

INVENTORY OF SHARED WATER RESOURCES IN WESTERN ASIA

دراسة مسح الموارد المائية المشتركة في غربي آسيا

BGR Federal Institute for Geosciences and Natural Resources

الاسكوا ESCWA

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How to cite: ESCWA-BGR Cooperation, 2012. Inventory of Shared Water Resources in Western Asia (Online Version). Chapter 7: Orontes River Basin. Beirut.

Chapter 7
Orontes River Basin





Orontes River Basin

EXECUTIVE SUMMARY

Also known as the Assi River, the Orontes is the only perennial river in Western Asia that flows north and drains west into the Mediterranean Sea. Its flow regime shows typical winter peak flows due to increased precipitation, and summer low flows maintained exclusively by groundwater discharge.
The river is mainly used for irrigation purposes with several agricultural projects planned in the three riparian countries. Water quality at the headwaters is generally good, but deteriorates in the middle and lower reaches of the river due to agricultural, urban and industrial activities.
There is no basin-wide agreement between the three riparians, but there are several bilateral agreements in place on issues such as water allocation (Lebanon-Syria) and the joint construction of infrastructure (Syria-Turkey). Orontes Basin politics are heavily influenced by the status of Turkish-Syrian relations in general, and discussions over the sharing of the Euphrates River in particular.

BASIN FACTS

WATERCOURSE RIPARIAN COUNTRIES	Lebanon, Syria, Turkey
BASIN COUNTRIES	Lebanon 8% Syria 67% Turkey 25%
RIVER LENGTH	404 km
BASIN AREA	26,530 km^2
MEAN ANNUAL FLOW VOLUME	1.2 BCM
MAIN DAMS	9 (max. storage capacity: 939 MCM)
PROJECTED IRRIGATED AREA	~300,000 ha
BASIN POPULATION	5.86 million



The Dardara Falls on the Orontes in Lebanon, 2009. Source: Andreas Renck.

MAIN AGREEMENTS

LEBANON - SYRIA	1994 – Agreement on the Distribution of Orontes River Water Originating in Lebanese Territory, which specifies water allocation between the two countries.
SYRIA - TURKEY	2009 – Memorandum of Understanding concerning the construction of the joint Orontes River Friendship Dam.

KEY CONCERNS

WATER QUANTITY

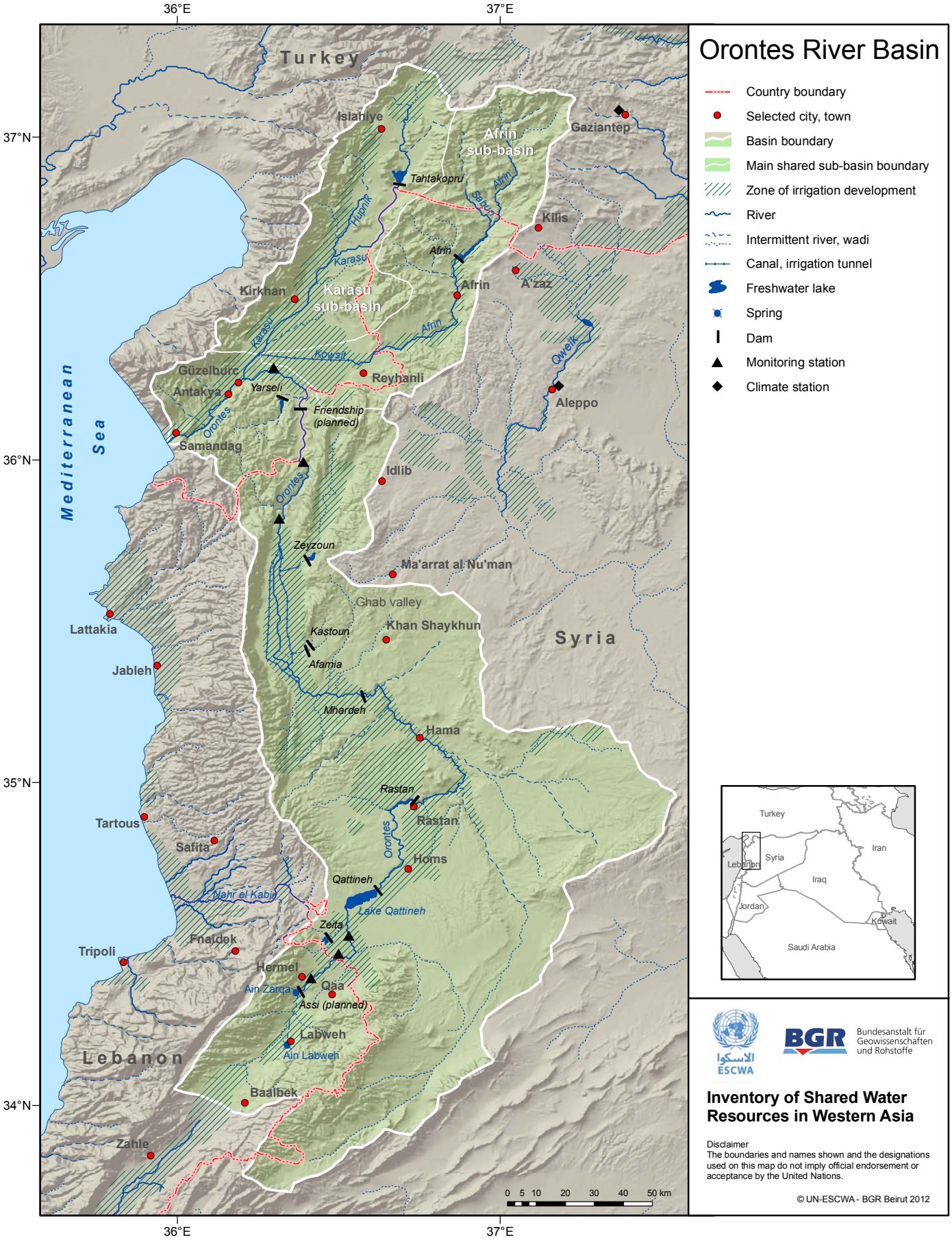
The Orontes River is under intensive use in all three riparian countries, mainly for agricultural purposes. The implementation of additional irrigation projects will place further pressure on the resource. While Lebanon and Syria have agreed on water allocation issues, Turkey and Syria have not. There is no agreement between the three riparians.

WATER QUALITY

In its middle and lower reaches, the Orontes is heavily polluted with untreated effluents that are directly discharged into the riverbed. Water quality issues have not been addressed in the cooperation context.

TERRITORIAL

Syria and Turkey have not resolved the question of the disputed province of Hatay.



Orontes River Basin

- Country boundary
- Selected city, town
- Basin boundary
- Main shared sub-basin boundary
- Zone of irrigation development
- River
- Intermittent river, wadi
- Canal, irrigation tunnel
- Freshwater lake
- Spring
- Dam
- Monitoring station
- Climate station

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Inventory of Shared Water Resources in Western Asia

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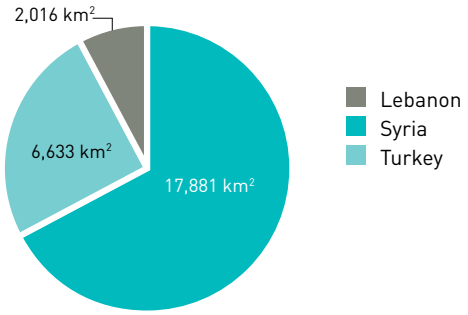
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Geography

The Orontes River[1] originates in Lebanon and flows through Syria and Turkey before discharging into the Mediterranean Sea. The Orontes has two tributaries which are shared between Turkey and Syria: the Karasu and the Afrin. The latter originates in Turkey, passes through Syria and discharges into the Orontes in the disputed Hatay region in Turkey.

The Orontes Basin area is estimated at 26,530 km^2, of which 25% is located in Turkey, 67% in Syria and 8% in Lebanon.[2]

Figure 1. **Distribution of the Orontes Basin area**



Source: Compiled by ESCWA-BGR.

RIVER COURSE

The Orontes River forms the main artery in the Orontes Basin, which consists of several sub-basins. The river has a total length of 404 km, of which 38 km lie in Lebanon,[3] 280 km in Syria, 27 km along the Syrian-Turkish border, and 59 km in Turkey. It is the only river in Western Asia that flows to the north and drains to the west into the Mediterranean Sea. The Orontes River originates in Lebanon, not far from the city of Baalbek in the Bekaa Valley. It rises from the karstic Labweh Spring and flows north, entering Syria to the north-east of Hermel, where it flows through an area of intensive irrigation with a network of drainage canals for agricultural use. Farther downstream, the Orontes broadens into the dammed Lake Qattineh,[4] and then crosses the wide Homs Plain. The river passes the cities of Homs and Hama before turning west and across the fertile Ghab Valley over a distance of 40 km. The Orontes is mainly canalized in this reach.[5] Before the river reaches Turkey in the province of Hatay, it meanders through Syria and subsequently forms the Syrian-Turkish border for almost 25 km. In Turkey, the river turns south-west and is joined by two tributaries, the Karasu and the Afrin,[6] before finally reaching Antakya and discharging into the Mediterranean Sea near Samandag.

The Rebel River

The Orontes River is also known as the Assi in Arabic, which means "rebel". This is because, unlike most rivers in the region, it flows from south to north before draining into the Mediterranean to the west.

MAIN SHARED TRIBUTARIES -THE AFRIN & KARASU SUB-BASINS

The Afrin River, which is shared by Syria and Turkey, is a major tributary to the Orontes. The river originates on the southern slopes of the Kartal Mountains in Turkey,[7] crosses the border into Syria and passes through the city of Afrin. In the past, the Afrin naturally discharged into Lake Amik. Today the river is drained through the artificial Nahr al Kowsit channel and redirected towards the Orontes River. Infrastructure on the river includes the Afrin Dam in Syria, which was constructed in 1997 with a capacity of 190 MCM.[8] The Afrin River has a total length of 131 km, including 54 km in Syria.

An estimated 60 MCM/yr of the Afrin flow originates in Syria,[9] but most of the flow volume (approx. 250 MCM/yr) originates in Hatay Province in Turkey.[10]

The Karasu is the second main tributary of the Orontes River. With a total length of 120 km, the river rises in Turkey and subsequently forms a small part of the Syrian-Turkish border. It discharges into the Orontes River at the confluence with the Afrin River north of Antakya (see Overview Map). The annual flow volume of the Karasu is approximately 40 MCM/yr.[11]

SUB-BASIN FACTS

RIVER	AFRIN	KARASU
BASIN COUNTRIES	Syria (43%) Turkey (57%)	Syria (3%) Turkey (97%)
RIVER LENGTH	131 km	120 km
BASIN AREA	3,920 km^2	2,952 km^2
MEAN ANNUAL FLOW VOLUME	60 MCM	40 MCM
DAMS	Afrin Dam	Karasu Dam
PROJECTED IRRIGATED AREA	28,000 ha (downstream of the dam)	..

BOX 1

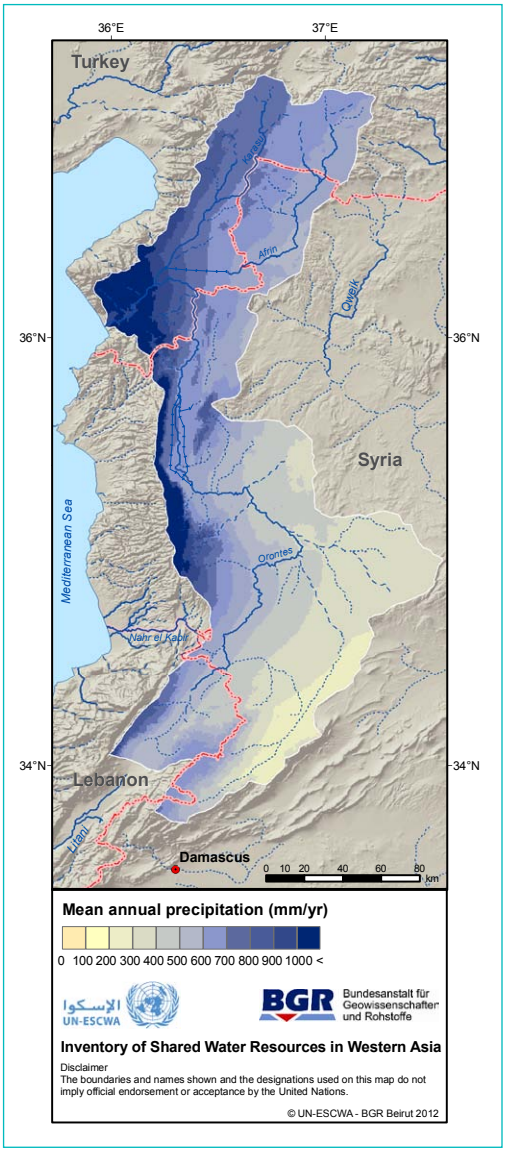
Lake of Antioch or Lake Amik

Before it was drained, the Lake of Antioch or Lake Amik was a large freshwater lake within the Orontes Basin in Hatay Province. Draining and land reclamation around the lake began in the 1940s, specifically for cotton production and to eradicate malaria. In the second half of the 1960s, the State Hydraulic Works (DSI) in Turkey initiated a major drainage project, channelling the lake's tributaries, the Karasu and the Afrin, as well as other rivers, directly to the Orontes River. By the 1970s Lake Amik had completely disappeared and its bed was being used as farmland in what is now known as the Amik Plain. Today, Hatay Airport is located on land that once lay at the bottom of the lake.

CLIMATE

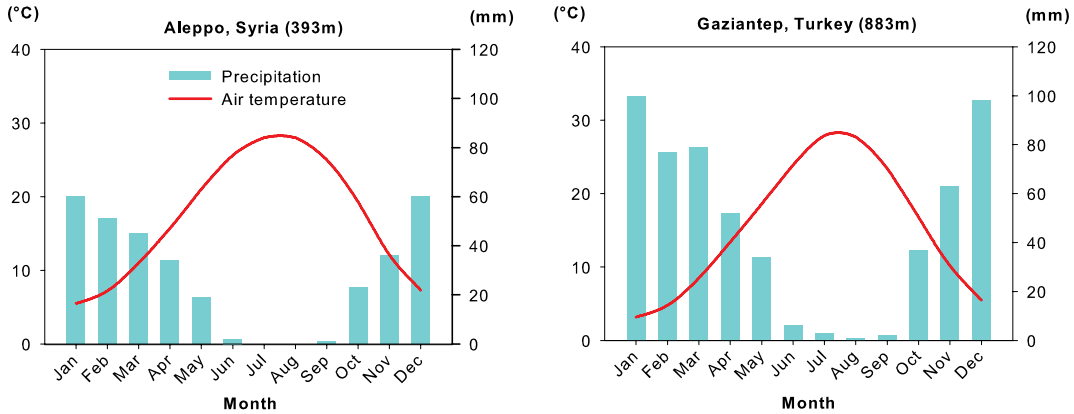
The climate in the Orontes Basin is characterized by Mediterranean winter precipitation (snow on higher ground and rain elsewhere), which decreases in intensity and quantity as one travels inland from the Mediterranean coastal plain (Figure 2). Precipitation in the basin ranges from around 300 mm/yr (the mean annual rainfall at Aleppo, Syria, is 332 mm) to around 800 mm/yr,[12] with highs in December and January and lows in June and July (Figure 3). Average annual basin precipitation is estimated at 644 mm.[13] Summers are dry and hot. The mean annual air temperature on the coast is around 20°C (measured at Tripoli, Lebanon), decreasing to 17.2°C (measured at Aleppo, Syria) further east.

Figure 2. Mean annual precipitation in the Orontes Basin



Source: Compiled by ESCWA-BGR based on data provided by Worldclim, 2011.

Figure 3. Climate diagrams for Aleppo, Syria, to the east, and Gaziantep, Turkey, to the north-east of the Orontes Basin



Source: Compiled by ESCWA-BGR based on data provided by Worldclim, 2011; Climate Diagrams, 2009; Phytosociological Research Center, 2009.

POPULATION

Estimates show that the Orontes Basin has a population of almost 5.7 million. In Lebanon, the population living in the basin is estimated at 381,000 people.[14] The area of the basin situated in Syria comprises 4.2 million inhabitants,[15] while more than 1 million people live in the area of the basin that lies in Turkey.



The Ghab Valley, Syria, 2009. Source: Adel Samara.

Table 1. **Estimated basin population**

RIPARIAN COUNTRY	COUNTRY POPULATION (MILLIONS)	ESTIMATED POPULATION IN THE BASIN		SOURCE
		MILLIONS	AS PERCENTAGE OF TOTAL BASIN POPULATION	
Lebanon	3.75	0.38	7	LOCALIBAN, 2009.
Syria	20.9	4.20	74	Ministry of Irrigation in the Syrian Arab Republic, 2010.
Turkey	73.7	1.10	19	Turkstat, 2010.
Total		5.68		

Source: Compiled by ESCWA-BGR.

Hydrological Characteristics

The sources of the Orontes River are karstic springs that lie at an altitude of 690 m in the Bekaa Valley in Lebanon. The river is mainly fed by groundwater (groundwater contributes up to 90% to stream-flow). Groundwater recharge depends on the snow cover in Mount Lebanon and the Anti-Lebanon Mountains.[16] Generally, the Orontes Basin receives 400 to 500 mm of rain annually, which is characteristic of the Mediterranean climate. In Syria, small streams and springs originating in the Coastal Mountains to the west and Zawiyeh Mountains to the east contribute to the Orontes river flow. Additional water sources originate in the Ghab Valley.[17] In Turkey, the Orontes River receives input from its two northern tributaries, the Afrin and the Karasu.

ANNUAL DISCHARGE VARIABILITY

The mean annual flow volume for the whole Orontes Basin including both the Afrin and Karasu tributaries is estimated at about 1,200 MCM. The mean annual flow volume for the period between 1932 and 2010 was 410 MCM at Hermel, Lebanon. At Darkosh at the Syrian-Turkish border, the mean annual flow volume was 949 MCM/yr between 1964 and 2010 (Table 2). The Darkosh records show a minimal, though statistically significant, negative trend (Figure 4). From Darkosh onwards, if not before, the Orontes can be considered a regulated river.

The mean annual discharge at Hermel is 13 m^3/s and further downstream at Darkosh 30.1 m^3/s. Despite data gaps, the latter shows a quite regular variability,[18] with drier and wetter periods compared to the mean, and no extreme drought or flood periods (Figure 4).

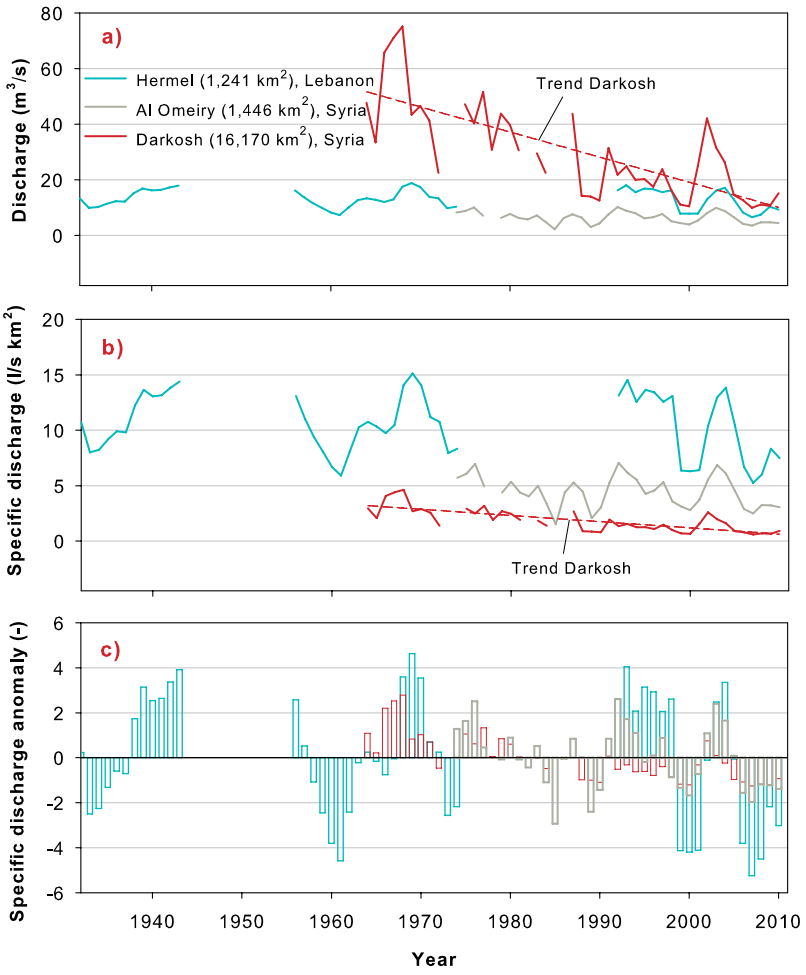
Available data for Al Omeiry station close to the Lebanese-Syrian border north-east of Hermel show a mean annual discharge of 6.4 m^3/s.[19] The difference in flow volume between Hermel and Al Omeiry (410 MCM/yr and 202 MCM/yr respectively) indicates that there is significant water abstraction from the Orontes River in this region, possibly for irrigation purposes.

Table 2. **Summary of annual flow volume statistics for the Orontes River (1932-2010)**

STATION (DRAINAGE AREA, km^2)	PERIOD	MEAN (MCM)	MINIMUM (MCM)	MAXIMUM (MCM)	CV[a] (-)
Hermel, Lebanon (1,241)	1932-2010	410	200	590	0.27
Al Omeiry, Syria (1,446)	1974-2010	202	70	310	0.32
Darkosh, Syria (16,170)	1964-2010	949	320	2,360	0.56

Source: Compiled by ESCWA-BGR and modified based on GRDC, 2011; Ministry of Irrigation in the Syrian Arab Republic, 2012; Ministry of Energy and Water in Lebanon, 2011.
(a) Coefficient of Variation. For information on definition and calculation of the CV see 'Overview & Methodology: Surface Water' chapter.

Figure 4. **a) Mean annual discharge, b) specific mean annual discharge and c) discharge anomaly time series of the Orontes (1932-2010)**



Source: Compiled by ESCWA-BGR and modified based on GRDC, 2011; Ministry of Irrigation in the Syrian Arab Republic, 2012; Ministry of Energy and Water in Lebanon, 2011.

FLOW REGIME

Figure 5 shows the mean Orontes river flow regime at different gauging stations with increasing basin area (normalized monthly discharge). Generally, the downstream station Jisr al Shughur (15,130 km^2) exhibits a high-flow season from December to May and a low-flow season from June to November. The Orontes river regime cannot be considered entirely natural due to regulation on the main river stem by canals and dams, but it retains certain natural seasonal characteristics. The increased discharge during the high-flow period is typically generated by increased rainfall throughout the Mediterranean rainy winter season and by snowmelt originating in the mountainous basin areas during spring. The river flow regime is maintained entirely by groundwater discharge during the dry summer months as indicated by the upstream gauging stations at Hermel (1,241 km^2) and Al Qusayr (1,890 km^2), similar to a groundwater flow regime without pronounced seasonal variations.

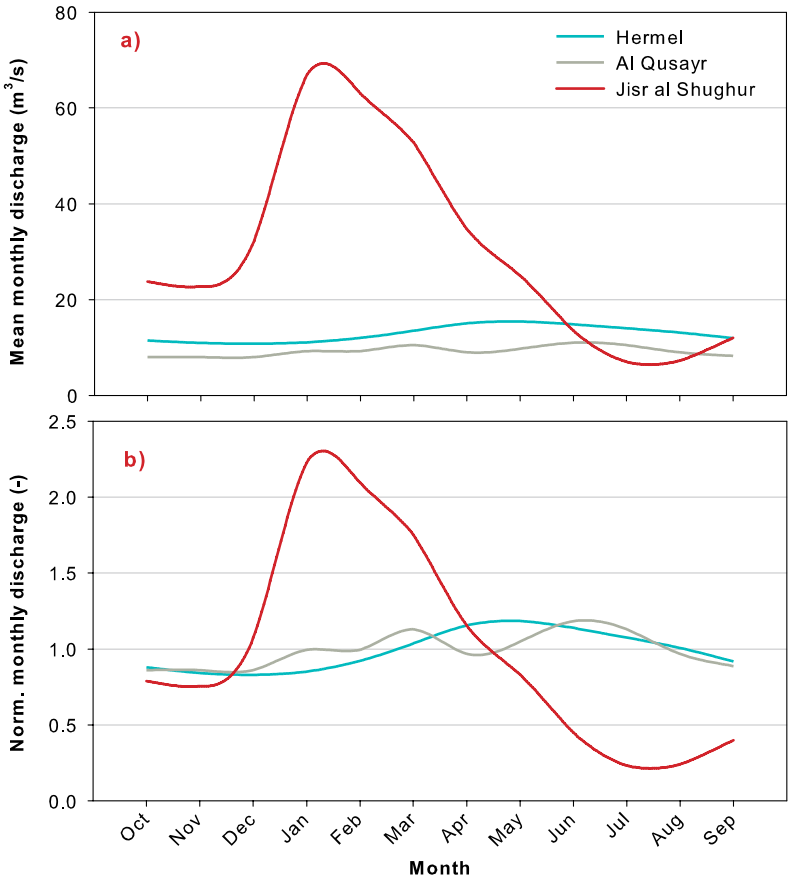
GROUNDWATER

The largest contributor to Orontes river flow is the Zarqa Spring in Lebanon with a mean flow of between 11 m^3/s[20] and 13.6 m^3/s.[21] The long-term average discharge at the Hermel station (13 m^3/s) just downstream from the Zarqa Spring confirms these values.

However, recent data for the Zarqa Spring published by the Syrian Central Bureau of Statistics shows lower flow rates (Table 3). These values are close to – and probably reflected by – mean annual discharge at the downstream Al Omeiry station (6.4 m^3/s), upstream from which some abstraction for irrigation takes place.

The annual amount of groundwater recharge in the Syrian part of the Orontes Basin is estimated at 1,607 MCM, of which 1,134 MCM discharges as spring flow and the remaining 473 MCM is stored in aquifers and eventually withdrawn from wells for irrigation and water supply.[22]

Figure 5. **Mean monthly flow regime of the Orontes River at different gauging stations (1932-2010)**



Source: Compiled by ESCWA-BGR and modified based on GRDC, 2011; Ministry of Irrigation in the Syrian Arab Republic, 2012; Ministry of Energy and Water in Lebanon, 2011.



Ain Zarqa, the source of the Orontes, Lebanon, 2009. Source: Andreas Renck.

Table 3. **Mean flow rate of the main springs in the Orontes Basin in Syria**

SPRING	FLOW RATE (m^3/s)											
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Ain Zarqa	5.41	6.02	5.41	6.02	...	...	...	...	4.12	4.94	4.94	5.10
Ain Bared	1.10	2.50	1.21	1.04	1.49	2.78	5.18	4.07	1.56	1.19	0.69	0.82
Ain Fowar	0.07	0.01	0.43	0.41	0.81	1.29	2.02	1.6	1.53	0.77	0.31	0.39

Source: Central Bureau of Statistics in the Syrian Arab Republic, 2010.

Water Resources Management

All three riparian countries use the water resources in the Orontes Basin for agricultural, domestic and, to a lesser extent, industrial purposes. However, Syria and Turkey have dominated water resource use in the basin with various development plans to increase irrigated surface area. In 2009, FAO estimated total irrigated area in the basin at 300,000-350,000 ha, of which 58% lies in Syria, 36% in Turkey and 6% in Lebanon.[23] The annual water withdrawal for agriculture in the whole basin is estimated at about 2,800 MCM.[24]

The basin's sustainability is threatened by heavy exploitation of water resources and economic expansion, particularly in Syria and Turkey. This has resulted in the lowering of the water table, depletion of water storage in underground reservoirs and considerable reduction in spring yield.

Table 4. **Main constructed and planned dams in the Orontes Basin**

COUNTRY	NAME	COMPLETION YEAR	CAPACITY (MCM)	PURPOSE[a]	BACKGROUND INFORMATION
Lebanon	Assi Dam	Under construction	27 (Phase I) 37 (Phase II)	WS, I, HP	A Chinese contractor started construction of the diversion dam (Phase I) in 2005. Israel bombed the construction site during the 2006 Lebanon War.
Syria	Rastan	1960	228	I	Reservoir surface area: 21 km^2 Irrigated area: 59,841 ha
	Mhardeh	1960	50	I	Reservoir surface area: 4.5 km^2 Irrigated area: 72,000 ha
	Qattineh	1976	200	I	Reservoir surface area: 60 km^2 Irrigated area: 22,000 ha
	Kastoun	1992	27	I	Reservoir surface area: 3 km^2 Irrigated area: 3,000 ha
	Zeyzoun	1995	71	I	The dam is located at a bypass canal to the Orontes. In 2002, it ruptured and collapsed resulting in civilian casualties, and damage to villages in Syria and cultivated land in Turkey.[b] The dam has since been repaired.
	Afamia	1997	27.5	I	Reservoir surface area: 1.8 km^2 Irrigated area: 5,470 ha
	Zeita (Bassel al Assad)	2003	80	WS	This dam is partly supplied by a canal that crosses the Lebanese-Syrian border.
Turkey	Tahtakopru	1975	200		Reservoir surface area: 24.3 km^2
	Yarseli - Beyazcay River	1989	55	I	Reservoir surface area: 4 km^2
	Reyhanli Dam	Construction began in 2010.	..	I	—
Turkey & Syria	Orontes River Friendship Dam	Under construction	110	I, HP, FC	Syria and Turkey agreed under a 2009 bilateral agreement to undertake the joint Orontes River Friendship Dam project on the Syrian-Turkish border. 40 MCM of the dam's capacity will be used to prevent flooding, while the rest is destined for energy production and irrigation. Construction began in 2011.

Sources: Compiled by ESCWA-BGR based on data provided by Central Bureau of Statistics in the Syrian Arab Republic, 2008; General Directorate of State Hydraulic Works in Turkey, 2011; Ministry of Local Administration and Environment in the Syrian Arab Republic, 2003; Ministry of Energy and Water in Lebanon, 2011; Ministry of Irrigation in the Syrian Arab Republic, 2011.
(a) Water Supply (WS), Irrigation (I), Hydropower (HP) and Flood Control (FC).
(b) BBC News Middle East, 2002.

DEVELOPMENT & USE: LEBANON

At present, the use of the Orontes in Lebanon is limited to small-scale farming, fish farms and individual use. Total water use is estimated at 21 MCM/yr, of which around 23% is used for domestic purposes, and the rest for irrigation.[25] Official figures estimate irrigated areas in the Lebanese part of the basin at 1,703 ha. Most of this land is irrigated by wells.[26] It is likely, however, that these figures only refer to the perennial northern section of the Orontes River downstream of the Zarqa Spring, which has also been the focus of Lebanese-Syrian cooperation. FAO estimates of irrigated area in the Lebanese part of the Orontes Basin are much higher (18,000-21,000 ha),[27] possibly because they refer to the entire topographic catchment, including the agricultural areas around Labweh, Al Ain, Ras Baalbek and El Qaa.

The Lebanese Ministry of Energy and Water has plans to increase the exploitation of water resources in the basin. One of the projects under consideration is the Assi scheme, planned following consultations with the Syrian Government and aimed at developing water use for irrigation, domestic use and power generation in the regions of Baalbek and Hermel.[28] The project is divided into two phases: the first phase includes a diversion dam with a storage capacity of 27 MCM near the Zarqa Spring, three pumping stations and a network for the irrigation of around 3,000 ha. A second phase aims to construct a 37 MCM capacity dam upstream of the Hermel Bridge (Table 4), with several pumping stations and a network for the irrigation of 3,800 ha, as well as a hydroelectric power plant providing approximately 50 MW of electricity per day. Altogether, the proposed irrigation schemes comprise a new irrigated area of 6,800 ha in the Hermel and Al Qaa area of the basin.[29]

BOX 2

Progress Made on the Assi Project in Lebanon

The Assi Project was officially launched in 2004, with a Chinese contractor starting construction with a local partner in 2005. Phase 1 of the project was already well underway when Israel bombed the construction site during the 2006 Lebanon War. As the Lebanese Higher Relief Council was slow to provide compensation for losses suffered, the contractor demanded a renegotiation of the contract before resuming work. This has resulted in a dispute within the Ministry of Energy and Water about whether to cancel the contract and issue a new invitation to tender or to meet the current contractor's demands. The Lebanese Council of Ministers formed a special committee in 2011 to resolve this issue.

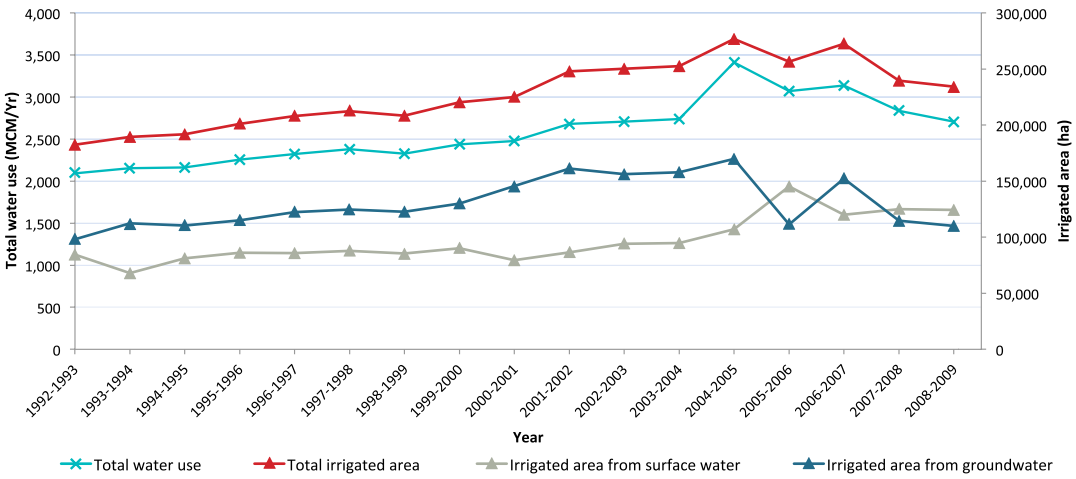
Source: Ministry of Energy and Water in Lebanon, 2011.

DEVELOPMENT & USE: SYRIA

Since the early 1950s, Syria has intensively developed water resources in the Orontes Basin. In terms of water use, the Orontes River constitutes the second most important river in Syria after the Euphrates, providing 20% of the country's total estimated water use volume.[30]

According to official data, total annual water use in the Orontes Basin has increased from around 2,000 MCM in 1992 and temporarily exceeded 3,000 MCM in 2004-2005 (Figure 7). Average annual use for the period from 1992 to 2009 was around 2,582 MCM.[31] Agriculture is the largest water user, consuming about 1,977 MCM annually (77% of total water use), followed by domestic water use at 9% and industry at 8% (Figure 6).

Figure 6. **Evolution of total water use and irrigated areas in the Orontes Basin in Syria (1992-2009)**



Source: Compiled by ESCWA-BGR based on data provided by Ministry of Irrigation in the Syrian Arab Republic, 2012.

Both groundwater and surface water are heavily exploited in the Orontes Basin in Syria, and average annual groundwater use for irrigation (1,111 MCM or 56%) exceeded surface water use (886 MCM or 44%) during the period between 1992 and 2009.

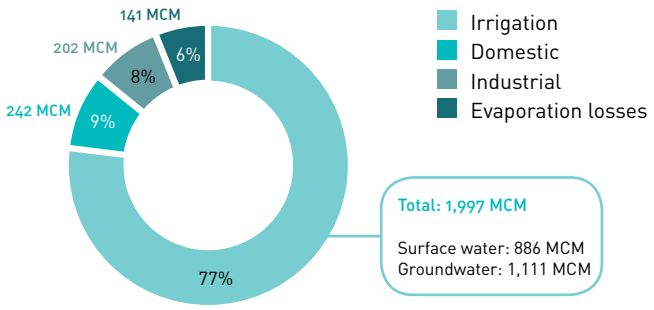
In order to increase irrigation capacity, Syria has over the years built more than 40 dams in the basin. The total reservoir capacity of all dams in the basin reached about 950 MCM in 2006.[32] A number of these dams, such as the Rastan, Qattineh, Zeita and Mhardeh Dams, have a large reservoir capacity (Table 4). The Zeita Dam near the Lebanese-Syrian border is partly supplied with water diverted from the main stream of the Orontes in Lebanon through the left-bank Zeita Canal. Both this canal and the right-bank Jawsiyeh Canal are also used for direct irrigation of downstream Syrian lands. The two canals are located between the Hermel and Al Omeiry monitoring stations. Diversions through these canals may partly explain the decrease in long-term average annual discharge (approx. 200 MCM/yr) between upstream Hermel and downstream Al Omeiry.

Two main agricultural areas in Syria are supplied with water from the Orontes: the region between Homs and Hama, and the Ghab, a large, formerly swampy valley. The latter was systematically drained from 1950 onward to reclaim land for irrigated agriculture. The Ghab project included the expansion and deepening of the Orontes riverbed, and the construction of dams for flow regulation and irrigation water. An area of about 70,000 ha is irrigated as part of the project, which consumes around 330 MCM/yr of reservoir water and another 150 MCM/yr of groundwater.[33] The region between Homs and Hama is partly supplied from Lake Qattineh via the Homs-Hama canal, which provides water to an area of about 23,000 ha. However, as the reservoir does not meet demand, it is supplemented by groundwater wells, which irrigate another 20,000 ha in this part of the basin.[34]

The total irrigated area in the Orontes Basin in Syria has increased from approximately 200,000 ha in 1992 and temporarily exceeded 250,000 ha in 2004-2008 (Figure 6). In the first half of the data period, irrigation with groundwater clearly dominated, but irrigation with surface water has gained momentum since 2004, possibly due to the construction of dams and other irrigation infrastructure or because of stricter regulation of groundwater abstractions. On average, an area of about 97,000 ha (43%) is irrigated by surface water, and 130,000 ha (57%) by groundwater (Figure 8).

Municipal and industrial use of the river is low due to water quality issues caused by untreated effluents into the Orontes River. These sectors

Figure 7. **Mean water use across sectors in the Orontes Basin in Syria (1992-2009)**

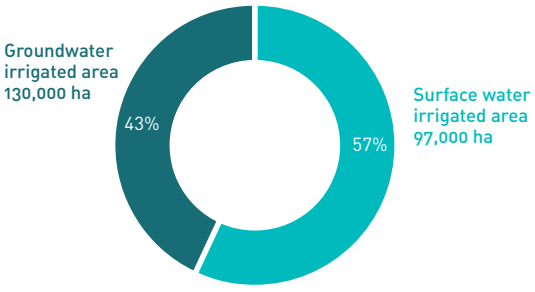


Source: Compiled by ESCWA-BGR based on data provided by Ministry of Irrigation in the Syrian Arab Republic, 2012.



Lake Qattineh near Homs, Syria, 2009. Source: Adel Samara.

Figure 8. **Irrigated area in the Orontes Basin in Syria (1992-2009), by source**



Average total irrigated area: 227,000 ha

Source: Compiled by ESCWA-BGR based on data from the Ministry of Irrigation in the Syrian Arab Republic, 2012.

are mainly supplied by groundwater, which is overexploited following the intensive drilling of wells.[35] Based on data presented in Figure 6, average total annual groundwater use in the Orontes Basin can be estimated at 1,466 MCM[36] and surface water use at 1,115 MCM.[37]

The intensification of water use in the Orontes Basin in Syria has raised the question of long-term sustainability. For example, the average annual discharge of more than 20 springs in the Ghab Valley dropped from approximately 18 m^3/s between 1965 and 1971 to 4.2 m^3/s in 1995-1996.[38] Water tables in some parts of the western Orontes Basin have dropped as much as 57 m in 10 years.[39]

DEVELOPMENT & USE: TURKEY

The most important dams in the Turkish part of the Orontes Basin are the Yarseli and Tahtakopru Dams, which are both located on tributaries of the Orontes (Table 4). The Tahtakopru Dam was built in 1975 on the Karasu River and has a maximum capacity of 200 MCM, with a reservoir area of 24.3 km^2.

In recent years, a dozen new water resource development projects have been planned and implemented in the Turkish part of the Orontes Basin. These projects are designed to regulate the flow of the river and its tributaries for irrigation and flood protection purposes. They also aim to provide water for domestic use and for the generation of electricity.[40] Once completed, the projects will irrigate an area of almost 100,000 ha, produce 180 GWh/yr of electricity and provide 37 MCM/yr of potable water.[41]

In 2004, Turkey proposed the construction of a joint dam on the Orontes River in Syria to generate power and provide irrigation water to both countries. Five years later, in December 2009, Turkey and Syria signed a memorandum of understanding regarding construction of the Friendship Dam on the Orontes River. The two countries agreed to split the costs of the dam, which will benefit both riparians by protecting land and settlements from floods and droughts. It will also irrigate 13,334 ha of farmland[42] and generate almost 16 GWh/yr of electricity.[43] The construction of the Orontes River Friendship Dam started in February 2011.

WATER QUALITY & ENVIRONMENTAL ISSUES

The quality of surface and groundwater in the basin varies, mainly according to the level of agricultural activity. While the quality of the Orontes headwaters is generally good, it deteriorates in the middle and lower reaches of the river due to agricultural, urban and industrial activities.[44] Increasing water pollution in these parts of the river is partly due to eutrophication, a process through which a large influx of nutrients causes excessive growth of algae.[45]

In 2000, levels of major ions and trace metals found in the river in Lebanon mostly reflected the basin's natural conditions. However, increases in nutrient concentrations and heavy metals were attributed to increased agricultural runoff and urbanization in the basin.[46]

In Syria, the Orontes Basin is considered one of the country's most disturbed hydrological ecosystems.[47] In addition to agriculture, there is intensive industrial activity in the basin and industrial wastewater is discharged into the river with limited or no treatment.[48] Industries mainly include cement and steel factories, a sugar processing plant, a fertilizer plant, a thermal power plant and an oil refinery.[49] Moreover, water quality is threatened by domestic wastewater discharge in many parts of the basin.[50] In places where the river is used for domestic needs and irrigation, epidemics such as typhoid, dysentery and cholera have been observed.[51] According to the Ministry of Irrigation in Syria, analysis of water samples



The Orontes in Hama, Syria, 2009. Source: Adel Samara.

Table 5. Mean Biochemical Oxygen Demand (BOD) and nutrients in the Orontes River in Syria (2010-2011)

		BOD (mg/L)	PO_4-P (mg/L)	NO_3-N (mg/L)
Station	Al Omeiry	0.14	0.05	1.48
	Lake Qattineh outlet	9.78	1.05	1.43
Total Range		0-16.2	0.003-2.71	0.68-4.52
Guideline[a]		3-6 (for fisheries and aquatic life)	0.1	0.2

Source: Compiled by ESCWA-BGR based on data provided by Ministry of Irrigation in the Syrian Arab Republic, 2012.
(a) For further information on the different water quality parameters and their respective guidelines, see 'Overview & Methodology: Surface Water' chapter.

of phosphate, nitrate and Biochemical Oxygen Demand (BOD) since 1995 indicate that concentrations exceed permissible limits. The downstream part of the river (after Lake Qattineh) is particularly affected, while the upper part of the Orontes in Syria (up to Al Omeiry) has acceptable water quality.[52] Samples from 2010 and 2011 showed elevated nitrate concentrations even at the Al Omeiry station (Table 5).[53]

Moreover, sediment samples from the river have shown high concentrations of heavy metals (Table 6).[54] These were also detected in soil samples taken in the Orontes Basin, outlining significant differences between soil irrigated by Orontes River water and soil irrigated by groundwater alone: the former contained extremely high levels of arsenic (Ar), chromium (Cr), cobalt (Co) and nickel (Ni) throughout the river course. This contamination was mainly attributed to sewage sludge and phosphate fertilizers.[55]

Table 6. Concentrations of heavy metals in sediment samples in the Orontes River in Syria in 2010

PARAMETER	MEAN CONCENTRATION (ppm)	RANGE (ppm)	GUIDELINE[a] (ppm)
Cr	91.8	38.8-168	80
Cu	160	31.8-335	65
Ni	129	35.1-228	21
Pb	25.4	8-63.2	50
Zn	310	64.1-598	200

Source: Compiled by ESCWA-BGR based on Hajj and Ismail, 2011.
Note: Samples were taken from 11 sites along the Orontes River in Syria.
(a) Based on Sediment Quality Guidelines of the National Oceanographic and Atmospheric Administration (NOAA) in Hajj and Ismail, 2011.

In Turkey, the draining of Lake Amik (Box 1) caused severe environmental damage, flooding and droughts, and the productivity of reclaimed and irrigated land has decreased due to increased soil salinity.[56]

Overall, the most critical parameters of water quality in the Turkish part of the basin are phosphate levels and salinity. High concentrations of phosphate were found, especially around the city of Antakya, possibly as a result of untreated sewage sludge discharged into the river.[57] Agriculture and aquatic life are threatened by the high salinity of surface water, with a mean Electrical Conductivity (EC) value of 1,100 µS/cm for the period from 1995 to 2002.[58] In the lower part of the basin, drainage and groundwater also present high levels of salinity (Table 7).[59]

Heavy metal concentrations in the Turkish part of the Orontes Basin are generally low.[60] However, at the specific sampling site of Güzelburç (about 5 km from Antakya), cadmium (Cd) levels exceeded the allowed concentrations for drinking and irrigation water, and lead (Pb) levels were higher than the acceptable limits for drinking water. This sampling site is polluted by a number of industrial waste sources, sewage water and domestic waste, in addition to irrigation effluents.[61]

Table 7. Mean Electrical Conductivity (EC) values of the Orontes River in Turkey (2002-2003)

	IN DRAINAGE WATERS	IN SHALLOW GROUNDWATER	GUIDELINE FOR IRRIGATION
EC (µS/cm)	1,210	1,290	<700
Range	640-1,740	390-2,220	

Source: Compiled by ESCWA-BGR based on Odemis et al., 2006.

Agreements, Cooperation & Outlook

AGREEMENTS

There are a number of bilateral agreements in place on the Orontes River, although none include all three riparians, Lebanon, Syria and Turkey.

Formal cooperation between Turkey and Syria dates back to 1939 when the two countries signed the Final Protocol to Determine the Syria-Hatay Border Delimitation. The agreement determined that the water of the Orontes, Karasu and Afrin Rivers are to be equitably shared in places where the rivers constitute the border between Syria and Turkey.

Negotiations over the Orontes between Lebanon and Syria date back to the 1940s. Formal cooperation started in 1972 when the two riparians signed a bilateral agreement concerning water use in the river basin.[62] However, this agreement never came into force due to the political situation in the two countries. Subsequently, Lebanon and Syria signed and ratified the Fraternity, Cooperation and Coordination Treaty in 1991, establishing the formal basis for cooperation between the two countries in the domain of water and other sectors.[63] The Lebanese-Syrian Joint Committee for Shared Water was established under this treaty, with representatives from the Lebanese Ministry of Energy and Water and the Syrian Ministry of Irrigation. In September 1994, the two countries signed a second agreement specific to the Orontes, building on the 1972 agreement. It acknowledged that the waters of the river are shared and stated that the parties agree to divide the resource. Accordingly, the Agreement on the Distribution of Orontes River Water Originating in Lebanese Territory accorded Lebanon an annual share of 80 MCM of water, while the remaining 323 MCM was allocated to Syria,[64] provided that the river's resources within Lebanon reached 400 MCM/yr or more.[65] However, the terms of the agreement were deemed unfavourable to Lebanon, and an annex added in 1997 identified four sub-basins and a main spring[66] which have been excluded from Lebanon's 80 MCM/yr share.[67] In addition, it was agreed that all water extracted from the river near the Hermel Bridge and sources such as rainfall, springs and groundwater are considered part of the Lebanese share. Conversely, Lebanon shall not implement any

Table 8. **Water agreements on the Orontes River**

YEAR	NAME	SIGNIFICANCE	SIGNATORIES
1939	Final Protocol to Determine the Syria-Hatay Border Delimitation	The protocol specifies where the waters of the Orontes, Karasu and Afrin Rivers constitute the border between Syria and Turkey. Although water use in the basin is not specified, the protocol states that water is to be utilized in an equitable manner.	Syria, Turkey
1972	Agreement on Water Use	First bilateral agreement on water use in the Orontes Basin.	Lebanon, Syria
1991	Fraternity, Cooperation and Coordination Treaty	The treaty provides the formal basis for cooperation between the two countries in the domain of water and other sectors. Several joint entities were established, including the Lebanese-Syrian Joint Committee for Shared Water.	Lebanon, Syria
1994	Agreement on the Distribution of the Orontes River Water Originating in Lebanese Territory	The agreement states that the signatories consider the water resources of the Orontes as common waters. It specifies that – based on an annual discharge rate of approximately 400 MCM – Lebanon is to receive 80 MCM with the remainder allocated to Syria.	Lebanon, Syria
1997	Annex to the Agreement on the Distribution of Orontes River Water Originating in Lebanese Territory	The annex identifies four sub-basins and a main spring, which are to be excluded from Lebanon's annual share as agreed in the 1994 agreement. The later 2001 amendment allows Lebanon to establish infrastructures on the river.	Lebanon, Syria
2009	Turkish-Syrian Strategic Cooperation Council Agreement	At the High-Level Strategic Cooperation Council Meeting, the two countries agreed that water would be a focus point for cooperation with specific emphasis on improvements to water quality, the construction of water pumping stations and joint dams, as well as the development of joint water policies. During the meeting, Syria and Turkey signed a memorandum of understanding related to the construction of the joint Friendship Dam.	Syria, Turkey

Source: Compiled by ESCWA-BGR based on data provided by Scheumann et al., 2011; Comair, 2009.



The Afrin Dam, Syria, 2009. Source: Andreas Renck.

projects that could limit the river's flow.[68] The 1994 agreement was amended in 2001 in order to allow Lebanon to construct a dam on the Orontes.

COOPERATION

Prior to the Syrian uprising that started in March 2011, Turkish-Syrian ties had improved, as evidenced by the number of agreements the two countries signed and joint projects they initiated between 2006 and 2010.

Before this rapprochement, however, Turkey and Syria had disagreed about various aspects of water use in the Orontes Basin. Often these disputes were influenced by the two countries' position on the Euphrates River.[69] When Syria complained about Turkey's construction of dams on the Euphrates and claimed Turkey was not releasing sufficient water from its dams, Turkey invoked Syrian use of the Orontes River. This made negotiations more complicated. When negotiations over the Euphrates between Iraq, Syria and Turkey were initiated in the early 1980s, Turkey insisted on including the shared waters of the Orontes, while Syria at the time refused to discuss Orontes water with Turkey. The Syrian refusal was motivated by its claim to the province of Hatay. It argued that the Orontes was a national river that only flowed within Syrian territory before draining into the Mediterranean Sea (Box 3).[70]

BOX 3

The Province of Hatay

Situated on the north-eastern Mediterranean shore at the foot of the Taurus Mountains, the province of Hatay is the downstream riparian of the Orontes River. Historically, both Turks and Arabs have populated this land and sovereignty over the territory has changed several times, with the province even enjoying a brief stint as an autonomous republic. In 1939, the province of Hatay was incorporated into Turkey de facto, although Syria has never officially recognized the move. Both countries continue to use Hatay as a negotiating card in their discussions over international water rights.

Syrian-Turkish dialogue improved in the 1990s and resulted in an economic rapprochement in the form of a 2004 Free Trade Agreement, which also defines and recognizes state boundaries.

Cooperative ties between Lebanon and Syria over the Orontes are strong. A special joint committee for the Orontes River was created under the Lebanese-Syrian Joint Committee for Shared Water, which is the central entity through which both countries cooperate over issues related to shared water resources. The membership of the Orontes River Joint Committee is drawn from both countries. The Committee comprises two subcommittees.

The River Protection and Environmental Preservation Subcommittee is responsible for coordinating and supervising issues related to river hydrology, river pollution and river infringements. The Subcommittee for the Expropriation of Lands in the Vicinity of the Zeita Canals (Figure 9) addresses issues related to lands that straddle the Lebanese-Syrian border in the vicinity of the Zeita Dam.[71] The parties have agreed that Syria is to compensate landowners for work related to the canals on Lebanese territory, while Lebanon is to enlist its local authorities to enforce the rule of law and prevent damage to the infrastructure of the canals. Members of the subcommittees hold monthly meetings in Lebanon or Syria to discuss issues related to the basin, and exchange hydrological data and results of water quality analysis. The members also specify joint measures in order to tackle problems such as violations and infringements along the river's course, as well as river pollution from sewage and fisheries.[72]

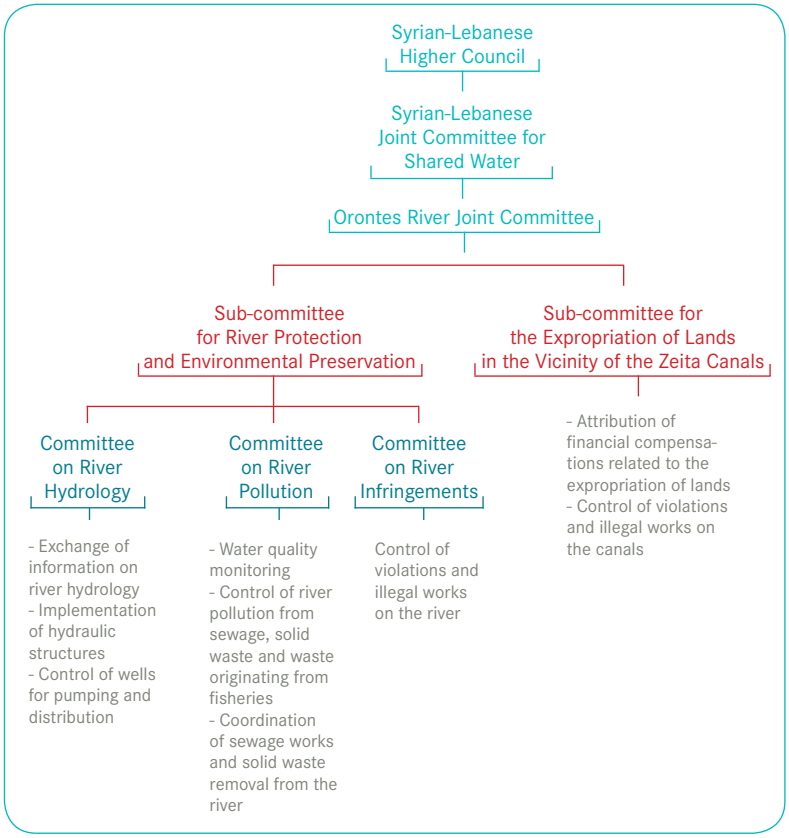
OUTLOOK

With the improvement of bilateral relations, Syria and Turkey have launched a joint dam project on the Orontes River in Syria. In 2009, both countries signed a memorandum of understanding for the construction of the Syrian-Turkish Orontes River Friendship Dam to provide water for irrigation and hydropower. Construction on the dam started in February 2011.

In Lebanon, the Orontes River is likely to be further exploited in the coming years. For instance, the newly developed National Water Sector Strategy lists the surface storage potential of the Assi Dam in the supply-and-demand forecasts.[73]

Lebanon and Syria have solicited international donors for assistance in water supply management and hydrological monitoring, and various projects have been launched.

Figure 9. **Organizational structure and roles of the Orontes River joint subcommittees**



Source: Compiled by ESCWA-BGR based on data provided by Ministry of Energy and Water in Lebanon, 2011.

Notes

1. Also known as Nahr al Assi.
2. The basin area was delineated based on topography and stream network (Lehner et al., 2008). FAO, 2009, p. 77, states that the basin covers a surface area of 24,660 km^2 of which almost 70% lies in Syria, 23% in Turkey and 8% in Lebanon. Kloosterman and Vermooten, 2008, p. 7, state that the drainage catchment has a surface area of 21,666 km^2, while the Strategic Foresight Group, 2011, p. 102, gives a figure of 21,634 km^2.
3. Measured at the Labweh Spring.
4. Lake Qattineh, also referred to as Lake Homs, is about 15 km from the city of Homs. It is mainly used for irrigation and industry.
5. According to UN-ESCWA et al., 1996, p. 160, the canals are not large enough, which causes frequent overflowing during flood periods.
6. At this point, the Afrin joins the Orontes in the form of a canal.
7. UN-ESCWA et al., 1996, p. 160.
8. Ministry of Irrigation in the Syrian Arab Republic, 2009.
9. Kolars, 1992.
10. Ibid.
11. Fakioglu in Scheumann et al., 2011 p. 303.
12. World Bank, 2001, p. 2.
13. FAO, 2009.
14. LOCALIBAN, 2009. The Lebanese part of the basin comprises the districts of Baalbek and Hermel in Bekaa Governorate.
15. Ministry of Irrigation in the Syrian Arab Republic, 2010; Syrian Dutch Water Cooperation and Ministry of Irrigation in the Syrian Arab Republic, 2008.
16. UN-ESCWA et al., 1996, p. 160.
17. Sofer, 1999.
18. Coefficient of Variation = 0.2.
19. Ministry of Irrigation in the Syrian Arab Republic, 2012.
20. Wolfart, 1967.
21. UNDP, 1970.
22. FAO, 2009.
23. FAO, 2009, p. 80.
24. Ibid.
25. Ministry of Energy and Water in Lebanon, 2002.
26. Ibid.
27. Based on percentages presented by FAO, 2009, p. 80.
28. During the Syrian-Lebanese Higher Council meeting in March 2001.
29. JICA et al., 2003.
30. World Bank, 2001, p. 11.
31. Ministry of Irrigation in the Syrian Arab Republic, 2012.
32. Ministry of Irrigation in the Syrian Arab Republic, 2006.
33. Shapland, 1997, p. 145.
34. Kibaroglu et al., 2005, p. 68.
35. World Bank, 2001; Kloosterman and Vermooten, 2008.
36. This total is composed of the following parameters: groundwater use for irrigation added to an assumed 80% groundwater share in domestic and industrial water use. Kibaroglu et al., 2005, p. 70, estimate that the annual amount of groundwater used for irrigation, domestic water supply and industry in the basin exceeds 1,500 MCM.
37. This total is calculated as follows: surface water use for irrigation + full attribution of evaporation losses + an assumed 20% surface water share in domestic and industrial water use. The resulting value is far lower than the total river water use estimate of 1,721 MCM/yr in IPTRID-FAO, 2006.
38. IPTRID-FAO, 2006.
39. This refers to the period 1990-1999 as stated in FAO, 2003, p. 342.
40. Kibaroglu et al., 2005, p. 70.
41. Ibid.
42. EMWIS, 2011.
43. Hurriyet Daily News, 2010.
44. FAO, 2009.
45. Davie, 2003 in Varol et al., 2011.
46. Saad et al., 2004.
47. Syrian Dutch Water Cooperation and Ministry of Irrigation in the Syrian Arab Republic, 2008, p. 22.
48. Ministry of Irrigation in the Syrian Arab Republic, 2012.
49. Hajj and Ismail, 2011; Kassem et al., 2004.
50. Syrian Dutch Water Cooperation and Ministry of Irrigation in the Syrian Arab Republic, 2008, p. 21.
51. Scheumann et al., 2011.
52. Ministry of Local Administration and Environment in the Syrian Arab Republic, 2003, p. 23; Ministry of Irrigation in the Syrian Arab Republic, 2012.
53. Ministry of Irrigation in the Syrian Arab Republic, 2012.
54. Hajj and Ismail, 2011. Samples were taken in 2010.
55. Kassem et al., 2004.
56. Shapland, 1997; Caliskan, 2008.
57. Agca and Odemis, 2009.
58. Odemis et al., 2006; Agca and Odemis, 2009. The guideline for irrigation water is set at less than 700 µS/cm based on FAO, 1994.
59. Odemis et al., 2006.
60. Agca and Odemis, 2009. Samples were taken in 2004-2005.
61. Yilmaz and Dogan, 2008. Samples were taken in 2003-2004.
62. Sofer, 1999.
63. Syrian-Lebanese Higher Council, 1991.
64. The agreement is based on an assumed total annual discharge of 403 MCM in the Orontes Basin.
65. Syrian-Lebanese Higher Council, 1994, article 3.
66. The four basins are Yammouneh, Marjhine, Jabal al Homr and Orgosh; the spring is the Labweh Spring.
67. Comair, 2009.
68. Syrian-Lebanese Higher Council, 1997.
69. Shapland, 1997.
70. Kibaroglu et al., 2005, p. 70.
71. Ministry of Energy and Water in Lebanon, 2011.
72. Syrian-Lebanese Higher Council, 2011.
73. Ministry of Energy and Water in Lebanon, 2012.

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