread of water-born intestinal and skin diseases.[92]

Wastewater treatment is also a major issue in IDP camps, where consequences are often worse than for the general population and where wastewater sewage and treatment range from extremely poor to non-existent.[93] Only 39% of surveyed households in the northern parts of the Orontes Basin are connected to simple, often open, sewage systems,[94] while around 85% of displacement camps do not have operational wastewater networks in place at all.[95]

The extremely poor quality of water services in IDP sites in the northern part of the Orontes Basin has led directly to a public health crisis, including both physical and mental health.[96] A lack of clean water for sanitation and hygiene, poor to non-existent systems for dealing with wastewater, and the use of contaminated water have led to the spread of communicable water-borne diseases such as cholera, scabies, and leishmaniasis.

▼ Syrian refugees fill water from a tank at Kalbeet camp in northern Idlib as reports indicated an outbreak of cholera, October 29 2022. Reliance on unsafe water increases the risk of contracting the water-borne disease. Source: Yahya Nemah / EPA

Additionally, the lack of privacy, hygiene, and physical health undermines personal dignity and mental health for those affected, especially for women and girls. [97]

Disrupted Access to Safe Drinking Water

On a national level, the ICRC estimates that the level of access to clean drinking water dropped by 40% compared with the situation before the armed conflict, affecting millions of people.[98] The breakdown of public water infrastructure and management, as described above, has led to a number of uncoordinated coping activities, each with its own set of consequences. For example, some communities have noted increases in private well drilling, which threatens to further exacerbate groundwater depletion when unregulated (see also section 10 on groundwater).[99]

This was the case for one schoolteacher living northwest of Jisr al-Shughour, who said: "Unfortunately, there are currently no organisations trying to secure water for the people, nor are there any efforts by the local council of the village of [...]. There are no companies, but rather just individuals who dig the well, put a pump, draw water, and sell this water to tankers, and in turn, the tankers sell water to civilians at high prices."

Many households in northwestern Syria have become increasingly reliant on water trucking as pre-conflict water networks have become progressively more expensive and/or inoperable. As of August 2022, 63% of local communities and 73% of people in camps rely on water trucks. These water networks cannot supply the necessary amount of water to the region, however, due to unstable power supplies and the high operation costs of diesel-fuelled power-generating systems.[100]

In another village northwest of Jisr al-Shughour, a retired citizen told researchers; "...When we relied on [water] tanks for years after the departure of the Syrian regime, there was difficulty in obtaining water and high prices."

Following the 2021 electricity shortages, drinking water availability across the country has ranged from 30 to 60 litres per day, down from 80 to 125 litres per day in 2010. In March 2022, the national per capita share of drinking water was 64% of pre-crisis levels in urban areas, and 38% in rural areas, according to the UNDP.[101] Alongside availability issues, the safety of water sources is also deteriorating, as levels of chlorinated water continue to drop. According to an OCHA report, just 81% of the water from water networks and 61% of the water from water trucks across the country was chlorinated in 2022, down from 90% and 81%, respectively, the previous year.[102]

Unreliable access, availability, and safety issues with drinking water have also led to the rapid growth of the bottled water sector. This market boom is a result of damage to sanitary water delivery networks and government sterilisation stations, as well as the previously mentioned increasing spread of waterborne diseases, including cholera and malaria.[103] Even so, it is difficult for many communities to trust that bottled water has been adequately sanitised.

One activist from a village near the Turkish border described these concerns: "Unfortunately, [bottled water] companies do not sterilise the water or treat it. They only fill it directly from the spring. For example, my 8-month-old child drank healthy [bottled] water and suffered from severe diarrhoea. When I took him to the hospital, I found 50 cases of children with severe diarrhoea conditions."

This was echoed by a male healthcare professional living near Idlib city, "For drinking water, only healthy [bottled] water is used in my home for fear of diseases for my children. This is a financial burden on me, but it is also a priority for me, and I will not give it up."

These new informal water infrastructures and the bottled water market pose a heavy financial burden for local communities that cannot keep up with high water prices. Combined financial and water insecurity grew considerably during the summer months as the need for water increased, with some local individuals reporting a need for more than double the amount of water tanks used in the winter.

This was true for the previously mentioned activist near the Turkish border, whose family's "...consumption in winter is 2-3 tanks, in summer it is 4-5 tanks. The tank is 15 barrels, which means that in the summer we need 500 Turkish liras for water."

Testimonies demonstrate that the situation can vary considerably depending on local governments or other local organisations' support. For example, this same activist interlocutor expressed frustration as the local authority "has responded very poorly on the issue of drinking, it obstructs all solutions represented by resupplying water from the spring to the [mountain] villages, for the reason that it benefits from selling water through tankers, as well as the bottled water companies affiliated with [the local authority]."

Effects of Population Displacement on Water Acces

Syria hosts the second-largest (after Sudan) internal displacement crisis globally, with 7.2 million people internally displaced at the end of 2023.[104] In the Orontes Basin, the first three years of armed conflict saw the departure of three-quarters of the area's four million inhabitants, with people moving from the densely populated cities and irrigated rural areas to rural areas at the borders of the neighbouring countries of Lebanon and Türkiye or abroad.[105] Moreover, there has been a major shift in the demographic makeup of the north and south of the basin since the beginning of the conflict, with many religious and ethnic minorities such as Kurdish, Alawite, Christian, Shia, Ismaili, and Circassian populations having migrated or having been displaced to the central and southern government-controlled areas, while the north is now predominantly Sunni.[106]

Since then, the region has remained in a protracted crisis of displacement, with the northern part of the Orontes Basin in Idlib and Aleppo governorates hosting more than half of all Syrian IDPs, many located in formal and informal camps along the border with Türkiye.[107]

In 2017, record numbers of displaced persons were recorded in Syria by UN OCHA and partners: almost three million people, of which 30% (over 700,000 people) were located in the governorates of Idlib, Hama, and Homs. In 2019, in addition to those already there, new IDP arrivals in the Orontes Basin peaked at 1.1 million individuals, more than the rest of Syria combined.[108] At the start of 2020, northwest Syria was estimated to host over 2.8 million IDPs, a number which fell to 1.8 million in 2023, spread across more than 1,500[109] IDP sites in northwest Syria. Mass displacement continues, highlighted by the following critical statistics:[110]

- In the Dana subdistrict of Idlib, the nearly one million resident IDPs are more than five times the district's original resident population.[111]
- Almost 80% of IDP households in Syria have been displaced for over five years.
- 79% of IDP sites in the northern part of the Orontes Basin (Idlib and Aleppo provinces) are "critically overcrowded".[112]
- While most Syrian governorates accommodate IDPs in pre-existing public buildings and community facilities (including in Hama and Homs), more than 80% of IDP sites in Idlib and Aleppo are informal camps, while around 10% are planned camps.[113]
- In September 2023 alone, an estimated 5,300 families (estimated 26,500 persons) were displaced throughout the Northern Aleppo and Idlib governorates as a result of increased hostilities.[114]

The unresolved conflict in Syria has left locals fearful of new violence and the possibility of future displacement. At the same time, a collapsed economy and minimal basic infrastructure and services in their areas of origin leave IDPs unable to return.

The effects of displacement and protracted conflict compound already precarious water access. One school teacher living in a village west of Aleppo city spoke of the changes to water security that the village has experienced alongside an influx of displaced peoples: "During the time of the Syrian regime, water reached all the homes of [the village] and its quality was good, as it was treated and drinkable. This is according to the people of the area. I was forcibly displaced from the Damascus countryside in 2017 and have lived in [this village] since that time. But now, water is highly calcareous, its costs are high, and it is very scarce."

Currently, residents - and especially IDPs - in the northern part of the Orontes Basin do not have sufficient access to affordable, clean water.[115] More than 70% of IDPs acquire water from water trucking services without much assurance about the safety of the usually untreated water (see section 10 on Groundwater).[116] Because of limited access to safe sources, water is mainly used for drinking and cooking (more than 85% of households surveyed by REACH in northwest Syria have enough water for drinking and

Syrian Sub-Districts Hosting the Highest Number of IDPs and Returnees

May 2022

Sub-districs	District	Governate	Returnees	IDPs	Population	% of IDPs and Returnees over population
Dana	Harim	Idlib	0	972.592	1.153.807	84 %
A'zaz	A'zaz	Aleppo	9	231.095	296.528	78 %
Jandairis	Afrin	Aleppo	11	80.448	103.764	78 %
Maaret Tamsrin	Idlib	Idlib	0	247.457	322.116	77 %
At Tall	At Tall	Rural Damascus	2	196.780	261.733	75 %
Salqin	Harim	Idlib	0	137.755	211.589	65 %
Afrin	Afrin	Aleppo	0	113.100	187.868	60 %
Al Bab	Al Bab	Aleppo	36	106.324	202.118	53 %
Jaramana	Rural Damascus	Rural Damascus	175	299.146	603.551	50 %
Qatana	Qatana	Rural Damascus	137	144.114	294.809	49 %
Idleb	Idlib	Idlib	141	145.739	301.377	48 %
Atareb	Jebel Saman	Aleppo	0	90.829	190.917	48 %
Lattakia	Lattakia	Lattakia	48	409.096	934.064	44 %
Al-Hasakeh	Al-Hasakeh	Al-Hasakeh	117	126.030	291.962	43 %
Damascus	Damascus	Damascus	2.550	600.097	1.818.517	33 %
Homs	Homs	Homs	2.618	189.147	635.030	30 %
Qudsiya	Rural Damascus	Rural Damascus	404	99.476	343.238	29 %
Ar-Raqqa	Ar-Raqqa	Ar-Raqqa	27	108.302	379.993	29 %
Hama	Hama	Hama	16	162.317	750.466	22 %
Jebel Saman	Jebel Saman	Aleppo	18.860	166.860	1.667.719	11 %

Table 2. Syrian subdistricts hosting the highest number of IDPs and returnees (May 2022). Subdistricts from the Orontes basin are highlighted in blue. Source: UN OCHA (2022) Humanitarian Needs Overview Syrian Arab Republic.

cooking), but less so for sanitation and health.[117] For example, in the Al-Eman camp, established in Jindires after the earthquakes of February 2023, there were only nine litres of water available per person per day, while humanitarian standards mandate at least 20 litres.

Regarding sanitation, 70% of the camps lack showers and half of the latrines available in the camps require maintenance, according to recent assessments of 48 IDP camps across northwest Syria by Médecins Sans Frontières.[118] In the Al-Eman camp, there is only one latrine available for every 90 people.[119] In the Badama and Harim subdistricts, more than 10% of households included someone who could not access a latrine.[120] Most of the soil in northwest Syria is very rocky, making it difficult to dig adequate toilets and sewage holes.[121]

The same displaced schoolteacher living west of Aleppo spent time teaching within the IDP camps in her region, describing the ways in which water, sanitation, and hygiene (WASH) issues in these settings can exacerbate health concerns: "I noticed that sewage passes through canals within these camps, filled with insects while children play in them. In addition, there is also a lack of water in the camps, and there is no daily bathroom for children [there]. Therefore, infectious diseases spread widely in the camp, things like scabies and digestive diseases, such as severe diarrhoea and cholera. I have seen many cases of leishmaniasis among children, causing real disfigurement in children's faces."

Lastly, many of the IDP sites are located on the Orontes River floodplains, exposing the already extremely vulnerable IDPs to the risk of flooding (more on this in section 11 Flooding). Trees in the plain's surrounding forests and orchards are cut down by the residents of displacement camps in an unregulated manner, as they search for firewood for heating and cooking.[122] Without the trees, less water is absorbed into the soil, leaving the valleys even more prone to flooding, the groundwater reserves unreplenished, and the region less climate resilient.

Climate as a Driver for Migration and Armed Conflict in Syria: Academic Perspectives

Based on the annotated bibliography of the Syrian Climate-Migration-Conflict Nexus by Angermayr, G., et al. (2022).[123] The scientific debate on the relationship between the Syrian armed conflict and climate change has been ongoing for many years. In particular, there has been significant discourse concerning climate change and drought as contributing factors in rural-to-urban migration and the 2011 uprising. While some academics dispute a causal link between climate change and the conflict outbreak, based on the argument that socioeconomic and humanitarian crises predate the 2006-2010 drought,[124] the vast majority of the academic community contends that climate and environmental vulnerabilities are part of an interrelated set of sociopolitical, economic, and environmental factors and insecurities, such as poor governance, poverty, and resource mismanagement, that collectively contributed to the eruption of conflict.[125]

Despite wide-scale agreement in the academic community as to the existence of a relationship between climate and conflict in Syria, discrepancies exist concerning the concrete details of that relationship. For example, different research articles place the drought between different years, with time frames ranging from 2007-2009 to 2006-2011. This inconsistency not only reveals a lack of consensus on the defining features of drought but also underlines academic disagreement on notions of severity, given that a three-year difference in drought length can have enormous environmental and human impacts. Research gaps arise due to a lack of reliable data on the links between drought and migration. Traditional academic conceptualisations of migration, and particularly research on climate-related migration in Syria, often fail to engage with the growing critical climate migration literature, and as a result overlook the complex, dynamic, and multi-directional relationship between climate and migration. For example, drought-related migration could be short- (temporary or seasonal) or long-term, short- or long-distance, planned, or unplanned, etc. Recent underexplored topics in this field include voluntary and involuntary immobility, in which populations are either unable or unwilling to migrate despite experiencing the consequences of climate change. Voluntary and involuntary mobilities challenge traditional understandings of communities experiencing climate change and highlight the importance of understanding climate-related migratory decisions, patterns, and perceptions within the context of biophysically measured climate stressors. Furthermore, little is known about the post-migration experiences and livelihoods of Syrians—including farmers—who have left their lands. More research on this would inform policymakers and civil society organisations that work towards the well-being of Syrian refugees in their new host regions. While the exact causal mechanisms linking climate change and conflict are still unclear, it is widely accepted that climate change negatively affects socioeconomic, political, and cultural structures, and even more so in conflict-affected societies. It is therefore essential to discuss how communities in fragile environmental regions and conflict-affected countries can adapt to climate change and (re)build climate-resilient, peaceful societies. Attention to the impacts of climate change on this conflict should not divert attention away from fundamental political and economic motives behind the protests and shift responsibility away from the Syrian government.[126] Instead, a critical, transdisciplinary understanding is necessary about how the climate crisis and a socioeconomic and political crisis are interwoven and can risk reinforcing one another.

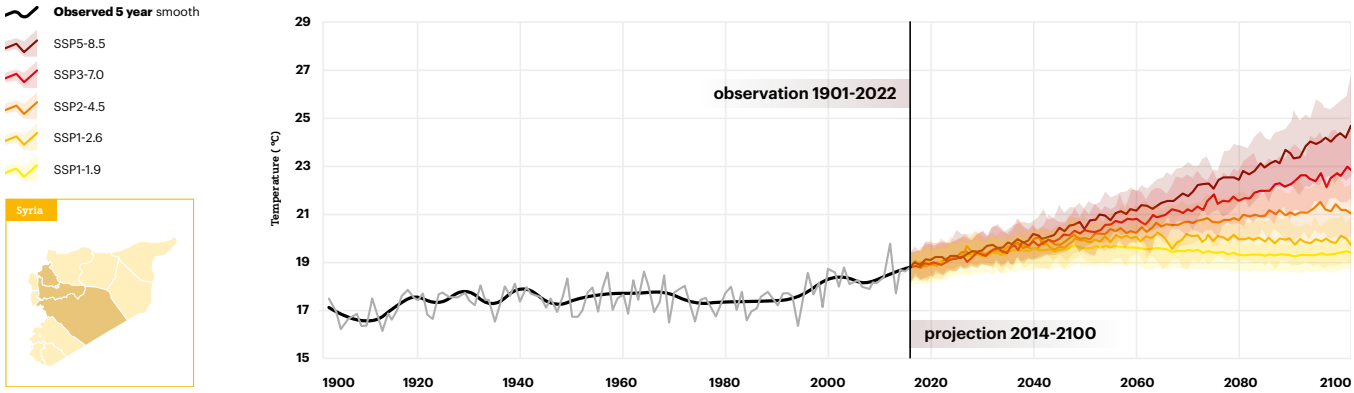
For more details, check the full annotated bibliography. [127] It provides an article-by-article summary of the 25 peer-reviewed research articles published on the climate-conflict nexus in Syria, where the post-2005 drought is discussed together with the Syrian uprising and subsequent armed conflict.

Shrinking Surface Water Availability

Most parts of the Orontes Basin have shown a decrease in surface water availability in lakes and rivers over the past decade. As it is difficult to differentiate between various factors contributing to that trend, this report describes the most important trends that can be monitored in the following three ways: climate change with increasing temperatures and decreasing precipitation, lake surface extent, and changes in agricultural land use.

▼ A shepherd leads his herd in the almost dried Duwaysat Dam outside the town of Al-Diriyah in the province of Idlib on November 9, 2021. Low rainfall, structural damage and extraction by struggling farmers have emptied the reservoir, leaving it completely dry for the first time. Source: Abdulaziz Ketaz / via AFP

Figute 7. Observed average annual temperature 1901-2022 (black) and projected average annual temperature 2014-2100 (coloured), including 10-90th percentile range, (CMIP6 multi-model ensemble, 5 SSP scenarios), averaged over the Homs, Hama, and Idlib districts. Source: Climatic Research Unit gridded Time Series (CRU TS) and Coupled Intercomparison Project Phase 6 (CMIP6) through the World Bank Climate Change Knowledge Portal.[128]



Climate Change and Decreasing Precipitation

Climate change is already clearly manifesting in the Orontes River Basin. The average annual temperature worldwide has risen by approximately two degrees in the past century, and it is expected to rise another by one to even five degrees by 2050, according to the worst-case scenario, i.e. the current global trend (see Figure 7). This has serious implications for water availability, as precipitation patterns are shifting and evapotranspiration increases.[129]

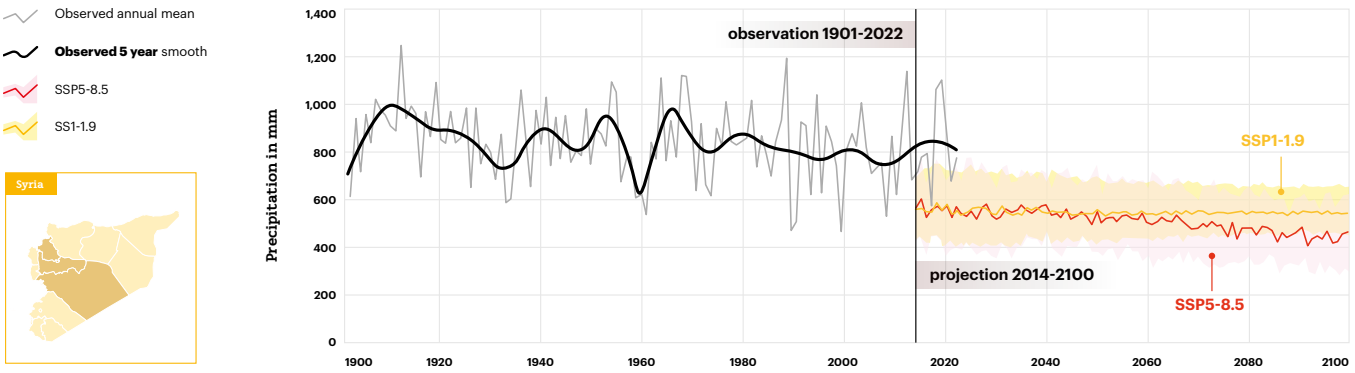
A female field researcher located west of Idlib city commented on the change in rainfall patterns, stating "In general, it is known that desertification and drought increase year after year, and the reason is the lack of rain."

Precipitation varies along the basin area: the western mountains capture moist air from the Mediterranean Sea and receive between 600 to 900 mm of rain annually, while the semi-arid eastern parts of the basin only receive between 300 and 500 mm annually (Climatic Research Unit gridded Time Series - CRU TS).[130] Most precipitation falls during the winter months, from November until March.

Figure 8 shows that the observed rainfall in the basin remained around 400 mm per year over the past decade, hinting only at a slight decrease compared to the beginning of the 1900s. Yet from the 1960s onwards, and even more clearly since the 1990s, rainfall has become increasingly variable and intense, with some winters seeing high levels of rainfall and others receiving very little (see Figure 9). Two winters ago, Syria experienced its most severe drought in 70 years, spanning from October 2021 to March 2023.[131]

The effects continued to be felt in August 2023, when a high school teacher expressed, "There is a drought and a lack of rain this year. The rains have been very scarce."

Overall, climate models contain more uncertainties in modelling rainfall patterns than surface air temperature. The precipitation projections from the model used for Figure 8 (CMIP6 multi-model ensemble SSP 1-1.9 and 5-8.5) show a large discrepancy with the observed rainfall patterns in the decades before from CRU TS,



likely because other rainfall data was used to build the models. Therefore, it is better to only interpret trends from the projected precipitation data instead of comparing them with the observed data. According to the worst-case scenario, i.e. the current global climate change trajectory (SSP5-8.5), a decrease in annual precipitation of around 50 mm can be expected by the end of this century, mainly during the winter months (see Figure 9).[132] Combined with higher evapotranspiration due to higher temperatures, this means that much less moisture will be available to trickle into the soil for agriculture, ecosystems, and both groundwater and surface water reservoirs.

A media activist around the age of 70 corroborated this perceived change over time: "There is little rain and high temperatures. Thirty years ago, there were floods in the Orontes River, where the height of the water reached 15 metres and the water reached the cities and villages. We no longer witness these phenomena, only that there is a scarcity of water and [the river] is receding"

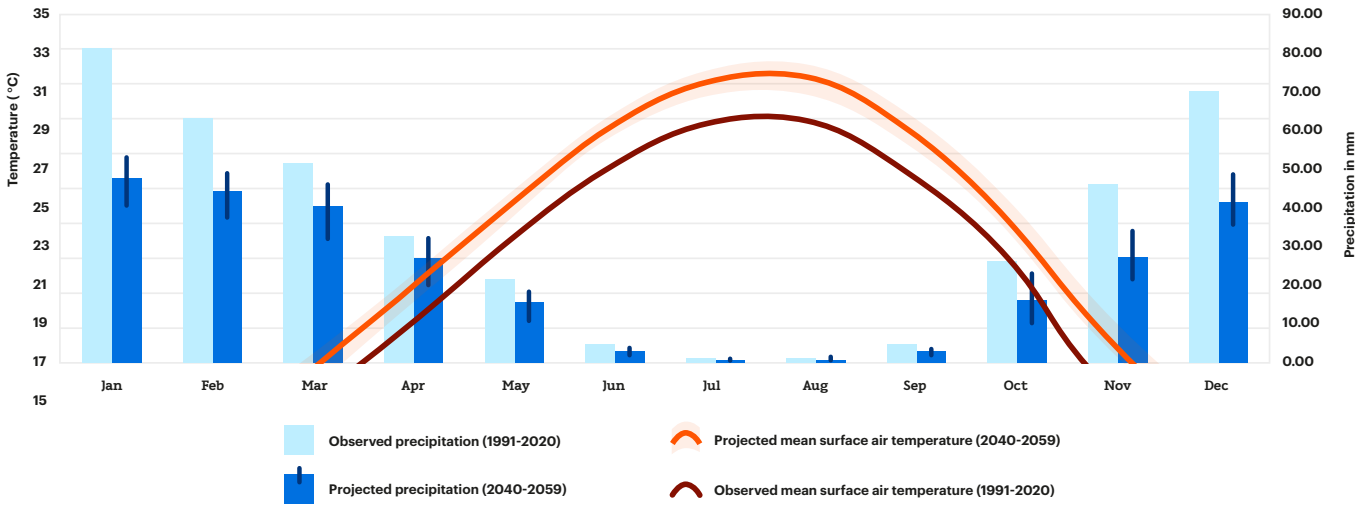
The Drying Up of Northern Lakes and Reservoirs

Since the start of the revolution in 2011, the Syrian part of the Orontes Basin has lost 19 km² of its surface water, including both permanent and seasonal lakes and reservoirs (see Figure 10). This equals a loss of 18% of 2011 surface water levels. Another 2 km² of lakes have since degraded from permanent to seasonal water bodies. This loss mainly occurred in the northern part of the basin, downstream of Hama, including around the Sarout, Deir Schmail, and Qastun Reservoirs, as well as the Maydanki Reservoir on the Afrin Tributary. The impacts are severe, given that the less water available in the lakes, the higher the concentration of pollutants.

At the same time, the Syrian part of the Orontes River gained 2 km² of permanent water and 30 km² of seasonal water between 2011 and 2021, while 4 km² turned from seasonal to permanent water bodies. This means a net increase of surface water extent over the entire Orontes Basin of 1,3 km² of permanent water and 12 km² of seasonal water bodies. These increases in available surface water are observed in the southern (upstream) part of the basin, around the large Qattinah and Rastan Reservoirs, as well as the smaller Zeta and Tildo Reservoirs. This combination of shrinking and increasing lake or reservoir surfaces has been visualised in the maps below (see Figure 10).

The years of drought before the armed conflict (see Box 3: Summary of the academic debate on climate as a driver for migration and armed conflict in Syria) can partially explain this net increase in the surface extent of freshwater between 2011 and 2021 over the entire basin. However, the contrast between an increased water extent in the southern, upstream part of the basin and a decrease in the northern/downstream section is striking. Precipitation followed a similar trend in the past decades in the three governorates, and therefore cannot explain the difference. As a result, the discrepancy is more likely due to a difference in water management and use, including damming and irrigation for potential household, industrial and agricultural use.

▼ Figure 9. Monthly precipitation (bars) and temperature (line) for Idlib, Hama, and Homs districts, comparing current climate (1991-2020) in grey scales with future climate (2040-2059, CMIP 6 model ensemble scenario 4.5, SSP 5-8.5) in colour. Source: World Bank Climate Change Knowledge Portal.



Testimonies have mentioned that more water is being stored in the southern part of the basin for more intense irrigation in the regime-held areas, decreasing the amount of water flowing north.

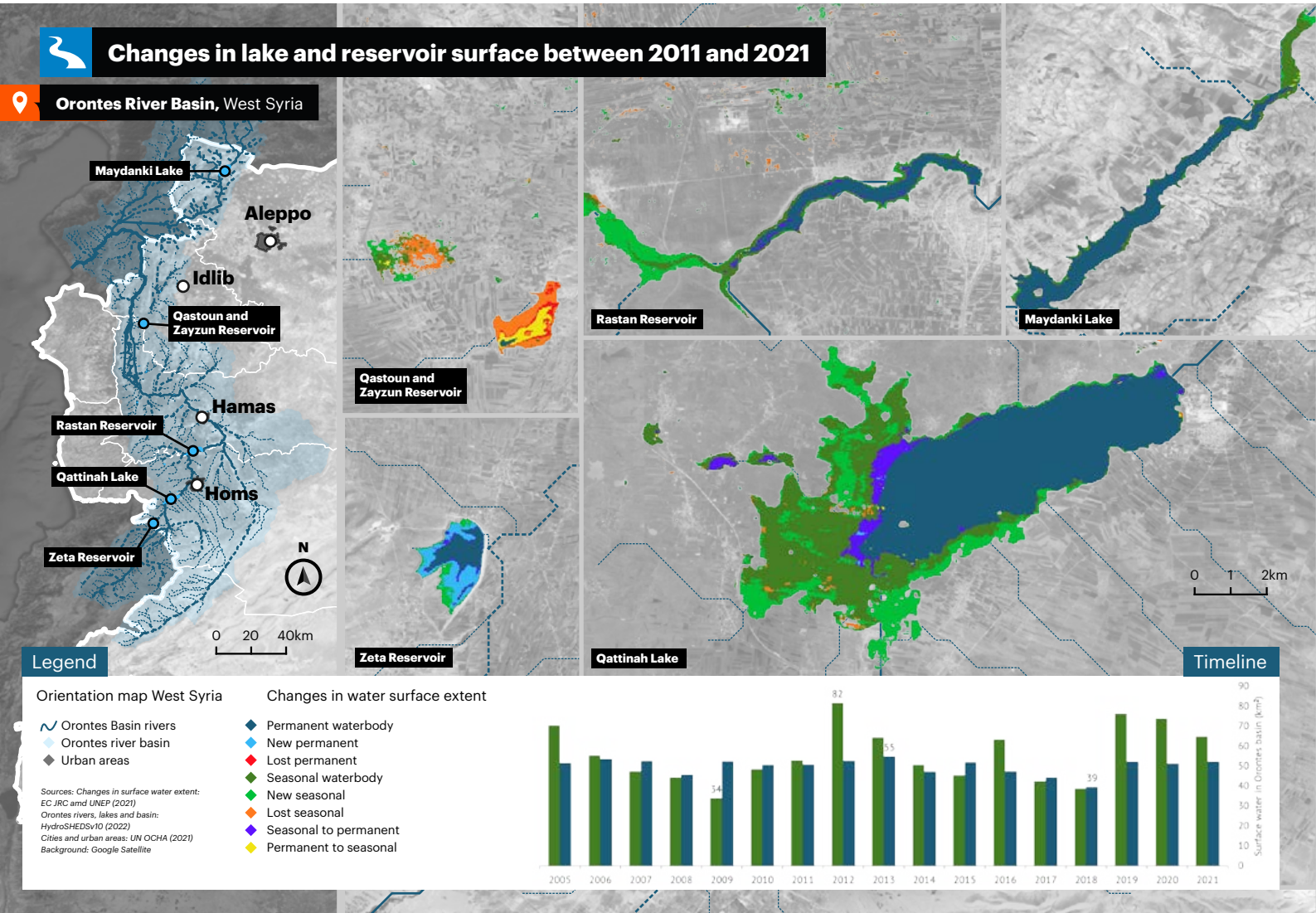
A field researcher from a village near the Turkish border corroborated this, stating: "Regarding irrigation, the water flow of the Orontes River has decreased due to the Syrian regime's reliance on withdrawing water with pumps on the Plains of Homs and Hama and preventing it from reaching northern Syria. This is a malicious policy that did not exist before. Idlib's soil is better; it was getting more water, as Idlib is considered the breadbasket of the entire Syria."

Several streamflow measuring stations have been active on the Orontes River, including. Al-Qusayr station close to the border with Lebanon; Jisr al-Shughour station, just upstream of where the Orontes forms Syria's border with Türkiye; and Demirköprü station, just across the border in Türkiye.[133] Unfortunately, no river discharge data can be found available online for the period since 2011. This missing information is crucial to understanding the hydrological effects of different activities in the basin, including the impacts of conflict, climate change, and water storage for irrigation purposes, as well as planning for integrated, sustainable water management in the region.

Agricultural Land Use and Irrigation

Water availability is not only dependent on a changing climate but also on how it is consumed. Agriculture is the largest source of water use in the Orontes Basin. In pre-conflict times, agriculture accounted for over 77% of the total water usage in the Orontes Basin, with household water use coming in second at 9% and industrial use at 8%.[134] Irrigation activities and infrastructure were present in the region as early as the Bronze Age and were expanded during the Hellenistic, Roman, and Byzantine periods.[135] Between the late 1950s and 1980s, agrarian reforms and the centralised agricultural policy established large irrigation schemes along the river, most notably in the Al-Ghab Plain, which benefited many farmers in the Orontes region. Later irrigation developments by the Syrian government

Figure 10. Changes in lake and reservoir surface area between 2011 and 2021, including permanent and seasonal surface water extent. Permanent water surfaces are present throughout the whole year, including during the dry summer period. Seasonal water is only observed during one or several months throughout the year, most often during the wet winter months and withspring meltwater. Source: EC JRC and UNEP (2021) Global Surface Water Data.[136]

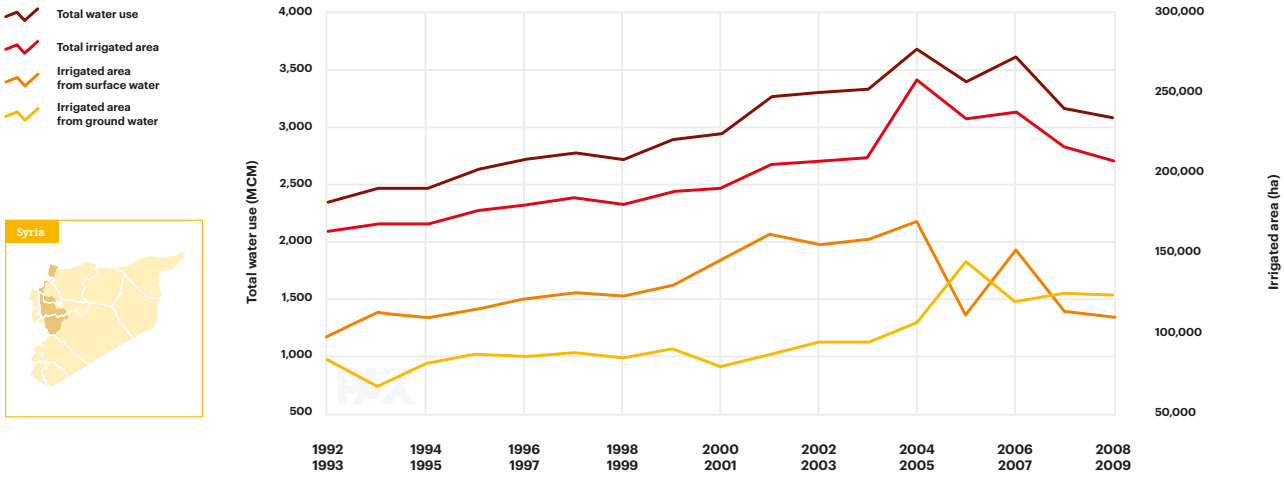


mainly focused on the Euphrates Basin.[137] Nevertheless, the Orontes infrastructure, such as irrigation canal networks, reservoir dams, and underground water pipes have played an important role in boosting the agricultural activities and food security in the area. Between 1992 and 2008, the total area of irrigated agricultural land in the Orontes Basin increased from around 180,000 to 250,000 ha, ranging from orchards and vegetable production in the south to the vast plains between the Al-Ansariyyah Mountains (جبال الأنصارية) in Latakia in the west and the Zawiyah mountain range (جبل الزاوية) in Idlib in the east. This increase in agriculture has been a heavy burden on both surface water and groundwater resources (see Figure 11).[138] Overall, the basin produced around a quarter of Syria's total agricultural production until the start of the conflict.[139]

The early years of the conflict (2011 to 2013) saw an estimated reduction of 15% of the basin's irrigated lands,[140] although other sources claim higher numbers. Figure 12 shows a map of exactly where and when the agricultural lands of the Orontes Basin were abandoned and recultivated. Compared to a baseline from 2000-2004, almost 39,000 ha (4.5%) of agricultural lands had been abandoned before the revolution (2005-2010) and around 150,000 ha (17.2% of agricultural lands) have been abandoned since the onset of the conflict (2011-2020).[141] 55,000 ha (6.3% of the total agricultural land) was recultivated between 2008 and 2020. This means that the Orontes Basin experienced a permanent net loss of around 130,000 ha (15.4%) of agricultural lands between 2005 and 2020, mostly in the higher elevations of the basin, further away from the main river canals, but also closer to the main river such as southeast of Hama city (towards Salamiyah) and in its northern reaches on the river's direct floodplains south of Darkush.[142]

Various conflict-linked drivers have led to a reduction in water availability and irrigation, while also to a lesser extent having led to increased local cultivation. For many years, the region has been a frontline between different conflict parties, which has put the irrigation infrastructure there at high risk of military targeting and made it vulnerable to destruction and looting. The water supply in the Al-Qusayr district, as one example, was interrupted due to the destruction of springs and channels in 2011.[143] Numerous irrigation channels across the entire basin have been damaged by bombing and fighting, and most irrigation infrastructure has been abandoned by the personnel that maintain it.[144] In a more recent example, near the Zayzoun Dam in 2020, more than 2 km of water pipelines were dug up and removed. These pipelines had previously pumped water from the Orontes River to the Zayzoun and Qastun Reservoirs to irrigate the Al-Ghab Plain, in the western Hama governorate.[145] This has led to less water being available for farming in the Al-Ghab Plains, as it instead now flows downstream in the Orontes River towards Türkiye.

Evolution of water use and irrigated areas in the Orontes Basin, Syria, between 1992 and 2009

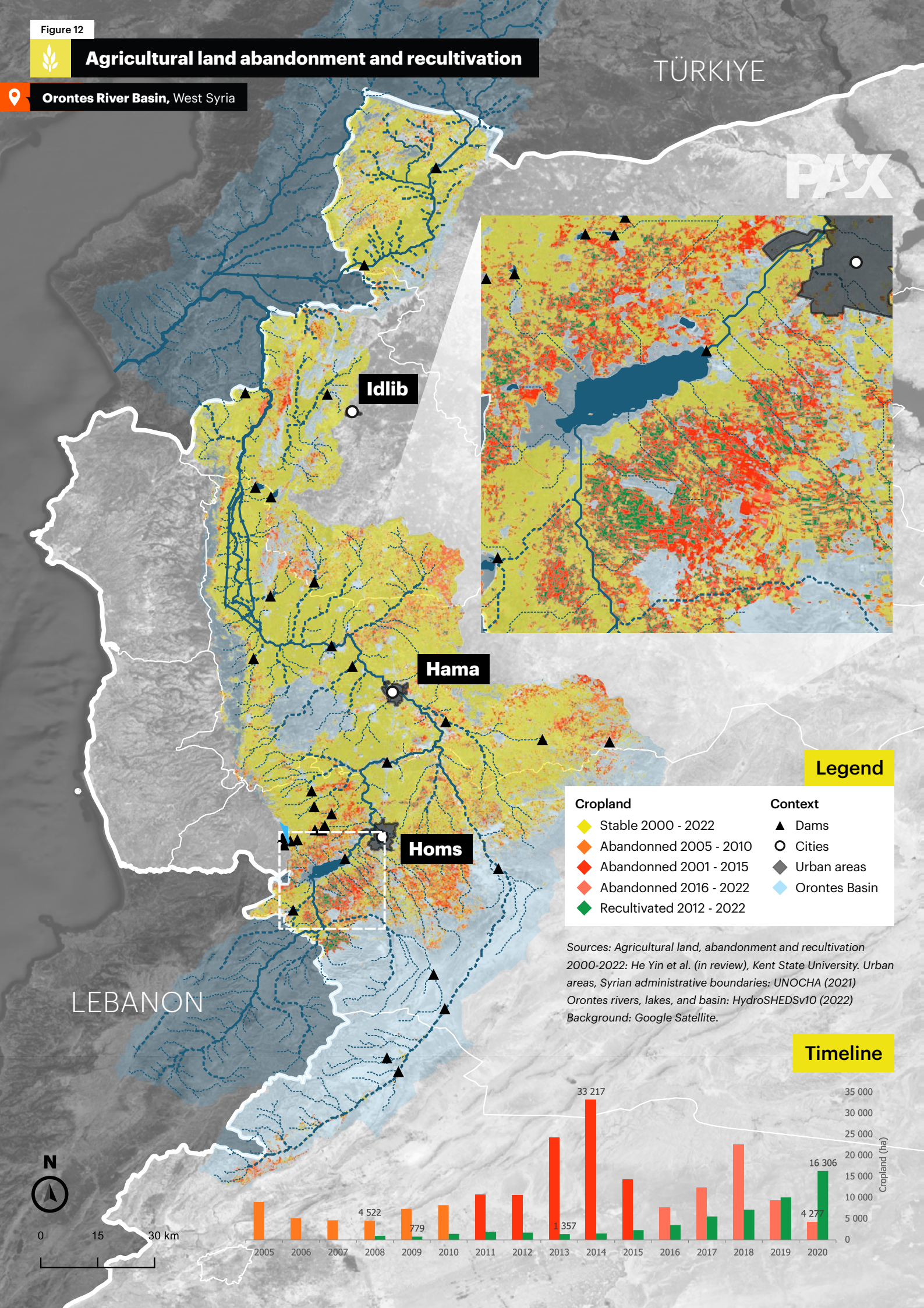


▲ Figure 11. Land abandonment (2005-2019) and recultivation (2008-2020) in the Orontes Basin, Syria. Source: Yin, H. et al. (in preparation) based Landsat, Sentinel-1, and Sentinel-2 imagery from 2000 to 2022. [146]

Figure 12

Agricultural land abandonment and recultivation

Orontes River Basin, West Syria



Furthermore, the testimonies gathered by PAX report a lack of laws and coordination on irrigation from the Orontes' shared region between the Turkish and Syrian sides, with Türkiye advancing irrigation projects and leaving the Syrian side with fewer water resources, as evidenced by the statement from a civilian of a town close to the Turkish border, northwest of Idlib:

> "Türkiye has set up a number of pumps, about 12, in the state of Hatay to draw water to vast agricultural areas. The capacity of the pump is 12 inches, according to my information. This is near the Burda Dam that Türkiye built in the Alans area. As far as I know, there are no laws to protect water resources. Türkiye and the [Syrian] regime are responsible for the deterioration of the water situation by establishing irrigation pumps."

A similar issue was reported between the southern and northern reaches of the Orontes within Syria. A resident of a village northeast of Idlib attributed shrinking water availability in the northern reaches of the river to the control over Homs and Hama by the Syrian regime in the south:

> "As for the waters of the Orontes River, [...] according to my information, the Syrian regime has set up dozens of pumps that draw from the Orontes River and irrigate vast agricultural areas created by the Syrian regime, which are far from the Orontes River. Their aim is to deprive northern Syria from benefiting from the waters of the Orontes River."

Yet, according to the above-mentioned civilian close to the Turkish border, recultivation flourished when the Syrian regime was no longer present in their region and many new irrigation projects were set up, albeit unplanned:

> "There are uses of water in agriculture, where additional agricultural areas have been created and special projects have been developed to irrigate and care for these new agricultural areas that have arisen in the areas of Hayat Tahrir al-Sham [the de-facto government in the Idlib governorate]. Agriculture has flourished in our regions with the departure of the Syrian regime, but in the end, it is random and lacks planning."

Where there is insufficient surface water or diverted Orontes water for irrigation, water is pumped from drill holes reaching water-holding aquifers in the subsoil by individuals and organisations alike, including aid organisations, as outlined by a female field researcher from a village close to the Turkish border:

> “As for irrigation, the Qatar Red Crescent and the Cham Takaful Organisation are working to install energy panels for irrigation projects. The irrigation projects that the Syrian regime had established required maintenance by the previously mentioned organisations, projects such as the Al-Allaniya, Al-Farouqiya, Al-Tulul, and Khair al-Jamous irrigation projects. New projects by organisations in the region include the Delphia and the Mishrifieh projects. There are also some local underground wells whose owners sell water to the people via tankers”.

▼ Solar panels used for agricultural water pumps are visible in this satellite imagery, showing post-harvest haystacks near the town of Sheik Youssuf, Idlib in June 2023. Source: Airbus

Groundwater

Prior to the armed conflict, groundwater in the Orontes Basin was the main source of drinking water for local inhabitants,[147] but it was also increasingly used for irrigation. In 2009, the FAO estimated the amount of groundwater in the Syrian part of the Orontes Basin to be over 1,500 million m³, of which 70% flows out as spring water and 30% is stored underground in aquifers. The depth of the groundwater table[148] differs from one area to another, depending on the distance to the main river and the regional geology, in turn determining the depth of groundwater wells (see Figure 13).[149]

Two types of wells exist. The first are surface wells, which range from 70 to 120 metres deep to reach underground aquifers just below the surface. These aquifers are replenished seasonally during the winter, when the rain seeps into the upper layers of the soil. However, in cases of water and soil pollution, this groundwater can become contaminated, while these aquifers can also run dry during summer droughts. The second type of well reaches much deeper (500 metres or more), drilling through impermeable rocks to access pockets of water trapped below. Unlike shallow wells, these deep wells are independent from rainwater refills and uncontaminated by pollution sources in the topsoil and surface water. However, they can take thousands or even millions of years to refill if they run dry.[150]

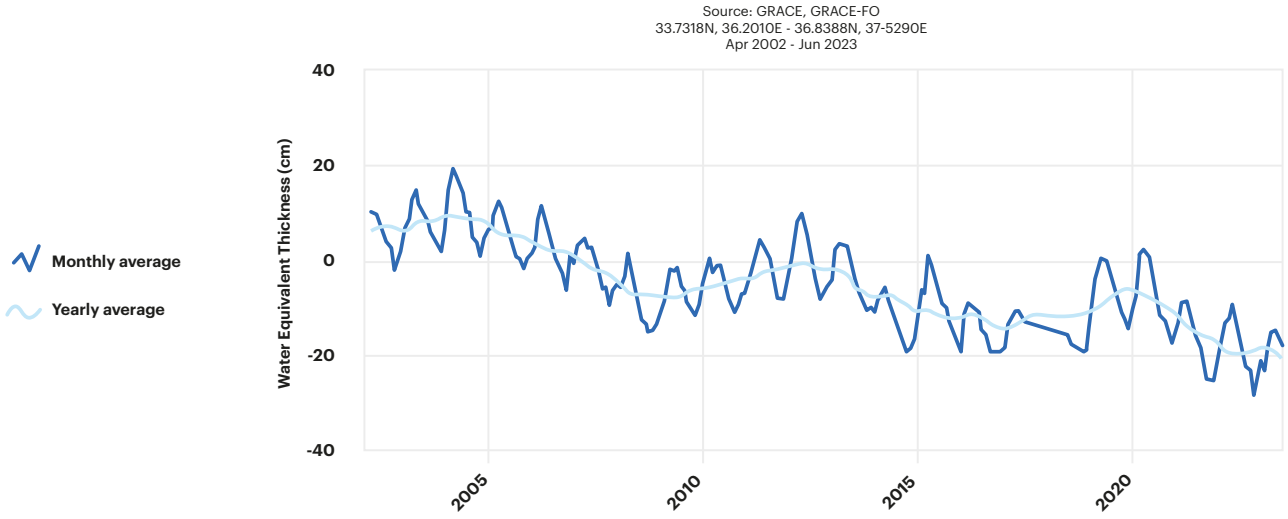
As the precipitation rate decreased during the years before the conflict (see Figure 8 in the previous section), areas irrigated with groundwater increased, while rain-fed cropland decreased. More than half of groundwater wells in the Hama and Homs provinces were estimated to be dug illegally.[151] Uncontrolled extraction led to a clear drop in the annual discharge of 26 springs in the Al-Ghab Plain: almost 20 m^3/s of water discharged in the 1960s decreased to 4 m^3/s in the 1990s. The expansion of irrigation using groundwater has been most intensive in the Al-Ghab Plain and the Idlib governorate.[152]

Satellite-derived data on groundwater storage, available from 2002 onwards (see Figure 13), shows a clear trend of decreasing groundwater reserves in the Syrian part of the Orontes Basin preceding the March 2011 revolution: a decrease of 14,2 cm water equivalent thickness between spring 2002 and spring 2009. This is roughly equal to a loss of 142 litres per square metre of available land, or 1,420,000 litres/ha of land. Between spring 2009 and spring 2012, the last years before the revolution and during the first year of the armed conflict, groundwater storage replenished with around 7,6 cm water equivalent thickness.

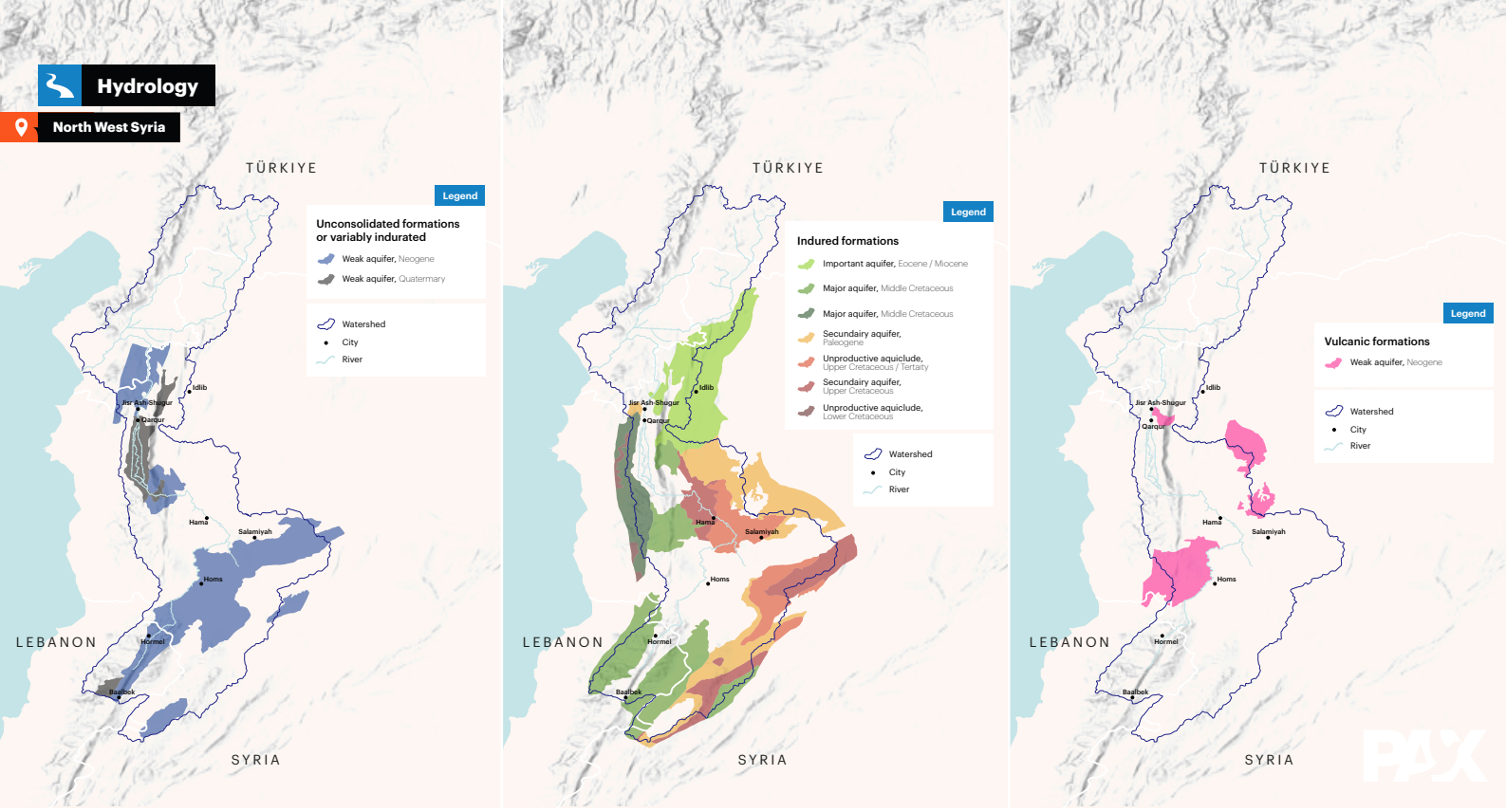
During the armed conflict, water infrastructure such as dams, reservoirs, springs, wells, pumps, and irrigation canals have been severely damaged by fighting and looting and have suffered from lack of maintenance. One area in which this occurred was Idlib's Al-Ruj Plain. By 2014, 15,000 ha of cropland had completely dried up and around 13,000 ha of formerly irrigated land became reliant on rainfall to grow wheat and barley.[153] Similarly, in the district of Al-Qusayr, more than 20,000 ha of irrigated land dried up in the first years of the conflict and ceased to be cultivated, after around half of the 6,000 wells and 11,000 pumping facilities were destroyed or looted.[154]

The decreasing availability and quality of surface water during the armed conflict induced the uncontrolled growth in the drilling of new groundwater wells.[155] Today, the large majority of the 4.5 million people living in northwestern Syria, including around 3 million IDPs, rely on boreholes and [156] The Water Resources Department of the Salvation Government, which has de-facto control of much of Idlib province, registered around 1,000 boreholes in the province but admits that it has no accurate statistics due to a lack of staff in their administration.[157] Satellite-derived data confirms an estimated loss of groundwater storage in the Syrian part of the Orontes Basin of around 22,5 cm water equivalent thickness between spring 2012 and spring 2023 (see Figure 13). That is equal to 225 litres per square metre, or 2,250,000 litres/ha of land.

Many testimonies included comments about the over-exploitation of artesian wells and springs through the digging of private or informal wells within communities. One male retiree from a village northwest of Jisr al-Shughour noted how the change in governance affected the use of wells.



▲ Figure 13. Monthly (dark blue) and yearly (light blue) changes in groundwater storage between April 2002 and June 2023 in the Syrian part of the Orontes River Basin in comparison to baseline storage averaged over the period of 2004 – 2009 (respectively for each month and yearly), presented as changes in water equivalent thickness (cm). Note: water equivalent thickness is not the same as groundwater depth, or changes in groundwater depth. Rather, it estimates the changes to groundwater volume stored underground. The (changes in) groundwater depth depend on the thickness of geological layers and their ability to hold or repel water. Source: GRACE, GRACE-FO through the NASA GRACE Data Analysis Tool.[158]



▲ Figure 14. Simplified map of groundwater resources and natural spring of the Orontes River Basin. Source: Zwahlen F., et al. (2016).[159]

Groundwater resources are being extracted at an unsustainable rate in the Syrian part of the Orontes Basin. As the groundwater table lowers, supply is depleted and many groundwater wells run dry.[160] As the depth necessary to reach water continues to grow, the cost of drilling and pumping water increases, putting an extra financial burden on locals to access water. For example, groundwater-irrigated croplands in the districts of Kafr Zaytah, Kurnaz, and Qal›at al-Madiq dried up in 2014 due to a lack of fuel and electricity to power the pumps.[161] In addition, over-pumping and exploitation are leading to a decrease in groundwater quality: the less water there is in an aquifer, the more it becomes concentrated with minerals such as salt, sulphur, and lime. Consequently, many groundwater wells have become unsafe for human consumption, leading to skin and kidney diseases. Using this water for irrigation also causes an accumulation of minerals in the soil, increasing its salinity, which is harmful to many crops and results in low yields.

Flooding

Floods are not the first thing that comes to mind when describing water issues in semi-arid regions. They are a common natural hazard in the area, however, most often in the form of flash floods. These should not be overlooked because of their ability to arrive rapidly, their destructive impact, and their increasing frequency due to climate change.

The mountains in the western part of the Orontes Basin receive large amounts of precipitation during winter periods. In early spring, meltwater from melting snow then adds to the basin's runoff and surface waters. Based on historical data (1960-1999),[162] more than 400 km² of the Orontes Basin in Syria can be expected to flood between 10 cm and 1 m deep at least once every 10 years, mainly in the Al-Ghab Plain. With many agricultural villages and towns situated in the floodplains of the Orontes, floods regularly claim victims, including citizens, infrastructure, and fertile fields.

Settlement in the area has intensified since the armed conflict began, with many IDP camps located on the shores of the Orontes River for easy access to water. Floods frequently wash away these temporary shelters, the personal belongings of IDPs, stored food, and equipment, displacing the camps' inhabitants once more.[163] For example, in November 2016, 21 displacement camps in the Atmeh and Karama camp clusters were hit by flooding.[164] In December 2018, severe storms affected the regions of Idlib and western Aleppo: 43 displacement camps in the Atmeh, Karama, and Qah clusters reported problems with flooding such as inundated tents and access ways, and property damage.[165] In March 2019, flash floods hit humanitarian relief and IDP camps in Idlib province, affecting 6,500 families, damaging road infrastructure, and destroying food stocks.[166] 115 camps in the Idlib region reported problems related to the floods.[167] Atmeh camp was the most affected, with over 40% of the site washed away.[168] In June 2020, severe flooding in Ma'aret Tamsrin affected 20 IDP sites, killed three inhabitants, and destroyed sanitation infrastructure and hundreds of shelters.[169] In March 2023, storms and heavy rains flooded 30 displacement sites in northwest Syria, damaging and destroying 1,500 tents.[170]

The devastating earthquake of February 2023 on the Turkish-Syrian border destroyed several natural and manmade river embankments in northwest Syria. An agricultural dam collapsed and flooded Al-Tloul and nearby villages in the Salqin subdistrict, forcing approximately 7,000 people to evacuate their homes.[171] 18 km² of young crops were also destroyed in the flooding.[172]

▲ Destruction of IDP camps as a result of rainstorms in the Idlib governorate and northern and eastern Aleppo countryside, resulting in 63 camps damaged and 33,742 people affected, March 19, 2023 . Source: Syria Response Coordinators via Facebook.

Farming households were left without shelter, irrigation facilities, or income. Syrian engineers are highly concerned about identified cracks in the Maydanki Dam, 12 km upstream of Afrin in northern Aleppo governorate. Although Syrian dams have been constructed to withstand extreme conditions (such as magnitude 9 earthquakes) and reported to be safe based solely on theoretical (rather than actual) conditions,[173] there is a lack of monitoring and maintenance despite visible damage from bombardments, earthquakes, and water leaking into cracks.[174]

In the opposition-held region of northwestern Syria, years of fighting, bombardments, the 2023 earthquake, and flooding have collectively taken a heavy toll on the region's inhabitants and internally displaced people. With every disaster, the region has become more inaccessible to aid. Destroyed hospitals, electricity, and water infrastructure have left these communities extremely vulnerable to floods. Before the start of the armed conflict, Türkiye and Syria had begun collaborating to prevent further flood disasters in their joint areas of the lower Orontes.[175] This included, among other measures, an early flood warning protocol (2008), two flow measurement stations, and large-scale flood protection infrastructure (i.e. the Asi River Friendship Dam). However, since the beginning of the conflict, the measurement stations have experienced telecommunication issues and are no longer operational, while the Friendship Dam has not progressed further than the first celebratory foundational stones in February 2011.

A flood modelling exercise showed that in the North Dana sub-district of Idlib, 5,724 shelters would be hit by a flash flood of a magnitude expected once every 25 years, inundating the camps to a depth of at least 0.2 m.[176] Looking ahead to 2050, climate change projections do not expect an increase in flooded areas.[177] Only 65 km² of the Orontes Basin in Syria (compared to more than 400 km² historically) is expected to flood by between 10 cm and 1 m in depth once every 10 years, mainly upstream of the Qattinah Lake and around the Rastan Reservoir Lake.[178] Most floods recurring every 10 years are not expected to rise above 10 cm high. For floods that occur around once every 25 years, more than 450 km² is expected to flood between 10 cm and 1,5 m deep, a figure in line with historical values of 1960-1999.[179]

Interestingly, floods are not perceived as a major issue by the interviewees of this report's testimonies. One elderly activist located in the northwest of Idlib mentioned that "thirty years ago, there was a flood of the Orontes River where the height of the water reached 15 metres, and the water reached the cities and villages. We no longer witness these phenomena, only that there is a scarcity of water, and it is receding". It is important to note, however, that there were no inhabitants of the IDP camps along the river among the interviewees of this report.

Effects of the 2023 Earthquake on Water Resource

Numerous agricultural regions in northwest Syria were affected by the earthquake on February 6th, 2023, particularly along the banks of the Orontes River, which connects the province of Idlib to Türkiye. The earthquake and subsequent aftershocks caused cracks and fissures in areas of farmland. These fissures allowed volcanic sands to be ejected from deep within earth to the surface, contaminating surface soil and preventing the trees from absorbing the nutrients they need, causing them to dry out and die. According to local officials in NW Syria, some 2,000 ha were affected by this phenomenon.[180]

The earthquake also caused changes in the geography of the affected region. The Orontes' water level increased in certain places, while receding in others. In some areas where the level of the river rose to equal the level of the soil, the land flooded, drowning crops and damaging the roots of the trees. A female field researcher from a village close to the Turkish border stated: "As for the earthquake, we witnessed a flood of the Orontes River, which led to the flooding of some of the streets of the surrounding villages and destroying some agricultural [cultivation and harvest] seasons."

Altering the water level of the river has also changed the position of private and public irrigation pumps relative to the groundwater table, leading some farmers to enjoy plentiful water while it became more difficult and expensive for others to acquire water.[181] One resident from a town close to Idlib noted "The earthquake caused the destruction of many wells, causing the water to descend to greater and greater depths."

The earthquake caused flooding around 100 km to the south of the epicentre of the quake in several towns in the Idlib governorate, damaging bean and wheat crops in the area. The UN reported that thousands of people were forced to evacuate their homes and lands as a result of the flooding, with the most affected communities being the villages of Al-Tloul, Jisr al-Maksur, Al-Mashrafiyah, Jakara, and Hamziyah.[182]

Gendered Impacts of Water Degradation in the Orontes Basin

Communities also face severe economic hardships due to a lack of reliable water sources and subsequent impacts on agriculture. Women in particular are disproportionately affected, as many who live in agricultural communities face the double burden of having to seek alternative forms of income while also bearing the majority of domestic responsibilities.[183] Women's participation in agriculture in Northwest Syria, particularly in the form of waged seasonal migratory labour, has been steadily increasing: in 2010, just before the armed conflict, it accounted for 60.7% of the total share of the economically active population in agriculture, meaning more women than men working in agriculture.[184] In addition, domestic labour, such as cleaning, cooking, and caretaking, is growing as resources (including food and water) become less available, more family members fall ill, and psychological distress increases. As women are traditionally tasked with most water-related household tasks such as laundry, cleaning, cooking, and bathing, they are at the frontlines of water scarcity and are forced to adapt lifestyles and labour to having less access to water. Furthermore, as a result of the conflict, 28% of Syrians over the age of two reportedly have a disability (a number which jumps to 37% in northern Syria), presenting another challenge for domestic labourers who provide care for disabled community and family members despite the lack of available resources (and while often having disabilities themselves).[185] Syrians with disabilities face significant discrimination, resulting in physical and financial insecurity, while women with disabilities are reportedly two to three times more likely to experience violence.[186]

Women seeking alternative forms of labour, often in traditionally male-dominated sectors, have experienced rising workplace harassment and gender discrimination, with many women feeling too financially insecure to seek recourse.[187] Workplace conditions are particularly difficult for women whose husbands are not present (including widows and those whose husbands emigrated, have been detained, or are missing), since these women often have no childcare options and must bring their children to work.[188] Information regarding women's participation in informal or illegal workplaces, including sex work, within the Orontes Basin is sparse. Further research into this and the structural mechanisms (or lack thereof) for justice and accountability for labour rights violations and instances of sexualised and gender-based violence (SGBV) and discrimination within the context of the Orontes Basin would help shed light on the gendered impacts of water insecurity.

This expansion of women's roles, inside and outside the household, has also been perceived by some men as a threat to traditional and local gender roles and notions of masculinity (in particular, masculinity as derived from the role of primary financial provider or breadwinner). The perceived threat to masculinity has, in many cases, led to increased psychological stress for all household members, feelings of powerlessness and insecurity among men, and subsequently a surge in levels of domestic and gender-based violence.[189]

Forcibly displaced communities, moreover, often experience the gendered consequences of water insecurity more acutely, as the overlapping socioeconomic, cultural, and environmental stressors are amplified by the vulnerabilities and inequalities of displacement. As previously outlined, the Idlib and Aleppo governorates in northwest Syria host more than half of all IDPs in the country.[190] The gendered impacts on livelihoods are more severe for displaced peoples when assets are left behind, livelihoods are lost, and families are separated (resulting in disrupted family structures).[191] Forcibly displaced peoples also often move to camps in resource- and infrastructure-poor areas, with fragile or unequal governance structures.[192]

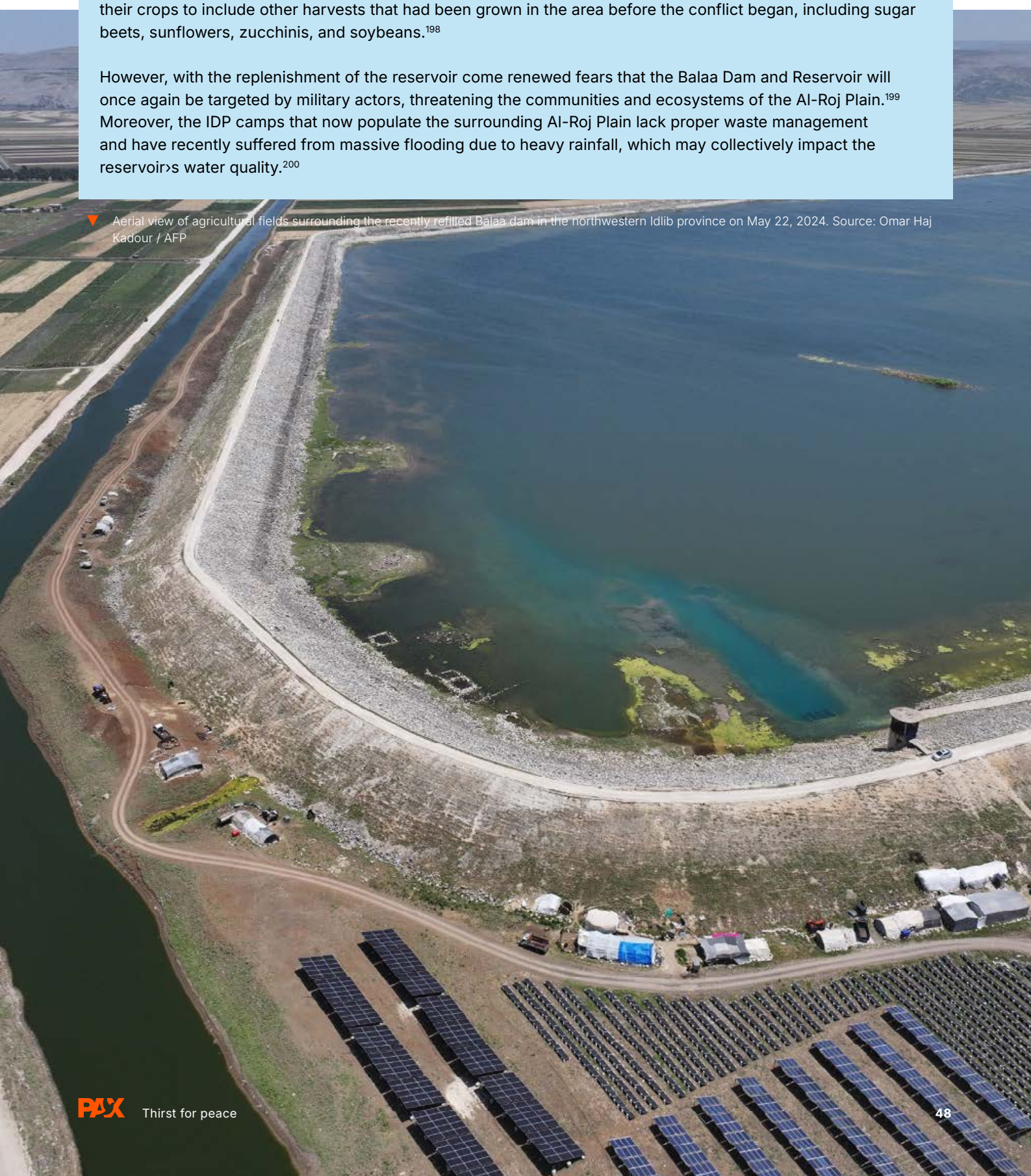
Within these IDP camps, displaced women are more at risk of different forms of SGBV, especially in self-settled camps with little or no safe WASH facilities.[193] Due to a lack of privacy and security around latrines, bathing facilities, and water collection points (which are often tents made of mud or small open pits), these makeshift facilities are often the location of SGBV, particularly for women and girls.[194] Conversely, the poor lighting and lack of proper infrastructure may reduce the usage of WASH services by women and girls who fear SGBV, resulting in increased health risks.[195] The increased and disproportionate health impacts of water insecurity and displacement on women and children are highlighted by a male healthcare professional living near Idlib: "The earthquake caused an increase in the number of people who do not own homes, and thus an increase in the number of [IDP] camps. Consequently, there is an increase in skin and digestive diseases that affect children and women, in particular. This is the greatest harm, in my opinion."

These gendered impacts of water insecurity must be understood within the broader context of conflict in the region. Experts outline how, throughout Syria, direct and indirect violence disproportionately affects women and girls, whereby they experience a range of human rights abuses from various conflict actors, including unlawful killings, deprivation of liberty, discrimination, and gender-based violence.[196] Women and girls also face systemic discrimination, exacerbated by the conflict, including the deprivation of their rights to legal redress, civil documentation, education, medical care, and effective participation in public and social affairs.[197] Women and girls simultaneously experience these various forms of violence and discrimination, and the layered effects extend far beyond the confines of specific instances of explicit violence. The gendered impacts of water degradation and lack of water resources thus cannot be disaggregated from the gendered impacts of other short- and long-term systems of violence and insecurity, as they are one of many structural factors that combine to create layers of vulnerability.

Temporary Replenishment of the Balaa Reservoir

Out of service as a result of over a decade of conflict, the Balaa Reservoir and Dam in the north western Idlib province were temporarily restored in 2024 when pumps were repaired and reconnected to the electricity grid, allowing water from the Orontes River to be pumped into the reservoir. As a result, farmers who had been relying on increasingly scarce and unreliable rain water were once again able to consistently irrigate their crops. When the reservoir was dry, farmers were limited in what they could grow but were once again able to expand their crops to include other harvests that had been grown in the area before the conflict began, including sugar beets, sunflowers, zucchinis, and soybeans.[198]

However, with the replenishment of the reservoir come renewed fears that the Balaa Dam and Reservoir will once again be targeted by military actors, threatening the communities and ecosystems of the Al-Roj Plain.[199] Moreover, the IDP camps that now populate the surrounding Al-Roj Plain lack proper waste management and have recently suffered from massive flooding due to heavy rainfall, which may collectively impact the reservoir›s water quality.[200]



Aerial view of agricultural fields surrounding the recently refilled Balaa dam in the northwestern Idlib province on May 22, 2024. Source: Omar Haj Kadour / AFP

Conclusion and Recommendations

The water resources of the Orontes River Basin have been severely degraded during and due to the armed conflict in Syria since 2011. This report gathered evidence on a broad range of conflict-related issues that each contributed to water insecurity in the region, exacerbated by the impacts of climate change. These range from water contamination by industrial sites, military pollution, and the lack of proper wastewater treatment, to placing additional strain on diminishing water resources through unsustainable water extraction and use. Among the biggest challenges to water security in the Orontes Basin affecting public health, ecosystem functioning, viable agriculture, and dependent livelihoods are the following:

- **Much of the basin's water infrastructure is non-functional due to conflict-inflicted damages, the looting of pumps, and a lack of personnel and maintenance. The greatest concern is wastewater treatment, which is practically non-existent in many areas. The unregulated discharge of untreated industrial and household waste has led to widespread infectious diseases.**

- **The large numbers of IDPs in formal and informal settlements, mainly located downstream of the Orontes River at the northern border between Syria and Türkiye, are experiencing the lowest availability of sanitation services and clean drinking water. Without any proper water management systems in place, including wastewater treatment, the displacement crisis contributes to the dangerously low quality of the Orontes' waters.**

- **As a coping mechanism to inadequate water resources, individuals have turned to private well drilling to access groundwater for irrigation, selling it untreated from water trucks. Various sources of evidence have clearly demonstrated how both groundwater levels and quality have decreased due to the armed conflict.**

Furthermore, it is important to highlight that toxins such as heavy metals and chemicals from destroyed industrial facilities, irregulated industrial waste, and toxic remnants from munitions and explosives are difficult to analyse remotely. Much of the Orontes Basin's soil and water is expected to be contaminated by these waste products. Soil and water samples must be gathered and analysed to understand the severity of their negative impacts on the Orontes' water quality.

Lastly, climate change is already manifesting in the region, with the observed temperature increases of the past decades projected to continue in the coming decades. Decreasing precipitation levels have already severely affected surface water availability in the Orontes Basin, in turn leading to uncontrolled water pumping and the further depletion of groundwater. Moreover, as extreme weather events such as floods become more frequent in the region due to climate change, flood protection infrastructure is incapable of properly protecting inhabitants and existing irrigation infrastructure is no longer sufficient to deal with highly variable rainfall patterns.

This report calls upon all regional actors to treat water insecurity as a priority and to prevent further damage to water resources and infrastructure.

However, addressing these pressing water-related challenges sustainably in the absence of a meaningful peace process is hardly possible. Only when inclusive and genuine negotiations are resumed towards a political solution in Syria, as prescribed by UN Security Council Resolution 2254, can local civil society organisations, local and regional administrations, and international actors work towards a sustainable process and ensure clean and adequate water resources for the communities of the Orontes Basin. In the meantime, the report concludes with the following recommendations to the international community:

1. **In providing humanitarian aid, improve standards and implementation of wastewater management and sanitation services. This can start with household water quality testing and filtering kits but should result in an integrated water management plan for each IDP camp and informal settlement.**

2. **Provide financial and technical support for the reconstruction of the Orontes' critical water infrastructure and management, adapted to a changing climate. This encompasses public irrigation, drinking water infrastructure, and wastewater treatment plants. Amid the complexities in regional governance and the sensitive political landscape, the introduction of an independent technical assistance project focusing on infrastructure works could be a feasible solution.**

3. **Provide expertise on the development of a local to regional framework to regulate and strengthen standards of water management, including water treatment, groundwater pumping, and wastewater discharge from households, IDP camps, input-intensive agriculture, and industrial facilities such as factories and olive oil presses. The design and monitoring of such a framework and standards should include local communities to allow better management of water resources through community-based mechanisms, ensuring that the needs and concerns of local communities living in the Orontes Basin are adequately addressed.**

4. **Provide financial and technical support to the Orontes Basin's agricultural sector towards climate-resilient agriculture. This should focus on water conservation and climate-resilient farming practices.**

5. **Provide financial and training support to regional researchers and organisations to set up rigorous sampling and research on toxicity levels in soil, surface water, and groundwater in areas of damaged industrial facilities and intense munitions use. This would ensure that there are no risks to nearby communities and supportive ecosystems from these threats.**

6. **Set up an early warning system throughout the Orontes basin to monitor flood and drought risks. This should include the regular measurement of groundwater and surface water streamflow parameters of the basin, as well as regular rainfall observations, dam integrity measurements, hydrological models for storms and dam failure, flood risk maps, and communication and response systems in case of drought and flood alerts.**

While addressing water insecurity in Syria, actors should ensure that they develop holistic strategies that continue to place the needs and the rights of local communities at the epicentre. As such, actors should adopt a "do no harm" policy to ensure that their operations, especially if conducted in cooperation with local governing actors, do not cause harm or injustice, exacerbate social divisions, or contribute to paying "war crime dividends". Furthermore, it is crucial to develop a better understanding of the ways in which different identities such as age, ethnicity, gender expression, socioeconomic status, and disability experience water insecurity in the Orontes Basin. As such, more comprehensive and readily available analysis of the intersections of water insecurity is necessary for meaningful and effective solutions that meet the needs of different demographics within the basin to be established.

Appendix 1
Testimony Optional Guiding Questions

1) What are your **sources** for water?
(Rainfall, rivers, lakes, ground water, irrigation infrastructure...?)
   a) Is there anyone or any organisation/institution responsible for managing this water resource?
   b) Are there private companies that provide water? What is their source of water?
2) Have these sources **changed** since the start of the conflict?
a) **availability** of water; b) **access**; c) **quality** of water; d) **cost** of water
3) If water availability/access/quality has changed, what are the main **reasons** for that?
4) What do you mainly **use** the water for?
   a) What do other people in your **household** use water for (get a sense of different usage, roles and responsibilities by age groups and gender)
   b) and other people in your **community**? (Get a sense of different usage for different livelihoods)
   c) Is that different compared with **before the conflict**?
5) Have you heard of any **water-related diseases** spreading in your area since the beginning of the conflict, such as cholera, diarrhoea, dysentery, hepatitis A, typhoid, and polio?
6) Have you been affected by any **natural disasters** since the start of the conflict?
(Droughts, floods, storm, wildfire, heatwave, dust storms)
7) Have you noticed any **long-term changes** in the water system over the past 30 years?
   a) Desertification, seasonal rainfall patterns and seasonal rivers, salinisation, temperature increase?
   b) If there is a change in water resources, how has it **impacted** your
      i) health
      ii) household
      iii) livelihood
      iv) community?
      (Public health, loss of income, increased prices for water, movement of people, displacement, seasonal migration, long-term migration)
8) How are **governing bodies** responding to the situation? What is the impact of their response?
9) Do you know if there are any **laws or policies** for the protection of water resources?
10) Have you heard of **tensions** over access to water?
   a) And if so, what happened?
   b) Is there a process/**mechanism for resolving** disputes around water? Who is responsible?
   c) Have there been any attempts to prevent or resolve tension around water use?
11) Have there been any attempts made to **prevent or resolve** the degradation of water resources since the start of the conflict?
12) How do you **address changes** in the water situation and their impacts on your life?
   a) Is there anything you would want to address but feel like you cannot?
   b) Are there reasons why you might not want to address water issues discussed?
   c) Who do you think is responsible for the water-related challenges in your area?
13) How do you see the **future of the water situation** in your community/village/area? What do you expect will happen in the future
14) How do farmers **irrigate** their lands during a whole year season in your area?

Information about the testimony provider:
- Name/nickname (optional).
- Livelihood.
- Area.
- Age.
- Number of family members and gender

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