To cooperate or not to cooperate...? : collective action for rehabilitation of traditional water tunnel systems (qanats) in Syria

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Chapter 4 Groundwater and qanats in Syria

Introduction

This chapter deals with the status quo of qanats in Syria. It describes their current ecology, distribution throughout the country and their status of abandonment. Not many English publications are published on the geographical distribution of qanats in Syria except for some articles by Lightfoot (1996, 1997, 2000).

During the reconnaissance survey, 44 qanat sites in Syria were identified. Secondary data were collected in the form of historical data, satellite images, topographical maps of 1:50.000 and copies of original field jottings of an earlier survey carried out by Professor Dale Lightfoot in 1994. These secondary data formed an itinerary for the survey. The survey took place at various intervals between 2000 and 2001 with a continuous fieldwork period from April-June 2001. Collected during the fieldwork were data on qanat discharges, chemical water composition and rainfall from the Regional Directorates of Irrigation in Homs and Damascus and the Arab Center for Studies of Arid Zones and Dry Lands (ACSAD). Additional discharge data and chemical/biological water composition were collected during the survey using manual flowmeters, pH and EC meters and hydrological samples.

The following chapter on Syrian qanats is based mainly on above described empirical field data and semi-structured interviews during our reconnaissance survey combined with secondary data from Professor Lightfoot of Oklahoma State University to whom I am indebted for sending us his original fieldnotes before we set off for our survey.

Organisation of this chapter

The first sections describe the history, distribution and status quo of qanats in Syria. The second section of this chapter describes the current situation of groundwater management in Syria based on published literature. The current status of groundwater resources is necessary to contextualize the situation of qanats in Syria. It was, however, not within the scope of this study to provide a complete and comprehensive analysis of the overall groundwater situation in Syria.

4.1 Status of flowing Qanats in Syria

Before we conducted our reconnaissance survey in 2001, the last study of distribution and status of Syrian qanats to be published was by Lightfoot. Fieldwork for this publication was done in the winter of 1993 and summer of 1994. Lightfoot found 67 sites throughout Syria comprising a total of 239 individual qanat galleries. Only 12% (29 qanats at 16 separate sites) were flowing. Of the 210 separate qanats that had dried up, 193 of these had ceased flowing after the introduction of pumped wells in the 1970's (Lightfoot, 1996).

Fieldwork was conducted to produce a recent map of the distribution of Syria's qanats. We visited in total 42 sites for reconnaissance during the years of 2000 and 2001 in intermediate fieldwork periods guided by Lightfoot's earlier map and fieldnotes. This total of 42 sites contained 91 qanats of which 30 were still running at the time of inspection, most of them were located in southwest Syria (18). In middle Syria only four qanats were still running and in northwest Syria only eight. Others were dry or trickling and almost abandoned.

This section combines Lightfoot's findings in 1994, secondary data and the results of our reconnaissance survey to give a current overview on the status and distribution of qanats in Syria. Corona aerial photographs were used in some cases to locate those qanats that were difficult to identify on the ground. Bearing in mind that some qanats are beyond repair after collapse or flashfloods, the overview is certainly not fully comprehensive and new discoveries of qanats will certainly be done in the future. A detailed map of the distribution of qanats can be found in Appendix 1, Map 3 as well as an overview of main site information in Appendix 3.

4.1.1 Distribution of flowing qanats throughout Syria

The starting point of our reconnaissance survey was a general map that Prof. Dale Lightfoot of Oklahoma State University (USA) developed in 1994. Lightfoot's map helped us re-identify those qanats still in use and maintained. At these sites, landreform policies, pumpwells and other environmental factors did not cause abandonment of the qanats yet. A flowing qanat is also a potential indicator of collective action at community level. Besides this valuable information, we used secondary data of the Directorate of Irrigation of the Awaj/Barada basin. On the sites we asked our keyinformants for more sites or running qanats and finally developed a comprehensive dataset that is compiled in two geo-referenced databases "General Site Information (GSI)" on the site characteristics and "Qanat Information (QI)" on specific qanat characteristics.

In total 44 sites in Syria containing 101 qanats were identified. Syria is divided in three regions of flowing qanats; North West, South West and Middle Syria. The other regions have qanats but there were no reports of active use at the time of investigation.

Five of the recorded sites by Lightfoot in the North West were re-identified (Membej, Harim, Salquin, Armanaz and Khirbet Martin). In 1994, only the qanats of Membej were reported to be dry. In 2001, all five sites except Harim had dried up. An additional five sites not recorded by

Lightfoot were identified where water was present (Shallalah Saghirah, Jdain, al Qubayji, Marata Es-Shelf and Mou'allaq). Only Shallalah Saghirah was in fact flowing. In all other sites cleaning took place with support from the Directorate of Irrigation, during the nineties. Out of the 10 identified qanat sites in the North West, only 2 are still flowing: Shallalah Saghirah and Harim. In Harim, the Directorate of Irrigation undertakes regular cleaning of the open irrigation canals. Complete renovation of these irrigation canals took place in 1995. In 1999 no cleaning had taken place since decades in Shallalah Saghirah.

In Middle Syria, we re-identified 12 of Lightfoot's sites and discovered five more. Of these 17 sites, eleven were dry, three had static water and three were flowing. The three flowing sites are Arak, Taybeh and Breij. The most active site is Breij, where the users perform regularly cleaning of the open sections. They tried to clean the tunnel in the beginning of the 1990s but stopped after a while when they found asbestos pipes installed by the government in the 1970s. In 1993, the irrigation directorate of the Aasi Basin (Homs) conducted a study and sent a proposal for renovation but nothing happened. In Taybeh, water is still flowing but the user's community replaced the qanat at the outlet in 1979 with a diesel operated pump.

In South West Syria, 10 sites were re-identified and 7 more discovered. Of the total of 17 sites, 6 were dry, one flowed only in winter and ten were flowing. The map in Appendix 1 shows that the most active qanat region is the South West. If we use flowing qanats and maintenance history as indicators we observe that collective action at community level is strongest in the South West. This is most likely due to the favourable biophysical and environmental factors, a long uninterrupted history of social organisation related to the qanats and, thirdly, a policy of regional government support in the awaj/barada basin.

4.1.2 Short historical background of Syrian Qanats

Dating qanats is virtually impossible as there are rarely documents and inscriptions that mention the construction (Lightfoot, 1997). Most dating is done through circumstantial evidence. Studies in Achaemenian history suggest that the qanat technology originated in northern Persia, during the time of Urartu's old kingdom (Goblot, 1979; Briant, 2001). Lambton (1989) explains that the oldest known document is a cuneiform text[32] that mentions a qanat built by Sennacherib (705-681

[32] *This cuneiform tablet written in Akkadian is currently at the Louvre (Paris) and is an elaborate and detailed description of the 8th campaign of the Assyrian King Sargon II in 714 B.C. against the kingdom of Urartu that was led at that time by Rusa or Ursa 1st*

BC), whose father, Sargon II, claims to have learnt the secret of tapping underground water in his campaign against Urartu (Lambton, 1989; Goblot, 1979; Lassoe, 1953). The establishment of the Achaemenid Empire seems to have enabled the spread of the technique further west and eastwards (Lambton, 1989; Goblot, 1979; Wilkinson, 1977). Some attain that the spread did not happen until Parthian times[33] and recently, questions have been posed on the exact translations of the Sargon text and whether they refer to qanats or to "staircases" to wells and springs (Weisgerber, 2003; Briant, 2001).

Until today, archaeological evidence lacks to sustain a comprehensive theory on origin and diffusion and the current scientific debate centres around the pattern of diffusion and the role of the Persian empire in the spread of the technique (Briant, 2001). For example it is not clear whether the Urartians have developed the technique and spread it westwards, whilst the Persians might have taken the technique to the southern regions such as Oman and other countries on the Arabian Peninsula. The introduction of qanats in Central Asia and China may have developed through contact with the Armenians of Urartu. Wuttman's discovery in 1993 of ostraca dating from the fifth century B.C. during the time of Xerxes or Artaxerxes 1st at the site of 'Ayn Manawir at the Kharga Oasis in Egypt indicates a Persian connection (Wutmann *et al.,* 2000). It establishes a quasi-definite link between the Achaemenid Empire and the introduction of qanats into Egypt. Forbes (1964) already mentions that Persians had used qanats in the water supply of the Kharga Oasis in Egypt, and Persian potsherds are reported in qanats of the Negev desert (Lightfoot, 1996). Notwithstanding, the Persian influence in technology transfer must have been substantial. It is possible that qanats were present in Syria during the Achaemenid era with regard to the expansion pattern of the Persian Empire.

Although the earliest record of the existence and use of qanats in Syria is difficult to trace; it is generally believed that qanats must have certainly been used during Roman-Byzantine times (Lightfoot, 1996; Kobori, 1982, 1990; Caponera, 1973). Until today, Syrians refer to the tunnels as "qanat Romani" (Lightfoot, 1996; Kobori, 1982). Much circumstantial evidence like potsherds, coins and oil lamps tend to prove this theory. It proves that the qanats were in use but the construction is not dated, it could well be Persian qanats re-used by the Romans. Goblot (1979) claims that the technology had already been transferred to Syria by at least the 2nd century B.C. placing the introduction contemporary with

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(Goblot, 1979)

[33] *The first lengthy report on qanats appeared in a text by Polybius (X.28) about the time of the Parthian king Arsaces II.*

the Greeks in Syria (Lightfoot, 1994). Much archaeological research is still needed to explore the relationship with a potential Persian or even Greek introduction. What is certain is that during this time, qanats were in use in the region and must have been known by Roman water engineers. Syria became a Roman province in 64 B.C. and for this study we assume that construction of underground water supply systems would have started from this year onwards. Therefore the first qanats in Syria are at least 2071 years old.

The development of qanats greatly influenced settlement patterns and local politics and created a regime capable to dig and maintain the qanats. In Greek and Roman times, the qanats in Syria played a vital role in the further expansion of the empire and development of thriving desert cities like Palmyra. With the foundation of the Byzantine Empire, the Syrian province knew some prosperous periods both politically and economically. In northern Syria, settlements grew out to be centres of religion, science, philosophy and arts. Most of these settlements were provided with water from qanats or handdug wells. Having overcome the Byzantine forces at Yarmuk, the Arabs overtook the country in 636 A.D. along with Iran and Egypt. The Omayyads (661-750) made Syria and Damascus the centre of the Muslim Empire (Cotillon, 1993). The state ruled by the Omayyads was highly centralized and with the inherited qanats from previous empires Syria became the most prosperous province of any Islamic caliphate, and agricultural production flourished (Lightfoot, 1996: Kobori, 1990; Goblot, 1979). The building and diffusion of qanats after the Islamic Empire most probably continued due to continued contacts with Persians and the historic spread of Islam (Lightfoot, 1996). Qanats must be constantly repaired to maintain waterflow and local populations have continuously altered the shape and construction of qanats. In some cases qanats lay abandoned for years and were re-used by new settlers such as Bedouin groups or other migrants. Some qanats were re-used and altered during the French mandate (Lightfoot, 1996). In the twentieth century, qanat building slowed down, except for some occasional attempts in the Ghouta Oasis of Damascus (Goblot, 1979; Lightfoot, 1996).

4.1.3 Ecology, characteristics and different types of qanats

Rainfall, evapo-transpiration, topography, morphology and hydrogeology determine the locations and original discharge of the qanats in Syria (Lightfoot, 1996). All qanats in Syria are found at or below the 500mm rainfall isohyet and almost 90% within 25km of uplands (Lightfoot,1996). Most qanats can be found in arid alluvial plains at the margins of highland areas or rivers (Lightfoot, 1996; Beaumont, *et al*, 1989). Alluvial aquifers are the shallowest and most widespread water bodies in the Middle East (Beaumont, 1989). Due to topographical and geological diversity, the Syrian qanats vary considerably in type and construction. In Syria, we can distinguish three main types of Syrian qanats;

a) spring-based – dug in calcareous karstic solid rock near mountainous areas.
b) infiltration-based – dug in alluvial plains of relatively flat surface.
c) river-based – dug in the alluvial plain of a main river.

The variety of qanats in Southwest Syria is high. While the qanats in northwest Syria are short and often spring-based, the qanats in middle Syria are long and based on infiltration. Southwest Syria contains river-based qanats, mainly around the city of Damascus and various spring-based and infiltration-based qanats. Further differences are due to the rainfall zone, morphology of the surroundings, soil type and the available groundwater resources. Northwest Syria has higher rainfall, is hilly and mountainous whilst middle Syria, the "Badia", is a dry steppe with a graduate slope and the soil is sandy and limestone. The southwest of Syria is mountainous and in the West where the Anti-Lebanon Mountains and Qalamun range run parallel his dry highland provides excellent surroundings for qanat construction. The yearly snowfall in both the Qalamun and anti-Lebanon ranges ensures a good supply of recharge into both the alluvial plains and the underlying geology. This is most probably why the concentration of qanats is so high. In the eastern part of southwest Syria, the boundary of the steppe runs along the mountain range. Here longer infiltration based qanats can be found, such as those in Dmayr.

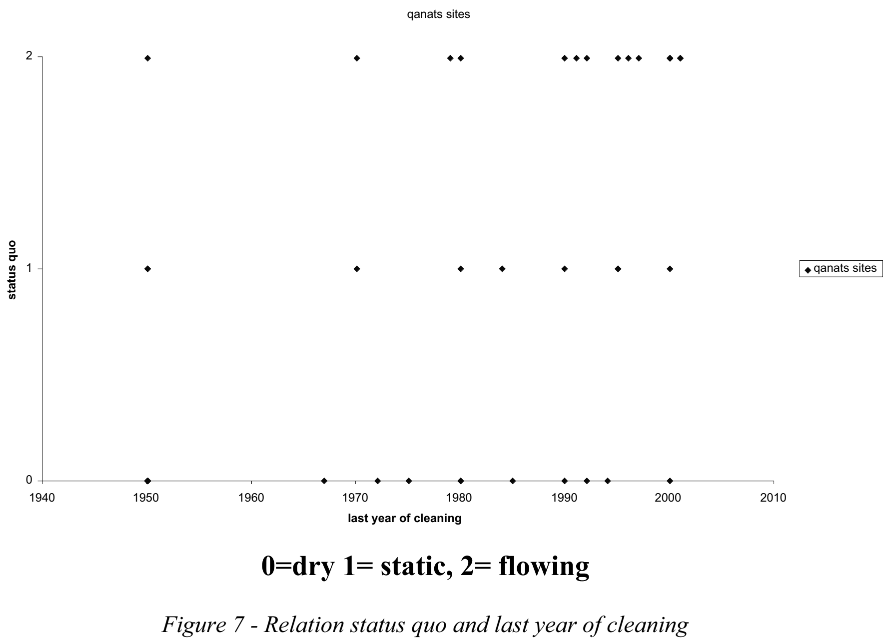
In turn, the locations of qanats in Syria, as in other qanat countries (Bonine, 1989; Wilkinson, 1977), greatly influenced settlement patterns and traditional field systems. The village and town sites as well as the amount of irrigated land are determined by qanat construction. Depending on the estimated flow, cycles, local morphology and soil types, the amount of land to be irrigated was designated at time of construction. Seasonal climatic variation causes variability of irrigated landsize with the smallest surface irrigated during summer time when the qanats provide a base-flow. At some sites, such as Dmayr, users have agreed to a special summer and winter irrigation cycle. The effect of global climate change on qanats has not been investigated properly but farmers do report a decrease in rainfall over the past decades as the main cause for the drying-up of qanats. However, this must be seen in perspective in relation to the increase in water demand due to population growth, the introduction of pumpwells and subsequent overexploitation of the aquifer resulting in lower groundwater tables.

4.1.4 Ownership, leadership and abandonment of qanats; state and fate

On the surface, it seems that the abandonment of qanats is related mostly to a combination of falling groundwater tables due to over exploitation, a high rate of migration of the users' population and the poor existence of a traditional regime to regulate use and ownership.

At a national level, we can say more about the multidimensional relationship between ownership, leadership and abandonment of qanats. Qanats must be regularly cleaned and maintained to ensure water flow (Lightfoot, 1996; Kobori, 1990; Beaumont *et al.,* 1989; Goblot, 1979; Wilkinson, 1977). "Flowing qanats" can be used as an indicator for collective action; there seems to be a correlation between activeness in cleaning the tunnels and the status of the qanats.

Figure 7 shows the relationship between the last year of cleaning and the status quo of the qanat. Based on our findings in 2001 (n=44), the values on the Y-axis show the status of qanats (0=dry, 1=static, 2=flowing) and the X-axis represent the last year of cleaning. Most flowing qanat sites were regularly maintained and recently cleaned, therefore we assume that we can take "flowing" qanats as an indicator of collective action at the site.



0=dry 1= static, 2= flowing

Figure 7 - Relation status quo and last year of cleaning

Different types of ownership of qanats systems exist. Full ownership of a qanat in Syria consists of the land where the underground tunnel is situated, connected are the rights to use the water of the qanat and the land irrigated by the water of the qanat. Property rights in Syria are characterized by a co-existence of the customary law ("'*urf")* and the formal legal system of the state ("*qanun"*) (Rae, 2002). The customary laws are largely based on Islamic principles on property and land tenure stemming from 19th century Ottoman practices (Metral, 1981, 1982, 1987).

The Ottoman Land Code of 1858 was based upon both Ottoman practice and Islamic law. It defined the five categories of land: private ownership ("mulk"), State land ("miri") and endowment ("waqf"), dead land ("mewat"), and public land for general use such as pastures for the use of particular towns and villages, markets, parks and places to pray ("metruke"). The Code remains the basis for modern state legislation and the division into these forms of land tenure remains in place today (.....) Private ownership may be obtained either through transaction, such as sale ("bay") or gift ("hiba"), possession, including the reviving of dead land ("mewat") and inheritance.

(source: UN-Habitat, 2005)

Full ownership or "*mulk*" refers to owning the land and its resources and having the right to use and transfer, either in making it a gift, settling it as an endowment ("*waqf*") or giving it to relatives or descendants (cf. Lewis, 1987, 2000; Vincent, 1995). In Syria, state land is called *"amlak ed-dawlah*" and in 1952 the state ordered that "*mewat*" land was to be re-classed as "*amlak ed-dawlah*" (Rae, 2002). The ancient categories of "*miri*", *mewat'* and "*metruke*" are formally referred to as state land. All qanats in Syria are either "*mulk*" or "*amlak ed-dawlah*". Although qanats in other countries can be part of "*waqf"* when solely owned by a religion-based institution such as a mosque or church, such full ownership in Syria was not found. However "*partial* "*waqf*" in qanat sites was found where the full ownership was "*mulk*" of a large group of different families, as well as monasteries and mosques. "*Mulk*" qanat ownership can thus be divided in land owned by one related family or tribal group and land that is owned by several, not necessarily related, families and groups. Thus we categorized ownership of Syrian qanats in; 1) *private*, where one related family or tribal group owns the full qanat land and water rights 2) *communal*, where a community consisting of various extended (unrelated) families and other groups owns the full qanat land and water rights 3) *state*, where the government has ownership and responsibility of the qanat and its land and water rights *("amlak ed-dawlah").*

Leadership refers to the person or entity that is responsible for initiating and organizing qanat maintenance according to the users. The leader also manages disputes between users at community level. In most communities the leadership is in the hands of the *mukhtaar* (*lit.* "chosen one") referring to the headman of the village. The *mukhtaar* is authorised to stamp and sign papers to verify identity and serve as a respected witness (Rabo, 1996). Often the tribal or religious *shaykh* is regarded as second witness in conflict. In a negligible few communities, the first responsibility was with the local religious leader or *shaykh* so we did not include this category in our analysis. In other cases, the state, or "*dawlah*", has the responsibility to initiate cleaning and maintenance and solving conflicts. The state in Syria constitutes the cadre of police and army officials, Ba'ath party organisations and the various ranks of political and administrative bureaucrats (Rabo, 1986). Rabo argued that the Syrian state could not simply be labelled an authoritarian elite that represents the "petty bourgeoisie". Although the Syrian state is a repressive one "*...it also controls the avenues to careers, economic welfare and prosperity for a great many Syrians. Through this while complex of contradictions and ambiguities, Syrian politics are acted out" (Rabo, 1986).* Indeed the state has often met public demands by building schools, roads and increase access to higher education and the rural parts of the country have greatly benefited from the Ba'ath party policies (Rabo, 1986). There are also qanat sites with no clearly identified leadership.

Private and communal *ownership* are not necessarily connected to community *leadership*. In many cases, although the qanat is "*mulk*" (private or communal), the state is regarded as the main entity to take care of the upkeep of the qanat and settle any disputes. To establish ideas on the relationship between ownership, local leadership and collective action, we have correlated the status of qanats as indicators of collective action with these two variables. If we compare the status of qanats as identified by Lightfoot in 1994 (n=27) with our survey data from 2001 (n=44), we see some interesting results as displayed in Table 2.

Status of qanats	Dry	Static	Flowing
Status quo 1994 (n=27)			
Ownership			
Private	4	-	1
Communal	0	-	10
State	7	-	5
Leadership			
None	2	-	2
Mukhtaar (community)	7	-	4
State	2	-	10
Status quo 2001 (n=44)			
Ownership			
Private	4	1	3
Communal	3	5	11
State	12	3	2
Leadership			
None	5	3	2
Mukhtaar (community)	7	5	4
State	7	1	10

Table 2 - Types of ownership and leadership related to status quo

According to the data in 1994, communal ownership was strongly related to collective action. Out of all flowing qanats, 62.5% was communally owned. However, looking at types of leadership, we see contradictory results. Where we would expect a correlation between community leadership and collective action, state leadership is actually strongly related to flowing qanats (62.5%). Similarly with the data of 2001, we see 68.75% of flowing qanats are communally owned as opposed to 63.16% of dry qanats owned by the state. However, again, state leadership is strongly related to collective action. These contrasting results can be explained by the fact that the political environment in Syria does not encourage initiative at local levels for fear of losing the repressive power. Likewise, many people do not feel comfortable to develop initiatives without involvement of the state authorities. Most qanat users referred automatically to the state as the responsible entity to take initiative and settle disputes. Even if the qanat was formally communally or privately owned, the users were not willing to invest time and money in cleaning and waited for the state to take action on their behalf. A further investigation into the willingness of the qanat users to invest in qanat maintenance sheds some light on its relationship with flowing qanats (see Table 3).

Status of Qanats	**Dry**	**Static**	**Flowing**
Status quo 2001 (n=44)			
Willingness to invest			
Yes	3	2	8
No	16	7	8

Table 3 - Willingness to invest and status quo

If we look at the relationship of the willingness to invest in maintenance at community level and the status quo based on our survey data from 2001 (n=44), it is clear that unwillingness to invest is strongly connected with the lack of collective action. Of all dry qanats, 84% did not have a user's community that was willing to invest either in time or financially in maintenance of qanats. The qanat damage was "too far gone" and members of the community decided they couldn't do anything to repair it (*cf.* McCay, 2002). Some qanats were observed to be dry because of lack of regular cleaning i.e. the calcareous deposits and debris had chocked the tunnels and prevented seepage of groundwater *(cf.* Lightfoot, 1996). But in many situations this process did not trigger collective action. One farmer put it like this: *" The qanat is dry because of God ("min Allah"). If the qanat is dry, we will have to wait for the rains to clean it again so it can flow and if it is flowing we do not have to clean it anymore"*. This refers to what McCay (2002) calls "dismissal of human agency". Culture and religion play a great role in how people perceive and determine cause and effect (McCay, 2002; Douglas, 2002). In this case, God (through lack of rainfall) and not humans have caused the qanats to dry. Therefore the responsibility to make the qanat flow lies with God and not with humans. In "cultural theoretical" terms, we can say that in those qanat communities where there is no willingness to invest, the people rely heavily on state authorities (hierarchy) and leave the maintenance to fate (fatalism).

In summary, the above analysis shows the multi-dimensional nature of the causes of abandonment of qanats. Falling groundwater tables through industrialized over-exploitation, landreform and migration have often been identified as main causes (Hoogesteger and Vincent, 2006; Lightfoot, 1996; Vincent, 1995; Beaumont, 1971, 1989, 1993; Safadi, 1990; Birks, 1984; Kobori, 1982). Lack of collective maintenance is strongly related to the dryness of qanats. Types of ownership and leadership have a profound impact on the non-emergence of collective action. *Communal* ownership seems to be beneficial for the maintenance of qanats, but *state* leadership appears to initiate collective action crucial to maintaining regular upkeep. These conclusions seem contradictory but when looking at investment attitudes, we see that many of the users attribute the causes of dryness of qanats to non-human phenomena like God or rainfall hence people do not feel inclined to invest. Together with the political history of the state apparatus in Syria, the result is a heavy reliance on state and fate to repair and clean qanats.

4.1.5 Laws, rights and regulations for qanat use

Qanat irrigation systems know a complex organisation of cycles and rights based on time, volume and discharge (Lightfoot, 1996; Beaumont, *et al.*1989; Wilkinson, 1977). In Syria much of these systems remain partially intact at flowing qanat sites. Three main use rights of qanat water can be distinguished; the right to drink, the right to use the water domestically and the right to irrigate. The right to drink and use water to wash before prayer is free to everyone that visits the qanat (outlet). This is based on the so-called Islamic "Law of Thirst' that all people and animals must be allowed to drink and use the water. The right to use the water for domestic purposes is free but generally confined to those living in close proximity of the qanat outlet. Irrigation rights are not free and confined to certain families and groups. According to Islamic law, water cannot be owned unless it is stored and measured (Vincent, 1995; Bulloch & Darwish, 1993; Metral, 1982; Caponera, 1973). Islamic law distinguishes between rivers, springs and wells (Bulloch & Darwish, 1993) and the spring category that applies to qanats. Natural springs are free for all to use. Those who have "uncovered a spring and caused it to flow" own the discovered spring communally. If a spring is uncovered on someone's private land, ownership is not disputed but Islamic law obliges the owner(s) to offer water free of charge to others (Vincent, 1995; Bulloch & Darwish, 1993; Metral, 1982). It is difficult to establish who actually uncovered the spring at qanat sites in Syria but those families and groups who have the right to use the qanat water for *irrigation* define the users communities that own the qanat.

The irrigation rights are bound to a complex system of timeshares and cycles. Each qanat user has the right to irrigate for a certain period at a designated time. His/her water share is measured in time and sometimes volume when the qanat has an irrigation reservoir. For each qanat, the total of timeshares is arranged in a rotation cycle or period of irrigation called "*addan*". For example, Dmayr has three qanats; Drasia qanat, Maitaroun qanat and Mukabrat qanat. The *addans* are respectively 26, 28 and 16 days. It is not clear what process defines the length of the *addan.* Many qanat users did not remember and explained that the very first families originally owned each day. This would mean that in Dmayr there were originally 26, 28 and 16 user families for each respective qanat. With the qanats dated somewhere in the 2nd century A.D. it is unlikely that this is the case. Another possible explanation is that the soil and crops require this particular cycle of irrigation for it to be fertile. In any case, the length of the *addan* is rarely changed. The lengths of the timeshares however do change and are subject to inheritance, division and sale.

Another measurement that is observed to regulate qanat use is the use of irrigation reservoirs or "*birkeh*" in Arabic. If a qanat gives sufficient water, the flow and thus irrigation practices will continue for 24 hours/day. However, when a decrease in flow is observed and does not provide enough pressure to reach the outermost lands, the users will build a collection reservoir to regulate the flow. The reservoir is then opened for a specified amount of hours per day. The collected body of water will then provide enough pressure to reach the outer borders of the irrigated land. The *birkeh* is often guarded by a so-called "*natur*" who opens and controls the valve, directs the flow towards the users at the designated times and measures the given volume using a pole placed in the birkeh. In most cases, the user's community pays the fee of the *natur* through a pooled money system called "*sunduq*" (lit.box). In this system, the users pay a certain fixed amount per year for their irrigation shares to a qanat committee consisting of the biggest shareholders. These payments are collected in a common fund from which repairs, fees for the *natur* and other costs are paid.

There are regulations and laws that protect the tunnel of the qanat system. The main traditional law to prevent qanats from drying out is the so-called "*harim*" principle where no water well can be sunk within a specified distance from another water project (Vincent, 1995, Beaumont *et al*. 1989; Caponera, 1973). In Syria, *harim* is a defined boundary around the qanat tunnel, source area or outlet in which it is forbidden to drill wells or dig another qanat. The exact definitions of the boundaries vary from site to site but the range is between 1 and 5 kilometres depending on the local conditions. In Syria specifically, the *harim* rule is barely implemented on the existing qanat sites. In Dmayr and the Qalamun region, some communities still apply the rule. In the Damascene countryside, the *harim* is defined at 1 km2 around the source of any qanat with a discharge of 10 l/s. For example in Dmayr, when the Ministry of Tourism wanted to build a hotel resort with health spa supplied by one of the sulphuric qanat springs in its vicinity, the local farmers' association and qanat users managed to stop the construction based on *harim*.

Apart from the customary laws and rules, the national water legislation does not have any reference to qanats in particular. Most of the qanats are regarded as springs underneath private or community lands therefore implying private or community ownership or under the control of the Directorate of Antiquities. The local or regional governments do not pay specific attention to qanats or qanat maintenance apart from the southwest. For the past 15 years the government has allocated a certain budget on a yearly basis to maintain qanats where necessary in this region.

There is a discrepancy between the official legislation on water management and the support/maintenance needs of qanats. Where the qanats used to be subject to a body of rules and regulations of a central government in the past, in Syria today, the systems are not regarded as significant. The priorities for the government today are geared towards bigger groundwater projects that promise a higher return, albeit short-term. For the institutional context and enabling environment of collective action on maintenance this could prove to be detrimental to the longevity of qanats.

4.2 Groundwater resources, policy and institutional reform in Syria

Water policy is a sensitive issue in Syria. Syria's national policies on water and irrigated agriculture have always been based on a strong desire for food self-sufficiency. This is reflected in the amount of water that irrigated agriculture draws from Syria's water resources compared to industrial and domestic use (See Table 4).

Syrian Arab Republic	1993-1997	1998-2002
Agricultural water withdrawal (10^9 m3/yr)	*13.6*	*18.93*
Domestic water withdrawal (10^9 m3/yr)	*0.53*	*0.66*
Industrial water withdrawal (10^9 m3/yr)	*0.28*	*0.36*
Total water withdrawal (summed by sector) (10^9 m3/yr)	*14.41*	*19.95*
Agricultural water withdrawal as part of total (%)	*94.38*	*94.89*
Domestic water withdrawal as part of total (%)	*3.678*	*3.308*
Industrial water withdrawal as part of total (%)	*1.943*	*1.805*

Table 4 – Total water withdrawal in Syria per sector - source: FAO Aquastat 2004[34]

The current water crisis means that this policy simply will not hold up in the future (Elhadj, 2004; Salman, 2004). Syria is now water-poor and still weighs heavily on agricultural resources: as a dominant economic sector it counts for 32% of the GDP and 60% of the non-oil exports (Salman & Mualla, 2003; Bazza & Najib, 2003; Le Moigne, 1992). The Euphrates is the country's main river but with an unequal

[34] http://www.fao.org/ag/AGL/aglw/aquastat/dbase/index.stm

distribution of its irrigation water the country is not able to meet the increasing water demand (Kabour, 1992);

It is apparent that water demand in Syria will grow more rapidly within the next twenty years: forecasts expect that the Syrian population will increase from 18 million in 2001 to more than 28 million in 2020. This increasing demand for water puts enormous strain on the underground aquifer, which results in lowering water levels and increasing salt concentration. As stated above, it is clear that any solution that allows an increase in water resources will be of great advantage to the country. Many solutions were undertaken by the government of Syria to solve the problem by building dams and creating multipurpose reservoirs. Water that becomes available by catchment is used in power generation and in irrigation. The development of non-conventional water resources including water desalination technologies will constitute an important source of water that augments the national water budget. Desalination technologies will permit Syria to invest the seawater and its brackish water in the eastern regions in order to obtain industrial and fresh drinking water.

Source: Higher Institute of Applied Science and Technology Damascus, 2003

A government policy based on increased water supply without looking at demand management is ecologically dangerous. Hunt (2004) analysed that an unlimited increase of local supplies either by global water movement or desalination will remove the main limitation for population growth and ultimately lead to disruption of the entire ecosystem. The challenge is to look at water resources, not only from the supply side but also from the demand side. This section looks at recent development on Syrian policies to manage its groundwater resources. Solutions are multi-faceted and are sought in building dams, desalination, artificial groundwater recharge, expansion of irrigation schemes, increase of water supply by rivers like the Euphrates, increase in the supply of freshwater sources in coastal regions, demand management of urban water use and irrigation efficiency and waste water management (ElHadj, 2004; Salman, 2004; Salman & Mualla, 2003; Bazza & Najib, 2003; Hamdy, 2001; World Bank, 2000; Beaumont, 1993; Wakil, 1993; LeMoigne, 1992; Rabo, 1986).

4.2.1 Challenges per groundwater sector

The growing groundwater scarcity and dramatic drop in levels since the 1990s have triggered studies at national level by the Japan International Cooperation Agency (JICA), the Netherlands and the UN

Food and Agriculture Organisation (FAO). All of these studies mention the lack of access, availability and reliability of national water resources data (Elhadj, 2004; Salman, 2003, 2004; Bazza & Najib, 2003). The country water balance does not seem to be consistent and varies according to the different sources of information (Salman, 2004). Despite this data inconsistency, all studies consulted agree that groundwater is the single most important challenge for Syria in the future.

By far the main demand for groundwater comes from irrigated agriculture (more than 90% of the total water use), which has doubled in surface area since 1985 due to furrow irrigation for subsidised crops like wheat, cotton and sugar beet combined with an inability to prevent excessive abstraction and inadequate demand management (Salman, 2004; Bazza & Najib, 2003). The result is the mushrooming of pumped wells for irrigation and a serious country-wide drop in groundwater levels except in the coastal areas. Agriculture is the main cause of over-exploitation and degradation of water quality in the Arab region (UNDP, 2003, 2005). Therefore the main policy issue in this sector is to increase water use efficiency at the demand side. Since 2003 there has been a real push for more efficient irrigation technologies like drip irrigation and institutional reform such as the establishment of coordination mechanisms and possibly Water Users Associations (Bazza & Naijb, 2003).

Urban water supply is the second increasing problem in Syria. In the past 20 years, urban populations have grown exponentially in Syria as in many other countries in the Middle East. In the major cities of Damascus and Aleppo there is a regulatory summer schedule for drinking water supply. The diminishing water sources and urban population growth force local municipalities to halt the supply of drinking water to specified blocks of households at 18:00 or earlier if the drought is severe. This restriction is lifted as soon as the first rains arrive. Also, the piped distribution system looses a considerable amount of water due to leaks and cracks. Industrial use of water has increased with the urban population growth and expansion of industrial production areas and factories.

4.2.2 Institutional reform and Syrian water legislation

International studies and the lack of consistent information and data on water resources led in 2002 to the establishment of the Syrian Water Resources Information Centre (WRIC) with international support from Japan[35]. The longterm objective is to achieve integrated and sustainable surface and groundwater management in Syria (Salman, 2003). This was a first concrete step of reform within the water sector. All

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[35] *http://www.wric-sy.org*

previous attempts had been cosmetic (Salman, 2004). Lack of coordination between ministries and directorates was identified as a great hindrance to the implementation of strategies (Salman, 2004; Bazza & Najib, 2003). Until recently, the Ministry of Irrigation (MoI) had most responsibilities for Syrian water resources. With its headquarters in Damascus it was decentralized to basin level in general directorates for the respective basins (Aleppo, Yarmouk, Barada & A'awaj, al A'asi: Orontes, Steppe (Badia)/Homs, al Khabour & Tigris Basin (Jazira), al Furat (Land Reclamation), and al Saahel or Coastal Areas). In January 2006, the organization of the MoI initiated a drastic reform to improve efficiency following policy recommendations. These recommendations included the establishment of a General Organisation for Water Resources (GOWR) and a move away from the basin levels. No data is available on the impact of this reform at local level. At the time of our fieldwork, the overall institutional framework was hierarchically organized and it is not expected that this had radically changed.

Syrian water laws and policies with regard to sustainable use of groundwater aquifers had been severely underdeveloped until 2000 when well-drilling licensing was banned. Increasing realization of the groundwater crisis led to subsidies for modern irrigation technologies at farm level and the development of several measures in 2000 and 2001. Table 5 shows an overview of the main policy measures.

Measures	**Legal Document**
• Well drilling is banned in the Cretassic layer • Only public ministries can drill wells in the Cretassic layer for domestic water supply	Decision no. 6 (17/02/2001)
• Forbidding cultivation of irrigated summer crops in the steppe areas to preserve fossil aquifers	Decision no. 30 (21/10/2000)
• Obligation to license all unlicensed wells by July 2001	Decision no. 22 (30/04/2001)
• Well drilling licensing is banned • Licensing renewal for drilling wells to replace old ones is banned • Well deepening licenses are subject to conditions • Pumping system installation is not permitted unless renewable water is available	Circular no. 13 (31/08/1999) Circular no. 31 (03/06/2000)
• Installation of flow meter in wells • Grant irrigation license to farmers in flow meters	Decision no. 31 21/10/2000
• Allocate annual budgets and loans for	Decision no. 3

adoption of modern irrigation techniques and strategic crops	03/05/2000
• Establishment of a inter-sectoral ministerial committee to promote conversion from traditional irrigation methods to modern irrigation techniques	Decision no.11 05/07/2000

Table 5 - Main water policy measures (adapted from FAO, Bazza & Najib, 2003; Fiorillo &Vercuei, 2003)

The official procedure of closing a well is as follows: if the government discovers the drilling of a well, the well is closed, the drilling equipment confiscated and drillers and farmers taken to court for trial. Usually they have to pay a fine or serve some time. If it is observed that a new well is already drilled, the well will be closed and farmer arrested. The issuance of drilling licenses moved many farmers into "illegal" well drilling (Wessels *et al*, 2001). In a short participatory survey on groundwater use that we carried out in Aleppo Province[36], we found that many "illegal" wells are increasingly dug and closure is rarely done. Actual implementation of groundwater measures proved to be very difficult and through clientelism and patronage, most farmers avoided being fined or arrested. The spread of the technology also had severe social consequences; in northern Syria we found several villages where families killed each other because someone had drilled a pumped well too close to his neighbour. The rapid increase of privately owned pumped wells, or "pump revolution" as Molle (2003) calls it, has widespread hydrological, socio-political and economical implications throughout the Middle East and Asian arid countries (Molle, 2003). It is also one of the main causes for the abandonment of qanats.

4.2.3 Qanats versus pumps, competing for the aquifer

The competition between pumps and qanats for water resources had been identified early since the introduction of the new pumped well technology in the 1960s in the Middle East. Ehlers & Saidi (1989) reported that "*The change from qanat irrigation to water exploitation by means of motor pumps and large dams has had tremendous effects on the fragile ecology of the arid highlands of Iran"*. Molle (2003) reports that in the Assadabad region that Ehlers & Saidi studied, the numbers of wells were 39 in 1962, 439 in 1969 and a staggering 1,386 in 1979; all qanats dried up. Between the 1960s and the 1980s qanats in Iran symbolized

[36] *Wessels, J.I., Arab, G., Aw-Hassan, A. (2001) Participatory Survey on Institutions and Ground-water use, Aleppo Province, Syria- project report for NRMP, ICARDA, Syria, 29 pp.*

backwardness as opposed to the promising future of diesel pumps (Molle, 2003; Ehlers & Saidi, 1989). Hoogesteger (2006) also reports that most qanats in the Zayandeh Rud river basin have dried up due to drilling of deep boreholes. Similarly in Syria, the rapid drying up of qanats corresponds with the introduction of tube wells (Lightfoot, 2003, 1996). The most vivid example of which are the dried up qanats around Homs. After the landreform in 1958, the allocation of land to formerly landless families, gave households the opportunity to exploit the water resources underneath the land. The farmers had enough capital to buy drilling and pump equipment and there were no restrictions. The Ministry of Public Works and Water Resources did issue as law (no 208) to prohibit digging of wells in certain areas like the Ghouta Oasis but these were completely ineffective (Naito, 1985). Currently by far most of Syria's agricultural groundwater supply is provided by pumps.

Apart from the geophysical consequences of falling groundwater tables, the introduction of pumped wells also had considerable social implications. Formerly cohesive qanat communities disintegrated when the users started to drill pumped wells. Investment costs in construction were high compared to the maintenance costs of qanats, but with the growing demand for irrigated agriculture and the short-term high return from pumps, the well-off farmers often decided to opt for drilling a private well. This created a discrepancy with poorer farmers who could not afford to invest in modern technology. In Syria, at those qanat sites that dried up since the introduction of pumped wells, migration rates were very high. At the qanat sites where pumps did not destroy the qanats, the social organization stayed relatively intact and qanats kept flowing.

In January 2006, a drastic reform of the organization of water institutions started. The shift will implicate a move away from an organisation based at basin-level. Water policy in Syria has long been focused on the increase of water supply. This focus is now being gradually shifted towards control of water demand. Since 2000 new measures and laws have been implemented towards this goal. But we found that the laws on well drilling are completely ineffective on the ground. The use of (illegally) drilled boreholes and the consequent falling of groundwater tables are the biggest challenge for qanats at national level in Syria. Even though, at sites not affected by pumps, collective action for qanat maintenance slowed down. A deeper analysis of what really happened at community level is needed to find endogenous dimensions that inhibit collective action for qanat maintenance.

4.3 Conclusions

Discussed is the status quo of flowing qanats in Syria. Our national reconnaissance survey formed the basis for an update of the findings of Lightfoot in 1993/1994. It gives a most current overview of the distribution and status of flowing qanats in Syria. 44 sites in Syria containing 101 qanats were re-identified and discovered. Three main types of qanats can be distinguished; spring-based, infiltration-based and river-based. A general trend of abandonment is confirmed in our results. Biophysical causes for abandonment are found in silting up of calcareous deposits, earthquakes, floods and dropping groundwater levels. Sociocultural causes mainly lie in the lack of collective maintenance, adoption of new extraction technologies, high rate of migration of users and the socio-political impact of Syria's landreform in 1958.

A short historical background of Syrian qanats is given. Archaeological evidence lacks to sustain a comprehensive theory on the diffusion and role of qanats in Syria's history. However, it is generally assumed that qanats in Syria must have been used since Roman-Byzantine times. The development of qanats in Syria influenced land use patterns playing a vital role in expansions of Greek, Roman, Byzantine and Islamic Empires.

Flowing qanats can be used as an indicator of the presence of collective action at community level. The cause of abandonment is not one-dimensional and at national level we focused on the multi-dimensional causal relationship between ownership, leadership and abandonment of qanats. A strong relationship between communal ownership and collective action was found. However, we also found that private and community ownership of qanats is not necessarily correlated to community leadership for collective maintenance. In many cases, the state is regarded as the main entitity to initiate and lead collective action on qanats. The unwillingness to invest in maintenance is strongly related to the lack of collective action. A dry qanat or a qanat silted-up with calcareous deposits does not trigger collective action of the users community. There seems to be a "dismissal of human agency" in the local perception on the causes of the drying up of qanats. In those communities where there is no willingness to pay, people rely heavily on state authorities and leave the maintenance to fate.

Rules, rights and regulations for qanats are mainly based on customary principles and Islamic law. The irrigation rights are bound to a complex system of inherited and traded timeshares and cycles. Furthermore there are regulations in place to protect the tunnel and groundwater extraction area of the qanat system. There is a discrepancy between the priorities of the national legislation on water management and the maintenance needs of qanats. Only in one district (Damascene country side) has the government had a regular subsidy system for maintenance of qanats.

In 2006 a reform of water institutions was initiated. It remains to be seen how these reforms will affect the situation for qanats on the ground. Illegal well drilling and avoidance of laws were found to be present and difficult to stop without an adequate policing body.