Atlas of the Orontes Basin Rivers
second edition
July 2022

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Edition in honor of the memory of Professor Ronald Jaubert, Director of the Orontes Basin Program (2012 - 2021).

Professor Ronald Jaubert, Apamea - al-Ghab, Orontes River Basin, 2005

The Atlas is one of the products of a research program conducted by the Graduate Institute of International and Development Studies in collaboration with Geo Expertise.

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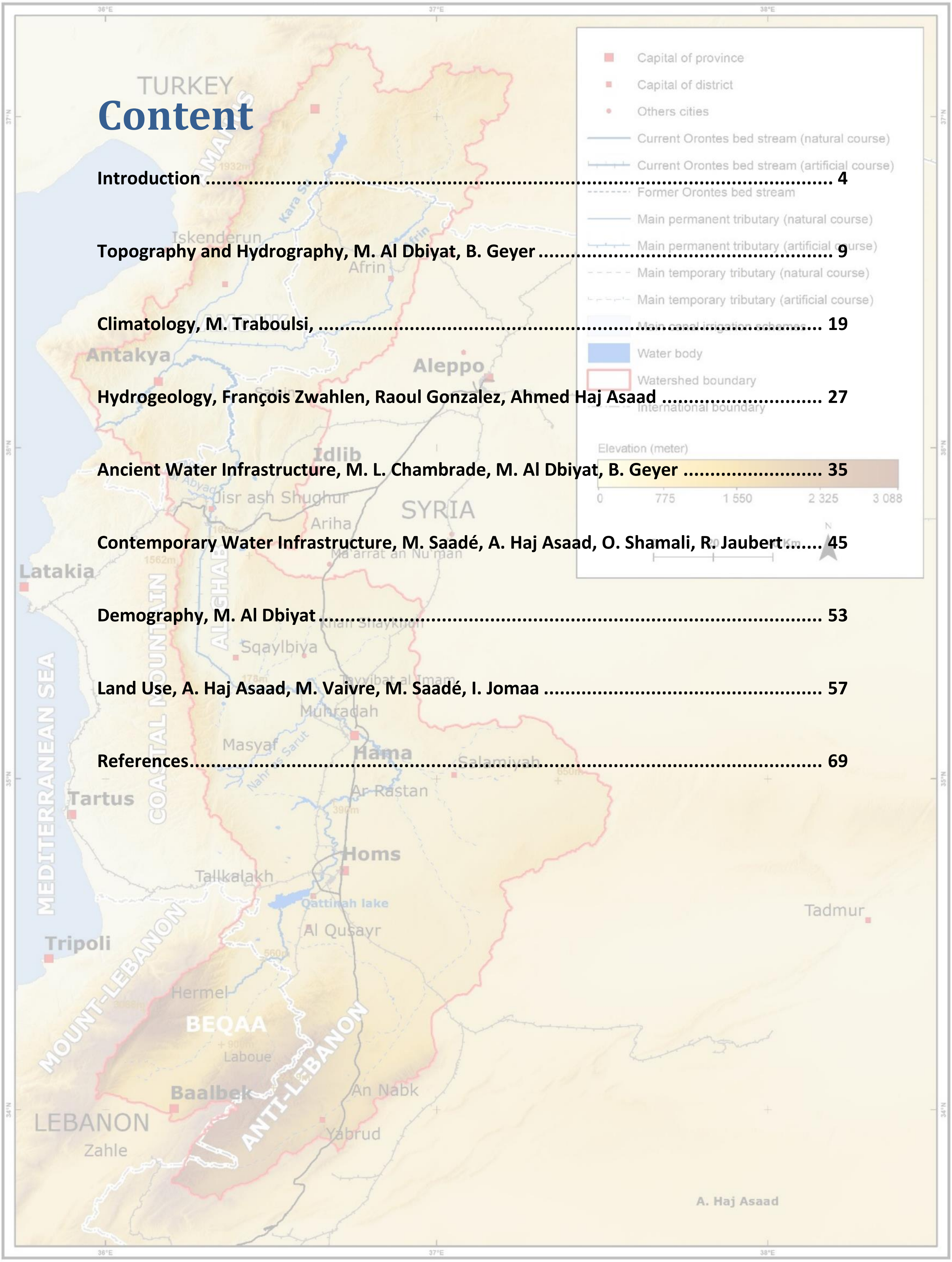
Content



Capital of province
Capital of district
Others cities
Current Orontes bed stream (natural course)
Current Orontes bed stream (artificial course)
Former Orontes bed stream
Main permanent tributary (natural course)
Main permanent tributary (artificial course)
Main temporary tributary (natural course)
Main temporary tributary (artificial course)
Water body
Watershed boundary
International boundary
Elevation (meter)
0
775
1 550
2 325
3 088
TURKEY
SYRIA
LEBANON
MEDITERRANEAN SEA
COASTAL MOUNTAIN
MOUNT-LEBANON
ANTI-LEBANON
BEQAA
Iskenderun
Afrin
Antakya
Aleppo
Idlib
Jisr ash Shughur
Ariha
Latakia
Sqaylbiya
Muhradah
Masyaf
Hama
Salamiyah
Ar Rastan
Tartus
Homs
Tallkalakh
Qattinah lake
Al Qusayr
Tripoli
Hermel
Laboue
Baalbek
Zahle
An Nabk
Yabrud
Tadmur
A. Haj Asaad


Ein ez Zarka, Lebanon, Orontes Rivers Source, december2015

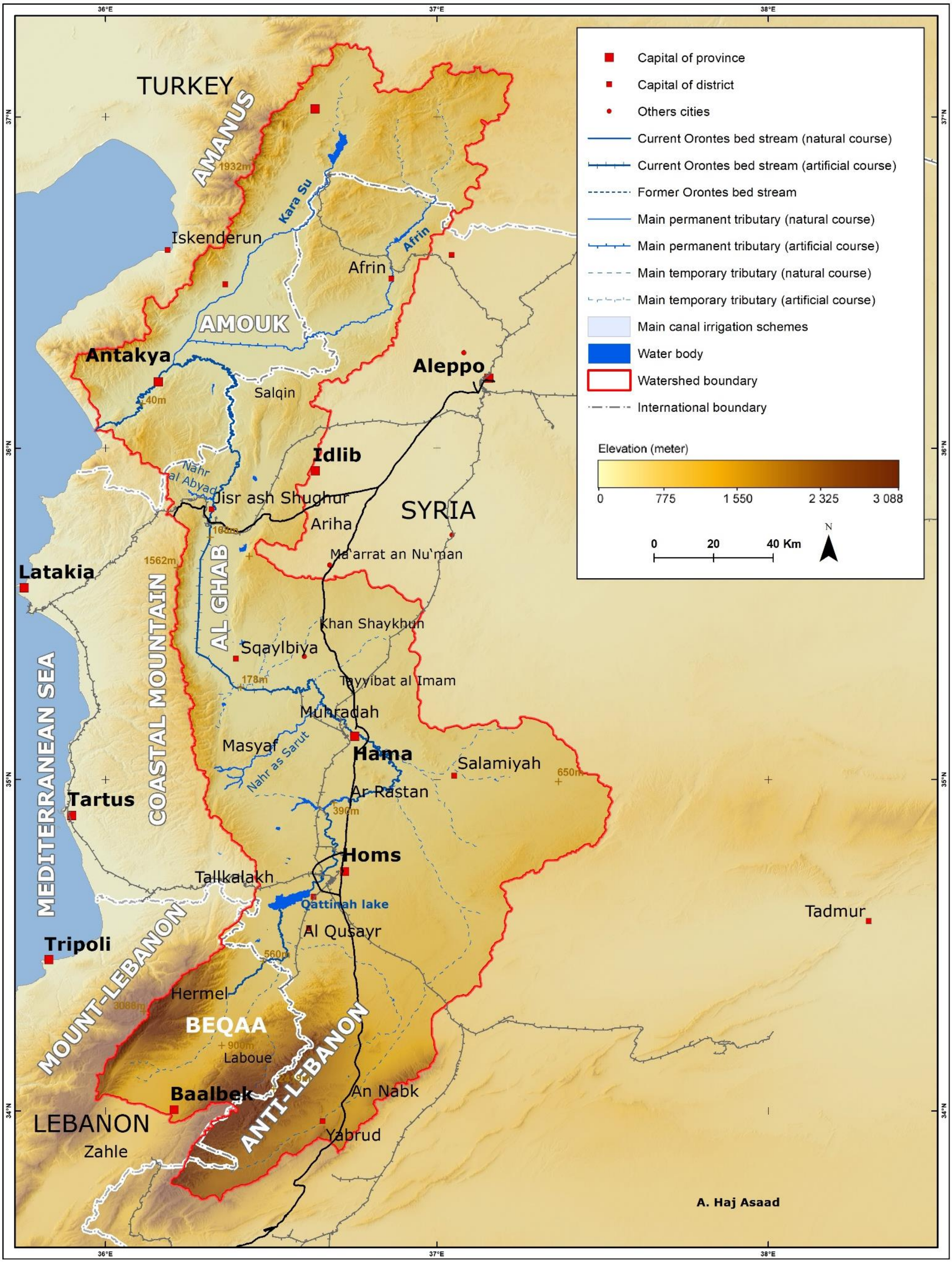
Introduction

This Atlas aims to provide a comprehensive overview of water resources, infrastructures, usages and management issues in the Orontes River basin. It is developed within a research program led by the Graduate Institute of International and development Studies with the support of the Global Program Water Initiatives of the Swiss Development and Cooperation Agency as part of an overall project on Water Security in the Middle East. The program aims to analyze water management challenges and perspectives and to establish a multidisciplinary scientific and technical network on water management in the Orontes River basin including Lebanese, Syrian and Turkish organizations. It is conducted in collaboration with the Lebanese Agricultural Research Institute, the Hydrogeology Center of the University of Neuchâtel, the Laboratory of Geographic Information Systems of the Federal Institute of Technology, Lausanne, the Faculty of Geosciences and Environment of University of Lausanne, the "Maison de l'Orient et de la Méditerranée", Lyon.

The Atlas is under development, the current version focuses on the upper and middle reaches of the basin. The Turkish section of the basin will be addressed in the third phase of the program. The atlas presents maps, short descriptions, tables and charts addressing several topics from the physical environment to water usages and their evolution in a spatial and historical perspective. It will be gradually completed with additional topics and will also examine the lower reach of the basin.

The history of human settlement in the Orontes River basin and the spatial distribution of activities are largely related to the availability and exploitation of water resources. The oldest dated water infrastructures, dating back to the Bronze Age, are found in the upper reach of the basin. These installations were extended in the Hellenistic, Roman and Byzantine periods and restored from the 1920s. While the Orontes River and the numerous springs located in the basin were the main source of water until recently, underground resources currently provide over 50% of the water extracted in the basin. Furthermore, over 80% of the surface water originates from springs. Groundwater management has become a critical issue.

Overview



Capital of province
Capital of district
Others cities
Current Orontes bed stream (natural course)
Current Orontes bed stream (artificial course)
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Main permanent tributary (natural course)
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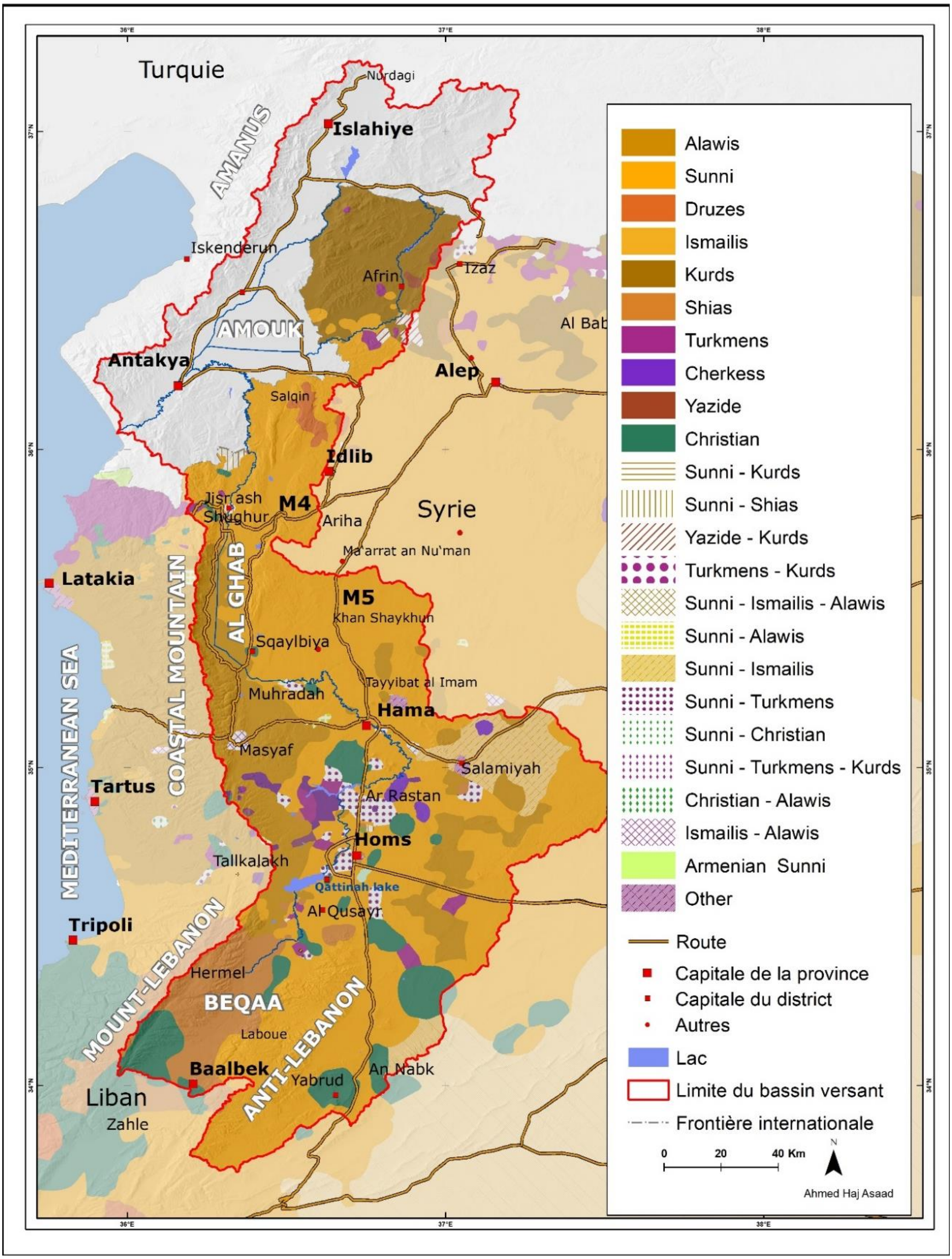
Main canal irrigation schemes
Water body
Watershed boundary
International boundary
Elevation (meter)
0
775
1 550
2 325
3 088
0
20
40 Km
N
TURKEY
AMANUS
1932m
Kara Su
Iskenderun
Afrin
Afrin
AMOUK
Antakya
Aleppo
Salqin
140m
Idlib
Nahr al Abyad
Jisr ash Shughur
Ariha
SYRIA
Ma'arrat an Nu'man
Latakia
1562m
AL GHAB
COASTAL MOUNTAIN
Khan Shaykhun
Sqaylbiya
178m
Tayyibat al Imam
Muhradah
Masyaf
Hama
Nahr as Sarut
Salamiyah
650m
Ar Rastan
390m
MEDITERRANEAN SEA
Tartus
Homs
Tallkalakh
Qattinah lake
Al Qusayr
Tadmur
Tripoli
MOUNT-LEBANON
560m
Hermel
3088m
BEQAA
900m
Laboue
ANTI-LEBANON
An Nabk
Baalbek
LEBANON
Zahle
Yabrud
A. Haj Asaad
36°E
37°E
38°E
37°N
36°N
35°N
34°N

The Lebanese section of the Orontes River basin, the northern Beqaa valley, is often viewed as poor and marginal. However, it is an area where large private investments have been made in the past three decades in irrigation development. The Lebanese and Syrian sections of the basin, in many respects, contrast each other, in terms of the intensity of the exploitation of water resources to the structure of the economy and the role of State in governing water resources. They are also closely interlinked making transboundary water management a complex issue hardly reducible to the water-sharing agreement between the two countries.

With more than four million inhabitants the Orontes River basin in Syria is an area of prime importance for both agriculture and industry. The basin contains the two major urban centres of Homs and Hama, several medium size cities and a wide range of industrial activities. Land irrigated using surface water and groundwater covers over 290’000 hectares, close to the area irrigated in the Euphrates basin which has received far more attention in the past four decades. The Orontes basin became one of the first industrialized regions of Syria with the establishment of state plants such as the sugar factory in 1948 and oil refinery in 1957 in Homs. The state industrial sector grew in the 1970s and 1980s with the establishment of plants including a fertilizer production factory close to Lake Qattinah, spinning mills and a large metallurgical complex in Hama. Industrialization accelerated in the 1990s with the development of private industries in particular chemical and pharmaceutical plants. The agricultural and industrial development in the region, led to a strong growth in the population of the Orontes basin.

In Syria, the Orontes River basin was subjected to a profound economic and environmental crisis prior to 2011. It comprises some of the most conflict-affected urban and rural areas in the country. The Orontes River basin is a key region in the ongoing conflict and will remain so during the post-conflict transition period. Massive population displacements and the widespread destruction are linked to the highly strategic nature of the basin due to the diversity of the population, the borders areas with Lebanon and Turkey, the access to the coastal areas, the Damascus – Aleppo highway and the large water and agricultural resources.

Diversity of the population in Orontes Basin



Topography and Hydrography

The Orontes, a Complex River

Mohamed Al Dbiyat, Bernard Geyer

The Orontes is the Levant's greatest river. It drains northern Beqaa, a portion of mainland Syria and of the Turkish Hatay, from the slopes of Lebanon to the foothills of the Taurus, over a stretch of nearly 610 km. Its watershed covers more than 24,870 km² with 2205 km² in Lebanon (9%), 17,110 km² in Syria (69%) and 5552 km² in Turkey (22%). Its waters, though scarce but perennial, have carved one of the most characteristic landscapes in Syria, "the Orontes gardens".

Shaped by Tectonics

The Orontes River has been shaped by tectonics (Weulersse 1940, p 11.): its course – and the same is true of the Litani and the Jordan – corresponds to the great Syrian ditch, with a North-South axis, located on a transform fault that is part of the Red Sea rift system, which extends from the Gulf of Aqaba to the Amanus. From the Orontes headwaters in the Beqaa, down to the Amouk depression in the Province of Hatay through the Al Ghab depression, the river flows along this major tectonic axis and into the Mediterranean, below the city of Antakya.

Its longitudinal profile reveals a complex geological history and is characterized by long stages, covered with alluvial floodplains or uplands carved out by the river and connected by abrupt gradient changes marked by rocky sills (Weulersse 1940, p. 15, fig. 4). The upper Orontes, upstream the Aïn ez Zarqa spring, 650 m high, is very similar to a "wadi", a seasonal stream, or even a temporary one, whose thalweg (main channel) is not clearly defined. Actually, the river source is a little above Hermel, where the karstic springs of Aïn ez Zarqa (the blue spring) gush out, and where, carving its way across an arid plateau, it winds through a steep and narrow, yet lush, valley. Shortly afterwards, it then reaches its first level, at about 500 m above sea level, where both Lebanon's mountain ranges disappear, giving way to the "Homs Gap" and the fertile Tell an Nabi Mindu plain it flows across. Basalts, which occupy most of the Homs gap and the Jabal al Hulw region, have squeezed the river into flowing further away to the North-East. When flowing out of the plain, its embankment steeps deeply into the basalt Homs plateau, resulting in a new break in slope, which remains steep all the way to Ar Rastan. There, it leaves the basalt and flows across soft senonian chalk, and the valley widens – though it is still carved across a plateau. The barrier of the basaltic Jabal al-Ala mesa forces the river to again change its course, to the northwest this time, towards Hama. Close to the Al Lataminah village, the next break in slope occurs, resulting from the very low basic level of the Al Ghab tectonic rift. Its gorges are steep, and they carve out the hard Cenomanian limestone down to the citadel of Shayzar where, thanks to a fault-line, the greatest step can begin. Indeed, from Shayzar à Qarqur, there stretches out a two-fold flat landscape, which for a long time remained largely unhealthy marshlands: the plains of Al 'Asharinah and Al Ghab, which correspond to rift valleys. In Qarqour, a break in slope closes the Ghab with a basaltic sill. From there, the Orontes flows down the slopes to Darkush and reaches the plain of Amouk, its last stage, which it crosses all the way to Antakya where the last break of slope leads it to its Mediterranean outlet.

A Complex Watershed

The Orontes watershed, a vast and complex one, can be divided into well-differentiated sections:

- Upstream to the plain of Homs, can mainly be found glacis systems whose surfaces are topped with conglomerates, and are marked with arid climate and soils, all the more so as they lie in the vicinity of Mount Lebanon highlands, which drastically ward off incursions of moist air masses. Yet, those highlands – and their, albeit lower, counterparts: the Anti-Lebanon – are at the origin of the karstic supply provided by the abundant springs that generate the Orontes and feed the large Northern Beqaa "oases": Baalbek, Laboue, Hermel, but also the smallest oases of Younine of Fakehe or Ras Baalbek. The progressive broadening of the Beqaa towards the north has enabled the establishment of a parallel network – in the Qaa "drainpipe", which collects the waters in the north-west of the Anti-Lebanon though it is no longer functional (Besançon and Sanlaville 1993, p. 14).
- The Tell an Nabi Mindu plain, which hosts Lake Qattinah (or Lake of Homs) is a large Neogene outcropping generated, behind basalt flows, by a once very large body of water. The presence of the "Homs Gap" between Mount Lebanon to the south and the Syrian coastal mountains enables the flow of moist air thwarted elsewhere by the barrier of mountain massifs. Hence, the plain benefits from a climate favorable to rain-fed crops, but irrigation is nonetheless widely developed there, again thanks to waters drawn from the river and springs. This accounts for the agricultural wealth of the region, where cereal crops and orchards are widely developed and gardens are concentrated around urban areas.

Topography and Hydrology

- Between the Tell an Nabi Mindu plain and the one of Al ‘Asharinah and of the Al Ghab, the river flows through several, first basalt then limestone plateaus, through very steep-sided valleys. The often bare surfaces of these plateaus, now reclaimed by fruit trees, traditionally used to host rain-fed grain farming. Contrary to these areas where edaphic aridity still has some impact, the bottom and alluvial terraces were the domain of waterwheels and occupied by lush crops, thanks to irrigation: this is an oasis economy, based on gardens, and which supplements the large grain economy. Most Orontes River tributaries converge toward that area. The most important ones are the Wadi Maydani, which drains all the northeast of the Anti Lebanon up to the Yabrud highlands, and the Wadi Al Kafat Who, flowing from Salamiyah, marks the foray of the basin into the arid eastern margins, up the Jabal al-Bil ‘as, a part of the Palmyrean chain to the north (about 100 km from the Orontes).
- The Al Ghab corresponds to a rift valley where sediment transported by the river is trapped. It is actually composed of two compartments, the Al ‘Asharinah low land the Al Ghab itself. The Orontes travels through the first from east to west before flowing around the rocky outcrop of Al Asharinah and through the Ghab from south to north. The whole area, naturally poorly drained and also fed by powerful springs from the coastal mountains and Syrian Jabal az Zawiyah karsts, has long been unhealthy and swampy. The Al Ghab, 80 km long and some 15 km wide, enjoys a very gentle slope (0.1 ‰); so, it has a very flat surface and the river, due to the rise of its bed, used to make a slight relief. In those days, these bank-lifts were the only inhabitable areas; there also, and only in the highest parts, lived Bedouin or mountain people in semi-lacustrine villages, relying mainly on fishing (Weulersse 1940, p 73.), buffalo breeding and small sorghum crops.
- The Qarqur-Darkush narrow pass, which contributes to the river flow thanks to springs fed from the Jabal Kosseir and Jabal al-Wastani and from the Rug depression of tectonic origin between Jabal az Zawiyah and al Wastani (Besançon et Geyer 1995) has also been completely transformed by development work on the Al Ghab (Mazloum 1954). To achieve the draining of marshes, the basalt Qarqur lock was removed; besides, the course of the Orontes was deepened from 4 to 6 m and widened from 11 to 30 m over the 5 km between the villages of Kufayr and Qarqur (Métral J. and Métral F. 1979, p. 308).

River Catchment and Regime

The Orontes is different from the other Levant rivers because it flows almost from end to end in subhumid Mediterranean bioclimatic region; therefore it enjoys significant precipitations (typically between 400 and 500 mm per year), which contribute to increasing its flow rate from upstream to downstream. But it is fed primarily from steep mountains, mainly limestone, which, well watered as they are, play the role of water towers, surrounding it almost all along its course, supplying many powerful springs, in all seasons. That is when it acquires its karstic nature together with the relative regularity of its flow throughout the year – further accentuated by the regulating role of the alluvial plains it flows across. Weulersse J. (1940, p. 50) characterizes the river by the “abundance of its mean flow, the regime regularity, the absence of devastating floods and the fixity of its bed.”

In Lebanon, ¾ of the flow rate is due to inputs from the Aïn ez Zarqa springs with an average flow of around 11 m3 /s, at an altitude of 650 m. Thus, the river regime in Al Qusayr, a small town located just upstream of the Qattinah dam lake, has all the characteristics of a mainly karstic watercourse regime. It has little inter-annual variations (the ratio between wet and dry years is 2 only). During the 1965-1973 period (dams have since profoundly disrupted the regime of the river), the minimum average annual river flow rate was at 14.8 m3 /s, while the maximum mean annual rate was only 17.2 m3 /s (Kerbé 1979). High waters start in June, averaging 16.5 m3 /s, with a nearly four-month delay relatively to maximum rainfalls occurring in January-February; this is partly due to the melting of the snow on the Lebanon Mountains that feed the karstic springs. The Orontes then experiences the most marked arid climate in its course, which is part of the explanation for the preponderance of karstic inputs. Low waters, meanwhile, occur in September, with an average flow of 12.6 m3 /s – still remarkably high because it is still supported by karstic inputs.

The area from Al Qusayr to Lake Qattinah is very little fed by inputs from tributaries that drain the southern and southeastern basin, located on the Anti-Lebanon eastern slopes and glacis. In this part, real tributaries have all but disappeared, due to the region’s marked aridity, sheltered as it is by the mountains: as a result, it receives less than 200 mm of precipitation per year. The Wadi Ar Rabi'ah is the biggest one, which drains the Qara and Hisya regions, and flows into the Orontes south to Al Qusayr. The southernmost part, fed by small karstic springs in the Anti-Lebanon, is traversed by the Al Majarr main wadi. The latter drains the Asal Alward area west of Rankus up to Yabrud and An Nabk. It then nearly dries up more or less in the arid lands of Northern Sadad and ends up in the Maydani wadi. The latter opens into the Orontes northeast of Ar Rastan and thus drains all the northeast of the Anti-Lebanon as well as the arid areas located east of Homs. Like in the area east of Al Qusayr, the intake is low here as it mainly depends on rainfall, already reduced over most of this region.

Flow measurement stations are rare on the river and no other data is available down to Shayzar. Reports then show lower intake with a specific module from 5.4 l/s/km2 at the entrance of the Lake of Homs, only 2.77 l/s/km2 to the Al ‘Asharinah plain (Besançon and Sanlaville 1993, p. 17). However, it is worth pointing out that, though there are many tributaries on this section (on the left bank, the Nafseh and the Nahr as Sarut Wadis that flow down the Jabal al Hulw; on the right bank, the Maydani Al Kafat and Al Durat Wadis), their inputs are mostly due to the surfaces that lie there and add on to the main catchment basin, more so than to seasonal if not temporary flow-rates – always rather slow compared to yearly averages. In addition, springs, essentially from the Hama plateau drainage, are less numerous here. Consequently, the river regime is, in this section, more substantially marked by seasonality. Note that, on this plateau, some valleys have been barred with small dams, in order among other things to store water during seasonal runoffs, so as to sustain irrigation and groundwater supply. This is the case of the Al Kafat dam on the eponymous wadi, and of the one built across Zayzun on the eastern slope of the Al Ghab. There are 40 dams in the Orontes basin, almost all located in Syria (only the Tahtaköprü dam on the Kara Su and the Yarseli one on a tributary of the Orontes are in Turkey. In Lebanon, a dam has been scheduled downstream of the Aïn ez Zarqa springs). Two of them, among the biggest ones, are designed for energy production (Ar Rastan and Muhradah), while the Qattinah dam, along with 20 others, provide irrigation water. The others are used to control the flow. These are built across wadis, to store water, like the Zeita dam, whose particular feature is to be fed by the river also, just before the Orontes flows into Syria, through a canal. The three major dam storage capacity – Ar Rastan, and Muhradah Qattinah – is 200 to 500 million m3 per year.

Just after flowing past the Shayzar gorge and into the Al ‘Asharinah plain, its regime is again dominated by karstic inputs, and integrates waters from the great Tall Al’Uyun spring. The river flow is then set at 18 m3 /s on average and is inflated due to the large number of springs flowing on the edges of the Ghab, fed from the coastal range on one hand and the Jabal az Zawiyah on the other. These springs average flow-rate is estimated at 13 m3 /s (Abdulsalam 1990, p. 50). The mean annual flow rate of the river, out of the Ghab plain is about 40 m3 /s. During wet years, the average maximum flow can reach 102 m3 /s (1968-1969) while it may come down to 23.4 m3 /s in dry years (Kerbé 1979). It should be noted that it is at high water (April-June) that agriculture water needs peak.

But the plentiful and relatively regular Orontes waters are not only beneficial. They also have a downside, in this region marked by the great number of depressions, rift valleys and deep depressions, where, due to poor drainage, water can accumulate, creating vast marshy wetlands that are repulsive until they have been drained. Even today, the drainage of the Ghab remains difficult during very wet years, despite all the work that has already been done (Besançon and Sanlaville 1993, p. 19). Finally, the Qarqur-Darkush narrow pass also brings its contribution to the river flow through sources fed from Jabal al Kosseir, Jabal al Wastani and the polje Ruj. It is through these gorges that the Orontes flows out of the area under study.

The volume of the Orontes waters, as it exits Lebanon, is estimated at 403 million m3 , of which 80 Mm3 are allocated to Lebanon according to the Syro Lebanese water sharing agreement . The total water resources in the Orontes basin are estimated at 2340 Mm3 /year, including inputs from Afrin and Kara Su. Where the Orontes flows into Turkey, the annual potential is 1400 Mm3 /year (Droubi 2012). The Orontes River accounts for about 13% of water resources in Syria, estimated at a total of 18,134 m3 / year.

Groundwater Input

The Orontes basin is characterized by a complex geological structure and lithology. Rocks are generally very permeable, and deeply karstified: limestones and dolomites of the Jurassic and Cretaceous chalky limestone of the Paleogene. Even basalt, as it is fractured, feeds the groundwater. Fractures facilitate the resurgence of springs, especially on both sides of ditches. The estimate of available groundwater in an aquifer is based primarily on estimating the recharge of these waters by precipitation or directly from rivers. Due to average (400 to 500 mm/year) rainfall inputs, (except in the east of the Hama Salamiyah axis, where the basin sinks into arid margins in the northern Beqaa and in the south-eastern Syria part in the region of Al Yabrud and An Nabk) and the good permeability of geological formations, most groundwater in the Orontes basin may be considered as renewable. Indeed, a recent study (ACSAD, 2012) estimated the recharge of groundwater at about 2,441 Mm3 /year.

Springs total flow-rate is estimated at 275 Mm3 /year. The Al Ghab region is considered the richest in groundwater throughout the Orontes area basin. It receives about 782 Mm3 /year in renewable recharge, in addition to about 568 Mm3 /year lateral flows from surrounding areas. In total, groundwater resources are about 1350 Mm3 /year (ACSAD, 2012).

Therefore, groundwater is said to feed about 90% of the total runoff of the Orontes basin, mainly thanks to karstic springs, the main one being the Aïn ez Zarqa spring, but also the Al Ghab springs; these gush out at the foot of the eastern slopes of the coastal range, the biggest ones being Nab` al Barid (0.94 m3 / s) and Ayn al Fawwar (0.93 m3 /s). Finally, groundwater is deemed able to provide approximately 56% of water needs for agriculture in the whole basin of the Syrian Orontes, where the irrigated area is estimated at about 85,000 ha (Alchami, 2000)**.**

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Climatology

Rainfall and Temperature Regimes

Myriam Traboulsi

The rainfall regime

The Orontes basin receives highly variable rainfall related to its topographic features. Rainfall decreases in Lebanon from south to north, from 400 mm in Baalbek to less than 200 mm in Qaa, and then increases in the Syrian section of the basin. The natural passage in the coastal mountain between Tripoli and Homs lets through maritime influences far inward (466.9 mm / year in Homs, 409.7 mm / year in Qattinah). The Syrian coastal mountain is lower than that in Lebanon, which favors valley stations. An average of 368.0 mm / year was recorded in Ar Rastan, 383.9 mm in Muhradah and 335.3 mm in Hama. Salamiyah located further east, receives 300.9 mm. North of the valley, the Nahr al Kabir pass also allows the penetration of maritime influences. Northern stations are better endowed, with rainfall at 502.5 mm, where 679.1 mm can be recorded in Idlib and 679.1 mm in Jisr ash Shughur.

The rainy season runs from October to May (Fig. 1) with a concentration of rainfall in the three winter months (December, January and February) that accounts for more than 50% of the annual total (61.7% in Qaa, 58.1% in Hermel, 57.4% in Al Qusayr, 58.9% in Homs, 59.7% in Muhradah and 55.5% in Jisr ash Shughur). This reflects the high frequency of disturbed weather patterns generating rainfall during this period (Traboulsi, 1981, Blanchet, 1993; Blanchet and Traboulsi, 1993, Traboulsi, 2004). The average monthly maximum is to be found in January as regards all stations and it is between 20 and 22% of the annual total. Spring rains take second place, accounting for between 19% and 23% of the annual total, while autumn rains account for only 15 to 20%. Summer rains are merely the expression of a few thunderstorms restricted in time and space (0 to 1.9%). The dry season is due to the presence of subtropical high pressures in altitude (500 hPa level).

Given the apparent movement of the sun, the rainy season, combined with advections of cold polar air, corresponds to low temperatures, while the dry season corresponds to high temperatures.

Mean Annual Precipitation in Lebanon and Syria

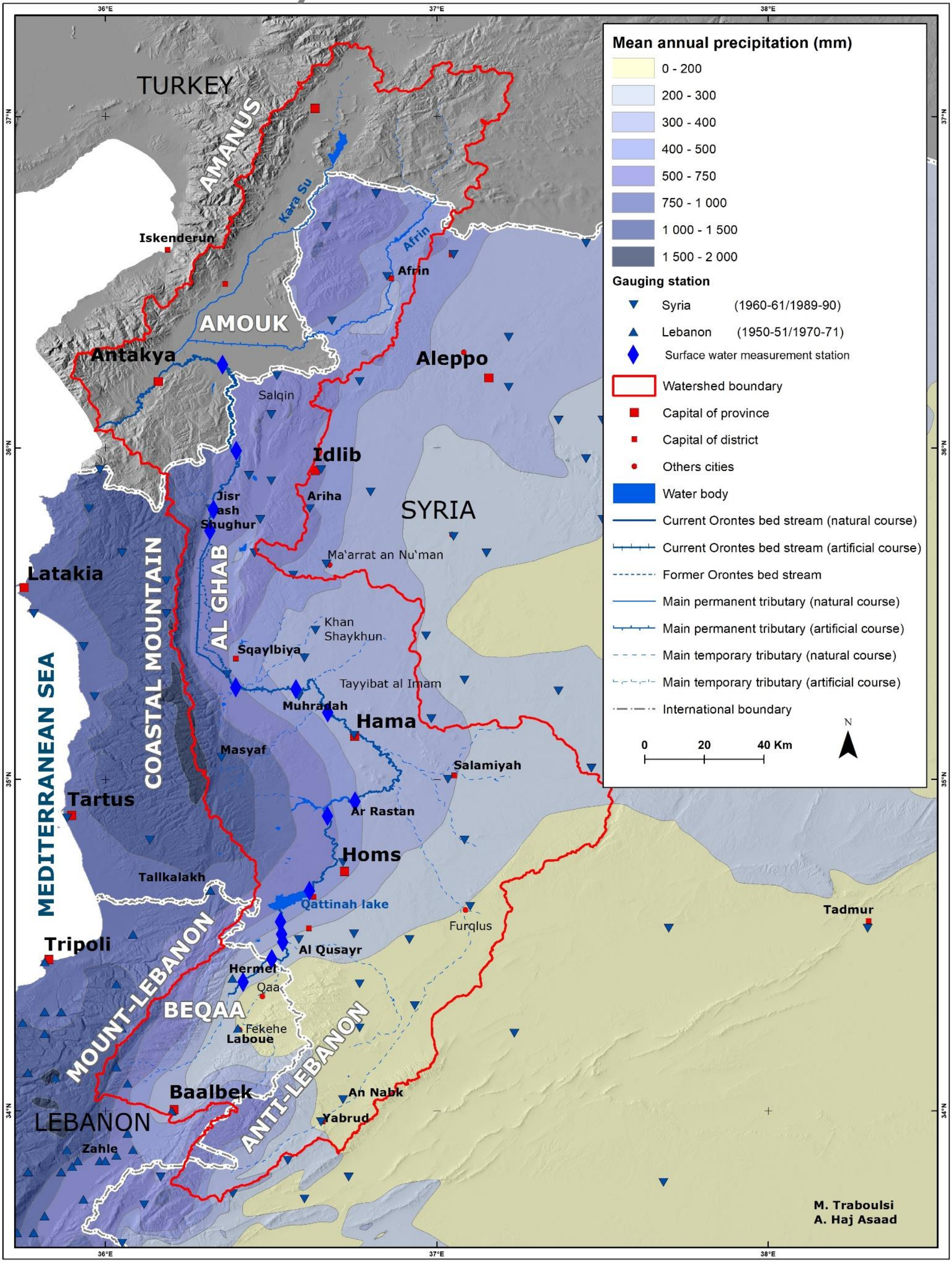
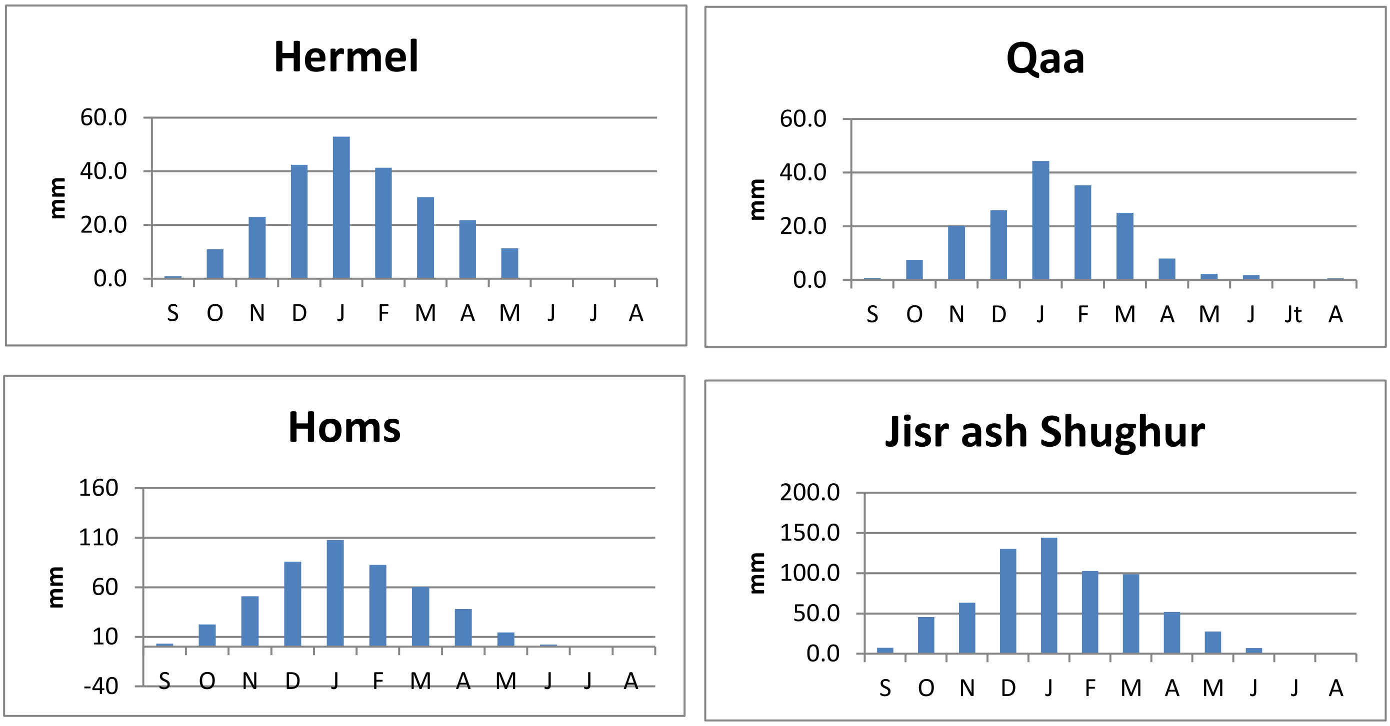


Figure 1: Average rainfall regime in the Orontes valley



Rainfall variability

Rainfall varies considerably from year to year depending on the frequency of disturbed weather types generating rain, which in turn are characterized by great irregularity. Both "dry" and "wet" years, 1972-73 and 1966-67 respectively, illustrate the fluctuations in rainfall in the region (Fig. 2). During the years 1966-67, the Orontes valley received in Syria more than 500 mm and less than 200 mm in 1972-73.

The ratio between the extreme "dry" and "wet" years varies between 3 in Jisr ash Shughur and 9 in the Beqaa. The variation coefficient of annual rainfall is at 24 in the Al Ghab Valley and increases toward the east and south of the basin (31.1 in Salamiyah, 31.9 in Furqlus and 34.5 in Al Qusayr).

Variability is much more marked on a monthly scale -- a very rainy month one year may be dry the following one. Monthly variation coefficients in the four stations, in Fekehe, Hermel Salamiyah and Homs (Table 1) show that the spring and autumn months, experience the strongest variability, whereas it is relatively low at the heart of the rainy season. (Traboulsi 2004)

Figure 2: Interannual rainfall variability

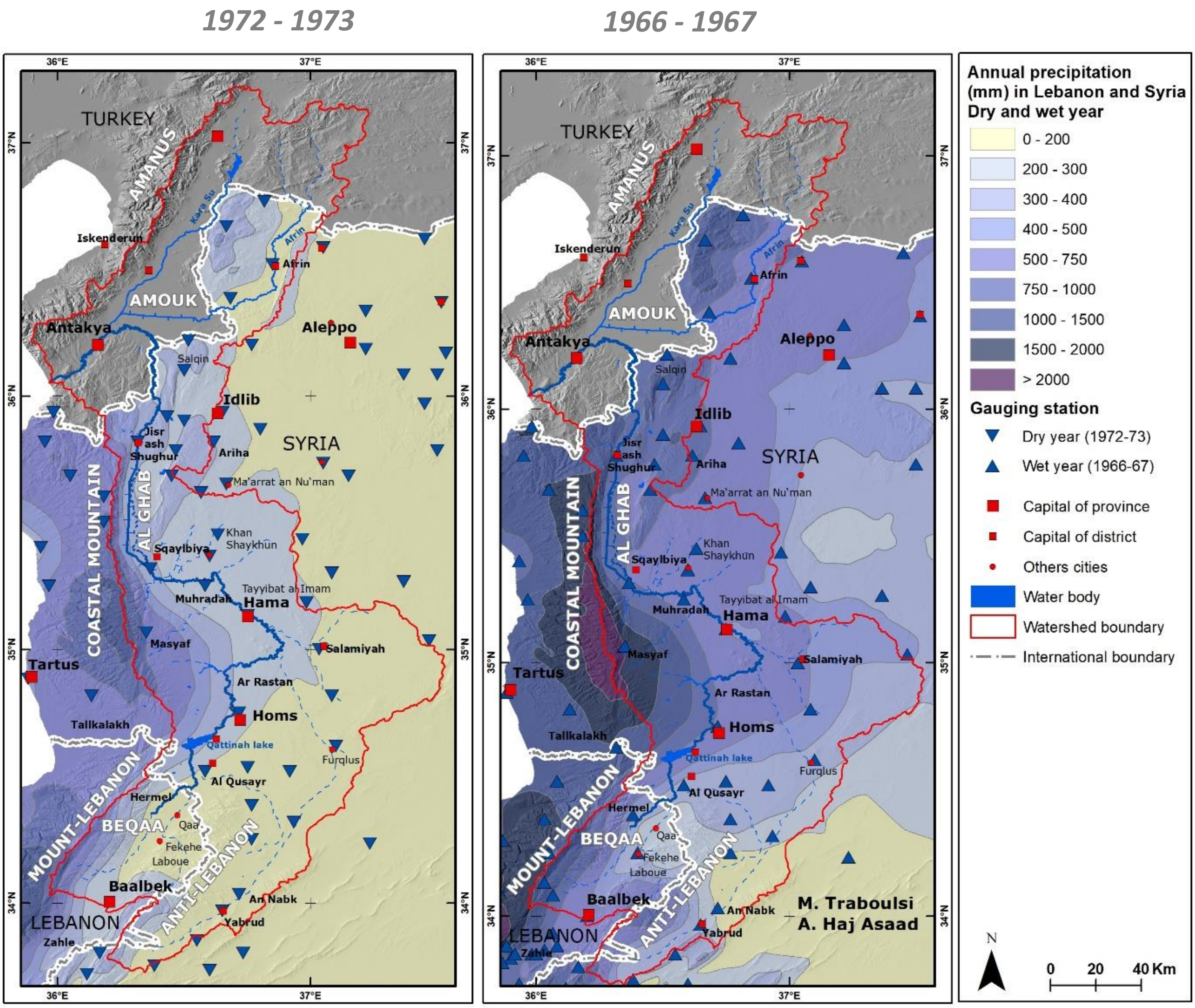


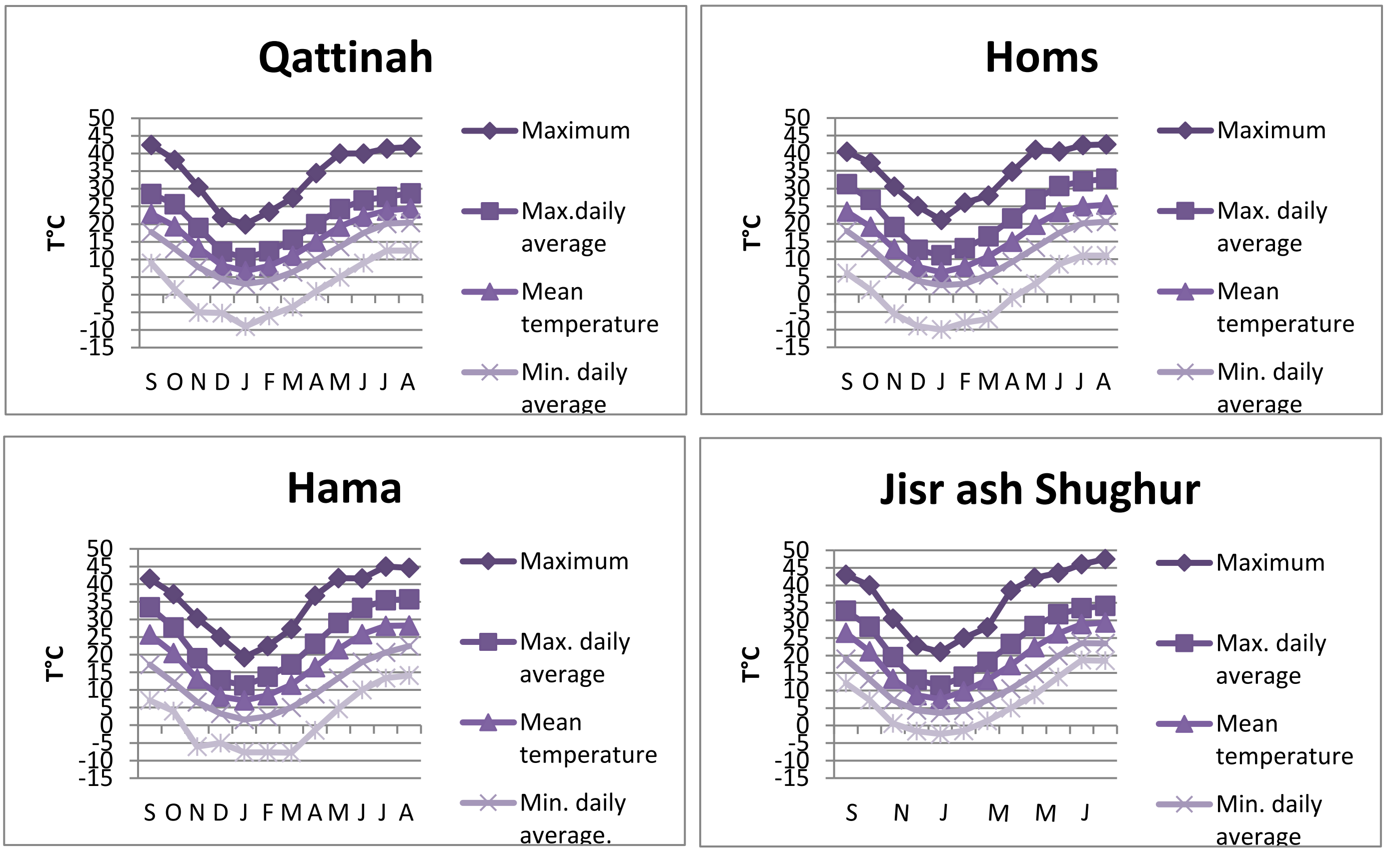
Table 1: Coefficients of monthly variations

	S	O	N	D	J	F	M	A	M	J
Fekehe (1967-2001)		79,4	63,0	48,2	66,7	48,9	70,0	83,0	78,2	383,0
Hermel (1932-1971)	380,6	114,9	75,7	67,0	60,8	52,9	68,1	79,6	138,6	-
Salamiyah (1965-1995)	313,8	122,1	76,1	53,9	59,7	68,0	55,5	73,7	112,1	331,2
Homs (1965-2004)	449,4	98,9	56,5	54,9	40,7	79,6	50,1	70,1	120,9	274,0

The average thermal regime

The average annual temperature regime is Mediterranean (Fig. 3). The lowest average is in January. The Syrian-Lebanese mountain barrier prevents softening maritime influences from getting through. This average is 6.6 °C in Al Qusayr, 6.7 °C in Qattinah, 6.3 ° C in Homs and 7 °C in Hama. Jisr ash Shughur, higher in latitude and altitude, recorded a higher average of 7.6 °C thanks to the Nahr al Kabir passage . The highest monthly average is in August (24.5 ° C in Qattinah, 25 °C in Homs, 28.3 °C in Hama and 29.4 °C in Jisr ash Shughur). For 6 months (4 months in Homs and Qattinah), it remains above 20 °C and for 4 months (2 months in Homs and 1 month at Qattinah), it is above 25 °C in Hama and Jisr ash Shughur (June, July, August and September).

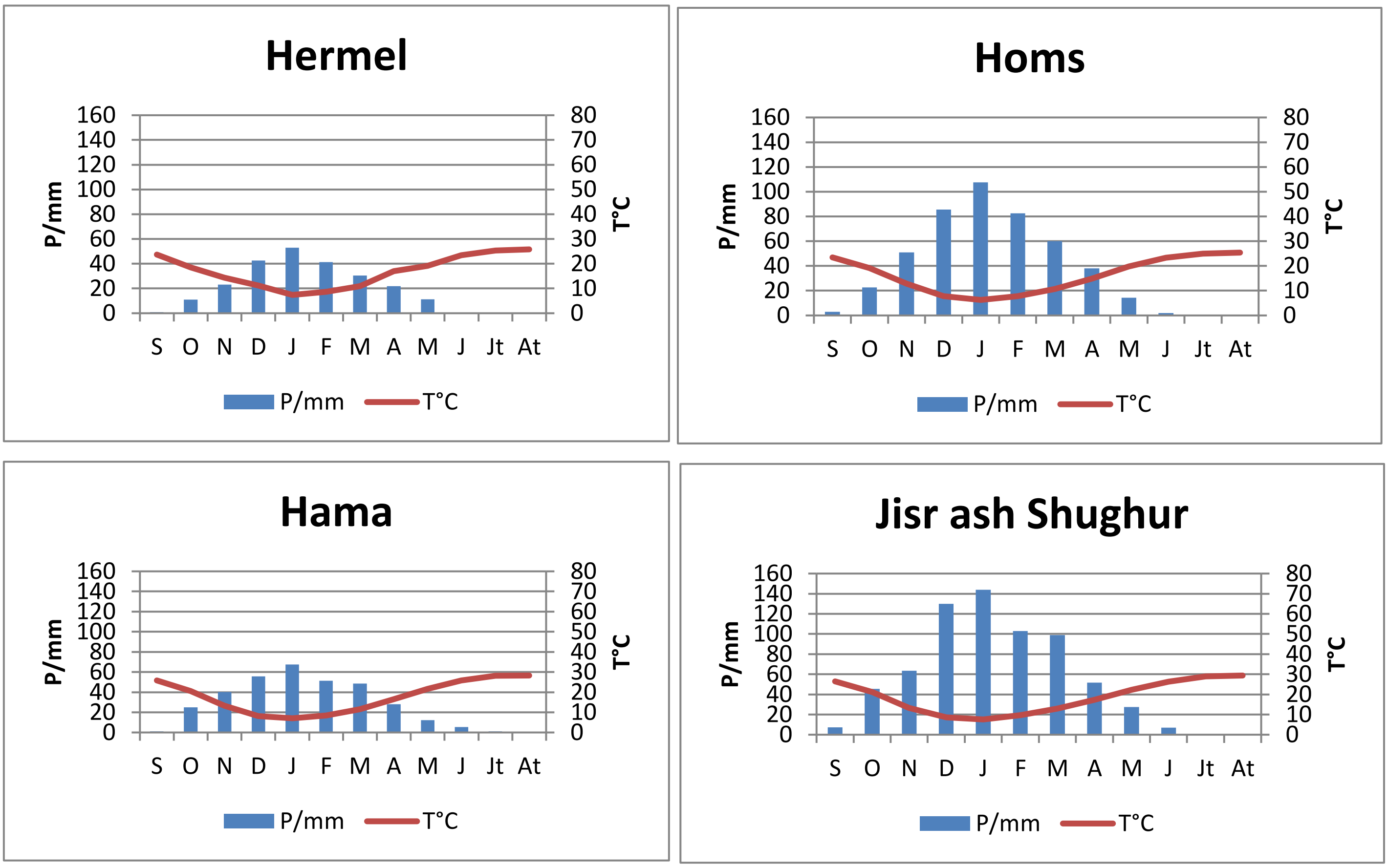
Figure 3: Average thermal regime in the Orontes valley



The average minimum temperatures follow the same rhythm. They record the lowest values in January (1.6 °C in Hama, 2.6 °C in Homs, 3.0 °C in Qattinah and 3.6 °C in Jisr ash Shughur. They remain below 5 °C during the three winter months (December, January and February), and below 10 ° C for 6 months of the year (5 months in Jisr ash Shughur). The absolute minimum is -10 ° C in Homs, -9.0 in Qattinah and -7.8 in Hama at the same period, while it is -2.4 °C in Jisr ash Shughur for the period between 1957 and 1999 (-9 , 0 °C between 1955 and 1969).

As for maximum temperatures, the monthly average exceeds 20 °C as early on as in the month of April and reached 30 °C for 4 months (in Qattinah, the average daily maximum does not reach 30 °C). The absolute maximum, occurring in August (in July in Hama), reached 47.5°C in Jisr ash Shughur, 44.6 °C in Hama, 42.5 °C in Homs and 41.8 °C in Qattinah. The dry season extends from 5 months in Jisr ash Shughur to 8 months in Hermel (Fig. 4).

Figure 4: Umbro-thermal diagrams showing the length of the dry season in the Orontes valley.



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Hydrogeology

Hydrogeological Structures

François Zwahlen, Raoul Gonzalez, Ahmed Haj Asaad

The Orontes basin contains significant karstic water resources, which largely fed the Orontes River before the extensive development of irrigation. Three important lithological units constitute the huge water reservoir of the Orontes River basin: two thick limestone formations from the Jurassic era and Mid-Cretaceous era supply the springs located in the upstream part of the basin and a more recent formation from Eocene-Miocene supplies the springs located in the downstream part of the basin.

The Orontes basin also includes several secondary aquifers from the Upper Cretaceous era and Paleogene era that outcrop over large areas. Because of their low porosity and relatively high permeability, these formations with modest water resources are often significantly over-exploited. However, their initial piezometric level is sometimes completely or partially recovered after particularly wet years.

The Jurassic and Mid-Cretaceous aquifer complex

As shown on the different cross-sections, the thicknesses of the fractured and generally karstified aquifers formations from the Jurassic and Mid-Cretaceous eras, may each approach or exceed one thousand meters thick. Even if these formations are certainly not equally fractured and karstified, they contain groundwater flowing through them and from one to the other, using tectonics faulting or fractures, even if they are separated by lower Cretaceous quite impermeable formations. At the scale of basin, we can simplify and consider the Jurassic and Cretaceous formations as a unique complex aquifer forming a very large reservoir in hydraulic continuity. Furthermore, in areas where this Lower Cretaceous layer forms a thin barrier hydraulic heads differences can form between the two aquifers, and large transfers of water can be expected, because the of the considerable extension of these two formations.

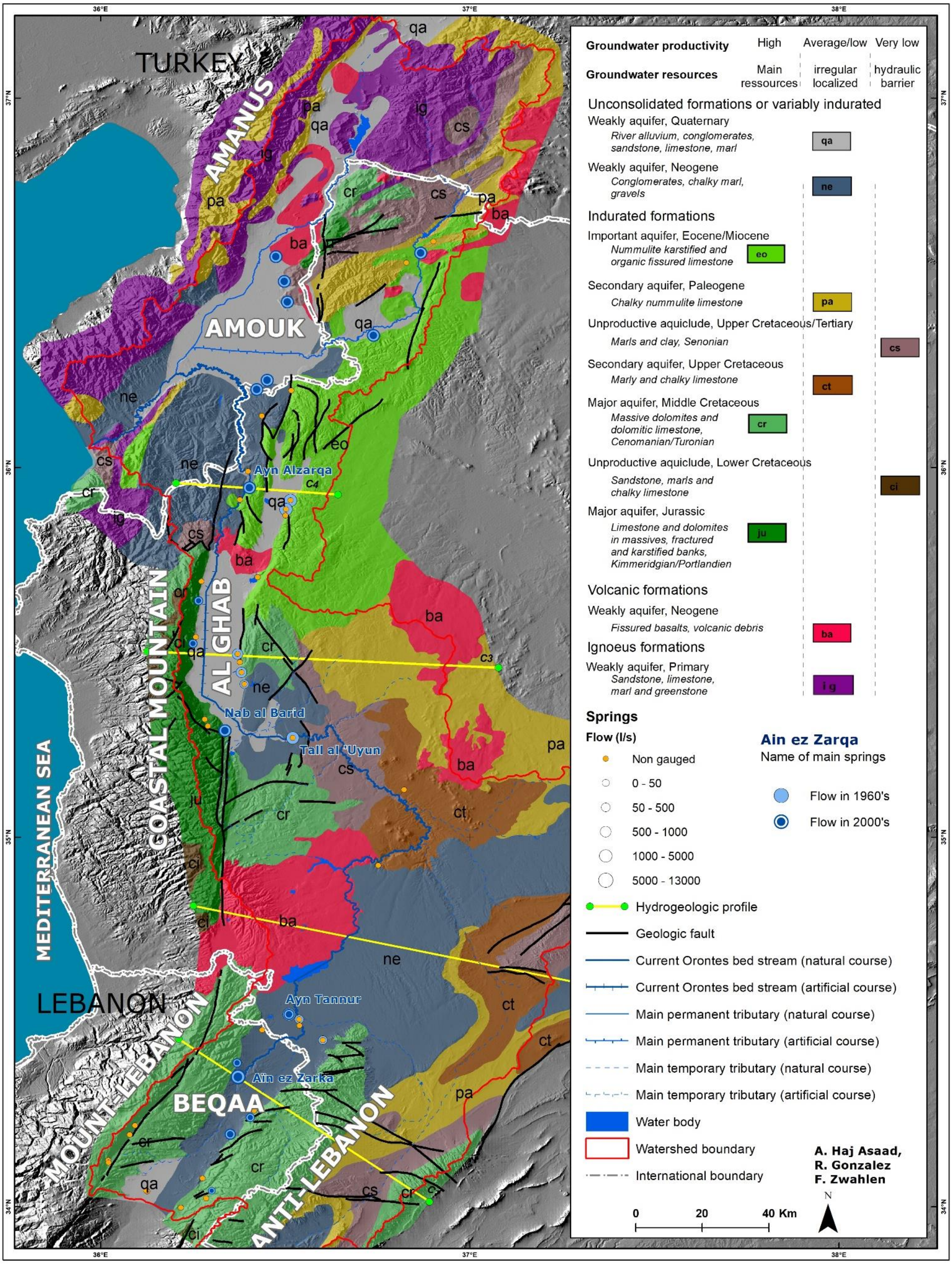
In the southern and central part of the basin, this vast karstified reservoir supplies many springs, which have an average annual flow up to 13 m3 /s. Their regime is more or less stable throughout the year because of the very large water reserves, the high hydraulic conductivity, the well-developed internal drainage and the extended confinement of this complex reservoir. The recharge of the Jurassic-Cretaceous reservoir is particularly important in the highest areas of the basin, specifically in the Mount Lebanon and the Anti-Lebanon Where limestone formations outcrop; the recharge rate could reach 60%. Taking place mainly during winter season, the recharge can locally extend to the spring during the melting of the snow cover.

The Eocene-Miocene aquifer complex

In the north of the basin, significant groundwater resources are contained in the limestone Eocene– Miocene formations, which form a regional shallow aquifer but with high extension. Where they outcrop, these highly cracked, fractured and karstified formations offer particularly favorable infiltration conditions, similar to those mentioned above for the aquifer complex Jurassic and Mid-Cretaceous. Water resources of these formations are particularly high despite precipitation, which are so much lower than those observed on the Mount Lebanon.

These limestone Eocene-Miocene formations are the source of many springs: those of Ruj depression and those located along the Orontes upstream from the border, including Aïn ez zarqa, a remarkable spring with a stable and particularly high flow.

Hydrogeological structures
Lebanon, Syria and Turkey

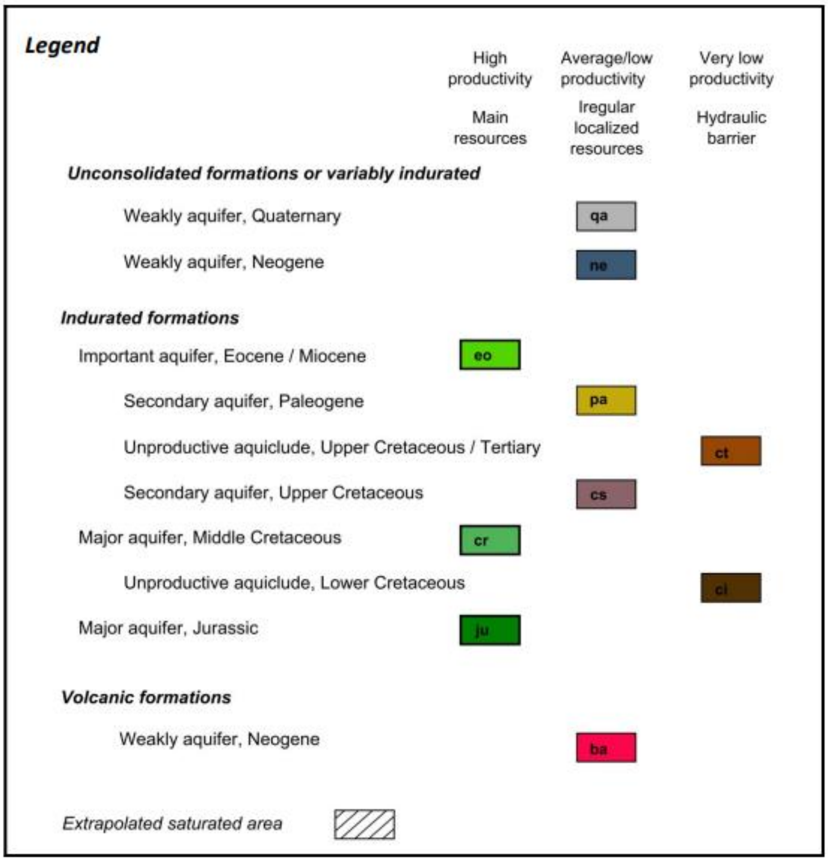


Springs

Inventory of groundwater sources and resurgences of major interest of the Orontes basin, contains around 30 springs, including several major located close to the Lebanon-Syrian border, as Aïn ez Zarqa and Ayn at Tannur The evolution of their annual average flow between the 1960s and the 2000s is difficult to access precisely. We generally observe a significant decrease because of the intensive use of water more specifically groundwater pumping from deep wells, due to recent and rapid development of new irrigated lands, mainly in Syria.

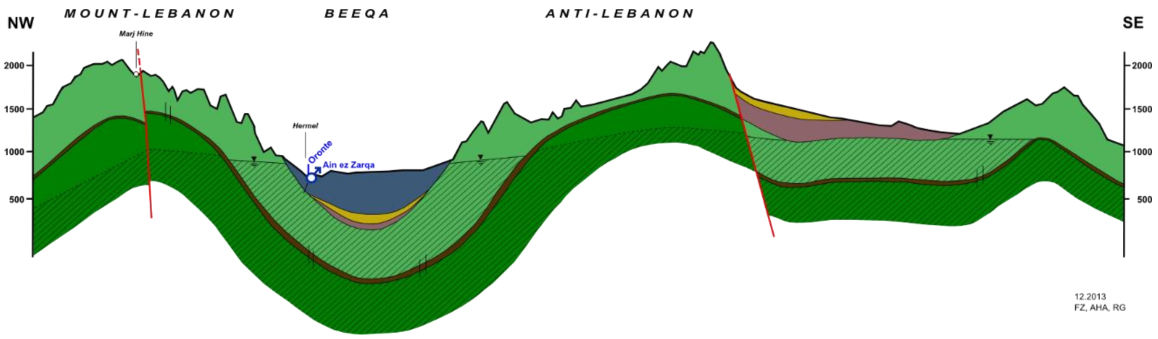
Supplied by groundwater coming from Jurassic and Mid-Cretaceous aquifer, the main sources in Lebanese territory are Aïn ez Zarqa (Orontes spring, 1.01) and Ain el Laboue (1.02), in Syrian territory close to the border are Aïn at Tannur (2.01), Uyun as Samak (2.02) and Ayn al Damamel (2.03). Remote groundwater discharge of the same Jurassic and Mid-Cretaceous aquifer has been much more affected downstream, in particularly in the East of the Ghab areas. Some springs have even been dried.

Cross sections



❖ C1

C1



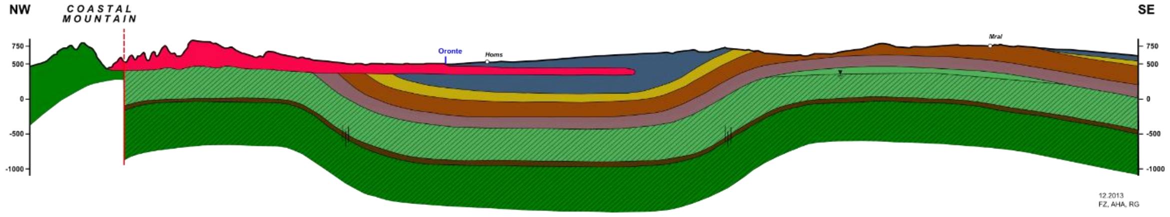
This hydrogeological cross-section is located in the upstream part of the Orontes River, where it flows in the Beqaa valley between the Mount Lebanon and the Anti-Lebanon Mountains. The system of Yammmouneh fault is visible in the Mount Lebanon, where it probably forms a preferential flow path for recharging the major Cretaceous and Jurassic aquifers.

The Aïn ez Zarqa spring, which spurts out in the bed of the Orontes Rivers, is present on this cross section. This resurgence ensues from probable fractures allowing the flow of water from the middle Cretaceous through the Neogene formation.

The middle-Cretaceous is saturated under the Beqaa; the groundwater level is located at the edge of the Neogene era. Overflow springs can occur when the groundwater level rises above the edges of the plain. The recharge of the middle-Cretaceous and Jurassic aquifers comes mainly from the Anti-Lebanon Mountains. Most of the precipitation falling on the Mount Lebanon flow towards the Mediterranean Sea.

❖ C2

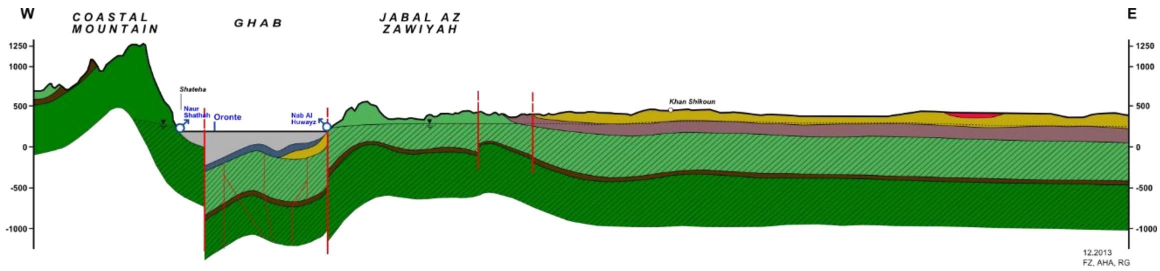
C2



This cross-section begins at the southern limit of the Coastal Mountain and goes through the city of Homs. The Orontes flows between crumbly and volcanic Neogene formations. The major middle Cretaceous aquifer is probably confined in its western part by the volcanic Neogene unit, contrary to its eastern part, where many wells have been drilled.

❖ C3

C3

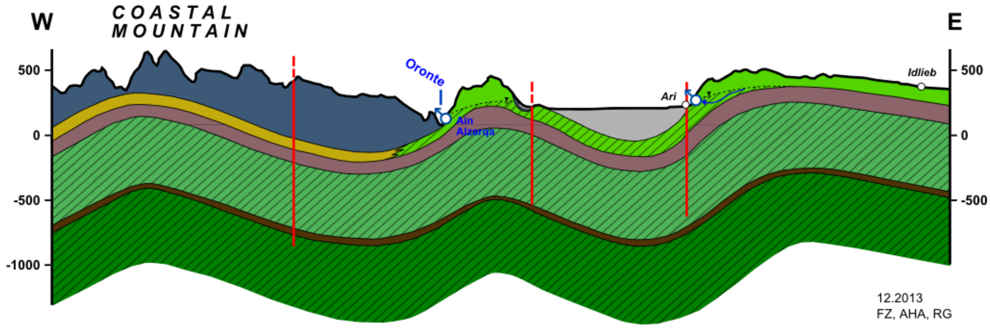


This cross-section goes across the highest part of the Coastal Mountain and the Ghab valley. The Orontes River flows through a multitude of channels, of which only the main channel has been shown. Faults both sides of the quaternary deposit give rise to many resurgences, like the Naur Shathah (2.17) and the Nab Al Huwayz (2.15) springs.

To the east, the piezometric level in the aquifer of the middle-Cretaceous is probably in equilibrium with the level of the shallow aquifer. Exchanges must occur between the two aquifers, causing some subrecharge of the shallow aquifer by the deep aquifer of the middle-Cretaceous era in areas of high exploitation of the shallow aquifer.

❖ C4

C4



The important Eocene-Miocene aquifer can be observed on this cross-section. This aquifer supplies two springs: the Aïn al Baqq (2.24) spring close to the village of Ari and the Aïn ez Zarqa spring near the steep-sided bed of the Orontes River. This spring remains remarkably stable over years, which remains to be explained.

Water Infrastructures

Ancient Water Infrastructure

Marie-Laure Chambrade, Mohamed Al-Dbiyat, Bernard Geyer

The Orontes basin has been home to water supply practices with diverse amenities. These are irrigation channels, aqueducts1 , qanats (underground galleries connected to the surface through a string of wells), dams, norias (waterwheels), watermills but also wells, built or simply summarily dug in alluvial table. These developments would make it possible to exploit water from springs, shallow groundwater and the river, to supply cities such as Baalbek-Heliopolis, Hama and Homs and to provide water for irrigation. The earliest water amenities were likely located in areas receiving less than 300 mm of mean annual rainfall, in the south-eastern part of the watershed from the Beqaa to the regions of Wadi al Majarr and Salamiyah.

One of the characteristic examples of spring exploitation involves those in Laboue, whose waters were collected and carried through channels to the north of the Beqaa. The longest of these canals, including a qanat on part of its course, flows along the foothills of the Anti-Lebanon to Syria (fig. 1).

Figure 1: “Canal of Zenobia” (a) and detail of its course on the foothills of Anti-Lebanon (b) (M. Al-Dbiyat)

a

b

Ancient hydraulic structures in Lebanon and Syria

According to local legend this canal was built by Queen Zenobia (267-272 AD) to carry freshwater from Laboue to Palmyra in central Syria, the capital of her kingdom. Although its origin actually dates back to the Roman-Byzantine period (64 BC - 636 AD), there is no evidence supporting this narrative and its route seems to end before Hisyah to the south of Homs, at the foot of the Anti-Lebanon Mountains. The water supply of the Roman city of Baalbek-Heliopolis was also provided in part by a canal that carried water from the source of Nabaa Lejouj, located on the slopes of the Anti-Lebanon (Parrot 1929). The few traces preserved from these developments suggest the existence, from the Beqaa to the Al Ghab plain, of a whole network of canals that could go back to these ancient times. In Syria, it is worth noting the existence of the qanat al 'Ashiq (the "lover's canal"). Dated 116-117 AD, it carried water flowing from 'Ayn ez Zarqa', west of Salamiyah, down to the city of Afamiya, on a journey of about 150 km (Balty 1987). The canal was destroyed by an earthquake in 1157 and restored in 1491; its course was modified to flow towards Hama2 (Kamel 1990).

Qanats collect subsurface groundwater and convey it by gravity to their outlet, sometimes several miles away (Lombard 1991). They are used for irrigation and domestic purposes. Qanats in the Orontes watershed are grouped in the most arid areas like the northern part of the Beqaa Valley and the Easternmost areas of the watershed in Syria: the Salamiyah area and the Wadi al Majarr region (fig. 2). The oldest qanats date back for the most part, to the Roman –Byzantine period, perhaps in rarer cases to the Persian period (537-332 BC; Lightfoot 1996).

Figure 2: Qanats in Ar Ruhaybah (wadi al-Majarr area; 34°16'42"N, 36°55'50"E)

The Orontes waters were exploited mostly with norias, which permit to raise the water and pour it in an aqueduct through a system of bucket wheel (Delpech et al 1997; De Miranda 2007; Al-Dbiyat 2010). They are distributed along the Orontes River downstream of the city of Homs and there are many of them between Ar Rastan and Al ‘Asharinah, where 95 norias were identified (fig. 3). The norias are rural, used for field crop irrigation, or urban, supplying towns and gardens (Al-Dbiyat 2010). The famous gardens of Hama flourished until the 1940s and were served by a dozen norias that were exclusively dedicated to them (Boissière 2005; fig. 4). The existence of the Orontes norias is attested from the Byzantine period (395-636 AD.), thanks to a mosaic in Afamiya dated 469 (Dulière 1974; fig. 5), but the first waterwheels could go back to the Hellenistic period (300-64 BC; Balty 1987). Construction continued into the 1940s, with the exception of the Al Rawaniyya waterwheel in Hama built in the 1990s (De Miranda 2007). The Orontes norias are no longer used for irrigation but some have been restored and are maintained in operation for patrimonial purposes (De Miranda 2007).

There is also the network of canals diverting the Orontes waters for irrigation in the area of Al Qusayr. The canals are associated to three ancient dams, one on the bridge of Hermel and two in Syria , Saiyad Aali and Homariyeh, close to the border. Dams and irrigation channels are difficult to date, although they have been documented in the Near East from the Bronze Age onwards (3600-1200 BC). Canals on the right bank are considered as “Romans” by locals (Métral & Métral 1990), which means that they were “ancient”. They are indeed made from a different kind of workmanship than the others and were originally built underground, then discovered and restored around the 1830s (Duraffourd 1929, quoted by Métral and Métral 1990).

Finally, the presence of many watermills, sometimes associated with norias, should be noted in the Orontes River basin. Few details exist to date these. Many of them may go back to the Ottoman period (Al-Dbiyat, pers. com.), as mention is made of the Rabun mill and waterwheel southeast of Hama for example, in texts that date them back to 1563 (De Miranda 2007). But this type of facilities were used in antiquity, at least since the Roman period (Mays 2010 and endnote 3), and milling technology may have reached Syria by the first century AD (Lewis 1997).

While the ancient facilities that are known and dated with certainty would therefore not predate the Roman-Byzantine period, it is likely that water projects -- wells, canals or dams -- were built much earlier. We must not forget that it was in the flourishing period of the Bronze Age that witnessed the urban phenomenon on the banks of the Orontes River. We will discuss here, the case of the Qattinah Lake dam (or Lake Homs; Calvet and Geyer 1992), a little upstream of Homs, which allowed water to flow to the orchards of this important and ancient city and meet the needs of its inhabitants The scarcity of references to water projects earlier than the Roman period is easily explained by difficulties to date such structures, by their subsequent reuse, or by their disappearance, (especially if they were not in masonry). Beyond these difficulties, archaeological knowledge demonstrates that the Orontes River had been a centre of attraction for thousands of years, especially for the development of prestigious cities, overlooking rich territories: Homs as well as Hama or Tall an Nabi Mindu, the ancient Qadesh. This prosperity was due, in particular, to the presence of the river, but also to the exploitation groundwater resources in a relatively well-watered region, but still subject to aridity -- and, more importantly, to the seasonality of precipitations.

Figure 3: Noria in Al ‘Asharinah in 1932 (IFPO) (a) and in 2002 (M.-L. Chambrade) (b)

a

b

Figure 4: Tell, gardens and norias in Hama in the 1930s (IFPO) (a) and in 2009 (M. Al-Dbiyat) (b)

a

b

Figure 5: Mosaic in Afamiya representing a noria (Kamash 2012)

Notes

1. Following A.T. Hodge (1992), P. Leveau (2004) and Z. Kamash (2012), we define aqueducts as masonry channels, open or roofed and less than one meter wide, providing water by gravity flow from a spring, a river or a reservoir to a settlement as primary purpose. Therefore, in the text as on the map, we will refer to the broad term "canals" because their construction or primary purpose are in some cases not well-defined yet and some of them can be of different type along their course (e.g. "canal of Zenobia").

2. Only that portion could be plotted accurately from topographic maps and satellites photos.

3 . J-Ch. Balty does not give any argument for his hypothesis but we know that Romans have used waterwheel technology, and also watermills (cf. infra in the text), thanks to the book of Vitruvius (1st century BC) De Architectura (Maufras 1847).

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Water Infrastructures

Contemporary Water Infrastructure

Myriam Saadé, Ahmed Haj Asaad, Omar Shamali, Ronald Jaubert

Water infrastructures currently in service in the upper and middle reach of the Orontes basin are restored ancient infrastructures, such as the Qattinah dam or canals feeding the irrigated perimeter of Qusayr. The rehabilitation of these canals initiated in the 1920s, was followed by the extension of water networks in order to increase irrigated areas, particularly in the plain of Homs in the 1930s. In the late 1950s, the construction the Ar Rastan and Muharadah dams were the first stage of the Al Asharinah and Al Ghab irrigation development plans. Some facilities such as waterwheels (norias) have been gradually abandoned in favor of others, in particular motor pumps installed all along the course of the Orontes River. The construction and operation of the Ar Rastan dam reduced the river discharge thus putting out of use many waterwheels (Delpech et al 1997). The introduction and generalization of motor pumps substantially increased the extraction of groundwater which led to a profound transformation of the exploitation of water resources in the basin.

Development of the Upper Orontes

Ancient water facilities located between the northern Beqaa and Lake Qattinah, in the Upper Orontes, have been relatively little changed during the twentieth century. In the Lebanese part of the basin, oases – or ghoutas – exploit the many springs located in the area, namely, Younine, Laboue, Fakiyé and Ras Baalbeck at the foot of the Anti-Lebanon; Hermel and Qasr at the foot of Mount Lebanon (Weulersse 1940). The largest irrigation network which is fed by the Laboue springs was slightly modified in the 1960's. The main change took place during the civil war with the redefinition of water distribution rules. During the the 1970s, and especially since the end of the civil war, canal irrigation systems were overwhelmed by the proliferation of boreholes and the subsequent extension of irrigation from groundwater, particularly in the “Projects area” north of Qaa along the Syrian border (Audi 2013). Downstream, across the border with Syria, several perimeters are irrigated from canals fed from the river. Five water intakes are located in the three main river waterfalls, 3 km upstream of the LebaneseSyrian border, in Lebanese territory. These canals irrigate a total of 6,800 ha in Syria and 100 to 200 ha in Lebanon. They are also used in Lebanon for domestic water supply and for the disposal of wastewater from nearby villages. Canals along the river side that allowed small scale irrigation on the banks were abandoned in favor of fish farming and tourism (restaurants, hotels...).

Development of the Middle Orontes

The initial studies conducted during the French Mandate aimed at defining the hydro agricultural potential of the middle reach of the basin. The studies identified two main areas for irrigation developments, the plain of Homs and the plains of Al Asharinah and Al Ghab. The development of the latter two areas, respectively from the 1930s to the 1950s and the 1950s to the 1970s, led to the construction, of dams on the Orontes River and its tributaries (Table 1). In the late 1950s, the young Syrian Republic built the dams of Rastan and Muhardah, in 1958-1960 and 1959-1961 respectively, and raised to 500 million m3 of the total storage capacity, fed the 12 600 km2 catchment area upstream of Muhardah. The reservoirs provided only seasonal flow control of the Orontes River. From the late 1980s, seven new dams of smaller capacity were built. In addition, 24 dams of local importance were built upstream of Lake Qattinah, and in the governorates of Homs, Idleb and Aleppo in the district of Afrin. Since the 1980s, the whole area has been marked by an increase in the drilling of boreholes and intensive groundwater exploitation, not without consequence on the use of public waterworks.

Contemporary hydraulic structures in Lebanon and Syria

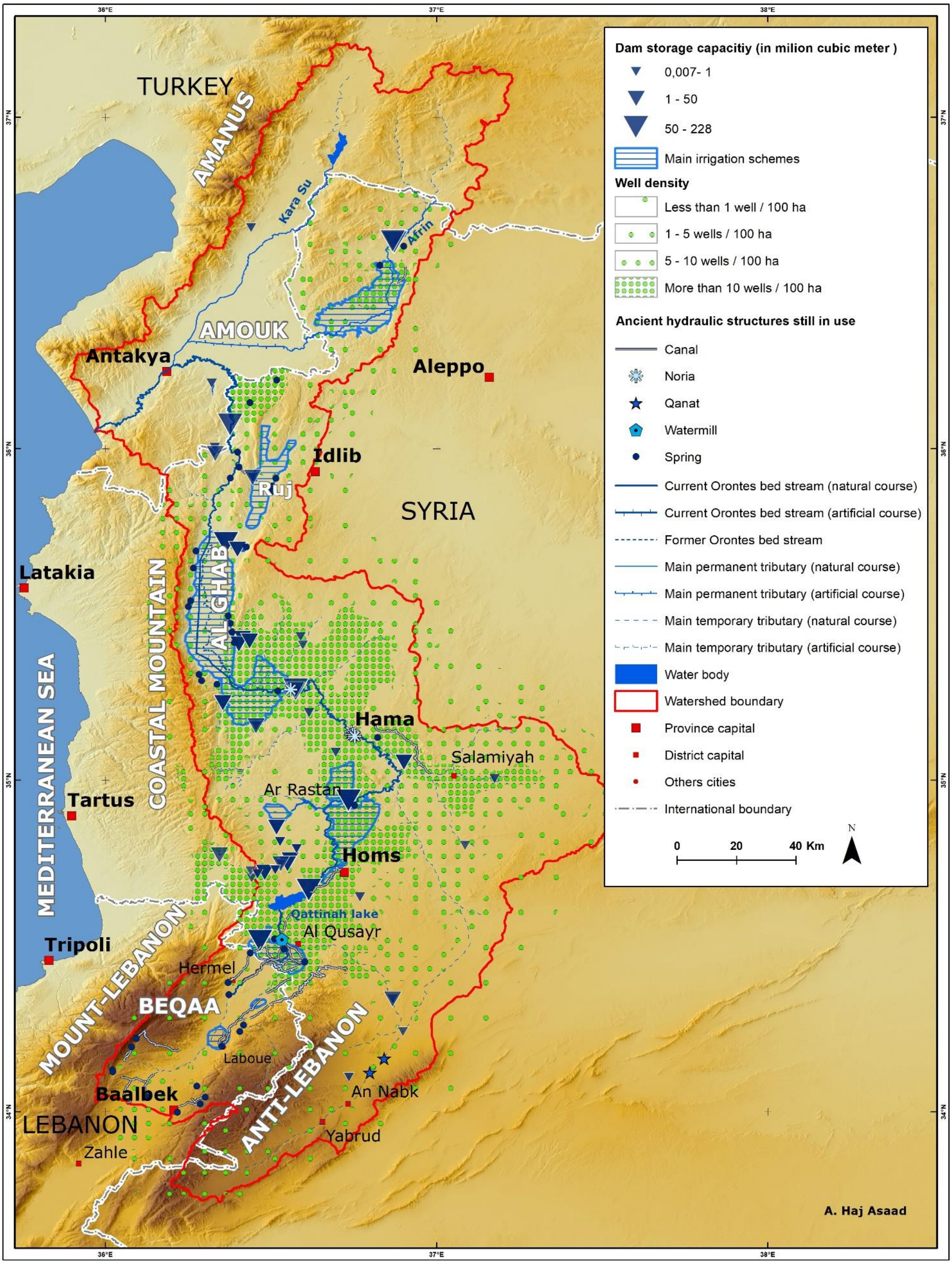

Table 1: Main dams on the Orontes

Name	Year of construction	Capacity (in millions of m^3)	Irrigated area (ha)
Qattinah	1938-1940	185	22000
Rastan	1958-1960	250	59841
Muhardah	1959-1961	50	72000
Afamia A	1996	27.5	5470
Afamia B	1997	38	Undocumented
Afamia C	1997	23	Undocumented
Zayzun	1995	71	Undocumented
Kastoun	1992	27	3000
Abu Barra	1987	8	Undocumented
Salhab	1992	7.75	Undocumented

Source: Shamali and Droubi, 2013

The Homs-Hama irrigated perimeter

A large irrigated area extends along the Orontes River between the cities of Homs and Hama. The irrigation schemes are fed by the reservoir of the Qattinah dam, possibly one of the oldest dam still in operation. Before the modern redevelopment of the Homs plain, three canals were fed from the lake, one of them used to supply water to the city of Homs for domestic usages and for irrigating 1,000 hectares of gardens. Gibert (1949) estimated that a total of 2,000 ha were irrigated in the Homs plain in the 1940s. The development of these irrigated gardens, initiated during the French Mandate in 1936, involved the raising of the Qattinah dam (1938-1940) to increase the storage capacity of the reservoir. It also involved building a 68 km canal between the cities of Homs and Hama; and connecting this canal to a network comprised of secondary, tertiary and quaternary canals (Gibert 1949). The irrigable area was estimated at 60,000 ha, only a part of which has been brought under irrigation. The canal irrigation scheme, irrigated about 20,200 ha in the late 2000s. The Homs-Ar Rastan section of the irrigation network, built between 1936 and 1942, irrigated 13,000 ha and the Ar Rastan-Hama network, built between 1944 and 1950, supplied 72,00 ha. The irrigated area decreased by 15% to 20% on the past 15 years.

Development of the Al Asharinah and Al Ghab plains

Over the three decades following the independence, during the agrarian reforms period, major hydraulic works were launched in the Al Asharinah and Al Ghab plains, where large irrigated state perimeters were established. Both areas are located northwest of the city of Hama, in the Middle reach of the basin. The Al Asharinah plain spreads over 15 km from east to west. The Al Ghab plain made up of lacustrine sediments, stretches over 10 km wide and 50 km long. Both these regions were originally swamps, fed by the annual flooding of the Orontes and by perennial springs in the foothills. Fishing used to be the main economic activity (Thoumin 1936).

In 1950, the Syrian government initiated the Middle Orontes project to recover 35,000 hectares of land and irrigate between 65, 000 and 70, 000 ha. The Al Ghab Office was created in 1951 to implement the project. Despite government instability during 1958 to 1963, the project remained a priority of the first Five-Year Plan (1960-1965) and benefited from public investments until the late 1970s although supplanted by the Euphrates development project as the flagship program of Syria's irrigation policy. In the wake of several assessments, including the one conducted by the Dutch company NEDECO, the project was implemented between 1960 and 1968. The work consisted, at first to blow up the basaltic lock located in Karkur north of the Al Ghab plain; drain the swamps; and broaden and deepen the bed of the Orontes between Karkur and Kfeir. Two dams were built at Ar Rastan and Muhardah to regulate the flow of the river and supply irrigation water (Ar Rastan dam). All irrigation and drainage systems were operational in 1968. Nearly 950 km of main and secondary canals were built. The unhealthy and difficultto-access marshy plain became, , an intensive agriculture pilot region in a span of two or three decades (Métral 1979). Currently, the irrigated areas of Al Ghab and Al Asharinah cover an area of 45,800 ha and 26,000 ha respectively.

The operation of these schemes has met with a number of difficulties. The development of the Al Ghab irrigation scheme especially, faced strong physical constraints related to the climate, water and soils. Diagnoses made between 1972 and 1978 on irrigation and drainage revealed drainage and maintenance problems and irrigation regulation deficiencies. Farmers' coping strategies such as pumping from drainage collectors cause further damage to the system. Following these observations, the Al Ghab and Al Asharinah perimeters were renovated in 1986: drainage and irrigation networks were improved and the storage of surplus water from the winter period was increased. This phase included the rehabilitation of the Karkur dam in order to reduce its exploitation. This work was completed by the construction of the Abu Barra and Salhab dams on Orontes tributaries for flood-control and water storage, and by the creation of the Afamia A, B, C; Kastoun and Zayzun reservoirs, to store the excess water pumped during the winter.

From the mid-1990s, both irrigation schemes experienced other difficulties related to the deterioration of the situation of the Orontes in general, and in the Al Ghab and Al Asharneh areas in particular (Droubi and Shamali 2013; Shamali 2014). Low rainfall during the 1993-2001 and 2005-2008 seasons and intensive extraction of groundwater, contributed to the depletion of aquifers and reduction in the flow of springs. Rough estimates of the water balance sheet indicate that, if the 594 million m3 required for irrigation is to be balanced, the amount of water provided from the Upper Orontes (Rastan and Muhardah dams) should be increased by about 200 million m3 . Because of reduced water resources in the Upper Orontes and low of water storage in the Ar Rastan reservoir, in 1998-1999 and 1999-2000, Al Ghab and Al Asharinah irrigated areas had virtually no supply from the irrigation network. These areas were then entirely dependent on springs and groundwater. Conversely, during the 2002-2003 season, high rainfall and releases from the Ar Rastan reservoir caused flooding in the Al Ghab perimeter.

Structural problems such as the fragmentation of holdings, the average size of which is of 400 m2 superscript, and inefficient water distribution policies have contributed to the water shortage. Despite this, irrigated areas continued to expand thanks to the exploitation of groundwater resources which are also used in dry years to supplement the supply of surface water from canal networks.

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Demography

Population Density and Demographic Trends

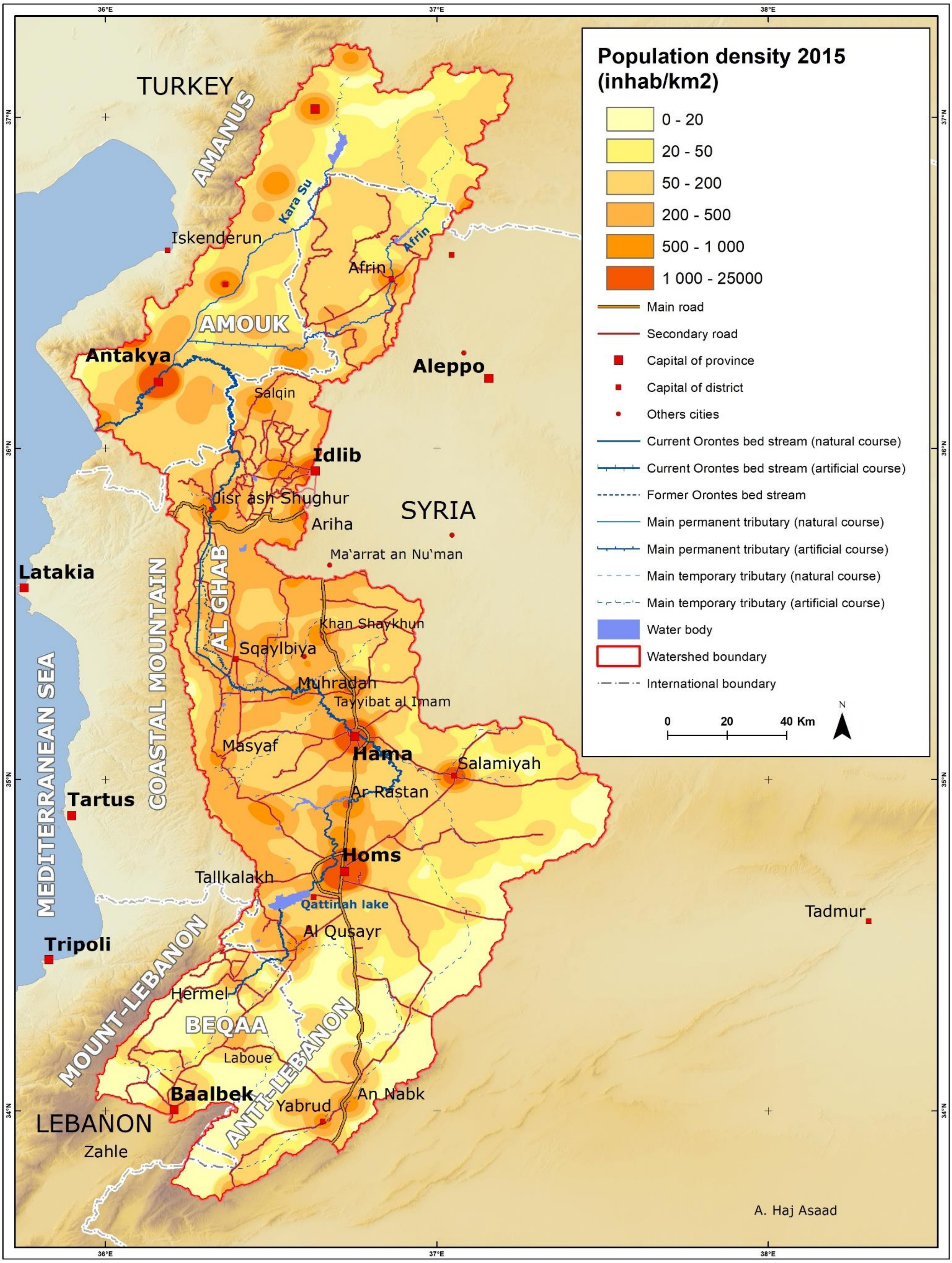
Mohamed Al Dbiyat

Population density and distribution The settlement and urbanization of the Orontes River basin has been organized since ancient times around water resources that have seen developments early on. The basin includes a large number of archeological sites. From the south to the north, the main sites include ; the city of Baalbek (Heliopolis) and the Neolithic site of Laboue in Lebanon, the cities of Kadesh (Tall Nabi Mindu), Emese (Homs), Qatna (Al Mashrafah), Arethusa (Ar Rastan), Epiphany (Hama), Nasriyah (city of the Bronze Age now abandoned), Larissa (Muhradah) , Apamea (Qalaat al Mudiq) in Syria and Antioch (Antakya), in Turkey, capital of the Roman province of Syria. These ancient cities have been occupied continuously since their establishment with the exception of Nasriyah.

In 2011 the total population of the Orontes basin was close to 6 million inhabitants divided among Lebanon (380,000 Hab., 6%), Syria (4.20 million, 69%) and Turkey (1.48 million, 24%). The average population density is 215 inhabitants per km ^{2} with a large heterogeneity in the distribution of the population over the territory. The majority of this population is currently concentrated in Syria, in the two main urban centers of Homs and Hama in the center of the basin. The population density is the lowest in the arid and mountainous zones in the south and east of the basin with less than 50 inhabitants per km^2.

In the Lebanese section of the Orontes basin, the population density and rate of urbanization in the region are the lowest of the country. Baalbek is the first city of the northern Beqaa area with nearly 35,000 inhabitants. It is followed by Hermel with 12,000 inhabitants and the towns of Ras Baalbek, Laboue et al Ain, Qaa and Aarsal whose population is between 2,000 and 5,000 inhabitants. The habitation of all these towns is related to the presence of springs. The Orontes basin in Syria is one of the most densely populated regions of the country with the highest regional urbanization rate. In continuation of the northern Bekaa, the population density increases sharply in the border district of Al Qusayr. This is explained by the fact that the boundary was drawn along the irrigation canals watering the downstream plains of Al Qusayr and Tall An Nabi Mindu. Further south, the basin includes large agricultural resources and industrial plants.

Population Density in Lebanon, Syria and Turkey



In Syria, the urbanization rate for the Orontes River basin is 53%. A quarter of the basin's population leaves in the two cities of Homs and Hama, with 700,000 and 350,000 inhabitants respectively in 2010. Half of the urban population leaves in medium size cities such as Salamiyah (70,000 Hab.), Jisr ash Shughur (43,000 hab.) Masyaf (25,000 Hab.) And Muhradah (18,000 Hab.), Yabrud (25,891 Hab.), An Nabk (32,548 Hab.), in the south and Afrin (36,562 Hab.) in the north.

Demographic trends

The Orontes River basin has experienced strong population growth, particularly in Syria, since the 1950s. In addition to a high birth rate, the population growth has been fueled by migrants attracted by the large hydro-agricultural development projects undertaken in the region such as the Al Ghab irrigation scheme. Migration flows took place in two main waves: first, migrants settled in rural areas until the late 1960s and second, rural-urban migration within the basin increased sharply in the 1980s.

The agricultural development policy implemented after the coming to power of the Ba'ath Party strongly reduced the rural exodus in the 1960s and 1970s. Later, the education policy favored the migration of young people, who were attracted by jobs in the public services, to the administrative centers in particular Homs and Damascus. The rural-urban migration has accelerated since the1990s as a result of the agricultural economic crisis. Prior to the conflict, the Orontes basin was one of the most severely crisis-affected areas in the country.
Between the last two population censuses of 1994 and 2004 the annual growth rate was of 3% for the Syrian section of the Orontes basin, substantially higher than the national average of 2.57% in the same period.

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Land Use

Land Use Classification and Summer Irrigation

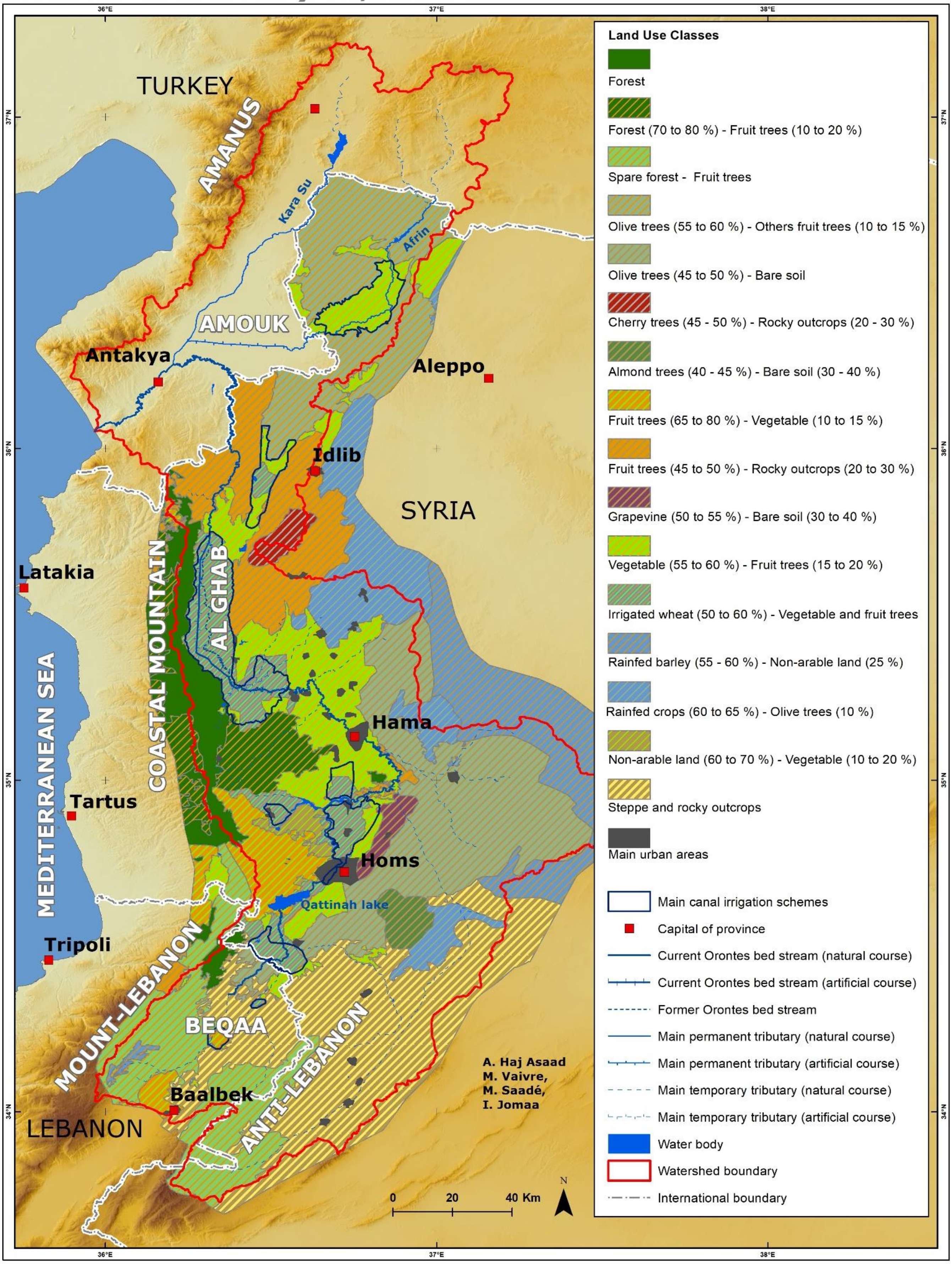
Ahmed Haj Asaad, Mikael Vaivre, Myriam Saadé, Ihab Jomaa

The land use in the Orontes River basin and its evolution are related to the availability of land, water resources and climate characteristics. It is also related to the economic, political and institutional contexts of the region. All these elements induce a large diversity in land use patterns and rapid changes in the allocation of cultivated areas. These have driven significant changes in the spatial distribution of water use for agriculture particularly due to the intensification of the exploitation of groundwater resources. In 2010, ground water accounted for over 50% of the water used for irrigation. The land use map has been derived from satellite data and agricultural statistics for 2010. The classification is based on the dominant or the two dominant natural or cultivated vegetation covers. The area and relative importance of the 16 classes is given in Table 1.

Table 1: Land use classes (Lebanon and Syria)

	Class	**Area (ha)**	**%**
1	Forest	122'911	4.79
2	Forest 70 - 80% -Fruit trees 10 - 20%	94'176	3.67
3	Sparse forest - Fruit trees	204'083	7.95
4	Olive trees 55 - 60 % - Other fruit trees 10 - 15 %	217'072	8.45
5	Olive trees 45 – 50% – Bare soil 30 – 40 %	323'439	12.6
6	Cherry trees 45 - 50 % - Rocky outcrops 20 – 30%	17'042	0.66
7	Almond trees 40 - 45 % - Bare soil 30 – 40%	21'997	0.86
8	Fruit trees 65 – 80% - Vegetables 10 – 15%	91'735	3.57
9	Fruit trees 45 - 50 % - Rocky outcrops 20 – 30%	190'335	7.41
10	Grapevine 50 – 55% - Bare soil 30 – 40%	16'915	0.66
11	Vegetable 55 - 60 % - Fruit trees 15 - 20%	281'449	10.96
12	Irrigated wheat 50 - 60%, Veg. and fruit trees 20-30%	148'524	5.78
13	Rainfed crops 60 - 65% - Olive trees 10%	172'324	6.71
14	Rainfed barley 55 - 60% - Non arable land 25%	223'968	8.72
15	Non arable 60 - 70% - Vegetable10 - 20%	16'153	0.63
16	Steppe and rocky outcrops70 - 80 %	425'749	16.58
	Total	**2'567'872**	**100**

Land Use in Lebanon and Syria, 2010



The most suitable areas with regards to land and water resources are located in the Orontes valley and in the district of Afrin in the north of the basin. These lands are mainly used for the production of cereals, vegetables or are planted to fruit trees (classes 8, 11, 12) and cover 20% of the study area. These areas have been home to several water projects, the oldest of which are located in the upper and middle reach of the basin. Canal irrigation schemes cover Nearly 40% of the total area of the tree classes 8, 11 and 12.

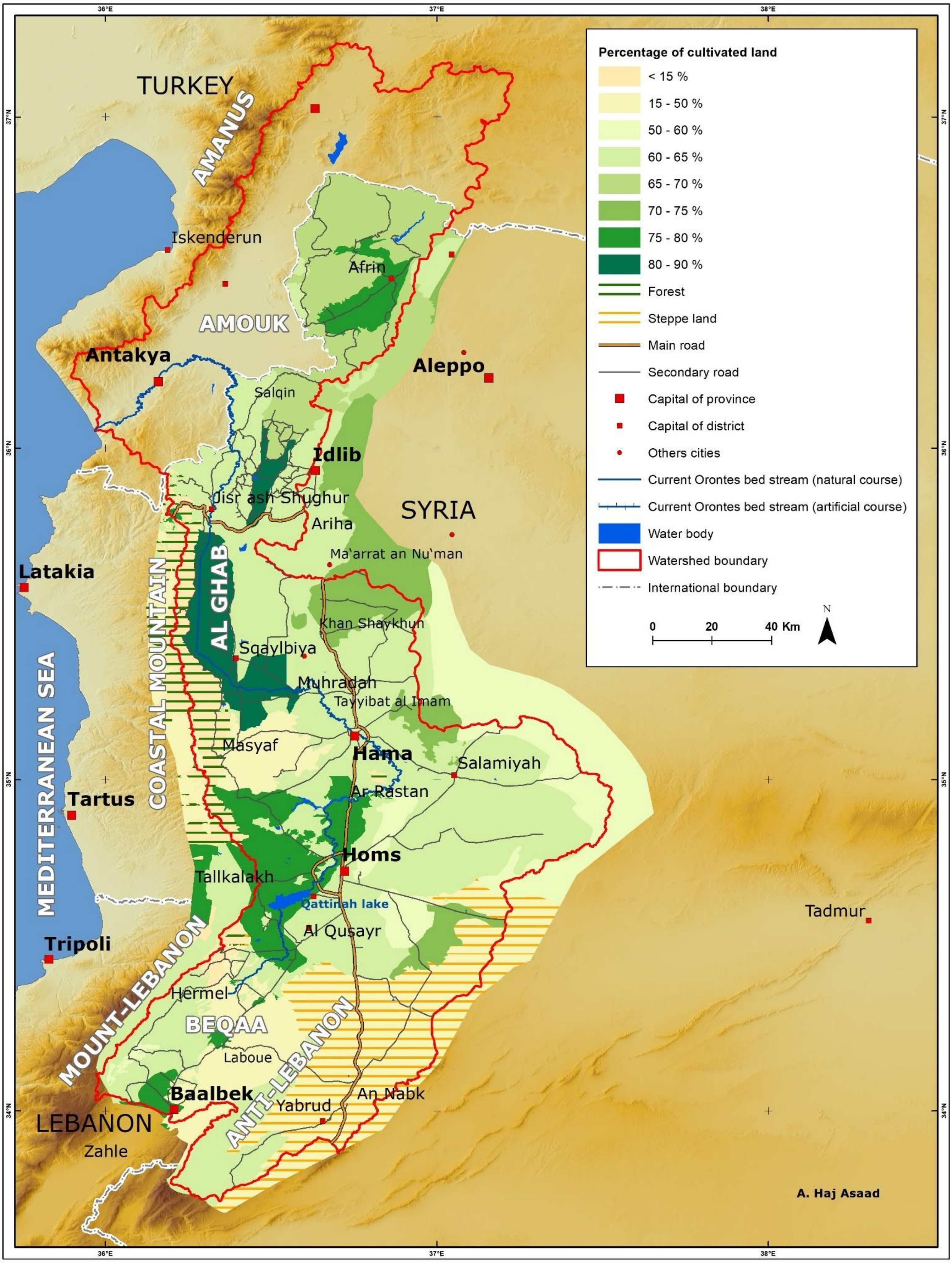
Cultivated Land

For the whole study area 45% of the land is uncultivated due to climatic, soil and/or topographical constraints. Steppe and dense forest areas cover almost 20% of the territory. In addition, large areas are uncultivable particularly due to the presence of rocky outcrops including large superficial calcareous crust zones (Table 2).

Table 2: Uncultivated and Cultivated land Per Classes (Lebanon and Syria)

		Area (ha)		
	Class	**Total**	**Uncultivated**	**Uncultivated**
1	Forest	122'911	122'911	0
2	Forest 70 - 80% -Fruit trees 10 - 20%	94'176	65'923	28'253
3	Sparse forest - Fruit trees	204'083	153'062	51'021
4	Olive trees 55 - 60 % - Other fruit trees 10 - 15 %	217'072	65'122	151'950
5	Olive trees 45 – 50% – Bare soil 30 – 40 %	323'439	129'376	194'063
6	Cherry trees 45 - 50 % - Rocky outcrops 20 – 30%	17'042	5'113	11'930
7	Almond trees 40 - 45 % - Bare soil 30 – 40%	21'997	9'899	12'098
8	Fruit trees 65 – 80% - Vegetables 10 – 15%	91'735	9'173	82'561
9	Fruit trees 45 - 50 % - Rocky outcrops 20 – 30%	190'335	57'101	133'235
10	Grapevine 50 – 55% - Bare soil 30 – 40%	16'915	6'766	10'149
11	Vegetable 55 - 60 % - Fruit trees 15 - 20%	281'449	56'290	225'159
12	Irrigated wheat 50-60%, Veg. and fruit trees 20-30%	148'524	14'852	133'672
13	Rainfed crops 60 - 65% - Olive trees 10%	172'324	34'465	137'859
14	Rainfed barley 55 - 60% - Non arable land 25%	223'968	67'190	156'778
15	Non arable 60 - 70% - Vegetable10 - 20%	16'153	11'307	4'846
16	Steppe and rocky outcrops70 - 80 %	425'749	340'599	85'150
	Total	**2'567'872**	**1'149'149**	**1'418'724**

Percentage of cultivated land in Lebanon and Syria



Part of the calcareous crust surfaces, after being fractured or perforated, can be planted to fruit trees. This technique was used in the Byzantine period, prevalent in the east of the area under study. In Syria, an additional constraint comes from the ban on cultivation enacted in 1995 in areas receiving less than 200 mm of annual rainfall according to the administrative division of the country into five agro climatic zones (Table 3).

Table 3: Definition of agricultural zones in Syria

Agricultural zones	Mean annual rainfall
1 A	higher than 600 mm
1 B	from 350 to 600 mm with precipitation higher than 300 mm 2 years out of 3
2	from 250 to 350 mm with precipitation higher than 250 mm 2 years out of 3
3	from 250 to 350 mm with precipitation higher than 250 mm 1 year out of 2
4	from 200 to 250 mm
5	less than 200 mm

Source: Statistical Abstract 1994, Central Bureau of Statistics, 1995, Damascus

However, the 200mm limit does not necessarily correspond to the actual average rainfall. Thus in the areas of the Al Qusayr district that receive on an average less than 200 mm of annual rainfall, are classified in zone 4 and were not affected by the ban on cultivation, but the latter applies to the arid areas south and southeast of the study area.

Fruit tree expanded

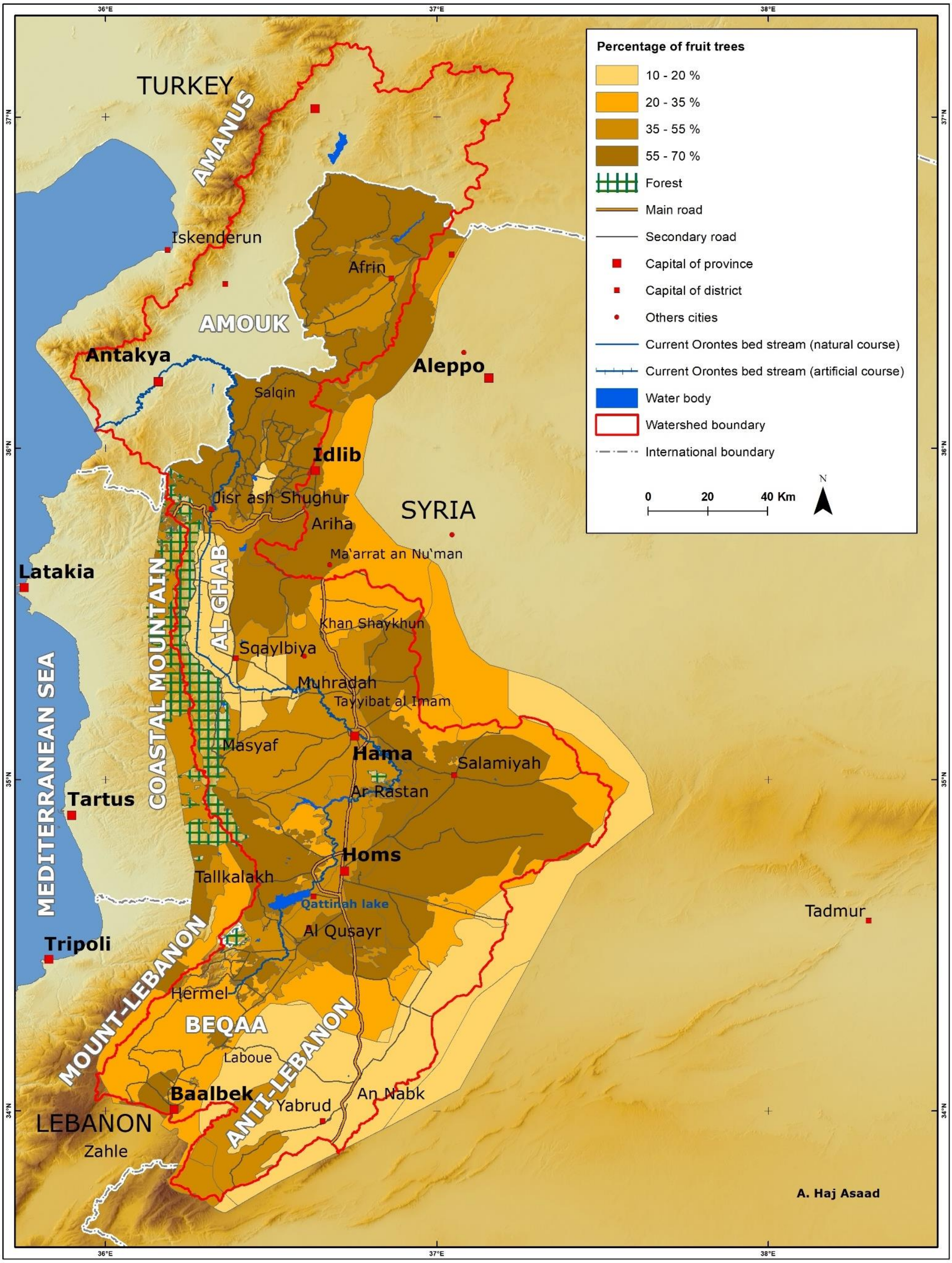
Cultivated areas are divided almost equally between fruit tree orchards and annual crops. Olive trees are the first fruit tree production covering 31% of the cultivated area and 61% of the tree area followed by almond trees and grapevines.

Fruit tree orchards have expanded considerably since the 1980s, first in the center of the basin and then, in the second half of the 1990s to the east. Orchards have also expanded in Lebanon in the areas of Baalbeck and Laboue in the 1970s and more in recently south of the village of Qaa.

Table 4: Area Planted to fruit Trees

	Area (Ha)	**%**
Olive trees	437'401	61.3
Almond trees	81'572	11.4
Grapevine	53'941	7.6
Pistachio trees	38'401	5.4
Cherrie trees	35'967	5.0
Apple trees	27'358	3.8
Figs trees	9'784	1.4
Apricot trees	7'814	1.1
Peache trees	5'551	0.8
Pomegranate trees	4'277	0.6
Plum trees	3'102	0.4
Pear trees	1'739	0.2
Nut trees	1'320	0.2
Citrus Crops	594	0.1
Other	4'871	0.7
Total	713'692	

Percentage of fruit trees in Lebanon and Syria



Annual crops are largely dominated by barley and wheat covering 37% and 35% respectively of the area devoted to annual crops. Lentils come in third position far behind with 5% of the total annual crop area followed by potatoes, corn, sugar beets and cotton (Table 5).

Table 5: Area Planted to Annual Crops

	Area (Ha)	%
Barley	226'789	36.89
Wheat	217'924	35.45
Lentils	30'824	5.01
Potatoes	19'187	3.12
Maize	18'428	3.00
Sugar beet	14'662	2.39
Cotton	13'490	2.19
Cumin	11'247	1.83
Chickpea	8'750	1.42
Broad beans	7'058	1.15
Rampling vetch	6'625	1.08
Cucumber	5'373	0.87
Tobacco	4'664	0.76
Onion	3'984	0.65
Coriander	3'811	0.62
Water melon	3'553	0.58
Tomato	2'634	0.43
Peanuts	2'197	0.36
Eggplant	1'451	0.24
Musk	1'292	0.21
Bitter vetch	1'238	0.20
Squash	1'176	0.19
Pepper Green	1'127	0.18
Beans	1'014	0.16
Flowering sern	994	0.16
Green peas	988	0.16
Sunflower	858	0.14
Garlic	857	0.14
Cabbage	845	0.14
Sorghum	821	0.13
Other	846	0.14
Total	**614'707**	**100**

Barley is produced mainly on rain-fed lands east of the basin; this cereal is entirely used as animal feed. Wheat production is concentrated in the center of the basin and over 50% of the wheat growing area is irrigated.

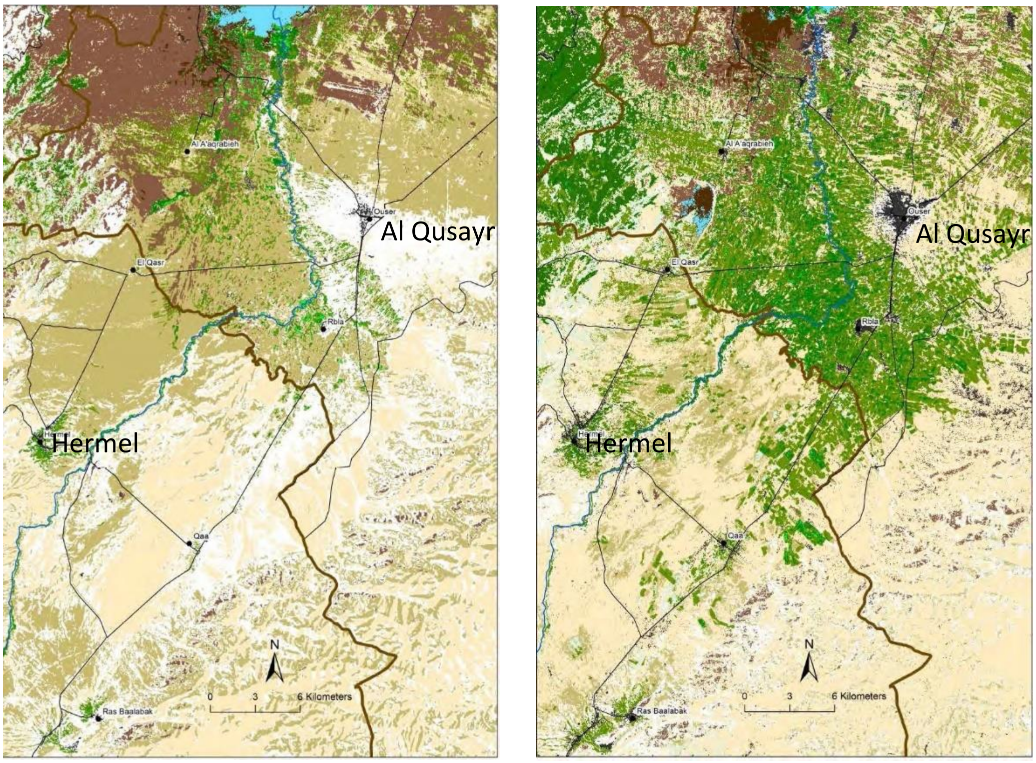
About 25% of cultivated land in the study area is irrigated and contributes to over 50% of the total crop and tree production. As much as 40% of the area is irrigated from surface water and groundwater and about 60% exclusively from groundwater. Canal irrigation schemes systems cover about 135,000 ha. Most of these lands are irrigated from surface water and groundwater. The increased use of groundwater since the 1980s has indeed reduced the flow of irrigation networks. This decrease led to the drilling of wells and boreholes in canal irrigation schemes which increased the extraction of groundwater further reducing the flow of surface water. The irrigated schemes of Al Qusayr, Ar Rastan and Al Asharinah are currently areas of high concentration of wells.

Summer Irrigation 1985 -2010

The use of groundwater has led to a considerable expansion of irrigated areas in Lebanon and Syria. However, the trend is significantly different depending on the area. In the southern part of the basin, the remote sensing analysis shows a considerable extension of the irrigated area between 1985 and 2010 in the region of Qusayr in Syria and to a lesser extent in Lebanon. (Fig 1).

Figure 1: Summer irrigation , Al Qusayr, 1985-2010

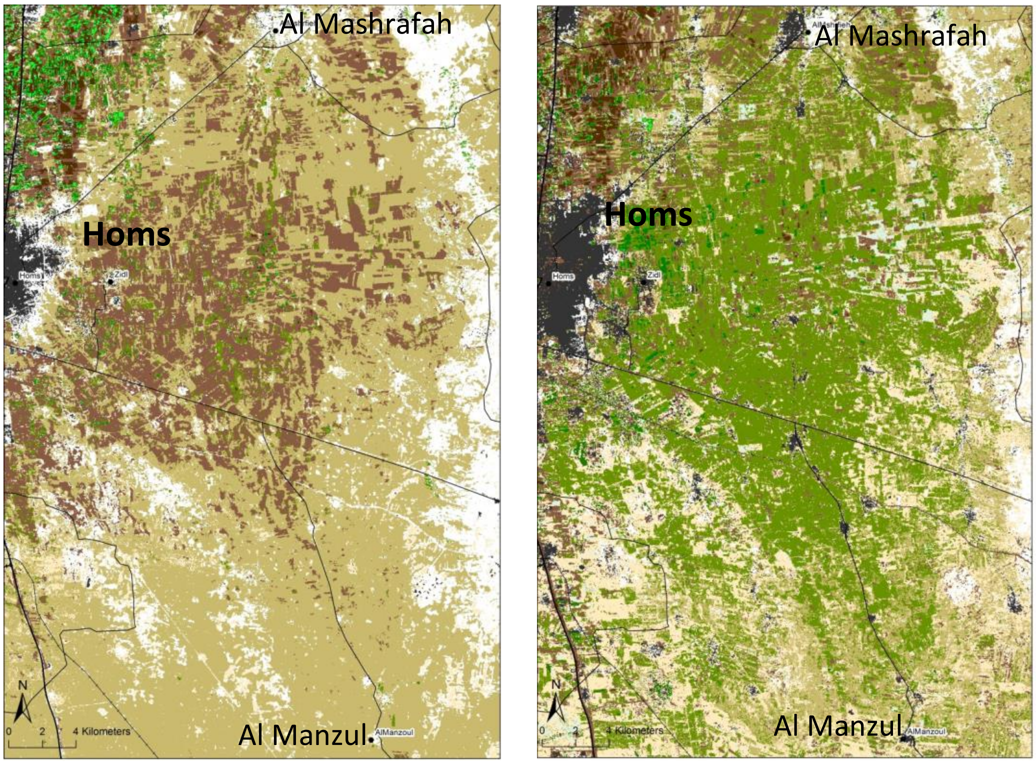
1985 2010



A large extension of the irrigated areas also took place east of Homs (Fig.2)

Figure 2: Summer irrigation, east of Homs, 1985-2010

1985 2010



The increasing exploitation of groundwater in these areas provides a least a partial explanation of the contraction of summer irrigation in the north of Homs. A similar phenomenon occurs in the north of the Syrian section of the basin. There is a contraction of irrigated areas in the Al Ghab irrigation scheme that can be linked with the expansion of irrigated areas south and east of the irrigation scheme (Fig. 3, 4).

However, other factors contribute to the contraction of the irrigated area in the Al Ghab irrigation scheme. This area has indeed been one of the hardest hit by the decline in farm income since the early 2000s and more recently by the rising price of fuel and fertilizer due to the removal of subsidies in 2008 and 2009 respectively.

Figure 3: Summer irrigation, Ar Rastan, 1985-2010

1985 2010

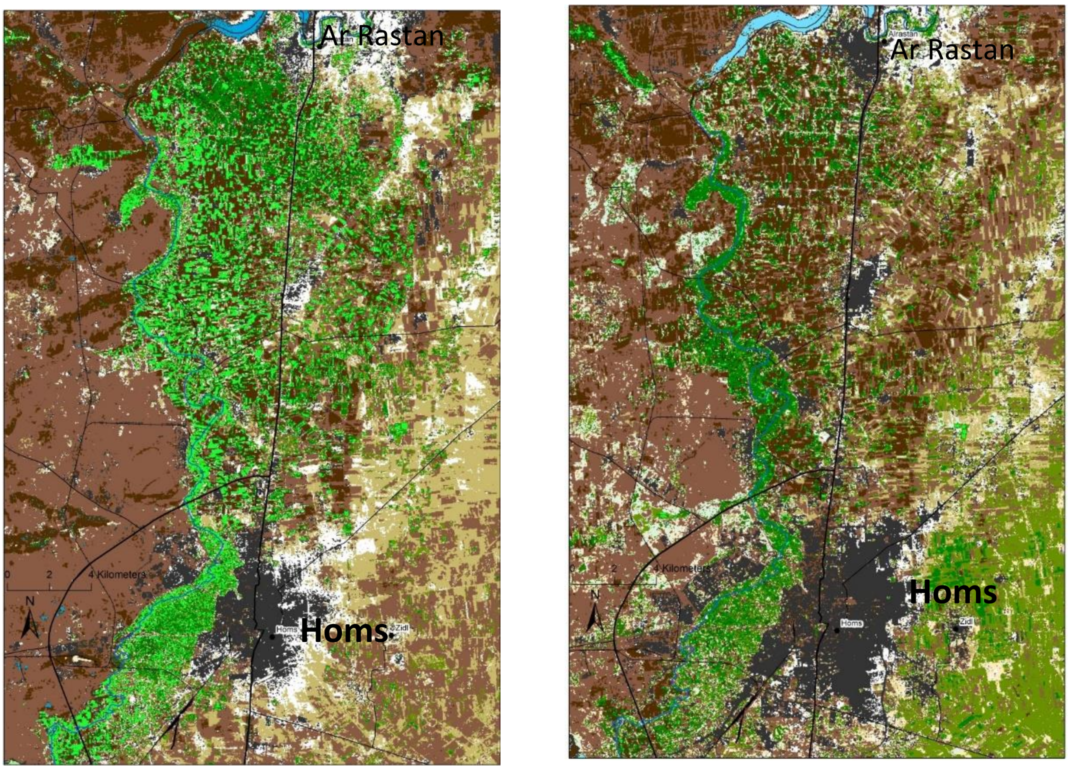
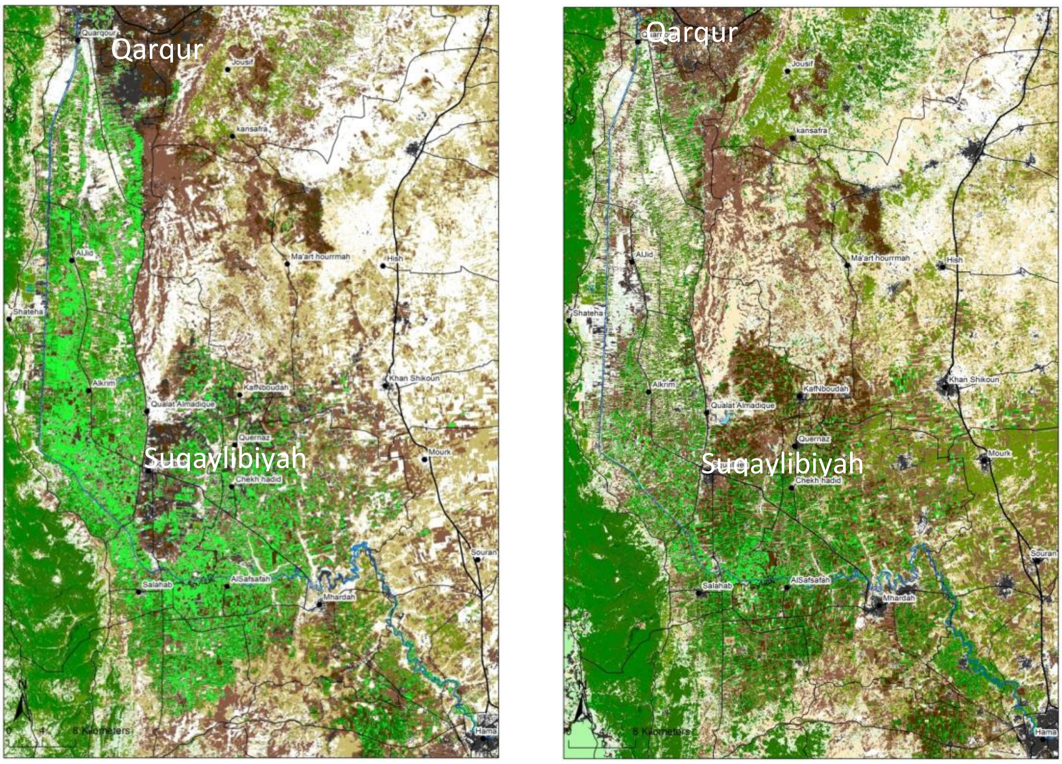


Figure 4: Summer irrigation, Al Ghab, 1985-2010

1985 2010



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