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Cultural Heritages of Water

The cultural heritages of water in the Middle East and Maghreb

Les patrimoines culturels de l'eau

Les patrimoines culturels de l'eau au Moyen-Orient et au Maghreb

THEMATIC STUDY I ETUDE THEMATIQUE

First edition I Première édition

United Nations Educational, Scientific and Cultural Organization
Arab Regional Centre for World Heritage (ARC-WH) under the auspices of UNESCO

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Cover (from left to right)
Algérie - Vue aérienne des regards d'entretien d'une foggara (N.O Timimoune, Georges Steinmetz, 2007)
Oman - Restored distributing point (UNESCO website, photo Jean-Jacques Gelbart)
Iran - Shushtar, Gargar Dam and the areas of mills (nomination file, SP of Iran, ICHHTO)
Tunisie - Vue de l'aqueduc de Zaghouan-Carthage (M. Khanoussi)
Turkey - The traverten pools in Pamukkale (ICOMOS National Committee of Turkey)

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Cultural heritages of water – Introduction for a thematic study in the spirit of the World Heritage Convention

(I) The cultural heritages of water in the Middle East and Maghreb

Prof. Michel Cotte

1 Context of thematic study

The thematic study proposed by ICOMOS follows considerable reflection and many actions at international level, particularly under the auspices of the various agencies of the UN, UNESCO, and specialised NGOs with acknowledged expertise. The focus of these organisations is guided by a concern to encourage the sustainable development of human societies, and particularly to help master the technical, social and cultural factors linked to access to water and the use of water. This is easily understandable in view of regional situations characterised by rapid demographic growth and equally swift changes in individual and collective behaviour. Over recent years a series of urgent and in some cases disastrous situations have arisen in the field of water access. Sociotechnical systems for the acquisition and use of water have steadily increased in scale, requiring increasing quantities of resources which are, at best, stable, and in some cases are non-renewable. Because of climate change, resources today are under threat from long-term trends which are quite difficult to predict with precision on a regional basis, but which are however certain to occur. This combination of factors relating to challenges in the water sector is quite rightly generating profound concerns about this issue.

In this context, a return to traditional cultural heritages linked to water – some dating back more than a thousand years - would seem to be a necessary, or at least useful, approach. The initial aim of the approach we are adopting here is to provide assistance for recognising, studying and preserving heritage of this type. From this viewpoint, the framework provided by the World Heritage Convention is an important tool, and can provide instructive insights, when it comes to identifying sites and cultural landscapes with Outstanding Universal Value which are linked to the exploitation and use of water by human societies both today and in the past. It can play perhaps an even more important role in providing a methodology for the identification and then the preservation of such heritages, in a wider context, not only for properties which could be nominated for the World Heritage List, but also for properties of regional or local importance. The aim will also be to establish benchmark examples, which are highlighted for the benefit of everyone, and whose transmission to future generations can be assured in an appropriate way. A distinction must be drawn here between living heritages, which are still active and supporting contemporary human communities, and archaeological heritages or relict landscapes, which bear witness to the societies of the past.

Finally, an international water heritage which is appropriately identified, and whose true value is recognised, can constitute a thesaurus of sustainable technical solutions whose tangible, social and energy costs are reasonable when compared to the extreme responses of contemporary techno-science applied to the field of water. It is important to compare with equanimity modern solutions with ancestral wisdom in the management and use of water heritages.

2 The importance and richness of the theme of water as a cultural heritage of humanity

Water clearly has a special place amongst the many relationships which exist between man and nature. It is a permanent and essential human need. It is important to note that the human body contains about 80% of water, in a variety of forms. This permanent biophysical equilibrium must be maintained, and is quite simply crucial for life itself. Wildlife accompanies water resources and adapts to them, in particular by the evolution of species. Man tries to free himself from this purely deterministic situation by his technical responses and his social organisation, in order to control and manage his access to water resources on a sustainable basis. Access to water is a vital element common to all human civilisations; there are no exceptions, meaning that all civilisations have a water culture. In the course of history, this has led to a wide variety of tangible and social expressions, which we may consider to be one of the fundamental heritages of humanity.

Social groups have always organised, and continue to organise, the management and use of water. Management is necessary on an everyday basis, but its technical and social implications continue into the medium-term and long-term future, and sometimes into the very long-term. Societies try to sustainably control this relationship of dependency in all its various components, which is a prerequisite for the survival of the human group; and they know, more or less consciously, that, if they do not succeed, their collective future will be compromised, in a more or less long-term perspective.

A distinction should first be drawn between fresh water and salt water. The subject of the sea, and more generally man's relations to the marine environment, will not be considered in this initial approach. In itself this is an extremely rich theme, whose frontiers are quite clearly marked compared with the subject we are considering here, although there are some obvious points of contact and similarities, and also some overlaps (estuaries, polders, desalination of water, etc.). We will limit the field of heritage considered to fresh water and inland water. Other thematic studies may be carried out subsequently to complement the approach considered here.

Water meets essential individual and collective needs, but these needs are constantly evolving, as a result of the demography of societies and changes in uses in many fields of human activity. The needs may be direct (food, hygiene, etc.) or indirect (agriculture, industry, energy, transport, etc.). On the one hand we have everyday practices relating to individual, family and professional consumption, and on the other hand we have the social organisation relating to water management and distribution, and to waste water treatment, within a particular territory. We know that differences in per capita water consumption between different contemporary human societies can be considerable.

Furthermore, water as a raw material is never a pure product, in the chemical sense of the term, i.e. consisting entirely of water molecules. Many chemical and biochemical elements are present, either necessarily as in the case of pH, or in certain circumstances and variably for dissolved oxygen and gases, soluble mineral salts, mineral loads, and the presence of various organic and biological elements, and of pollutants, etc. An implicit or explicit concept of water quality and of clean water thus emerges. These physicochemical realities and their representations are essential for water uses, and they determine such uses in the context of a given civilisation. It is well known that an excess of magnesium salts makes water dangerous for human and animal consumption, and that the excessive presence of sodium chloride destroys all the benefits of agricultural irrigation. Conversely, the presence of a particular chemical element in natural water creates a specific situation, which may for example encourage the development of spas. The issue of the bacteriological and microbial germs present in drinking water is also of vital importance in water uses. Links between human health and perceived water quality are often made in the representations of societies. Such representations also bear witness to an intangible heritage of behaviour and customs, practical knowledge, and symbolic values and myths, such as sites with healing waters, or on the contrary, waters with an evil influence. For example, in the first third of the 20th century, in the West, advertising claims were made that the presence of mineral radioactivity in mineral waters for human consumption was extremely favourable for health, as the waters came from granite rock formations in which this phenomenon was a natural occurrence!

Any given civilisation always produces tangible equipment and social rules intended to ensure that the many needs we have just outlined are met. It must also be able to cope with evolution and changes in water parameters. Civilisation produces technical and collective organisation factors which are linked to the management and uses of water. Generally speaking, traditional societies have developed sustainable solutions forming stable sociotechnical systems well adapted to a given situation and period. Indeed, without this rational management of water, they would certainly not have survived very long. Each one has produced a water culture about which we can learn from the heritages which have come down to us today, in the form of living or archaeological heritages, whose components are directly connected to regional and local hydrological and climatic data. Societies have of course not been spared accidents, or climatic and natural changes which have caused failures, but the time scales of the changes were slower and the quantitative data involved were less vast than is the case today. The contemporary period has in fact given rise to irreversible hydrological changes, which were only rarely attained in earlier historic periods. This makes it all the more important and urgent to identify, recognise and preserve the water heritages established down the ages.

This heritage, taken as a whole, is a direct expression of man's response to natural conditions which are more or less favourable, and to resources which are more or less abundant, and more or less regular, and which may be hard to access. This is why the heritage is fundamental, and expresses one of the undeniable tangible bases of all civilisations. Natural conditions are also highly diverse, as the presence of water is extremely variable and changing depending on the geographical and climatic data of a region, from one season to another, and from one historic period to another. The extremes of nature are not rare, from near-absence of water to excessive presence, giving rise to everyday practices, and to the dangers of the exceptional, and of the potentially destructive event: drought, drying up, flooding, erosion, etc.

A founding trilogy of man's relations to water can be discerned in given geographical, climatic and social contexts. It begins with an assessment of the water needs of the human group confronted with the accessible water resources of its environment. This duality between demand and available resources guides us towards the second point: the technical structuring of the ground and the subsurface, in order to control water and place it at the disposal of the users. At the same time, the third point emerges: sociotechnical organisation of water is necessary for efficient management, and this can in some cases deeply and durably determine the characteristics of some human groups. In this sense, from the outset, the relationship between man and water clearly produces both heritage and culture, in the sense of both tangible goods and the associated intangible values.

In point of fact, looking beyond the technical aspect, but always accompanying it, we find the construction of a corpus of knowledge and beliefs which guides both social practices and individual behaviour. The rational and spiritual dimensions of human thought have long been closely interconnected. The rational dimension expresses the comprehension of the reproducibility of natural phenomena linked to hydrology and local climate, as we have already clearly shown for the heritages of astronomy and archaeoastronomy[1]. In particular, this involves behaviour consisting of

[1] Clive Ruggles & Michel Cotte, *Heritage Sites of Astronomy and Archaeoastronomy in the context of the UNESCO World Heritage Convention*, ICOMOS & IAU Thematic Study, Paris e-edition 2010, paper edition 2011 *Heritage Sites of Astronomy and Archaeoastronomy in the context of the UNESCO World Heritage Convention*, ICOMOS & IAU Thematic Study, Paris, ICOMOS & IAU, e-edition June 2010, Bognor Regis (UK), Ocarinabooks, August 2011.

observation, knowledge and prediction of the natural world, in this case for the various manifestations of the water cycle, in the air, on the ground and underground. Systems of representation and transmission of this knowledge and/or these beliefs support the social organisation. A corpus of water-related knowledge and practices emerges, forming in its essence an intangible heritage which is closely associated with the built heritage and with landscapes. These data, gathered through intelligence, are necessary to enable man to take effective action in order to master his environment, and to find in it what he needs to sustainably meet his water needs, both for himself and for the satisfactory accomplishment of many of his activities. The intangible dimension of water heritages is also important in that it enables access to the magical beliefs and the sacred behaviour of social groups. While water is one of the four founding elements of the physics of Aristotle, it is also to be found in myths and religions: the rainsticks of certain Amerindian civilisations, the cults and divinities linked to springs in Western Antiquity, and the offerings made to streams and rivers in all parts of the world, etc. Many of these elements furthermore overlap on to the field of science, in the contemporary sense of the term, and representations: healing waters, the water diviner's rods, etc. There is therefore a particularly rich intangible universe associated with water heritages, which needs to be analysed in order to establish the value of the sites.

3 Structure of water heritages, and suggestions of a possible typology

In view of its importance, a water heritage generally has several constitutive levels, each of which has a number of social and cultural implications. Furthermore, it intervenes directly at the various levels of a society; accordingly, any deterioration or improvement in the socio-technical water management system has an impact on several dimensions of the fabric of society. In the water heritage, many tangible and intangible elements are brought into contact with each other, making it a very complex example of heritage, in terms not only of its definition but also of the recognition of its own values and an understanding of its relationship with the other cultural elements in its environment. In other words, the water heritage is never on its own, for it is always intended for an ultimate purpose which encompasses it. It intervenes as the basic component of a social structure, understood in a wide sense ranging from water-related customs to water-related law, and from economic data to the political control of individuals and of territories. In turn, the water heritage often throws light on the way a society functions as a whole.

In this sense, water heritage is a good illustration of a sociotechnical system in a given context. It is a good representative of technological heritages in general, in terms of its sensitivity to natural and social settings, its robustness and its ability to adapt to changing situations; and its ability to transcend sociopolitical events. It is all the more involved in a given culture in that it constitutes a decisive tangible base of that culture. Conversely, water culture often explicitly illustrates the values, ideals and problems of a society in a given geographic and historic context. It acts both as a marker and as testimony of these cultures. The strength and permanency of the presence of water as a heritage is also a weakness in recognition terms: it is so closely bound up with the other parameters of the society that it is difficult to isolate it from them. It is a constitutive entity whose traits are sometimes hard to distinguish from the other cultural attributes of a site, and indeed their disassociation would be artificial and in many cases detrimental to the value of the whole. What is the significance of a magnificent urban ensemble of fountains without the town itself? What is the value of an *aflaj* without the oasis which it has generated, or archaeological testimony to the life of the past to which it gave rise? In addition to this trait, it is worth noting that the water heritage is often commonplace, and that there is a repetitiveness in the vernacular elements, sometimes of a

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http://www.international.icomos.org/world_heritage/WH_Committee_34th_session_Brasilia/ICOMOS_IAU_Thematic_Study_Heritage_Sites_Astronomy_2010.pdf very modest nature, which constitute its presence in individuals' everyday lives. This repetition may be extremely unspectacular. Often, the force of the water heritage is not dazzling, but emerges from the repetition and the density of its recurrence.

Mention should be made here of the sensitivity of the Annales School to the tangible history of societies over a long period[2]. It has also insisted on the necessity of establishing a total history of societies, i.e. based on the value of a whole which is far more significant than its component parts considered separately. In our view, the same is true for the heritage. This leads us to reinterpret heritages (as in the case of most technical and scientific heritages) which have already been recognised. This requires a specific insight into the tangible conditions forming the basis of the social constructs, which are in this case the built structure of water, and the related landscapes. What we are dealing with here are not only important components of a larger whole, but also factors which explain long-term trends at work in a human society considered from an overall viewpoint.

Furthermore, as stated earlier, it is important to draw a distinction between two main categories of property which embody a water culture. Ancient properties which are still functioning constitute living heritages, which are almost always still evolving, while others can be characterised as archaeological remains. However, the basic elements involved in their design, construction and use are the same, it is simply that the degree of the testimony they provide, or the degree of historical knowledge, are not the same. The former are evolving, and the latter are fixed and unchanging.

Beginning with the most tangible level, which is in fact the level which bears the heritage concept in the spirit of the World Heritage Convention, water questions are first of all present in hydraulic engineering projects and water-related structures, whose functions can be extremely diverse. They form the technical basis of water culture in a given place at a given time. The idea of technical cultures of water provides a guiding thread for identifying the elements of a heritage property in this field. We then take into account territorial elements, followed by social and anthropological elements, which leads us to consider elements of representation and intangible heritage. A typology may be sketched out, it being understood that there are overlaps between categories and sub-categories:

1 **The acquisition, management and control of water** to make it available for purposes of human use:
- water collection, drainage, wells, boreholes, etc.,
- the storage of water at various scales, dams, cisterns, etc.,
- the transport of water as a tangible resource, water mains,
- water treatment upstream and downstream of use (settling, filtration, pollution removal, recycling, etc.).

All these stages of water acquisition have several levels: the tangible level of course (hydraulic engineering), the technical knowhow and knowledge of human groups, social organisation (which may impose severe constraints) for uses of water, and the associated representations.

2 The various types of water use give rise to clearly differentiated cultural particularities, but at the same time great constants seem to exist in various fields of human realisation. Hydraulic

[2] France. A school of history which developed during the inter-war period, created by Marc Bloch and Lucien Febvre; Fernand Braudel was an illustrious representative of the *Annales* school in the mid-20th century.

techniques, and their architectures and management may thus be seen as a subset of more general situations which may define heritage properties in relation to:

- housing and domestic life,
- town planning and architecture,
- water as a subsistence resource in agriculture, irrigation and fishing, etc.,
- hydraulic energy, industry, etc.
- transport by waterways, canals, etc.

3 The management of constraints and the control of natural water

- dry or arid zones, the management of water shortages and the corresponding technical and social solutions,
- excess water, torrential rain, flooding and protection techniques: dykes, polders, detention basins, housing on stilts, pumping, etc.,
- the drainage of humid zones for territorial or industrial purposes,
- construction in humid zones, foundations, hydraulic architecture, etc.

4 Water and health, water quality and the associated representations

- concepts of water purity and cleanness,
- water as a drink,
- water as a vector of cleanliness and hygiene, in relation to concepts of the body and of health, spas, etc.,
- water as a vector of disease,
- water pollution.

5 Water, and water-related knowledge, knowhow, myths and symbols

- water as a scientific question and as a technological question,
- water resource forecasting and water prediction,
- water as a symbolic and religious theme, etc.

6 Cultural landscapes of water

- in its functional associations with its tangible cultural environment,
- in its associations with its natural environment,
- as a landscape project with its own values (parks, gardens, urban perspectives, etc.).

It might be considered appropriate at this point to go into detail about the diversity of each of these categories, but it is primarily the regional views and the case studies in the thematic studies which will illustrate the categories and give them their true consistency. The aim here is simply to suggest a framework which can help in identifying the components of a heritage and in evaluating its significance. The framework should also facilitate the drawing up of inventories and the making of comparisons. Each of these basic water heritage categories in turn is involved in relationships with other heritage dimensions, which then need to be interrelated to each other. This typology should facilitate the identification of the tangible and intangible attributes of the heritage properties concerned; it is primarily methodological in nature.

Looking beyond an analytical typology, it is worth noting that the various tangible levels of water heritages all require technical intervention capacities from human groups, and social organisation enabling them to act with a sufficient degree of effectiveness. Water heritages seem at first sight to be a remarkable illustration of the concept of the technological maturity of a society, as expressed both in the control and everyday management of the hydraulic system and in the design and realisation of major systems. This gives rise to the appearance of thresholds of collective knowhow and social organisation which authorise the development of certain human settlements which had previously been unthinkable, or at least a remarkable degree of expansion reaching previously unthinkable levels. The development of artificial oases from aflaj or qanat systems, the polder civilisation and the control of watershed canals, etc., immediately spring to mind.

While water constitutes an underlying dimension of all human culture, and while all civilisations regularly face water control and management questions, the extreme variety of terrestrial geoclimatic conditions is obvious, ranging from flooding to drought, from the level of precipitation to the hydrological behaviour of the ground, from springs to rivers and from lakes to aquifers, etc. The same applies to the social and technical responses of various human groups, depending on the period, and depending on the structure of technical systems used to deal with water questions. The situations encountered are highly diverse. The major development options of human societies determine the structure of their relationship to water, but at the same time, hydrological, geographic and geological data determine the major sociotechnical choices which make them possible, or sometimes impossible, and make them sustainable or unsustainable. This is a dialectical and dynamic relationship, affected both by major features which are constantly present down the ages, and by founding events or disasters.

4 The various forms of water heritage which have already received recognition

Cultural water heritages can exist in different tangible forms, in the categories we have proposed above, based on different functions and uses of water. This approach however does not coincide with those of the forms of recognition already granted, on the conventional basis of the implementation of the Convention, for reasons relating to archaeology, architecture, town planning and cultural landscapes. Furthermore, it is clearly the case that the main categories of interactions between man and water, which we have examined under the previous point, do not always coincide with conventional approaches to heritage, with the exception of major water monuments, and also of certain landscapes. The interactions relate in fact to several fields of tangible and intangible heritage.

We will now present a brief overview of forms of water heritage which have already received recognition, in which water is in most cases a component of a property forming part of a more complex ensemble: a town, a territory, a landscape, a technological ensemble, etc. The water component is sometimes simply mentioned, and nothing more, rather than being truly analysed, both with regard to its heritage forms and its significance. Examples in which the water heritage is placed at the centre of the recognised Outstanding Universal Value are however relatively rare. When this does happen, the water heritage is associated with other components and other values, which accompany it. The study of uses has clearly shown that water is always at the service of a human, social, economic or aesthetic project. Accordingly, it is typically a technical heritage, a tool at the service of a society. This reminder of the quite widespread organic complexity of heritages recognised by the Convention is important. In practical terms, it is the stage of analysing and understanding a property which leads to the detailed inventory of its constituent attributes, and to the definition of its components in the most precise way possible.

We know therefore that technical and/or scientific heritages often form only one specific tangible component of a property amongst others. They are one of the property’s structural features, and in some cases merely a decoration, and these heritages do not attain, on their own, the level of a property of Outstanding Universal Value, in the sense stipulated by the Convention as a condition of inscription. The hydraulic element produces a substructure, a tangible base, a testimony of cultural practices in a vaster and more complex ensemble. It is integrated into the ensemble with its own values and its specific significance. It is therefore important, with a view to applying the Convention in a way which is open to new subjects using a more balanced approach, to emphasise the importance of hydraulic technologies in ensembles which have been recognised in the past, and whose significance – like the statement of OUV itself – will change over time. In this respect, there is quite a revealing example: the Pont du Gard (France) was initially recognised as an outstanding example of 2nd century Roman monumental architecture in Gaul with a high degree of integrity. It was then considered, at least at national level, as a noteworthy bridge, with a history which is significantly more complex as this was a later function of the structure, and then, more recently, as an element in a much vaster ensemble: the Roman water supply system for the city of Nîmes, i.e. as an aqueduct. Here are therefore three stages in the recognition of the value of a property whose hydraulic function (for which it was however primarily designed) was only recognised in the last instance!

However, water heritages have already been recognised and inscribed as such on the World Heritage List. The properties which are most spontaneously related to the application of the Convention are often spectacular structures in the hydraulic engineering category, in its most monumental works. The catchment, conservation and distribution of water have produced remarkable and often impressive results in many civilisations, to which many properties still bear witness. They are still in use in many cases, demonstrating a particularly long technological time scale, which is specific to water heritages: they are sustainable structures, which are particularly representative of certain civilisations.

Let us propose a rough guide to the various recognised forms of water heritage, bearing in mind that, as in the case of water typologies, heritages often fall into more than one category.

- Monuments to hydraulic technologies, such as the D.F. Wouda Steam Pumping Station (Netherlands) and the hydraulic lifts on the Canal du Centre (Belgium). It is important to note that properties forming sets of buildings, in the terminology of the Convention, often include hydraulic monuments such as the water intake and the remains of the great dam/bridge of Shushtar (Iran), Saint-Ferréol dam in the supply system of the Canal du Midi (France), and Pontcysyllte Aqueduct and Canal (United Kingdom).

- Hydraulic techniques as part of an archaeological ensemble: the canals, cisterns and tunnels of Petra (Jordan), the wells of Al-Hirj (Saudi Arabia), the aflaj system remains of Al Ain (United Arab Emirates), etc.

- Artificial expanses of water as the landscape component of a monument or monumental ensemble: the basins of the Taj Mahal (India), the canals and fountains of the gardens of Versailles (France), and of the Alhambra in Granada (Spain), the Villa d'Este in Tivoli (Italy), Summer Palace in Beijing (China), etc.

- Hydraulic techniques forming part of an urban ensemble: the defence line of Amsterdam, the canal ring area of Amsterdam inside the Singelgracht (Netherlands), the water main of the Medina of Fez (Morocco), the qanats of Bam (Iran).

- Hydraulic development of the territory, as a technological hydraulic ensemble, and in many cases as cultural landscapes. Examples: the historical hydraulic system of Shushtar already mentioned (Iran); the irrigation system of Dujiangyan (Chine); the *aflaj* irrigation systems of Oman; in the Netherlands, Beemster Polder, the site of the Kinderdijk-Elshout watermills; the hydraulic system of the Upper Harz (Germany), the rice terraces of the Philippine Cordilleras, etc.

- Canals: this point has already given rise to a standard thematic approach (Annex to Operational Guidelines for the Implementation of the World Heritage Convention). Canals can be linked to the previous category, of which they form a part.

- Landscapes associated with lakes and rivers: Ferrara, City of the Renaissance and its Po Delta (Italy), the banks of the River Seine in Paris (France), the Rhine Valley (Germany), etc.

It is worth noting the extreme diversity of the forms of water heritage, which is clearly reflected in many categories already recognised by the World Heritage Convention. Man's relationship with water produces heritages which are quite remarkable in their own right, but it also produces large numbers of components of far more complex properties.

5 Water as heritage in man's everyday life

At the opposite end of the scale from monumental structures or majestic landscapes, which are quite readily recognised by the Convention, mention may be made of practices on a more modest scale which are related to everyday human activities and vernacular built structures. Geographically and historically they are also extremely diverse, for there is no society which can do without water, one of the keys to the development and expansion of the human race. This leads us to note the extraordinarily widespread nature of water heritages, and to underline the great variety of examples. Alongside major hydraulic structures, which are easily identifiable, a vernacular water heritage also exists. Often, the two go together, and the links between them form a territory on an intermediate urban or rural scale.

In a given place, and in a given society, the cultural elements associated with water are very often repetitive and recurrent, and thus abundant, and often ordinary. In particular, they form the everyday water use structures which accompany individual life and social life. The greatest differences and the greatest inequalities exist in organised relationships with water, both in societies of the past and of today, between the exhausting quest for a rare resource, and a sometimes automatic and thoughtless use of a raw material which is unconsciously considered to be inexhaustible. This habitual dimension of water thus gives rise to a great wealth of tangible natural and artificial elements; it tends to generate repetitive heritages, which are in themselves undemonstrative. They are diluted in the rhythms and gestures of everyday life. Historians have sometimes reminded us of the importance of this everyday tangible history, associated with the human condition, demonstrating the role that it plays over long historic periods.

But we come up here against an important difficulty: a water heritage, yes, but one which is sometimes drowned or diluted, in a sense, in extremely ordinary everyday structures. The elements which bear witness to water on an everyday basis are apparently simple and well identified, constant and repetitive over time, as we have stressed: facilities in the family home, the neighbourhood water fountain at village level, and community management of water, etc. It is essential to find out where the key issues of this repetitiveness are situated, in terms of heritage which could be considered in connection with the World Heritage Convention: clearly in innovation, in the exceptional nature of practices or in their exemplary quality, by their response to extreme situations demonstrating the remarkable adaptation of a human group to a situation which is no less remarkable. The traditional soil desalination practices of Chipaya Indians, in Bolivia, have generated landscapes which are at first sight quite modest, but which are based on an inventiveness and adaptability to an extreme territory which are quite unique and outstanding.

These heritages which satisfy vital needs must be supplemented by structures intended to provide security in dealing with water - and its various natural manifestations, whether permanent or exceptional - such as dykes and flood drainage ditches, the control of catchment basins and the conservation of soil in the event of torrential rain, etc. This is another type of heritage, producing a complementary sociotechnical system adapted to given risk situations. It requires specific techniques and knowhow, which are sophisticated in some cases, but also a social organisation which is both strict and equitable to serve these ensembles, in the initial sense of a collective good that is necessary for the life of the group, in this case in the field of protection against the excesses and brutally destructive force of water.

The relationship of a society to its everyday water heritage, and to the threatening and accidental aspects of that heritage, also generates representation systems which contribute to social and in some cases religious structuring, and in the process often become attached to other beliefs and other reference systems to form sets of intangible values.

6 Evaluating cultural heritages of water, their integrity and their authenticity

As with any property wishing to find out what possibilities it has of being inscribed on the World Heritage List, the first requirement is an analysis of the elements of which it is composed. The general format of the dossier presented in the *Operational Guidelines* sets out the major successive stages of the approach to be adopted. The first part is based on the drawing up of an inventory and a description of the constituent elements, and then on their historic and contextual understanding. For water heritages, their design, realisation and successive adaptations should be presented. It is then necessary to describe their uses and their socioeconomic roles down the ages, the regulation and control elements, and finally the intangible elements associated with these elements, both in the field of knowledge and knowhow and in the field of beliefs and customs. The approach then goes on to a second stage, in which the value of the property is established by means of an analysis of the integrity and authenticity of its constituent elements.

In the case of water heritages, the question of the integrity and authenticity of properties becomes particularly significant. Like most technological heritages, they face a dual constraint: first of all maintenance, with all the associated works and possible modifications, and secondly adaptation to demand and to changes in uses. We all know that the need to maintain living hydraulic heritages is a very important consideration for their functional conservation. By its very nature, a hydraulic heritage requires repairs and periodic renovations, for example to deal with water tightness, silting, hydraulic mechanisms, etc. A hydraulic system should be seen as a fixed functional machine, whose parts interact with each other. A malfunction or weakness in one element has an impact on the functioning of the other elements, and on overall performance. A hydraulic system, and more generally any technical system, is a dynamic whole, and its managers must necessarily adopt a global and functional approach in managing it. The approach of reducing a hydraulic property to its static architectural integrity, particularly for a living property, is wholly inadequate. Functional integrity is a crucial concept in this context, and it is based on technical data which must be considered in the dossier. The same applies to the concept of authenticity of uses, i.e. their present conformity to traditional practices. This leads to a history of the maintenance and adaptation of the network, which is also in line with the general idea of the history of conservation. We then stress the importance of a history of uses and their evolutions in establishing authenticity, which is not only a chronological inventory of what exists, but a placing into historical perspective of the context of water uses.

If the technical management of a hydraulic system is stopped, because of an exceptional situation (troubles or war), this can cause major deterioration in a matter of years or even a matter of months. Any resumption of service requires rehabilitation work, and sometimes technical changes, network extensions, and the remodelling of systems deemed to be obsolete or unsuitable in view of changes in uses. This is a common term in the history of industrial heritage which is now becoming very familiar.

More generally, a hydraulic system inevitably evolves over time, and needs to be adapted to situations which can change at various technical or social levels, on variable time scales: hydrological and climatic conditions, variation in aquifers, local or regional demographic changes, changes in individual or collective human needs, agronomic or urban transformations, pollution and deterioration of water quality, etc. This is the fate of any living hydraulic system; it is constantly readjusted to suit user demand, depending on the accessible resources. This ability to adapt is a condition for the sustainability of the system; but the ensuing tangible and technical results are added to the results of maintenance. This is a major difficulty for evaluation in terms of integrity and authenticity, which reinforces the need for a technical history and a social history of the hydraulic system. Evolutions and technical changes form an integral part of their history, which is not only the history of their design and their period of origin (which is sometimes more assumed than genuinely demonstrated by archaeology). These adaptations in the light of circumstances are consubstantial with the value of the property, and they have occurred both for heritages which are still living and for those which are today archaeological remains or relict landscapes. Some additional remarks need to be made on this point.

As for early hydraulic systems which are still in use, and there are many of them, the adaptations and extensions which stemmed from the technological revolution linked to industrialisation in the 19th and 20th centuries have significantly changed a certain number of parameters relating to authenticity, particularly with regard to materials, and thus forms and appearance. The use of metal, and then of concrete and reinforced concrete, and chemical waterproofing, etc., revolutionised certain technical practices. The same applies to mechanisation and the different strata of motorisation in pumping. These factors have often profoundly changed certain elements of hydraulic systems, causing them to be rebuilt. They thus made possible facilities which had previously been unthinkable, and changed quite profoundly the nature of the initial characteristics of the nominated property, or completed them in comprehensible ensembles serving the same hydraulic purpose. We are thinking here for example of the Kinderdijk-Elshout polder, inscribed on the World Heritage List (Netherlands, 1997), or windmills of the modern period (16th – 17th centuries) which supplement the systems of drains and valves dating from the Middle Ages; they were supplemented by the steam engine (19th – early 20th century), and then by contemporary electric pumps with Archimedes' screws. A detailed technical analysis of the changes made must be carried out, not to arrive at the inevitable conclusion that many constituent elements are not original and thus not authentic, but rather to evaluate the extent to which the initial concept has been maintained, or the technological spirit conserved. It is necessary to determine if there is continuity in the technical water system put in place down the ages, or if too great a disruption has taken place, which changes the nature of our profound understanding, and thus the expression of heritage values. In the same spirit, the analysis of the social conditions of the use of water, in the traditional system and in the system of today, leads to an important dimension of authenticity of use. From this viewpoint, the link between technical change and change in water-related law is an important point to be considered.

In a final phase of the value analysis comes the comparative analysis with similar properties, already recognised or more anonymous, in the nearby or regional environment, and then on a wider scale in comparable fields. Added to the previous descriptive and evaluative elements, it makes it possible to determine whether the property has Outstanding Universal Value, and on the basis of which criteria, or if it is merely a property of regional or local significance. For further details of this approach, reference should be made to the ICOMOS publication: "*What is OUV?*"[3].

The last part of the dossier consists of issues relating to the protection, conservation and management of the property, which form a series of commitments in the context of a clearly established system for the management and monitoring of the property.

7 The choice of a thematic study topic and choice of an initial region

Starting out from the obvious richness and complexity of the water heritage question, it is necessary to find a coherent and thus limited theme, as it is not possible to study everything at the same time without causing confusion. It is then necessary to envision a regional study of the theme, to provide it with coherence (particularly from a cultural viewpoint) and a feasibility scale. Several major approach paths and a number of methodological remarks enable us to stake out an initial general framework for the study of water heritages, and a region of application.

From the outset we have eliminated a chronological study of hydraulic systems, which is unhelpful as the techniques used seem to transcend the limits of historic periods and should be seen in the context of the long course of history. Furthermore, these techniques have a quite spontaneously universal nature, in the sense that they are shared by all human groups, by cultures of all periods and civilisations, but in practical forms which have numerous variations. We are clearly dealing here with one of the fundamental determinants of the relationship between man and nature, determinants whose sustainable management gives rise to water heritages. Two main possible pathways are opened up for reflection: 1) the anthropic approach to the "needs / human realisations" pairing; 2) the geographic and climatic approach of the conditions imposed by the environment on man in his management of water. But they are very closely complementary, extremely general, and do not enable the definition of a thematic framework on their own. It is necessary to go further.

A thematic category-based approach to the man/water relationship is one possible path, and is indeed attractive, as it demonstrates quite well the limitations of a subject, and seems to lead to clear distinctions which are relatively easy to understand. This could be done for example by following the general typology presented in point 3 of this document: "techniques used by man for the acquisition and management of water", or more specific sub-themes similar to the heritage categories mentioned in point 4: "water and town planning", "agriculture and water", "spas", etc. This is essentially the approach we saw in the 1990s with the "transport canal" subject, which was introduced as a typological example in the annexes to the *Operational Guidelines*. Without in any way ruling out this thematic study possibility, it seems in our view today to suffer from two limitations. The first has already been referred to: in many cases properties belong to several categories simultaneously, and they form ensembles whose value is not appropriately analysed in this kind of framework. The second is that the mainly intangible dimension of some of the categories tends to marginalise them and cut them off from the other categories, such as "water

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3 http://www.international.icomos.org/publications/monuments_and_sites/16/pdf/Monuments_and_Sites_16_What_is_OUV.pdf

knowledge and knowhow". This kind of approach is better suited to helping to draw up an inventory of, and classifying, an existing heritage, in the context of a general sub-regional view.

The anthropic approach however leads us to wider approaches than those we have just mentioned, and which were referred to earlier in chapter 4 of this document, such as "water monuments" or "water landscapes". We have pointed out that, while it is possible to distinguish hydraulic properties as such on the basis of categories, this remains relatively exceptional. As a result, properties whose components are larger or more complex are less well understood, and it is thus difficult to take their characteristics into account in an appropriate way. Conversely, elements that are on a smaller scale or more repetitive may be marginalised, or forgotten, unless they are treated as subcategories which link up with those of the preceding point. This remains a traditional heritage approach, which is primarily helpful in the case of clearly identified sites whose dominant aspects are either monumental or landscape-related.

Geoclimatic categories constitute a second general approach option, from the viewpoint of environmental conditions, and this seems to be a fruitful path to consider. This obviously means the loss of the previous categorical clarifications, but it enables us – at first sight – to envision subjects whose classification with regard to the previous points is complex. It sets the boundaries of the subject by considering similar hydrological and climatic conditions, i.e. a type of challenge that Nature throws down to the sustainable development of human groups. A subject of this type means taking as the point of departure the framework of the relationship between man and water. The approach should make it possible to observe the results of the adaptation of regional human groups to the question of water, in the various phases of their history. It guides the interpretation of heritage towards the description of sociotechnical systems which are appropriate for responding to a given geoclimatic situation, to perceive ensembles existing within certain territories, and finally to identify the best testimony. This approach to the water heritage is aimed at identifying stable and sustainable forms rather than exceptional representatives. It provides us with a new value for assessing heritage, through the testimony of a successful and sustainable adaptation of the relationship of a human group to the water resources of its territory. It is also an assessment of the difficulties of this adaptation, of its constraints, and of the threats to which it is subjected. This is what could be referred to as a *sustainable development heritage*. We suggest, particularly for living heritages, that they should be studied as such.

From this viewpoint, we identify quite simply:

- Arid regions, deserts
- Semi-arid regions (steppes, savannah, etc.)
- Regions with a Mediterranean climate
- Humid tropical and subtropical regions
- Equatorial regions
- Humid temperate regions
- Nordic regions

At this point, it is possible in our view to establish an initial main thematic framework which encompasses the three first categories, i.e. regions in which water is rare either permanently or temporarily. These categories correspond to an initial major water heritage theme, that of the rarity of water, to differing degrees. We can study it under the general title: "**Cultural heritages of water in arid, semi-arid and Mediterranean regions"**. Two other major themes should be examined at a later stage: firstly, tropical and equatorial regions, and secondly, humid temperate regions and Nordic regions.

There are several reasons why this first main thematic framework is particularly important. These regions are today undergoing demographic expansion, like the rest of the planet of course, but fresh water needs there are amplified and exacerbated by its rarity. The populations directly concerned by these heritages are numerous, and for them these development questions are absolutely crucial. The diversity of the geographic regions concerned is very considerable, as shown by the mapping, and the comparisons can be extremely rich, with regard to heritage, history and development examples.

The overall mapping study we have carried out, and which is included in this publication, shows that all the world's major regions are affected. A general study would therefore be very extensive and thus difficult to carry out, and it seemed to us more appropriate to select a region, if possible, which as a whole is emblematic of these questions. **The region of the Middle East and the Maghreb** meets this criterion, and offers at first sight a set of advantages which in our view are crucially important for launching an initial thematic study inside the general framework of water rarity. The limits of the region are clearly defined, its dominant geoclimatic conditions are relatively homogeneous, and they fully correspond to the established framework. Only the question of the Mediterranean climate could be discriminating and give rise to a difficulty, as not all the countries in the region have a Mediterranean climate, whereas arid and semi-arid conditions are common to all to a greater or lesser degree. It is moreover a key climate which can be found in other major regions, but without in any way characterising them all. Would it have been best to exclude it from the region, and only deal with part of the region? That would have been an arbitrary step in our view, and would have inconsistent with regional history, introducing an imaginary cut-off inside the States Parties themselves. The long shared heritage of Arabo-Islamic civilisation, and of the remarkable degree of diffusion of its hydraulic techniques both inside and outside that civilisation, was also crucial in the choice of this initial thematic study, lending it an exceptionally homogenous unity and cultural framework.

8 Conclusion

The proposed thematic study must be able to provide elements to identify and describe water heritages. We have tried to draw up a typological inventory which should primarily be seen as a methodological aid for anyone wishing to consider these questions, with a view either to achieving recognition and protection of such heritages by the World Heritage List or to protecting heritage in a national context.

We are fully aware that there is a dual challenge. Firstly, water heritage is highly diffuse, and is present wherever mankind has settled, which gives rise to a real challenge when it comes to authenticating and analysing the heritage. Secondly, a relatively large number of properties already inscribed on the World Heritage List have important hydraulic elements, which should be highlighted to a greater extent, particularly when the Statement of Outstanding Universal Value is periodically revised or if it is rewritten.

Finally, in the context of this initial thematic study, the distinction between archaeological heritage and living heritage is essential. Archaeological heritages will of course be very well represented, and they are essential in a region whose protohistory and history are remarkable in every way. It is therefore important to establish an appraisal of this heritage with the greatest care. However, living water heritages are a vital consideration for us, in a context in which water is rare and there is increased pressure from demand, particularly since the mid-20th century with the development of modern technologies involving mechanical pumping, access to deep aquifers, and the use of new materials such as reinforced concrete, steel, etc. A form of negation, or ignorance, of ancient tangible and intangible water heritages has often prevailed. There have been many cases in which existing heritage has been abandoned or rebuilt more or less radically, to the detriment of solutions which had however demonstrated their sustainability. Our study of living heritages of water must take these questions on board in order to provide an overall appraisal, but this time not from the viewpoint of current systems, but from the viewpoint of the Ancient and the Modern, while considering them in the light of the challenges of the future. Our hypothesis is that a *sustainable development heritage* does exist in the field of water, and that it is up to us to identify it and study it for everyone's benefit.

Les patrimoines culturels de l'eau, introduction pour une étude thématique dans l'esprit de la Convention du patrimoine mondial

(I) Les patrimoines culturels de l'eau au Moyen-Orient et au Maghreb

Pr. Michel Cotte

1 Le contexte de l'étude thématique

L'étude thématique proposée par l'ICOMOS fait suite à un nombre important de réflexions et d'actions internationales intervenues notamment dans le cadre des différentes agences de l'ONU, de l'UNESCO et d'ONG spécialisées aux compétences reconnues. L'attention de ces organisations est guidée par le souci de développement durable des sociétés humaines, notamment d'aider à une maîtrise des facteurs techniques, sociaux et culturels liés à l'accès à l'eau et à son usage. Cela est bien compréhensible dans le contexte de situations régionales marquées par un rapide développement démographique, et un tout aussi rapide changement des comportements individuels et collectifs. Des situations urgentes et parfois dramatiques sont régulièrement apparues ces dernières années dans le domaine de l'accès à l'eau. Les systèmes sociotechniques d'acquisition et d'usage de l'eau n'ont cessé de s'amplifier, sollicitant de plus en plus des ressources qui, elles, sont dans le meilleur des cas stables et parfois non renouvelables. En raison du changement climatique, elles sont aujourd'hui menacées d'évolutions de long terme assez difficiles à prévoir de manière précise, en fonction des régions, mais dont les occurrences sont par contre certaines. Cette conjonction de facteurs à propos des enjeux de l'eau marque profondément les esprits, et à juste titre.

Dans un tel contexte, le retour vers les patrimoines culturels traditionnels de l'eau, parfois millénaires, semble une démarche nécessaire, pour le moins utile. Une aide pour leur reconnaissance, leur étude et leur préservation constitue le premier objectif de la démarche que nous entreprenons ici. Le cadre de la *Convention du patrimoine mondial* est de ce point de vue un outil important et susceptible d'une mise en œuvre profitable, afin d'identifier des sites et des paysages culturels de Valeur Universelle Exceptionnelle reposant sur l'exploitation et l'usage de l'eau par les sociétés humaines du passé et d'aujourd'hui. Elle l'est aussi, et peut-être plus encore, comme une méthodologie permettant une identification puis une préservation de ces patrimoines, dans un sens étendu, non seulement pour des biens pouvant prétendre à la *Liste du patrimoine mondial* mais aussi pour des biens de valeur régionale ou locale. Il s'agira aussi d'identifier des exemples de référence, bien mis en valeur, au profit de tous, et dont la transmission aux générations futures pourra être assurée dans de bonnes conditions. Il faut là distinguer entre les patrimoines vivants, encore en activité et supportant des communautés humaines contemporaines, et les patrimoines archéologiques ou les paysages fossiles qui témoignent de sociétés du passé.

Enfin, un patrimoine international de l'eau convenablement identifié et reconnu, à sa juste valeur, peut constituer un thésaurus de solutions techniques durables, à des coûts matériels, sociaux et énergétiques raisonnables par rapport aux réponses extrêmes de la techno-science contemporaine appliquée à l'eau. Il importe de comparer sereinement ces solutions modernes à la sagesse ancestrale de la gestion et de l'usage des patrimoines de l'eau.

2 L'intérêt et la richesse du thème de l'eau comme patrimoine culturel de l'Humanité

L'eau occupe sans aucun doute une place privilégiée au sein des nombreuses relations que l'Homme entretient avec la Nature. Il s'agit d'un besoin humain permanent essentiel. Il faut rappeler que le corps humain contient environ 80% d'eau, sous des formes diverses. Il s'agit d'un équilibre biophysique permanent et l'entretien de ce facteur hydrique est tout simplement déterminant pour la vie elle-même. La vie animale accompagne les ressources en eau et s'y adapte, notamment par l'évolution des espèces. L'Homme tente de s'émanciper de cette situation purement déterministe par ses réponses techniques et son organisation sociale, afin de contrôler et de gérer durablement son accès aux ressources en eau. Cet accès à l'eau constitue un élément vital commun à toutes les civilisations humaines ; aucune n'y échappe et toutes ont en conséquence une culture de l'eau. Au cours de l'histoire, cela a conduit à des expressions matérielles et sociales diversifiées, en un mot à l'un des patrimoines fondamentaux de l'Humanité.

Les groupes sociaux n'ont cessé et ne cessent d'organiser la gestion et l'usage de l'eau. Elle est nécessaire à l'échelle du quotidien, mais avec des implications techniques ou sociales de moyenne et de longue durée, parfois de très longue durée. Les sociétés tentent de maîtriser durablement cette relation de dépendance dans la diversité de ses composantes, comme une condition de la survie du groupe humain ; et elles savent, plus ou moins consciemment, que si elles n'y parviennent pas leur futur collectif est compromis, à plus ou moins long terme.

Il faut par ailleurs opérer une première distinction entre l'eau douce et les eaux salées. Le sujet de la mer et plus largement du rapport de l'Homme au milieu maritime ne sera pas abordé ici. Il constitue en lui-même un sujet extrêmement riche et assez bien délimité par rapport à celui que nous abordons-là, même si d'évidents points de contacts et des similitudes peuvent apparaître, des recouvrements également (estuaires, polders, désalinisation des eaux, etc.). Nous limiterons le champ des patrimoines envisagés aux eaux douces et continentales. D'autres études thématiques pourront éventuellement compléter l'approche envisagée ici.

L'eau apporte la satisfaction de besoins individuels et collectifs essentiels, mais qui ne cessent d'évoluer en fonction de la démographie et du renouvellement de ses usages, dans de multiples champs de l'activité humaine. Ces besoins sont directs : alimentation, hygiène, etc., ou indirects : agriculture, industrie, énergie, transport, etc. Nous avons d'un côté les pratiques quotidiennes de sa consommation individuelle, familiale et professionnelle, et de l'autre l'organisation sociale de sa gestion, de sa distribution et son traitement comme eau usée, à l'échelle d'un territoire. Nous savons que les différences de consommation d'eau par personne entre les différentes sociétés humaines contemporaines peuvent être considérables.

Par ailleurs, l'eau matière première n'est jamais un produit pur, au sens chimique du terme, c'est-à-dire exclusivement formée de molécules d'eau. Nombre d'éléments chimiques ou biochimiques sont présents, de manière obligatoire, comme le potentiel en ions hydrogène (pH), de manière circonstanciée et variable pour l'oxygène et les gaz dissous, les sels minéraux solubles, les charges minérales, la présence d'éléments organiques et biologiques variés, d'éléments polluants, etc. Une notion implicite ou explicite de qualité de l'eau et de propreté émerge. Ces réalités physicochimiques et leurs représentations sont essentielles aux usages de l'eau et elles les déterminent au sein d'une civilisation donnée. Il est bien connu qu'un excès de sel de magnésium rend une eau dangereuse à la consommation humaine et animale, et que la présence excessive de chlorure de sodium annihile tout effort d'irrigation agricole. Inversement, la présence de tel ou tel élément chimique dans les eaux naturelles crée une situation spécifique, par exemple propre au développement du thermalisme. La question des germes bactériologiques et microbiens présents dans l'eau potable est également une question vitale dans les usages de l'eau. L'association de la santé humaine et de la qualité perçue des eaux est souvent présente dans les représentations sociales. Celles-ci témoignent ainsi d'un patrimoine immatériel fait de comportements et de coutumes, de connaissances pratiques, enfin de valeurs symboliques et de mythes comme les sites d'eaux guérisseuses ou, au contraire, d'eaux maléfiques. Par exemple, dans le premier tiers du XXe siècle, en Occident, des eaux minérales destinées à la boisson humaine se vantaient, dans des publicités, de la présence de radioactivité minérale en leur sein comme étant très favorable à la santé, car elles étaient issues de massifs granitiques présentant naturellement ce phénomène !

Une civilisation donnée produit toujours des équipements matériels et des règles sociales destinés à organiser la satisfaction des multiples besoins que nous venons d'évoquer. Elle doit aussi être capable de faire face à l'évolution et au changement des données relatives à l'eau. Elle produit les facteurs techniques et d'organisation collective liés à la maîtrise de l'eau et à ses usages. Généralement, les sociétés traditionnelles ont développé des solutions durables formant des systèmes sociotechniques stables et bien adaptés à une situation et à une époque données. On peut même affirmer que sans cette maîtrise raisonnée de l'eau, elles n'auraient certainement pas survécu bien longtemps. Chacune a produit une culture de l'eau dont peuvent nous donner connaissances les patrimoines ayant survécu jusqu'à aujourd'hui, de manière vivante ou archéologique, et dont les composantes sont en prise directe sur les données hydrologiques et climatiques régionales et locales. Elles n'ont, bien entendu, pas été exemptes d'accidents ni d'évolutions naturelles les ayant mis en échec, mais suivant des temporalités de changement plus lentes et dans des données quantitatives moins vastes que pour le temps présent. La période contemporaine paraît avoir apporté des modifications hydrologiques irréversibles, ce que n'avaient que rarement atteint les époques précédentes. Cela rend d'autant plus importante et urgente l'identification, la reconnaissance et la préservation des patrimoines de l'eau édifiés au cours des âges.

Ce patrimoine, pris comme un tout, exprime directement la réponse de l'Homme à des conditions naturelles plus ou moins favorables, à des ressources plus ou moins abondantes, plus ou moins régulières ou d'accès difficile. C'est en cela qu'il est fondamental, exprimant l'une des bases matérielles incontournable de toute civilisation. Ces conditions naturelles sont elles aussi très diverses, car la présence de l'eau s'avère des plus variables, et changeantes selon les données géographiques et climatiques d'une région, d'une saison à l'autre, d'une époque à l'autre. Les extrêmes de la Nature ne sont pas rares, de la quasi-absence d'eau à son excès, engendrant à côté des pratiques quotidiennes les dangers de l'exceptionnel, de l'événement potentiellement destructeur : sécheresse, assèchement, inondation, érosion, etc.

Une trilogie fondatrice des relations de l'Homme à l'eau est discernable dans des contextes géographiques, climatiques et sociaux donnés. Elle débute par une appréciation des besoins hydriques du groupe humain confronté aux ressources en eau accessibles de son environnement. Cette dualité entre demandes et ressources disponibles guide vers le second point : la structuration technique du sol et du sous-sol, afin de maîtriser l'eau et d'assurer sa mise à disposition des usagers. Parallèlement, un troisième point se met en place : une organisation sociotechnique de l'eau pour sa gestion efficace, allant jusqu'à marquer profondément et durablement les caractéristiques de certains groupes humains. En ce sens, dès son point de départ, la relation de l'Homme à l'eau est manifestement productrice de patrimoine et de culture, tant dans le sens des biens matériels que pour des valeurs immatérielles associées.

En effet, au-delà de la technique, mais l'accompagnant toujours, nous trouvons la construction de corpus de connaissances et de croyances qui guident les pratiques sociales comme les comportements individuels. Les dimensions rationnelles et spirituelles de la pensée humaine ont longtemps été imbriquées entre elles. La première exprime la compréhension de la reproductibilité des phénomènes naturels liés à l'hydrologie et au climat locaux, comme nous l'avons déjà bien mis en évidence pour les patrimoines de l'astronomie et de l'archéoastronomie[1]. Elle implique en particulier un comportement d'observation, de connaissance et de prévision du monde naturel, ici pour les différentes manifestations du cycle de l'eau, dans l'air, sur terre et sous terre. Des systèmes de représentation et de transmission de ces connaissances et/ou croyances accompagnent l'organisation sociale. Un corpus de connaissances et de pratiques à propos de l'eau se dégage, formant par essence un patrimoine immatériel intimement associé au patrimoine construit et à ses paysages. Ces données d'intelligence sont nécessaires à l'Homme pour qu'il puisse agir efficacement afin de maîtriser son environnement et y trouver de quoi satisfaire durablement ses besoins en eau, pour lui-même et pour le bon déroulement de nombre de ses activités. La dimension immatérielle des patrimoines de l'eau ouvre aussi un accès important aux croyances magiques et aux comportements sacrés des groupes sociaux. Si l'eau est l'un des quatre éléments fondateurs de la physique d'Aristote, l'eau se retrouve aussi dans les mythes et les religions : les bâtons de pluie de certaines civilisations amérindiennes, les cultes et les divinités liés aux sources dans l'Antiquité occidentale, les offrandes aux cours d'eau un peu partout dans le monde, l'eau comme symbole de purification à peu près universel, etc. Beaucoup de ces éléments sont d'ailleurs à cheval sur le champ scientifique, au sens contemporain du terme, et les représentations : les eaux guérisseuses, les baguettes de sourcier, etc. Il existe donc un univers immatériel particulièrement riche associé aux patrimoines de l'eau, dont l'analyse est nécessaire à l'établissement de la valeur des sites.

3 Structure des patrimoines de l'eau, vers une typologie

Compte tenu de son importance, un patrimoine de l'eau possède généralement plusieurs niveaux constitutifs avec, chaque fois, un certain nombre d'implications sociales et culturelles. Par ailleurs, il intervient directement dans l'épaisseur de la société ; et toute détérioration ou amélioration du système sociotechnique de la gestion de l'eau a des répercussions dans plusieurs dimensions du tissu social. De nombreux éléments matériels et immatériels se rencontrent dans un système sociotechnique de l'eau, en faisant rapidement un exemple complexe de patrimoine, tant pour sa définition, pour la reconnaissance de ses valeurs propres que pour la compréhension de ses relations avec les autres éléments culturels de son environnement. En d'autres termes, le patrimoine de l'eau n'est jamais seul, car il est toujours destiné à une fin qui l'englobe. Il intervient comme composante de base d'une structure sociale, comprise dans un sens large allant des coutumes au droit de l'eau, des données économiques au contrôle politique des individus comme des territoires. En retour, un tel patrimoine éclaire souvent le fonctionnement social dans son ensemble.

En cela, le patrimoine de l'eau illustre bien un système sociotechnique dans un contexte donné. Il est un bon représentant des patrimoines technologiques en général, par sa sensibilité aux conjonctures tant naturelles que sociales, mais aussi par sa robustesse et par son aptitude d'adaptation à l'évolution des situations ; également par sa capacité à transcender les événements sociopolitiques. Il est d'autant plus impliqué dans une culture donnée qu'il en constitue une base matérielle décisive. Inversement, une culture de l'eau illustre souvent et de manière explicite les valeurs, les idéaux comme les problèmes d'une société inscrite dans un contexte géographique et historique donné. Il agit comme un marqueur et comme un témoignage de ces cultures. La force et la permanence de la présence patrimoniale de l'eau est aussi une faiblesse en termes de reconnaissance : il est tellement imbriqué dans les autres données de la société qu'il en constitue

[1] Clive Ruggles & Michel Cotte, Heritage Sites of Astronomy and Archaeoastronomy in the context of the UNESCO World Heritage Convention, ICOMOS & IAU Thematic Study, Paris e-edition 2010, paper edition 2011 Heritage Sites of Astronomy and Archaeoastronomy in the context of the UNESCO World Heritage Convention, ICOMOS & IAU Thematic Study, Paris, ICOMOS & IAU, e-edition June 2010, Bognor Regis (UK), Ocarinabooks, August 2011. http://www.international.icomos.org/world_heritage/WH_Committee_34th_session_Brasilia/ICOMOS_IAU_Thematic_Study_Heritage_Sites_Astronomy_2010.pdf

une donnée difficilement isolable. C'est une entité constitutive dont les traits sont parfois malaisés à distinguer des autres attributs culturels d'un site, et dont la dissociation serait artificielle et souvent préjudiciable à la valeur de l'ensemble. Que signifie un magnifique ensemble urbain de fontaines sans la ville elle-même ? Que vaut un ensemble d'*aflaj* sans l'oasis qu'il a généré ou des témoignages archéologiques de la vie passée qu'il a su générer ? À un tel trait constitutif s'ajoute la remarque sur la banalité fréquente des patrimoines de l'eau et la répétitivité d'éléments vernaculaires parfois bien modestes, à l'échelle du quotidien des individus. Souvent, sa force même n'est pas dans l'éblouissement du monument ou du paysage exceptionnels mais dans la répétition et la densité de son maillage au service des Hommes.

Évoquons ici la sensibilité de l'*Ecole des Annales* à une histoire matérielle de longue haleine des sociétés[2]. Elle a également insisté sur la nécessité d'une histoire totale de ces sociétés, c'est-à-dire sur la valeur d'un tout largement plus significatif que ses composantes prises isolément. Nous pensons qu'il en va de même pour le patrimoine. Cela nous conduit, comme pour la plupart des patrimoines techniques et scientifiques, à une relecture des patrimoines déjà reconnus. Cela implique une mise en lumière des conditions matérielles sur lesquelles reposent les constructions sociales, ici le bâti de l'eau, ses espaces et ses paysages. Il s'agit non seulement de composantes spécifiques importantes d'un ensemble plus large, mais aussi de facteurs explicatifs des tendances de longue durée à l'œuvre dans une société humaine considérée d'un point de vue global.

Par ailleurs, il importe de distinguer deux grandes catégories principales de biens porteurs d'une culture de l'eau. Les biens anciens encore en fonction forment des patrimoines vivants, presque toujours en cours d'évolution ; d'autres ont un caractère de vestiges archéologiques. Toutefois, les éléments de base qui ont présidé à leur conception, à leur réalisation et à leur usage sont les mêmes, simplement leur degré de témoignage ou leur connaissance historique ne sont pas identiques. Les uns sont évolutifs et les seconds figés.

En partant du niveau le plus matériel, celui-là même qui supporte le concept de patrimoine dans l'esprit de la Convention du patrimoine mondial, les questions de l'eau sont d'abord présentes dans les aménagements hydrauliques et les constructions de l'eau, dont les fonctions peuvent être très diverses. Ils forment la base technique d'une culture de l'eau en un lieu et à une époque donnée. L'idée des cultures techniques de l'eau donne un fil conducteur pour identifier les éléments d'un bien patrimonial dans ce domaine. Ensuite nous prenons en compte les éléments territoriaux puis les éléments sociaux et anthropologiques, ce qui nous conduit à envisager les éléments de représentation et les patrimoines immatériels. Une typologie peut être esquissée, avec bien entendu des recoupements entre catégories et sous-catégories :

1 **L'acquisition, la gestion et le contrôle de l'eau** pour la rendre disponible à des fins d'usage humain :
   - La collecte de l'eau, le drainage, le puisage, les forages, etc.,
   - Le stockage de l'eau à différentes échelles, barrages, citernes, etc.,
   - Le transport de l'eau ressource matérielle, les adductions d'eau,
   - Les traitements de l'eau en amont et en aval de ses usages (décantation, filtrage, dépollution, recyclage, etc.).

[2] France, Ecole historique fondée dans l'Entre-deux-guerres, crée par March Bloch et Lucien Febvre, Fernand Braudel en a été un illustre représentant au milieu du XXe siècle.

Tous ces stades de l'acquisition de l'eau sont à plusieurs niveaux : le niveau des réalisations matérielles, le savoir-faire technique et les connaissances des groupes humains, l'organisation sociale parfois très contraignante pour les mises en œuvre, les représentations associées.

2 **Les différents types d'usage** de l'eau induisent des particularités culturelles bien marquées, mais, en même temps, de grandes constantes dans différents domaines des réalisations humaines semblent exister. Les techniques hydrauliques, leurs architectures et leur gestion apparaissent alors comme un sous-ensemble de situations plus générales pouvant définir des biens patrimoniaux en relation avec :
- L'habitat et la vie domestique,
- L'urbanisme et l'architecture,
- L'eau ressource vivrière dans l'agriculture, l'irrigation, la pêche, etc.,
- L'énergie hydraulique, l'industrie, etc.,
- Les transports par la voie eau, les canaux, etc.

3 **La gestion des contraintes et le contrôle des eaux naturelles**
- Les zones sèches ou arides, la gestion de la rareté de l'eau et ses solutions techniques et sociales,
- L'excès d'eau, les pluies torrentielles, les inondations et les techniques de protection : digues, polders, bassins de rétention, habitat sur pilotis, pompage, etc.,
- Le drainage des zones humides à des fins territoriales ou industrielles,
- La construction en zone humide, les fondations, l'architecture hydraulique, etc.

4 **L'eau et la santé, la qualité de l'eau et les représentations associées**
- Les notions de pureté et de propreté de l'eau,
- L'eau comme boisson, l'eau et l'alimentation, l'eau et l'élevage,
- L'eau comme vecteur de propreté et d'hygiène en relation avec les conceptions du corps et de la santé, le thermalisme, etc.,
- L'eau comme vecteur de maladies,
- Les pollutions de l'eau.

5 **L'eau, sa connaissance, ses savoir-faire, les mythes et les symboles associés à l'eau**
- L'eau comme question scientifique et comme question technologique,
- La prévision des ressources en eau et les prédictions de l'eau,
- L'eau comme mythe, comme thème symbolique et religieux, etc.

6 **Les paysages culturels de l'eau**
- Dans ses associations fonctionnelles avec son environnement culturel matériel,
- Dans ses associations avec son environnement naturel,
- En tant que projet paysager avec ses valeurs propres (parcs, jardins, perspectives urbaines, etc.).

Il conviendrait de détailler la diversité de chacune de ces catégories, mais ce sont surtout les vues régionales et les études de cas des études thématiques qui illustreront ce propos et qui lui donneront sa véritable consistance. Il s'agit ici seulement de la suggestion d'un cadre pouvant aider à l'identification des composantes d'un patrimoine et à l'évaluation de ses significations. Il doit aussi permettre de faciliter les inventaires et les comparaisons. Chacune de ces catégories de base des patrimoines de l'eau s'inscrit à son tour dans des relations avec d'autres dimensions patrimoniales, et qu'il convient d'articuler entre elles. Cette typologie doit aider à identifier les attributs matériels et immatériels des biens patrimoniaux envisagés ; elle est avant tout d'ordre méthodologique.

Au-delà d'une typologie analytique, notons que les différents niveaux matériels des patrimoines de l'eau nécessitent tous des capacités techniques d'intervention des groupes humains et une organisation sociale leur permettant d'agir avec un niveau d'efficacité suffisant. Les patrimoines de l'eau semblent *a priori* illustrer de manière remarquable la notion de maturité technologique d'une société, inscrite tant dans le contrôle et la gestion quotidienne du système hydraulique que dans la conception et la réalisation de grands ensembles. Des seuils de compétences collectives comme d'organisation sociale apparaissent, autorisant le développement de certaines implantations humaines jusque-là impensables, ou du moins leur expansion remarquable à des échelles jusque-là inenvisageables. Nous pensons spontanément au développement des oasis artificielles à partir des *aflaj* ou *qanâts*, à la civilisation des polders, à la maîtrise des canaux à point de partage, etc.

Si l'eau constitue une dimension sous-jacente à toute culture humaine et si toute civilisation se confronte régulièrement à des questions de contrôle et de gestion de l'eau, l'extrême variété des conditions géo-climatiques terrestres est une évidence, allant des inondations aux sécheresses, du niveau des précipitations au comportement hydrologique des sols, des sources aux rivières, des lacs aux nappes phréatiques, etc. La situation est semblable pour les réponses sociales et techniques apportées par les différents groupes humains, suivant les époques, suivant la structure des systèmes techniques en regard des questions de l'eau. Les situations rencontrées sont donc fort diverses. Les grandes options de développement des sociétés humaines structurent leurs relations à l'eau, mais réciproquement, les données hydrologiques, géographiques et géologiques déterminent les grands choix sociotechniques en les rendant possibles, ou parfois impossibles, durables ou non. Il s'agit d'une relation dialectique et dynamique, traversée tant de grandes constantes sur la longue durée historique que d'événements fondateurs ou désastreux.

4 Les différentes formes des patrimoines de l'eau déjà reconnues

Les patrimoines culturels de l'eau peuvent exister sous différentes formes matérielles, dans les catégories que nous venons de proposer à partir des fonctionnalités et des usages de l'eau. Cette approche croise toutefois celles des reconnaissances ayant déjà eu lieu, sur les bases classiques de la mise en œuvre de la Convention, par l'archéologie, l'architecture, l'urbanisme ou les paysages culturels. Il est par ailleurs clair que les grandes catégories d'interactions entre l'Homme et l'eau, examinées au point précédent, ne recoupent pas vraiment les approches classiques du patrimoine culturel, à l'exception des grands monuments de l'eau, de certains paysages également. Ces interactions appartiennent à plusieurs champs du patrimoine matériel et du patrimoine immatériel.

Nous allons proposer un rapide tableau des formes déjà reconnues du patrimoine de l'eau où celui-ci est, le plus souvent, une composante d'un bien formant un ensemble plus complexe : une ville, un territoire, un paysage, un ensemble technologique, etc. Cette composante de l'eau est parfois simplement mentionnée, sans plus, et non véritablement analysée, tant dans ses formes patrimoniales que dans ses significations. Les exemples où le patrimoine de l'eau est au centre de la Valeur Universelle Exceptionnelle reconnue sont par contre relativement rares. Dans ce cas, elle est à son tour associée à d'autres composantes et à d'autres valeurs qui l'accompagnement. L'étude des usages a clairement montré que l'eau est toujours au service d'un projet humain, social, économique ou esthétique. En cela, elle est typiquement un patrimoine technique, un outil au service d'une société. Ce rappel de la complexité organique assez générale des patrimoines reconnus par la Convention est une remarque importante. Pratiquement, c'est l'étape de l'analyse et de la compréhension d'un bien qui conduit à l'inventaire détaillé de ses attributs constitutifs et à la définition la plus précise possible de ses composantes.

Nous savons donc que les patrimoines techniques et/ou scientifiques ne forment souvent qu'une composante matérielle précise d'un bien parmi d'autres. C'est l'une de ses données structurelles, parfois un simple ornement, et ces patrimoines n'atteignent pas, à eux seuls, le niveau d'un bien de Valeur Universelle Exceptionnelle, au sens prévu par la Convention comme condition de l'inscription. L'élément hydraulique produit une substructure, une base matérielle, un témoignage de pratiques culturelles au sein d'un ensemble plus vaste et plus complexe. Il s'y intègre avec ses valeurs propres et ses significations particulières. Il est donc important, dans une perspective d'application de la Convention ouverte vers des sujets nouveaux et dans une approche mieux équilibrée, de souligner la portée des technologies hydrauliques au sein d'ensembles anciennement reconnus, dont les significations comme la déclaration de Valeur Universelle Exceptionnelle sont appelées à évoluer au cours du temps. À ce titre, voici un exemple assez révélateur : le Pont du Gard (France) a tout d'abord été reconnu comme un représentant exceptionnel et très intègre de l'architecture romaine monumentale du IIe siècle en Gaule. Il a ensuite été considéré, du moins au niveau national, comme un pont éminent, avec une histoire sensiblement plus complexe car c'est une fonction plus tardive de cet ouvrage d'art, puis, plus récemment, comme élément d'un ensemble bien plus vaste : le système d'adduction d'eau romain de la ville de Nîmes, c'est-à-dire comme un aqueduc. Voici donc trois étapes de reconnaissance de la valeur d'un bien dont la fonction hydraulique, qui pourtant présida à sa conception, n'a été reconnue qu'en dernier !

Cependant, des patrimoines de l'eau ont déjà été reconnus et inscrits comme tels sur la Liste du patrimoine mondial. Les biens les plus spontanément en rapport avec l'application de la Convention sont des réalisations souvent spectaculaires appartenant au génie hydraulique, dans ses œuvres les plus monumentales. La captation de l'eau, sa conservation et sa distribution ont donné des résultats remarquables et souvent impressionnants dans de nombreuses civilisations, dont aujourd'hui encore de nombreux biens témoignent. Ils sont encore en usage dans de nombreux cas, montrant une temporalité technologique particulièrement longue, propre aux patrimoines de l'eau : ce sont des structures permanentes, très représentatives de certaines civilisations.

Proposons une esquisse de ces différentes formes reconnues du patrimoine de l'eau, en sachant que comme pour les typologies de l'eau, elles se recoupent fréquemment entre elles.

- Les monuments des technologies hydrauliques comme la station de pompage à la vapeur de Woudda (Pays-Bas) ou les ascenseurs hydrauliques du Canal du Centre (Belgique). Il faut noter que des biens constituant des ensembles, au sens de la Convention, comprennent souvent des monuments hydrauliques majeurs comme la prise d'eau et les vestiges du grand pont barrage de Shushtar (Iran), le barrage de Saint-Ferréol dans le système alimentaire du canal du Midi (France), le pont-canal de Pontcysyllte (Royaume-Uni), etc.

- Les techniques hydrauliques comme partie d'un ensemble archéologique : les canaux, citernes et tunnels de Pétra (Jordanie), les puits d'Al-Hirj (Arabie saoudite), les vestiges d'*aflaj* d'Al Aïn (Emirats Arabes Unis), etc.

- Les plans d'eau artificiels comme composante paysagère d'un monument ou d'un ensemble monumental : les bassins du Taj Mahal (Inde), les canaux et les fontaines des jardins de Versailles (France), de l'Alhambra de Grenade (Espagne), la Villa d'Este à Tivoli (Italie), le Palais d'été à Pékin (Chine), etc.

- Les techniques hydrauliques comme partie d'un ensemble urbain : la ligne de défense d'Amsterdam, le quartier des canaux du Singelgracht à Amsterdam (Pays-Bas), l'adduction d'eau de la Médina de Fès (Maroc), les qanâts de Bam (Iran), etc.

- L'aménagement hydraulique du territoire, en tant qu'ensemble technologique hydraulique et très souvent en tant que paysages culturels. Exemples : le système hydraulique historique de Shushtar déjà mentionné (Iran) ; le système d'irrigation de Dujiangyan (Chine) ; les systèmes d'irrigation *aflaj* d'Oman ; aux Pays-Bas le polder de Beemster, le site des moulins de Kinderdijk-Elshout ; le système hydraulique du Haut-Harz (Allemagne), les rizières en terrasses des cordillères des Philippines, etc.

- Les canaux : ce point a déjà fait l'objet d'une approche thématique de référence (annexes des *Orientations devant guider la mise en œuvre de la Convention*). Ils peuvent être rattachés à la catégorie précédente dont ils forment une partie.

- Les paysages associés aux plans d'eau et aux rivières : Ferrare, cité de la Renaissance et son delta du Pô (Italie), les rives de la Seine à Paris (France), la Vallée du Rhin (Allemagne), etc.

Notons la variété des formes du patrimoine de l'eau qui se retrouve avec beaucoup de facilité dans de nombreuses catégories déjà reconnues par la Convention. La relation de l'Homme avec l'eau produit des patrimoines à part entière, tout à fait remarquables, mais elle produit également, et en grand nombre, des composantes de biens largement plus complexes.

5 L'eau, patrimoine du quotidien de l'Homme

À l'opposé de ces réalisations monumentales ou paysagères majestueuses, volontiers reconnues par la Convention, des pratiques d'échelle plus modeste peuvent être évoquées, se rapprochant des activités humaines quotidiennes et de ses constructions vernaculaires. Elles aussi sont de localisations géographique ou historique les plus diverses, car il n'existe pas de société qui puisse se passer d'eau, l'une des clés du développement et de l'expansion de l'espère humaine. Cela nous conduit à noter le caractère extraordinairement répandu des patrimoines de l'eau et à souligner la multiplicité de ses exemples. À côté des grands aménagements, facilement identifiables, un patrimoine vernaculaire de l'eau des plus diversifiés existe aussi. Souvent, l'un ne va pas sans l'autre et leurs articulations forment un territoire d'échelle intermédiaire, urbaine ou rurale.

En un lieu donné, dans une société donnée, les éléments culturels associés à l'eau sont très vite répétitifs, récurrents et donc abondants et souvent ordinaires. Ils forment notamment les structures quotidiennes des usages de l'eau qui accompagnent la vie individuelle comme la vie sociale. Les plus grands écarts et les plus grandes inégalités existent dans ces rapports organisés à l'eau, tant dans les sociétés d'hier qu'aujourd'hui, entre la quête épuisante d'une ressource rare et un usage parfois machinal et irréfléchi d'une matière première inconsciemment jugée comme inépuisable. Cette dimension habituelle de l'eau est donc porteuse d'une grande richesse d'éléments matériels naturels et artificiels ; elle tend à générer des patrimoines répétitifs, en eux-mêmes peu démonstratifs. Ils sont dilués dans les rythmes et les gestes de la vie de tous les jours. Les historiens nous ont toutefois rappelé l'importance de cette histoire matérielle quotidienne associée à la condition humaine, démontrant son rôle structurant des sociétés sur de longues durées historiques.

Nous rencontrons cependant là une difficulté notable : un patrimoine de l'eau, certes, mais qui peut être noyé et dilué, si l'on peut dire, dans des structures du quotidien d'une grande banalité. Les éléments témoins du quotidien de l'eau sont apparemment simples et relativement simples à identifier dans leur banalité répétitive : les équipements aux échelles de la maison familiale, du puit, de la fontaine de quartier, à l'échelle du village et de la gestion communautaire de l'eau, etc. Il faut chercher où se situent les enjeux de cette répétitivité, en termes de patrimoine pouvant être considéré dans le cadre de la Convention du patrimoine mondial : à l'évidence dans l'innovation, dans l'exceptionnalité des pratiques ou dans leur caractère exemplaire, par leur réponse à des situations extrêmes prouvant l'adaptation remarquable d'un groupe humain à une situation qui ne l'est pas moins. Par exemple, les pratiques traditionnelles de désalinisation des sols par les Indiens Chipayas, en Bolivie, ont généré des paysages *a priori* bien modestes, mais qui reposent sur une inventivité et un degré d'adaptation à un territoire extrême, tout à fait uniques et exceptionnels.

Ces patrimoines de la satisfaction des besoins vitaux doivent êtres complétés des réalisations de sécurité face à l'eau et à ses différentes manifestations naturelles, qu'elles soient permanentes ou exceptionnelles. Il s'agit par exemple d'ensemble de digues et de fossés drainant contre les crues, la maîtrise d'un bassin versant et la conservation des sols en cas de pluies torrentielles, etc. C'est un type de patrimoine résultant d'un système sociotechnique adapté à des situations données de risques. Il suppose des techniques et des savoir-faire spécifiques, parfois sophistiqués, mais aussi toute une organisation sociale à la fois stricte et équitable au service de ces ensembles, au sens d'un bien collectif nécessaire à la vie du groupe, là dans le domaine de la protection contre les excès et la brutalité des eaux.

Les rapports d'une société à son patrimoine quotidien de l'eau ou à son côté menaçant et accidentel génèrent eux aussi des systèmes de représentations qui participent à la structuration sociale et éventuellement religieuse du groupe humain, en s'agrégeant souvent à d'autres croyances, à d'autres systèmes de référence pour former des ensembles de valeurs immatérielles.

6 L'évaluation des patrimoines culturels de l'eau, leur intégrité et leur authenticité

Comme pour tout bien désireux de connaître ses possibilités d'accéder à la Liste du patrimoine mondial, une analyse des éléments susceptibles de le composer est en premier lieu nécessaire. Le format général du dossier présenté dans les *Orientations* propose les grandes étapes successives de la démarche à entreprendre. La première partie repose sur un travail d'inventaire et de description des éléments constitutifs, puis de leur compréhension historique et contextuelle. Pour les patrimoines de l'eau, il s'agit de présenter leur conception, leur réalisation, leurs aménagements successifs. Il faut ensuite décrire leurs usages et leurs rôles socioéconomiques au cours des âges, les éléments de régulation et de contrôle, enfin les éléments immatériels associés aux attributs matériels, tant dans le domaine de la connaissance et des savoir-faire que dans celui des croyances et des coutumes. La démarche conduit à une seconde étape d'établissement de la valeur du bien par l'analyse de l'intégrité et de l'authenticité des éléments le composant.

Dans le cas des patrimoines de l'eau, la question de l'intégrité et de l'authenticité des biens prend un relief particulier. En effet, comme la plupart des patrimoines technologiques, ils sont soumis à une double contrainte : d'une part l'entretien avec son cortège de travaux et de possibles modifications et, d'autre part, l'adaptation à la demande et à l'évolution des usages. Nous savons tous que le besoin d'entretien des patrimoines hydrauliques vivants est une donnée très importante de leur conservation fonctionnelle, donc de leur intégrité. Par nature, un patrimoine hydraulique a besoin de réparations et de réfections périodiques, par exemple pour l'étanchéité, l'envasement, les mécanismes hydrauliques, etc. Il faut considérer un système hydraulique comme une machine fonctionnelle fixe, dont les parties interagissent entre elles. Le disfonctionnement ou la faiblesse d'un élément entraîne des conséquences dans le fonctionnement des autres comme dans la performance d'ensemble. Un système hydraulique, plus largement tout système technique, est un ensemble dynamique et ses gestionnaires en ont forcément une approche globale et fonctionnaliste. Réduire un bien hydraulique à une intégrité architecturale statique, surtout pour un bien vivant, est très insuffisant. L'intégrité fonctionnelle est une notion ici essentielle, et elle se base sur des données techniques que le dossier se doit d'aborder. Il en va de même pour la notion d'authenticité, l'authenticité des usages en particulier, c'est-à-dire leur conformité présente à des pratiques traditionnelles. Cela conduit à une histoire de l'entretien et de l'adaptation du réseau, qui rejoint l'idée générale d'histoire de la conservation. Nous soulignons ensuite l'importance d'une histoire des usages et de leurs évolutions dans l'établissement de l'authenticité, qui n'est pas seulement un inventaire chronologique de la construction de l'existant, quand elle est connue, mais une mise en perspective historique des usages de l'eau et de leur contexte.

Un arrêt de la gestion technique d'un ensemble hydraulique, lié à une situation de troubles sociaux ou de guerre, peut entraîner d'importantes dégradations, parfois en quelques années voire en quelques mois. Toute reprise de service nécessite des travaux de remise en état et, parfois, des changements techniques, des extensions de réseaux, des refontes de dispositifs jugés obsolètes ou mal adaptés à l'évolution des usages. C'est un terme commun à l'histoire du patrimoine industriel qui commence à être bien connu.

Plus largement, un ensemble hydraulique est destiné à évoluer au cours du temps et à s'adapter à des situations qui peuvent changer à différents niveaux techniques ou sociaux, et en suivant des temporalités variables : conditions hydrologiques et climatiques, variations des nappes phréatiques, changements démographiques locaux et régional, évolutions des besoins humains, transformations agronomiques ou urbaines, pollution et dégradation de la qualité des eaux, etc. C'est le lot de tout système hydraulique vivant ; il ne cesse d'être réajusté à la demande des usagers en fonction des ressources accessibles. Cette capacité à s'adapter est une condition de la pérennité du système ; mais les résultats matériels et techniques qui en découlent s'ajoutent aux résultats de l'entretien. C'est une difficulté majeure pour leur évaluation en termes d'intégrité et d'authenticité, ce qui renforce le besoin d'une histoire technique et d'une histoire sociale de l'ensemble hydraulique ; l'une ne va pas sans l'autre. Les évolutions et les changements techniques font partie intégrante de leur histoire, qui n'est pas seulement celle de leur conception ou de leur moment d'origine, parfois plus supposé que réellement démontré. Ces adaptations aux circonstances sont consubstantielles à la valeur même du bien, et elles sont intervenues tant pour des patrimoines encore vivants que pour ceux aujourd'hui à l'état de vestiges archéologiques ou de paysages reliques. Cela entraîne quelques remarques complémentaires.

Pour les systèmes hydrauliques anciens encore en usage, et ils sont nombreux, les adaptations et les extensions qui ont accompagné la révolution technologique liée à l'industrialisation du XIXe et du XXe siècle ont pu modifier de manière importante un certain nombre de paramètres de l'authenticité, en particulier les matériaux et, partant, les formes et les apparences. L'usage du métal, puis celui du béton et du béton armé, les imperméabilisants chimiques, etc., ont pu révolutionner certaines pratiques techniques. Il en va de même pour la mécanisation et ses différentes strates de motorisation du pompage. Ces facteurs ont pu modifier en profondeur certains éléments des systèmes hydrauliques, littéralement les refonder. Ils ont pu en particulier permettre des installations jusque-là impensables, et dénaturer assez profondément les caractéristiques initiales du bien proposé, ou bien les compléter, formant des ensembles compréhensibles au service du même but hydraulique. Nous pensons par exemple au polder de Kinderdijk-Elshout, inscrit sur la Liste du patrimoine mondial (Pays-Bas, 1997), où les moulins à vent de la période moderne (XVIe – XVIIe siècles) viennent compléter les systèmes de drains et de vannes remontant au Moyen Âge ; ils sont complétés par la machine à vapeur (XIXe – début XXe siècles), puis par les pompes électriques contemporaines à vis d'Archimède. Une analyse technique fine des changements intervenus doit être conduite, non pour arriver à la conclusion fatale que beaucoup d'éléments constitutifs ne sont pas des originaux, et donc pas authentiques, mais plutôt pour évaluer en quoi l'intégrité du concept initial a été maintenu et l'esprit technologique de l'ensemble conservé. Il est nécessaire de savoir s'il y a continuité du système technique de l'eau mise en place au cours des âges ou si une rupture trop importante est intervenue qui en dénature la compréhension profonde et donc l'expression des valeurs patrimoniales. Dans le même esprit, l'analyse des conditions sociales de l'usage de l'eau, dans le système traditionnel et dans celui d'aujourd'hui, conduit à une dimension importante de l'authenticité d'usage. De ce point de vue, le lien entre changement technique et changement du droit de l'eau est un point important à envisager.

Dans une dernière phase de l'analyse de la valeur vient l'étude comparative avec des biens similaires, déjà reconnus ou plus anonymes, dans l'environnement proche ou dans celui de la région, puis à plus grande échelle dans des domaines comparables. Jointe aux éléments descriptifs et évaluatifs précédents, elle permet de déterminer si le bien a une Valeur Universelle Exceptionnelle et suivant quels critères, ou s'il est plus simplement un bien d'ordre régional ou local. Pour approfondir cela, nous renvoyons notamment à la publication de l'ICOMOS : « *What is OUV ?* »[3].

La dernière partie du dossier est constituée par les questions de protection, de conservation et de gestion du bien, formant une série d'engagements au sein d'un système de gestion et de suivi du bien clairement établi.

7 Choix du sujet de l'étude thématique et choix d'une première région

Partant de l'évidence de la richesse des patrimoines de l'eau, il est nécessaire de rechercher un thème cohérent et donc limité, car tout ne peut être étudié en même temps sous peine de confusion. Il est ensuite nécessaire d'envisager une étude régionale de ce thème, pour lui donner une cohérence, notamment culturelle, et une échelle de faisabilité. Plusieurs grandes voies d'approche et quelques remarques méthodologiques nous aident à préciser un premier cadre général pour l'étude des patrimoines de l'eau, et une région d'application.

Nous éliminons d'emblé l'étude chronologique des systèmes hydrauliques, peu pertinente tant les techniques à l'œuvre semblent transcender les périodisations pour s'inscrire dans la longue durée de l'histoire. Par ailleurs, ces techniques ont un caractère assez spontanément universel, au sens où elles sont partagées peu ou prou par tous les groupes humains, par des cultures de toutes les époques et de toutes les civilisations, mais dans des formes pratiques aux nombreuses variations. Nous sommes bien dans l'approche de l'un des déterminants fondamentaux de la relation de l'Homme avec la Nature ; déterminants dont la maîtrise durable forme les patrimoines de l'eau. Deux grandes voies possible s'ouvrent à notre réflexion : 1) l'approche anthropique du couple besoins - réalisations humaines ; 2) l'approche géographique et climatique des conditions imposées par son environnement à l'Homme dans sa maîtrise de l'eau. Mais elles sont intimement

[3] http://www.international.icomos.org/publications/monuments_and_sites/16/pdf/Monuments_and_Sites_16_What_is_OUV.pdf

complémentaires, très générales, et elles ne permettent pas de définir un cadre thématique à elles seules. Il faut aller plus loin.

L'approche par catégories thématiques du rapport de l'Homme à l'eau est une voie possible, séduisante même car, d'échelle plus réduite, elle cerne assez bien les limites d'un sujet et elle semble conduire à des distinctions claires et simples à comprendre. Ce serait suivre par exemple la typologie générale mise en avant au point 3 de ce document : « les techniques d'acquisition et de gestion de l'eau par l'Homme », ou bien choisir des sous-thèmes plus précis qui rejoindraient les catégories de patrimoines évoquées en 4 : « l'eau et l'urbanisme », « l'agriculture et l'eau », « le thermalisme », etc. C'est au fond la démarche que nous avons connue dans les années 1990 avec le sujet des « canaux de transport », introduit comme exemple typologique dans les annexes des *Orientations*. Sans du tout disqualifier cette possibilité d'étude thématique, elle nous semble souffrir aujourd'hui de deux limites. La première, déjà indiquée, est que, dans de nombreux cas, les biens appartiennent à plusieurs catégories, simultanément, et ils forment des ensembles dont la valeur n'est pas convenablement analysée dans un tel cadre, trop restrictif. La seconde est que la dimension majoritairement immatérielle de certaines de ces catégories tend à les marginaliser et à les couper des précédentes, comme « les connaissances et les savoir-faire de l'eau ». C'est une démarche qui doit plutôt être retenue pour aider à inventorier et à classifier un existant patrimonial, au sein d'une vue générale subrégionale, mais non pour définir un sujet d'étude.

La démarche anthropique nous conduit cependant à des approches plus large que celles que nous venons d'évoquer, déjà abordées au chapitre 4 de ce document, comme « les monuments de l'eau » ou « les paysages de l'eau ». Nous avons vu qu'il est possible de distinguer des biens hydrauliques en tant que tels répondant à ces catégories, mais cela restait relativement exceptionnel. Du coup, des biens aux composantes plus larges ou plus complexes sont moins bien compris et leurs caractéristiques ont du mal à être bien prises en compte. Dans l'autre sens, des éléments d'échelle plus réduite ou plus répétitifs peuvent êtres marginalisés, voire oubliés, à moins de les traiter comme des sous-catégories qui rejoignent celles du point précédent. Cela reste une approche patrimoniale traditionnelle, surtout fructueuse pour des sites bien typés où les aspects monumentaux ou paysagers sont dominants.

Les catégories géo-climatiques forment une seconde générale option d'approche, par l'angle des conditions environnementales, et elle semble fructueuse à envisager. Elle perd, bien entendu, les clarifications catégorielles précédentes, mais elle nous permet *a priori* d'envisager les sujets complexes à classifier par les approches précédemment envisagées. Elle délimite le sujet par des conditions hydrologiques et climatiques similaires, c'est-à-dire un type de défi que la Nature pose au développement pérenne des groupes humains. Un tel sujet revient à prendre comme point de départ le cadre de la relation de l'Homme à l'eau. La démarche devrait permettre d'observer les résultats de l'adaptation des groupes humains régionaux à la question de l'eau, au cours des différentes phases de leur histoire. Elle oriente la lecture du patrimoine vers la description de systèmes sociotechniques aptes à répondre à une situation géo-climatique donnée, à percevoir des ensembles à l'échelle de territoires, enfin à en identifier les meilleurs témoignages. Cette approche du patrimoine de l'eau vise à identifier les formes stables et durables plus que les représentants exceptionnels. Elle nous propose une nouvelle valeur d'appréciation du patrimoine, par le témoignage d'une adaptation réussie des rapports d'un groupe humain aux ressources hydriques de son territoire. C'est aussi une appréciation des difficultés de cette adaptation, de ses contraintes, comme des menaces auxquelles elle est soumise. C'est ce qu'il est possible de nommer un *patrimoine du développement durable*. Nous suggérons, notamment pour les patrimoines vivants, de les étudier comme tels.

De ce point de vue, nous identifions assez simplement :

- Les régions arides, les déserts
- Les régions semi-arides (steppes, savanes…)
- Les régions de climat méditerranéen
- Les régions tropicales et subtropicales humides
- Les régions équatoriales
- Les régions tempérées humides
- Les régions nordiques

Arrivé à ce point, il nous semble possible de délimiter un premier grand cadre thématique regroupant les trois premières catégories, c'est-à-dire les régions où l'eau est rare d'une manière permanente ou temporaire. Elles correspondent à un premier grand thème des patrimoines de l'eau, quand celle-ci est rare, à des degrés divers. Nous pouvons l'étudier sous le titre général : « **Les patrimoines culturels de l'eau dans les régions arides, semi-arides et méditerranéennes** ». Deux autres grands thèmes seront à examiner ultérieurement : les régions tropicales et équatoriales d'une part, les régions tempérées humides et les régions nordiques d'autre part.

L'intérêt de ce premier grand cadre thématique est renforcé par plusieurs remarques. Ces régions sont aujourd'hui en expansion démographique, comme le reste de la planète, bien entendu, mais les besoins d'eau douce y sont amplifiés et exacerbés par la rareté. Les populations directement concernées par ces patrimoines sont nombreuses, et il s'agit pour elles de questions de développement absolument cruciales. La diversité des régions géographiques concernées est très importante, comme le montre la cartographie, et les comparaisons peuvent être des plus riches, tant en termes de patrimoine, d'histoire que d'exemples de développement.

L'étude cartographique d'ensemble que nous avons réalisée, et qui se retrouve dans cette publication, montre que toutes les grandes régions du monde sont concernées. Une étude générale serait donc très lourde à conduire et il nous a semblé plus pertinent de sélectionner une région, si possible emblématique dans son ensemble de ces questions. **La région du Moyen-Orient et du Maghreb** répond à ce critère et elle offre *a priori* un ensemble d'avantages qui nous ont semblé déterminants pour lancer une première étude thématique au sein du cadre général de l'eau rare. La région est bien délimitée, ses conditions géo-climatiques dominantes sont assez homogènes et elles correspondent pleinement au cadre établi. Seule la question du climat méditerranéen pourrait être discriminant et pose question, car tous les pays de la région ne le partagent pas, alors que les conditions arides et semi-arides sont communes à tous, à un degré ou à un autre. C'est par ailleurs un climat-charnière que l'on retrouvera dans d'autres grandes régions, mais sans du tout les caractériser dans leur ensemble. Fallait-il l'exclure au sein de la région pour n'en traiter qu'une partie ? Cela nous a paru arbitraire et démenti par l'histoire régionale, introduisant une coupure fictive au sein même des Etats parties. Le long héritage partagé de la civilisation arabo-islamique, et d'une diffusion remarquable de ses techniques hydrauliques en son sein et au-delà, a en outre été crucial dans le choix de cette première étude thématique, lui donnant une unité et un cadre culturel exceptionnellement homogènes.

8 Conclusion

L'étude thématique proposée doit pouvoir fournir les éléments pour identifier et pour décrire les patrimoines de l'eau. Nous avons essayé de dresser un inventaire typologique qui doit surtout être une aide méthodologique pour tous ceux qui voudront bien se pencher sur ces questions, que ce soit dans le but d'une reconnaissance et d'une protection de ces patrimoines par la Liste du patrimoine mondial ou dans celui d'une protection dans un cadre national.

Nous avons bien conscience d'un double défi : d'une part, le patrimoine de l'eau est très diffus et il est présent partout où l'Homme s'est implanté, ce qui constitue un véritable challenge pour son authentification et son analyse comme patrimoine. D'autre part, un nombre relativement important de biens déjà inscrits sur la Liste du patrimoine mondial possèdent des éléments hydrauliques importants qu'il serait bon de mieux mettre en lumière, notamment lors des révisions périodiques et des éventuelles réécritures de la Déclaration de Valeur Universelle Exceptionnelle.

Finalement, dans le cadre de cette première étude thématique, la distinction entre patrimoine archéologique et patrimoine vivant est essentielle. Le premier sera, bien entendu, très présent, et il est essentiel dans une région baignée par une protohistoire et une histoire en tous points remarquables. Il importe donc d'établir le bilan de ce patrimoine avec le plus grand soin. Toutefois, les patrimoines vivants de l'eau représentent pour nous un enjeu vital, dans un contexte d'eau rare et de pression accrue de la demande, notamment depuis le milieu du XXe siècle avec le développement de technologies modernes par le pompage mécanique, l'accès aux nappes profondes et l'usage de nouveaux matériaux comme le béton armé, l'acier, etc. Une forme de négation, voire d'ignorance des patrimoines matériels et immatériels anciens de l'eau a souvent prévalu. Il y eut souvent un abandon ou des restructurations plus ou moins radicales de l'existant, au préjudice de solutions dont la durabilité avait cependant fait ses preuves. Notre étude sur les patrimoines vivants de l'eau doit prendre en compte ces questions pour en dresser le bilan, mais cette fois non du point de vue des systèmes actuels, mais du point de vue des Anciens sur les Modernes tout en les confrontant aux enjeux du futur. Notre hypothèse est qu'il existe un *patrimoine du développement durable* dans le domaine de l'eau, et qu'il nous appartient de l'identifier et de l'étudier au profit de tous.

Sub-region A: Atlantic Maghreb

Les patrimoines culturels de l’eau au Maroc

Patrimoine culturel de l’eau en Mauritanie

Les patrimoines culturels de l'eau au Maroc

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1 Caractéristiques générales

1.1 Les données climatiques et hydrologiques générales

Comparé aux autres pays du Maghreb, le Maroc dispose des eaux de surface les plus importantes. Cette situation privilégiée, il la doit à sa façade atlantique et à l'importance de ses chaînes de montagne, plus particulièrement l'Atlas. Il est à la fois méditerranéen et atlantique, tempéré et saharien, maritime et continental. Cependant, le contexte hydrologique est marqué par la variabilité et l'irrégularité des précipitations et l'occurrence des cycles de sécheresse ce qui le classe parmi les pays arides et semi-arides. Le potentiel hydraulique du Maroc est appréciable, mais périssable : 20 Milliards de m3 par an répartis entre eaux souterraines (4 Mds de m3) et eaux de surface (16 Mds de m3). Aujourd'hui, les eaux souterraines sont utilisées à 67% de leur capacité (soit 2,7 Mds sur 4Mds de m3) ainsi que les eaux de surface (10,75 sur 16 Mds de m3). Le capital hydraulique est en diminution croissante du fait des usages agricoles, urbains et touristiques. Les belles nappes phréatiques qui ont rendu possible par le passé la révolution de la technologie des Qanats (ou khettara ; foggara) sont menacées d'extinction du fait de l'extension des pompages. Quant aux séguias (canaux traditionnels) qui ont étendu la conquête des irrigations jusqu'aux déserts et crêtes des montagnes, leur culture ne résistera pas longtemps à l'impact des grands barrages réservoirs. Cette situation qui risque de devenir tragique impose l'engagement de mesures urgentes et efficaces pour la sauvegarde du patrimoine hydraulique, mesures dont nous parlerons à la fin de ce rapport.

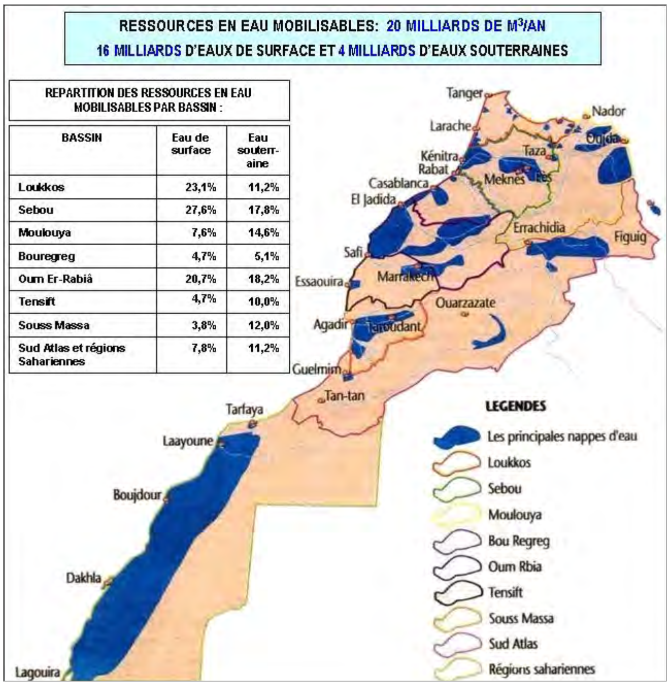

Figure 1. Carte des ressources hydrauliques du Maroc (ABHT-Marrakech)

1.2 Relations culturelles et échanges techniques avec les zones voisines

Le Maroc fait partie de l'aire géographique et culturelle du monde arabo-musulman. Les contacts avec l'Ifriqiya (Tunisie actuelle) et Al Andalus (Espagne musulmane) ont été importants au cours de l'histoire. L'approche du patrimoine hydraulique gagnerait à être intégrée dans les apports de la civilisation arabo-musulmane qui a permis aux cultures de l'eau de voyager et constituer l'héritage partagé entre le Moyen Orient et l'Afrique du Nord.

2 Sites connus et sites importants du patrimoine culturel de l'eau

2.1 Les sites à caractère archéologique

Le complexe hydro-agricole de Sidi Bouathmane (XIIe siècle)

C'est à Sidi Bouathmane (40 km au nord de Marrakech) que les ingénieurs de la dynastie almohade (XIIe siècle) ont érigé un complexe hydraulique et agricole formé de barrages, de bassins de décantation et de neuf citernes d'une capacité totale de 3254000 litres. Ce complexe était destiné à capter les eaux de ruissellement et à les acheminer vers de grands réservoirs pour satisfaire les besoins de l'armée et des caravanes en déplacement vers le nord. Le site archéologique étendu sur 1230m² représente un exemple du génie hydraulique qui a doté une steppe aride d'eau pérenne et permis aux techniques de stockage de satisfaire des besoins alimentaires et agricoles.

Figure 2. Les citernes de Sidi Bouathmane (archive M. El Faïz)

L'aqueduc de l'Oued Ouaar (XIIe siècle) (région de Taroudant)

On peut citer dans le même cadre, la réalisation du bassin de Gaba et de l'aqueduc de l'Oued Ouaar à l'ouest de Taroudant dans le sud du Maroc. Le bassin de Gaba, de forme circulaire, avait un diamètre moyen de 250m, une superficie approximative de 50000m², soit pour une profondeur de un mètre, une capacité totale de 100000m3. L'aqueduc construit sur l'Oued Ouaar avait, quant à lui, 100 mètres de longueur. Porté par des arches sur une hauteur de 15 mètres, il constitue un ouvrage à usage multiple, à la fois monumental et gracieux.

Figure 3. Aqueduc Oued Ouaar (archive M. El Faïz)

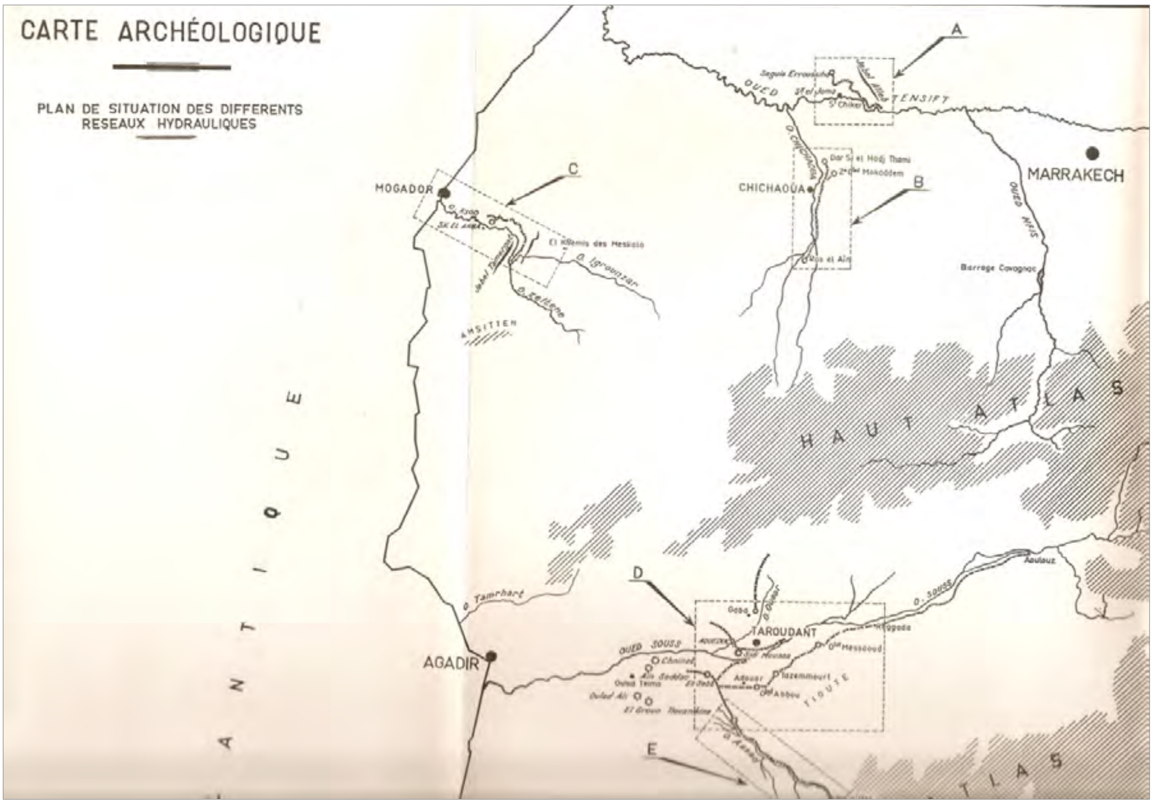

Figure 4. Carte des sites des sucreries du Maroc (Paul Berthier, Les sucreries au Maroc, op.cit.)

Le patrimoine hydraulique des sucreries du Maroc (XVIe siècle)

La dynastie des Saadiens (XVI-XVIIe siècles) a doté le Maroc d'un héritage hydraulique et industriel des plus importants. Quatorze sucreries réparties sur quatre sites archéologiques

(Chichaoua, Sidi Chiker, Essaouira, Agadir) témoignent de la maîtrise du machinisme hydraulique à des fins agricoles (culture de la canne à sucre) et industrielles (force motrice pour les pressoirs et la fabrication de pins de sucre).

Chaque site se distingue par ses ouvrages de prise de l'eau, ses barrages de dérivation, ses ouvrages de franchissement (aqueducs portés sur des arches), ses bassins d'accumulation, ses salles de machines (broyeurs et canaux d'écoulement), sa salle de fours et les ruines majestueuses de ses sucreries. A cet héritage exceptionnel, s'ajoutent 150 km de séguias (canaux) qui témoignent de l'évolution de l'ingénierie de l'eau.

Les tours élévatrices de l'eau de Tamesloht (région de Marrakech, fin du XIXe siècle)
Dans le vallonnement qui mène à l'entrée de la commune de Tamesloht, on distingue une ligne de tours carrées construites en briques et pouvant atteindre la hauteur d'une dizaine de mètres. Elles sont creuses et disposant chacune de deux tuyaux en céramique avec des diamètres variant de 0,40 mètres pour le plus grand à 0,21 mètre pour le plus petit. L'eau parvient à la base des tours par une canalisation enterrée. Elle emprunte le premier tuyau et, arrivée au sommet, elle se déverse dans le second et redescend au pied de la tour d'où elle est reconduite via la canalisation souterraine jusqu'à la seconde tour. (figure 5 - les tours de Tamesloht). Le réseau de deux kilomètres environ est ainsi parsemé de 13 colonnes qui fonctionnent comme des vases communicants destinés à alimenter le Palais et les jardins. La plupart des tours sont en bon état de conservation. Mais l'extension urbaine de la commune de Tamesloht menace la tour la plus proche du centre. D'où l'intérêt de la présentation d'un dossier de classement au titre du patrimoine hydraulique national.

Figure 5. Tours élévatrices de l'eau à Tamesloht (archive M. El Faïz)

Le barrage d'Irara dans le Tafilalet (près de Rissani)
Le Barrage d'Irara fut édifié au XVIIe siècle sur l'oued Ziz. Long de 1701 mètres et haut de 10 mètres, il fut construit en gradins à contreforts et en maçonnerie à la chaux. Ouvrage monumental, il constitue un chef d'œuvre de l'hydraulique des crues dont la région du Tafilalet fut le berceau. Le barrage est en bon état de conservation et continue à jouer son rôle lors des

crues. Un dossier de classement au titre du patrimoine hydraulique national est nécessaire pour la sauvegarde et valorisation de ce monument.

Figure 6. Barrage d'Irara (archive M. El Faïz)

Les khettaras de Fezna (près d'Erfoud)

L'oasis de Fezna fut tributaire de 15 khettaras (galeries drainantes souterraines appelées ailleurs foggaras, aflaj, kahriz ou qanat), taries et abandonnées depuis longtemps. Ce qui est important dans ce site, c'est l'alignement impressionnant des puits des galeries souterraines qui témoigne à la fois de l'ingéniosité des bâtisseurs des khettaras et des leçons que l'humanité peut tirer de leur tragique assèchement.

Figure 7. Vue des khettaras asséchées de Fezna (archive M. El Faïz)

2.2 Les sites vivants, toujours utilisés ou partiellement réutilisés

L'oasis de Jorf : un patrimoine d'eau, de palmes et d'ingéniosité humaine

Le site de Jorf constitue l'exemple le plus représentatif d'oasis tributaire de khettaras dans toute la région de Tafilalet. Plusieurs galeries de captage et drainantes de l'eau exploitaient depuis des siècles l'aquifère. Ce qui est remarquable, c'est qu'en plus des réalisations techniques, nous trouvons encore vivantes les règles de l'organisation sociale de la gestion de l'eau, les savoir-faire, les coutumes et représentations sociales. L'organisation sociale chargée de l'édification du réseau, de son entretien, de la répartition de l'eau et du règlement des conflits est marquée par l'intervention du Cheikh (premier responsable) des khettaras. Ce dernier, aidé de Mezregs (collaborateurs) joue un rôle fondamental dans la gestion du réseau hydraulique. Il s'agit d'une gestion appuyée sur les principes de la législation islamique et des coutumes locales orientée vers la recherche du consensus et l'application de solutions négociées et solidaires. Les paysages culturels liés à l'eau conservent leur authenticité et font de cette commune un patrimoine d'eau, de palmes et d'ingéniosité humaine. La construction des premières khettaras remonte à la fin du XVIIe siècle.

Figure 8. Vue des cheikhs de khettara qui incarnent la gestion patrimoniale de l'eau (archive M. El Faïz)

Les jardins historiques de l'Agdal et de la Ménara à Marrakech : le miracle de l'eau en zone aride

L'Agdal et la Ménara constituent les « monuments verts » les plus importants du Maroc. Ils représentent du point de vue de l'histoire et de l'art des jardins un intérêt considérable. Construits au XIIe siècle, à la même période que la Koutoubia de Marrakech et la Giralda de Séville, ils constituent aujourd'hui les plus vieux jardins encore vivants du Monde Arabe. Tout le réseau hydraulique ancien, formé par des séguias et des khettaras, des aqueducs, des tours élévatrices de l'eau, des sahrij (réservoirs) monumentaux, des bassins de décantation, mérite d'être restauré. C'est ce patrimoine hydraulique qui constitue l'une des originalités de l'Agdal et de la Ménara. Ces deux jardins peuvent, de nos jours, constituer le plus grand musée vivant de l'eau et des techniques hydrauliques au Maroc et dans le Monde Arabe.

Figure 9. Vue de l'Agdal avec ses deux bassins (archive M. El Faïz)

Fès : son réseau hydraulique et ses fontaines : un « don » de la rivière des perles (oued al-jawâhir)

Fès constitue une véritable cité de l'eau dans la mesure où non seulement son développement, mais aussi sa création furent largement conditionnés par la maîtrise des phénomènes hydrauliques. Un réseau primaire formé par les grandes dérivations de l'Oued Fès, un réseau secondaire constitué par des canalisations en poterie (kawâdis) qui assurent la liaison entre les canaux principaux et les bâtiments et installations desservies, un réseau tertiaire composé de conduites de différents diamètres et assumant la double fonction de l'alimentation en eau potable et de l'assainissement aux échelons les plus élémentaires du maillage hydraulique (habitations, moulins, édifices religieux, bains publics, etc.), tels sont les caractères qui méritent sauvegarde et réhabilitation avec les restes de leur organisation sociale et humaine. Rappelons ici que Fès fut la première ville du Maroc a être classée au Patrimoine de l'humanité (en 1981 avec les critères (ii) et (v)). Cependant, le patrimoine hydraulique de la ville, malgré son importance, ne fut pas apprécié à sa juste valeur.

3 Documentation existante

3.1 Il n'y a pas à ma connaissance d'Inventaires du patrimoine culturel de l'eau, de cartographie récente ou de base de données fiable et accessible.

3.2 Les documents d'archives, cartographie et plans anciens, doivent exister mais éparpillés dans des bibliothèques, non catalogués ou ordonnés.

3.3 Des collections photographiques anciennes et récentes en relation avec le patrimoine culturel et naturel de l'eau doivent exister en partie à la Bibliothèque Nationale de Rabat et dans des fonds privés. Elles ne sont ni cataloguées, ni organisées pas thème et disponibles.

3.4 Fouilles archéologiques : les seuls exemples que nous connaissons concernent les sucreries du Maroc qui remontent aux années 1960. Aucune suite ne fut donnée à ce travail pionnier mené par Paul Berthier.
Les fouilles plus récentes concernent le système hydraulique de Tamesloht menées en 2002 par le ministère de la Culture. Mais les résultats ne furent pas publiés.

4 L'état de la connaissance historique et technique sur le patrimoine de l'eau

Il reste général et éparpillé dans des études académiques, des thèses et mémoires de master.

4.1 On peut trouver dans les Maîtres de l'eau (op.cit.) une périodisation du patrimoine hydraulique suivant les dynasties régnantes au Maroc. On note un enrichissement à l'époque almohade (XII-XIIIe siècles) et saâdienne (XVIe siècle) et des abandons au XIVe siècle et XIXe siècle.

4.2 Les recherches actuelles sont marquées par l'absence d'études archéologiques et d'inventaires spécifiquement consacrés au domaine du patrimoine culturel de l'eau. Les études historiques et académiques abordent cette question parmi d'autres sans approfondir le sujet ou proposer un état des lieux complet et satisfaisant.

5 Menaces s'exerçant sur le patrimoine de l'eau

Dans les villes, le patrimoine hydraulique est menacé par les extensions urbaines souvent anarchiques et peu soucieuses de la mémoire des lieux. L'exemple des jardins historiques de l'Agdal et la Ménara est édifiant à cet égard. Le spectacle « son et lumières » érigé à la Ménara en 2003 et abandonné depuis, la tranchée ouverte au sud de l'Agdal, l'urbanisation d'une partie de la zone tampon de l'Agdal extérieur, toutes ces opérations constituent des infractions à l'intégrité des paysages culturels de l'eau et menacent de les faire disparaître.

Les sites des sucreries sont soumis au pillage de leurs pierres par les chantiers de construction et l'infrastructure routière.

La surexploitation de la nappe phréatique constitue la menace la plus grave pour l'avenir de la technologie des galeries drainantes souterraines et risque à terme de les détruire.

6 Protection légale en vigueur

On peut relever pour le Maroc le paradoxe de la situation qui protège quelques fontaines urbaines au titre du patrimoine national alors que les khettaras ne disposent d'aucune législation protectrice. La même remarque est valable pour l'hydraulique des sucreries, les aqueducs et le reste des monuments de l'eau (séguias historiques, siphons, tours élévatrices de l'eau, etc.). L'absence de code du patrimoine, de loi sur le paysage, de zone de protection du patrimoine urbain architectural et paysager, constitue les grande lacunes au Maroc qui menacent de faire disparaître à plus ou moins longue échéance les patrimoines culturels de l'eau.

7 Conservation et gestion des patrimoines de l’eau

Absence de vision d’ensemble de la conservation des patrimoines culturels de l’eau et de leurs paysages caractéristiques.

Les sites archéologiques relèvent principalement du ministère de la Culture du Maroc. Ils n’ont pas de plan de gestion. Les sites vivants connaissent quant à eux plusieurs intervenants :
Ministère de la Culture ; Ministre déléguée auprès du Ministre de l’Energie, des Mines, de l’Eau et de l’Environnement chargée de l’Environnement ; Agence nationale pour le développement des zones oasiennes et de l’arganier ; Ministère de l’Habitat, de l’Urbanisme et de la Politique de la ville. Tous ces intervenants agissent sans coordination.

Les sites du patrimoine culturel de l’eau montrent tout le parti que les communes et certaines villes peuvent tirer de leur sauvegarde et valorisation dans la perspective du développement durable. En l’absence de législation protectrice de ce patrimoine spécifique, les sites concernés sont menacés de disparition à plus où moins longue échéance.

8 Conclusion

Le Maroc peut se prévaloir d’un patrimoine hydraulique des plus impressionnants dans la région du Monde Arabe. La présence d’un pouvoir central qui se renouvelle au cours des siècles et l’impact limité des guerres ont favorisé la conservation des héritages du passé. Mais l’absence d’un code de l’urbanisme qui puisse maîtriser l’évolution des villes et des campagnes, l’existence d’un lobby immobilier très fort, l’absence de code du patrimoine et de lois sur le paysage, tous ces éléments constituent les grands handicaps du Maroc et peuvent conduire à une issue tragique pour ses patrimoines (hydrauliques ou autres).

Les besoins pressants en termes de protection et conservation de l’héritage hydraulique consistent à doter le pays des codes dont nous avons parlé (urbanisme, patrimoine, paysage). Le Maroc dispose d’une loi de l’eau 10/1995 qui a pour objectif la gestion intégrée des ressources hydrauliques et leur protection. Il faut la rendre effective et instaurer des périmètres de protection sévère dans les sites où l’eau a une haute valeur patrimoniale.

Les recommandations qui me semblent essentielles pour l’ensemble des pays se trouvant dans des zones arides et semi arides, sont :

- Généralisation des lois de l’eau visant à protéger les eaux souterraines et instaurer une gestion participative et concertée des ressources hydrauliques ;
- Faire des études hydrogéologiques le préalable à toute proposition d’inscription ou classement au titre du patrimonial national ou mondial ;
- Imposer à la promotion immobilière publique ou privée la prise en considération du patrimoine des cultures de l’eau et l’intégration d’une clause de sauvegarde dans les zones soumises aux pressions immobilières ;
- Etant donné l’urgence de la situation et le risque de disparition du patrimoine des cultures de l’eau, un mémorandum doit être rédigé à l’intention de tous les ministères de la culture concernés pour les pousser à faire un inventaire urgent de leur patrimoine hydraulique et à renforcer les règles locales de protection en attendant la mise en œuvre des codes dont nous avons parlé.

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Etude de cas
Les jardins historiques de l'Agdal de Marrakech (1157-2014) : un conservatoire national du patrimoine hydraulique

L'Agdal est un jardin historique au sens où le définit la charte de Florence de 1982. Il est remarquable à la fois par son ancienneté, l'originalité de son style, la valeur inégalée au Maroc de son patrimoine hydraulique et l'intérêt de ses compositions végétales et paysagères. Crée en 1157, il a le même âge que la Koutoubia de Marrakech, la Tour Hassan de Rabat et la Giralda de Séville. Sur les 403 jardins historiques recensés dans le Monde Arabe, il est l'unique témoin du XIIe siècle.

La création de ce jardin s'est effectuée de manière progressive durant les règnes du calife Abd al-Mu'min (1133-1163) et de son fils Abû Ya'qûb Yûsuf (1163-1184). Outre les facteurs liés à la stabilité et à la richesse du jeune empire de la dynastie des Almohades, on peut relever le rôle joué par les architectes et les ingénieurs hydrauliciens dans la conception et la réalisation de ce modèle.

C'est l'intérêt de ce jardin et sa fonction de conservatoire national du patrimoine hydraulique qui m'ont déterminé à lui consacrer la plus grande partie de mes recherches (cf. Bibliographie). Grâce à ces travaux et à la collaboration de collègues de notre université et du ministère de la Culture, l'Agdal fut distingué par l'attribution du XIème Prix International Carlo Scarpa des Jardins (Trévise, Italie, mai 2000). L'action de la sensibilisation s'est prolongée par la création en 2005 de l'Association Ibn Al 'Awwâm pour la sauvegarde du patrimoine de l'eau, des jardins et des paysages et la réalisation de la première étude préalable à la sauvegarde et valorisation de l'Agdal (2008).

Toutes ces connaissances sont aujourd'hui nécessaires pour envisager la sauvegarde du patrimoine hydraulique de l'Agdal et sa valorisation dans la perspective d'un développement durable.

Le patrimoine hydraulique de l'Agdal comporte les éléments suivants :

1 La séguia Tasoultant (canal royal) construite au XIIe siècle sur une distance de 25 km. Elle comporte des ouvrages de franchissement (aqueducs, siphons) et des équipements industriels (moulins à eau) qui méritent d'être entretenus et restaurés.
2 Cinq khettaras (Ayn Dar, lalla chafia, Zemzamia, Berda jdida, Berda Kdima) ou galeries drainantes qui constituent des exemples du génie des eaux souterraines.
3 L'art des saharij (bassins) constitue une des grandes originalités de l'Agdal. Les grands bassins et les petits (chouirjat), les fontaines et les vasques, tous ces monuments érigés à la gloire de l'eau, varient à l'infini les paysages de ce jardin construit à l'échelle de la ville. Outre ces éléments fondamentaux, qui ont très peu varié au cours du temps, l'Agdal nous a conservé les techniques d'irrigation et les pratiques de jardinage héritées du Moyen-Age arabe.

Le bassin de Dar Al Hana et celui d'AL Gharsia qui emmagasinent dans leurs réservoirs près de 160000 m3 d'eau doivent bénéficier d'une action prioritaire pour les entretenir et les sauvegarder en tant que monuments de l'eau.

En plus des répartiteurs de l'eau (ma'ida), qui sont des monuments de l'architecture hydraulique, l'Agdal dispose d'un grand canal de décantation des eaux et de moulins qui constituent les éléments du patrimoine industriel du Maroc.

Figure10. Le bassin de décantation des eaux de l'Agdal (archive M. El Faïz)

Nos travaux ont montré combien la longue histoire de l'Agdal fut tributaire de la maîtrise des techniques hydrauliques. C'est grâce à la mobilisation des eaux de surface (séguias) et des eaux souterraines (khettara) que la création des enclos jardinés fut possible dans le milieu aride et semi aride de Marrakech. Dans cette histoire nous devons rappeler le souvenir des ingénieurs hydrauliciens, tél Al Haj Ya'ish de Malaga, qui furent les bâtisseurs oubliés de cette hydraulique des Empires.

Le patrimoine culturel de l'eau en Mauritanie

Mohamed Mahmoud Mohamed Ahmed Yehdhih et Assane Gaye

1 Caractéristiques générales de la Mauritanie

La République islamique de Mauritanie est située en Afrique de l'Ouest entre le 15e et le 17e degré de latitude Nord et le 5e et 7e degré de longitude Ouest, avec une superficie de 1 030 700 km^2. Le pays est limité au nord-ouest par le Royaume du Maroc, au nord par l'Algérie, à l'est et au sud-est par le Mali et au sud-ouest par le Sénégal et s'ouvre à l'Ouest sur une façade atlantique de plus de 700 km.

Figure 1. Carte de situation de la Mauritanie (ISESCO / SMRRC : Plan d'action dans le contexte du Post-HFA 2015, mars 2014)

Le climat, saharien au nord et sahélien au sud, est généralement chaud et sec. Les maxima dépassent 44°C en mai-juin, et les minima peuvent descendre jusqu'à 10°C en janvier et février. Les vents, à dominance nord-est, sont très fréquents et favorisent la progression de l'ensablement. La saison des pluies, qui conditionne en grande partie la production agropastorale, est très irrégulière dans le temps et l'espace.

1.1 Climat et hydrologie

La Mauritanie se divise en quatre régions naturelles :

- La région centrale est parsemée de plateaux escarpés : à l'est s'ouvrent de larges cuvettes dunaires ;
- Le fleuve Sénégal a creusé une vallée le long de la frontière sud du pays ;
- L'est est constitué de zones de pâturage, alors que le sud constitue la zone agricole grâce aux alluvions du fleuve Sénégal ;
- La majorité du territoire se trouve dans le désert du Sahara avec des plaines et des reliefs peu accidentés avec quelques regs (roches). Pourtant au Nord, il existe de hauts plateaux

avec un sommet à 915 m d'altitude : Le mont Kedia d'Idjil. Dans le centre du pays, la cuvette du Hodh est bordée au sud-est par des plateaux gréseux (Adrar, Tagant). La façade maritime a une longue bande de dunes de sable.

Climat

Le climat de Mauritanie est régi par trois centres d'action (Diagana M. Y., 1998) :

- L'anticyclone des Açores, centré au sud-ouest de l'archipel des Açores;
- L'alizé maritime issu de cet anticyclone souffle de manière permanente sur le littoral mauritanien de direction nord, nord-ouest ;
- L'anticyclone de Sainte Hélène ou mousson : centré sur l'Atlantique Sud, il souffle de direction sud ou sud-ouest. Il est responsable des pluies estivales.

L'action de ces différents courants d'air engendre une grande variabilité annuelle des précipitations.

La saison des pluies est très hétérogène dans le temps et dans l'espace. Elle s'étend sur une période de quatre mois, de juin à septembre, selon un gradient nord-sud et ouest-est de quelques millimètres à 450 mm/an. La variabilité interannuelle des pluies est d'autant plus forte que les pluies sont peu abondantes (Nation Unies 2001).

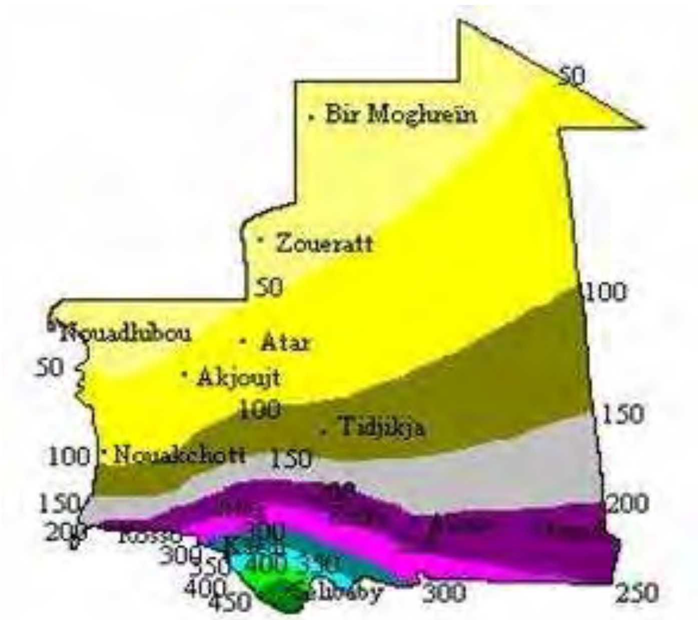

Figure 2. Répartition spatiale des précipitations (ISESCO / SMRRC : Plan d'action dans le contexte du Post-HFA 2015, mars 2014)

La Mauritanie est habituellement divisée en quatre zones écologiques :

- La zone aride ou saharienne correspond à la façade maritime et couvre 75 % de la superficie du pays. Elle demeure exposée à l'ensablement et à l'érosion hydrique ;
- La zone sahélienne se trouve entre les isohyètes 200 et 400 mm et couvre 16 % de la superficie du pays. C'est une zone essentiellement sylvo-pastorale avec néanmoins une activité croissante de cultures derrière barrages ;
- La zone du fleuve couvre 2% de la superficie du territoire et elle est le siège traditionnel d'activités agro-sylvo-pastorales du pays ;
- La façade maritime s'étend sur une superficie de 25 000 km^2 et de 50 km de large. Elle abrite deux parcs naturels: le Banc d'Arguin et le Diawling.

Figure 3. Carte de localisation des zones écologiques en Mauritanie (ISESCO / SMRRC : Plan d'action dans le contexte du Post-HFA 2015, mars 2014)

Hydrologie

La Mauritanie recèle près de 320 zones humides continentales d'environ 320 000 ha, principalement localisées dans les parties sud et sud-est du pays. Il s'agit le plus souvent de zones inondées d'eau douce, situées en domaines alluvial ou lacustre, quelques fois palustres, à caractère permanent ou temporaire (Grezoh, 2002).

Le pays recèle également d'importantes ressources en eau souterraine, caractérisées toutefois par de grandes disparités géographiques. Le contexte apparaît favorable dans le sud-ouest, le sud et le sud-est et moins favorable dans le reste du pays.

La mise en œuvre de cette eau souterraine est confrontée au problème de la répartition géographique : certains des aquifères les plus importants se trouvent dans les zones désertiques éloignées des centres urbains.

Le réseau hydrographique de surface est peu développé et est constitué essentiellement par le fleuve Sénégal et les 405 retenues d'eau (barrages et digues) qui constituent la principale possibilité de mobilisation des eaux de surface temporaires.
La gestion du fleuve, ressource partagée entre le Mali, la Mauritanie et le Sénégal, est accordée à l'Organisation de Mise en Valeur du fleuve Sénégal (OMVS).

1.2 Relations culturelles et échanges techniques avec les zones voisines

L'histoire des sites du patrimoine culturel de l'eau en Mauritanie est intimement liée à celle de l'espace urbain traditionnel, inscrit dans celui des oasis et de la vie des nomades éleveurs de Mauritanie.

L'économie traditionnelle, essentiellement pastorale, était fondée sur une double complémentarité : élevage-agriculture, campement-cité car le pasteur nomade avait également besoin du commerçant citadin et du paysan qui le nourrissait de son mil et de son sorgho.

Ainsi, les antiques cités, Chinguetti, Ouadane, Tichitt et Oualataqui ont été pendant des siècles des foyers de rayonnement culturel et spirituel à travers lesquels des échanges multiformes se sont développés. Ce sont à la fois des oasis et des étapes obligées sur les longues pistes caravanières qui relient le Soudan au Maghreb.

Les « Anciens *ksour* de Ouadane, Chinguetti, Tichitt et Oualata » ont été classés par le Comité du patrimoine mondial de l'UNESCO comme patrimoine culturel de l'humanité en 1996 (critères (iii) (iv) (v)). Ces cités appartiennent à l'ancienne Afrique des cités commerçantes et savantes implantées sur les pourtours du Sahara, à des époques où le commerce transsaharien irrigue le continent africain.

Elles ont été des villes très actives qui ont fondé leur accumulation historique (accumulation de savoir, de richesses monétaires, de constructions et d'ouvrages urbains) sur des flux internationaux auxquels elles offraient en retour la vente de services (soins sanitaires, hébergement, services intellectuels, sécurité, réconfort, gardiennage des denrées, courtage, groupage, services bancaires, etc.) de fournitures indispensables (vivres, animaux de charge, eau, etc.) ou de force de travail. Il arrivait que certaines cités produisent certaines denrées, et font extraire le sel dont elles chargeaient leurs propres caravanes participant ainsi au grand commerce saharien (par opposition au petit commerce local).

2 Sites culturel de l'eau

Ce sont essentiellement des sites de points d'eau naturels ou façonnés par l'homme tel que puits et autres creusés et exploités autrefois avec des moyens d'exhaure traditionnels liés à l'histoire de l'usage de l'eau pratiqué dans les cités anciennes et le milieu nomade. C'est ainsi que l'eau est levée dans le delou soit à bras d'homme, ou par traction animale au moyen d'une poulie ou d'un shadouf de contrepoids surtout dans les oasis.

2.1 Les principaux sites importants du patrimoine culturel de l'eau en Mauritanie.

Les sites situés dans les quatre cités anciennes sont essentiellement des puits:

Puits de Oualata

Autrefois appelée Birou (mot soninké signifiant «puits»), Oualata était une ville saturée de puits. Chaque maison, dit-on, avait son propre puits. Et selon une tradition locale, il y aurait eu jusqu'à 150 puits disséminés dans la Batha de Birou.

De ce patrimoine «puisatier», il ne reste aujourd'hui que neuf puits dans la Batha et le puits central de la ville historique. Ce dernier, appelé Bir M'bouyé foré en 1845 (année de la soif), est actuellement utilisé par certains pour enfouir les déchets, bien qu'il ait bénéficié de certaines tentatives de réhabilitation dans le cadre de la mise en valeur du patrimoine culturel de la ville ancienne, parfois maladroites et non entretenues sur le plan patrimonial. Les autres puits, d'une profondeur pouvant aller jusqu'à plus de 30 mètres, servent pour l'essentiel au bétail après assèchement des eaux de surface retenues par le barrage.

Le potentiel hydraulique de Oualata

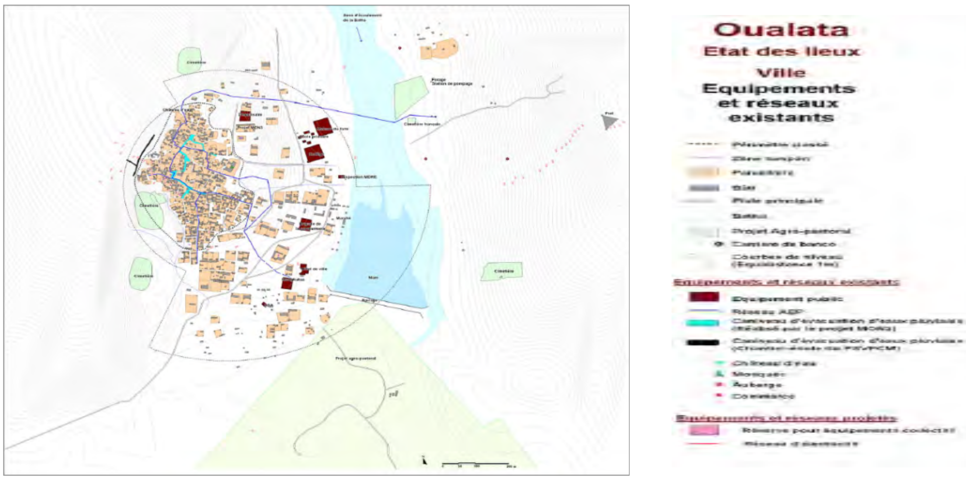

Figure 4. Plan de situation de Oualata (Projet Sauvegarde et Valorisation du Patrimoine Culturel Mauritanien rapport général, mars 2005)

Les eaux de surface

Situé sur un versant ressemblant à un cratère, Oualata présente un réseau hydrographique simple : les eaux sont drainées au fond du vallon par un cours d'eau unique collectant les ruissellements. Sur les versants, les écoulements peuvent être violents, du fait des pentes abruptes et de la nature rocheuse du terrain. Ce qui présente l'avantage de limiter le temps de filtration des eaux et d'augmenter les volumes ruisselés, mais aussi l'inconvénient, par rapport à l'infrastructure urbaine et les ouvrages de retenue d'eau, d'une intense activité érosive.

Les eaux souterraines

Fortement influencées par les écoulements de l'unique cours d'eau et des recharges obtenues par le barrage, les eaux souterraines de Oualata sont emmagasinées dans une nappe phréatique et un réseau de failles géologiques. Ce qui révèle à la fois le caractère saisonnier et discontinu des capacités de cette ressource renouvelable.

Puits de Ouadane

Le système d'exploitation d'eau à Ouadane était basé autrefois sur les puits dont on peut citer, le puits fortifié de Garn El Kasba situé dans la Batha, à une vingtaine de mètres de la muraille, et est relié à la ville par un corridor fortifié. Au droit de ce puits, deux maisons de surveillance, desservies par l'une des principales artères de l'ancienne cité qui permettaient de contrôler les allées et venues dans la cité.

Le potentiel hydraulique de Ouadane

Les eaux de surface

Les eaux de l'oued de Ouadane, passant au pied de la falaise, débouchent dans une cuvette, cultivable en décrue, située à une quinzaine de kilomètres de la ville.

Les eaux souterraines

Les eaux souterraines sont constituées par la nappe phréatique alimentée par l'oued de Ouadane et par un réseau de failles dans le socle gréseux. Bien qu'estimées « importantes », les ressources en eau ont fortement diminué ces trente dernières années du fait de la sécheresse.

Figure 5. Plan de situation de Ouadane (Projet Sauvegarde et Valorisation du Patrimoine Culturel Mauritanien rapport général, mars 2005)

Puits de Tichitt
Un réseau de puits dans la palmeraie capte la nappe phréatique pour l'irrigation et parfois l'alimentation en eau potable. Situés dans la Sebkha, deux puits captent une nappe saumâtre servant à l'alimentation du bétail, en particulier les nombreux troupeaux camelins qui viennent «pâturer» la saline.

Puits de Chinguetti
Avant l'aménagement du premier réseau de Chinguetti, dans les années 1970, l'exploitation des eaux était basée sur les puits et puisards. Ce qui permettait à la fois de répondre aux besoins de consommation humaine et d'arrosage d'appoint aux palmiers. L'essentiel des puits est disséminé le long de l'oued, et encore, aujourd'hui certains de ces puits sont exploités.

Sites du Parc National du Banc d'Arguin
Le parc national du Banc d'Arguin (PNBA), site inscrit sur la Liste du patrimoine mondial naturel de l'UNESCO, longe le littoral atlantique mauritanien sur 180 km et couvre une superficie de 12 000 km^2, répartie entre un domaine maritime et un domaine terrestre. Ce dernier appartient au Tasiast, secteur à vocation pastorale qui a longtemps constitué une étape importante des parcours pastoraux camelins en Mauritanie. Mais la sécheresse survenue a entraîné une irrégularité des parcours et une désaffection de ce territoire par une grande partie des pasteurs nomades et leurs troupeaux.

Les Puits du PNBA
Le parc national du Banc d'Arguin (PNBA) et ses environs immédiats offraient plusieurs *oglats* (trou d'eau temporaire creusé généralement en hivernage dans la terre ou le sable jusqu'à atteindre la nappe) et neuf puits (*hassi*). Ces puits, autrefois peu profonds, contenaient de l'eau douce et de l'eau saumâtre permettant un abreuvement rapide des animaux.

Avec la sécheresse, plus de la moitié des puits ont tari, et pour le reste, l'eau est devenue salée. Seuls trois puits étaient opérationnels en 2002, avec un faible débit et une grande profondeur (40 à 60 m). La fréquence actuelle des abreuvements des dromadaires est variable en fonction des saisons.

Moyens d'exhaure

L'eau est levée à bras d'homme ou par traction animale au moyen d'une poulie et d'un *delou* (outre) de 20 à 30 litres (Figure 4). En saison sèche chaude (*saïf*), avec la forte densité de bétail aux alentours des puits, les jours de grande affluence, beaucoup de troupeaux sont contraints d'attendre leur tour loin du puits. Pendant cette saison, pour éviter les heures d'attente aux puits et les longues journées de marche, certains pasteurs nomades laissent leurs dromadaires en libre pâture non loin de leur campement situé à proximité des puits, puisque leurs animaux ont l'habitude de revenir toujours au même puits.

Figure 6. Exhaure de l'eau à bras d'homme à l'aide d'une poulie avec un delou (outre) au puits de Bouir-Ed-déri Parc National du Banc d'Arguin (Sécheresse, 2008, Volume 19, Numéro 4)

Le paysage de l'eau dans les zones humides

Les zones humides font partie intégrante du paysage de l'eau en Mauritanie bien qu'elles soient généralement très peu connues. L'Est mauritanien dont la pluviométrie est plus ou moins importante, combine des conditions environnementales et sociales qui font des zones humides des ressources uniques, hautement diversifiées, multifonctionnelles mais vulnérables. Elles fournissent des ressources naturelles aux populations sédentaires et nomades, et possèdent également des fonctions vitales en termes de maintien de la biodiversité.

Ces îlots, qui constituent une grande valeur écologique mais également un potentiel économique et hydrique important, sont extrêmement diversifiés du point de vue de leurs caractéristiques physiques et de leurs usages, ainsi que du point de vue de la flore et la faune qu'elles hébergent.

Une prospection des zones humides réalisé par la Deutsche Gesellschaft für Internationale Zusammenarbeit (GTZ) en 2001 a permis de répertorier 244 sites dans l'Est mauritanien : 64 en Assaba, 151 dans le Hodh El Gharbi et 29 dans le Hodh Ech Chargui.

Figure 7. Vue plongeante sur une tamourt dans le Hod Ech Chargui (Rapport zones humides dans le Hodh El Gharbi mauritanien, février 2007)

Figure 8. Puits traditionnel sur une tamourt (Rapport zones humides dans le Hodh El Gharbi mauritanien, février 2007)

2.2 Les sites vivants, toujours utilisés ou partiellement utilisés

Site des oasis

En Mauritanie l'activité oasienne continue à s'exercer pour les besoins de l'agriculture maraichère sous palmiers et de la Guetna, saison de la cueillette des dattes où les Mauritaniens font des cures de repos, de loisirs. Cette période s'étend de fin juin à fin août de chaque année.
Les Mauritaniens entretiennent une longue histoire avec leurs palmiers dattiers. Conjuguant l'image des nuits calmes du désert, des douces brises, de la fraîcheur de l'air et des étoiles brillantes, les dattes et la Guetna ont été célébrées dans la littérature mauritanienne depuis des décennies. Les jeunes générations s'intéressent également à la dimension culturelle, économique et sociale de cette tradition.

Les puits en zones oasiennes

Dans les zones oasiennes arides en Mauritanie, les eaux de surfaces étant incertaines et rares, la seule ressource est l'eau souterraine. Celle-ci se présente en deux catégories : les nappes phréatiques inter dunaires et les nappes profondes. Les premières sont exploitées à l'aide de puits et les secondes requièrent la réalisation de forages.

Types de puits

C'est dans la région de l'Adrar qu'on rencontre des ouvrages de qualité, construits essentiellement en pierres taillées ou en cuvelage en béton armé, avec un grand réservoir d'eau. Dans le Tagant et les Hodhs, les puits sont aussi en pierres, mais de plus petits diamètres en général. Dans l'Assaba, la moitié des périmètres ne possèdent que des puisards en branchage.

Figure 9. Photo de puits en pierre taillée en Adrar (http://www.lestoilesmaures.net/sous-le-soleil
-des-perles-de-pluie.html)

Les moyens d'exhaure dans les oasis

L'exhaure traditionnelle au shadouf, qui est en voie de disparition dans l'Adrar, est pratiquée couramment dans les régions du Tagant, les Hodhs et l'Assaba. On s'en sert principalement pour arroser les palmiers. Elle consiste à puiser l'eau grâce à un pivot muni d'un contrepoids.

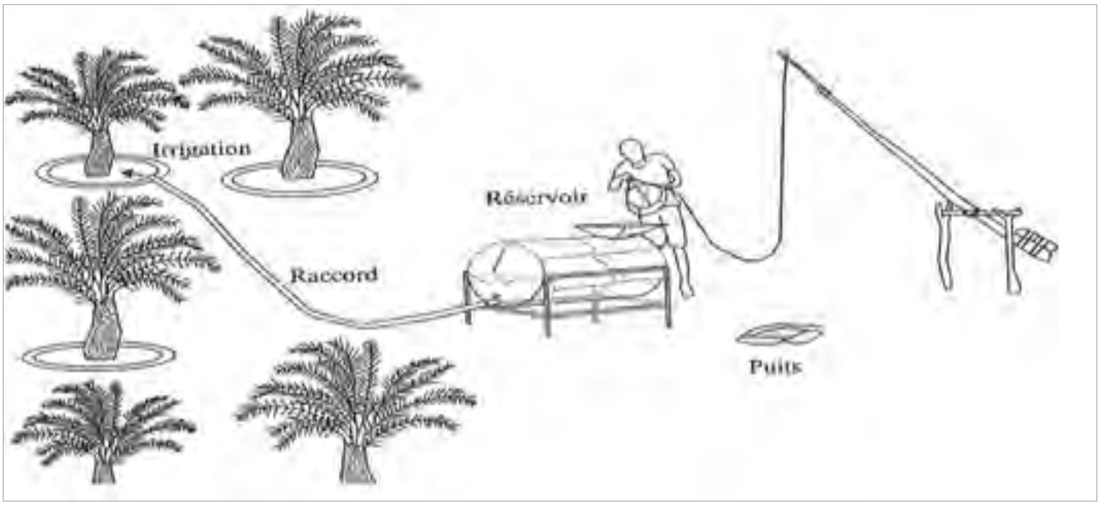

Figure 9. Schéma d'un système d'irrigation traditionnel amélioré avec shadouf (rapport Seyfoullah EL Abass / projet oasis, octobre 2009)

Figure 10. Système d'exhaure au shadouf dans une Oasis de Chinguitti (http://issanlat.free.fr/mauritanie.htm)

Site de l'oasis de Terjit

« C'est une espèce de grotte béante, ouverte au beau milieu d'un vallon, couverte par des stalactites vertes et où coule une eau pure, intarissable. Elle coule doucereusement de la montagne. Terjit est un petit miracle au beau milieu d'un désert pierreux. Le climat y est doux en toute saison et les effluves du ruisseau y caressent la vue et tempèrent les sens». (http://www.idoumou.com/la-guetna-en-adrar, 2012).

Figure 11. Oasis de Terjit (http://www.panoramio.com/user/782549/tags/Mauritanie)

Figure 12. Versant de la source de Terjit (www.Wikipedia.org)

Régime hydrique des zones humides et dynamique

La majorité des zones humides de l'Est et du Sud-Est Mauritanien correspondent à des systèmes hydrographiques fermés endoréiques, c'est-à-dire qu'elles constituent le point final de l'écoulement et du ruissellement de l'eau de surface : l'eau s'écoule dans les oueds situés dans le bassin versant de la zone humide, et est ensuite bloquée par un cordon dunaire pour finalement aboutir dans des mares ou des lacs fermés.

La différence entre les apports et les pertes d'eau détermine la taille, la profondeur et la permanence de la zone humide. L'alimentation en eau des zones humides se fait par les précipitations, les flux de surface et les flux souterrains. L'intensité des pluies et la capacité d'infiltration du sol déterminent l'équilibre entre ces deux flux. Les pentes douces, les sols perméables et le couvert végétal augmentent l'infiltration et réduisent donc le ruissellement et les flux de surface.

Les sorties d'eau se font par évapotranspiration, évaporation, infiltration et consommation. Les zones humides ouvertes telles que les oueds perdent aussi leurs eaux par écoulement au profit de zones en système fermé. En climat aride, l'évaporation est la principale perte d'eau : elle est colossale en saison sèche, en particulier sous l'effet du vent. Elle varie saisonnièrement selon la couverture végétale. La consommation par les animaux, pour l'usage domestique et pour l'irrigation est négligeable comparée aux apports d'eau.

L'extraction d'eau en zone humide

L'eau est extraite des zones humides pour l'abreuvement des animaux, la consommation humaine, les usages domestiques et l'irrigation des jardins potagers. L'extraction due à ces activités est négligeable par rapport au volume d'eau total, mais peut devenir plus importante durant les années de sécheresse. L'extraction à grande échelle de l'eau en provenance des zones humides pour la construction de routes et d'autres infrastructures ont des effets mitigés.

2.3 Les paysages culturels liés à l'eau

La ville est souvent implantée face au désert mais au beau milieu d'un terroir agricole et d'élevage prospère ou qui a été prospère. Ces grands sites sont la première richesse patrimoniale de ces villes anciennes.

Dans le passé, les ressources hydrauliques des cités anciennes étaient constituées de réseaux de cours d'eau développés et pérennes qui permettaient une intense activité agricole, des puisards de faible profondeur creusés dans l'affluent des oueds et des puits creusés dans le rocher qui servait à l'alimentation en eau potable surtout en période de soudure en été.

De ces infrastructures hydrauliques et archéologiques, il ne reste que quelques vestiges dans les cités anciennes à savoir le puits fortifié de Garn El Kasba de la ville de Ouadane situé dans la Batha, qui est relié à la ville par un corridor fortifié et le puits (Bir) M'bouyé à Oualata.

Figure 13. Muraille et puits fortifié (Projet Sauvegarde et Valorisation du Patrimoine Culturel Mauritanien, rapport général mars 2005)

Le premier est entouré d'un corridor fortifié assurant sa protection alors que le second le Bir de M'bouyé à Oualata ne jouit d'aucune protection et est menacé de destruction complète.

3 Documentation existante

L'inventaire exhaustif du patrimoine culturel de l'eau n'a jamais était réalisé dans le pays. Et aucune base de données ni cartographique récente n'est disponible. Cependant on note à côté des puits situés dans les villes anciennes et la zone côtière (Banc d' Arguin), l'existence des sources d'eau au niveau des oasis de l'Adrar et du Tagant ainsi que dans les zones humides du Sud-Est du pays. Quelques manuscrits anciens mentionnent les usages de l'eau par les populations urbaines ou nomades.

4 L'état de la connaissance historique et technique sur le patrimoine de l'eau en Mauritanie

Il faut partager la vie des nomades pour prendre conscience d'une vérité première : l'eau que les *Regueibat* du Grand Nord mauritanien appellent *rahma*, la miséricorde de Dieu, est l'élément structurant fondamental de l'espace nomade.

Les puits sont donc creusés soit au pied des versants de roches tendres et des éboulis, soit dans les couloirs inter-dunaires, soit le plus souvent le long des oueds. Il convient de distinguer le puisard (*ogol*, pl. *oglat*) de faible profondeur vite creusé pour un stationnement bref, et le puits (*bir*, pl. *ebyar*) profond de plus de 10 m qu'il faut donc coffrer avec des fascines ou des pierres pour éviter les éboulements et qui est le point de convergence des troupeaux. « L'ancienneté, attestée par les traditions, de nombreux puits coffrés, leur localisation dans des régions dépourvues de nos jours d'un écoulement saisonnier incitent à penser qu'ils ont été creusés à une époque moins aride, au cours de laquelle le niveau piézométrique était plus élevé qu'actuellement et surtout un niveau superficiel saisonnier pouvait guider le choix des sites à forer » (Charles Toupet, 1983).

Le problème de l'exhaure est fondamental. Le récipient utilisé est le *delou* fabriqué dans une peau de chèvre et dont l'ouverture est maintenue par un cercle de fer. Sur les puisards, le puisage est effectué uniquement par les hommes. Sur les puits profonds équipés de poulies taillées dans le *Balanites aegyptiaca*, l'exhaure est assurée par la traction animale : bœufs, ânes ou chameaux.

Les Mauritaniens ont su étendre, dans des limites resserrées, cet espace restreint : dans le domaine de la culture sous pluie en établissant leurs champs dans des cuvettes au pied des versants afin de les faire bénéficier du ruissellement; dans le domaine de la culture de décrue, en construisant des barrages.

Il convient de faire une place à part aux oasis où, à l'ombre des palmiers-dattiers, de petits carrés formant une mosaïque colorée sont intensivement jardinés : blé et orge l'hiver, mil l'été, légumes et fourrages en toutes saisons. Les rigoles creusées à la houe, qui entourent ces planches de cultures, sont irriguées par gravité à partir d'un bassin (*hodh*) qui alimente un puits à balancier (*achilal* ou shadouf) creusé dans la nappe alluviale. Il est à noter, en effet que la majorité des palmeraies mauritaniennes sont situées le long des oueds.

Dans l'espace urbain traditionnel, les ressources en eau ont joué un grand rôle dans le développement historique des cités archéologique du pays qui constituait des centres culturels et de commerce transsahariens importants.

Ainsi, au niveau de Ouadane les ressources d'eau de surface permettaient aux populations *Bafour,* ancien peuple de la cité, de mener des activités agricoles. Le puits fortifié de *Garn El Kasba,* de la ville de Ouadane situé dans la *Batha,* est relié à la ville par un corridor fortifié qui jouissait d'un contrôle strict de la part des responsables de la ville.

Au niveau de Oualata, les ressources en eau constituaient un enjeu capital pour le développement de la cité. Autrefois appelée *Birou* (mot soninké signifiant «puits»), Oualata était une ville de puits. Ces derniers sont construits dans des rochers ce qui leur ont permis de résister aux intempéries.

4.1 Périodisation du rapport de l'homme à l'eau

L'on sait que la faiblesse des pluies, leur extrême irrégularité et la précarité des pâturages dans les zones semi-arides contraignent les éleveurs à effectuer des migrations pastorales. Les citernes naturelles sont exceptionnelles et le plus souvent temporaires : mares égrenées le long des *oueds*, *gueltas* tapies au pied des escarpements. Il lui faut donc, pour conduire son troupeau vers les pâturages que la pluie aura fécondés, observer avec vigilance l'état du ciel et interpréter comme autant de signes indicatifs la saute de vent, la baisse de température, l'apparition attendue du premier nuage. Il lui faut aussi jalonner son itinéraire de points d'eau : une longue expérience transmise de père en fils et consignée dans les chroniques tribales lui permettra de choisir les lieux de puisage les plus sûrs en fonction de la topographie, de la nature de la roche, de la répartition de la couverture végétale et du comportement des animaux sauvages. Un vieux proverbe malicieux rappelle que sept éléments sont nécessaires à l'établissement d'un campement *émiral* : un *mallem* (forgeron), un médecin, un enseignant, un *qadi* (juge), un puisatier, un pâtre et, en dernier lieu, un *émir* (chef de tribu guerrière).

Une brève description de l'économie de l'eau dans la société traditionnelle Mauritanienne de l'époque, montre qu'elle était caractérisée par les principaux aspects suivants :

L'aspect primordial était que les hommes exerçaient une pression faible sur un milieu naturel fragile et qu'ils ne portaient donc pas atteinte aux réserves en eau. Cela est évident pour les nomades, du fait de leurs déplacements continuels mais ce l'est aussi pour les citadins car les villes, peu nombreuses et peu importantes, à l'époque voyaient leur population varier souvent au cours de l'année tant les échanges ville-campagne étaient fréquents. Le second aspect, qui était lié au premier, était une exploitation parcimonieuse de l'eau. La distanciation entre le point d'eau et l'habitat, qu'il s'agissait du campement ou de la maison urbaine, était un phénomène constant.

Les raisons qui tenaient à la sécurité, à la salubrité, à la commodité, étaient nombreuses et elles entraînaient inexorablement une économie de consommation. Il faut ajouter que le citadin ne se distinguait pas du nomade par son niveau de vie; il était également frugal. Un troisième trait concernait le régime juridique. On sait que le droit musulman fonde la propriété sur l'effort : le puits appartenait donc à la tribu de celui qui l'a creusé. En général le droit de puisage était accordé gracieusement aux autres tribus qui en faisaient la demande, mais en période de sécheresse, des conflits surgissaient. Il y avait d'autres sources de contestation qui peuvent dégénérer en échauffourées sanglantes : utilisation d'un même point d'eau par des éleveurs et des cultivateurs ; établissement de plusieurs barrages sur le cours d'un même oued, le remplissage du barrage amont se faisant au détriment de l'alimentation du barrage aval. Le dernier aspect était le rôle fondamental que les esclaves et les affranchis jouaient dans l'exhaure de l'eau : c'était là un trait majeur qui reliait la société maure traditionnelle à toutes les sociétés méditerranéennes et orientales héritières à la fois des traditions gréco-romaines et arabes (Charles Toupet, 1983).

4.2 Etat des recherches actuelles

Il n'existe pas de recherche spécifique au thème patrimoine culturel de l'eau en Mauritanie.
Cependant, nous pouvons signaler plusieurs études réalisées dans le cadre général du patrimoine culturel de la Mauritanie qui font mention souvent des sites culturels de l'eau.
Plus spécifiquement, au début des années 2000, sur la base d'un cofinancement de l'Etat Mauritanien et de la Banque Mondiale, est mis sur pied le « Projet Pilote de Sauvegarde et Développement des villes du Patrimoine Mondial de Mauritanie» placé sous la responsabilité de l'Autorité «Programme Sauvegarde Valorisation du Patrimoine Culturel Mauritanien» (PSVPCM).
Les objectifs du projet sont de déterminer l'état des lieux des villes anciennes à savoir, (i) Les méthodes de sauvegarde et développement de ces cités, (ii) Le cadre institutionnel et juridique adéquat pour la sauvegarde et développement de ces cités.

5 Menaces s'exerçant sur le patrimoine de l'eau

Située en zone saharo-sahélienne, la Mauritanie se caractérise par la faiblesse de ses ressources hydriques, qu'il s'agisse des eaux souterraines ou des eaux de surface. La vague de sécheresse du début des années 1980 a profondément ébranlé la société traditionnelle fondée sur le pastoralisme et la culture du palmier dattier dans les oasis. Le développement du maraîchage a été fortement encouragé par l'Etat mauritanien afin de procurer aux anciens éleveurs un moyen de subsistance, et ainsi les maintenir dans les territoires de l'intérieur. Cela a entraîné d'importants programmes de pompage.

Les menaces anthropiques

En milieu oasien le développement du maraîchage, dans un contexte de raréfaction de la ressource en eau, n'a pu se faire que grâce à la substitution de l'exhaure traditionnelle (*shadouf*) par des motopompes, dans les années 1970. Ces motopompes, de débit important (environ 40 m3/heure), ont procuré aux maraîchers d'importantes quantités d'eau, en dépit de l'augmentation sensible des surfaces cultivées, mais au prix de graves perturbations pour l'environnement hydrogéologique de certaines oasis.

L'effet conjugué de la vague de sécheresse du début des années 1980 et la surexploitation de la ressource, au moyen de motopompes à haut débit, met en péril le développement des oasis notamment dans les régions du nord Mauritanien où la ressource est déjà rare.

En zone humide, le développement accéléré de l'agriculture peut altérer et détruire les écosystèmes. L'expansion de cette activité implique le défrichement de la végétation naturelle de ces zones fragiles pour la mise en culture des terres. En même temps, si des barrages sont construits à des fins agricoles en amont des zones humides, la dynamique hydrologique est complètement perturbée : l'eau est déviée, ce qui empêche le remplissage de la zone. L'expansion de l'agriculture de décrue par le captage de l'eau des zones humides a pour conséquence une capacité de stockage réduite et une diminution de la recharge souterraine.

Le pâturage et l'abreuvement des animaux constituent un usage fréquent dans les zones humides de l'Est mauritanien.

Elles constituent aussi des endroits idéaux pour s'installer, du fait de leur richesse en ressources pastorales et botaniques et de la présence de terres fertiles pour l'agriculture. L'intensification des pressions humaines sur les zones humides, conséquence de la sédentarisation, entraîne la dégradation de l'environnement des ressources.

Les menaces naturelles

Certains sites connaissent une intense activité érosive d'origine éolienne, qui contribue à ensabler de nombreux puits, sites oasiens et zones humides. Aujourd'hui, certains sites sont entièrement ensevelis par le sable. Outre cette implication sur les sites, l'ensablement modifie continuellement les axes naturels d'écoulements d'eau et provoque le tarissement des puits et l'assèchement de certaines mares des zones humides.

De par leurs situations géographiques, les villes anciennes sont soumises à l'action des vents qui génèrent un ensablement touchant les sites d'eau. L'origine de l'ensablement provient de la Majabat El Koubra et Lemreyé en passant par le plateau pour se déposer sur certains endroits. Ceci est visible au Sud du périmètre maraîcher de Oualata, où on observe des cordons dunaires pour l'instant de tailles inférieures à ceux observés à Tichitt et Chinguetti. Ils sont généralement orientés est - ouest.

La ville de Oualata est exposée à l'ensablement dans toutes ses parties. Mais sa partie Nord-Est est spécialement ensablée au point de gêner la circulation et de menacer la stabilité des bâtiments. On passe d'une érosion en nappe à des dunes à crêtes bien marquées. La hauteur des dunes varie entre 0.5 et 1.5 m.

6 Protection légale en vigueur

Sites logés dans les villes anciennes :
Ses sites doivent bénéficier de la protection légale du patrimoine des villes anciennes ainsi libellée :

- En 1989 les sites du patrimoine de l'eau situés dans le Parc National du Banc d'Arguin, sont inscrits sur la Liste du patrimoine mondial. Les puits installés au Parc National du Banc d'Arguin font partie du patrimoine de ce Parc et bénéficient de son statut de protection ;
- En 1993, la création de la Fondation Nationale pour la Sauvegarde des Villes Anciennes (FNSVA), établissement public chargé de piloter la campagne de sauvegarde et de promotion des dites cités ;
- En 1995, le classement dans le patrimoine national de la ville de Chinguetti en même temps que les trois autres villes anciennes : cet arrêté de classement pris en application de la loi du 31 juillet 1972 relative à la mise en valeur du patrimoine culturel, architectural et archéologique mauritanien, procède au classement des trois autres villes anciennes : Ouadane, Tichitt et Oualata ;
- Enfin, en décembre 1996, inscription sur la Liste du patrimoine mondial de Chinguetti, Ouadane, Tichitt et Oualata.

Sites zone humide
Les zones humides bénéficient de la protection du Code pastoral mauritanien, qui permet et incite à une plus grande prise de responsabilité des communautés locales dans la gestion de leur environnement. Il offre en effet une place importante à la concertation entre les usagers des ressources naturelles au niveau local et au niveau communal.

Sites des oasis
Les sites des oasis hors territoire des villes anciennes ne bénéficient pas de protection à part celle des propriétaires surtout pour ceux qui sont encore opérationnels et qui contribuent à l'entretien des palmiers à moindre coût.

7 Conservation et gestion du patrimoine de l'eau

Très tôt après l'indépendance et en quête de valorisation de son patrimoine culturel, historique et naturel, la Mauritanie, prit la mesure de son passé. Les quatre villes anciennes de Chinguetti, Ouadane, Tichitt et Oualata, seules villes de la Mauritanie à avoir été habitées sans interruption depuis le Moyen âge jusqu'à nos jours furent prises comme des références. Il s'agissait de les sauvegarder. La démarche de leur inscription sur la Liste du patrimoine mondial, obtenue en 1996 a marqué une étape importante dans ce processus de conservation. Le Parc National du Banc d'Arguin, inscrit sur la Liste du patrimoine mondial dès 1989 comme bien naturel est également repéré comme site de valeur naturelle exceptionnelle à préserver, comprenant un important patrimoine de l'eau.

Globalement, l'idée de sauvegarde et de mise en valeur patrimoniale en Mauritanie est une idée neuve que peu de gens comprennent et acceptent; il s'agit d'une idée à expliquer, à concrétiser, à répandre et à faire accepter par tous. Les personnes, les familles, les groupes nationaux mauritaniens font sans cesse référence à leurs origines, à leur histoire mais manifestent peu d'intérêt pour la conservation de leur patrimoine immobilier et la perpétuation de leur passé sous la forme de monuments.

Les programmes actuellement en cours et envisagés devant bénéficier au patrimoine culturel de l'eau sont les suivants :

- Projet pilote de Sauvegarde et Développement des villes du Patrimoine mondial de Mauritanie pour les villes d'Ouadane, Chinguetti, Tichitt et Oualata, rapport final 2003 ;
- Bet ACT Consultants et Tasmim : ville de Ouadane, novembre 2004 ;
- Act Consultants - Tasmim - Atelier Michel Dupin – villes de Chinguetti, Tichitt, Oualata, février 2005.

8 Conclusion

La société traditionnelle mauritanienne a fondé l'organisation de son espace sur une utilisation diversifiée et parcimonieuse de l'eau. Les bouleversements sociaux et la sécheresse ont entraîné une nouvelle structuration de l'espace avec ses espoirs et ses contradictions. Toutes ces mutations ont été accélérées et amplifiées sous l'effet de l'effroyable sécheresse vécue de 1971 jusqu'aux années 1990.

La réaction des populations désemparées au déficit pluviométrique d'une ampleur et d'une durée sans précédent a engendré une désertification généralisée et une nouvelle occupation de l'espace qui résume toutes les contradictions accumulées à la fois par l'évolution de la société et par l'impact du cataclysme.

Les marques de cette désertification sont inscrites dans le paysage : massifs dunaires jadis fixés, aujourd'hui découverts et remaniés constamment par le vent, destruction des peuplements arborisés, en particulier des gommiers, nombreux puits abandonnés ou comblés marquant le tarissement de la nappe phréatique ou l'abaissement de son niveau.

Cette situation n'a pas empêché l'Etat de préserver les cités culturelles, les parcs naturels et les oasis qui accueillent les sites culturels de l'eau. Ainsi, nous pouvons considérer comme sites vivants récupérables, en milieu urbain les puits des villes anciennes, en milieu nomade les puits du Banc d'Arguin, en milieu oasien la source de Terjit et en zone humide Tamourt N'aj.

Par la valorisation de ses sites, la Mauritanie peut reconstituer son patrimoine culturel de l'eau dans une optique de développement durable axé sur la particularité climatique du pays.

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Etude de cas
Paysages culturels liés à l’eau, cas de la ville de Oualata : le puits Bir M'bouyé

Lieu
Willaya Hod Chargui

Historique
La cité de Oualata fut créée au VIIIe siècle, appelée à cette époque Birou et attachée à l’Émirat Koumbi Saleh, habitée par les Soninkés au XIIe siècle ; on note l'installation de populations berbères puis arabes qui auraient bâti leur propre ville de « Ioualaten », à côté de l'ancienne localité. Entre le XIIe et le XIIIe siècles, la cité a connu son apogée et se développe intellectuellement et commercialement et devient une grande cité caravanière. A partir du XVIIIe siècle, Oualata perd de son ampleur et s'efface progressivement au profit de Néma, point terminal de la piste de Saint-Louis ancienne capitale de la Mauritanie à l’époque coloniale.

Après quelques décennies d'isolement, la ville commence à bénéficier d'une nouvelle aura, d'une nouvelle dimension culturelle et historique qui lui a permis en décembre 1996, avec Chinguetti, Ouadane et Tichitt, d’être classée par l'UNESCO sur la Liste du patrimoine mondial en tant que bien culturel.

Le patrimoine culturel de l’eau de la cité de Oualata
L’eau représente une partie des valeurs culturelles parmi les plus importantes de cette cité ; son histoire s’est manifestée lors de l’islamisation de la cité par Yahya el Kébir ben Chouâb Ben Moussa el Kadhem, arrivé de Bagdad.

C’est ainsi qu’on raconte, que Yahya et ses compagnons sont arrivés à Birou en plein jour. Le disciple est parti demander aux habitants une corde pour puiser l'eau. Comme ceux-ci refusèrent, Yahya donna trois pierres à ses disciples pour qu'ils les jettent dans le puits. Quand la première pierre fut jetée, l'eau jaillit et déborda jusqu'au niveau du sol. Quand la deuxième pierre fut lancée, l'eau se transforma en sang; et quand la troisième pierre tomba, le sang se transforma en sable. Les habitants de Birou qui assistaient à la scène, s'effrayèrent. Ils s'écrièrent: 'Tahabreït" (injonction à des voyageurs qu'on ne peut pas supporter), et à leur tour supplièrent Yahya de les laisser puiser l'eau dont ils auraient besoin pour trois jours, et de les laisser quitter les lieux. Alors Yahya les rassura et les invita à embrasser l'Islam, et tous ensemble ils restèrent (ACT Consultants - Tasmim - Atelier Michel Dupin - Dossier ville Oualata - Février 2005).

Ce patrimoine culturel de l’eau s’est développé et il est constitué :

1 Des réseaux de cours d’eau de surface développés dans la vallée témoignant d’une époque ancienne pluvieuse qui permettaient une activité agricole et assuraient l’alimentation en eau des populations de la cité et des animaux pendant l’hivernage et même une partie de la période d’été ;
2 Des eaux souterraines exploitées par de nombreux puisards environ 150 puits de faible profondeur (environ 3m) creusés dans l’affluent des oueds dans les alluvions sablonneuses qui se détruisent lors des inondations issues de l’hivernage. Entre temps de les reconstruire, la population se ravitaille avec les eaux de surface issues des pluies, et des puits creusés dans le rocher et coffrés avec des fascines ou des pierres pour éviter les éboulements qui servaient à l’alimentation en eau des populations et bétails surtout en période de soudure en été. Il s’agit des puits de Bir M'bouyé ce puits fut foré en 1845 (année de la soif) et les puits de la Batha.

Figure 1. Puits (Bir M'bouyé) situé à droite de la photo (Projet Sauvegarde et Valorisation du Patrimoine Culturel Mauritanien, rapport état de lieu Oualata)

Le delou (récipient en peau de chèvre) est le type d'exhaure utilisé pour contenir l'eau tirée du puits. Il est fabriqué dans une peau de chèvre et dont l'ouverture est maintenue par un cercle en bois ou en fer. Sur les puisards, le puisage est effectué par les hommes. Sur les puits profonds équipés de poulies, l'exhaure est assurée par la traction animale : bœufs, ânes ou chameaux.

Chaque famille disposait de son propre puits. Seul le puits Bir M'bouyé subsiste mais dans un état lamentable malgré quelques tentatives de restauration pour des fins de conservation du puits historique. Pour la préservation de ce site, un effort doit être fait pour sauvegarder ce monument culturel qui peut être intégré dans une composante patrimoine culturel de l'eau en Mauritanie.

Sub-region B: Mediterranean Maghreb

Le patrimoine de l’eau en Algérie : une succession d’héritages

Les patrimoines culturels de l’eau, l’exemple de la Tunisie

Le patrimoine de l'eau en Algérie : une succession d'héritages

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Proverbe écossais *« Ce n'est que lorsque le puits s'assèche que l'on découvre la valeur de l'eau ».*

1 Introduction : bref historique de l'alimentation et du partage de l'eau en Algérie

Depuis la préhistoire, la région méditerranéenne méridionale, est l'une des régions où l'environnement et les activités humaines sont fortement perturbés par le déséquilibre entre les besoins en eau et les ressources disponibles. Aujourd'hui, plusieurs facteurs accentuent ce déséquilibre : le réchauffement climatique et la démographie en forte expansion. Les populations sont soumises à un stress hydrique considérable ce qui peut accentuer fortement la pauvreté.

Le présent article se concentrera sur le patrimoine de l'eau en Algérie en distinguant dans ce pays immense ce qui est le plus significatif dans la partie nord du pays d'une part et dans la partie sud d'autre part.

La partie nord est essentiellement marquée par les apports techniques et architecturaux successifs des Romains puis des Ottomans, les Français et, de nos jours, les Algériens. La partie sud du pays et en particulier dans les régions sahariennes désertiques du Centre et du Sud Ouest algériens des spécificités séculaires, telles les **foggaras,** existent et la gouvernance traditionnelle de l'eau peut apporter aujourd'hui des réponses de durabilité de la ressource.

2 Le patrimoine de l'eau au Nord de l'Algérie

2.1 L'héritage romain

Si les populations locales berbères, peu nombreuses, pouvaient se contenter des sources abondantes et pérennes des montagnes et des plateaux du Nord de l'Algérie, l'arrivée des romains dès la fin du Ie siècle s'accompagna d'une forte urbanisation comme en témoignent les remarquables sites que sont Djemila (à l'Est de Sétif), Thamugadi (près de Timgad), Tipaza (près d'Alger), pour ne citer que ces exemples.

La colonie de Cuicul/Djemila[1] s'est établie à 900 mètres d'altitude, sur une dorsale montagneuse entourée de ravins. La ville, difficile d'accès et donc facile à défendre fut fondée à la fin du Ie siècle (vers 96) probablement par les vétérans de l'empereur Nerva[2]. C'est avant Thamugadi (près de Timgad) fondée par l'empereur Trajan en l'an 100, l'une des dernières colonies de garnison en Afrique romaine.

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[1] Le nom de Cuicul est celui d'un village ou d'un lieu berbère qui n'avait pas encore été latinisé en Djemila.
[2] Nerva, né 8 novembre 30 à Narniet mort le 27 janvier 98 à Rome, est empereur romain du 18 septembre 96 jusqu'à sa mort.

Sous les Antonins (96 à 192) Djemila s'embellit dans le sud de la ville, d'un forum, d'un capitole, de plusieurs temples, d'une curie, d'un marché, d'un théâtre et de grands thermes[3] (sous le règne de l'empereur Commode[4]). Ces travaux d'urbanisation comportaient d'importants aménagements hydrauliques depuis le captage des sources abondantes et pérennes dans la haute vallée de l'oued Guergour jusqu'à la construction de réservoirs de stockage et l'établissement d'un réseau de distribution : une fontaine (photo 1.a) aux larges bassins jouait le rôle de château d'eau d'où partaient les canalisations vers les quartiers, les thermes (photo 1.b et 1c) et les immeubles. Le système assurait à la population un ravitaillement régulier en eau pure et les moyens de pratiquer quotidiennement des bains comme il était d'usage à l'époque[5].

L'évacuation des eaux usées se faisait dans toute la ville par des égouts qui se dirigeaient vers les vallons de l'oued en aval.

Photo 1.a. La fontaine conique de Djémila Yellès

Photo 1.b. Les thermes vus depuis le baptistère de Djémila, Cyril Preiss 2008

Sous les Sévères (192 à 235) de nouveaux quartiers s'organisent au sud du forum, autour d'une vaste place, de nouvelles rues sont tracées, et la ville devient peu à peu une cité où il fait bon vivre, où se développent de luxueuses demeures.

Vers le milieu du IIIe siècle, une crise économique faisant suite à de mauvaises récoltes paralysa le commerce et freina le développement de la ville. Cuicul se voit continuer une vie urbaine dynamique. Au IVe siècle, la conversion de la population au christianisme insuffla un regain d'activité et d'expansion urbanistique avec l'érection d'un quartier chrétien. Un baptistère et une basilique s'implantent à l'extrémité sud de la ville. Les maisons luxueuses des notables ne cessent d'être développées atteignant des superficies considérables, s'équipant même en thermes privés.

[3] Les bains publics sont connus sous le nom de Thermes de Caracalla. Ils occupent une surface de 2600 m^2.
[4] Commode (31 août 161 - 31 décembre192) est un empereur romain qui régna de180 à 192.
[5] Pour les anciens Romains, en particulier les hommes, le bain était à la fois une occupation quotidienne et un loisir collectif.

Photo 1.c. Les thermes de Djémila (vue partielle), UNESCO

Photo 2. Thermes romains à Tipasa, UNESCO

Cuicul est occupée en 431 par les Vandales[6] qui y persécutent les catholiques jusqu'à leur départ après les accords conclus avec Genséric[7] en 442.

Lorsque la ville fut reconquise par les Byzantins, elle retrouva un semblant de stabilité et d'activité, mais tomba dans l'oubli à la fin du VIe siècle.

Au vu de l'état de conservation des ruines, Djémila a été inscrite par l'Unesco sur La liste du patrimoine mondial en 1982.

De même, la ville de Thamugadi/Timgad, construite par l'empereur Trajan disposait aussi d'infrastructures : de bains publics et d'un système de toilettes avec eau, canaux et bassins. Elle est inscrite sur la Liste du patrimoine mondial depuis 1982.

Tipasa, située sur le littoral ouest à une quarantaine de kilomètres d'Alger également équipée de thermes (photo 2), bains publics, était un important comptoir commercial punique à l'époque Romaine. Elle fut également inscrite en 1982 sur la Liste du patrimoine mondial.

La ville d'Alger (al Djazair) est peu développée à l'époque Romaine. Cependant, des besoins en eau grandissant se font sentir et les faibles apports des cours d'eau qui l'alimentent se révèlent vite insuffisants. Les ingénieurs romains étudient donc la possibilité de faire venir davantage d'eau dans la ville au moyen d'aqueducs.

2.2 L'héritage ottoman

Si les premiers aqueducs d'Alger sont d'origine romaine, le développement de ce mode d'alimentation en eau de la ville est l'oeuvre des Ottomans. Selon des sources historiques,

[6] Les Vandales sont un peuple germanique oriental. Ils conquirent successivement la Gaule, la Galice et la Bétique (sud de l'Espagne), l'Afrique du Nord et les îles de la Méditerranée occidentale lors des Grandes invasions, au V^{ème} siècle. Ils fondèrent également le « royaume vandale d'Afrique » (439–534).
[7] Genséric est roi des Vandales de 427 à 477. Il est l'un des principaux personnages de la période qui voit la chute de l'empire romain au V^{ème} siècle.

épigraphiques arabes et turques, la présence de fontaines et de réseau et système hydraulique à Alger est important. Al Bakri, grand géographe andalou, décrit fin du XIe siècle le port de la ville et sa source « *Le port est bien abrité et possède une source d'eau douce, il est très fréquenté par les marins de Ilfrikiya, d'al Andalous et autres* ». Si l'eau fournie aux citadins provenant de sources et les puits situés à l'intérieur de la ville, Léon l'Africain de passage à Alger indique qu'en 1516, la ville utilisait l'eau de la rivière qui donna plus tard son nom à une des portes d'Alger « Bab el Oued ». Nicolas de Nicolay (1550) rapporte que le but de la forteresse de l'Empereur était de défendre les sources qui fournissaient Alger en eau par des canalisations. Les Ottomans vont construire quatre aqueducs (figure 1) pour remplacer les antiques puits et les citernes (djeb).

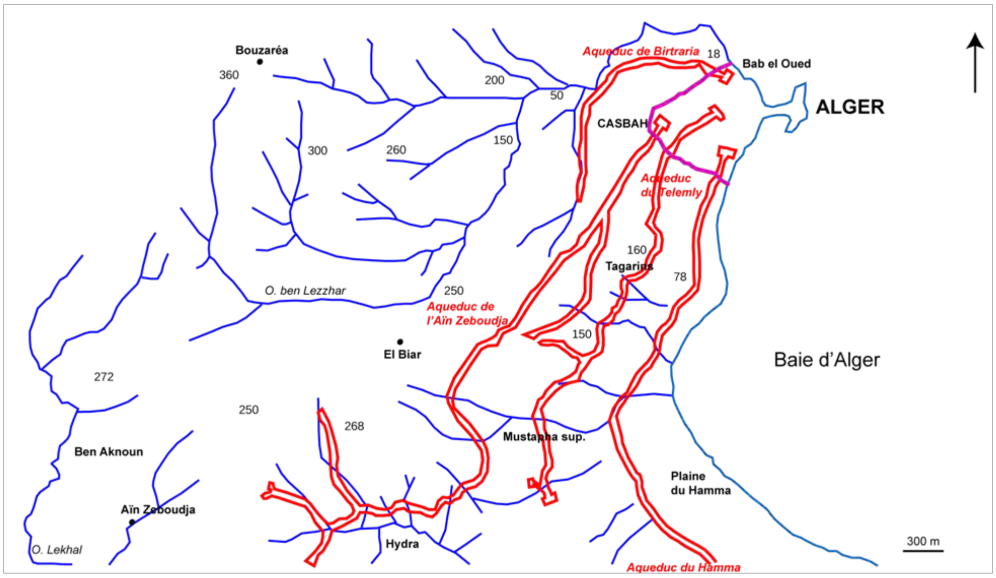

Figure 1. Schéma des aqueducs de l'algérois (Y. Djellouli et F. Mesner, 2014, ESO 6590)

1 L'aqueduc du Télemly, un des premiers travaux hydrauliques dans l'enceinte d'Alger (XVIe siècle), serait l'œuvre de Hasan Khair ad-Din, long de 2 km et avec un débit estimé à plus de 500 m^3/jour il puisait son eau dans le quartier Mustapha supérieur, depuis une source. A partir de cet aqueduc, Alger devient une des rares grandes villes du monde arabe à être alimentée par un ensemble de canalisations provenant de sources (dont celle située non loin de la colline de *Kudiat al-Sâbün*) à l'extérieur de ses remparts.

2 L'aqueduc du Hamma de 5 km de longueur rentre en ville par le quartier Bab Azzoun. On attribue le début de sa construction dès 1662 par l'Andalou Mûsa al Andalousi architecte fuyant l'Espagne, puis consolidé en 1758 par Ali Pasha. Il ramenait l'eau de la source du Hamma, son débit était de plus de 700 m^3/jour (Anonyme)[8].

3 L'aqueduc d'Aïn-Zeboudja (source de l'olivier sauvage), appelé aujourd'hui aqueduc du Val d'Hydra, en raison de son emplacement dans ce quartier nouvellement urbanisé d'Alger, a été construit entre 1619 et 1639, du temps de la régence d'Alger. Il est l'oeuvre de Mussa el Andaloussi, un de ces nombreux réfugiés ayant fui l'Andalousie pour trouver refuge dans les

[8] Anonyme : *Le système de l'eau à Alger pendant la période ottomane* (XI^{ème}-XIX^{ème} siècles). Archinet.org/system/publications/contents/4394/original/DPC0824.pdf. pp. 42-53.

villes du Maghreb où ils contribuèrent, grâce à leur savoir-faire, à l'aménagement de ces cités et particulièrement à leur approvisionnement en eau. L'aqueduc captait les eaux des sources naturelles du plateau de Ben Aknoun et de Dely-Ibrahim situées à environ 10 kilomètres de la médina pour les y acheminer. Long de 12 km, il alimentait la casbah, en passant par les Tagarins (haut de la Casbah). On estime que son débit était de plus de 700 m^3 par jour. Cet aqueduc (photo 3) était d'autant plus important qu'il alimentait la Citadelle, siège du pouvoir de la Régence, de même que 14 fontaines de la Casbah (on comptait près d'une centaine au XVIIe siècle), les fontaines publiques, ainsi que les jardins luxuriants qui l'entouraient et contribuaient à la réputation de la ville.

Dès les premières années de la colonisation française, Gobot, peintre militaire chargé de faire le relevé des monuments de la Régence, en a fait une représentation dans un tableau toujours visible au musée des Beaux-arts d'Alger, où il apparaît dans toute sa splendeur.

C'est le seul aqueduc ottoman dont il reste aujourd'hui des vestiges, lesquels ont été classés monument national (depuis janvier 2008 seulement). Dans ce cadre l'aqueduc d'Aïn-Zeboudja, fait actuellement l'objet d'une opération de confortement initiée par la Direction de la culture de la wilaya d'Alger. L'opération est louable, on peut l'applaudir puisqu'elle est en cours et on se félicite du classement du monument et de la mise en valeur de ce patrimoine historique et archéologique. C'est un témoin notable du système hydraulique d'El-Djazaïr[9]. L'aqueduc d'Aïn-Zeboudja faisait partie de l'ensemble des quatre grands aqueducs convergeant vers la Casbah avec l'aqueduc du Hamma au sud de la ville, celui de Birtraria qui pénétrait à la Casbah par le nord-ouest et celui du Telemly qui y arrivait par le nord-est. Les eaux ainsi acheminées jaillissaient alors des nombreuses fontaines réparties dans chacun des quartiers de la médina. Les aqueducs du Télemly, du Hamma et de Birtraria ne sont plus visibles aujourd'hui.

4 L'aqueduc de Birtraria qui amenait son eau à la porte de Bab el oued, captant plusieurs sources, est le plus court des aqueducs d'Alger et a une capacité de plus de 100 m^3/jour. Il a été représenté en timbre d'Algérie 1830 (photo 4).

Photo 3. Vestiges de l'aqueduc d'Aïn Zeboudja à Alger (Aghiles, 2009)

Photo 4. Vue figurée de l'aqueduc de Birtraria en 1830, représenté sur un timbre

[9] Nom Turc d'Alger.

Avant la mise en place des aqueducs, l'eau consommée à Alger provenait essentiellement des sources à l'extérieur de la ville et était transportée par des porteurs d'eau (esclaves, salariés, marchands, etc.) qui constituaient une corporation d'autant plus vaste que les besoins augmentaient. Une partie de l'approvisionnement provenait aussi des citernes recueillant l'eau de pluie et des antiques puits dont l'eau était saumâtre du fait de la proximité de la mer.

A l'époque ottomane, la multiplication des aqueducs transforma profondément cette corporation. En effet, les distances à parcourir sont plus réduites à celles des fontaines (publiques) aux usagers, qu'il s'agisse des palais, de hammams (bains), des jardins ou de particuliers. Les aqueducs et les fontaines nécessitaient de l'entretien, lequel était assuré à la fois par les services urbains sous l'autorité du Dey et par les individus usagers qui étaient souvent mobilisés par les mosquées au nom du rôle purificateur de l'eau dans la religion musulmane. Intervenaient également dans les investissements comme dans l'entretien, du mécénat de la part des riches personnalités de la ville.

2.3 L'héritage de la colonisation française

L'étude du système de l'eau hérité de la période ottomane se heurte à quelques difficultés dont celle du réseau qui se dégrade. Il reste à Alger quelques fontaines et vestiges à l'intérieur de la ville et les anciens aqueducs venant de l'extérieur. Le réseau a été modernisé durant l'époque coloniale française, surtout au XXe siècle, répondant ainsi à une demande fortement croissante. A l'époque de la conquête française, l'aqueduc du Télexer apportait son eau à vingt neuf fontaines et l'aqueduc d'Ain Zéboudja en alimentait quatorze à l'intérieur de la ville.

En arrivant, le colonisateur français voyait surtout l'espace rural algérien comme un grenier à blé pour la métropole. La loi du 16 juin 1851 classait toutes les eaux d'Algérie dans le domaine public, d'où le conflit structurel avec le droit coutumier musulman. Ceci facilita l'accès aux terres irriguées pour les colons. Mais les limites des réserves des bonnes terres irriguées ou irrigables amènent à réaliser la première génération des barrages réservoirs (deuxième moitié du XIXe siècle) et une petite hydraulique fondée sur le principe « *pour faire une bonne colonisation il fallait faire une bonne hydraulique agricole* ». Cependant ces barrages construits trop rapidement, ont connu des problèmes multiples, exemple des ruptures de digues ; cette politique hydraulique agricole coloniale fut un échec. Ce n'est qu'après la première guerre mondiale que les grands travaux hydrauliques de grands barrages, seront lancés avec le programme dit de 1920 constituant une oeuvre remarquable : Les barrages construits dans le nord du pays, (barrages de Béni-Bahdel, de Bou-Hanifia, de Bakhadda, de l'Oued-Fodda, du Ghrib, du Ksob, des Zardézas et de Foutu-el-Gueiss) constituent un ensemble considérable, qui a augmenté d'une façon importante le potentiel économique de l'Algérie, grâce à la législation spéciale sur l'exploitation de l'irrigation (décret-loi du 30 octobre 1935). Cette politique de grande hydraulique se poursuivra jusqu'à l'indépendance où on comptait une vingtaine de grands barrages réservoirs, avec une capacité de 1452 millions de m^3 et un potentiel irrigable de 128 000 ha. De plus la petite et moyenne hydraulique a été développée avec des barrages réservoirs, des barrages de déviation et des barrages collinaires), des pompages et des forages, et la création de points d'eau pour l'alimentation (humaine et pastorale). Même si des ouvrages existent encore, le résultat est mitigé pour la politique hydro-agricole coloniale. Dans les villes, un réseau d'eau d'alimentation en eau potable et un réseau d'assainissement ont été mis en place, surtout dans les quartiers dits « européens ». Ces réseaux représentent un patrimoine de modernisation dans les villes ; ils ont continué à servir jusque longtemps après l'indépendance, même parfois dans la vétusté.

Actuellement la volonté du ministère des Ressources en Eau a permis de mettre des moyens colossaux pour la construction de nouveaux barrages. De même, les transferts d'eau vers les régions où la ressource manque (eau de pluie ou eau fossile) se multiplient y compris dans le Sahara, par exemple le transfert, par canalisations souterraines, de l'eau fossile du forage d'Ain Salah vers la ville de Tamanrasset (740 km). Plusieurs infrastructures (grands et petits barrages, retenues) sont en chantier ou construites, on attend plus de quatre vingt barrages pour 2030 selon ce ministère, ceci serait en prévision des changements climatiques annoncés (entre autre).

3 Le patrimoine de l'eau au Sud de l'Algérie : les foggaras

3.1 Aspects généraux et historiques

Dans les zones arides, les hommes ont réussi à relever des défis d'une implantation humaine durable, particulièrement dans les oasis, en utilisant d'ingénieux procédés de captage de l'eau : **les foggaras**, considérées comme patrimoniales. Elles sont nommées (avec plus de 27 noms) : *kanats* (ou *qanats*) en Iran[10], *foggaras* en Algérie, en Tunisie, *khettara*s au Maroc, *Kriga* en Tunisie, *Karez* (*Kariz*) en Chine, en Azerbaijan, au Pakistan et en Afghanistan, *Sahridj* au Yémen, *falaj* aux Emirats Arabes Unis et à Oman, ...

Les foggaras, système traditionnel de captage et de partage des eaux, sont considérées comme l'organe principal pour la vie dans le désert.

Cette technique ancienne de plus de mille ans est née dans la Perse antique, où l'oasis d'Irbil (en zone aride d'Iran) semble être la première, à la fin du VIIe siècle av. J-C à l'utiliser. Cette technique s'est propagée dans des pays du même continent, en Inde et en Chine, au Moyen Orient, puis en Afrique du Nord où elle a été introduite par les musulmans Almoravides au cours des Xe, XIe et XIIe siècles.

Dans le Sahara algérien, plus spécifiquement, les foggaras auraient été introduites au XIe et XIIe siècles par El Malik El Mansour, qui aurait creusé la première foggara à 15 km d'Adrar au lieu dit Tamantit (Hassani 1988). Ensuite, les foggaras ont été développées dans le Touat et le Gourara par des tribus arabo-berbères sur la base de l'esclavage de la main d'oeuvre noire (Harratine) locale ou provenant des régions voisines du Mali, du Niger et du Soudan (Bisson, 1992 ; Arrus, 1985).

Dans le Sahara algérien le passage du nomadisme à la sédentarisation a été favorisé par le système d'irrigation traditionnel des foggaras. Ce système ingénieux a permis d'installer et de maintenir des oasis, qui jouaient le rôle d'étape pour les voyageurs, passagers, caravaniers, avant la traversée du désert du Sahara.

Selon Ansari (2005) l'ingéniosité du procédé réside dans sa conception et son adaptation aux conditions de la vie et du climat sahariens : il supprimait les corvées d'eau épuisantes, qui prenaient l'essentiel du temps des habitants, et assurait un approvisionnement sans risque de tarir la nappe d'eau.

[10] Elles sont en diminution puisque sur les 50.000 utilisées en Iran, seules 20.000 sont encore fonctionnelles (Kheirabadi, Masoud, 1991).

On compte aujourd'hui en Algérie plusieurs centaines de foggaras, actives ou taries : sur les 1400 foggaras 907 sont pérennes et en service et malheureusement 493 taries selon l'Agence Nationale des Ressources Hydrauliques (ANRH) de l'Adrar (Ansari, 2005).

3.2 Fonctionnement des foggaras

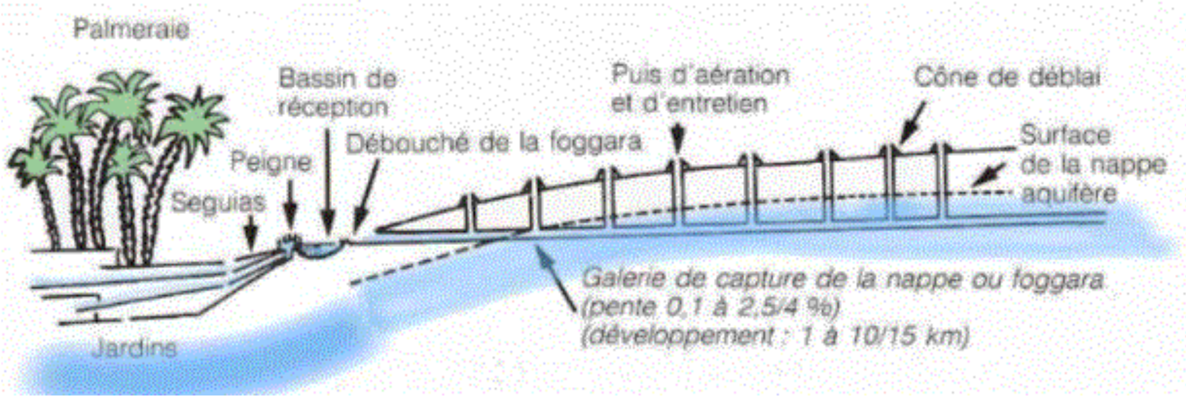

Figure 2. Schéma du fonctionnement normal d'une foggara
(Michel Janvois: http://zoumine.free.fr/tt/sahara/donnees_geo_clim_bota/foggara.jpg)

Etablir une foggara consiste à créer une « source » artificielle en creusant des galeries[11] en pente très faible qui vont rejoindre et pénétrer en amont la nappe aquifère du plateau. L'eau de la nappe suinte le long des parois des galeries et y forme un ruisseau permanent (figure 2).

Ces galeries souterraines sont marquées en surface par des regards qui permettent l'entretien et l'évacuation périodique du sable encombrant les galeries. Un survol du bassin de capture d'une foggara montre l'ampleur du réseau ainsi créé[12] (photos 5a, 5b)

Photo 5.a. Vue aérienne des regards d'entretien d'une foggara, N.O Timimoune, Georges Steinmetz, 2007

Photo 5.b. Vue au sol des regards d'entretien d'une foggara (Algérie, Terre d'Afrique 2011)

L'ingéniosité du procédé de captage réside dans sa conception et son adaptation aux conditions de la vie et du climat sahariens.

[11] Le travail de creusement est évidemment colossal et n'a pu se faire sans le travail de très nombreuses personnes.
[12] On estime à des milliers de kilomètres l'ensemble des Foggaras du Gourara et du Touat.

L'approvisionnement en eau est assuré à débit constant, sans risque de tarir la nappe. L'évaporation est limitée au minimum. Le débit des foggaras a fait l'objet de nombreuses études à toutes les époques, car il représente le principal facteur de l'économie des communautés de ces régions. Nous retiendrons quelques chiffres globaux : 0,83 m^3/seconde au Gourara, 1,80 m^3/seconde au Touat et 0,58 m^3/seconde au Tidikelt. Ces chiffres doivent être pris avec précaution car la mesure de référence traditionnelle le « habba »[13] varie selon les lieux. Les systèmes de mesure de l'eau sont eux-mêmes variables comme les appareils de mesure de l'eau[14]. Dans le Tidikelt, le Touat et le Gourara, les communautés se sont dotées d'un mesureur de l'eau *(kiyâl el ma,* en arabe) pourvu d'un appareil appelé *chegfa* ou *el kîl al-asfer* (« la mesure jaune »)[15].

L'apport hydraulique de la foggara règle l'extension et la géométrie de l'espace cultivé, dont la structure résulte d'un réseau de canaux de distribution ainsi que de la quantité d'eau disponible. Le sol n'a donc ici aucune valeur, car c'est l'eau qui en détermine la possibilité d'utilisation et la propriété. Les titres de propriété de l'eau au Tidikelt étaient ainsi évalués en *habba*. La qualité d'une foggara dépend :

- des formations géologiques qui renferment la nappe d'eau. Pour les foggaras qui drainent les eaux de la nappe d'eau du continental intercalaire (CI), système aquifère non renouvelable, chaque volume d'eau extrait influe sur le volume global ce qui se traduit par le rabattement continu du niveau statique de la nappe aquifère ;
- des forages d'eau avoisinant ;
- de la longueur de la partie inactive et la perte par infiltration et évaporation (limitée du fait que la conduite est enterrée).

Le système de captage de l'eau de la foggara se prolonge au-delà du débouché à l'air libre par le système de partage et de distribution de l'eau, se faisant par un système de peignes ou kasria et de canaux (figure 3 et photo 6).

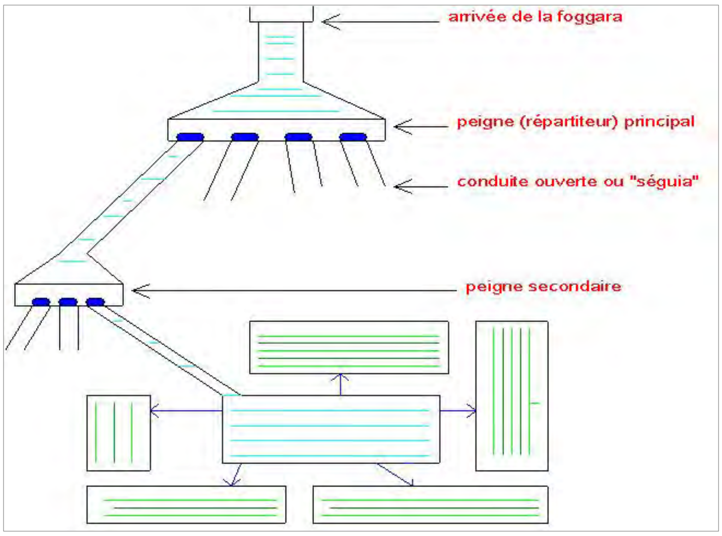

Figure 3. Schéma du système de partage de l'eau dans une foggara (M. Gast, 1998)

[13] Autour de 3,3 litres par minute.
[14] Ou du temps d'arrosage. En Ahaggar, c'est le temps de remplissage du bassin de stockage *(majen)* et de son utilisation pour l'arrosage, qui représente l'unité de base, quel que soit le débit de l'eau.
[15] Le *chegfa* qui est un cylindre de cuivre percé sur sa surface latérale de trous de différents calibres. La méthode de mesure consiste à faire passer toute l'eau dans les trous du cylindre, en bouchant le nombre de trous nécessaires pour que le niveau de l'eau ainsi arrêtée reste constant dans le cylindre. L'on fait alors la somme des orifices par lesquels l'eau s'écoule pour connaître la valeur du débit.

Photo 6. Kasriate et Seguias (Pietro Laureano)

L'élément essentiel du système de partage et de distribution de l'eau arrivée au niveau des Ksour[16] et des jardins est l'utilisation de peignes distributeurs en cascades : les kasriates[17] (figure 3 et photo 6). L'eau est acheminée jusqu'au niveau des utilisateurs via les seguias (canaux répartiteurs). Deux méthodes de partage sont utilisées : soit volumique et soit horaire (Remini et *al.,* 2010).

En Algérie c'est la méthode volumique qui est le type de partage le plus répandu dans toutes les oasis à foggaras albiennes. Chaque copropriétaire est destinataire d'un volume d'eau déterminé selon des normes établies par les oasiens eux-mêmes, en général en fonction de sa contribution à l'entretien et à la maintenance de la foggara.

La méthode horaire est caractéristique des foggaras des sources des montagnes et des oueds. Elle est basée sur l'unité de temps utile pour irriguer les jardins tour à tour. On retrouve ce procédé pour les foggaras de Moghrar au pied du Mont des Ksours de l'Atlas saharien. Remini et *al.*, (2010) indiquent que dans la région d'Adrar, le partage des eaux de la foggara de Hanou, qui est une foggara horaire, s'effectue au tour à tour. Il n'y a pas de kasriates comme dans les autres foggaras avoisinantes. Les seguias relativement importantes partent directement d'un grand madjen (réservoir). La foggara est obstruée une à deux fois par jour pour permettre de reconstituer le niveau requis, puis l'eau est libérée pour un temps donné, proportionnel à la contribution financière versée par le bénéficiaire (Oleil, 1994).

Dans une oasis, le sol n'est pas la valeur principale, car c'est l'eau qui en détermine la possibilité d'utilisation et la propriété. Le système de répartition de l'eau et de calcul des contributions influence par conséquent la totalité de la société oasienne tant dans ses valeurs économiques que dans ses qualités esthétiques et ses références symboliques. Dans ce cadre, la « source »

[16] Pluriel de Ksar (village traditionnel en général fortifié).
[17] Pluriel de Kasria.

artificielle (ou débouché de la galerie de la foggara) acquière une dimension quasi sacrale. C'est ainsi que lui sont accolés mausolées, fontaines, vasques ornementales et autres monuments.

Dans l'ensemble saharien, plusieurs types de foggaras sont recensés en Algérie (figure 4). Certaines, captent les eaux de la nappe fossile albienne, d'autres les eaux de sources ou des bassins versants de montagnes comme celles de l'Atlas saharien (Mont des Ksours), d'autres plus originales et même uniques au monde, captent les eaux de pluie et les collectent pour les redistribuer comme celle de Ghardaia.

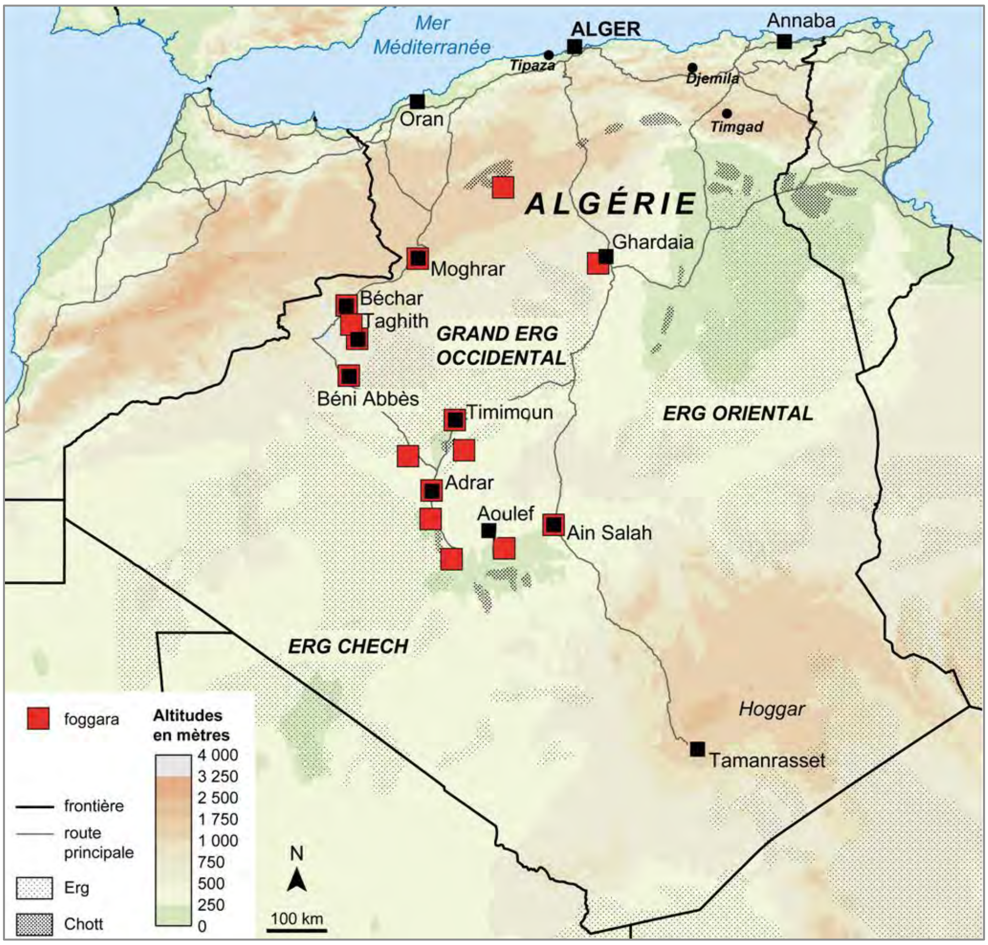

Figure 4. Carte de l'Algérie (avec les villes et l'emplacement de foggaras ici figurés superposés) Y. Djellouli et S. Angonnet, ESO UMR 6590

4 La documentation sur le patrimoine de l'eau

Le patrimoine de l'eau en Algérie est sous la responsabilité du ministère de la Culture qui a établi une liste des sites et monuments classés. Cette liste est disponible sur : http://www.m-culture.gov.dz/mc2/fr/sitesetetmonuments.php#[18]

18 Cette liste est reprise par le site Wikipedia avec, à chaque fois que cela est possible, une photo (dans le cas contraire un appel à contribution est posté).

Dans cette liste, on retiendra, pour ce qui est du patrimoine de l'eau :

- Fontaines arabe et marabout ou Hamma lieu dit « les Platanes au jardin d'Essai, ouvrage hydraulique, Mon.Fun/Mod à Sidi-M'hamed.
- Fontaine de la cale aux vins, ouvrage hydraulique médiéval, à Oued Koriche, Casbah
- Fontaine de l'Amirauté, oeuvre d'art, à Oued Koriche, Casbah
- Bain Maure Thermes médiévaux à Nedroma, Wilaya de Tlemcen
- Ain El Fouara Fontaine, oeuvre d'art/Mediéval, Setif
- Citerne d'Hippone, ouvrage hydraulique antique, Annaba
- Aqueduc romain, ouvrage hydraulique antique, Constantine
- Bains dits de « Emir AbdeEl Kader Thermes/Mod, à Sidi Kada, Mostaganem
- Aqueduc antique à Sidi Ammar, ouvrage hydraulique antique à Sidi Ammar, Cherchell
- Aqueduc à 5 Km de Cherchell, ouvrage hydraulique antique
- Château d'eau, ouvrage hydraulique antique à Hadjout
- Bains de Pomperianus, Thermes antiques à Oued Athmania, Wilaya de Mila

Ce ministère de la Culture possède une Médiathèque du patrimoine qui comporte une « Base Mémoire » constituée d'importantes archives photographiques.

La conduite des travaux de recherche et de conservation du patrimoine est confiée au Centre National de Recherches Préhistoriques, Anthropologiques et Historiques (CNRPH) qui dépend de ce même ministère.

5 L'état de conservation et les facteurs affectant le patrimoine, protections légales, réhabilitation des foggaras

5.1 L'état de conservation et les facteurs affectant le patrimoine

L'état de conservation du patrimoine identifié et classé est très varié et dépend de l'attention qui lui est porté par les pouvoirs publics et des ressources qui lui sont consacrées. Si au lendemain de l'indépendance du pays, la conservation du patrimoine n'a pas été une priorité, l'identification, le classement et la mobilisation de la documentation des sites ont fait des progrès considérables aidés en cela par la coopération bilatérale (de la France notamment), multilatérale (Union européenne) et internationale (UNESCO).

Un bon exemple est celui des fontaines, comme celui de la « fontaine jaune » de la Casbah d'Alger (photo 7).

Selon Boualem Demdoum (2012) : « Six seulement des quelque deux cents fontaines datant du XVIe siècle ont résisté à l'usure du temps et continuent d'alimenter les gens en eau potable fraîche : Aïn Sidi Ramdan, Aïn M'zaouqua, Aïn Bir Djebah, Aïn Sidi M'hamed Chérif, Aïn Sidi Benali et Aïn Bir Chebana. Ces « sources de vie » d'antan, qui portent des noms calligraphiés sur de la céramique pour certaines, des carreaux de faïence d'origine ou encore des colonnes en marbre pour d'autres, coulent en continu pour le plus grand bonheur des riverains comme des simples passants… Les six fontaines donnent, à première vue, l'apparence de petits monuments historiques bien conservés n'étaient-ce les touffes de mousse qui les envahissent ici et là, les carreaux de faïence fissurés pour certaines ou carrément décollés par endroits pour d'autres… L'historien Abderrahmane Khelifa, rappelle que la Casbah d'Alger comptait à l'origine 175 fontaines intégrées dans un système hydraulique « très élaboré » et alimentées par quatre aqueducs… L'architecte Nabila Chérif (2008) travaillant sur les bains et les fontaines d'Alger de l'époque ottomane, affirme qu'il n'y a aucune difficulté technique à restaurer ces fontaines… Entre utilité, efficacité, esthétique et nostalgie, les fontaines encore « vivantes » de la Casbah d'Alger interpellent les regards, font oublier, le temps d'une visite, l'état délabré dans lequel se trouve la plus grande partie de l'ancienne médina et redonnent l'espoir de revoir un jour ce site historique renaître de ses cendres ».

Photo 7. La fontaine jaune de la Casbah d'Alger (Le Midi Libre, Algérie, 19 mai, 2012)

Une partie importante du patrimoine non classé a été vouée à l'abandon pur et simple (cas de nombreuses foggaras) voire à sa destruction pour faire place à de nouvelles constructions. Les matériaux récupérés ont été recyclés de différentes manières y compris pour des usages privés.

Parallèlement à la mobilisation du ministère de la Culture, des associations locales comme l'Association de protection et de promotion des sites et monuments historiques de la Région de Sédrata (Wilaya de Souk Ahras) se mobilisent pour redonner vie au patrimoine dont il existe encore des traces.

5.2 Les protections légales

L'Ordonnance n°67-281 du 20 décembre 1967 est le texte fondamental qui organise les fouilles et la protection des sites et monuments historiques et naturels en Algérie.

Cette Ordonnance concerne les biens mobiliers et immobiliers présentant un intérêt national du point de vue de l'histoire, de l'art et de l'archéologie qu'ils existent sur le domaine public et privé de l'Etat comme appartenant à des particuliers. Il indique les procédures de classement ainsi que les servitudes qu'entraîne le classement. Bien évidemment, le déplacement ou la destruction des dits biens est interdite et les contrevenants passibles de sanctions. Les monuments historiques font partie intégrante du patrimoine national et sont placés sous la sauvegarde de l'Etat. Des collections nationales sont constituées dans le but de préservation et de protection. Aucune construction nouvelle ne peut être adossée à un monument classé ni élevé dans son champ de visibilité. Les travaux d'entretien demeurent à la charge des propriétaires ou affectataires publics ou privés mais les travaux autorisés par le ministère. Les différents services de l'Etat, des Départements et des Communes sont quant à eux tenus d'assurer la garde et la conservation des immeubles et objets mobiliers dont ils sont propriétaires, affectataires ou dépositaires. Les dépenses nécessitées par ces mesures sont, à l'exception des frais de construction ou de reconstruction, obligatoirement inscrites à leur budget.

5.3 La réhabilitation des foggaras

Beaucoup de spécialistes sont inquiets de la lente déchéance de ce système plusieurs fois millénaire de partage des eaux qui pourrait faire partie du patrimoine national, du désintérêt des jeunes et des pompages excessifs dans l'eau fossile de la nappe albienne qui mettent en danger les foggaras.
Il faut dire que l'entretien des foggaras par les procédés traditionnels de curage est fastidieux et pénible. Il exige une main-d'œuvre spécialisée apte à effectuer ce type de travail et disponible (Khadraoui, 2007). Le savoir-faire est en train de se perdre et cet état de fait a largement contribué à la crise profonde qu'ont connu dans les années 1980, les foggaras d'Algérie. Beaucoup ont été délaissées voire abandonnées. Ce patrimoine important a perdu sa grandeur d'antan.

Des actions de réhabilitation des foggaras ont cependant été initiées par différents intervenants soit dans une logique économique soit au titre de la sauvegarde du patrimoine national matériel et immatériel.

A titre d'exemple, on peut citer le commissariat au développement de l'agriculture dans les régions sud qui a lancé en 2007 un important projet de réaménagement des palmeraies du Tidikelt à travers l'exploitation et la valorisation des oasis existantes. L'objectif de ce vaste projet est de renforcer les investissements en vue de rationaliser la gestion des ressources naturelles et notamment de l'eau, à travers des actions visant les forages (le diagnostic et la réfection des forages existants), la réalisation de nouveaux forages de remplacement, l'électrification et l'équipement des forages et puits existants, l'amélioration des réseaux de drainage, ainsi que la préservation et le renforcement des foggaras.

Plusieurs solutions techniques permettent de restaurer et/ou d'améliorer et/ou de sauvegarder les débits des foggaras. Lorsqu'une foggara en bon état est fonctionnellement morte, c'est que le niveau de la nappe aquifère a baissé et que la partie drainante de la foggara ne pénètre plus la nappe d'eau. Une solution, traditionnelle, d'extraction de l'eau présente dans le sous-sol d'une foggara fonctionnellement morte est d'installer des puits à balancier (photo 8) au niveau même de la Palmeraie ou du jardin. Ces puits peuvent être motorisés.

Les méthodes modernes permettent soit de profiter de la partie drainante existante et d'en extraire l'eau pour irriguer des terrains implantés dans le voisinage[19] soit de « corriger » le débit

[19] Les aménagements agricoles récents, gros consommateurs ont imposé la généralisation des motopompes, greffées parfois directement sur un conduit de la Foggara et ont, en quelque sorte, révolutionné le système de l'agriculture oasien et des terres ont été mises en valeur en dehors des palmeraies traditionnelles. Parallèlement, l'accès à la propriété foncière agricole a été encouragé par l'Etat algérien, d'où un système économique agricole de plus en plus productif (de fruits, de légumes et de dattes) pour la consommation locale et pour l'exportation, utilisant les facilités d'accès à l'eau dans les puits à motopompes, ce qui rend quelque peu obsolètes les formes d'agriculture oasienne traditionnelle.

de la foggara vivante en y injectant de l'eau pompée dans la nappe aquifère (éventuellement profonde) via des forages annexes. L'installation des motopompes utilise les puits d'aération et d'entretien de la foggara (figure 6).

Photo 8. Puits à balancier, Joseph Chauveau, 2010

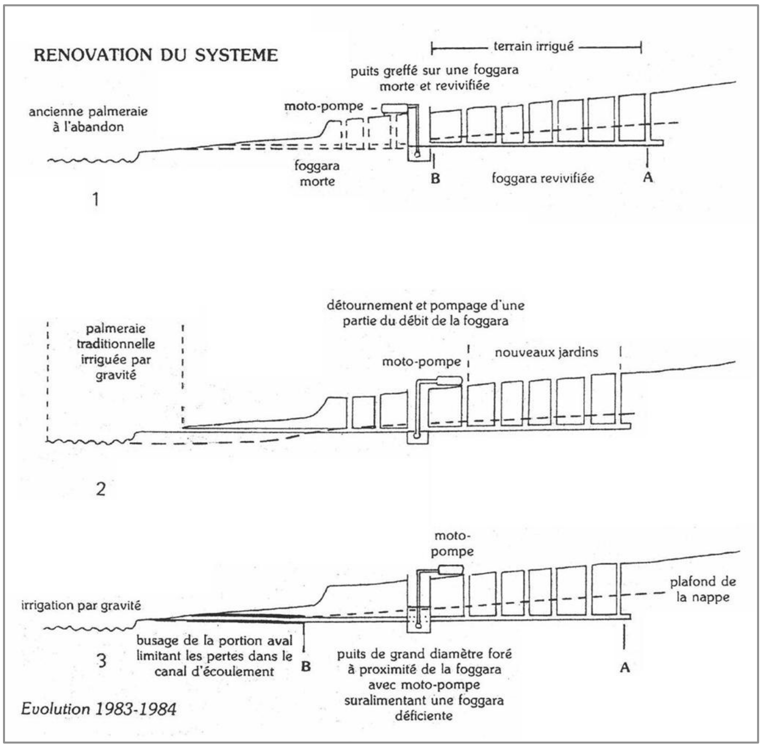

Figure 6. Réhabilitation d'une foggara avec des moyens techniques modernes (M. Gast, 1998)

La réhabilitation des foggaras est essentielle pour l'agriculture oasienne et pour la stabilisation des populations sahariennes. Il faut non seulement restaurer et sauvegarder les infrastructures mais aussi adopter des pratiques de gestion de l'eau, spécifiques aux milieux hostiles en s'inspirant des pratiques traditionnelles héritées. L'exemple des projets dans la wilaya d'Adrar (El Mansour, Charouine et Tmainout El Kbira) montre que, suite aux travaux de réhabilitation de leurs foggaras, les oasis avec des palmeraies sur plus de 600 ha et 3.000 palmiers dattiers ont pu être sauvés, d'autres palmeraies ont pu être sauvées comme témoigne le président de l'Association des Amis de Timimoun, septembre 2014.

Les travaux de sauvetage et/ou de réhabilitation de ce patrimoine culturel de l'eau qui permet de maintenir la vie dans le Sahara et le système traditionnel oasien sont pris en charge soit par l'Etat algérien soit par des partenaires nationaux[20] ou internationaux (UNESCO, PNUD et Commission Européenne notamment).

6 Conclusion

Vaste pays aride au quatre cinquième, en Algérie les populations ont toujours eu le génie de trouver des solutions de vie, voire de survie, y compris dans les sites les plus reculés. D'époque en époque, les héritages d'alimentation en eau, de construction d'ouvrages, parfois sophistiqués comme le système des foggaras, se succèdent. Depuis l'époque romaine avec la construction de réservoirs de stockage, de réseaux de distribution, de fontaines et de thermes, … jusqu'à l'époque ottomane où des ouvrages grandioses ont été érigés avec des aqueducs amenant l'eau depuis de longues distances pour alimenter les cités et répondre aux besoins des populations, le défi est permanent. Les sites romains sont labellisés par l'UNESCO, comme ceux de Djémila (1982) et les aqueducs font l'objet de classement au niveau national comme l'aqueduc de Zeboudja en 2008. L'époque coloniale française s'est d'abord intéressée aux zones rurales avec la construction de barrages, dont certains disparus aujourd'hui, d'autres demeurent dans un état de dégradation telle que leur réhabilitation coûterait plus que la construction d'un nouveau barrage. Le patrimoine de l'eau dans le sud algérien est le plus original car unique au monde pour le cas du système de captage des eaux de crues au M'zab à Ghardaïa, avec les anciens puits (dans l'oasis ou dans les ksours) qui méritent d'être réhabilités. De même les foggaras du sud ouest algérien, captant des eaux superficielles, ou de montagnes de l'Atlas saharien ou surtout des nappes fossiles qui affleurent, représentent un véritable patrimoine qui mérite une attention particulière et au moins une inscription au patrimoine national.

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[20] Les services de l'Etat contribuent avec des moyens financiers et humains, les propriétaires des foggaras fournissent la main d'œuvre et le savoir faire traditionnel nécessaire.

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Etude de cas N1
Les foggaras de la Vallée du M’zab

Le système de partage des eaux pluviales, particulier et unique au monde est situé à Ghardaïa dans la partie centrale du Sahara septentrional algérien. Ce système a été mis en place depuis plus de sept siècles, par deux savants et a permis aux Mozabites la mise en valeur de la vallée du M’zab depuis le XIe siècle. La vallée du M’zab avec ses cinq ksour dont Ghardaïa, est classée au patrimoine national (1971) et au patrimoine de l’Humanité par l’UNESCO en 1982. Avec son paysage historique et sa culture, elle constitue le berceau d’une civilisation ksourienne millénaire. A l’origine, la sédentarisation dans la vallée du M’Zab était fondée sur le concept oasien avec l’association symbiotique dans un même lieu de trois éléments fondamentaux : l'eau, la palmeraie et le ksar, éléments contigus, l'un protégeant l'autre et l'un profitant des effets positifs de l'autre; ce qui a permis à l'homme de vivre et de s’adapter aux conditions environnementales de l'hostilité saharienne des siècles durant. De nos jours la vallée du M’zab est une référence dans la parfaite harmonie entre l’organisation sociale, le système d’urbanisation, la typologie architecturale, la maîtrise des ressources hydriques et l’équilibre écologique. Le label de l’UNESCO lui est dédié pour l’ingéniosité du système d’urbanisation dans la maîtrise de la structuration territoriale et le savoir-faire architectural.

Le système hydraulique consiste à récupérer, en amont de la palmeraie, les eaux des crues dans des canaux, qui vont par la suite les acheminer vers l’ouvrage de partage des eaux, (photo 9a et 9b) pour l’épandage dans les parcelles agricoles et le remplissage de la nappe. Ce système est subdivisé en deux parties essentielles où l’une collecte et canalise les eaux ruisselées vers l’ouvrage de partage, et l’autre distribue équitablement, dans les jardins de la palmeraie les eaux collectées. Les Oumanas Essail, association séculaire, assure le contrôle du fonctionnement du système traditionnel et de son entretien.

Photos 9a et 9b. Arrivée de l’eau dans l’exutoire canal Bouchemdjen (Y. Djellouli, 2009)

On note deux éléments fondamentaux dans cet aménagement ancestral : des diguettes et des puits capteurs.

- Une série de diguettes installées le long de l’oued, dans la traversée de la palmeraie, ayant un rôle important en cas de fortes crues. Les Oumanas essail comptaient 15 diguettes, dont il ne reste trace que de trois ouvrages où seuls deux sont fonctionnels.

- Une série de puits capteurs d'eau qui atteignent le Turonien et qui ont la faculté d'absorber toute l'eau qui leur est déversée. Ces puits sont alimentés soit par le réseau de canaux de l'ouvrage de partage, soit par l'effet des seuils d'épandage des diguettes. Notre enquête auprès des Oumanas essail (février 2010), indique que la palmeraie de Ghardaïa comptait plus de 120 puits capteurs, aujourd'hui dégradés pour la plupart.

Tous ces aménagements hydrauliques ingénieux méritent d'être plus valorisés pour récupérer tous les ruissellements, de la taille la plus faible jusqu'aux eaux de crues dévastatrices. La moindre goutte d'eau ruisselée en amont est récupérée dans des canaux et déviée vers l'ouvrage de partage des eaux pour la submersion des jardins. En cas de crues, l'excédent d'eau est complètement recueilli. Malheureusement, ces puits de captage ont été abandonnés, voire détruits ou remplis de béton. Des associations locales œuvrent pour leur réhabilitation.

Ce système de partage des eaux a continué à être unique jusque dans les années 1960. Depuis, la population ne cesse d'augmenter, entraînant l'extension de nombreuses parcelles agricoles, sur des sols arides, irriguées par l'eau fossile. Les travaux hydrogéologiques (ANRH) montrent que la région de Ghardaïa satisfait ses besoins en eau potable et pour l'irrigation à partir de la nappe du Continental Intercalaire et du complexe terminal. Pour répondre à la demande en eau, des moyens importants sont déployés pour mobiliser des capacités de plus en plus accrues. De plus, le nombre de forages augmente de dix par an (on compte 288 forages en 1999 et 379 en 2008), et des milliers de puits agraires puisent dans les nappes directement. Pour préserver la ville de Ghardaïa des événements exceptionnels comme l'inondation d'octobre 2008, des aménagements ont été proposés. La canalisation de l'oued M'zab qui traverse la ville et la « bétonisation » du lit mineur, sont des aménagements coûteux qui ont montré leurs limites. Ces actions menées rapidement, ne sont pas en adéquation avec la démarche du développement durable, alors que depuis des siècles d'ingénieux ouvrages respectaient l'environnement et répondaient à la demande sociale.

Etude de cas N2
Les foggaras du Sud-Ouest algérien

Les foggaras du sud ouest algérien (figure 5) comme celles du Touat, de Gourara et de Tidikelt (sud-ouest du Grand Erg Occidental) captent les eaux de la nappe fossile albienne[21] qui affleure dans cette région et qui alimente aussi les forages et les puits (Bisson 1958 et 1992; Gaillermou, 1993). Le plateau de Tadmaït constitue un véritable château d'eau.

Selon Dubost et Moguedet (1998), les oasis du Touat comptent 531 foggaras, dont 358 en activité. Les superficies irriguées par cette technique varient entre 7.000 ha et 3.000 ha, dont la production agricole est très variée avec des cultures « à trois étages » : le palmier dattier, les fruitiers et les céréales, légumineuses, cultures maraîchères, l'écoulement est souvent continu toute l'année, mais présente quelques interruptions.

Dans la région d'Adrar presque 300.000 personnes utilisent en agriculture les systèmes d'adduction de l'eau produite par les foggaras (photo 10).

Photo 10. Jardins de la région de Reggane irrigués par les foggaras (Association Yeu-Mali, 2009)

Dans quelque cas, les habitations sont rafraîchies par les galeries souterraines et alimentées par les ramifications d'eau potable. Un articulé système de répartition et calcul de la distribution hydraulique selon une répartition horaire ou continue du flux intéresse le réseau tout entier des cultures qui résulte par conséquent influencé dans sa forme, ses qualités esthétiques et sa valence symbolique. En général, le point de débouche de la galerie est significatif autant au point de vue sacral que de l'habitat. A savoir, il est caractérisé par mausolées, fontaines, vasques pour l'eau ou d'autres monuments.

[21] Il s'agit des eaux de la nappe du Continental Intercalaire du domaine du Système Aquifère du Sahara Septentrional vaste système partagé avec d'autres pays maghrébins (Libye et Tunisie) et qui couvre une superficie de près de 700.000 km^2 en Algérie.

Les foggaras de l'Erg captent les eaux de la nappe formée sous le Grand Erg Occidental, eau qui s'écoule lentement sous l'Erg, dans les anciens cours d'eau en provenance de l'Atlas saharien. Le débit est stationnaire durant toute l'année (contrairement aux foggaras de l'Albien), l'eau est moins salée et de bonne qualité. Elles sont une centaine dans la région de Timimoun, dont moins de 80 sont fonctionnelles. Pour certaines foggaras il est difficile de connaître leur longueur exacte; les galeries et les puits se perdant sous les dunes du Grand Erg Occidental. Ce type de foggara est fortement menacé par le phénomène d'ensablement (Remini et *al.*2010 et Bellil, 2002). Six des foggaras constituent un cas particulier puisqu'elles sont creusées en aval des grandes foggaras de l'Albien dans des oasis de Timimoun : elles captent uniquement les eaux d'infiltration et de drainage des eaux d'irrigation en provenance des jardins en amont.

La foggara de Moghrar, située au piedmont sud de l'Atlas saharien, constitue un cas particulier unique en son genre, Elle semblent être à son dernier stade de conservation en raison de l'assèchement de la nappe initiale qui l'alimentait de manière naturelle (sources de bassin versant du Mont des Ksours, de l'Atlas saharien). Elle déverse l'eau dans le madjen (réservoir) collectif situé dans la palmeraie, avant d'atteindre le réseau des seguias qui distribue l'eau dans les jardins. Pour préserver cette foggara, excellent ouvrage, les habitants et les services des eaux ont fait appel à un forage qui utilise les canalisations, canaux, rigoles et bassins de l'ancienne foggara.

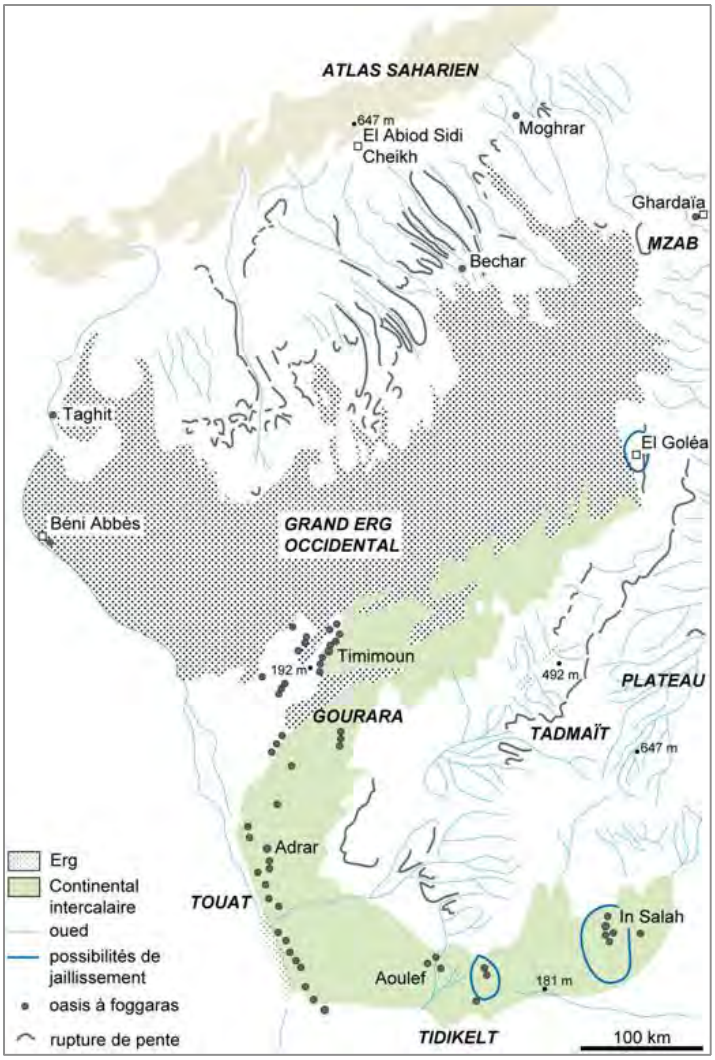

Figure 5. Foggaras du sud-ouest algérien repris de Bisson, 1999

On note aussi le cas de la foggara de l'Erg qui capte les eaux de la nappe formée sous le Grand Erg Occidental, grâce à l'eau qui s'écoule lentement sous l'Erg, dans les anciens cours d'eau en provenance de l'Atlas saharien. Son débit est stationnaire durant toute l'année (contrairement à la foggara de l'Albien), son eau est moins salée et de bonne qualité. Une centaine de ces foggaras, dont moins de 80 sont fonctionnelles, dans la région de Timimoun. Mais il est très difficile de connaître la longueur exacte de ce type de foggara ; les galeries et les puits sont perdus sous les dunes du Grand Erg Occidental. Même les vieux oasiens n'arrivent pas à localiser le puits mère et même une partie de la galerie. Ce type est fortement menacé par le phénomène d'ensablement (Remini et *al.*2010 et Bellil, 2002).

Les foggaras de la montagne alimentées par la nappe phréatique sont rares. Il en existent encore quelques unes (Remini et *al.*, 2010) comme celle de l'oasis de Taghit dont les eaux de ruissellement proviennent du Djebel Marhoma dans la région de Beni Abbès. La foggara est caractérisée par une longueur de la galerie de moins de 1 000 m. et plus large par rapport aux foggaras de l'Albien. Elles sont malheureusement abandonnées actuellement.

Les patrimoines culturels de l'eau, l'exemple de la Tunisie

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1 Caractéristiques générales

La Tunisie appartient à la sous-région Maghreb. Couvrant une superficie de 163 610 km2, elle a un climat qui varie grandement selon les régions et qui est de type méditerranéen au Nord et le long des côtes, semi-aride à l'intérieur du pays et aride au Sud. Elle fait partie des pays les plus pauvres en eau par habitant de la planète. En effet, selon l'*indice de Felkenmark* (eau disponible per capita) la disponibilité en eau, par habitant et par an, n'est que de 450m³ et, suite à la croissance de la population, elle est appelée à baisser encore dans les années à venir !

Figure 1. Pluie annuelle et apports des flux atmosphériques

1.1 Les données climatiques et hydrologiques générales

Avec une saison humide s'étendant de fin septembre au mois d'avril et caractérisée par une irrégularité des précipitations d'une saison à l'autre et d'une région à l'autre, la nature du climat a été déterminante dans l'occupation du sol et a conditionné le développement de l'urbanisation et l'évolution de l'urbanisme. Le volume global des pluies est, au total, faible en Tunisie. En effet, bien qu'il ne soit pas rare d'enregistrer de 1000 à 1500 mm par an dans certaines régions du Nord-ouest, les moyennes pluviométriques pour le reste du pays sont nettement plus faibles. Ces moyennes sont celles de plus des 2/3 du territoire national et oscillent entre 350 mm pour les régions relativement favorisées et 50 mm pour celles qui sont situées dans l'extrême Sud ! Cette pluviométrie capricieuse et peu abondante a engendré un réseau hydrographique relativement lâche et pour l'essentiel formé de cours d'eau à régime saisonnier. Même l'oued Majrada, de loin le principal cours d'eau du pays ne peut pas être qualifié de fleuve malgré ses 460 km de long, l'étendue de son bassin et le nombre élevé de ses affluents.

Cette carence en eau n'a pas empêché le pays de connaître une occupation humaine précoce et d'avoir une longue histoire. C'est ce qui a généré des patrimoines culturels liés à l'eau d'une valeur exceptionnelle et d'une richesse incomparable.

1.2 Relations culturelles et échanges techniques avec les zones voisines

Le patrimoine culturel de l'eau en Tunisie est à la fois le produit vernaculaire en réponse à un milieu défavorable à l'occupation humaine et le fruit d'échanges culturels et techniques avec des civilisations du pourtour méditerranéen, notamment la civilisation phénicienne et la civilisation romaine pour la période antique, la civilisation arabo-islamique pour la période médiévale et la civilisation européenne pour les périodes moderne et contemporaine.

2 Sites connus et sites importants du patrimoine culturel de l'eau

Cette place privilégiée pourrait être illustrée par le célèbre Hermaion d'El Guettar, petite oasis de la région de Gafsa dans le Sud-ouest tunisien. Connu de tous les spécialistes de la Préhistoire et datant d'environ 40 000 avant le Temps présent, il est considéré comme le plus ancien témoignage du sentiment religieux connu à ce jour. Il consiste en un amas de forme conique composé de galets grossièrement sphériques mélangés avec des silex taillés et des ossements d'animaux. Il a été érigé auprès d'une source, aujourd'hui tarie, par dépôts successifs en expression d'une dévotion au génie de la source.

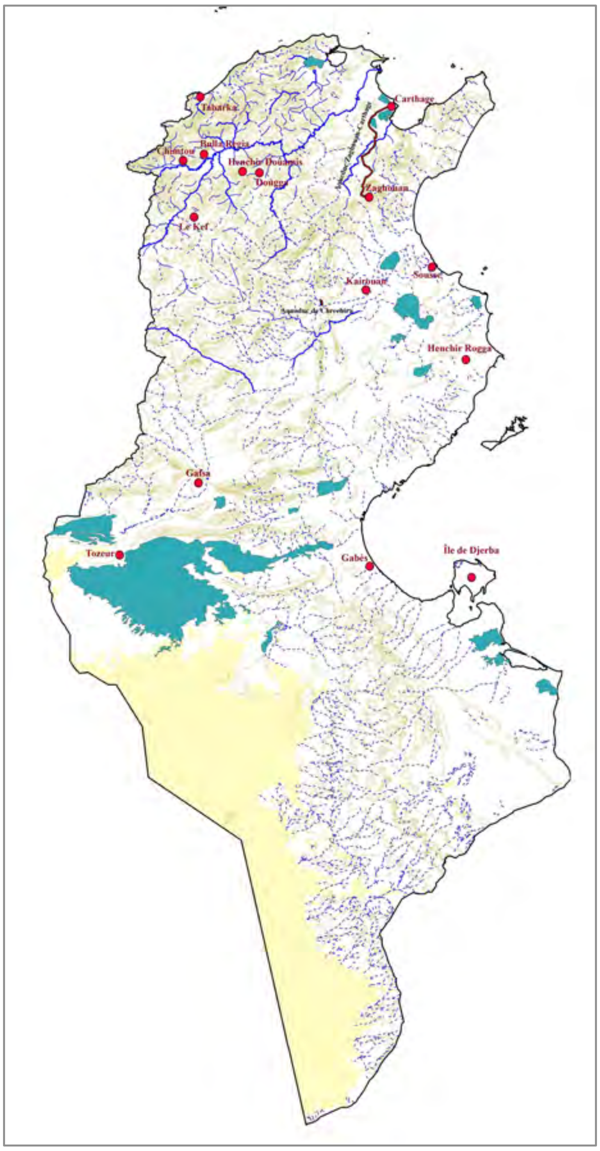

Figure 2. Tunisie, sites du patrimoine culturel de l'eau

Cette relation précoce avec l'eau s'est diversifiée avec le temps et a généré un riche patrimoine culturel d'une valeur inestimable et d'une grande variété typologique.
Comme il est aisé de l'imaginer, ce patrimoine a été d'une certaine manière une réponse aux contraintes du milieu naturel et aux besoins des hommes. Considéré dans son ensemble et avec ses différentes composantes, il mériterait d'être considéré comme l'une des formes les plus élaborées et les plus expressives du génie créateur de l'homme.

2.1 Le patrimoine culturel vernaculaire de l'eau

Il s'agit d'une catégorie qui, bien que modeste dans son aspect et rudimentaire dans ses techniques, ne présente pas moins un grand intérêt. Attestée principalement dans la partie méridionale du pays, elle a fourni la réponse à un milieu aride et à une pluviométrie avare. Selon les endroits, son but a été soit :

- **retenir les eaux** de ruissellement : les ***jessours***. Il s'agit d'un aménagement hydraulique qui est fréquent dans les régions arides du sud-est du pays. Il est d'autant plus nécessaire que les rares pluies sont souvent torrentielles engendrant des ruissellements violents et par voie de conséquence, une forte érosion. Aussi, pour pouvoir pratiquer l'agriculture, il a fallu barrer les ravins et les vallées pour retenir l'eau et le sol et maîtriser le ruissellement. La solution technique a consisté en une « belle invention » comme l'a qualifiée si joliment un grand géographe tunisien contemporain, celle des *jessours*, de petites levées de terre placées perpendiculairement à l'écoulement et munies de déversoirs et se succédant d'amont en aval et marquant de la sorte le paysage.

- **canaliser l'eau** des sources : les ***seguias***. Ce sont des canaux rudimentaires à ciel ouvert d'usage courant dans les oasis. Formant un réseau capillaire, ils permettaient l'acheminement de l'eau et l'irrigation des différentes parcelles. Avec le temps sa possession est devenue un moyen de pouvoir et un symbole de richesse valant, dans beaucoup de cas, plus que la possession de la terre.

- **capter les eaux** souterraines : les ***mkayel*** **(singulier :** ***mkoula*****)**. C'est un système d'une remarquable ingéniosité qui est attesté dans la région d'El Guetar, à environ 20 km à l'Est de Gafsa. Il consistait à capter l'eau d'une source artificielle et à la drainer en suivant une pente naturelle jusqu'à atteindre la surface du sol pour ensuite s'écouler en canaux à travers l'oasis et cela en creusant à intervalles plus ou moins réguliers des puits reliés par une galerie souterraine permettant à un homme courbé d'y circuler pour pouvoir assurer l'entretien. Ce système n'est pas cependant propre à cette région. Il se retrouve en Tunisie, dans le Nefzaoua sous le nom de *khrija* et sous des appellations différentes dans d'autres pays comme par exemples le sud algérien (*foggara*), le sud marocain (*khattara*), le sud-est de la péninsule arabique (*aflaj*), l'Iran (*karez*).

2.2 Les sites à caractère archéologique

Leur nombre est incalculable en Tunisie et leur datation couvre une très longue période allant de l'Antiquité jusqu'à la période contemporaine. Les plus anciens vestiges de cette catégorie de patrimoine archéologique sont constitués par les citernes découvertes dans les maisons puniques à Carthage et à Kerkouane et dont la datation se situe entre le IVe et le IIe siècle avant J.-C. Ce savoir-faire punique a été introduit en pays numide comme en témoignent les exemples de ce type qui ont été identifiés dans le site de Dougga et la batterie de citernes retrouvées dans la forteresse punique de Kalaat Bezzaz, dans la délégation de Oued Meliz, dans le Nord-ouest du pays. Cependant, c'est la période romaine qui a marqué d'une empreinte indélébile le sol avec le nombre impressionnant des installations hydrauliques disséminées à travers tout le pays et qui se caractérisent par leur richesse typologique et dont l'exemple le plus élaboré est, sans conteste, le complexe hydraulique Zaghouan-Carthage avec ses trois composantes principales, à savoir le grand nymphée de départ, l'aqueduc long de plus de 130 km et les grandes citernes de stockage.

Figure 3. Dougga, fontaine romaine de Terentius (M. Khanoussi)

Ce patrimoine archéologique des époques antique et médiévale consiste principalement en des :

- **bassins de captage** qui étaient nombreux mais dont la plupart a disparu suite à l'adoption de normes moderne et aux travaux de réfection.

- **puits** qui sont nettement moins nombreux que les citernes et dont certains sont de nouveau exploités après des siècles de comblement.

- **aqueducs**. Ils constituent l'apport le plus remarquable des Romains dans le domaine de l'hydraulique en Tunisie. Leur construction a été rendue nécessaire pour pallier au manque d'eau dans les villes qui a été engendré par la croissance de la population et, surtout, par la très forte augmentation de la consommation causée en partie par la multiplication des établissements thermaux publics.

  Il existe cependant quelques aqueducs ou portions d'aqueduc qui datent d'une époque plus récente comme par exemples, l'aqueduc de Chrechira dans la région de Kairouan datable de l'époque aghlabide ou le tronçon ajouté à l'aqueduc romain Zaghouan-Carthage à l'époque hafside pour amener ses eaux à la Manouba, dans la banlieue de Tunis.

- **citernes et bassins** qui forment le type le plus fréquent. On les trouve isolés, notamment dans les demeures privées, ou en batterie pour celles publiques. Certaines avaient une capacité de stockage impressionnante comme à l'exemple des citernes romaines de la Maalga à Carthage qui pouvaient contenir jusqu'à 44000 m3 ! D'autres, de capacité moindre, avaient cependant un rôle important dans l'approvisionnement de leurs villes en eau comme c'était le cas pour les citernes de

Bulla Regia, Carthage, Chimtou, Dougga, Henchir Douamis, Le Kef, Rougga, Sousse, ou Tabarka.

- **fontaines, nymphées, sbils** que l'on trouve en règle générale dans les agglomérations urbaines et qui jouaient à la fois le rôle de point d'approvisionnement pour ceux qui en avaient besoin et, aussi, d'éléments de décor et d'embellissement de la ville.

2.3 Les sites vivants, toujours utilisés ou partiellement réutilisés

Avec l'époque médiévale, une grande partie du patrimoine culturel de l'eau légué par la période romaine est tombée en ruine. Les besoins en eau durant cette période et jusqu'au début de l'époque moderne ont été satisfaits par les puits et, surtout, par les citernes privées et publiques, que l'on trouvait aussi bien en milieu urbain, qu'en milieu rural. Un autre type dont l'origine semble remonter à la période antique et qui a connu une large diffusion durant la période médiévale dans les régions du centre et du sud du pays est constitué par les grands bassins à ciel ouvert dont l'exemple le plus connu est celui des bassins aghlabides à Kairouan qui constituent l'une des trois composantes du Bien inscrit en 1988 sous le nom de « Kairouan » sur la Liste du patrimoine mondial naturel et culturel avec les critères (i) (ii) (iii) (v) et (vi). La déclaration de la Valeur Universelle Exceptionnelle (VUE) du bien mentionne, quant à elle, le patrimoine de l'eau en précisant que : « Les Bassins des Aghlabides, un réservoir à ciel ouvert formé de deux citernes communiquant entre elles et qui remonte au IXe siècle, constituent un des plus beaux ensembles hydrauliques conçus pour alimenter la ville en eau ».

Avec l'instauration du Protectorat français en Tunisie en 1881, on assiste à un changement radical dans le rapport de l'homme avec l'eau. Comme l'écrit l'historien Béchir Yazidi, le « rapport à l'eau » de la population se modifie lentement. L'équipement hydraulique, décidé par les pouvoirs publics s'installe progressivement dans les villes. Toutefois, cette amenée massive d'eau va changer les pratiques et les comportements". Les besoins croissants amèneront la construction de grands barrages, la réalisation d'importants travaux d'adduction sur de longues distances et l'édification de réservoirs de grande capacité et des châteaux d'eau avec des matériaux nouvellement inventés (béton, béton armé). Toutefois hélas, cette catégorie de constructions peine encore à être reconnue comme ayant une valeur patrimoniale !

2.4 Les paysages culturels liés à l'eau

Pratiquer l'agriculture dans un milieu hostile est l'un des défis que l'homme a relevés au prix d'une ingéniosité sans borne et d'efforts physiques de forçats ! C'est ce qui a permis la création de nombreux paysages culturels liés à l'eau, notamment dans les zones arides et du pré-désert. Les oasis en constituent des exemples parmi les plus remarquables. À ce sujet, il convient de mentionner l'inscription de l'oasis de Gabès sur la Liste indicative du patrimoine mondial culturel et naturel et celle de Gafsa (voir étude de cas n°3) comme « Système Ingénieux du Patrimoine Agricole Mondial ». S'étendant sur des dizaines d'hectares, ces deux oasis sont le produit de la conjugaison de l'eau des sources et du labeur des hommes. C'est en effet la maîtrise millénaire de cette eau, de sa distribution au moyen d'un système capillaire de canaux en terre et sa répartition selon un mode de calcul d'une grande ingéniosité qui ont donné naissance à des espaces cultivés dans des milieux naturels très défavorables. C'est aussi l'eau qui a déterminé la forme de l'occupation du sol dans l'île de Djerba et qui en a fait le paysage culturel que l'on connaît aujourd'hui et qui vient d'être, lui aussi, inscrit sur la Liste indicative du patrimoine mondial culturel et naturel.

Une pluviométrie avare et l'absence de sources ont imposé pendant des siècles un mode d'occupation du sol très dispersé, les fameux *menzel* (champ agricole avec habitation) et ont obligé les habitants à s'équiper d'installations hydrauliques de petites dimensions pour recueillir et stocker les eaux des rares pluies qui tombaient.

3 Documentation existante

Le patrimoine culturel de l'eau en Tunisie est l'objet d'une documentation riche et variée qui comprend aussi bien des descriptions de voyageurs des époques médiévales (Hassen al-Wazzen alias Léon l'Africain, *Description de l'Afrique*. Paris, 1981 réimpression) et modernes (Victor Guérin, *Voyage dans la Régence de Tunis*. Paris, 1872), que des études scientifiques accompagnées de relevés d'architecture et de photographies (Gauckler P. (dir.), *Enquête sur les installations hydrauliques romaines en Tunisie*. 3 vol. Tunis, 1899-1904), sans compter les innombrables dessins peintures et même les films documentaires. Cette documentation demeure toutefois très dispersée et attend toujours de faire l'objet d'un inventaire exhaustif.

3.1 Inventaires du patrimoine culturel de l'eau, cartographie récente, bases de données, etc.

Il n'existe pas à ce jour un inventaire exhaustif et spécifique pour le patrimoine culturel de l'eau en Tunisie. Au lendemain de l'instauration du Protectorat français, un inventaire qui n'a porté que sur les constructions d'époque romaine a été réalisé. Sous le titre *d'Enquête sur les installations hydrauliques romaines en Tunisie*, ses résultats ont été publiés en trois volumes entre les années 1899-1904. Il a consisté en l'inventaire de ces installations avec une description le plus souvent sommaire accompagnée quelquefois de dessins et de plans schématiques.

3.2 Documents d'archives, sources écrites, cartographie et plans anciens, etc.

D'Ibn Chabbat, mathématicien et hydraulicien avant la lettre du XIIe siècle qui dans un traité célèbre a fixé le plan de partage des eaux et à l'optimisation de l'irrigation dans les oasis du Jérid dans le Sud-ouest du pays et qui est resté en application jusqu'à une date récente, aux documents d'archives conservés dans les établissements publics ou dans les collections privées, en passant par la riche documentation graphique réalisée par des brigades topographiques de l'armée française, c'est une très grande masse d'informations qui se trouve à la disposition de la recherche auprès des Archives Nationales à Tunis, ou dans les archives de l'armée de terre française au Château de Vincennes, dans les archives de l'Académie de Belles-Lettres à Paris et dans les archives de l'Université d'Aix-en-Provence.

3.3 Collections photographiques anciennes et récentes en relation avec le patrimoine culturel et naturel de l'eau

Les exemples les plus spectaculaires de ce patrimoine, tels que l'aqueduc romain de Zaghouan-Carthage, le grand nymphée romain de Zaghouan plus connu sous le nom de « temple des eaux », le bassin de captage antique de Gafsa, les bassins des Aghlabides à Kairouan, pour ne citer que les plus célèbres ainsi qu'une infinité de monuments de notoriété nettement plus modeste ont souvent retenu l'attention et ont bénéficié d'une documentation photographique appréciable. Elle demeure toutefois très dispersée et peu utilisée dans les études, alors qu'elle peut constituer une source d'information d'une grande valeur notamment pour évaluer l'ampleur des changements intervenus dans le domaine et pour étudier des monuments disparus depuis. La collection de photographies conservée dans la photothèque centrale de l'Institut National du Patrimoine à Tunis constitue, à cet égard, une mine pour les chercheurs étudiant le patrimoine architectural lié à l'eau.

3.4 Fouilles archéologiques, emplacement des résultats de fouille

De ce riche patrimoine, seulement un nombre extrêmement infime a fait l'objet d'investigations archéologiques. On peut citer à ce propos et à titre d'exemples les travaux de fouilles et de recherches qui ont intéressé :

- le complexe hydraulique romain de Zaghouan-Carthage ;
- l'aqueduc et les grandes citernes d'époque romaine de Chimtou (recherches inédites) ;
- l'aqueduc et les grandes citernes d'époque romaine de Dougga ;
- les citernes d'époque romaine de Bulla Regia, le Kef et Rougga, l'antique *Bararus* près d'El Jem, dans le Sahel ;
- l'aqueduc et les citernes d'époque romaine de Henchir Douamis (thèse de Doctorat. Tunis, Faculté des Sciences Humaines et Sociales, 2014) ;
- les nymphées et fontaines d'époque romaine en Tunisie (thèse de Doctorat. Paris, Université de Paris-Sorbonne, 2014).

Les résultats de ces recherches ont été publiés dans les revues scientifiques spécialisées telles que *Africa* (revue de l'Institut National du Patrimoine de Tunisie), les *Cahiers de Tunisie* (revue de la Faculté des Lettres et Sciences Humaines de Tunis, aujourd'hui Faculté des sciences Humaines et sociales) ou le *Römische Mitteilungen* (Revue de l'Institut archéologique Allemand de Rome). De nombreuses autres recherches ont consisté en des travaux de prospection dans différentes régions du pays et ont intéressé des installations hydrauliques datant des époques antiques et médiévales. Leurs résultats ont fait l'objet de mémoires de Mastère et de thèses de Doctorat encore inédits.

3.5 Conclusion sur la documentation la plus appropriée pour effectuer des études comparatives

La documentation la plus appropriée pour servir à des études comparatives est constituée par les inventaires, les études scientifiques et les photographies.

4. L'état de la connaissance historique et technique sur le patrimoine de l'eau en Tunisie

4.1 Périodisation du rapport de l'homme à l'eau

Les études effectuées depuis plus d'un siècle sur le patrimoine culturel de l'eau en Tunisie ont permis des avancées très importantes dans le domaine de la connaissance historique et technique des installations et aménagements hydrauliques. Si la présence humaine et l'occupation du sol remontent en Tunisie aux premiers temps de la Préhistoire, il a fallu attendre les temps historiques pour voir la construction des premières installations hydrauliques permettant à l'homme de ne plus rester à la merci des eaux vives, des sources ou des cours d'eau. Dans l'état actuel des connaissances, c'est aux Phéniciens venus de la côte orientale de la mer Méditerranée qu'il faut attribuer la première grande phase de construction des installations hydrauliques consistant en des puits et des citernes dont la grande majorité était à caractère domestique. Toutefois, c'est la période romaine qui, de loin, est celle qui a vu la multiplication de ce genre d'installations, leur extension géographique sur l'ensemble du territoire et la réalisation des ouvrages les plus élaborés sur le plan technique. Le savoir-faire ainsi acquis s'est poursuivi, mais avec une ampleur moindre, durant l'époque médiévale.

4.2 Etat des recherches actuelles concernant le patrimoine de l'eau et leur contexte

La recherche sur le patrimoine culturel de l'eau en Tunisie durant les différentes périodes historiques n'a cessé de retenir l'attention des chercheurs depuis la fin du XIXe siècle. Cette recherche a revêtu différentes formes : études archéologiques et historiques dont bon nombre avait un caractère académique, et inventaires (voir bibliographie).

5 Menaces s'exerçant sur le patrimoine de l'eau

5.1 Menaces s'exerçant sur la conservation des sites archéologiques, action de l'homme et action de la nature

Ayant perdu pour la plupart leurs fonctions premières, les installations hydrauliques des époques antique, médiévale et moderne ont cessé de faire l'objet d'entretien et de réparation et sont tombées en ruines. Leurs vestiges archéologiques sont aussi menacés de disparition suite à la conjugaison de nombreux facteurs dont les principaux sont l'urbanisation et l'extension de l'urbanisme, la modernisation de l'agriculture et sa mécanisation. Que faire devant cette situation qui s'aggrave de jour en jour? Le plus urgent est d'étendre la protection juridique dont jouissent de nombreuses installations hydrauliques des époques antique, médiévale aux installations de type vernaculaire. Que l'on rencontre dans le sud du pays. Attestant de la grande faculté d'adaptation de l'homme à son milieu et de son génie créateur sans limite, ces installations ont été à l'origine de la formation des paysages culturels dont la valeur patrimoniale est incontestable.

5.2 Sites et biens en usage présent : pression des réaménagements récents et impact des techniques modernes d'exploitation et de gestion de l'eau

Depuis l'introduction dans le pays des techniques et matériaux modernes, le patrimoine culturel de l'eau hérité des périodes précédentes ne cesse d'être l'objet d'altération, dégradation et souvent même de destruction totale ou partielle. De même, la substitution généralisée d'une gestion étatique aux modes de gestion traditionnels a fortement contribué à ces atteintes.

5.3 Abandon d'usage ou manque d'entretien

L'extension sans cesse plus grande des réseaux d'adduction moderne et la généralisation de plus en plus grande de l'accès de la population à l'eau potable et d'irrigation à partir des réseaux publics ont engendré la négligence de l'entretien des installations hydrauliques traditionnelles et même, dans de très nombreux cas, leur abandon pur et simple.

5.4 Réutilisations inappropriées ou partiellement appropriées en regard de la conservation des patrimoines culturels de l'eau

Si un grand nombre de monuments hydrauliques antiques sont aujourd'hui abandonnés et à l'état de ruines, d'autres ont trouvé une nouvelle utilisation qui s'avère dans bien des cas inappropriée. Dans les sites archéologiques de Bulla Regia, Dougga et Henchir Douamis, par exemple, des citernes d'époque romaine ont été restaurées et servent depuis de réserves pour les objets archéologiques et de dépôts pour le matériel et les matériaux. Dans la campagne de Chimtou, les vestiges de grandes citernes romaines, bien que classés « monument historique », sont réutilisés par les habitants du voisinage comme écurie pour leurs bétails. C’est, hélas, l’un de nombreux cas constatés dans le pays où la protection juridique n’est pas une garantie pour assurer la sauvegarde du patrimoine culturel bâti.

6 Protections légales en vigueur des monuments et des sites archéologiques ou historiques

La protection juridique ne concerne qu’une partie de ce riche patrimoine. Cette protection, à caractère général, est assurée par la loi 1994-35 du 24 février 1994 relative au code du patrimoine archéologique, historique et des arts traditionnels, plus connue sous le nom de « Code du patrimoine » et qui assure une protection juridique à ce patrimoine selon les prescriptions des articles 1 et 4. Un petit nombre de composantes de ce patrimoine bénéficie toutefois d’une protection juridique spécifique en tant que monuments historiques classés comme par exemples, les citernes romaines de la Maalga à Carthage par le décret du 12 mai 1901, les bassins de captage plus connus sous le nom de « piscines romaines » de Gafsa par le décret du 3 mars 1915, le temple des eaux de Zaghouan par le décret du 8 juin 1891, l’aqueduc romain de Dougga par le décret du 8 juin 1891. Un nombre infime est classé patrimoine mondial comme les installations hydrauliques appartenant aux sites archéologiques de Carthage, Dougga et Kerkouane et aux médinas de Tunis, Kairouan et Sousse, ou comme l’oasis de Gafsa qui est classée « Système Ingénieux du Patrimoine Agricole Mondial de l’UNESCO ». D’autres figurent sur la Liste indicative du patrimoine mondial comme c’est le cas pour les installations hydrauliques de l’île de Djerba, de la médina de Sfax, d’une partie des composantes du complexe hydraulique de Zaghouan-Carthage et des carrières antiques de marbre numidique de Chimtou.

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Etude de cas N1
Le complexe hydraulique de Zaghouan-Carthage

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Classé sur la Liste indicative du patrimoine mondial culturel et naturel et classé « monuments historiques » par les décrets du 8 juin 1891, 24 mars 1892, 12 mai 1901, 16 novembre 1928, et 27 août 1953, il s'agit du plus grand complexe du genre jamais réalisé en Tunisie et l'un des plus importants de l'Empire romain. Construit au début du IIe siècle après J.-C., son lieu de départ est situé sur le versant nord du jebel Zaghouan. Le complexe associe trois composantes essentielles : les captages de quatre sources principales avec dotation d'un cadre monumental, le grand nymphée et le bassin de captage de Aïn Jouggar, un aqueduc de 132 km dont de nombreux tronçons marquent à ce jour le paysage en de nombreux endroits avec des arcades de plus de 20 m de hauteur, et les citernes de stockage de la Maalga à Carthage, auxquelles il faut ajouter les grands thermes publics de Carthage, dits thermes d'Antonin, situés en bord de mer et qui constituaient l'aboutissement de l'ensemble.

Figure 1. Vue de l'aqueduc de Zaghouan-Carthage (M. Khanoussi)

Les bassins

Ils sont formés par :

- le « temple des eaux » qui est un monument de plan d'une grande originalité : une *cella* précédée de gradins donnant sur une cour semi-circulaire entourée à l'Est et à l'Ouest de portiques et au Sud d'un bassin en double cercle et encadré de deux escaliers

- et par le bassin de captage de la source de Aïn Jouggar. Englobé dans une forteresse byzantine, il est formé d'une exèdre couverte par une semi-coupole et pourvue de trois niches hautes et étroites. Une ouverture percée dans la partie inférieure de chaque niche permettait à l'eau de s'écouler dans l'exèdre pour prendre ensuite son chemin vers l'aqueduc.

L'aqueduc

Du grand nymphée sort la principale branche de l'aqueduc qui se dirige ensuite vers Mogurone où elle se joint à une deuxième branche venant de la source de Aïn Jouggar, longue de 33,64 km. Une troisième branche prend sa source à Aïn Jour et, à quelques kilomètres au nord de Mogurone, rejoint l'aqueduc. À partir du point de jonction, les trois branches constituent la conduite principale qui amenait l'eau jusqu'à Carthage. Le tracé de l'aqueduc est souvent à fleur du sol ; mais il est tantôt enterré, tantôt porté sur des piliers. Au total, 17 km du tracé sont portés, dans différentes sections sur des arcades. Long de 4,5 m, le pont-aqueduc sur l'oued Miliane et dans sa plaine reste le plus monumental. Son tronçon sur le lit de l'oued se distingue par ses deux étages d'une hauteur totale de 34 m. La conduite est dotée de dispositifs hydrauliques de contrôle, d'aération et de régulation dont les uns sont jusqu'à nos jours en bon état de conservation. Il s'agit essentiellement de regards généralement de forme circulaire et de bassins régulateurs. Protégés juridiquement suite à leur classement comme « monument historique » depuis la période du Protectorat français (1881-1956), ces vestiges qui sont conservés sur plus de 50% du parcours, appartiennent au domaine public. Leur conservation est assurée par les services de l'Institut National du Patrimoine.

Après un parcours total d'environ 132 km, l'aqueduc arrive à Carthage, dans les citernes de la Maalga, situées au nord-nord-ouest de la colline de Byrsa.

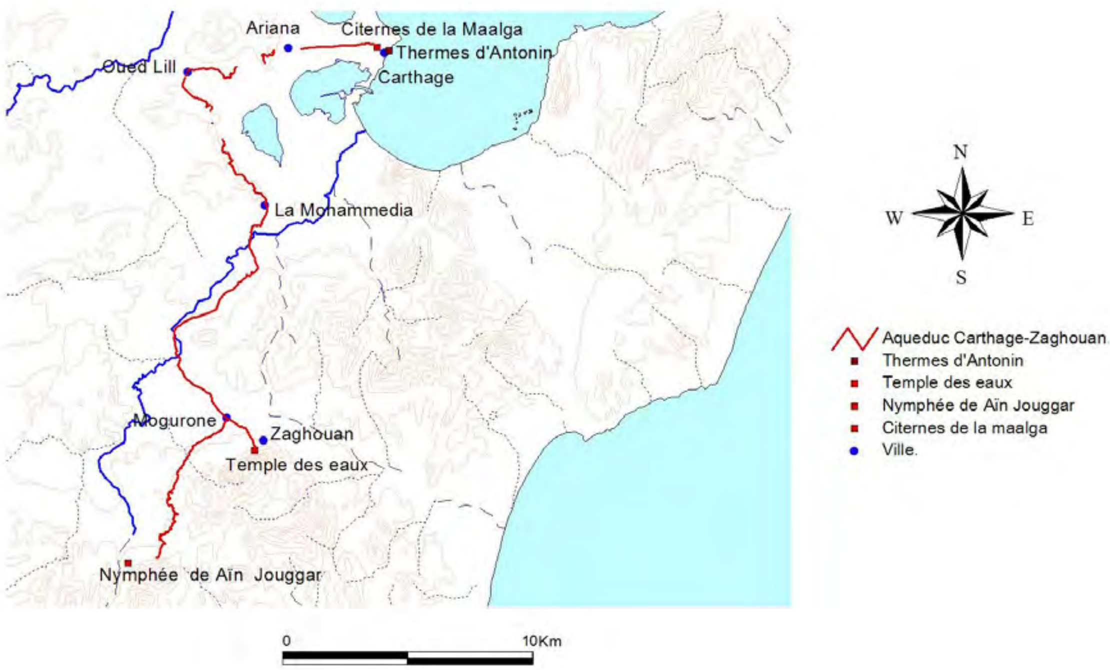

Figure 2. Plan indiquant le tracé de l'aqueduc de Zaghouan-Carthage

Les citernes de la Maalga

De forme rectangulaire de 130,75 m de long (Est-Ouest) et 101,95 m de large, l'ensemble est composé de seize compartiments dont quinze, sont accolés longitudinalement et le seizième se trouvant en position transversale. Exception faite du compartiment qui délimite à l'ouest le réservoir et qui a 90 m de longueur, les compartiments longitudinaux ayant, chacun, 100 m de long sur 7,40 m de large. Le compartiment transversal, d'orientation est-ouest ayant 132 m de long sur 3,5 m de large. Chaque compartiment est doté d'une voûte en berceau reposant sur des murs pleins. Des portes de communications sont percées dans les parties inférieures des murs mitoyens. Du côté nord, le mur extérieur de l'ensemble s'appuie sur le flanc d'une petite colline et, pour renforcer le monument, les murs extérieurs formant les autres côtés sont pourvus de contreforts. La capacité de ce réservoir est évaluée à 44000 m3. Bien que tombé en abandon depuis de nombreux siècles, il se trouve aujourd'hui dans un état de conservation relativement satisfaisant. Exception faite du compartiment transversal qui a subi quelques dommages et de quelques voûtes couvrant les compartiments longitudinaux qui sont en partie effondrées, le reste du monument garde encore intact son aspect d'origine.

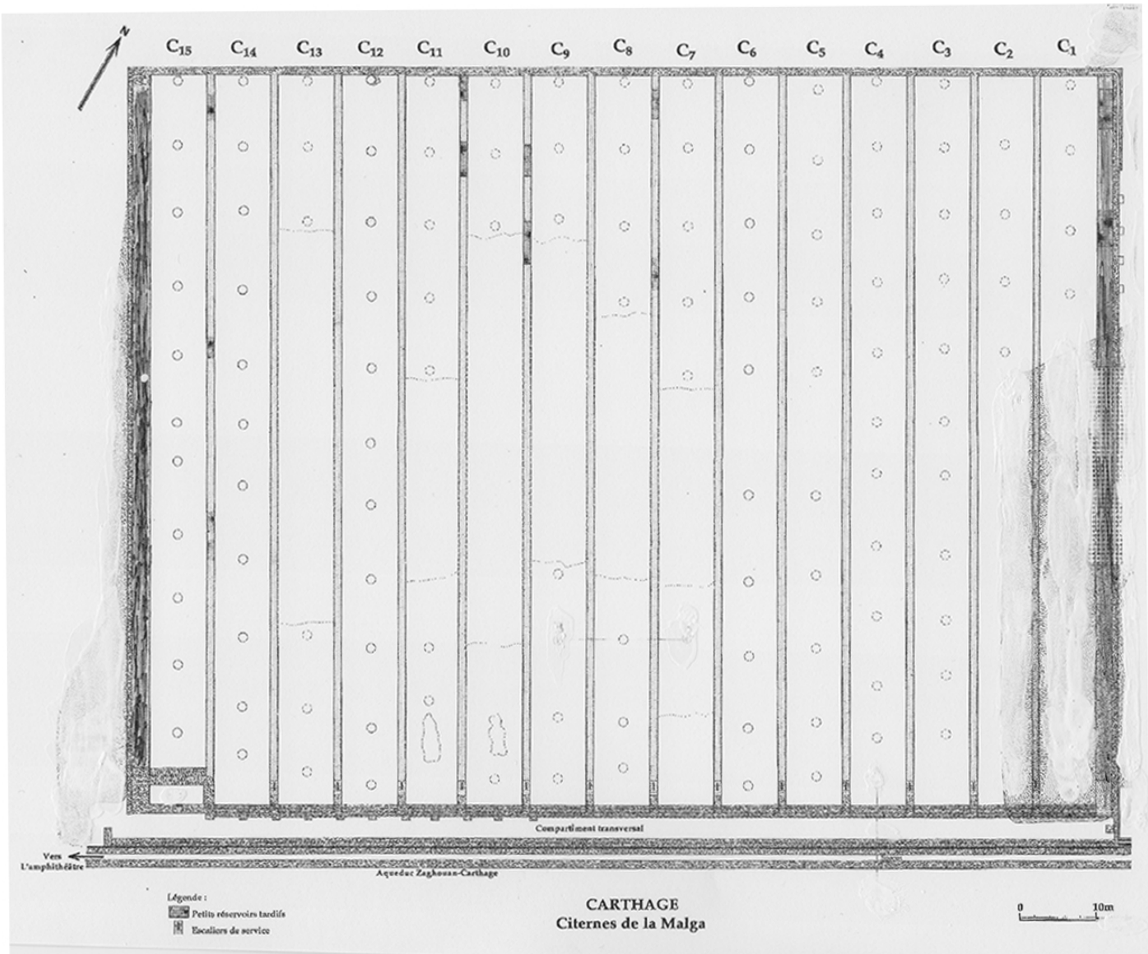

Figure 3. Plan général des citernes de la Maalga

Figure 4. Vue générale des citernes de la Maalga (M. Khanoussi)

Etude de cas N2
Les bassins des Aghlabides de Kairouan

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Classés « monument historique » par le décret du 3 mars 1915 et « patrimoine mondial » en 1988 avec la médina de Kairouan (critères (i), (ii), (iii) (v) et (vi) http://whc.unesco.org/fr/list/499), les bassins des Aghlabides, connus sous le nom de mawajil bab Tunis, sont situés à 750 m au Nord de la porte Tunis. Ils ont été construits sous le règne de l'Emir aghlabide Abu Ibrahim Ahmed entre (242- 249 H / 856 - 863 après J- C).

Le monument se compose de trois éléments principaux: un petit bassin, un bassin principal et deux citernes voûtées. Le petit bassin de décantation se trouve sur le côté nord du bassin principal. Il est de forme circulaire, mesurant 34,80 m de diamètre, 5m de profondeur, et est doté de 17 contreforts de l'intérieur et de 30 contreforts de l'extérieur avec une distance de séparation moyenne mesurant 3,10m et en alternance en termes de juxtaposition. A l'extérieur, le mur s'élève à 1,10 m du niveau du sol.

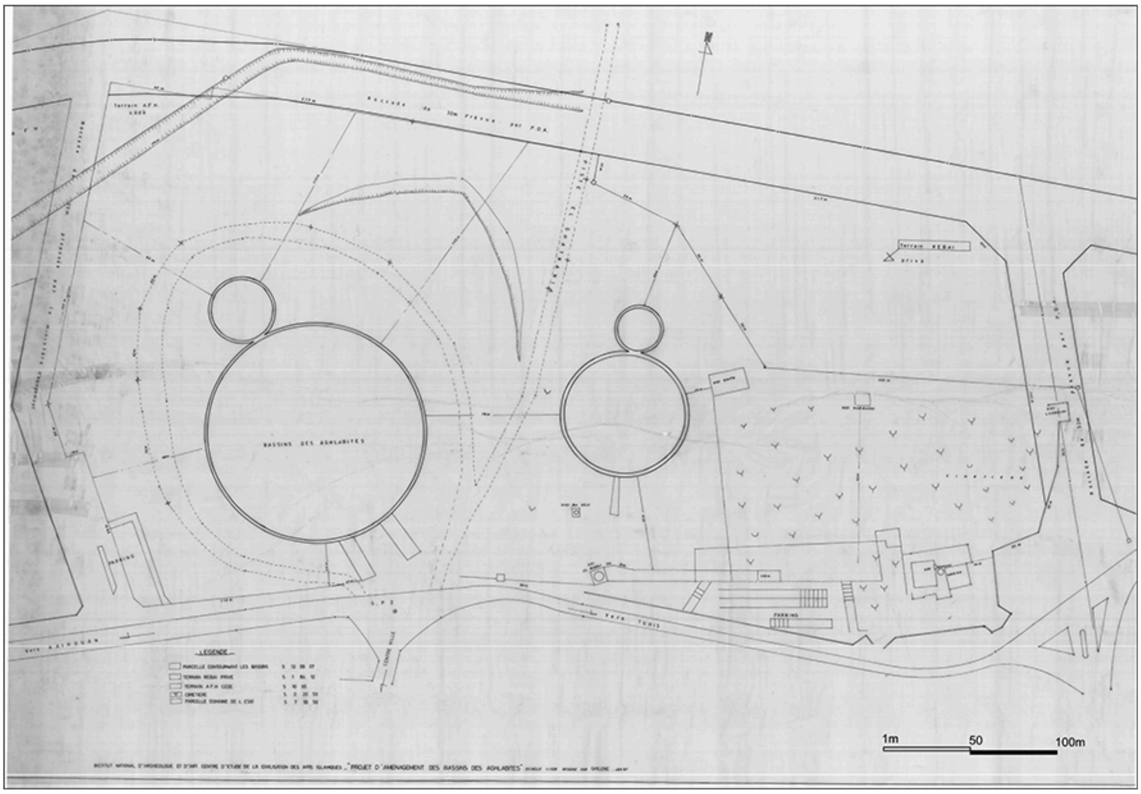

Figure 1. Plan des bassins des Aghlabides

Le bassin principal se trouve au Sud du petit bassin. De forme circulaire et mesurant 128m de diamètre et 4,80m de profondeur, il est entrecoupé de 64 contreforts intérieurs et de 118 contreforts extérieurs. Il est d'une capacité d'environ 57000m3. Dans sa partie centrale, était édifié un dôme sous lequel prenait place le prince, amené là par barque. Les colonnes de cet aménagement existent encore aujourd'hui.

Les deux bassins communiquent entre eux par une ouverture rectangulaire, aménagée dans le mur de séparation. Les deux bassins sont séparés par un mur d'une épaisseur de 1,50m, et qui s'élève au-dessus du niveau du sol extérieur d'environ 1,10m.

Les deux citernes de puisage sont parallèles et indépendantes l'une de l'autre. Situées au Sud du grand bassin, elles sont de forme rectangulaire et mesurent chacune de l'extérieur 32m de long et 10m de large. Le toit est couvert par de longues voûtes en berceau soutenues par des arcs sur des piliers à section carrée. Chaque citerne est reliée avec le grand bassin par une baie pour assurer le passage d'eau. Quatre escaliers de 4 marches chacun sont aménagés dans les quatre côtés de chaque citerne. Six orifices de puisage de forme rectangulaire sont aménagés dans la partie supérieure de chaque citerne. L'alimentation de ces citernes étaitt assurée par les eaux de pluie et par cellee de l'oued Merguellil.

Figure 2. Vue aérienne des bassins des Aghlabides (M.-S. Bettaïeb)

Les bassins des Aghlabides sont considérés comme les plus grands en Tunisie et dans le monde arabe. La période médiévale était très impressionnée par l'ampleur de l'ancienne architecture de l'époque antique. Cela a incité Abu 'Ubayd Allah al -Mahdi le Calife fatimide à dire: «j'ai vu deux choses en Ifriqiya que je n'ai jamais vu de comparable en orient: l'une c'est le réservoir qui est près de la porte de Tunis, et l'autre c'est le Qaçr el-bahar. Le château du lac qui se trouve dans la ville de Raqqada » (près de Kairouan).

Les bassins ont été l'objet durant la période husseinite de travaux de restauration, et ont continué à être exploités jusqu'au début de l'époque contemporaine comme cela ressort de la documentation des époques médiévale et moderne. Pour leur entretien régulier, un agent était en charge de la surveillance du remplissage et de la distribution de l'eau dans les différentes unités. Le souci majeur était toutefois leur remplissage en période de sécheresse!

Après avoir joué un rôle d'une grande importance dans l'approvisionnement de l'agglomération et cela en complément aux puits et aux citernes situés intramuros, les bassins aghlabides qui sont encore en bon état de conservation ont perdu leur fonction première et ne sont plus qu'une attraction touristique exploitée par l'Agence de Mise en Valeur du Patrimoine et de Promotion Culturelle (AMVPPC). Propriété publique, leur conservation est assurée par les services de l'Institut National du Patrimoine.

Etude de cas N 3
Le système d'irrigation dans l'oasis de Gafsa

Mustapha Khanoussi

Gafsa est l'oasis la plus septentrionale de la Tunisie. Sa partie historique est classée par l'Organisation des Nations-Unies pour l'Alimentation et l'Agriculture (FAO) « Système Ingénieux du Patrimoine Agricole Mondial » (SIPAM). Elle est le don de sources pérennes dont les eaux ont servi principalement à l'irrigation d'une agriculture étagée caractéristique des oasis qui a émerveillé les Romains. Dans son Histoire naturelle, l'auteur latin Pline l'Ancien s'est fait l'écho de cet émerveillement dans sa description de l'oasis de *Tacapes* / Gabès. Cette agriculture irriguée s'est développée grâce à une ingéniosité exceptionnelle et à des efforts répétés contre l'hostilité du milieu naturel. Le système d'irrigation repose sur un mode de gestion fondé sur deux principes essentiels : l'espace et le temps.

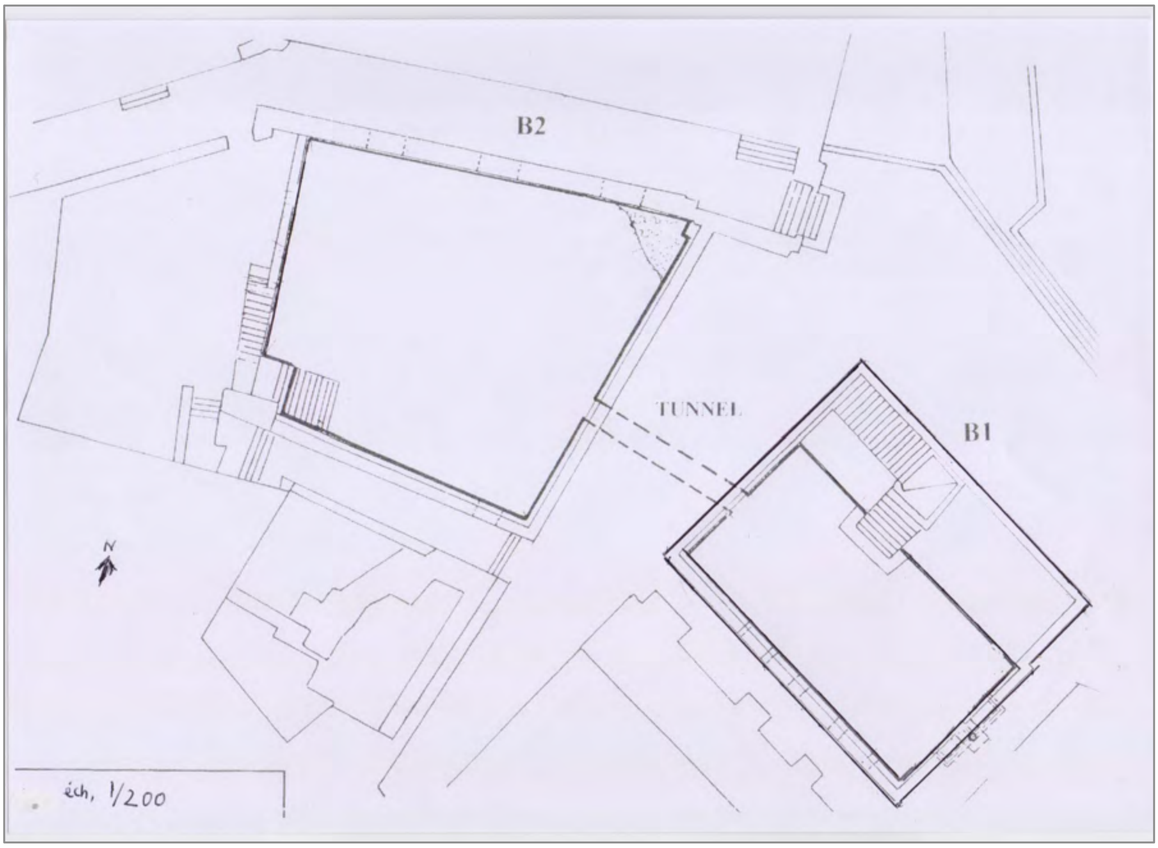

Figure 1. Plan général du complexe hydraulique de Gafsa

Pour l'espace, l'eau de chaque source principale constituait une branche de laquelle se subdivisaient des séguias (canaux à ciel ouvert) secondaires qui à leur tour se subdivisaient en séguias tertiaires et quaternaires formant un réseau capillaire qui quadrillait tout l'espace de l'oasis et permettant ainsi à l'eau d'arriver à chaque parcelle cultivée.

Quant au principe temps, un auteur anonyme du XIIe siècle dans un ouvrage intitulé *Kitab al istibsar* (Le livre de l'élucidation) rapporte que "les gens de Gafsa avaient dans l'irrigation de leurs vergers un grand génie avec des repères stricts et un calcul précis." Ce principe il était géré au moyen du *gadous*, terme d'origine latine (*cadus*) désignant la cruche en poterie. C'était un récipient troué au fond et qui, rempli d'eau, servait à mesurer le temps. L'eau était répartie entre les différentes parcelles par fraction de temps calculée avec le *gadous.* L'usage de cette horloge hydraulique a disparu aujourd'hui.

Figure 3. Oasis de Gafsa, bassin de captage antique après tarissement des sources (M. Khanoussi)

Figure 4. Oasis de Gafsa, canal traditionnel (M. Khanoussi)

La structure géologique de la région a favorisé la résurgence de nombreuses sources que les habitants ont classées en deux catégories :

- la grande eau englobant les sources publiques accessibles à tous et se trouvaient pour la plupart à l'intérieur de l'agglomération et dont les plus importantes étaient captées dans les deux bassins datant depuis l'Antiquité et appelés communément « piscines romaines » et oued el Kbir (le grand fleuve) et oued es-Sghir (le petit fleuve) ;
- la petite eau désignant des sources à débit faible appartenant à une ou à quelques familles seulement.

Un rite païen qui a traversé les siècles : le sacrifice sanglant à l'occasion du curage des bassins de Oued el Bey/ Piscines romaines

L'eau qui jaillissait des sources des « piscines romaines » était l'objet d'une attention particulière. Elle participait pour part importante à l'irrigation de l'oasis. Aussi, le complexe a été placé à l'époque romaine sous la protection du dieu Neptune et des Nymphes. Ce nom Neptune

(*Neptunus* en latin) ne devait pas désigner le Poséidon des Grecs, mais plutôt un génie berbère, protecteur des sources. Pour s'assurer sa bienveillance et ses bonnes grâces, des sacrifices sanglants lui étaient offerts à l'occasion du curage plus ou moins régulier des bassins. Dans une ambiance de fête et après avoir été parés et promenés dans l'oasis, des bœufs étaient alors immolés et leur viande partagée entre les membres de la communauté. Ce rite païen a traversé les siècles et a survécu à tous les changements. Il est resté vivace jusqu'à la fin des années 60 du siècle dernier. Comme pour les autres oasis, ce système d'irrigation plurimillénaire est devenu incapable de satisfaire les besoins d'une oasis qui a vu sa superficie s'étendre de manière notable. Ce rite qui a ponctué la vie des Gfasa depuis des millénaires a ainsi, suite au tarissement des sources de Oued el Bey, disparu à jamais et avec lui c'est une partie de l'âme authentique de l'oasis qui s'en est allée!

Si le réseau d'irrigation garde en grande partie son authenticité en dépit de l'introduction de l'usage de canalisation en ciment, c'est le mode de gestion traditionnel, à caractère communautaire, qui a disparu et qui est passé sous le contrôle direct ou déguisé de l'État. Ce réseau qui était la propriété collective de la communauté des propriétaires des parcelles dans l'oasis historique n'a plus personne aujourd'hui en charge de sa conservation. Une action de sensibilisation est entreprise par l'Association de la Sauvegarde de la Médina (ASM) en vue de garantir la protection de ce qui subsiste du réseau en tant qu'élément d'un Bien classé « Système Ingénieux du Patrimoine Agricole Mondial ».

Sub-region C: Egypt, North-Sudan, Eritrea

Water Heritage of Egypt and Nile Region

Water Heritage of Egypt and Nile Region

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1 General characteristics of the Nile region

1.1 Climate and Hydrology

The Nile is formed by three tributaries: the Blue Nile, the White Nile, and the Atbara. They join north of Khartoum to form the Main Nile. The river then flows northward through Lake Nasser, the second largest man-made lake in the world, before splitting into two major distributaries just north of Cairo, the Rosetta branch to the west and the Damietta to the east.

The Nile Valley in Sudan and Egypt is rainless during the northern winter. Between the period from 1900 to 1998, the Nile tributaries in the highlands of Ethiopia received a mean of 1,421 mm per year, with > 2000 mm in the southwest to around 1000 mm in the northeast, with about 70 percent of rainfall occurring between June and September. Most of the northern region falls under the influence of the northeast trade winds, which causes the prevailing aridity. By contrast, the more distant sources of the Nile in Equatorial Africa, located in parts of the East African lakes region and south-western Ethiopia, experience tropical climates with well-distributed rainfall. The Blue Nile contributes about 60 percent of the total flow of the Nile.

1.2 Cultural Relations and Technical regional Exchange

The Main Nile in Egypt and Sudan is the downstream part of the greater Nile Basin, which is shared among 10 riparian regional states. The transboundary character of the Nile requires coordination efforts to ensure an equitable, fair distribution of water, while at the same time ensuring that no harm is inflicted on any of the countries of the Nile Basin. This issue became a subject of international interest when irrigation projects in Egypt and Sudan required the regulation of the flow of Nile floods. Early in the 20th century when the British occupied both Egypt and Sudan, bilateral agreements and treaties were signed to ensure that the flow of water from its distant sources was not interrupted. By November 1959, Sudan and Egypt signed an agreement for the utilization of the shared waters of the River Nile. This agreement considers the rights of other riparian countries to the Nile waters. Since then, countries of the Nile basin have been engaged in regional co-operative activities: 'HYDROMET', 1967–1993; 'TECCONILE', 1993–1999; and 'Nile Basin Initiative (NBI) formally launched in 1999.

The NBI provided a unique forum for the countries of the Nile to put a co-operative process in place to realize tangible benefits in the basin and build a solid foundation of trust and confidence. By 2010, a final draft of the Cooperative Framework Agreement (the Entebbe Agreement) to be signed by all Nile Basin countries was prepared, with a few articles remaining under consideration. The Entebbe Agreement was signed by Uganda, Kenya, Tanzania, Ethiopia, Rwanda, South Sudan and Burundi. Egypt and Sudan did not sign it and the situation became complicated when Ethiopia began the construction of a mega dam on the Blue Nile. A period of tense relationships prevailed until the end of 2014, when reconciliatory statements and measures then paved the way to more effective cooperation.

2.a Water Archaeological Sites

The greatness of Egyptian civilization is the legacy of one of the first human achievements in the domain of irrigation farming on the banks of a great river. At that time, it was matched only by the Mesopotamian civilization, and was later followed by Indian and Chinese civilizations.

Figure 1. Location Map of Principal Water Heritage Sites

1 Alexandria; Underground cisterns, hammams.
2 Cairo: Rhoda Nilometer, sabils, cisterns, Al-Khalig, Magra Al-Ayoun Aquaduct, hammams.
3 Wadi garawi rockfill dam
4 El-Lahun Dam, Faiyum
5 Itsa Dam, Faiyum.
6 Giza ; Gisr Saladine
7 Wadi Tumeilat Canals of the Pharahs
8 Dandereh Temple, Nilometer.
9 Luxor, Karnak harbor, Madient Habu Harbor
10 Kom Ombo, Kom Ombo Temple Nilometer
11 Aswan, Elephantine Nilometer
12 Kharga Oasis, Ain Manawir Qanat.

Descending into Egypt from Equatorial Africa and Ethiopia, the Nile River has created a narrow, fertile floodplain providing the setting for agricultural developments and riverine transport that was necessary for the rise of Egyptian civilization.

The modern floodplain is surrounded by older and higher deposits belonging to earlier, mightier rivers that once flowed in a deep trench formed in association with the Great African Rift 25 million years ago.

Infiltrated with mud from distant sources of the Nile in Ethiopia and Equatorial Africa, the Nile River is an outstanding geological wonder and a salient feature of the African continent. Along its course in Egypt, the Nile is met by no tributaries and is characterized by a sinuous channel with traces of ancient parallel distributaries. In historical times, as it approached the Mediterranean, the main channel divided into numerous channels forming a distinct deltaic plain. Today, only two branches are recognizable; other branches have either been silted up or converted, in part, into canals.

Figure 2. Nile cultural landscape, Aswan (Fekri Hassan)

The Nile floodplain was occupied in prehistoric times by inhabitants that subsisted on foraging, hunting, fishing, and fowling, and it was transformed into a remarkable cultural landscape after the advent of agriculture 7000 years ago. Early farmers contended with the rise of Nile flood waters in the summer and the dramatic fall in water level during winter. To overcome problems due to excessive or reduced amounts of water than required for the course of the agricultural cycle, an ingenious system was perfected over the years. Drains were dug to prevent water logging, and irrigation canals were excavated to carry water to high grounds at the edge of the floodplain. Cross-embankments perpendicular to the floodplain were constructed to slow water movements northward following the slope of the land. Water was then allowed to flow northward to irrigate the fields following the northward, seaward slope of the floodplain.

Numerous waterworks and structures testify to key developments in the long water history of Egypt.

2.a.1 Nilometers

The oldest Nilometers are associated with the temples at Philae, Elephantine, Madinet Habu, Dandra, Karnak, and Kom Ombo. The Greek geographer Strabo (ca. 63 B.C.-A.D. 20) gave an accurate description of the Nilometer.

There are two Nilometers at Elephantine Island. The most famous one is a corridor Nilometer associated with the Temple of Satis, with a stone staircase that descends along the corridor. It is one of the oldest Nilometers in Egypt, last reconstructed in Roman times, and was still in use as late as the 19th century CE. Ninety steps lead down to the river and they are marked with Roman, Demotic, and Hieroglyphic numerals. Inscriptions near the water's edge were carved deeply into the rock during the 17th Dynasty (ca. 1550 BC). The Nilometer was restored in 1870 by Khedive Ismael. The other Nilometer is a rectangular basin located at the island's southern tip, near the Temple of Khnum and opposite the Old Cataract Hotel, and is probably the older of the two.

Figure 3. Elephantine Nilometer, Aswan (Fekri Hassan)

The Nilometer on Philae Island, south of Aswan, now moved from its original location, is a staircase with graduations carved on its internal walls.

In 2010, excavations in the Avenue of the Sphinx in Luxor revealed the remains of a Nilometer, which contained a collection of New Kingdom clay vessels. Constructed out of sandstone, the Nilometer is a cylindrical structure, seven meters in diameter, and has spiral steps that once led to the Nile inlet.

The Nilometer in the temple of Dandereh is located to the west of the temple of Hathor. It consisted of a staircase in a rectangular well.

Further north, there is a spectacular Nilometer in the north-western area of the Temple of Kom Ombo. It consists of a circular shaped well, connected to a smaller water well, and it was constructed during the Roman period.

Today, the most well-preserved Nilometer as a heritage site and monument is certainly the Rhoda Nilometer (see case study n°1).

2.a.2 Historical Dams

- **Sadd el-Kafra, Wadi al-Garawi** (see case study n° 2)
  One of the earliest outstanding achievements is the first rock-fill dam at Wadi al-Garawi, the Sadd el-Kafra (سد الكفرة) dam, located 10 km southeast of the Helwan suburb of Cairo Egypt.

- **The Middle Kingdom Hydraulic Project** (see case study n° 3)
  The Middle Kingdom dam at El-Lahun, for hydraulic control in the Faiyum Depression, was a important project constructed in the Second Millennium BC.

  Contrary to the common belief that the Faiyum Depression, located in the desert south-east of the older capital Memphis, was used as a reservoir to hold water during periods of high floods to be re-directed during low Nile events to the Nile floodplain, the lake level was actually maintained well below the level of the connecting channel to allow back-flow into the Main Nile channel. The myth was a result of the misinterpretation of a statement by Herodotus. Recent investigations have revealed that after the lake was filled to the required level, sluices in the dam at the entrance of the inlet channel were closed. Excess floodwater was stored in an artificially-dug, narrow and elongated reservoir in front of the dam to prevent over-flooding of the floodplain and which could be used through a canal that ran along the desert edge of the Nile floodplain, from Faiyum to Memphis, to provide water to the pyramid funerary towns and farming villages.

- **Itsa Dam and Lake El-Mala'a**
  In addition to the Middle Kingdom dam at El-Lahun, another dam extends over 8 km between Itsa and Shidmuh, in the southeast part of the Faiyum Depression. The basin of El-Malaa now under cultivation was covered by a lake created by the dam as early as the 3rd cent. B.C.

Figure 4. Itsa-Shedmu Dam, Faiyum (Fekri Hassan)

- **Saladin Giza Embankment/Barrages جسر صلاح الدين ألايوبي بالجيزة**
  Constructed under the Ayyubid Saladine in 1173, this was a remarkable construction consisting of an arched embankment to control the water level in the Pyramid's Canal (now Khalig al-libini) between the Pyramids of Giza and the Nile opposite Fustat. It had 40 wide arches and stretched over 6 miles. It was converted into a barrage making it possible to irrigate Giza when the Nile was only 12 cubits high, compared to 18 earlier. It was maintained and restored in Mameluk times, but was eventually destroyed when the Ismael opened the road to the Giza Pyramids in 1869. Another embankment was built by Mameluk Sultan Qait Bey in 1480 on the Zumur Canal, at the start of the Pyramids Street. It was also destroyed in 1869.

- **Abu al-Manga Barrage**
  This barrage was constructed by the Mameluk Sultan Baibars in 1266-1267 to contain water during the flood season in order to increase water level so that the lands of Sharqyia could be easily irrigated. It had sluices that were closed and opened as needed. It was restored in 1487, though the Al-Manga canal has since silted up and the barrages have been destroyed except for a small part which still carries the lion statues of Sultan Baibars. The remaining part was restored by Khedive Abbas Helmi II.

2.a.3 The Wadi Tumilat Canal of the Pharaohs

The legacy of digging navigable canals in Egypt goes back to the excavation of five canals, during the reign of Pepy I (2321-2287 BC), in the granitic rock of Nubia to allow the passage of large floats and barges loaded with huge blocks of granite. However, the kings of the 12th dynasty of the Middle Kingdom (2055-1985 BC) are believed, on the basis of an account by Aristote, to have initiated the process. In addition to their remarkable achievements in dam building in the Faiyum, they undertook the excavation of a great navigable waterway that connected the Nile at Heliopolis, north of Memphis, to the Red Sea. An older branch of the Nile used to run along this line, but would have been silted during the low Nile period of the First Intermediate Period, which began earlier under Papi II (2278-2184 BC). Ships had to be dismantled and transported on land to the Bitter Lakes, then connected with the open sea through a natural waterway where they were reassembled. By the Middle Kingdom (2055 - 1650 BC), the southern part of this route had silted up. Trips to Punt on the Red Sea Coast of the Horn of Africa under Mentuhotep III (2004-1992 BC) had to be reached through Wadi Hammamat across the Red Sea Hills in Upper Egypt.

Undaunted, the kings of the Middle Kingdom apparently took on the task of restoring navigation from the Nile to the Red Sea, a project as ambitious as the digging of the Suez Canal in modern times.

The Canal of the Pharaohs was likely still navigable during the reigns of Hatshepsut and Thutmose III (1473-1425 BC), who made intensive use of their navy for both economic and military ventures. However, the canal was subject to siltation due to fluctuations in Nile flood levels and, at times, a lack of maintenance. The canal was re-excavated under the Egyptian Pharaoh Necho II (610-590 BC) and work was resumed on the canal during the Persian occupation of Egypt under Darius I (522-486 BC). A stela, one of four commemorating the construction of the canal by Darius I, was located at Wadi Tumilat. The canal was reactivated again under Ptolemy II (285-246 BC), who fitted the canal with a lock to remedy the difference between the sea water level and the level of the canal around 274/273 BC, and a trench 100 feet wide, 30 feet deep and about 35 miles long was dug as far as the Bitter Lakes.

In the 2nd century AD, the canal was still in use and was dubbed the "River of Trajan" by Ptolemy the Astronomer. The canal remained in use until it suffered from silting during the 7th century AD, but was then re-excavated soon after the Arab conquest of Egypt in 641 or 642 AD by Amr ibn al-'As. In 767 AD it was closed on purpose by one of the rulers in order to stop supplies reaching Mecca and Medina. The canal was discovered in 1799 during the Napoleonic Expedition.

2.a.4 Nile Harbours

Although harbours on the Mediterranean Coast and the Red Sea Coast range in date from the 4th Dynasty to Late Antiquity, very few Nile River harbours or quays have been found apart from those at Karnak and Birket Habu.

The great artificial harbour of the palace-city of Amenhotep III (1390-1352 BC) is located at western Thebes, known as Birket Habu. The basin, about 2.5 km by 1.0 km wide and more than 6.0 m deep, was excavated and connected to the river by a navigable canal. At present, the basin is about 2.5 km west of the course of the Nile, as the Nile shifted eastwards. Over the past 3,000 years the basin has gradually silted up until it almost reached the level of the surrounding floodplain.

In Karnak, Luxor, over 250 m of a great embankment built to protect the temple from high floods was discovered. The embankment was constructed of 14 courses of sandstone blocks and the width of the wall was 1.60 m. The embankment linked into the tribune, which was probably built at the same time. This seems to have been some time after Dynasty XXII (945-715 BC), and was modified by Taharqa of Dynasty XXV (690-664 BC). The upper parts of the embankment seem to have been restored during the Greco-Roman period.

Figure 5. Nile Harbor, Karnak Temple, Luxor (Fekri Hassan)

2.a.5 Qanats

Outside the Nile Valley, one of the key principal developments in hydraulic structures was the excavation of qanats سرداب . قناة. These are subterranean tunnels with a slight slope leading from a source of water to a lower, cultivable area. They are dug through the use of several digging shafts at close intervals which had to be maintained against wall collapse, wind-blown sand,

and siltation. A spectacular example is located at Ain Manawar, in the Kharga Oasis, with archaeological evidence dating from the reigns of Artaxerxes I (465-424 BC) and Darius II (424-405 BC) of the Persian Dynasty, though the area was then abandoned at the time of Nepherites I during the 29th Dynasty (399-393 BC).

Notable qanats are also found in Dakhla, Baharia and Farafra Oases. Some are still flowing with water and should be conserved.

2.a.6 Aqueducts

Aqueducts, widely associated with the Roman period in many parts of the world, were adopted by Ibn Tulun (868-883 AD) in order to convey water over a distance of 2.5 km from a well supplied by a water pool (Birket el-Habash) located south of the first Islamic capital Al Fustat, south of modern Cairo, to supply water to the inhabitants of a cemetery (Al-Qarafa al-Soghra). Water was carried by a water conduit, 48 cm wide, above an arched aqueduct.

Figure 6. Magra el-Ayoun Aqueduct, Misr el-Qadima-Qasr el Aini, Cairo (Fekri Hassan)

The Magra el-Ayoun aqueduct, still visible along the cornice of the Nile, north of Qasr el-Aini, was constructed by the Ayubbid Sultan, Saladine, to supply water to the citadel he built as a fortress on top of the Mokattam Hill. The aqueduct, now called Magra al-Ayun, was completed by Saldine's successors; Al-'Adel (1200-1218), Al-Kamil (1218-1238), and Al-Saleh Nagm el-Dine Ayub (1240-1250). The aqueduct was later restored, renovated and extended by Al-Naser ibn Qalawoon in 1313 AD, with the addition of four large water wheels (*Naoura*) to carry water from the Nile to the top of the aqueduct. The aqueduct was renovated again by Mameluke Sultan Barquq (1382-1399) and Qaitbey (1468-1496). In 1508, Sultan al-Ghouri moved the intake point, digging a new well connected to the Nile through a tunnel. In 1814, the aqueduct was restored under Mohamed Ali Pacha, and an extension added to reach his mausoleum and that of Al-Imam Al-Shafaei. Until 1892, water was delivered to a basin at the location now occupied by the Mosque of Al-Sayada Aisha. At the time, water was carried through seven water wheels. The length of the aqueduct is about 3.1 km, with an initial elevation at the intake point of 23 m.

Attempts are underway to conserve this aqueduct which could become a major cultural resource for water history and heritage tourism. An urban water museum could be integrated with a visit to the Roda Nilometer (مقياس النيل الروضة) across the river, and the different water supply points, the Sebils (سبيل) of medieval Cairo. Of special importance are the underground cisterns of Al-Moez street where Nile water was brought from the Nile on camels to be provided freely to passersby and draft animals. The waterwheel is of particular importance as one of the key features of water management in urban water supply and for the irrigation of rural areas. The remains of a waterwheel can be found in Magra Al-Ayoun مجري العيون, and a household saqqyia is located at the Palace of Al-Amir Taz built in 1352.

2.a.7 Urban Canals

One of the most important barrages in the history of Cairo is the Al-Khalig (originally Khalig Amir el-Moumeneen خليج امير المؤمنين). The Khalig running along an abandoned course of the Nile provided water to Cairo's inhabitants after the Nile channel had shifted westwards. It entered the City at Bab el-Sha'ryia. It was extended and maintained during the Mameluk period beyond the gates of Fatimid Cairo. The Khalig was crossed by several bridges. At the time of the Napoleonic Expedition, it extended as far as Abbasa in Sharqyia Province following the previous course of the Nile. The length of the Khalig in Cairo was 46 km, with a width of 15 m, and water reached a level of up to 6 m during inundation.

The Khalig was originally deepened and re-excavated where it had silted up in 644 to re-establish the ancient canal first dug in Ancient Egyptian times to connect Memphis with the Red Sea. The original inlet was at Al-Sayeda Zeinab and Nuba street (Fum el-Khalig). Although maintained during the Mameluk period, it was neglected in the Ottoman period. In 1896-1898 it was filled in and became Al-khalig al-Misri street, which was later widened to become Port Said street.

2.a.8 Cisterns

Some of the most remarkable and hardly known monuments in Alexandria are its huge and spectacular subterranean multi-story cisterns, rather like underground cathedrals (http://www.touregypt.net/featurestories/alexandriacisterns.htm). In 1422, Ghillebert de Lannoy wrote to Henry V of England concerning Alexandria: "Underneath the streets and houses, the whole city is hollow. Under the ground there are conduits roofed over with arches, through which the wells are filled up once a year by the River Nile. And if this were not so, they would have no fresh water in the town, since it rains there very little or not at all and there are neither wells nor natural springs in the city. Thirty miles from here, starting from a village on the Nile called Hatse, a man-made canal begins its course. It runs for a mile close to the city, along the walls and flows into the sea in the Old Harbour [Western Harbour]. Every year, at the end of August and throughout all of September, the River Nile, which rises considerably at this time of year, flows through this canal to fill all the wells of the city for a year, and also the wells outside the city, which are used for watering the gardens."

Water was supplied to the cisterns from the Nile via a 20 km long canal, the Shedia Canal, dug from the Canopic branch of the Nile, to ensure a regular and controlled supply of water. The canal was maintained and repeatedly cleaned against siltation. The canal was still in use when visited by Abul Feda, Prince of Hama, in 1318.

Water flowing into the canal during the flood was loaded with silt and had to be cleared before it was drinkable. Water for houses and buildings was drawn from the cisterns with the aid of water wheels.

The Canopic branch, which fed the Alexandrian canal, eventually silted up. Mohammad Ali dug a new canal, the Mahmoudyia canal, and extended it eastward by about 50 km to the Bolbitine branch of the Nile, which flows into the sea near Rosetta.

During the Napoleonic expedition, the number of cisterns was estimated as 400, but later in 1872, Mahmoud el-Falaki listed 700 cisterns. Since then, the number of cisterns has continued to dwindle until there was only one ancient cistern that could still be visited in 1990, the el-Nabih. More recently, more than 200 lost cisterns have been re-located by Jean-Yves Empereur.

In Cairo, underground cisterns were discovered during the site management project of El-Moez Street, as well as in Sabil-Kuttab of Solayman Agha El-Silihdar.

2.a.9 *Sabils* of Cairo

Sabils are facilities which provide free, fresh water for passers-by and animals. They consist of an underground cistern and a room at street level. Water is lifted up to the top floor and dispensed through small water basins. A spout is sometimes provided for water delivery. Sabils were found almost everywhere in old Islamic Cairo during Mamluk and Ottoman times, and there were once more than 300 sabils across Cairo during the Ottoman period from 1517 – 1867. They were often associated with Kuttabs, a form of elementary school for teaching children how to read and write. Renowned sabils include Sabil and Kuttab of Qait Bey, Mohamed Ali Pacha, Abderrahman Katukhda, Khalil Effendi Al-Maqaigi, Soliman pacha Al-Kharboutli, Zein el-Abdine, Abi el-Iqbal Arfeen Bey, Taha Hussein el-Wardani, Kousa Senan.

Sabils were built by prominent, wealthy people as free standing buildings, with underground cisterns, in which the Nile's water was brought by camels and stored for redistribution. Through a hole in the ceiling of the cistern, water was pulled up in buckets and distributed through windows to passersby. Water was also delivered in troughs for horses and donkeys.

2.b Living Sites of Water Heritage

2.b.1 The Delta Mohamed Ali Barrage

The Delta Barrage was completed in 1862, during the early reign of Viceroy Ismail Pasha's (Later khedive Ismail) to control the flow of water in the branches of the Nile. The Rosetta section was 465 meters in length, with 61 arches of 4.8 meters in length each. The Damietta section was 545 meters long and had a similar number of arches and locks. When first operated, the foundations proved not to be strong enough.

In 1890, the foundations were strengthened. However, the barrage began to leak, necessitating the building of a new Barrage in 1939. The foundations were built in steel piling and concrete cement encrusted several meters below the sandy base. Granite from Aswan was used for part of the structure.

2.b.2 Water wheels

Water-powered wheels are associated with Faiyum. They are the city's main tourist attraction, and include seven waterwheels situated in the Bahr Sinnuris on the outskirts of the town and four more in the city centre, which are now the symbol of the Faiyum Governorate. These unique, large black wooden wheels were first introduced by Ptolemaic engineers and are capable of lifting water between four and five metres to fill channels which serve to irrigate the region. There are around two hundred of these unique water-powered wheels throughout the province, though they are not found anywhere else in Egypt. Waterwheels driven by animals were common elsewhere in Egypt but have now almost disappeared.

Waterwheels have been used widely in the countryside for irrigation since they were first introduced by the Persians, in addition to the Shaduf introduced earlier during the New Kingdom of Ancient Egypt. During the Ptolemaic period, irrigation devices included the Egyptian screw, invented in Alexandria.

Figure 7. Saqqyia, Madient el Faiyum (Faiyum City) Faiyum (Fekri Hassan)

Giant water wheels were used to lift water in urban areas to the higher levels of aqueducts. They could lift water up to 3 meters, and consisted of a vertical wheel, about 3 m in diameter, to draw water using jars (Qadus). The vertical movement of the wheel was made possible by a horizontal wheel with wooden gears.

2.b.3 Wells

One of the most remarkable of these wells is the Yusuf Well in the Citadel, which consists of two superimposed wells. Water is lifted from one well to the other by a water wheel. The lower well is 40.3 m deep, while the upper well is 50.3 m deep, with a total depth of 90.6 m. They were dug into the limestone bedrock underlying the Citadel. The well is descended by a spiral staircase (300 steps).

2.b.4 Hammams

Hammams are public bathhouses which, before modern water sanitation, provided an opportunity for the public to bathe. However, the hammam was also a social institution for beautification, socializing, celebrating special occasions, recuperating, as well as an opportunity for mothers to find suitable wives for their eligible sons. Hammams hosted men and women separately at different times or days of the week, with some specifically for women or men.

The hammams in Cairo were frequented in the past by artisans and merchants. Today they are frequented by labourers, the elderly and those who seek special medical help. A few hammams are still active and are restricted within the old historical quarter of Cairo. The number of working hammams is perhaps less than 20.

These hammams which were once highly integrated within the social fabric during the Mameluke period and which continued to play a major role in folk quarters until the 19th century, began to lose their value by the 1950s and certainly after the 1960s due to increasing westernization and the availability of running water in houses.

Hammams in Alexandria date back to the Ptolemies, and continued to exist throughout the Islamic period. An archival record of these hammams has been made by the Bibliotheca Alexandrina.

3 Existing documentation

Inventories, archive documents and collections of photographs are dispersed throughout several institutions, mostly those belonging to the Ministry of Antiquities (MoA), the Ministry of Culture (MoC) and the Ministry of Water Resources (MWR). They include the Archives of the Committee for the preservation of antiquities 1881-1979 (MoA), Archives of the Department of Islamic and Coptic Antiquities IMoA), Drawing Department, Center for the Documentation of Islamic and Coptic Antiquities (MoA), the Dar el-Kutub (National Library, MoC), and the Dar Al-Wathaiq al-Qawmyia al-Misryia (Egyptian National Library and Archives, MoC) founded in 1828.

4 State of historic and technical knowledge

Except for a few recent studies on el Kufra Dam, the El-Lahun Dam, the Itsa Dam, and the sebils and cisterns of El-Moez street in Cairo, no scientific or historical investigations are currently underway.

5 Threats

Heritage has always been threatened by the natural processes of decay and deterioration, but it has never been as threatened as it is today due to the expansion and intensification of human activities harmful to the preservation of cultural heritage. Such activities range from the demolition of heritage sites to the emission of chemical pollutants that hasten and aggravate the processes of decay, even of the most durable stones. Threats to water heritage sites in Egypt include:

1 Lack of administration and legislation required to protect sites and secure funds, resources, and qualified staff for appropriate conservation.
2 Lack of historical and conservation efforts.
3 Lack of a policy to valorise water heritage sites.
4 Deterioration due to neglect.
5 The impact of development - one of the main causes of destruction - due to population growth, industrialization, land reclamation, road building, and urbanization (e.g. Itsa Dam).

Different scenarios for the impact of climate change indicate that temperatures will rise throughout the Nile basin, but there is considerable uncertainty and disparity in spatial and temporal predictions of changes in precipitation, as to both magnitude and direction. This makes the analysis of the implications of these changes for stream flow more complicated and uncertain. Nevertheless, long-term changes and increasing inter-annual variability will require immediate intervention to counteract the effects of catastrophically low and high floods.

6 Legal protection in force

Monuments and sites in Egypt were protected by Law 117 Year 1983 (قانون حماية الاثار) until amended by Law 3 Year 2010 (الجريدة الرسمية العدد 6 مكرر في 14 فبراير 2010). The articles amended are articles 2 and 3, articles 1, 4, 5, 6, 7, 8, 10, 16, 17, 25, 32, and item G in article 34, and articles 35, 36, 39, 41, 42, 43, 44, 45. Law 61 Year 2010 also added a new article to Law 117 Year 1983 under No. 42 repeated.
http://laweg.net/Default.aspx?action=HP
Laws protecting historical buildings in Egypt consist of: (http://www.urbanharmony.org/ar_rules.htm)

- Building and Construction Law (2008) قانون البناء لسنة,
- Law 119 of Urban Harmony (2008)قانون التنسيق الحضاري لسنة2008
- Law Regulating Demolition of Buildings and Constructions Not Threatened by the Collapse and the Conservation of Architectural Heritage (2006). قانون تنظيم أعمال هدم المباني والمنشآت غيرالآيلة للسقوط والحفاظ على التراث المعماري لسنة 2006
- اللائحة التنفيذية لقانون التنسيق الحضاري لسنة 2008 (Executive rule for Urban Harmony Law Year 2008).
- اللائحة التنفيذية للقانون 144 لسنة2006 (Executive Rule for Law 114 Year 2006).

7 Conservation and management of water heritage

Other than the restoration of some of the sebils, hammams and water cisterns in Fatimid, Cairo, no systematic policy exists for the conservation of the archaeological or water heritage sites. All are severely threatened and require appropriate action for conservation.

8 Conclusion

As one of the two oldest irrigation civilizations, Egypt has a rich and varied collection of water heritage sites, monuments and lore. It boasts one of the oldest rock-fill dams and the first national hydraulic projects dating back to more than 3800 years ago. Gauges used to measure the height of Nile floods more than 5000 years ago set the stage for modern scientific measuring standards, systematic observations, and deductive logic based on the relationships between Nile floods and astronomical cycles. The Valley of the Nile, cultivated over the last 7000-5000 years ago, is a remarkable cultural landscape; never static, it remains bound to the regular rhythm of annual Nile floods and temperate weather.

Considering the excavation of canals and drains; the construction of embankments, barrages, and dams; as well as cisterns to store water; the digging of wells for urban and agricultural uses, and the employment of water-lifting devices to transfer water to higher grounds; Egypt is a microcosm of world water heritage because the history of Egypt is intertwined with that of Mesopotamia, Greece, Rome, Byzantium, and the Islamic world. Even qanats, the deep tunnels harvesting and transporting water downslope from hills to arable land in desert oases, are associated with Egypt at almost the same time they appeared originally in Persia.

The tangible water heritage sites and monuments are immersed in the minds of Egyptians, and their lore of tales, songs, poems, festivals and celebrations that keep its long water history alive and vibrant. However, the conservation, valorisation and documentation available on this important water heritage is negligible. This is regrettable at a time of rapid and radical change in Egypt and the world, given the significance of this heritage in relation to a sense of belonging, attachment to the land, and its informative messages for water management, especially as Egypt today is challenged by water poverty and the prospect of further scarcities in the future.

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Case Study N1
Rhoda Nilometer

Nilometers مقياس النيل were used from the earliest times of Egyptian civilization to determine the height of Nile floods every years in order to regulate water flow in agricultural land and to allocate taxes, which were reduced when low or high floods reduced agricultural yield. Nile flood reach their peak in the summer. The timing of maximum volume flood discharge, and hence the height of flood water level, varies considerably from one year to another.

At first graduated sticks were used to gauge the height of the flood. Later built structures, often associated with temples, were constructed near the ancient capital at Memphis and elsewhere up the Nile. These "Nilometers" consisted of a well connected to the Nile through a tunnel. The rise of water in the well was measured against graduations in a column or on the walls and stairs of the well. The measurements were in cubits and digits.

After the Arab Conquest of Egypt, a Nilometer was built at Rhoda on an Island close to Old Cairo under the Abbasid Caliph Al-Mutawakil in AD 861 on the remains of an earlier structure constructed about 715 by the Ummayidis. The earlier Nilometer was restored in 815 but was later destroyed by a flood in 850.

Figure 1. Rhoda Nilometer illustrated by Luigi Mayer, printed 1802, Rhoda Island, Cairo.

A wall was built around the Nilometer by the Fatimid Caliph Al-Mustanser in 1092. Repairs were made in 1128 under the Fatimids. The Mameluk Sultan Beibars added to it a cupola. The Nilometer was repaired again at the time of Sultan Qaitbey in 1341. Al-Ghouri constructed a palace near the Nilometer and was later imitated by the Turkish Sultan, Selim I.

During the Napoleonic expedition to Egypt, the Nilometer was rebuilt in 1801. The rebuilding was completed in 1802 after the departure of the French and a new wooded Kiosk, still remaining was added on top of the well structure.

The column of the Nilometer, marked by 19 cubits, is octagonal and rests on a one-cubit high granitic foundation. It is overlain with a wooden beam to fix it. The current beam dates to 1947. A stairway 45 steps, each 24 cm high, runs along the eastern corner of the southern wall.

The Nilometer was maintained by state officials. Celebrations and festivities marked the plenitude of the inundation وفاء النيل. Until the construction of the Aswan High Dam this was a national festival.

Case Study N2
Sadd el-Kafra Dam

One of the first outstanding achievements is the first rockfill dam at Wadi Garawi.

Sadd el-Kafra is a rockfill dam on Wadi al-Garawi, 10 km southeast of Helwan suburb of Cairo Egypt. The wadi is a dry water course that carries water during rain storms. It is the oldest dam of such size in the world. It was built around 2650 BC during the main period of pyramid building of the Old Kingdom. The purpose for constructing the dam is still unclear. It may have been an experiment in dam construction or for protecting royal installations and cemeteries across the river from the nation's capital located at that time at Saqqara and Dahshour. Alternatively, it could have been constructed to provide water for animal game threatened by increasing aridity. It was destroyed by flash floods during its construction and was never completed.

The dam was about 111 m long and 14 m high with a base width of 98m and crest width of 56m. The dam's core was 32m wide and consisted of 60,000 tons of earth and rock-fill. Surrounding the core were two loosely-filled rubble and rock-fill layer-walls. The downstream wall was about 37m wide, the upstream wall about 29m wide and they encompassed 2,900 m3 of material. Encasing the dam were upstream and downstream walls created from limestone ashlars in the manner used in building pyramids. The ashlars were set but not mortared in stepped rows. The dam would have stored about 500,000 m3 of water.

Figure 1. Wadi Garawi (Sad el-Kafara) Dam, Helwan, South of Cairo (Fekri

Lacking at the initial phase of construction of a spillway, the unfinished dam did not withstand a torrential flood. However, as the top of the dam was not beheaded and was not protected from flood water that would over-top the crest. The dam's proximity to the fertile Nile River and distance from populations indicates it was built for protection against such events, similar to those that still occur today. 22,100,000 cu ft of water and flooding would have caused the reservoir to flood into adjacent parallel wadis. The dam's failure likely made Egyptian engineers reluctant to construct another for nearly eight centuries.

Case Study N3
El-Lahun Dam

The Old Kingdom (2686-2181 BC) ended abruptly as a result of catastrophically low floods at a time between 4200 and 4150 years before present in response to a widespread global climatic event that led to a marked reduction in water flow from Ethiopia and Equatorial Africa. The drop in Nile floods was rapid and traumatic. The centralized government collapsed, towns were ravaged, severe famines took their toll of lives, and disorder and crime were rampant. For a period of 150 years, Egyptians strived to reinstitute order. Two major competing regional forces emerged, and after a series of armed conflicts, kingship of the whole country was restored by Mentuhotepe II (2040-2010 BC). His successors included Senusert II (1897-1878 BC). His grandson Amenemhet III (1844-1797 BC) had the foresight to embark on Egypt's, and the world's, first ambitious hydraulic project in the Faiyum Depression in the desert southeast of older capital, Memphis.

Figure 2. El-Lahun Dam, Faiyum (Fekri Hassan)

Senusert II decided to connect the depression to the Nile to re-introduce water into the depression. In addition, water inflow was controlled in order to keep water level in the depression sufficiently low so that the earlier lake bottom could be reclaimed for agriculture as a royal estate. A dam was constructed at el-Lahun at the point of entry.

The king himself oversaw the project and the king's pyramid and royal necropolis- the holiest place of kingship- were located there. The first organized town discovered in Egypt nearby at Kahun belongs to the organized community of workers who were engaged in the great Faiyum project. This industrial village provided papyri that provide a wealth of information that range from mathematical calculations to gynecological treatise. Senusert II was later immortalized in the works of classical writers as "Sesostris". Senwosri II placed a pyramid at the entrance of the inlet at el-Lahun, complimenting the pyramid of Amenemhê III, placed at Hawara, at the end of the inlet just before water flows into the depression. A huge mortuary temple that originally stood adjacent to this pyramid is believed to have formed the basis of the complex of buildings with galleries and courtyards called a "labyrinth" by Herodotus.

Queen Sobekneferu of the Twelfth dynasty also built at the complex. Her name meant "most beautiful of Sobek", the crocodile God worshipped there.

Contrary to the common belief that the depression was used as a reservoir to hold water during period of high floods to be re-directed during low Nile events to the Nile floodplain, the lake level was maintained well below the level of the connecting channel to allow back-flow into the Main Nile channel. The myth was a result of a misinterpretation of a statement by Herodotus. Recent investigations reveal that after the lake was filled to the required level sluices in the dam at the entrance of the inlet channel were closed. Excess floodwater was stored in an artificially dug narrow, elongate reservoir in front of the dam to prevent over flooding of the floodplain and to be used through a canal that ran along the desert edge of the Nile floodplain from Faiyum to Memphis to provide water to the pyramid funerary towns and farming villages.

The channel was called the “Great Channel,” Mewêr, in Greek Moeris. The waterworks in the Faiyum were later attributed to King of Marres, and the lake filling the depression was called Lake Moeris by the Greeks. The huge depression in the Faiyum is a natural geological feature and was freely connected to the Nile in prehistoric times and during the Old Kingdom. A quay on its northern shores was used to transport basalt building blocks from Gebel Qattrani north of the Lake through one of the oldest paved roads still in existence. The original Egyptian name of the lake was “Shei”, meaning “the lake.” It was later called Piôm, “the sea ,” which became “Fayum” in Arabic.

Sub-region D:
Syria, Lebanon, Palestine, Israel, Jordan

Water management in arid and semi-arid regions.
Challenges and solutions through the ages:
Examples from Syria and Jordan

Water management in arid and semi-arid regions. Challenges and solutions through the ages: Examples from Syria and Jordan

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1 General characteristics of the studied sub-region

Syria and Jordan are part of a greater historical entity referred to as "Bilad al-Sham", which also comprises the Levant and its hinterland. Both countries subdivide into two fundamentally different climatic zones, i.e. the north-western regions under a Mediterranean influence on one hand and on the other, the arid steppes and deserts in the central and eastern areas, which cover between 60% (Syria) and 80% (Jordan) of the territory. The annual rainfall varies between 500 and 1000 mm in the western mountainous areas and averages around 200 mm along the margins of the desert.

Fig. 1. Map with sites mentioned in the text and 200-100 isohyet (map: German Archaeological Institute, Orient Department, Th. Urban 2011 using SRTM data V2 CGIAR-CSI 9 m Database)

If one considers both countries as part of an integral region, productive lands with fertile soils receiving sufficient natural precipitation predominate in the west and the north. By tradition, these zones accordingly match with the chief areas of settlement and agriculture.

The principal perennial rivers in Syria are the river Euphrates with its two tributaries, the Balikh and the Khabur, and the Orontes. In Jordan, the major rivers are the River Jordan and its eastern tributary Yarmouk. Except for the now dried-up endorheic Ghouta lake near Damascus and that in the area of the river Qoueiq near Aleppo, there are no freshwater lakes in the region. The Lake Qattina southwest of Homs is artificial; it was created in the Roman Period through a barrage.

The Syro-Jordanian desert steppes to the east are part of the Irano-Turanian or Saharo-Arabian region with rainfall varies between 50 and 200 mm. In this area, a permanent natural water supply is assured only by the two large oases at Palmyra and Azraq that are fed by springs and groundwater.

The human use of arid and semi-arid zones, however, requires complex water management, though often with strikingly simple methods and yet high yields, as frequently verified by numerous instances that date back as early as Prehistory. Such methods include primarily the harvesting, storage, and distribution of winter precipitation, which frequently causes seasonal flash floods that turn otherwise dry wadis into torrential rapids.

2 Well-known and chief sites for the cultural heritage of water

2.1 Archaeological sites

In the same way as accepted for hunter and gatherer camp sites, it is thought that the first prerequisite for the region's earliest settling communities of the 11th millennium BCE to occupy a site permanently, was the perennial availability of water. Accordingly, primary water resources would have been rivers, streams, lakes, and springs which at first were left in their natural state.

This early period of sedentary life in the 11th millennium BCE is attested to by the evidence from the sites Mallaha, at the banks of Lake Huleh, and Ohalo II, on Lake Tiberias. Permanent settlements in the immediate vicinity of water resources dating to the 10th millennium BCE are e.g. known from Jericho in the Palestinian Territories, and Jerf el-Ahmar and Mureybet in Northern Syria. Jericho is located next to the high discharge spring Ain es Sultan, while Jerf al-Ahmar and Mureybet are located directly at the Euphrates.[i]

Wells too, were part of the earliest developments in hydraulic technology. Among the oldest known examples is the one discovered at the settlement of Sha´ar Hagolan, south of Lake Tiberias and dating to the 7th millennium BCE. Here, the water supply was warranted naturally by the lake and the nearby river Yarmouk. It is therefore also thought that the well may have served for prestige purposes of its owner.[ii]

In addition to sites located in ecologically advantageous zones, there were also settlements in less favourable areas of water supply. Such locations challenged communities to develop certain technological innovations. Although there is only very little direct material evidence from the earliest settlements, their actual locations often betray indirectly that measures may have been taken for storing winter runoff. In this respect, site Wadi Faynan (WF) 16 in the Southern Jordanian Wadi Faynan is located at the intersection of two wadis where accumulating surface runoff may have been collected and stored in depressions inside the wadi beds. Although such earth pits may have been quite simple, as reservoirs they may even so have prolonged the access to the water supply well beyond the rainy season.

Earliest evidences for built water storage facilities are found at Wadi Abu Tulayha, an 8th millennium BCE settlement in the arid Markaz basin, in South-eastern Jordan. Evidence from a cistern as well as a dam suggest that a systematic management of the water supply was intended to assure for both, drinking water and even temporary field irrigation.

Elaborate techniques of controlling surface runoff and wadis wells by means of dams, canals and masonry reservoirs have numerously been documented in the Basalt Desert at sites dating from the 4th millennium BCE and later. The evidence from sites like Jawa, in Jordan and Khirbet al-Umbashi not only reflects high technical knowledge, but also signals that this marginal region had even been under exploitation by irrigation agriculture. At the same time, however, there is also some indication of an apparently more humid climate phase between the 6th and 3rd millennium BCE.

However, while there are known examples for targeted water management as early as the Neolithic Period, genuine evidence for a so-to-speak "domestication of water" on a larger scale across the entire Near/Middle East emerges only by the 4th to 3rd millennium BCE. A marked increase in the number and sizes of settlement sites also called for an intensification of agriculture and consequently led to a greater demand for water. Large swaths of land came under irrigated cultivation in many parts of Mesopotamia, where epigraphic sources from the 3rd to 1st millennia BCE now also give written information on issues pertaining to the requirements, problems and yields of irrigation agriculture .

A famous example from Syria is the hydraulic management system at Mari, a major urban centre on the Middle Euphrates (Figure 2). Just the north of the city, a 20 m wide canal with dykes and several side canals had apparently served for irrigating land. The system may be dated already to the 3rd millennium BCE, at a time when the city was founded. Another canal reportedly also served the city's water supply. In addition to the canals, texts from the city's archives dating to the 2nd millennium BCE mention different facilities like dams and weirs and give information about various aspects of water management, such as the construction and maintenance of the hydraulic equipment. Additional canal systems are also known from the Western Euphrates, as well as from the KhHabur, although their dates yet remain unclear.

Although large-scale irrigation agriculture like that practiced in Mesopotamia was unknown to the Levant, artificial irrigation may have played an important role here too, in particular in regions with less than 200 mm of annual rainfall.

One example for this is known from the settlement at Hujayrat al-Ghuzlan near Aqaba which has been dated to the 4th millennium BCE. Hydrological probes have shown that a subterranean aquifer had been exploited to supply the settlement with water. Lined wells, intermediary collecting pools, distributive water canals, as well as a terrace system, testify to a differentiated water management that also included irrigation agriculture.

In urban centres too, water facilities improved. Sewage systems are attested to by clay pipes, as in the case of Habuba Kabira at the Euphrates, where wastewaters from domestic households were led through clay tubes into sewers below the streets and out of the city. However, since the city overlooked the river, water had to be transported into the city in the traditional way of carrying vessels or hides by either animals or humans.

Fig. 2. The floodplain of the Middle Euphrates near Halabiyyah (photo: German Archaeological Institute, Orient Department, A. Ahrens)

In essence, the water storage and distribution techniques that had been developed in the course of the third millennium BCE continued to be applied in the following millennia without undergoing any significant innovations.

It was only by the Hellenistic/Nabataean and Roman periods that more elaborate water management strategies came into use, although they continued to combine with the traditional techniques. Of particular interest is the increased appearance of partly enormous cisterns, either lowered into the bedrock or otherwise in masonry pools.

A prerequisite for viable masonry cisterns and reservoirs was the lining of the inside walls with a hydraulic, i.e. waterproof mortar. Such linings have been documented from periods no earlier than the Roman Period. Evidence for water cisterns is widespread through all regions of the Levant and its hinterland for the Roman, Late Roman/Early Byzantine and Early Islamic ~~P~~periods, as for example, at Qasr Mushash in Jordan (Figure 3). A particularly remarkable water reservoir is known from the Early Christian /Early Islamic city of Resafa, about 50 km south of the Euphrates and within the Syrian desert steppe. The recorded subterranean cisterns whose shapes and sizes are comparable to church naves had capacities of more than 20,000 m^3, which was enough to supply the city's estimated 6,000 inhabitants and its visiting pilgrims for an entire year with water (Figure 4). The cisterns were fed exclusively by winter runoff that accumulated in a nearby wadi before being channelled through an aperture below the city's ramparts.

Particularly intricate testimonials to the ancient water management of Jordan come from the Nabatean capital of Petra as well as the city Humayma/Auara, just to the south of Petra. Petra was inscribed on the UNESCO World Heritage List in 1985, with an Outstanding Universal Value (OUV) supported by criteria (i) (iii) and (iv). Justification of this OUV underlines: "An ingenious water management system allowed extensive settlement of an essentially arid area during the Nabataean, Roman and Byzantine periods (…); the remnant channels, tunnels and diversion dams that combined with a vast network of cisterns and reservoirs which controlled and conserved seasonal rains (…)".

Fig. 3. Large reservoir at Qasr Mushash in the Jordanian desert (*badia*), Early Byzantine to Early Islamic period (photo: German Archaeological Institute, Orient Department,K. Bartl)

Petra's water supply relied on both rain and spring water. The primary source was a relatively distant spring whose water was derived through an open canal into the city. The system was later supplemented by pipes. Winter rainfall was in addition collected in numerous cisterns. Cisterns, dams, canals, and pools were integrated to a complex coordination within water's administration. The water supply apparently even surpassed the basic needs of the resident population, since the recently proven existence of a large water pool in the city centre, right next to the great temple indicates that water also served purely aesthetic purposes (Figure 5).

A similarly complex water management to that of Petra has also been established for the settlement at Humayma, where the annual isohyet varies around 100 mm. Here water was diverted in two aqueducts over a distance of almost 25 km from two far-off springs and collected in large cisterns and reservoirs inside the city (Figure 6). Moreover, water was also stored in domestic cisterns below private houses. The water system also included other essential components, such as canals and barrages that were used for its distribution within the local agriculture.

Fig. 4. Large cisterns at the Early Christian/Early Islamic city of Resafa/Sergiupolis in the Syrian desert (photo: German Archaeological Institute, Orient Department,K. Bartl)

The water supply for the city of Apamea at the river Orontes in Syria relied entirely on an aqueduct during the Roman to late Roman/Early Byzantine Period (mid 1st century BCE to 7th century AD). The aqueduct transported water from springs 80 km away to the city's perimeter from where it was further distributed via two cisterns, an additional aqueduct, and a set of pipe networks over the city area.

Aqueducts, like norias, water tunnels, and qanats, are innovations from the Roman Period. In contrast to the hydraulic systems described above, such as cisterns, reservoirs, dams, and canals, which are appropriate for a temporary water supply, aqueducts only make sense if the water supply is intended to be permanent.

Fig. 5. Petra, view to the Great temple, pool complex left of the temple (photo: German Archaeological Institute, Orient Department,K. Bartl)

Fig. 6. Reservoir in Humayma in southern Jordan, Roman period (photo: German Archaeological Institute, Orient Department,K. Bartl)

Qanats (also known as falaj or karez) form a special category among the water supply systems. They had been in use in numerous regions of the Middle East since the 1st millennium BCE, possibly even earlier. Numerous representatives are known from Eastern Anatolia and Persia. The method exploits the interflow of an underground aquifer. A number of vertical shafts are lowered down to the water table at certain intervals where they are interconnected to form a slightly inclined, flow-directing channel. The groundwater is extracted at a "mother well", usually at the foot of a mountain from where it flows through the tunnel to a reservoir at the surface further downhill for further distribution.

Qanat systems are attested in Syria at sites like the Early Byzantine town of al-Andarin, in the western desert steppe, at Qara, south of Homs, and Qanawat, in Southern Syria. In Jordan they are mainly known in the north of the country, especially within the area of the ancient Decapolis (Gadara/Umm Qays, Abila/Qweylbeh, Capitolias/Bayt Ras, Garasa/Jerash), but occasionally also in other regions, as e.g. in the vicinity of the Roman military camp at Udhruh. Dating qanat systems is usually problematic, although in the Syro-Jordanian region none seem to antedate the Roman Period.

Underground water tunnels were like qanats introduced during the Roman Period. The best-known example is the long-distance tunnel for the water supply of the two Decapolis cities Abila/Qweylbeh, Gadara/Umm Qays, and Adra/Dara´a. This 170 km long conduit sets out from Wadi Harir in Southern Syria, where the winter precipitation was harvested in a dam. In addition to the wadi runoff, the network also drained the water from various springs as well that from Lake Muzeirib in Southern Syria. Within the territory of modern Syria, the system was designed for the most as an overground aqueduct, whereas the underground tunnel was established over a total length of 106 km. This man-made water network actually represents the largest of its kind known to have survived from antiquity.

Along with this hydraulic infrastructure for the supply of urban communities, there were also isolated facilities in desert areas that collected the winter floods in large wadis. One of them is the impressive Habarqa dam, east of Homs (Figure 7). Although there are no clear indicators as to its date, its main functional period seems to correspond to the Late Roman/Early Byzantine and Early Islamic Period. The Jilat dam in the Jordanian desert steppe represents a similar structure (Figure 8). Like the dam at Umm el-Walid, in the vicinity of the city of Madaba, it is generally accepted that it dates to the Early Islamic Period, although there is no firm evidence to confirm this. Because of the great effort it takes to build and maintain such systems, it is believed that they could be operated only by large centres.

Fig. 7. Harbaqa dam in the Syrian desert, east of Homs, probably of Roman date, re-used in Early Islamic times (photo: German Archaeological Institute, Orient Department,K. Bartl)

Fig. 8. Dam of Jilat in the Jordanian desert (*badia*), possibly of Early Islamic date (photo: German Archaeological Institute, Orient Department,K. Bartl)

In addition to reservoir and storage facilities, installations that served to lift river or well water to higher levels were also crucial in an efficient delivery of water from perennial sources. Such devices included the so-called shaduf, the sakieh, and the noria, to name but a few.

The shaduf consists of a wooden lever arm resting on a vertical support as well a recipient attached to a rope at the longer end of the lever arm. The container is used for scooping up water from the source. By moving the lever, to which a counterweight is fastened, the container is lifted, which then dispenses its contents into a reservoir. From here, the water is then led to the fields via a network of ditches and canals. The lifting and lowering of the lever can be done with the help of draught animals, which then requires the rope to which the animal is attached, to run horizontally through a pulley. Pertinent systems dating back as early as the 3rd millennium BCE are known from representations throughout Mesopotamia and Egypt, though because of the devices' ephemeral materials (wood, flax, hide), there is virtually no direct archaeological evidence.

The sakieh (or Persian wheel) is a water wheel rotated by means of a vertical lever, especially at wells. Scoops for lifting the water from the well are mounted at the wheel's circumference. The system can be powered by draught animals progressing in a circle. Different formal variations of the sakieh technology are known to date back to the Hellenistic to Roman periods. A well-known specimen preserved in an archaeological context is represented by the sakieh in Qusayr´ Amra, one of the famed Early Islamic Desert Castles in Jordan, which probably dates to the 7th/8th century (Figure 9).

Fig. 9 Sakiya at the Early Islamic "desert castle" Qusayr ´Amra, Early Islamic (Umayyad) period (photo: German Archaeological Institute, Orient Department,K. Bartl)

The noria waterwheels (arab. na´ur) are among the most impressive water lifting devices transmitted to us from ancient times. A noria is an upright wooden wheel, partly of considerable dimensions, whose scoop boxes or containers at the rim serve to lift water from a low-lying river bed to the adjacent river terraces or the houses of an adjoining settlement. As wheel's axles are mounted on bearings at the top of stepped stone supports, the wheel is set into rotary motion by the power of the inflowing water of the river. The thus lifted water is then discharged at the highest point into a tube that leads to an aqueduct before further distribution. Norias are often associated with milling devices.

A figural representation in a mosaic at Apamea/Syria testifies to the devices existence as early as the 5th century AD. In Syria, more recent specimens partly dating to the Ottoman Period are found at the Orontes River, in particular in the city of Hama (Figure10). Until recent decades, less elaborate variants were still in use along the river Habur, in Northeast Syria. At Hama, private households too, were supplied until in the beginning of the 20th century with Orontes water delivered by its norias and aqueducts.

Fig. 10. Water wheels (norias) at the Orontes in Hama, Late Ottoman period (photo: German Archaeological Institute, Orient Department,K. Bartl)

2.2 Cultural landscapes related to water

In Syria and Jordan, several prominent cultural landscapes have evolved through elaborate forms of water management. Next to the drainage basins around the Jordan, Orontes and Euphrates rivers, other landscapes have also been marked by the presence of oases, such as those at Palmyra, Damascus, and Azraq. In the past, the latter not only formed unique ecological environments, but also generated outstanding conditions for the evolution of cultural landscapes.

The site of Palmyra, Syria, is on the World Heritage List from 1980 with an Outstanding Universal Value expressed by criteria (i) (ii) and (iv), but apart mentioning it is an oases city there is no specific reference to its water management attributes. Like many other archaeological sites in Syria Palmyra has been affected by the civil war. Destructions of ancient monuments, illegal excavations, and looting of objects were reported since the beginning of the turmoils.
The fertility of the oasis at Palmyra owes primarily to the Afqa spring, which particularly during the Roman period encouraged the site to become the most important caravan stop between Mesopotamia and the Mediterranean. The spring has dried up in the meantime, while groundwater is being pumped to irrigate the palm gardens and to supply the modern town (Figure 11).

Fig. 11. View to the temple of Bel at Palmyra, in the background the oasis with date palms (photo: German Archaeological Institute, Orient Department,K. Bartl)

The water supply of the oasis Ghouta near Damascus relies for two-thirds on the perennial river Barada which is fed by the Fije source system (Figure 12). In the centre of the oasis, which today compares to an oversized garden with olive and fruit trees surrounding small hamlets, there once was an endorheic lake. Early travellers celebrated the Ghouta as being paradisiacal, while in 1850, the size of the lake was still compared with that of Lake Tiberias. The lake has disappeared long since, and the Ghouta has shrunk considerably through urban expansion.

Azraq, which is located in the Basalt Desert (Badia), about 100 km east of Amman, is the second largest oasis in the region after that of Damascus. Being fed by several springs, the area was only half a century ago marked by extensive wetlands and a rich plant and animal wildlife. The oasis also once formed a major stop for migration birds. Through increased drainage through the rapid growth of the capital city Amman since the 1970s, the springs in Azraq virtually dried out, while the oasis landscape dwindled in the in the 1990s. Today, the restoration of some of the water has allowed for the upkeep of a small nature reserve (Figure 13).

The river drainage systems in Syria and Jordan too, have shaped unique environments through the close relationship between water and human culture.

Striking evidence for early irrigation agriculture is known from the Euphrates region and dates back as early as the 3rd millennium BCE.

Fig. 12. The spring of Fije (Ayn Fije) near Damascus (photo: German Archaeological Institute, Orient Department,K. Bartl)

Fig. 13. Azraq wetland reserve, a recultivated part of the former oasis of Azraq (photo: German Archaeological Institute, Orient Department,K. Bartl)

The Orontes region forms a heterogeneous combination of different landscapes that have evolved over a remarkably long settlement history.

Hydraulic control facilities attested to in this region do not antedate the Roman Period. The most prominent one is the Qattina Lake which had formed in the Roman Period after the barraging of the Orontes and today still represents the chief water reservoir for the city of Homs and its surroundings. The particular topography of the Orontes valley, which partly cuts deeply into the surrounding terrain, led to the development of distinctive water elevators. By the Late Roman/Early Byzantine Period, water was thus transported by means of vertical wheels and aqueducts onto the river terraces. Numerous stone substructures preserved along the banks to the north and south of the city of Hama today still bear witness to this ancient method of exploiting the river's water (Figure 14). Also, the so-called Ghab wetlands, further downstream to the north, were drained extensively with the aim to develop agriculture as late as under the French Mandate (between the two World Wars, 20th century).

Fig. 14a. Orontes valley south of Hama, remains of a noria near Tall al-Ghazalat (photo: German Archaeological Institute, Orient Department,K. Bartl)

Fig. 14b. Orontes valley south of Hama, remains of two norias near Tall an-Naoura (photo: German Archaeological Institute, Orient Department,K. Bartl)

Fig. 14c Orontes valley south of Hama, remains of noria and a water mill near Ginan (photo: German Archaeological Institute, Orient Department,K. Bartl)

Due to its particular climate and its traditionally wealthy water resources, the Jordan Valley harbours one of the most important cultural landscapes in the Near East. Due to modern politics, however, the Jordan River now forms a state border, which complicates holistic considerations regarding cultural contexts. Ancient hydraulic systems are assumed to have consisted of canals, ditches and dams, but because of the intensive exploitation of the surrounding lands in recent years, no substantial remains have survived.

3 Obtainable documentation

3.1 Archaeological general missions

Over the past decades, important archaeological field missions to Syria and Jordan have generally adopted schemes relating to ancient water management. To name a few are the investigations carried out by French scholars in the "marges arides" in the western border zone of the Syrian desert, the Syrian Hauran region (Mouton, al-Dbiyat, 2009), as well as the desert steppes of Syria and Jordan for the Early Islamic Period (Genequand, 2012). In Syria, especially the norias at Hama have repeatedly been the object of technological and historical studies (Delpech et al. 1997; de Miranda 2007), whereas other projects have concentrated on water mills from the Roman and Ottoman periods.

In Jordan, much research has concentrated on the Nabatean/Roman water management within the Petra region, but in recent years also on the water supply in the desert steppes with a particular attention for the prehistoric periods.

3.2 Photographic collections

The collection of pictures taken under the French Mandate and now part of the IFPO photo archive represents one of the most valuable information resources on the ancient water heritage in Syria. As for Jordan, the APAAME-project, which since 1997 has endeavoured to capture among others ancient water management facilities in aerial photographs, too, is an indispensable source of information.

3.3 Location of archaeological excavation finds related to water management heritage

Important investigated sites with hydraulic systems in Syria are Al Andarin (desert steppe, east of Hama), Hama and its surrounding area (Western Syria), Resafa (central desert steppe, south of Raqqa), Khirbet al-Umbashi (Hauran, Southern Syria), Apamea (limestone massif, east of the Orontes), Bosra (Hauran, Southern Syria), Qanawat (Hauran, Southern Syria).

Important investigated sites with hydraulic systems in Jordan are Umm Qays/Gadara (Northern Jordan), Qasr Mushash (~~e~~Eastern desert/Badia), Jawa (~~e~~Eastern basalt desert/Badia), Wisad pools (~~e~~Eastern basalt desert/Badia), Qulban Beni Murra (Southern Jordan), Umm elWalid (Central Jordan), Hujayrat al-Ghuzlan (Aqaba, Southern Jordan), Petra (Southern Jordan), Humayma (Southern Jordan), Udhruh (Southern Jordan).

4 State of historic and technical knowledge concerning water heritage in the sub-region

Because of their overwhelming material evidence, the most important periods in both Syria and Jordan concerning ancient water management are the Roman, Late Roman/Early Byzantine, and Early Islamic periods. A number of individual studies (see. 3.3) have already furnished considerable data.

Much less information is however available for the pre-and proto-historic periods. Recently launched research in the Jordanian Eastern Desert (Badia) will prove crucial on this issue, as it fosters insight into the relationship between landscape structures and water management in semi-arid and arid areas.

5 Threats to water heritage

Currently, the major threat to the cultural heritage of water in Syria comes from its ongoing civil war, through which countless cultural properties are now at risk, or already destroyed. The six World Heritage sites of the Syrian Arab Republic are on the List of the World Heritage in danger from 2013 (World Heritage Committee decision n° 37 COM 7B.57). Urban sprawl as a result of demographic growth and a relentless expansion of the physical infrastructure had already imperilled this heritage over the years prior to the outbreak of hostilities in 2011. This latter phenomenon also applies to Jordan, where numerous archaeological sites are seriously endangered by recent construction schemes and agricultural expansion. In addition, widespread vandalism recorded at archaeological and historical sites in the country is a sad reflection of the lack of awareness as to the importance of cultural heritage and hence compelling absence of educational measures on this matter.

6 Legal protection in force

To our knowledge, there are no projects in either country that enforce the protection of ancient hydraulic installations. Issues pertaining to modern water management have been or are being treated in cooperation with various international organisations. In Syria for example, the modern water sector was until 2011 under the co-management of the German Agency for International

Cooperation (GIZ), while in Jordan, the German Helmholtz Society collaborates with the Ministry of Water and Irrigation.

7 Conservation and management of water heritage

So far, there has been virtually no project in either Syria or Jordan that has focussed on the protection and conservation of the cultural heritage of water. The maintenance of the Hama norias in cooperation with the Syrian Directorate General of Antiquities and Museums is one of the few, if not the only example for active intervention by public authorities to protect and maintain hydraulic cultural properties.

8 Conclusion

In semi-arid and arid environments, both temporary and permanent settlements as well as land use require differentiated forms of water management. The widespread scarcity of perennially available water from rivers, springs, and lakes calls for an increased control of runoff water obtained from seasonal precipitation. Heavy winter rainstorms in Syria and Jordan turn numerous dry wadi beds momentarily into rivers and occasionally, even otherwise desiccated landscapes into lakes. With an adequate management, this short-lived availability of a vital resource can actually be prolonged on a medium to even long-term perspective.

As indicated by the closeness of a number of prehistoric sites to wadi courses, the practise of harvesting, storing, and distributing surface runoff was probably familiar fact to early communities during the first stages of sedentary life. However, because of the low resilience of such structures, only very little direct evidence has survived. Conceivably, depressions would have been used as temporary reservoirs or dams, and ditches as canals for holding back or diverting water. These basic elements for storing and distributing surface runoff are at any rate observable on hydraulic facilities from all periods. Through varying the possibilities of combining the individual elements, the variety of applications could thus be increased.

Although in arid regions, rainwater alone cannot account for any agriculture on a greater scale, it nevertheless can sustain small subsistence economies, provided the ecological prerogatives, appropriate management, and stable demographics are given. This is especially true in the event that wells, being among the earliest water suppliers, are also needed for purposes other than direct consumption.

Large-scale irrigation agriculture in the region has been observed in the semi-arid desert margins of Northern Mesopotamia only, where a differentiated exploitation of the waters of the Euphrates and Khabur rivers led to greater yields and covering larger areas, but for which also considerably more complex forms of organisation were required.

Although the basic hydraulic installations cited above were supplemented with more sophisticated facilities like aqueducts, qanats, tunnels, and pipelines in later antiquity (i.e. the Graeco-Roman periods), their efficiency remained nonetheless bound to the existence of perennially exploitable water resources. By the Late Roman/Early Byzantine Period, which also coincides with the culmination in the ancient settlement history of Syria and Jordan, all water management technologies of the pre-modern age were already functioning. It was only by the 20th century that these became supplemented and replaced by modern technological innovations.

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[i] The investigations at Göbekli-Tepe in South-Eastern Turkey have shown that other forms of drinking water supply already existed in this early period. This significant Neolithic cultic site dating to the 10th and 9th mill. BCE is located in an area devoid of perennial water courses, springs, or wells and was therefore apparently exclusively dependent on rainwater. Storage of precipitation, which in this area varies around 600 mm/year, was obtained through basins and cisterns lowered into the bedrock. Grooves chiselled into the rock leading to the reservoirs reveal that the devices had served as pre-planned facilities to assure the site’s supply with water (Herman, Schmidt in Klimscha et al. 2012).

[ii] Since the Neolithic, wells have belonged throughout all periods to the most widespread devices for the domestic water supply, but in conjunction with elaborate water lifting devices, such as the sakieh (Persian wheel), they have also been essential in field irrigation. An important factor the effectiveness of a well was in that case the groundwater level.

Sub-region E: Turkey

The cultural heritages of water in Turkey

The cultural heritages of water in Turkey

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1 General characteristics

Situated at the crossroads of Asia and Europe, Turkey is a transcontinental country comprising the Anatolian peninsula at westernmost point of Asia and the Thrace region encompassing the European part of the country. It occupies a total area of 78 million ha, which is bordered by eight countries including Greece and Bulgaria at the northwest, Georgia, Armenia, Azerbaijan and Iran at the east, and Iraq and Syria at the south. Embodied as a peninsula, it is also surrounded by the Mediterranean Sea at the south, the Aegean Sea at the west, the Sea of Marmara between the European and Asian territories, and the Black Sea at the north. Its significant geo-strategical position has favored the genesis of multiple civilizations throughout history, which functioned as the focal points of transnational routes of commerce and cultural exchange.

1.1 General climatic data and general hydrological data

Turkey is located in the Mediterranean macroclimate region within the sub-tropical zone. Associated with its diverse terrestrial and geomorphological positions, however, the climate portrays a variety of geo-climatic conditions under the influence of multiple maritime and transcontinental weather patterns. The southern and western coastal regions have a Mediterranean climate, indicating a sub-tropical weather characterised by hot and dry summers, and mild winters. Under the impact of an inland sea and the vast Russian plain in proximity, the northern Black Sea region, on the other hand, is marked with high level of precipitation throughout the year, along with mild summer and winter conditions. In contrary, the southeastern Anatolia adjoining to the arid Middle East territories and the continental interiors of the country sprawling across a vast plateau with a high altitude are characterised by a semi-arid continental climate with hot and dry summers, and cold and semi-dry winters.

This climatic diversity also causes fluctuations in the level of precipitation, varying based on geo-climatic zones and seasonal weather conditions. Overall, the annual average precipitation is estimated to be 646 mm, but with large variations from one region to another. The northern coastal zone receives the highest rate of annual rainfall (1260-2500 mm), whereas inland areas have lower annual rates (320-600 mm). In relationship with global climate change, 2012 IPCC (Intergovernmental Panel on Climate Change) stated that there have been significant trends towards drier conditions in winter and annual precipitation, which yielded to longer periods of droughts and dry semi-arid climatic conditions in southern Europe, including Turkey, in the past 60 years. The annual rainfall variations lead to widespread and regional droughts of various intensities, especially in the inland areas, that seem to recur periodically.

Despite being one of the most water-rich countries within the Mediterranean region, Turkey is encountered with high levels of water security threats derived from numerous natural, socio-political, economic and cultural factors: challenges of acquiring and controlling water resources as a result of variant topographical conditions, unbalanced levels of precipitation and availability of resources, shifts in geological conditions leading to desertification and depletion of ground water sources, functional changes in the utilisation of water supplies, rapid population growth increasing the water demand, and the lack of an integrated water management system that allows the execution of regional, short-term infrastructure projects with adverse impacts. These effects of climate change and water-related policies adopted at regional level might result in water scarcity in Turkey in the upcoming years if necessary measures are not taken.

1.2 Cultural relations and technical exchanges with neighbouring zones

The cultural relations of Turkey with its immediate neighbours are built upon the Ottoman legacy inherited from the three successive empires, the Roman, Byzantine and Ottoman, their administrative structures, socio-economic dispersion and external relations. Governed by the same central authorities for a few centuries, Turkey shares a common history with almost all of its neighbouring countries.

This shared past has stipulated the dissemination of the common knowledge and technological advances to the territories under the same hegemony through commercial and cultural exchanges. Similar building techniques, equipments, and sometimes materials had been utilised to construct similar types of structures all around the Mesopotamia, Near East, Caucasians and the Balkans. It is possible, for instance, to detect similar kinds of hydraulic structures built during the Roman period, such as aqueducts and cisterns – despite varying in size and position – both in the ancient city of Ephesus at western Turkey and the city of Carthage in Tunisia. Additionally, the knowledge, social practices and traditions associated with the water-related tangible assets had also been transmitted from one civilisation to another. The rituals practiced in public baths or the daily life of women organised around fountains rendered similarities all around the former Ottoman states. Thus, a common corpus of tangible and intangible heritage assets is shared by Turkey and its bordering zones.

Figure 1. The regional map depicting the water-related heritage sites in Turkey (Source: GoogleEarth image customized and developed by Deniz Ikiz)

2 Known sites and important sites for the cultural heritage of water

Being at the crossroads of numerous civilizations for the past four thousand years, Turkey is rich in water-related tangible and intangible heritage assets (Figure 1) that bear testimony to the hydraulic technologies and engineering of various periods. These historic waterworks including pipes, canals, tunnels, aqueducts, inverted siphons, cisterns, dams, reservoirs and sewerage systems are geographically dispersed all around the country. The hydraulic structures from the Hittite period exist in central Anatolia, those from the Urartu period in eastern Anatolia, from the Hellenistic, Roman and Byzantine eras in western and southern Anatolia, whereas the Ottoman structures are scattered nationwide. Although most of them are no longer functional, some of the hydraulic properties are still in use for several centuries. Situated within ancient settlements, urban settings or landscapes, they portray the four-millenia-long tradition of water use.

2.1 Archaeological sites

Eflatun Pinar: The Hittite Spring Sanctuary (WH Turkey Tentative List 5912; 2014)
The Hittite spring sanctuary of Eflatun Pinar (Figure 2) is composed of a relief-covered wall of high boulders erected next to a spring at the top of a river valley in Central Anatolia. The remains of this sanctuary form the original walls of the basin, which is an outstanding example of the hydraulic technology developed during the Hittite era. The reliefs depict the religious practices of the period, complementary to the tangible evidence of the civilisation. This archaeological site was inscribed on the Tentative List in 2014 in regards to the criteria (iii), (iv) and (vi), suggested by the Stat Party, which are associated with the representation of an effective water regime and the intangible values attributed to it, the hydraulic technology utilising metal tools for the first time at such a large scale, and bearing of unique testimony to a cult monument of the Hittite period. This cultural property and its surroundings have been under protection of the national conservation legislation since 1994. The monument and the mound are designated as an archaeological conservation site, whereas the buffer zone is registered as a natural conservation area. Following the rescue excavation and surface cleaning interventions, a comprehensive conservation work and landscaping project were executed at the site in 2011. Currently, the site is in good state of conservation and it is well-presented, especially after the expropriation of some civic buildings impacting its visual integrity. Apart from the potential natural hazards such as flooding, there are no serious threats to the authenticity and integrity of the site.

Figure 2. The Hittite spring sanctuary of Eflatun Pinar, Central Anatolia, 2009
(Source: Tayfun Bilgin, Bora Bilgin, Ertugrul Anil)

Archeological Site of Perge (WH Turkey Tentative List 5411; 2009)

Perge is a long-established city located at southern Turkey where the initial permanent settlements date back to the Early Bronze Age. It is an exceptional example of urban planning practices conducted during the Late Classical, Hellenistic and Roman Empires. The significance of this ancient city also resides in its effective water supply and management systems dating from the 1st and 2nd centuries B.C. Conveying water through high-capacity channels, the hydraulic facilities present in the city including four monumental fountains, two baths, cisterns, and a sewerage system portray an image of a "water city" for that era. These hydraulic properties are generally well-preserved within the registered archaeological conservation area.

Allianoi

Located in close proximity to the ancient city of Pergamon (Pergamon and its Multi-Layered Cultural Landscape is on the WH List from 2014 under criteria (i) (ii) (iii) (iv) and (vi)), Allianoi (Figure 3) was a Roman spa settlement composed of multiple hydraulic structures like thermal baths, bridges and the nympheum drawing on the nearby hot springs. Initially mentioned by the medicinal writer Aelius Aristides concerned with the science of healing in the 2nd century A.D., its water was claimed to have healing powers. Associated with the existing tangible assets and its intangible attributes, the site pursued its thermal functions during the successive Byzantine and Ottoman periods. Affected by the adverse impacts of periodic flooding, neglect, and partial agricultural practices, it had been in a rather poor state of conservation during most of the 20th century. In 1994 the national government devised a plan to build a dam nearby, which included the heritage site within the potential reservoir area. Despite the international campaigns conducted by ICOMOS, Europa Nostra and local NGOs to save Allianoi, the ancient city is submerged in the reservoir since 2010.

Figure 3. The Roman spa settlement of Allianoi (Source: Europa Nostra Turkey)

2.2 Living Sites, which are still used or partially used

Kirkcesme waterway system

Due to the lack of a major river in close proximity, water supply to Istanbul has always been a great challenge. Thus, the Roman waterway system delivering water to the city from 150 kilometers away had been the longest span in its typology (Cecen, 1996). As the population of the city rapidly grew during the Ottoman era, the existing water conveyance structures were mostly restored. Furthermore, Ottomans were able to maintain an un–pressurized distribution system to meet the daily demand of urban population. The Kirkcesme (literally, “forty fountains”) waterway system (Figure 4) was then developed during the reign of Suleiman the Magnificent to mitigate the water shortage problem (Cecen, 1992). This system integrated a vast number of components either newly constructed, such as aqueducts (Figure 5), dams, pools and water lines, or restored and reused the pre-existing structures. Its significance resides in constituting the most developed public service project of the period, and being a masterpiece of Sinan’s architecture. The Kirkcesme waterways were fully functional for centuries with minor amendments until the establishment of central waterworks in the 19th century. Despite losing its original function ever since, these hydraulic structures pursue to be exceptional water-related assets situated within the cultural landscape of northern Istanbul. Although several components of the system like the aqueducts are registered to be under national protection, the lack of a holistic approach for their safeguarding makes them vulnerable to large-scale development projects. In fact, the forty fountains (Figure 6) utilised by local habitants within the city had been dismantled in mid-19th century as a result of urban infrastructure implementations. Constantly being threatened by natural hazards like flooding, and the recent urban development projects, such as the Canal Istanbul developed by the national government, augment the adverse impacts on the historic properties.

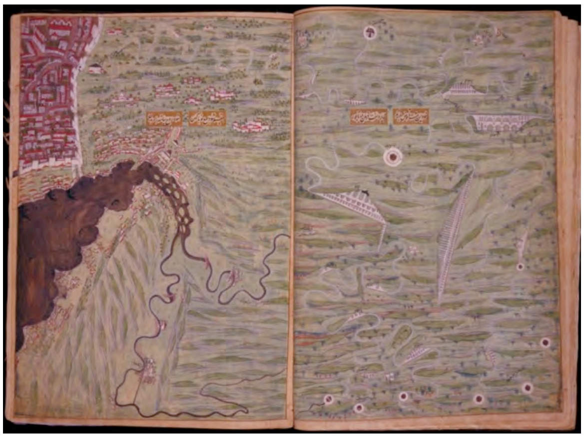

Figure 4. A miniature of Nakkas Osman depicting the Kırkcesme waterways system in Istanbul, 1579-80 (Source: y. 226-23a, Chester Beatty Library, Dublin, MS.413)

Figure 5. The Maglova Aqueduct in late 19th century, B. Kargopolou (Source: Istanbul University Archives of Rare Documents, 90763-0076)

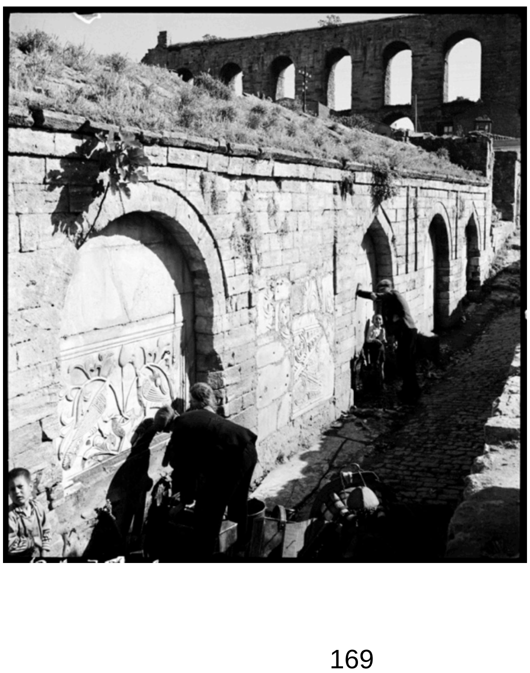

Figure 6. Kırkcesme fountains with the aqueduct of Valens in the background, 1935 (Source: ICFA.NA.0015, Nicholas

2.3 Cultural Landscapes related to water

Hierapolis – Pamukkale (on the World Heritage List from 1988 as mixed property under criteria (iii) and (iv) for cultural attributes and (vii) for natural attributes).
Pamukkale (meaning Cottonwool Castle in Turkish; Figure 7) is an exceptional natural landscape composed of calcite-laden waters that make up mineral forests, petrified waterfalls and a series of terraced basins. Established on this natural site enriched by mineralized warm water flowing from springs and creating pools and travertine terraces by the Attalid kings of Pergamom at the end of the 2nd century B.C, Hierapolis was developed as a Graeco-Roman thermal installation.

Figure 7. The traverten pools in Pamukkale (Source: ICOMOS National Committee of Turkey)

This mixed cultural landscape including natural water formations of Pamukkale and the complex ancient water supply system of Hierapolis providing thermal water to nearby villages and agricultural fields through canals was inscribed on the World Heritage List in 1988. The inscription criteria includes criterion (iii) attributed in regards to Hierapolis bearing an exceptional testimony the Graeco-Roman tradition of thermal water installations. Healing powers were attributed to the hot springs, which yielded to the construction of numerous thermal installations that provide hydrotherapy, accompanied by religious practices in the ancient city. Criterion (iv) was ascribed to the site for being an outstanding example of early Christian building ensembles including a cathedral, baptistery and churches. Then, criterion (vii) was assigned to the aesthetic values attributed to natural formation of the Pamukkale. This cultural and natural property, in general, has been in a good state of conservation. Its tangible assets are mainly intact and still prevails the attributes of Outstanding Universal Value. Pamukkale is registered at the national inventory as a mixed site, whereas Hierapolis is designated as an archaeological site, which are both under the protection of the national conservation legislation. However, there is no specific planning or legislative framework that ensures the safeguarding of the WH Site as a whole. As a result of this fragmentary status of legal protection, the decision-making mechanism concerning the heritage site involves the participation of a broad range of national and local actors to the management process. Decisions concerning the physical integrity of the site, moreover, require the approval of two different regional authorities. The multiplicity of decision-makers concerning the safeguarding of the site brings up a level of complexity to the management of the site. Both sites are important tourist attractions of the country, and intense tourist flows enforce an adverse impact on its integrity, causing pollution and deteriorations, especially on the material formation of the travertine of Pamukkale. The local authorities are in the process of setting up a periodic monitoring system to detect the pollution rate as part of heritage impact assessment. Additionally, an archaeological excavation and restoration project is undertaken at Hierapolis by a multi-disciplinary team of national and international experts. Complementary to these measures, a Site Management Directorate was recently established by the Ministry of Culture and Tourism, abiding by the national legislation of site management, which enhances coordination and communication between different actors. A management plan is also being developed by this authority, with the assistance of the Advisory Board, for the sustainable development and management of the historic site. This plan comprises strategies and action plans focusing on issues of accessibility, visitor management, risk management and better representation of the site.

Pergamon and its multi-layered cultural landscape (on the WH List from 2014 under criteria (i) (ii) (iii) (iv) and (vi))
Recently designated as a World Heritage Site, Pergamon is a multi-layered cultural landscape that embodies the archaeological and architectural remains of the Roman, Byzantine and Ottoman empires, respectively. Established as the capital of the Hellenistic Attalid dynasty, the water-related Hellenistic heritage of the ancient city contributes to the significance of the site. Water was initially conveyed through clay pipe systems of 20 km long, then a masonry gallery covered by a vaulted roof and a long arched aqueduct was added to the water supply system during the Roman period. Another important hydraulic structure in Pergamon has been the covered conduit like a twin tunnel, through which the river flow prevails.
The ICOMOS report for evaluation of the site by the WH Committee underlines the importance of water management issues for the development of the city: “Water was brought to cisterns and fountains on Kale Hill (which had no source of its own) by ceramic pipes and lead pipelines under pressure from mountains some 50 km to the north of the city, using the principle that water finds its own level to run down and up the intervening valley to a height of almost 200 m… In the Roman period, the water supply was improved to serve the greatly increased population (up to 150,000 from 40,000 in the Hellenistic period) by the addition of aqueducts to the north of the city.” The aqueducts and the majority of the pipe and conduit structures still remain, although they are partially destroyed and currently dysfunctional.

3 Existing documentation

3.1 Inventories

There has not been a comprehensive documentation that covers all the water-related cultural properties in Turkey. Nevertheless, relevant departments of specific national governmental bodies that are either proprietors or administrators of these properties generally keep an inventory of the listed hydraulic structures. These authorities are the Istanbul Water and Sewerage Administration (ISKI) Directorate of Waqf Water, the Directorate of Pious Foundations and the regional Conservation Councils. These inventories generally consist of a list of properties, and sometimes the building survey and architectural restoration projects that manifest their current state of conservation. Majority of these documents, however, are not open to public and requires authorization for access.

3.2 Archive documents

The archival documents related to cultural properties and sites in Turkey are restricted to the documentations of the Ottoman period. Thus, there are a highly limited amount of records documenting the structures of the pre-Ottoman era. These records are mostly available and classified under archeological sites of Hellenistic, Roman and Byzantine periods in Turkey at the archaeological archives of national and international research institutions, universities and private collections, such as Istanbul Archaeological Museums (http://www.istanbularkeoloji.gov.tr), German Archaeological Institute (http://www.dainst.org), and American Research Institute in Turkey (http://ccat.sas.upenn.edu/ARIT/). The Ottoman Archives of the Prime Ministry (http://www.devletarsivleri.gov.tr/) and the Directorate of Waqf Water possess Ottoman collections of written texts including manuscripts, books of accountants and water-related records, and visual documents that involve historic maps, drawings of main waterways (Figure 4), and several photographs. Some of these archival documents had been collected, transcribed and published by several scholars.

The Turkish and Islamic Arts Museum (http://muze.gov.tr/turkishislamic) in Istanbul also has a collection of historical maps manifesting the Suleymaniye Waterways and other Ottoman water supply systems; and other tangible assets such as marble inscriptions of Ottoman fountains. Sponsored by the Istanbul 2010 European Cultural Capital Agency, a visual exhibition depicting the water heritage and water culture of Istanbul entitled “Ab-ı Hayat / Water of Life: Water and water culture in Istanbul through ages” (http://abihayatsergisi.com) was established at the Turkish and Islamic Art Museum in 2010. This event illustrated the historical narrative depicting the development of water acquisition, management and distribution systems operated in Istanbul for the past 3000 years. It also exhibited water-related archival documents available at the collection of the Museum, such as collections of historical maps and drawings, and movable properties.

3.3 Collections of photographs

Even though there is no collection of photographs specified for the water heritage of Turkey, numerous collections of historic albums and publications present photographs of a variety of hydraulic structures dating to different periods. The Abdulhamid II Collection of Photographs available online (http://www.loc.gov/pictures/collection/ahii/) is the largest album that portrays the modernisation period of the Ottoman Empire. This vast collection also involves historical photographs of hydraulic structures in use in different regions of the state. In addition, numerous publications of national and foreign scholars that conducted archaeological studies in Turkey, such as Wolfgang Müller-Wiener and Albert Gabriel, also provide a rich collection of photographs depicting the water-related heritage existing in Anatolia and Istanbul.

3.4 Archaeological excavations

In addition to the documentation of archaeological findings and building remains present in archaeological sites, numerous studies of documentation and publication concerning the water acquisition, control and allocation systems employed in these sites have been conducted by national and international experts. These sources of data derived from archaeological excavations are available as publications in academic books, and journals, or in the archival documentations of the relevant institutions and research centres.

3.5 Conclusion

The cultural properties and sites that represent the water heritage of Turkey have not been fully documented yet. The existing documentation is limited in number, building type, period and geographical distribution. The archival documents solely cover the Ottoman waterworks, whereas ancient waterways are indicated only in the recordings and publications of archaeological excavations. Thus, the existing water-related properties are partially documented and there is no complete inventory. This situation clearly manifests the lack of interest and sufficient documentation in regards to water heritage in Turkey. Consequently, it is an immediate necessity to identify and document all the water-related properties and sites in the sub-region.

4 State of historic and technical knowledge concerning water heritage in the sub-region

4.1 Definition of periods in man's relationship with water

In the sub-region of Turkey, the historical progress of the technical knowledge and practice related to water heritage can be divided into three phases: waterway systems in pre-Ottoman era, waterworks in Ottoman era, and the urban waterworks of modernisation (Ozis, 1994). This historic division enables a better understanding of the technological developments of each period that facilitates the use of resource and advances the relationship of each society with water.

As a result of the desertification process occurred in the Mediterranean region during the period of 5000 B.C., the early settlers moved to the banks of Tigris and Euphrates within the sub-region where a high-level of hydraulic technology was developed. The Karakuyu dam constructed by the Hittites towards the end of the second millennium B.C. is known to be the most ancient dam in Anatolia. Referred as the “hydraulic civilisation” of near East Asia, the Urartians settled in vicinity to Lake of Van developed an elaborate and well-managed water supply system that are acknowledged as the pioneer of modern hydraulic technology (Garbrecht, 1980). The long-distance underground conveyance and distribution of water through masonry-lined canals and galleries, which are still in use for the past 2500 years, demonstrate the high capacity of the hydro-technical knowledge of the time. This civilisation is also acknowledged for orienting the local communities to farming.

Building up from these early technologies, the Roman period marks a time when the waterway systems were developed to distribute water over vast urban areas. As Asia, or Anatolia, constitutes the most affluent and developed province among its other Roman counterparts, the most prominent examples of Roman water technological heritage exist in Turkey. The main technical attribute of a Roman urban waterway network is the distribution of water through closed and un-pressurized conduits (Hodge, 2012). The aim was to attain a continuous flow that relies entirely on gravity. Since the main objective had been to keep the slope of conduits at a possible minimum, these waterways stipulated the construction of tunnels and aqueducts to carry the flow of water through hills and valleys. The water acquired by these structures was then stored in open or closed reservoirs, such as dams or cisterns, from where it was conveyed to settlements through pipes. The first of the three dams constructed in the Roman defense city of Dara (Figure 8), for instance, is known to be the oldest arch-type dam in the world. On the other hand, second century the dam near Aizanoi, in inner Aegean region, was the highest structure of its kind in classical Antiquity. Cisterns (Figure 9) were also vastly utilized within the walls of Roman and Byzantine cities to store water (Crow *et. al.*, 2008).

One of the greatest achievements of the Roman water technology was attained at public baths. Built of monumental scales, they not only provided facilities for personal hygiene but also functioned as public centers. Due to their colossal sizes and vast water consumption, massive economic sources were required for their construction and maintenance. As a consequence of changing economical and social conditions, on the other hand, none of the Roman baths survived after the 6th century in Anatolia.

Figure 8. The Roman dams in the ancient city of Dara, southeastern Turkey (Source: Deniz Ikiz)

Figure 9. The Byzantine Yerebatan Cistern in Istanbul (Source: Gulsun Tanyeli)

Construction of waterway systems or aqueducts constituted the most troublesome urban task in the pre-modern world. Not only such a task required massive funding and advanced technological input but also was problematic due to complex nature of its planning, construction and maintenance phases. Consequently, the daily domestic water capacity of cities supplied by Roman waterway systems was not surpassed for another 1700 years, till mid-19th century. Thus, the hydraulic technology transferred from the Roman and Byzantine periods also pursued to operate in most cities during the Ottoman era.

The most commonly known Ottoman public facility related to water had been the bath/hamam (Figure 10). Adopting a similar technology with its Roman counterpart, Ottoman bath was relatively small in dimensions and provided service in most quarters within cities. European voyagers of the time were especially intrigued by *hamams* and the culture associated with it, which were the primary architectural typologies articulated to create an illusionary east and Islamic world. Fountains had also been significant examples of water-related Ottoman architecture. As the final element of the water distribution systems, high aesthetic values were attributed to these structures rich in architectural design and adornments. In the 18th century, the aesthetic integration of water to the architectural composition of numerous monumental buildings also complemented to the perception and representation of water heritage in the region.

Figure 10. Bathing culture as an intangible heritage asset, Cemberlitas Hamam, Istanbul (Source: Gulsun Tanyeli- Banu Kutun)

As a result of rapid population growth and expansion of cities, the existing water acquisition, collection and distribution systems failed to meet the increasing demand for water. The traditional Ottoman water supply systems were highly fragmented and operated in low capacities. The modern schemes adopted in urban planning in the nineteenth century stipulated the implementation of central water supply systems in major cities (Tanyeli, 2000; 2009). European companies and experts were thus delegated the responsibility to adopt central waterworks to everyday life. As the mechanical pumping and modern sewerage mechanisms were adapted, the pre-existing public water facilities such as fountains, wells and cisterns were regarded inadequate for modern use. Following the nationalization of the private water-supply companies during the interwar period, most of the public fountains and baths were closed, and a majority of households were connected to centralized waterworks. Thus becoming dysfunctional in the twentieth century, the traditional water-related properties were inevitably neglected and most of them maintained a poor state of conservation.

4.2 State of current research

Until the second half of the twentieth century, there had been a limited number of water-related studies focusing on the ancient waterworks of Turkey, which were mainly conducted by foreign archaeologists and historians (Forchheimer and Strzygowski, 1893; Garbrecht, 1980; Crow, 2012; Hodge, 2012). As the worldwide interest on the subject augmented, more studies were undertaken concerning the tradition of hydraulic engineering and building technologies. Nevertheless, there is still a void in literature that covers the regional contributions to the universal significance of this type of heritage.

The existing literature focusing on the water-related heritage of Turkey is highly fragmented with regards to their building typologies, historical periods, and geographical distributions. This discourse requires a multi-disciplinary approach involving the joint study of archaeologists, historians, architects and civil engineers. The current research, however, is limited to the interest of researchers where archaeologists are mainly concerned with properties in archaeological sites, and art historians are primarily interested in architectural features and typologies. Moreover, the spectrum of each discipline is strictly confined to various periods in history. Even though there are numerous publications focusing on Ottoman waterworks, the contributions of Architect Sinan, or the Roman hydraulic engineering (Danisman, 1980; Cecen, 1996; Ozis, 1995), there is no specific study that discusses and analyses comparatively the progress of each period, or their interactions with one another. Hence, there is a gap in literature that introduces a holistic perspective to the studies of water heritage in the sub-region.

5 Threats to water heritage

The historic hydraulic structures and their settings in Turkey are currently threatened by natural and/or man-made hazards. Located in a nationally high seismic risk zone and in close proximity to natural water resources, the water heritage sites and landscapes are encountered with constant or periodic earthquake and flooding risks. The shifts in hydrological and climatic conditions as a result of climate change also give rise to new long-term trends that challenge further access to clean water.

Complementary to these natural hazards, the contemporary economic and urban development trends and activities also generate risks against the integrity of water-related properties. Rise in urban population growth stipulates the transformation of natural sites to new agricultural or construction zones by means of newly-adopted policies, which greatly impact on the values attributed to these sites. As it had been the case for the Roman spa settlement of Allianoi and the ancient city of Zeugma, large-scale development and infrastructure projects also highly threaten the existence of cultural properties and landscapes. These projects that only generate short- or medium-term revenues often cause permanent and non-reversible adverse impacts on the authenticity and integrity of those sites, like being submerged in the water reservoir of newly-constructed dams.

Intense tourist activities may also harden the integrated conservation of water-related structures and their settings. In Pamukkale, for instance, approximately 1.5 million tourists visit the site each year, which causes serious material deterioration and pollution of the natural formations. Other human-related activities that induce physical damages include treasure seeking and misusage of the properties. Hence, necessary measures have to be taken to mitigate these natural or man-related risks to ensure sustainability of this type of heritage.

6 Legal protection in Force

In Turkey, the safeguarding of listed properties and sites is ensured by the national conservation legislation. The primary regulation concerning the preservation of listed buildings and conservation areas is the 1983 Conservation Act that enhanced the engagement of conservation in the statutory planning system and introduced the new instrument of conservation oriented development plans for implementation. Despite the early adoption of this legislation, the status of registration and definitions are limited to movable and immovable cultural and natural heritage. Water heritage, thus, carries no specific formal status in terms of designation, conservation and management.

Another substantial law directly concerning World Heritage Sites introduced the notions of “management area” and “management plan” to the legislative framework for the first time in 2005. In addition to the definition of these notions, this regulation identifies the provisions for the assignment and operation of a site management unit, and sets the procedures for the preparation, execution, monitoring and revision of the management plan. The adoption of this law was immediately followed by the establishment of site management directorates and development of management plans for the cultural and natural sites inscribed on the World Heritage List or the Tentative List.

Nonetheless, manifold planning policies and initiatives have been adopted that contradict with the conservation priorities in the past decades. As part of a series of informal strategic planning frameworks, a new measure concerning earthquake mitigation of historic buildings was taken that enforced the application of inconvenient preservation methods. Furthermore, the 1982 Tourism Encouragement Act facilitated the construction of “tourist” facilities in close proximity to hydraulic structures, often with adverse impact on the properties. The assignment of diverse authorities and tools for the execution of plans and policies further enhance the paradoxical status of the existing legislative framework concerning water heritage in Turkey.

In conclusion, the fragmentary nature of the protection policy in Turkey fails to address tangible and intangible water-related heritage assets as coherent entities. Although historic hydraulic structures that are registered as listed buildings or situated within conservation areas are under the protection of the national legislation, the cultural properties that are not officially recognised are threatened to lose the values attributed to the sites. Thus, the water-related cultural and natural heritage properties have to be integrated into planning policies that recognise them as parts of a whole entity rather than detached fragments.

7 Conservation and management of water heritages

7.1 Conservation

As a result of the deficiencies and ambiguities existing in the planning and legislative frameworks, the safeguarding of water-related cultural and natural properties, and landscapes remains as a palpable challenge in Turkey. The conservation policies and practices are mainly in force for registered sites only, whereas the protection of unlisted structures is not a priority.

Major monuments have been well preserved in general, as a result of periodic maintenance and architectural restoration programmes implemented against the adverse effects of natural disasters and material deterioration. In archaeological sites anastylosis, “the reassembling of existing but dismembered parts”, is a valid intervention for the better presentation of the remains (ICOMOS, 1964: Article 14). In the ancient city of Sagalassos, the Antonine Nymphaeum – a monumental fountain – was completely re-erected by the archaeological excavation team through the utilisation of original materials and techniques. The hydraulic systems which are still in use are generally well-maintained and adapted to the current demands, often through attending to the principles of authenticity with regard to integrity in material usage and total appearance. The Urartian irrigation canals that are still functional mostly preserve their material and physical originality. The ones which are no longer in use, on the other hand, are often conserved to attract tourists and investments to generate revenues at local level. For example, the Ottoman baths are currently adaptively re-used to pursue their original function but the social practices and intangible values attributed to the facilities have changed. *Hamams* are common tourist attraction points and numerous activities, like pre-wedding gatherings, are conducted as new social practices associated with this type of water heritage.

Despite the efforts of conserving the nationally or regionally acknowledged heritage sites, the dysfunctional vernacular edifices have been in poor shape or completely lost due to lack of attention, abandonment, unlicensed demolition and development pressures. Small-scale vernacular elements situated within urban or rural areas, such as fountains, wells or cisterns are often neglected. This also goes for structures located in distant location and away from settlements. The aqueducts used to supply water to ancient cities but now, totally detached from settlements, are most times in poor conditions. Consequently, it is important to employ a holistic conservation approach for water-related heritage assets instead of ensuring the protection of individual buildings.

7.2 Management of properties and sites

In Turkey, currently, the processes of integrated conservation and management planning of cultural and natural properties are restricted to sites that are either inscribed or intended to be inscribed on the World Heritage List. Although the Site Management Act recently adopted stipulates management planning for all the heritage sites under protection, the limited number and capacity of expertise in heritage management has so far restricted the ongoing and completed processes to World Heritage Sites.

In this regard, effective management mechanisms are adopted and tools are developed only for hydraulic structures situated within designated sites. As some were previously listed, the waterworks in archaeological sites or cultural landscapes inscribed on the WH List are integrated to the management planning framework. Abiding by the Site Management Act, initial actions taken involve the appointment of a site manager and establishment of a site management unit for these sites. Then the management area and buffer zones are delimited and approved by the Ministry of Culture and Tourism, which is followed by the development of a management plan for the whole site. The plan usually involves the definition of the global vision, identification of the planning principles, plan objectives, strategies and actions, development of project packages and the explanation of the implementation, monitoring and evaluation processes. For each project package, the institutions in charge, the resources and the duration of the action plan should be determined. In compliance with the legislative framework, the authorised governmental bodies are responsible for the allocation of the funds and resources and the implementation of the action points they are assigned.

In spite of this well-structured framework of management planning for heritage sites, the deficiencies in the implementation and monitoring of the plans and projects have hindered the effective operation of the management systems so far. Local authorities have been rather slow in issuing regulations to harmonise the management plan with the existing planning framework. Developments should be regularly monitored, the monitoring and evaluation processes should be operated, and community participation needs to be ensured for the management plans to be effective. Keeping in mind that this management structure has only been adopted to a highly limited number of World Heritage Sites in Turkey, it can be concluded that the management of water-related heritage properties has been inadequate. The absence of appropriate management instruments and lack of coordination among various stakeholders participating to the decision-making process at different stages are the main challenges in the management of water heritage.

7.3 Sustainable development and current management of living properties

The responsibilities of maintenance, conservation and management of water-related living properties and sites in Turkey are delegated either to the proprietors or the local and national authorities in charge of their protection. These bodies are impelled to abide by the consented international conventions, the national legislation and planning policies concerning the safeguarding and sustainable development of the sites.

Despite the lack of appropriate tools and a holistic planning process, there are still several basic measures taken to mitigate negative impacts and threats to the integrity of living properties. Heritage impact assessments, for instance, are proven to be effective instruments in identifying temporary and permanent threats to the sites and proposing solutions for their alleviation. If such an assessment was conducted prior to the construction of the Yortanli Dam, for example, appropriate precautions could be taken that would inhibit the inundation of Allianoi. Relevantly, tourist management strategies adopted for Ephesus and Pamukkale are vital to ensure sustainability in the safeguarding of these sites. Periodic maintenance and interventions compliant with the unity of properties are also complementary to the management practices.

For living sites, it is also essential to adapt them to the current needs and demands of the users, while sustaining an integrated approach coherent with the tangible and intangible values attributed to them. Everyday water use structures often accompany specific social life and practices exercised periodically. Respectfully, some local authorities committed certain actions to pursue the Ottoman bathing culture in *hamams* and activated several fountains and wells in some settlements in order to sustain the engagement of communities with these facilities. They also become significant tourist attractions that portray the vernacular living traditions specific to these settlements. Furthermore, two former water-pumping stations were transformed to be adaptively re-used as the Istanbul Water Civilisations Museum in 2011. However, they have not been inaugurated for public use since due to political conflicts.

Raising awareness about the significance of water heritage and its components has to be also a priority of local authorities in order to enhance their safeguarding. During the World Water Forum that took place in Istanbul in 2009, for instance, a cultural route concerning the water heritage of Istanbul, including the structures of Kirkcesme waterways, was designated and several tours were organised to visit the sites. However, these efforts were limited to this special occasion, and no further actions were taken to carry it on. Educational and awareness raising activities should accompany conservation practices for the transmission of this heritage to future generations.

8 Conclusion

The rich water-related heritage in Turkey bears witness to the four-millennia of water utilization representing the hydraulic/building technologies and water management systems developed by multiple civilizations of different periods. Associated with the tangible assets, a corpus of knowledge and social practice that forms the essence of the intangible attributes complements the significance of water heritage in the sub-region.

Due to the lack of adequate documentation, knowledge and recognition, however, this kind of cultural heritage is not well-acknowledged and appreciated in Turkey. The limitations of the existing documentation, the fragmented nature of the current planning and legislative frameworks, and inadequate conservation policies, tools and management practices generate challenges for the safeguarding and sustainable development of water heritage at local and national levels. The priority of certain properties over less-known assets by means of registration and management also hinders the enhancement of a balanced representation. These complexities are, in fact, common to all types of cultural and natural heritage in Turkey.

In conclusion, this research is one of the initial studies that has employed a holistic and comparative approach to the water heritage of Turkey. It has defined its common significance, identified the important properties and landscapes, reviewed the existing literature on the subject, and analyzed the effectiveness of the existing conservation and management systems of such sites. Consequently, the findings of this study evince that the employment of normative tools that embrace water-related heritage sites holistically is crucial for their effective management. Furthermore, immediate actions should be taken to identify and document all the historic hydraulic structures in the region, and to raise awareness about their importance.

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Sub-region F: Iraq, Kuwait

Overview on Kuwait water heritage

Overview on Kuwait water heritage

Noora Al Musallam
National Council for Cultures Arts and Letters, Kuwait City

1 General characteristics

1.1 General climatic data and general hydrological data

Kuwait is a hot, arid state, with scanty rainfall. Dry summer winds are experienced most of the year. The general wind direction is North-western known for its heat and dryness and representing 60% of total wind yearly with speed reaching up to 19 m/s, on the opposite side and season; during spring the wind direction changes to south-eastern. In many cases strong South-eastern winds with velocity reaching up to 29.5 m/s can cause severe sand storms. The average rainfall in Kuwait is about 118mm a year. The pattern of rain in Kuwait is hardly detected; in some years it can add up to 40 rainy days and in some years as little as 8 days. Rain affects patches in Kuwait rather than the whole country. The season starts November and continues very intermittently till April, January being the heaviest.

1.2 Cultural relations and technical exchanges with neighbouring zones

Historically speaking, Kuwait is located on the boarders of Mesopotamia, a 7500 years old land. Mesopotamia is considered the most advanced civilization in the ancient world. Kuwait's history is shaped by its arid climate. Sparse rainfall concludes that people spent their lives seeking water for themselves and their herds aside from sea activities practiced by the inhabitants. Due to harsh climate and people's constant mobility; rulers seldom claimed these lands, it was mostly left independent and serving the region as an important transition zone for merchants of the Arabian Peninsula. Kuwait can be divided into two zones; Coastal and Wadi al Batin. Wadi al Batin is considered one of the 3 Pliocene Wadis that drained Arabia millions of years ago. Al Batin Wadi is a low basin, a several kilometers wide typography. It is geographically responsible for shaping modern Kuwait. As for the coastal zone, it is separated from the desert by Jal al Zor "al Zor shore", a low ridge running all the way from behind al Jahra to Mudairah. Between Jal al Zor and the sea lies a fair coastal strip, about 3 or 4 kilometers long. Several wells were discovered along this line, many of which are remembered by older inhabitants of the region. These wells seem like they were a part of a route network for caravans. In the northern desert of Kuwait, wells were a crucial part of survival. Accessing groundwater, methods of extraction, storing water and rainwater, these were skills that must be highly practiced in order to survive. Inhabitants in this area were semi settled depending on the availability of water. Also nomads and itinerary merchants crossing the merchant roads used to temporarily settle in these deserts.
There is a dense net of wells found parallel to the Gulf. It is assumed that in the prehistoric periods the ancient climate of the region was more humid leading to a larger amount of precipitation. It has also been recorded that the average yearly rainfall in northern Kuwait is higher than any other area in the region which is no surprise to excavate and record nearly 40 wells starting from Kuwait city, Jahra, Muheita and Mughaira to Dubaij.

Water in the northern region has been used by many civilizations through history; from the Neolithic settlements to nomads of the 3rd and 2nd millennium BC as well as the temporary settlements of Sassanian and Early Islamic periods during pilgrims, travelling to Mecca. Some wells were used periodically until mid-20th century.

Shatt al Arab was considered a long lasting source of freshwater during the first half of the 20th century. The location of Shatt al Arab is identified by the separation of west Iraq and east Iran. Shatt al Arab water comes from Tigris and Euphrates River, the starting point of this river in Al Qarna, north of Iraq. Rainwater and snowfall gathers in the mountains of east Turkey making their way over the Gulf throughout the year. When freshwater increases due to heavy rain season the freshwater from Shatt al Arab moves further within the Gulf. But in low rain seasons seawater is pushed within Shatt al Arab. Kuwaiti water boats travel to Shatt al Arab for freshwater, however due to the fact that it is located in Iraq; nominal amount of money is paid to Al Fao customs for leaving Shatt Al Arab with freshwater.

The Dilmun civilization has been recognized in Failaka Island since 1800 BC. Some seals were found during the Danish excavation (1958) dates back to the third millennium "Early Bronze Age". According to Hopkins University analysis and examination which indicated the following; "More than 50% of seals overlap in subject and style between Bahrain and Failaka. One can define an independent Gulf idiom". This includes illustrations of Enki "God of Sweet Water" found in seals.

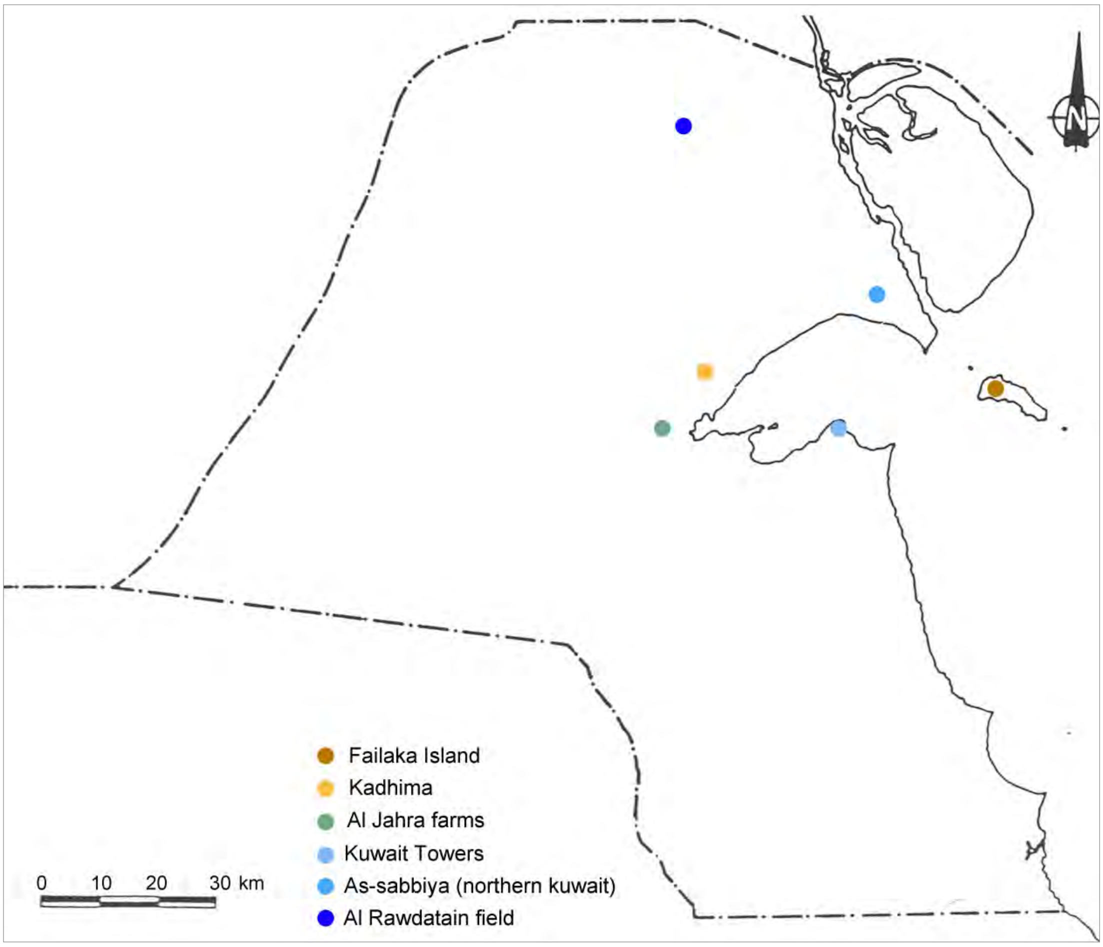

Figure 1. Regional map indicating the main sites for the cultural heritage of water (Research and Studies Center)

2 Known sites and important sites for the cultural heritage of water

Water sources sites in this particular region are considered very valuable and scarce. Most wells that were found in the first half of the past century are now dry and are not considered of importance, we need to also take into consideration that because these wells are not long lasting sources so the architecture and methods of construction built to extract water out is usually of a temporary state that lasts until the well is dry. Rain plays a very important role in forming these wells. During the Pleistocene era there were a lot of rainy and arid days, naturally during the rainy season, rainwater seeps through the pores of plutonic rocks creating fossil water. Since rainy season is scarce nowadays; fossil water is considered a limited natural resource and therefore wells are usually of an archeological nature. Some wells remain a good source of underground water like Al Rawdatain field. In the second half of the past century, when the oil was discovered, water sources changed drastically as with the modern methods were taking over the wells disappeared under modern infrastructures and others were filled with stones and covered by desert sand, *three wells were found in an excavation in Muheita and Dubaij.* Distillation plants were growing larger in number and later they were accompanied with the largest infrastructural water system in Kuwait with a distinctive architectural feature of both Water towers "mushroom towers" and Kuwait towers.

2.1 Archaeological sites

Failaka Island

In 1976 an Italian excavation from Venice University discovered a well dug into the bedrock in a location named Tell Khazneh located in Failaka Island, one of the nine Islands in the Gulf under Kuwait's rule. Failaka Island is considered a historical hub for various civilizations throughout the human settlement in the region. It is dug into the shelly conglomerate that was partly dug under the wall built on a chocolate-colored layer which the well was filled with after the 1974 excavation. The well predates the existing of the chocolate layer wall above it which means that the human settlement dates to the 5th century B.C. Through the French excavation in Failaka Island in 1984-1985, it was concluded that the well was cleared by the Italian excavation in 1976 excavation. It is probable that this was the earliest finding of the well (1976) and it was not found during the Hellenistic period and the accumulation found in the well in 1984 is most likely of the past 10 years only.

The chocolate layer partially covers the well-mouth in the southern section of square. Whatever material collected in the well filling may suggest or indicate new ideas regarding the chronological assessment. This is not possible to know until the Italian expedition is recovered. Nothing of significance remains from this well except for a few fragment of small architectural stones made usually of limestone, coarse limestone, local fine sandstone and local yellowish sandstone.

According to the John Hopkins University reconnaissance expedition to the Arab/Iranian Gulf, October, 1972 several notes indicate source of freshwater in the Island and estimate the age of the early settlements in the region.

The Danish expedition and excavation (1958 – 1963) conducted research in two separate Bronze Age sites (2000-1100 BC) and two Hellenistic sites. There are three Bronze Ages that are differentiated by wall width. There are physical proofs of wells found in early Bronze Age but no proper study has been conducted yet. Some interesting Early Bronze Age finding were discovered; a low square construction on the exterior side of one wall, it had the appearance of a well. Also, in Failaka Island, on north and east side of the Danish excavations lies an oasis on a low sandy plain, This is considered to be a large focal point for freshwater surrounded by palm trees. The excavation dates this oasis to be from the Dilmun civilization due to some shreds remains from pot.

Northern Kuwait

The stone curbs and walls found around the excavated wells in these areas prove a highly organized social structure with heavy and long usage. According to the Kuwaiti-Polish Archaeological investigates in Northern Kuwait, 2007-2010, wells were given codes:

Well- cistern SM 12, Muteita region

The discovery and study were conducted in 2008-2010. The well was found on a hollow desert plain sloping towards seacoast. The shaft consists of 22 layers of sandstone blocks without mortar, the stones used seem from a single local source and the flat blocks were of similar measurements.

Figure 2. General view of the well-cistern SM 12 at the end of the excavations, spring 2010 (M.Okulus, L.Rutkowski, F.Pawlicki, A.Reiche, L.Wojnarowicz, E.Mizak)

The blocks were arranged in “stretcher bond” [stones overlapping midway with the ones below and above]. The horizontal section indicated an opening of 3.25 m diameter from the top and 1.35 m at the bottom. The fullest well capacity is estimated to be around 10 cubic meters of water. The well is accessed by three steps, which are unfortunately of ruins now and a 9 m diameter circle (NS axis) by 8 m diameter circle (EW axis) surrounds the well, nearly three layers of sandstone blocks without mortar high. The construction is for either to protect inhabitants and animals from the deep shaft and to protect the well from sandstorms. The construction work on the well attests to a true skill of masonry work however, this observation does not aid into concluding to which era this well belongs so the date of the construction remains hypothetical.

Desert well complex SB 23-1 in Dubaji Area

Excavation work was in 2008-2010. Made of 23 layers of sandstone; this well is 4-meter wide from the mouth and 1-meter smaller at the bottom. It is surrounded by cliffs from three different directions and the water is collected from the north by two wadis cutting the cliff.

A curb is flush with the surrounding ground and gradually rising towards the south to a height approximately 70 cm, it was designed this way to cater for water collecting. At the depth of 2.9 m water appeared proving not only it collects rain water but also groundwater. The well has been buried with rubbish and desert sand. Many campfires stationed around the well; the walls are burnt as an apparent indication with a thick soot layer on the stones of the upper part of the curb and the collar of the shaft wall were cemented in the 1930s. The horizontal section of the shaft retains an oval looking shape but the construction does not look properly uniformed and very irregular. Two modern structures were found next to the well, it is believed that they are used for pumping water from well and they probably had electricity.

Figure 3. Well-cistern SB 23-1 in Dubaij, before exploration (M.Okulus, L.Rutkowski, F.Pawlicki, A.Reiche, L.Wojnarowicz, E.Mizak)

A smaller, inverted bottle shape like well SB 23-2 was dug close to SB 23-1, with a diameter of 1.25 m at the mouth. Walls of shaft were out of 12 regular layers of limestone, and the deepest part was hollowed out in bedrocks. The smooth surface of the walls of well is an indication that this well was permanently filled with water. Even now, after removing the sand layer water appeared at the bottom of the well. Chances are that these two wells functioned together as one structure. The form of the well creates pressure in underground water making it easier to surface up. There is a small horizontal shaft found at the bottom of well, it is assumed that it's leading to underground water pockets.

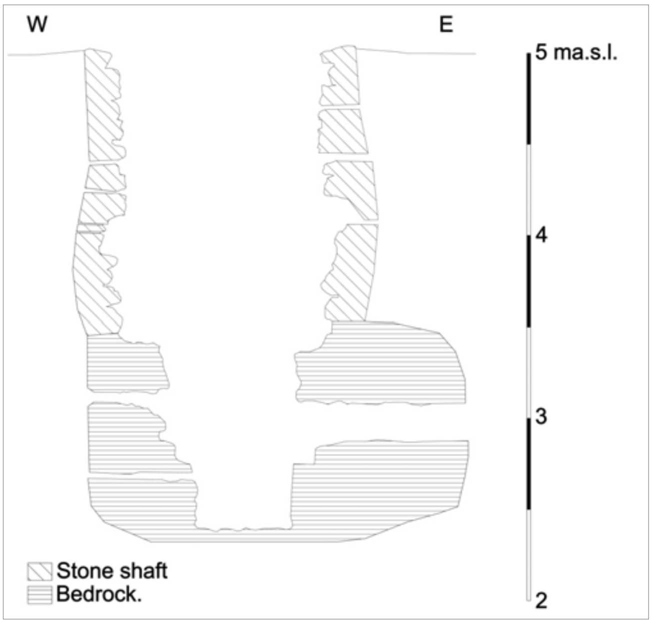

Figure 4. Section through SB 23-1, M.Okulus

Mughaira

In an area in the northern region of Kuwait, nearly 40 inhabitable archeological structures were found in an 800 m by 300 m area, indicating life in the area. The location overlooks salt flats, which probably dried the tidal bay when the site was occupied making it an easy access to sea for fishing and trading. Nearby the area and below the cliff lays a well well-known to current Bedouins. The well supplied the area in the early Islamic periods; 1200 years ago.

The well for Camel Caravan

Al Kadhima is a northern excavated area by a team of archeologist from Durham University in 2014. A part was discovered with 3 to 4 stones arranged in an unusual formation. It appeared that it has been surrounding a low-lying circular area filled with sand. After excavating the site, which turned out to be a circular stone lined well, 4.5 m wide and 5.5 m deep. Stones until 4 m depth were intact by a clayey mortar and last meter was cut through a green solid clay material. Water started to come out as excavators went deeper. It was brackish and quite drinkable. (Figure 4)

Around the well were notches caused by constant rope friction due to the action of taking buckets in and out the well through ropes. According to archeological analysis, the well went under several changes through the time it was used. Five troughs were found around the area with depth not exceeding 40 cm, a 3 m square looking basin. Archeologists reason the abundant number of troughs with heavy demand. Large number of camel caravans moved along the coastal trade route, filled with merchants and their herds. It is difficult to be certain of the exact date of the well but it can be estimated according to the surrounded excavated sites dating back to 7^{th} – 8^{th} century AD.

Figure 5. Kite photograph of well complex showing the camel-watering trough around the well (Mark Woolston household)

Al Jahra Farms

Al Jahra is located near Kuwait's bay head. It is historically acclaimed to be an important oasis filled with palm trees and vegetation. The historical fortress also known as the Red Palace was located in Al Jahra and was inhabited by the Sheikh. It is believed that in the courtyard there was 4 m deep well providing fresh water for the sheikh and the army when they fought against Muslim brotherhood, a sub division from Al Wahabis on October 10^{th} in 1920.

For the longest time Al Jahra farms provided fruits and vegetable supplies for Kuwait city. These farms are believed to have been alive since 1709. The red palace is the only historical monument left close to the location of these farms in the south of Jahra; the water system in consists of an old irrigation systems, old wells and different ways of distributing fields. The farms used to connect to the houses from the northern east side to the red palace. Mud walls surround the farm; some are still standing to this day. Traditional irrigation systems and water canals are optimized to this day as well. Basin based agriculture which suits palm trees and leafy plants. Some sand rock wells are maintained.

2.2 Living Sites, which are still used or partially used

Water towers and Kuwait Towers

When the oil industry boomed in the 50's, the population increased with higher standards of living. The search for freshwater grew higher in demand; Kuwait's first solution was to build two distillation plants (Figure 8) and distribute water through tank trucks. (1950 – 1953)

The freshwater demand increased and in 1965 the Ministry of Electricity and Water commissioned the Swedish architectural and engineering firm VBB "Vallenbyynadsbryan" to develop the first modern water supply system for Kuwait. The company divided the country into six service zones. Five out of six were already occupied and the later was for future expansion of the urban plan. The zones were divided according to altitude, location and density of population. The quantity of water would differ in each zone according to distance from distillation plant and water demand. The height of the towers would vary for adequate pressure. The towers supply both fresh and brackish water in separate pipelines. Freshwater is usually for residential and brackish water is for several purposes; firefighting, washing, street cleaning and irrigation.

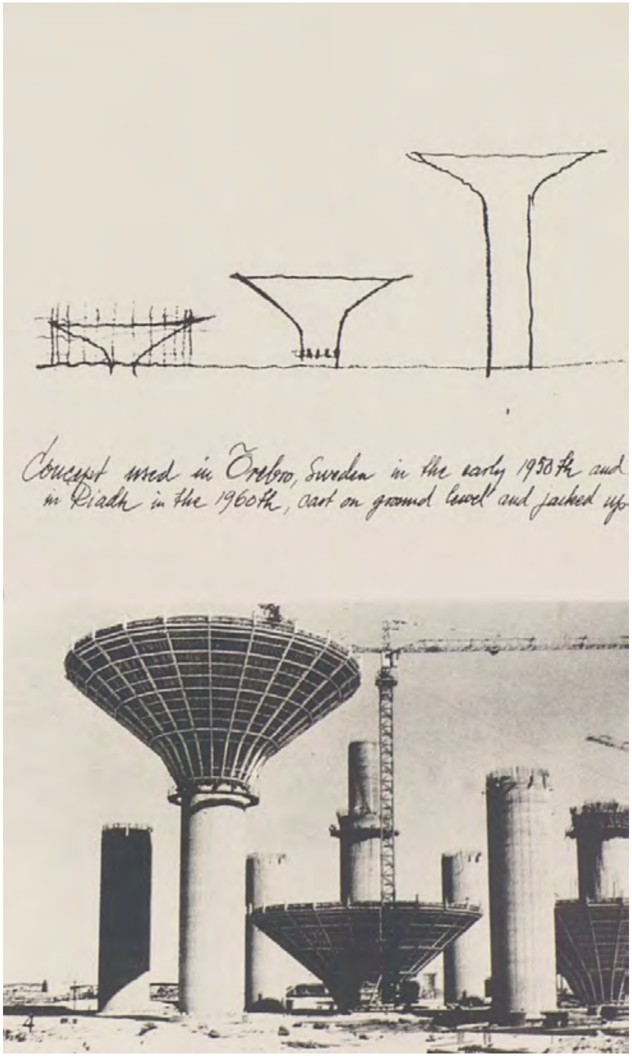

Figure 6. The process of assembling the mushroom towers (Aga Khan report)

By December 1976 the water tower project was completed. The most astonishing feature of the project is the thirty-three storage towers with a combined storage capacity of 102,000 cubic meters. These towers are divided into two types of physical structures. First group is Thirty-One Mushroom looking towers in each zone they are either six or nine towers. Due to the strategic location of the second group of the last three towers, they were designed differently and were named Kuwait towers. The Mushroom towers vary in height, color, arrangement and number. The space surrounding these towers is treated as a public space with some greenery, walking areas and seating. These Towers became a landmark of each district it serves. Concrete is the main element for the structural systems of these towers which are reinforced concrete and pre-stressed concrete. The concrete was mixed on site; it consisted of cement, local sand and gravel collected from desert, it didn't require a waterproof system due to its high quality. A wooden formwork was required for reinforcing concrete. For the Mushroom towers it was sliding wooden prefabricated formwork to be reused for 15 weeks of construction of the total of thirty-one mushroom towers. (Figure 5)

The mushroom towers were considered a structurally economical design that was aesthetically pleasing as well. Each reservoir contains about 3000 cubic meters capacity. The inverted conical shape insured water delivery at a constant pressure even at low water levels. The Kuwait towers formwork construction was made of plywood panel in order to achieve its tapering profile. Due to its prompt location it was requested by Sheikh Jabir Al Ahmed to design these three towers differently and more appealingly than the mushroom towers. The design was originally by

Malene Bjorn, with water storage over 9000 cubic meters. The Kuwait Towers hosted other functions, such as the viewing sphere, a restaurant and a café. The composition of the three towers is highly thought of, with two tower containing 4500 cubic meter water reservoirs, and the third needle like tower to illuminate the group at night. On June 2014 a Tentative List entry of Kuwait towers was submitted and approved by the UNESCO World Heritage Centre as a modern heritage monument. The team at the National Council for Cultures Arts and Letters is currently preparing the nomination file to be submitted on January 2016.

Al Rawdatain Fields

Groundwater fields with freshwater (underground brackish water):

1- Al Rawdatain low field, 114 ft. above sea level
2- Umm al Aish low field in the north (destroyed during Iraqi invasion, 1990-1991)

First usage of fresh groundwater was in 1962, with salinity levels between 600 – 1000 ppm. Groundwater was fresh which ultimately started Al Rawdatain water filling company, a Kuwaiti investment company.

The Al Rawdatain field was discovered by coincidence in May 1960 by the Ministry of Electricity and Water; searching for low sodium groundwater wells while working on Kuwait-Al Abdil road and from there Kuwait summoned a British engineering firm, Parsons Corporation, to study and dig Al Rawdatain field, producing 26 wells at that time.

Most of Kuwait’s natural water resource is brackish underground from Al Dammam limestone aquifer pouring onto Kuwait's group by the hydraulic pressure coming from Damam's formation. Brackish water is limited in Kuwait and it is generally abundant in the northern part in Al Rawdatain and Umm al Aish "where it occurs in the form of freshwater lenses floating on top of Kuwait's group of brackish water."

Al Rawdatain is a rectangular internal basin with width reaching up 4 -5 Km and length up to 15 Km. It is considered shallow with a descended mild slope on the edges. Rainwater is collected within creating a temporary Playa lake reaching up to 2-4 ft. deep; however, this lake is not a freshwater source of the field.

Al Rawdatain is considered a part of a bigger field that is divided into two. The surface of the field consists of rocks from sand and log gravels. As for the areas where water rafts; the rocks are from silts, fine sand and mud. The field is positioned in low lands consisting of 4 -6 inches of compact brown-grey silt. The deeper fields have a less compacted soil and their color changes from brown-red to brown-grey. The soil of the field's surface is locally of recent age whereas the lower layers of the field belong to Pleistocene era.

There are three layers in Al Rawdatain field which consists of freshwater, separated by layers of silt rock and laminated mud layers with low permeability. Most of the field's production is from the upper layer of the three.

The water quality varies in the degree of quality. Parson corporation studies indicated that the usable fresh groundwater of the field is in the upper part of saturated sandstone bed of Dibdibba's (an area in the region) formation. Quality ranges from 200 to 800 mg/l of TDS (Total Dissolved Solids). Freshwater is surrounded by brackish water. The deeper layers have a higher salinity level. Also the closer we are to the center of the field the salinity level will become higher.

Salinity levels raise when the production increases and an increase in the drop in water level. Al Rawdatain water contains high levels of magnesium and sulfate ions with a tendency of a corrosive effect.

The thickness of layers consisting of water within is constantly reducing throughout the years.

The evolution of any groundwater reservoir is subject to the amount of renewable water entering the reservoir on an ongoing basis.

According to a study published in 1979 by Parson's company surveying the field and concluding the field's daily production is 3.8 million gallons. 2.7 million is underground water, 7 million from naturally charging the field and 4 million from artificially charging the field. According the previous estimation, the life expectancy of Al Rawdatain field will terminate in the early 90's; this estimation lowered yearly production from the 70's and witnessed an increase in experimentations to increase life expectancy of the field. But this study is proved not accurate; as we reached 2015 with an abundant amount of water from these fields with regards to the experiments done for water increase back in the 70's. As for a study by Bergstrom in 1965 in University of California it was estimated that the life expectancy of the field is less than 500 years.

Between years 1962 -1976 highest production level recorded for both Al Rawdatain and Um Al Aish field was in 1967 with a sum of 1272 million gallons per day.

2.3 Cultural Landscapes related to water

The concept of Mai Sabeel

It is to offer fresh water for drinking without a fee for the public. An example of this concept was by Abdul-Aziz Ahmed Al Duaij, who opened a store in the old souk (Mubarakiya) by the name of Souk bin duaij, which offers fresh water for passing people for free. People started to call it "Sabeel Duaij".

It was two pottery pots filled with water from wells outside Kuwait city and transported by a camel. According to historian Farhan Al Fahran, Sheikh Yaseen was the first person in Kuwait to initiate “Mai Sabeel” concept back in Sheikh Abdullah Al Sabah reign (1762 – 1763), the second ruler of Kuwait.

Diminished historical water businesses and job opportunities

As the water business grew; new trades and job opportunities were created. Water delivery required a large and a strong labor force. An example of an emerging profession is the Al Kandri which is now a name of a large family in Kuwait today. Al Kandris hold two Kerosene tins by a rope hanging from a wooden stick and placed on his shoulder. (Figure 6) Al Kandiri originally means the water carrier in Persian and Kanadar means stick in Farsi.

Al Hammarah is a title of a man owning donkeys for water delivery purposes from various places and carrying water from wells outside of the old city walls to Kuwait city; this method goes back to the Gulf region. The carrier owns a donkey or a couple, one for his own usage and the other two are for renting. Each donkey can hold up to 3 water jars made of goat skins. Either water is delivered to houses or sold in "Souk Al Mai" The Water Market where the owner is obliged by a law established by the municipality in 14/4/1930 to take the water jars down the animals or he will face charges. After sealing a deal; either the costumers fills their jars or order Al Hammar for home delivery. When water from Shatt al Arab is scarce usually well water is sold, which is not very likeable by the public.

Figure 7. Al Kandari (National Maritime Museum, Greenwich)

Usually Al Kandiri and Al Hammar announce vocally around the neighborhood "Shatt! Shatt!" which means Shatt al Arab water and "Ad Mai" which means well water. Water is sold to the highest bidder. Sometimes buyers would pay weekly or monthly. The houses that receive water get a mark on their walls, saving fresh waters in pottery pots. Kandar and Hammarah would gather around water boat "Boom al Mai" once it arrives inside the port, either people swim to it with their jars to fill or they drive a small boat "Keter boom" to reach it. (Figure 7)

If Shatt al Arab waters from "Boom al Mai" is not taken away directly from the port by Al Kandiri or Al Hammar to sell it in different neighborhoods, it would be delivered and sold in Water Souk in Mubarakiya in the old city market near Mubarak shop "Kushk Mubarak". In some cases; women on their own used to balance Kerosene tints on their head to head to "Boom Al Mai".

Figure 8. A water boom docks on the beach in Kuwait (National Maritime Museum, Greenwich)

House delivery methods were tough and took a lot of time to be accomplished, resulting in "Al Mahara" which is basically two men pushing a three wheeler wooden carriage with water tanks. After the first sea water distillation plant (1951 and 1953), in those years water trucks started to deliver water around the streets by filling steel tanks distributed around different neighborhood . This method was used until 1958. Some areas use this method to this day.

An interesting job emerged, creating order in the logistic and financial department in the old water business. "Al Karrani" is the boat's accountant, keeping track on the arrival and departure of boats, amount of water shipped from Shatt al Arab and keeping track on the change in cost of water depending on several factors.

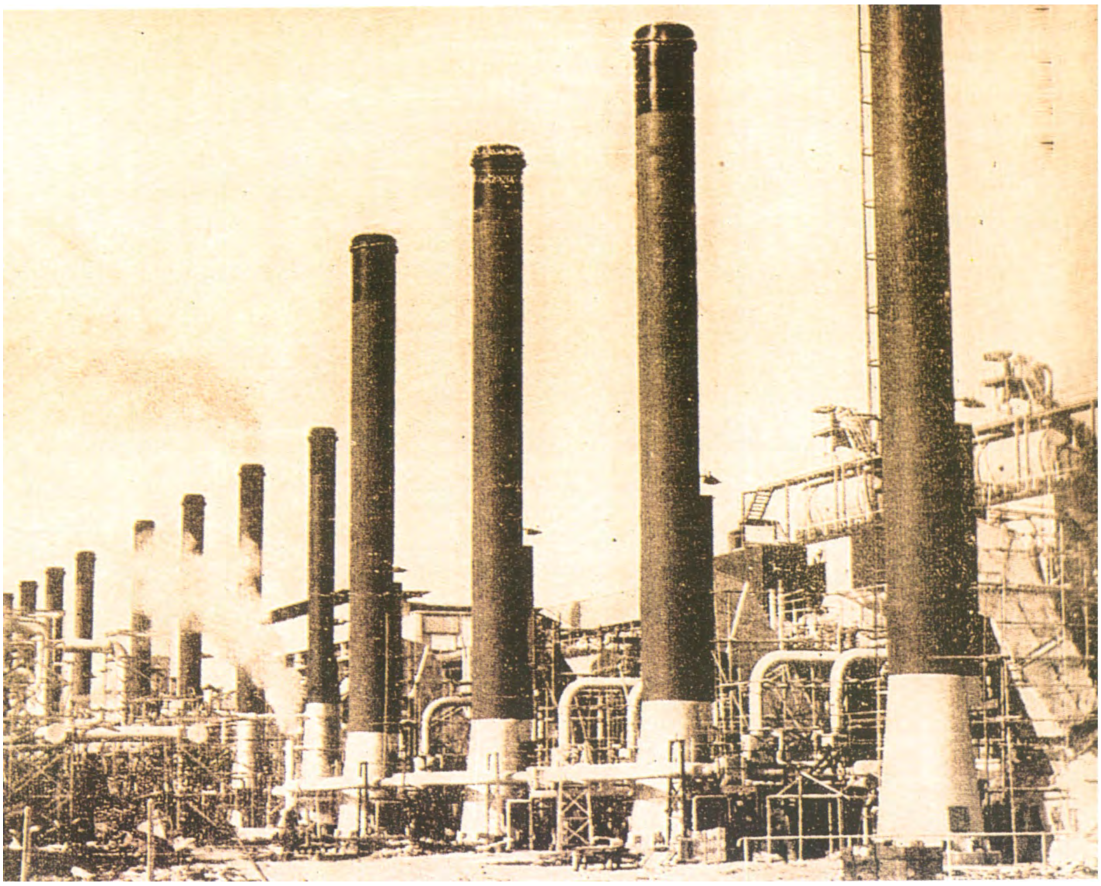

Figure 9. Water distillation plant in Shuwaikh established in 1953, Research and Studies Center of Kuwait

Kuwait Water Company

The Kuwait Water Company was established in 1939 under the command of Sheikh Abdullah Al Salem to supply the people with water at reasonable prices. All water boats owned by different families traveling to Shatt al Arab for water were bought by the company, owning up to 45 water boats "Abwam Al Mai" however; in the beginning it had about 25 ships only.

By 1940 it was owned by the government and some major merchants. Khaled Zaid Al Khaled was elected to head the company. In 1941 there was a water crisis and so KWC stopped selling water to whoever had a water basin in their courtyard, and in 1942 KWC increased capital, formed a new board of directors and built 11 ships. Families that owned water ships used to price their own water; however when KWC took over, many families sold their ships to the company. Also, KWC built 3 basins to store water and sell it to the public. The KWC also established a simplified paying system for the ship crew: 5 to 10 rupees each trip and the captain was paid double the amount, excluding food supply during trip.

Methods of gathering rainwater

Al Berka: a manmade pond in the middle of the courtyard of every house enclosed with cement, 4 meters deep and 4m in diameter at the bottom, but shrinking as it reaches the top of the opening to about 1m or 2m. This pond fits about 4000 gallons of water.

Shatar: is a huge piece of thick cloth hung from the top four edges of the courtyard with an opening in the middle on top of the pond "Al Berka".

Al Fintas: a semicircular wooden container.

Selhi: a container made from pottery with a cover that is usually opened during rainy season to gather water as much as it can contain, this is a very simple and guaranteed method to gather rainwater throughout the season not that it generates a large quantity but it is sufficient to serve basic needs for a short period of time.

Types and locations of historical wells

Groundwater; water extracted from the bottom of the earth by digging deep holes; in old Kuwait we had 4 types of wells:

1- Al Jeleeb: Most common and widespread type. It varies in depth and freshness. Nealy 156 wells are located in Kuwait. Most of these wells are diminished and only exist in literature context.
2- Al Ad: Freshwater, mostly in deep levels and it is available throughout the year. Nearly 9 are recorded in literature context.
3- Al Mashash: A group of shallow, low salinity level wells close to one another, mostly drinkable. Nearly 30 are recorded in literature context.
4- Al Thumailah: Dug in a rectangular hole, this type gradually regressions towards the depth after a rainfall. Sand dugout from the hole is kept close to it as an indication to its location. It's shallow and considered a low freshwater source but nonetheless has freshwater. Nearly 13 are recorded in literature context.

Wells in Kuwait have been discovered to have different historical background, some wells belong to the Bronze Age and others are as recent as the 20th century. Found nearly in every direction in Kuwai, there are certain locations however that are considered more common than the rest:

1- Kuwait city
2- Shamiya
3- Adailiya
4- Hawali
5- Al Niqra
6- Al Dasma
7- Al Salmiya (Dumna previously)
8- Al Ra’as

9- Al Beda’
10- Al Maseela
11- Al Funaitees
12- Al Fintas
13- Abu Hulaifa
14- Al Fahaheel
15- Al Shuaiba
16- Al Jahra
17- Malah
18- Al Mugwa
19- Al Sulayil
20- Ghudhi
21- Failaka Island

Shatt al Arab trip
Boats leave Kuwait's shore on high tide. The trip takes about 10 to 15 hours. During summer boats stop inside Shatt al Arab or in Abdan to get fresh waters. In order to fill the tanks; the boat must be stabilized by four anchors. Water is pulled out by "alzeelah". It takes about 3 to 4 hours to fill 10 tanks with 4000 to 5000 gallons.

The captain then pays Al Fao customs 3 rupees, and then the boat goes through inspection. In some cases the way back could be dangerous due to the heavy carriage.

Boats are evacuated in "Al Niqa'" which is manmade ports to prevent waves from flipping the boats over. Each boat pays about 10 to 20 rupees to park at "Al Niqa'".

3 State of historic and technical knowledge concerning water heritage in the sub-region

3.1 Definition of periods in man’s relationship with water

The definition will be presented as a chronological timeline representing important dates with regards to water heritage and man's relation to it.

Pleistocene era: Witnessed heavy longer rain periods and naturally during the rainy season, rainwater seeps through the pores of plutonic rocks creating fossil water. Since rainy season is scarce nowadays, fossil water is considered a limited natural resource.

3rd and 2nd millennium BC & Early Islamic periods: archaeological wells discovered in northern Kuwait serving the Neolithic settlements to nomads, the temporary settlements of Sassanian and Muslims during pilgrims, travelling to Mecca. Some remained in periodical use until mid-20th.

615 AD: Discovery of Abudawarah wells currently Al Hamra mall in Sharq, Kuwait city. Found nearly 1400 years ago.

1709: AlJahra farms, wells and ancients irrigation systems.

1820: Kuwaitis traveled to Failaka Island for fresh water.

1831: According to a statement by J.Ash Stalkler when he visited Kuwait "Water was not remotely close to being fresh."

1841: According to a statement by Captain Asse Henel when he visited Kuwait "The area is all deserts, sand and salt. No trees or jungles. Some trees exist; indicating wells in the region however, the taste and quality of these waters are not suitable for Europeans."

1896: Sheikh Mubarak Al Sabah sought after an efficient system to get freshwaters especially with the constant growth of the population.

1905: The first fresh water well discovered in Hawalli but lasted for three years only.

1908: Drought due to low rainfall.

1909: Boat owner Mohammed Al Yacob traveled to Shatt al Arab. His boat was equipped with wooden tanks to fill them with water and sell them back in Kuwait.

1910: Nearly 50 ships travelling to Shatt al Arab each carrying 5000 gallons.

1911: Scarcity in labor force concerning water shipment due to the pearl diving boom
Aside from these issues; the population increased due to the migration of merchants from Persia to Kuwait.

1912: Shakespeare, the British politician living in Kuwait suggested to the Sheikh to build a distillation plant with financial support from the Indian/British government. The debt was shared by many Kuwaiti merchants along with the Kuwaiti government costing 109,000 rupees.

1913: E.H.Pascoe, the geologist arrived from India for an initial scan for groundwater in Al Shuwaikh, Kubar Island and Warah Island.

1914: Sheikh Mubarak desired to establish the first distillation plant through a British agency.

1915: First machine to desolate water, from the English-Indian government. The water was less pure and more expensive therefore the machine was discarded shortly.

1917: Salem dam built in Al Shaab valley during Sheikh Salem bin Mubarak Al Sabah's reign.

1919: The first desalination plant started to fully function due to delays from WWI.

1921: The machine needed adjustment in order to reach the agreed amount of water. The company titled Scott and Co. but it didn't work and they paid Sheikh Ahmed Al Jabir 225000 rupees.

1924: The distillation plant station failed and was shipped to Eden.

1925: A seafarer placed several empty barrels in the hold of dhow and sailed to Shatt Al Arab.

1927: An agreement with Eastern and General Syndicate Ltd was established to dig a 140 ft. deep well in sharq and another 500 ft. deep with no luck in finding any freshwaters.

1929: The first distillation plant was closed due to its expenses and impure water.

14/4/1930: A law governing animals used to carry water. "Al Hammar" either delivers water to houses or sells water in "Souk Al Mai", the Water Market. He then must take the water jars down or else he will get a fine for tiring the animal.

1931: The water tanks on ships suffered from hygiene issues as a result the municipality ordered to clean the boats after every trip or else it will pay a fine worth 9 rupees.

1933: Nearly 600 wells were recorded by the British management.

1933: There were 49 water boats travelling to Shatt al Arab six journeys per day. Each boat has about 50000 to 80000 gallons of water.

1937: Sheikh Ahmed al Jabir started a campaign to find underground water with the assistance of groundwater hydrology consultants but no luck in finding it.

1938: The idea of building a pipeline to Shatt al Arab was highly supported however this meant Kuwait will still depend on Iraq for fresh waters; so the project never instigated.

1939: Sheikh Abdullah bin Salem Al Sabah established Kuwait Water Company to supply the country with water in a reasonable price. All water boats "Abwam Al Mai" were bought by the company totaling to 45 boats.

1940: Kuwait Water Company was owned by the government and some major merchants. Khaled Zaid Al Khaled was elected to head the company. In the beginning it had about 25 boats only.

1941: Another attempt in finding underground water. A lot of wells were discovered and are used to this day. High salinity level wells are naturally more common so the water extracted is for irrigation and construction.

1941: Water crisis which led KWC to stop selling water to families with a water basin at their courtyard.

1941: First field discovered in Kuwait with an abundant amount of groundwater was in "Sulaibiyah".

1942: Water price increased due to higher demand. The price of 4 gallons of water was a bit less than 1.5 rupees.

1942: Kuwait Oil Company dug a well close to Dasman palace, but the water was not drinkable.

1942: KWC increased capital, formed a new board of directors and built 11 new water boats.

1943: Water price increased to 1.5 rupees per 4 gallons.

1944: During WWII, water boats decreased to 28 boats due to lack of maintenance and water prices went from 1.5 rupees per 4 gallons to 1 rupee per 4 gallons.

1947: Second attempt for a distillation plant was on the horizon due to financial ease from the new petrol industry.

1948: A number of Kuwaiti merchants decided to go forward with Shatt al Arab pipeline with a capital of 1 million Sterling pounds but there were no guarantees from the Iraqi governments to assure the success of the project and the idea never came to life.

1948: The distillation plant was commissioned as an idea from Britain to Sheikh Ahmed al Jabir costing 6 to 8 million Dollars.

1948: Price of water was 1 rupee per 4 gallons.

1949-1950: The KWC built three basins to collect water on the shore, locations are as followed: Sharq, facing Nuqa'at aL Ghunaim and Qibla with total capacity of 880000 gallons. Water was pumped from boats to tanks through pipes.

1950: KOC built the first distillation plant in Al Ahmidi pumping about 120000 gallons per day to Kuwait city.

1950: Discovery of Al Abdiliyah field; a low salinity levels.

1951: KOC built the first real water distillation plant in Al Ahmidi port producing up to 100000 liters of water daily.

1953: Sheikh Abdullah Al Salem installed a desalination machine.

1953: The second desalination station was built in Shuwaikh port.

1955: The idea of Shatt al Arab pipeline was discussed once more by the Sheikh and Kuwaiti merchants but they decided to close the case once and for all and focus on expanding the distillation plant for more freshwater.

1958: Marked the end of delivering water by trucks around the streets by filling steel tanks distributed around different neighborhood.

1962: Marks the first usage of fresh groundwater with salinity level lower than 1000 ppm in Al Rawdatain and Um Al Aish.

1962: Discovery of Al Shaqayah field; a low salinity levels.

1964 to 1976: The average annual precipitation over land is 30.3 mm-242.4 mm, this is quite little for supplying fresh groundwater.

1965: Shuaiba station produced freshwater with seven distillation plants and a capacity of 14 million gallons of water per day.

1965: The Ministry of Electricity and Water commissioned a Swedish architectural and engineering firm VBB "Vallenbyynadsbryan" to develop a modern water supply system for Kuwait.

1970: The Gas and Water division, 1950 changed names to Underground Water Administration.

1971: Al Dasma group of wells (nearly 40) spread around the area of Al Dasma are used for irrigation because they are low in sodium.

1971: Southern Shuaiba station with capacity of 5 million gallons per day with six distillation plants totaling to 30 million gallons per day.

1973: An expedition from Hopkins University came to Kuwait. The expedition studied the history of residential areas since Prophet Mohammed's immigration.

"There are several expeditions afterwards; Denmark, Polish, Italian and French, all concluded that there was life in this area and people settled. They've also discovered hundreds of wells that were "folded" which mean that they excavated the edges of the well to the bottom. These wells are largely distributed in the northern area of Kuwait. Wells are usually found in areas where travelers pass by during their travels."

1976: An Italian excavation from Venice University discovered a well dug into the bedrock.

1976: The Water Tower project by VBB was completed.

1978: Eastern Doha station with seven distillation plants and capacity of 42 million gallons per day.

1983: Southern Doha station with 16 distillation plants and capacity of 110.4 million gallons per day.

1986: Discovery of Um Qadeer field; a low salinity levels.

1988: Water production lowered to 9 million gallons due to low maintenance, low efficiency and uneconomic operation.

1988: Capacity was lowered to 28 million gallons per day due to low maintenance, low efficiency and uneconomic operation.

1988: Southern Zour station with 16 distillation plants and capacity of 115.2 million gallons per day.

1990: After the Iraqi invasion destroyed Shuwaikh station; they were replaced with three distillers with capacity of 6.5 million gallons per day and a total of 19.5 million gallon per day.

1993: Kuwait's production of freshwater by desalinating brackish water reached 81 Million imperial gallons per day.

2003: Kuwait dedicated 8 units of Reserve Osmosis method with production capacity of 2 million imperial gallons per day and by today it produced 6.25 million imperial gallons per day.

2006: Sabbiya station with 4 distillation plants and capacity of 50 million gallons per day and another 4 distillation plants and capacity of 50 million gallons per day.

2012: North Shuaiba with 3 distillation plants and 45 million gallons per day.

2012: Maximum recorded consumption was in 87.283 Million imperial gallons.

2012: There are over 156820 connections to all private and commercial properties around the country for freshwater and 78702 connections for brackish water.

4 Legal protection in Force

Any legal protection with regards to water heritage falls under Kuwait's Law of Antiquities, 1960. The Law governs movable and immovable antiques, and Archeological excavation. Water Heritage can fall under all of the above-mentioned categories. In some cases like Archeological sites or antiques used for gathering water or even built immovable structures.

5 Conservation and management of water heritages

5.1 Conservation

- The well found in Sabbiyah under the SM12 code will be a part of an archaeological park in Sabbiyah.
- Al Jahra farms are under the NCCAL protection, to be preserved.
- Al Sabbiya and Failka Island are under NCCAL protection.

5.2 Sustainable development and current management of living properties

- Currently the National Council for Cultures, Arts and Letters is preparing the nomination file of Kuwait Towers for examination by the UNESCO World Heritage Committee of June 2016. A Tentative List entry was submitted on June 2014 and approved by the World Heritage Centre.

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Sub-region G:
Saudi Arabia, Yemen, Oman, United Arab Emirates, Qatar, Bahrain

Case study – The aflaj irrigation system (Oman)
Origin and technique of the Falaj System:
an evidence from the United Arab Emirates
Water heritage in Qatar

Case study

The *aflaj* irrigation system (Oman)

From the ICOMOS evaluation for the 30th World Heritage Committee Session, 2006

Basic data

State Party*:* The Sultanate of Oman
Name of property*:* The *aflaj* irrigation system of Oman
Location: Dakhiliya, Sharqiya and Batinah Regions
WH Listing*:* 2006 (WH property n° 1207)
Criterion*:* (v)
Serial nomination, name of the individual *falaj* (plural is: *aflaj*):

- Falaj Al-Khatmeen
- Falaj Al-Malki
- Falaj Daris
- Falaj Al-Jeela
- Falaj Al-Muyassar

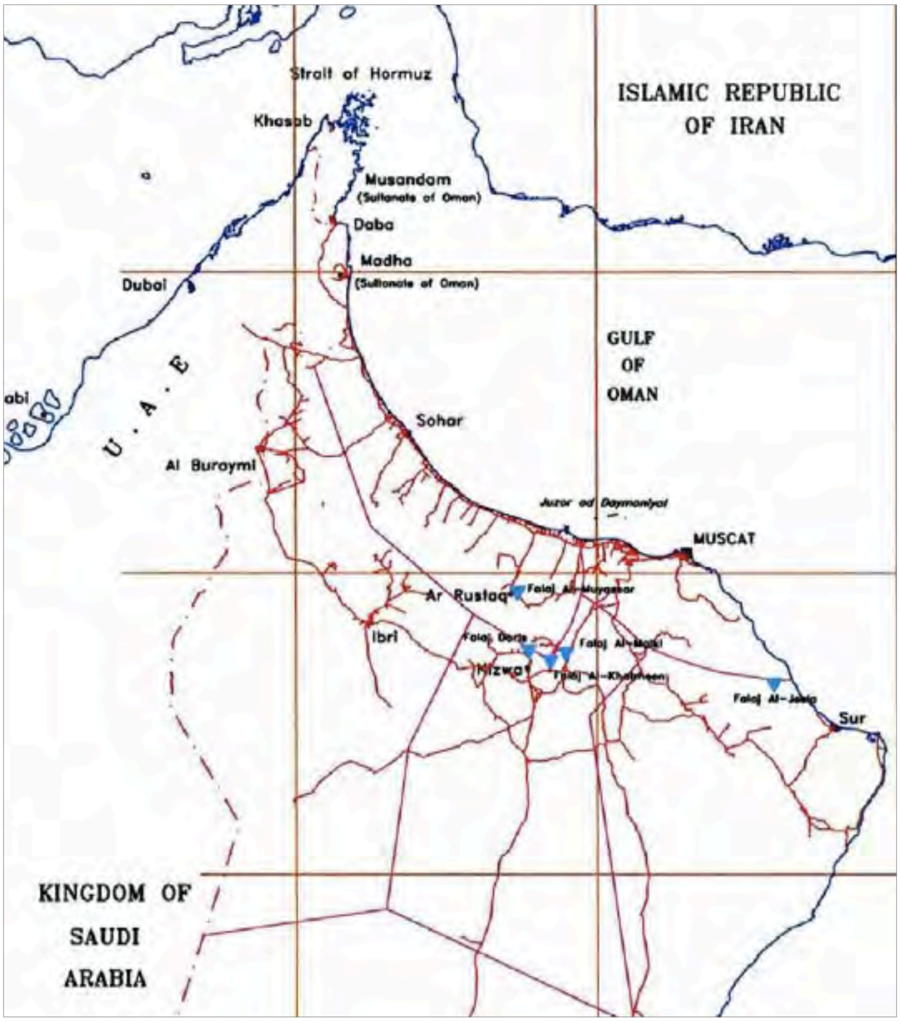

Figure 1. Location of the aflaj (nomination file, SP of Oman)

Figure 2. Falaj Al-Jeela, the open water channel (nomination file, SP of Oman)

Description of the properties, tangible attributes

Applied to water, *falaj* has come to mean a physical and social structure for the sharing of water among those who have a right to it.

The collection systems of five *aflaj* irrigation systems represent some 3,000 still functioning systems in Oman. The constructions in Oman are one of the largest concentrations of irrigation systems of this kind anywhere in the world.

The five nominated sites have been chosen to represent the sophistication and technological achievements of the total remaining working irrigation systems in Oman. Four of the sites lie around the Western Hajar mountains. The fifth site is in the southern end of the Eastern Hajar mountains.
The *aflaj* system of irrigation consists of tapping substantial underground water resources, springs or surface water and conducting the water by gravity alone often over long distances, to towns and villages where it is distributed to domestic and agricultural users. Relatively constant supplies of water are ensured by the *aflaj* system for large areas of desert throughout the year, and this in turn has led to the growth of permanent urban settlements based on an assured agricultural production and water resources for both people and livestock.

The areas nominated cover the collection and part of the distribution sections of five *aflaj* systems. This includes the underground channels which run between the mother well, spring or *wadi* (surface water) where the water is tapped, to the distribution network around the settlements, together with part of the above ground distribution channels around the plantations within settlements, and the associated buildings, such as mosques, watchtowers, houses, sundials, and water auction buildings.

Three types of *aflaj* are recognized in Oman: *Ghaili* (48% of all): this form is based on the perennial flow in a *wadi*; *Aini* (28%): the sources of water are perennial mountain springs; and *Daoudi* (24%).
The *Daoudi* type is the most exceptional of all. It taps into underground water sources at the foot of mountains. Deep "mother" wells are sunk to tap into the source of water and this is then conveyed to settlements on the plains through underground channels often over very long distances. The *Daoudi* is by far the most complex. Its construction relies on sophisticated engineering expertise and must also have demanded considerable labour forces and organisational capacity. A mother well is first dug at a point as near as possible to where the underground water system or aquifer emerges from the mountains. Finding this point demands traditional knowledge of the mountains and their geology. The mother well may need to be up to 60 m deep.

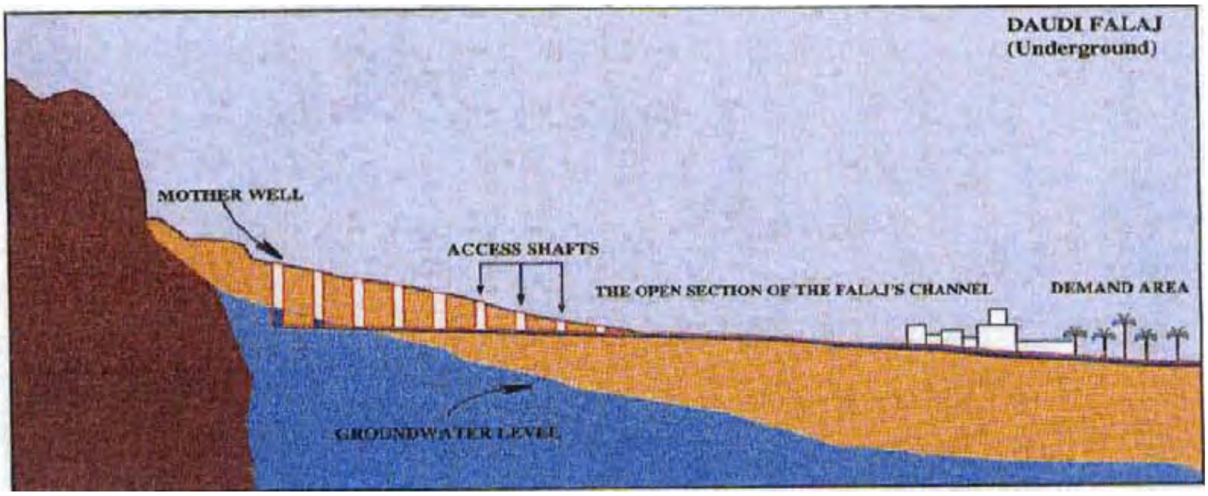

Figure 3.Schematic longitudinal section of a daoudi falaj (nomination file, SP of Oman)

History and development, intangible attributes

The precise dating of most of the underground channels is not known. The present network appears to result from several building campaigns, the earliest of which could be around 500 AD or even earlier. Recent archaeological evidence is suggesting that irrigation systems existed in the area as early as 2,500 BC, but when the first deep channels were mined and faced is not clear.

Historical records indicate that there was a period of falaj construction in Oman during the Yaruba Imamates in the second half of the 17th century, when the Portuguese were finally expelled from Oman, and it became the first independent state in the Arab world.

The success of the alfaj systems depends on the social and economic structures, which underpin it and have done for centuries. These are rooted in local communities and guarantee fair shares to stakeholders. The system is not based on any form of written or statute law, but rather on a traditional system of time-sharing that is passed from one generation to the next.

The fair and effective management and sharing of water in villages and towns is still underpinned by mutual dependence and communal values and guided by astronomical observations. Sundial and night sky positional observations (moon, planets stars) were used for determining the irrigation right and duration. The time distribution system for the water may be based on either a seven or ten-day cycle. The units allocated to shareholders vary from between 12 hours down to as little as 1.25 minutes.

Numerous watchtowers built to defend the water systems reflect the former total dependence of communities on the aflaj system.

Around 3,000 of these systems are still functioning and these reflect a restoration programme carried out by the Ministry of Water Resources over the past 25 years. This in turn demonstrates the crucial significance of the water systems as a major national resource that still underpins agricultural systems across a large area of the country.

Figure 4. Falaj Al-Khatmeen, distribution point at the end of the shari'a (nomination file, SP of Oman)

Outstanding Universal Value

Justification

Without the existence of the aflaj, there would be no more than impoverished settlement in the Gulf Region (or other desert regions). The *aflaj* technology has been bought to a high level in Oman and has been functioning successfully for more than two millennia.

The organisation of the water distribution systems is an outstanding example of a traditional structure at least a thousand years old which continues to play a vital role in society.

The combined *aflaj* systems in Oman are one of the largest irrigation systems anywhere in the world.

Criterion (v)

The collection of Aflaj irrigation systems represents some 3,000 still functioning systems in Oman. Ancient engineering technologies demonstrate long-standing, sustainable use of water resources for the cultivation of palms and other produce in extremely arid desert lands. Such systems reflect the former total dependence of communities on this irrigation and a time-honoured, fair and effective management and sharing of water resources, underpinned by mutual dependence and communal values.

Authenticity- integrity

The basic layout of the nominated *aflaj* is wholly authentic. There are some modern interventions such as the use of concrete for lining shafts, and cement for reinforcing the tops of the mother wells and access shafts, at some of the *shari'a*, and in the distribution channels to individual agricultural plots, and new building around the settlements.

The authenticity of the management of the aflaj is incontrovertible. The traditional system of ownership and management functions efficiently and is complemented by the administrative, technical and financial support from the Ministry of Water Resources.

Following existing documentation and oral memory, the today extension of each if the 5 *aflaj* seems similar to its traditional extension and use during 20th century.

Figure 5. Restored distributing point (UNESCO website, photo Jean-Jacques Gelbart)

Comparative analysis

There is some uncertainty about where and when the *daoudi falaj* type of irrigation originated. It is known in Iran, Armenia, in large parts of Central Asia and western China, in Chile and Peru in South America, as well as in Oman and neighbouring United Arab Emirates, Egypt, Morocco, and Spain.

There are close similarities between the *aflaj* in Iran and those in Oman. There are said to be 20,000 *qanats* still in use in Iran.

Threats

Development

The last few decades has seen rapid development in Oman including the smaller towns and villages. This had compromised some of the settings of the *aflaj* system. Road construction has also affected the water channels. The water flow has been affected as a result of development pressures and the flow rate falls during periods of drought.

Water demand

Increased development has led to increased demand for water, which has resulted in the drilling of large deep wells. This in turn has affected the level of underground water supplies.

Climate change
Lack of rainfall in the Gulf Region over the past two decades has seriously lowered the water table.

Visitors – Tourism
Currently it seems that very few visitors visit these sites.

Protection and management

Figure 6. Aflaj irrigation system in Oman
(UNESCO website, photo Ko Hon Chiu Vincent)

Legal provision
The *aflaj* systems are owned by the individual shareholders, with certain shares allocated to the mosque. The legal title to shares is recorded in the form of a registration document (*sukk*). Details of ownership and all transactions are recorded by the *wakeel.* Certain shares are owned communally by all the shareholders in the *falaj*.

The underground sections of the *aflaj* system are well protected. The key protection measure is the Water Wealth Protection Law.

Management system
There are complex and detailed traditional management systems for the management of the water and the water channels. It could be described as a co-operative water management, the best one in Oman.

The executive authority in each system is the *falaj* agent, or *wakeel*, appointed by the local sheikh in consultation with the stakeholders and advised by a technical expert, *arreif*. The *wakeel* is responsible for the overall management of the *falaj.*

Traditionally, *aflaj* have been financed entirely by their shareholders. Taking into consideration of important difficulties for maintenance during the 1970s, the Government of Oman assumed responsibility for *falaj* maintenance from the early 1980s. This responsibility continues.

Figure 7. Interior of large daoudi falaj lined with clay and stones (nomination file, SP of Oman)

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Origin and technique of the *Falaj* System: an evidence from the United Arab Emirates

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Preface

To start this research it should be noted that the present situation of insufficient water resources which have arisen since the mid-20th century is not the only one in mankind history. Ancient communities, especially those living in arid regions must have suffered from this phenomenon, which is caused today by both the increase in human population and natural climate change. In ancient times humans had little or no effect on this case, but today, the situation is different. The decline in ancient civilizations during the second millennium BC in the region, especially at Wadi Suq Period of the Bronze Age in the United Arab Emirates (UAE), has been attributed by some scholars to climate change. Jorgenson and al-Tikriti have stated that to overcome such a shortage of water in the Al-Ain region some of the inhabitants may have migrated to mountainous areas where flowing streams and springs still existed (n.d, p.34). In the view of the author, several generations in the UAE and Oman must have suffered from this climate change but eventually managed to find a solution to this natural cause. This solution came in the form of the *aflaj* (sing. *falaj.*) which caused human communities development and landscape change. It was however a temporary solution as water in *aflaj* flow permanently, i.e. 24 hours a day, without being controlled except when being redirected into the fields and, consequently, depleting the groundwater by time. The new irrigation system developed a new water culture different from that which was known before the creation of the *falaj*. ICOMOS, in the introduction of the thematic study, states that the relationship man and water clearly produces both heritage and culture, in the sense of both tangible goods and the associated intangible values. This can clearly be applied onto the Iron Age culture of southwest Arabia (Oman and UAE), as we will see below.

1 General characteristics

This chapter discusses the *falaj* irrigation system in the UAE concentrating on history, engineering and origin. Etymology of the word *falaj* is locally used in the UAE and Oman but its origin goes back to the Akkadian time some 4300 years ago (Wilkinson 1977). In his campaign to *Urartu* in 714 BC in the Lake Urmiya region, the Assyrian king Sargon, mentioned the term *palgu* as open ditch. This early record of the system as well as records of Polybius, the Greek historian of the 3rd – 2nd century BC made scholars, until recently, consider the Persian origin for this system as indisputable. It seems that using this type of irrigation system in the United Arab Emirates for several millennia, as the archaeological evidence has shown, helped the word *falaj* survive. Today, this sematic word is used in Arabia only. In southeast Arabia, occupied by the UAE and Oman, the system has been considered as equivalent to the *qanat* of Iran and was described as gently sloping tunnels for taping groundwater. However, recent excavations carried out in and around the city of al-Ain, UAE demonstrated that standard *aflaj* i.e., taping water from mother wells sent deep into the ground, rather than diverting surface water have been in use in the region since the beginning of the Iron Age (1300-300 BC). It is now known that this early date precedes the earliest known *qanat* in Persia by several centuries. The cultural sites of Al Ain (Hafit, Hili, Bdaa Bint Saud and Oases Areas) were listed as World Heritage in 2011 under criteria (iii), (iv) and (v). Three *aflaj* from the early Iron Age Period have been discovered at Hili and Bidaa Bint Saud, so far, whilst four more dating to the same period are today known from the UAE.

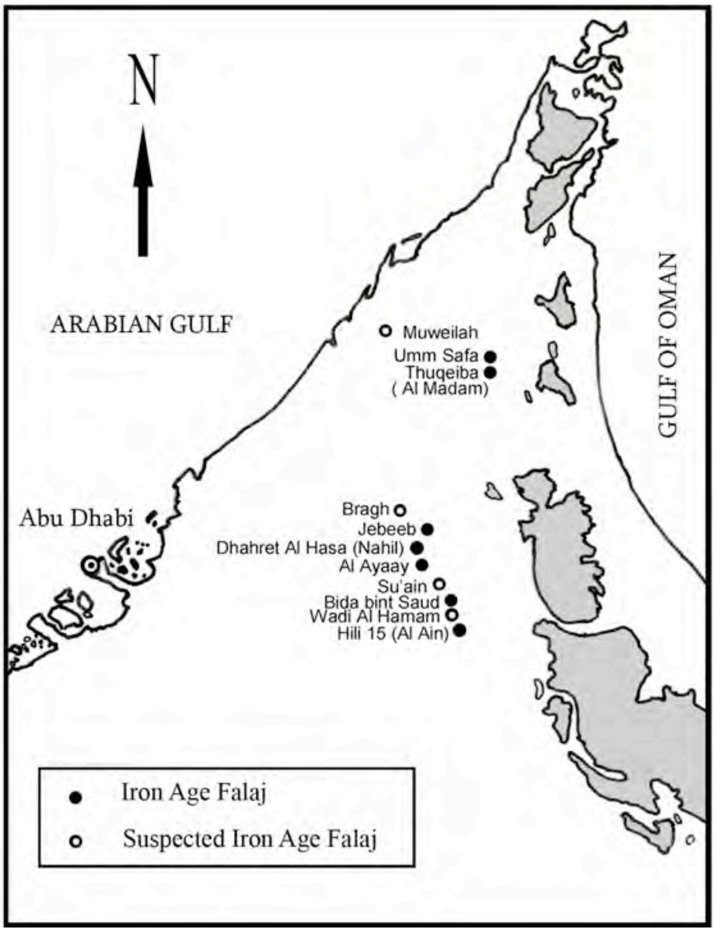

Figure 1. Map of the Iron Age *aflaj* in the UAE (after Al Tikriti 2011).

Apart from Iran and Arabia the *falaj* is known but it has different names in Iraq, Afghanistan, China and Central Asia. The system is also known in North Africa and, it seems that it has reached the northern coast of the Mediterranean such as Spain, Sicily and Greece from there. *Aflaj* of more recent dates are also known in Japan and Peru.

Regarding its techniques and engineering the *falaj* consists of five sections: The mother well(s), the tunnel, the cut and cover section, the *shari'a* and the surface channels. The mother well is the first step to start with while building a *falaj*. Locating a suitable aquifer and sinking a well to find out if the bulk of discovered water is large enough to build a *falaj* determines the go ahead with the construction or not. Once the mother well is dug and water is discovered, other nearby wells are also excavated and connected by tunnels in order to increase the supply. The tunnel, which is pierced with vertical shaft holes (*thuqab sing. thuqba*) is dug from the mother well to the field or vise versa. The *thuqab* are dug to allow ventilation and removal of the spoil. They can be used as access points to the tunnel whenever maintenance is necessary. The cut and cover section starts at a point where the top of the actual tunnel becomes closer to the surface, while the *shari'a* is the first place where water comes on the surface and can be utilized.

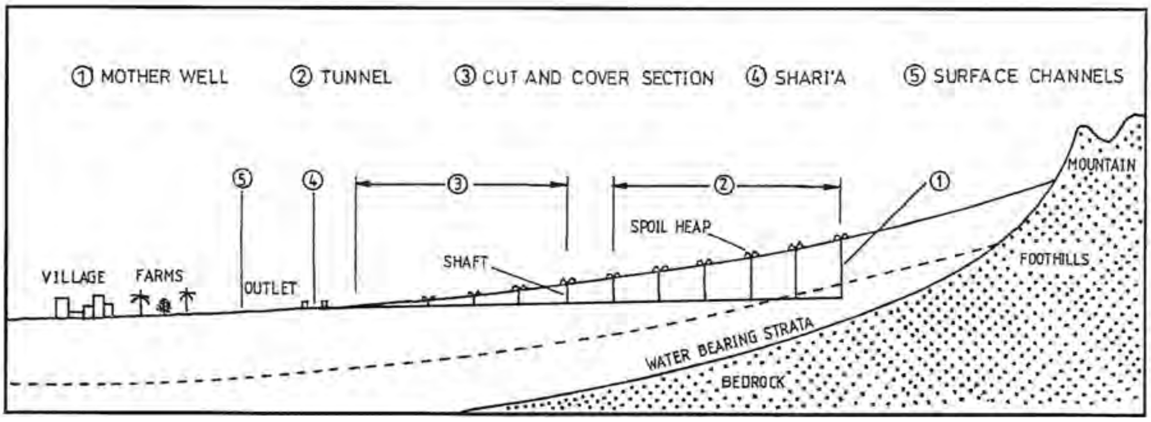

Figure 2. A diagram of the *falaj* sections (after Al Tikriti 2011)

1.1 Climatic and general hydrological data

In regards to the geography and climate the UAE is located on the margin of two rainfall zones; the Mediterranean, and the Monsoonal zone, which effects, the Indian Ocean in addition to south and south-east Asia. Annual rainfall is therefore low, with Mediterranean zone rains falling lightly between December and April, and occasional Monsoonal zone rain reaching the eastern part of the UAE during summer months (June, July and August). The climate of the Emirates is characterized by north winds from the Mediterranean called *shimal*, sometimes bringing winter rain; and southern wind called *suhayli* bringing sand storms from the “Empty Quarter” (Rub al-Khali desert in central southern part of the Arabian Peninsula) and sometimes followed by rains, if they come during the monsoon season. It should be noted however that palaeoclimate in Arabia during the late Quaternary was different from what is today, with more wet periods (Mclure, 1976). The climate was even substantially different in the Upper Miocene (6-8 million years ago) when mammals such as hippopotamus, elephant, giraffe and many other animals were still living in the western region of Abu Dhabi Emirate (Whybrow and Hill, 1999).

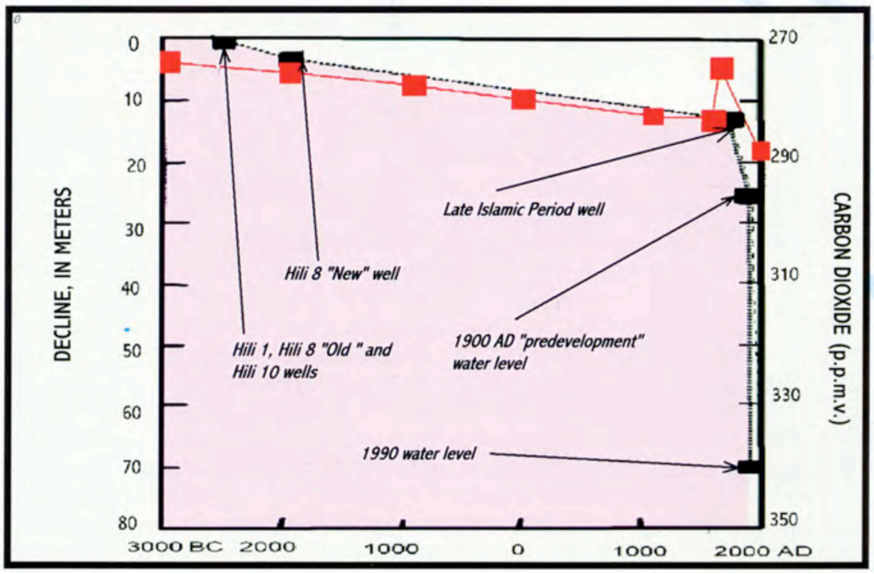

Figure 3. Hydrograph of water-level declines at Hili, Al Ain since the Bronze Age (after Jorgensen D & Al Tikriti W, modified from Indermuhle and others, 1999)

Being located close to the western foothills of al-Hajar Mountains, ancient communities in the al-Ain region utilized the water reserves generated over millions of years below the gravel plains which characterized the al-Ain and Buraimi region. A study carried out by Jorgensen and al-Tikriti has shown that while groundwater level was only 4 meters below the surface during the Early Bronze Age (ca. 3000 BC), it was dropped to about 70 meters or more during the twentieth century AD (ibid, p. 33) (Figure 3).

1.2 Cultural relations with neighboring zones

Southeast Arabia in general, as the archaeological evidence has shown, enjoyed cultural relations with ancient civilizations, particularly with Mesopotamia, Iran and the Indus Valley. Overseas trade was practiced with these civilizations especially Mesopotamia when the copper of Magan (ancient name of Oman and UAE) was exchanged for wheat, barley, onion and other agricultural products. Bitumen originating from Iraq was also a substance in demand for making boats in the lower gulf. Archaeological investigations in the UAE during the last five and half decades brought to light aboveground tombs and settlements with pottery imported from Iraq, Baluchistan and Pakistan. Within the region archaeological discoveries and historical researches have shown strong contact with neighboring Oman in terms of tangible and intangible heritage. Both countries have been sharing one method of irrigation system, the '*falaj'* since the beginning of the Iron Age.

2 Sites of importance for the cultural heritage of water

The archaeological evidence in ancient Arabia and elsewhere has shown that blocking the rain water with boulders and diverting it to the fields was the earliest irrigation methods used in arid countries. Digging vertical wells to exploit the groundwater was another method used in the UAE since the Bronze Age. The Neolithic communities must have used the same methods to meet their requirements though there is no archaeological evidence yet demonstrating this. From the Bronze Age however, there is ample archaeological evidence for this method use, as four wells of different depths were excavated at three different locations, giving evidence for the fluctuation in the groundwater level. Soon after the end of the Bronze Age the communities that lived during the Iron Age discovered a new irrigation method which may have been the result of attempts to overcome the droughts they had as a result of a climate change. The new method was the *falaj*. Six of these *aflaj* dating from the Iron Age have been discovered in the Al Ain region alone. These, along with the associated ancient settlements and the existing oases, which are irrigated by the same system, form the core of the water heritage, tangible and intangible. The intangible part is reflected in the water management methods used (see Nash H., 2011).

2.1 Archaeological sites

Around 5000 years ago underground water level at Hili (one of the Al Ain Heritage sites) was only 4 meters below the surface, as it was indicated by Well 1 excavated at the Early Bronze Age site at Hili 8. Pumping, however, has drastically affected the reserves. Wells from the Bronze Age excavated at Hili indicate that water was utilized by a traditional system; drawing water by buckets. The traditional *jazra* system, known as *Saqiya* in Iraq, which is described as animal water drawn system, was still known some years ago in both Oman and the UAE today countries (Figure 4). Around 1000 BC the *falaj* system was introduced by ancient inhabitants of the today UAE. Although the *falaj* was considered the possible result of mining tunnels in the northern Alburz and Armenia (Goblot, 1979), the author believes that its introduction was a result of a direct requirement for water exploitation as it does not seem to have any connection with the mining activities. The tunnels resulted of mining are not suitable for, draining water without proper engineering or considering the direction and the slope in advance. Digging irrigation tunnels need to be studied carefully before connecting them to the water source. Copper miners would not consider any of the conditions to obtain tunnels suitable for irrigation except when they have to drain out water during the mining process.

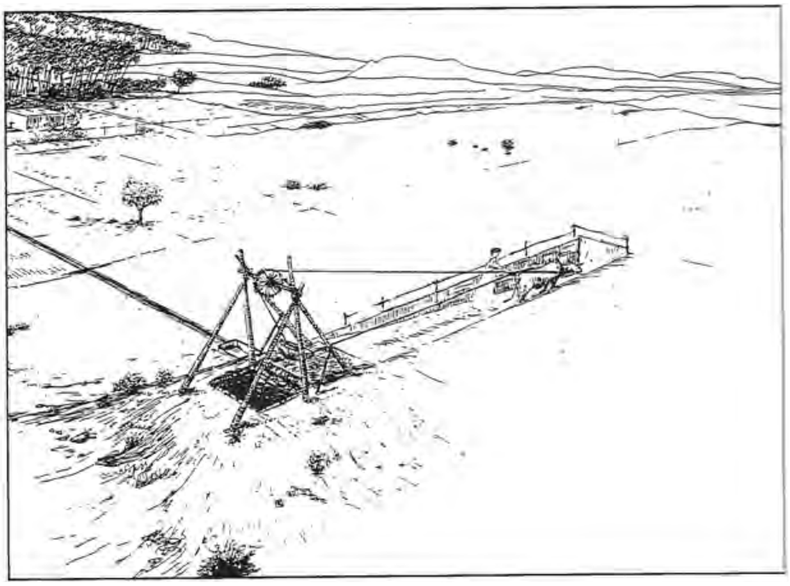

Figure 4. Sketch illustrating a *jazrah* (after Costa P & Wilkinson T. 1987)

Despite the extensive investigations in Iran, which have been going on since the nineteenth century, the *falaj* is still not known before the fifth century BC while the relatively recent explorations in the UAE brought to light at least five *aflaj* all from the Iron Age. We have to admit however that the system was extensively used in Iran during the Sassanid Empire. In the author's view the power that the Sasanians had on their neighbors, including the coasts of the Arabian Peninsula, as well as, Egypt seems to have been the reason for attributing this system and several other cultural aspects to Iran rather than to Arabia.

Figure 5. The surface channels of the Iron Age *falaj* at Hili-Site 15. (after Al Tikriti 2011)

Figure 6. 3000 years old *shari'a*-Site Hili 15 (after Al Tikriti 2011)

The Al Awamir tribe in Oman was specialized in digging *aflaj* throughout their history (Birks & Letts, 1976). Due to the decline that happened in the underground water, and the turmoil in the political situation since the Portuguese invasion, the tribe became more involved in maintaining the existence *aflaj* rather than digging new ones. It is natural that due to these changes they became more involved in the maintenance of the existing *aflaj* that their ancestors had dug. Falaj Al Aini (Sarooj), which irrigates the groves in the middle of the city of Al Ain, may have been originally built by the same tribe. In the 1940s Sheikh Zayed bin Sultan Al Nahyan, the Al Ain governor by then, employed Al Awamir tribe to extend this *falaj*, a job that lasted 18 years to complete.

Figure 7. Cut-and-cover section and a *thugbah* (shaft) at Hili-Site 15 (after Al Tikriti 2011)

At Hili, located in the city of al-Ain, the Department of Antiquities and Tourism (the name has been changed to Department of Historic Environment) discovered and partly excavated a *falaj* from the Iron Age (ca.1000 BC) designated as Hili 15. Surface channels, *Shari'a* with sluices still in situ, a cut and cover section, and two shafts have been excavated (Figures 5-7). In the exposed *shari'a* and at the surrounding area a large collection of pottery belonging to the Iron Age was discovered. A nearby Iron Age fortified site (Hili 14) may have been used, among other functions, as administrative place to manage the water shares and run the *falaj* (Figure 8). For this reason it was dubbed by the writer of this article *bayt al falaj*. It may have been also used as a caravanserai, as was explained by the French archaeologists who studied the site (Boucharlat, 1985). This *falaj* (Hili 15) and the nearby Iron Age site (Hili 14) are significant components of the Al Ain World Heritage site, inscribed in June 2011.

Two more Iron Age *aflaj* were discovered by the author at Bida Bint Saud, an area located at a distance of 14 km northwest of Hili 15. This discovery led to extensive excavations to be carried out to define the direction of these *aflaj*, the irrigated land and their date farms. Continuous work at Bida bint Saud revealed 11 shaft holes forming two lines at the first *falaj* and several others at the second (Figure 9). The *Shari'a* of the first *fala*j (Falaj 1) was discovered and turned out to be different from the aboveground *shari'a* at Hili 15. It was found at a depth of 3.8 m. below the surface of the ground. The access to the *shari'a* was made through steps descending to it from the northern side. While excavating the steps, fragments of Iron Age pottery were collected. Like Hili, a large public building is located near this *falaj* and thought to have served as *bayt al falaj (Figure 10)*. Since the discovery of *aflaj* at Bida bint Saud it became clear that the Iron Age *aflaj* are not confined to the Al Ain oasis only, as it was originally thought, but can be found anywhere along the western foothills of the Al Hajar Mountains. They have been later identified elsewhere at al-ayaay, al-jebeeb, Nahil, and Al madam Plain; all located north of al-Ain. Apart from sustaining farming communities they were also link posts on the ancient caravan routes, that was linking the Al Ain oases with other Iron Age settlements located in the northern today Emirates. Archaeologically speaking, no explorations have ever been taken place in the areas located across the very close boundary of Oman, a country which five of its many *aflaj* have been listed as World Heritage sites.

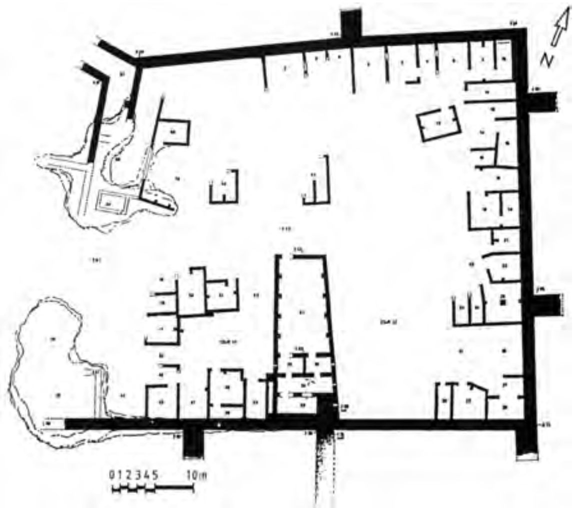

Figure 8. Plan of Hili 14 (after Boucharlat R & Lombard P, 1985)

2.2 Living site which are still used or partially used

The above mentioned sites are all archaeological remains and none of them are still used. They are dry and dead *aflaj* bearing witnesses to an ancient culture that once thrived some 3000 years ago. Most interesting about dating these *aflaj* is not only the datable artifacts found associated with them but also the obvious remains of settlement sites that were established on them. None of these ancient settlements remained except the ingenious system that was behind their establishment inherited from generation to another and still used in Al Ain and in other parts of the UAE. The existing oases in Al Ain, which form some components of the World Heritage sites in the city, are witnesses to the continuation of the system and constitute part of the water heritage in the region.

Figure 9. Falaj 1 at Bida Bint Saud

2.3 Cultural landscapes related to water

Since the introduction of the *falaj* system in the region some 3000 years ago we assume that Al Ain must have enjoyed a landscape different from what was in the Bronze Age when water exploitation methods were confined to the wells and the runoff surface water. Introduction of the *falaj* system allowed water to run continuously for 24 hours a day and subsequently, must have contributed to the expansion of the agricultural fields and products at the same time. Fields of palm trees and crops must have surrounded the existing well-preserved villages covered with sand, like the archaeological sites at Rumeilah and Hili (both World Heritage sites), some 3000 years ago. The Iron Age *falaj* at Hili 15 is significant not only for being the oldest known archaeological *falaj* and the most preserved, but also because of its impact on the domestic architecture of the Iron Age and on several other aspects of the culture. Today, the historical oases in Al Ain, which belong to the last few centuries, such as Hili, Qattarah, Mutaredh and Al Ain form parts of the World Heritage sites in the city and they all directly relate to water, transported to them by underground galleries. Some of these oases, especially those that yielded Iron Age fragments of pottery like Qattara oasis may have been established on much older ones. The existing oases dominated by date palm trees, together with the associated historical buildings, such as mud brick houses, mosques, forts and towers, which were mostly constructed in the nineteenth and the twentieth century, complete the landscape and are indebted to the invention of the *falaj* system. The same irrigation method is still used in watering the plants but, today, relying on pumped water due to the sharp decline of the groundwater at the source. The forts were built to be administrative places and symbols of authority, whilst the watch towers were erected to defend the community and ensure protection for the oases and the *aflaj.* Being components of the Al Ain World Heritage these structures are protected by law, frequently restored and Abu Dhabi Tourism and Culture Authority (TCA) has a plan to present some of them to the visitors.

Figure 10. Like Hili 14, this Iron Age building at Bida Bint Saud may have been used to administrate the nearby *falaj*.

3 Existing documentation

3.1. Al Ain map which has been developed by Al Ain Municipality with the help of TCA indicates the location of both the historical and archaeological *aflaj* within the city. Access to the map is limited to certain departments at the municipality.

3.2. Two general maps marking the historical and archaeological aflaj in the UAE have been produced by the author and published in his book titled "The archeology of the Falaj"... This book is the only publication which has researched the system in the UAE in details (see reference list). The book of J.C. Wilkinson (refer to the reference list) is another interesting document discussing water and tribal settlements in southeast Arabia and is worth consulting. Among some other publications on the subject the two papers written by Remy Boucharlat are of interest (Boucharlat 1985 and 2003).

3.3. Some photographs of the excavated *aflaj* and wells are available in the Department of Historic Environment TCA (best consult the author's book on the system).

3.4. Hili 15 and Bida bint saud (both Iron Age *aflaj*) and the dry Falaj Hazza'a (historical) are two sites where extensive excavations have been carried out. Finds, consisting mainly of fragmented pottery from *aflaj* and large complete storage jars from the associated settlement sites, are kept in the Department of Historic Environment. Some of these are on display in the Al Ain Museum.

3.5. The two above mentioned books published by Al Tikriti and Wilkinson and the other various papers and articles (a few are listed below) can be used for making comparative studies and further research.

Notes: None of these documentations, unfortunately, are possible to consult remotely.

4 State of historic and technical knowledge concerning water heritage in the sub-region

4.1. Humans in the Al Ain region in the UAE have been in relationship with water since prehistory and there are tangible evidence from the Bronze Age that wells were used for the daily human needs and limited farming. When the *falaj* system was created in the region, the relationship with water heritage continued and became stronger since that time and agricultural possibilities significantly enlarged. Between the remote Iron Age *aflaj* and the more recent ones still in use, there are three dry archaeological *aflaj* in Al Ain belonging to the Early Islamic Period. Their discovery has filled a gap in the long history of the system. Regardless of their dates, *aflaj* were created to maintain supplying water to the cultivated lands, however the increase in population and subsequently the increase in the cultivated lands and date farms must have put pressure on the land owners. Moreover, the real pressure in the view of the author is the continuous drop of groundwater level, which was solved by lowering the tunnel and the farms to meet the new groundwater level and maintain the water flow. This disseminated idea was costly, as it involves deepening the whole underground gallery and the farms. This solution, however, is a temporary one due to the continuous impact of the system on the groundwater level.

4.2. The state of the current research concerning water heritage is disseminated to a few institutions in the UAE. The Environment Authority in Abu Dhabi has documented hundreds of deserted and still in use wells within the territories of Abu Dhabi Emirate. These were mostly dug by the tribes or individuals who kept roaming the desert in the pre-Oil Era. The Historic Environment Department, TCA, is in charge of the archaeological explorations in the Emirate of Abu Dhabi. In addition to other duties, and because they are significant components of the water heritage, the department is concerned with the identification of dead *aflaj* and wells regardless of their dates. Documentation concerning the current hydraulic projects however is the job of the Department of Water and Electricity. The National Water Centre at the UAE University is a new entity which aims to support research in areas related to water sciences.

5 Threats to water heritage

The water heritage reflected in the archaeological sites is well conserved and protected as the majority of the sites are fenced and monitored. Nevertheless, they are exposed to the action of nature. The sites in use, such as living *aflaj* within the oases and outside, are managed by the municipality and they are not prone to real impact, despite the fact that cement has been used to waterproof the bottom of the channels and strengthen the sides. The real threat is the lack of interest of the new generations in maintaining their farms if the municipality stops acting on their behalf and stops feeding the *falaj* with pumped water. Because they are parts of the city landscape there is no reason, in the medium term, for the government to stop maintaining and providing water to the Al Ain oases. The additional supply is a mixture of water extracted from deep wells and desalinated water.

6 Legal protection in force

In general, the cultural heritage in the Emirate of Abu Dhabi is protected by the 1970 archaeology law. The Al Ain archaeological sites, especially those that have been inscribed on the World Heritage List in June 2011 are well defined and mostly fenced off. The Abu Dhabi Authority for Tourism and Culture holds ownership certificates of the mentioned sites, while the oases, living *aflaj* and water management are the responsibility of the Aflaj Section at the Al Ain Municipality. The Executive Council resolution No. 38 of 2005 made the Al Ain Municipality responsible for regulating, monitoring, managing and watering oases palms. The draft of the new Heritage Law, which has not yet been approved, is a comprehensive document that would lead to a better preservation and management of Abu Dhabi cultural assets, whilst the Preliminary Cultural Reviews (PCR) is a program initiated by TCA to control development and issue No Objection Certificates (NOC) to the developers.

The Municipality and the Urban Planning Council (UPC) are two entities responsible for planning and they are well aware of the cultural heritage of Abu Dhabi and the landscape of the city.

7 Conservation and management of water heritages

7.1 *Aflaj* and oases are a significant component of the water heritage in the Al Ain region and are still a living heritage in the UAE, despite the rapid modernization of the city. The early hydraulic project element has not much changed, except for the introduction of mechanical pumping due to the sharp decline in the groundwater level, and the use of concrete to both waterproof the bottom of the channels and strengthen their walls. The dry archaeological *aflaj* of the Iron Age are well preserved but some of them still need little intervention. Site 15 at Hili is a very well preserved *falaj* from the Iron Age but its exposed parts need sheltering to protect them and reduce the impact of nature.

7.2 Oases are regulated by the Aflaj Section at the Municipality, while TCA has defined the buffer zones around the oases, and also in charge of maintaining the existing landscape by the guideline which is preparing. These two entities are solely in charge of the oases and rely mainly on Law no. 38 of 2005 to exert their efforts and preserve such an important heritage. Though the system is not threatened by the existing plans the real threat lies in the low interest level of the owners and the ability to maintain the pumping of water into them.

7.3 The current management of living properties, i.e., water pumping, is a good solution to sustain development, however it is only temporary. Eventually, these *aflaj* will be under real threat. At the moment, TCA is implementing a conservation program at Qattara oasis which aims to present some of its historical buildings to the visitors. In cooperation with the Aflaj Section at the al-Ain Municipality, this should lead to organize visit tours to the *falaj* channels there and the farms.

8 Conclusion

Climate change must have had an impact on shaping cultures throughout the history of mankind. The reaction of the ancient communities of the Al Ain region towards these changes may have been the reason for the introduction of the *falaj* system, as less surface water led to groundwater exploitation. Al Ain is considered a focal point in the United Arab Emirates in terms of the *falaj* system, which seems to have played a significant role in shaping the history of the Oman Peninsula throughout the last 3000 years. Its existing oases, which are significant components of the Al Ain World Heritage site, are important heritage assets, not only for their ecological value, but also for the cultural value and way of life that has survived until today. Indeed, the creation of the traditional *falaj* system in the region was a revolution that led to the establishment of many settlements reminiscent in many ways to the modern Arab villages before the oil boom. Quite large fields must have been cultivated and the ancient landscape must have been not very much different from what it was before modernization. The former vertical irrigation system that was in use in the region during the Bronze Age was replaced by the horizontal one, i.e. taping ground water in gently sloping tunnels, rather than relying on wells only. This has helped the establishment of a new culture different from that of the Bronze Age. At Hili, a few hundred meters to the north of the Bronze Age settlements, an Iron Age *falaj* designated as Hili 15 has been extensively excavated and found in association with a fort-like building and other Iron Age habitation sites.

Outside Al Ain, the discovery of two Iron Age *aflaj* at the area of Bida Bint Saud, and examining three more *aflaj* of the same date further north, indicate that the system was already well established in the region. This Early date (Iron Age) proceeds with several centuries the foundation of the Achemanean Empire to which the system was mistakenly attributed. Recent excavations in the middle of Al Ain city have revealed three *aflaj* running close to each other and associated with mud brick buildings and a small mosque dated to the Early Islamic period, therefore filling a blank in the region's *falaj* and oases history in the region (Al Tikriti W. & *et al* 2015). The Al Ain oases are products of this ingenuous system and the continuation in using the system even today indicates the adherence of the local communities to the system over the last three millennia. This adherence however is threatened by further change in the climatic, the introduction of the machine, in addition to the fact that *aflaj* are permanent flow of water draining the ground reservoirs.

Encouraging state parties to give priority to water heritage and asking them to carry out further research, especially into the living sites aiming at promoting water heritage to the concerned governmental institutions, might be one method for sustaining them and also raising awareness among the public. The tourism point of view should also be considered as, if adopted, it could lead to a better protection, conservation and management of the sites, whether they are living or archaeological.

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Water Heritage in Qatar

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1 Introduction

Central to any holistic understanding of water heritage in arid settings is the relationship between occupation and the natural environment – why people live where they do. This is especially the case in Qatar where low rainfall and high temperatures coupled with low relief, result in the absence of fresh surface water and a relatively hostile natural environment. Unlike its neighbours, there are no supporting streams, springs or aflaj. The only natural water source is from groundwater occurring in the Tertiary marine limestone aquifers, and recharged during storm events through the internally draining *rawdha* system. The *rawdha* are shallow depressions formed at the surface by sub-surface solution and collapse within the limestone aquifer system (Figure 6). The two critical constraints on groundwater use are its quality/potability, and its availability by shallow hand-dug wells, which mostly tap a fragile freshwater lens precariously maintained by a low and erratic rainfall. For Qatar, these constraints dictate the nature of its occupation, and determine where settlements were established.

The history of Qatar is one of wells, which were the permanent fixtures used by transient populations, and around which settlements developed and evolved. The heritage of water use in Qatar is therefore intimately entwined with that of the wells, which are an expression of a fragile hydrological system dependant on the *rawdha*.

2 Climate

Qatar lies on a limestone peninsula extending 160 km northward into the Arabian Gulf, along a north-south anticlinal structure referred to as the Qatar Arch. Varying in width between 55 and 90 km, Qatar has an area of 11,437 km^2. Almost all of Qatar has an arid to hyper-arid climate with a highly unpredictable and erratic annual rainfall, averaging about 80 mm in the north and less in the south. Rainfall is mostly in winter, from winter westerlies. In addition, there is the winter *shamal,* the wind system from November to March, which is closely associated with frontal systems passing from west to east across the Arabian Gulf, and frequently associated with thunderstorms. As a consequence of its arid climate, high temperatures and lack of relief, Qatar had no permanent surface water, and prior to the modern era of desalinization, all potable water was obtained from the groundwater system. Groundwater recharge of the Tertiary limestone aquifers occurs mostly during storm events over the winter period.

The summer (June to September) is very hot with a low rainfall, when daily maximum temperatures can reach 40°C or more; winter is cooler with occasional rainfall. Spring and autumn are warm and mostly dry, with maximum temperatures between 25°C and 35°C and cooler night temperatures between 15 and 22°C (Figure 1). The annual average evaporation rates are 2,200 mm.

The arid to hyper-arid climatic setting across Qatar has been in place since the end of the *hydrological optimum* (Macumber, 2011) which lasted from about 7,500 to 6000 yr BP, and during which period rainfall was greater and sea levels reached levels up to 1-3 m above those at present. The subsequent decline in rainfall and fall in sea levels after 4,000 yr BP ushered in the present significantly more inhospitable arid climatic regime, one that has remained essentially unchanged throughout Islamic times up to the present.

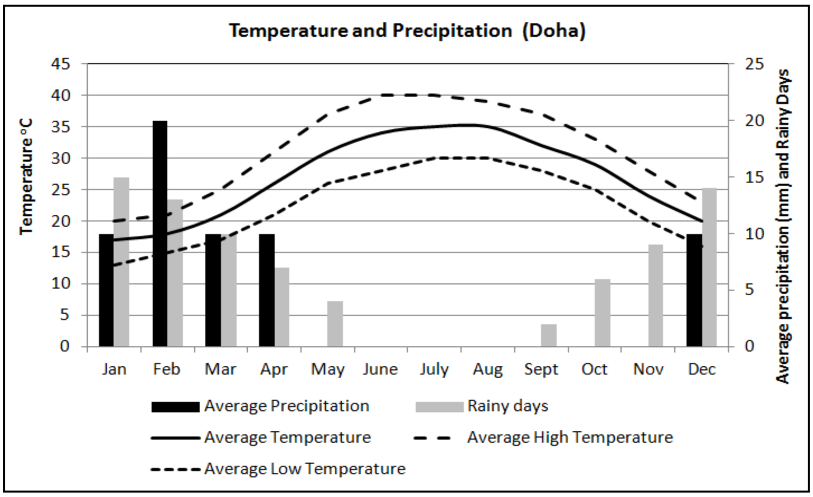

Figure 1. Climatic averages at Doha (data from Weatherbase.com, P. G. Macumber, 2014)

3 Water awareness in the context of landscape and hydrology - northern Qatar

Given the absence of surface water, the cultural heritage of water in Qatar lies in the awareness of the complex nature of groundwater occurrence, its accessibility by hand-dug wells and its usage/management. The relief across Qatar is low, being below 50 m in the north but reaching 103 m in the south where the landscape represents the dissected remnants of a former plateau. The flattish surface is mostly eroded across dense cryptocrystalline Eocene marine limestone of the Dammam Formation. The low relief coupled with the high aridity results in no permanent surface water, and occupation in the past was dependent on groundwater, only accessible by hand-dug wells. While most wells were shallow, commonly to depths of less than 10m, an occasional deep well was recorded, such as at Al Kararrah in the south, where the well was ~ 50 m deep (Lorimer,1908).

The relationship between settlement patterns, potable water and groundwater depth is clear from the distribution of settlements across Qatar in the past, and farms in the modern era. The location of settlements was controlled by the presence of a large fresh groundwater lens in the north and central parts of the country, and scattered small occurrences of fresh groundwater in the south. The archaeological record on water availability is sparse and reference mostly restricted to the occasional mention of wells being present at sites across Qatar (e.g. De Cardi, 1976;Tixier,1980; and Inizan 1988), or at individual sites (e.g the Abbasid site at Murwab - Geurin and Al Naimi 2009). There are also broader accounts of groundwater occurrence - Eccleston 1981, Lloyd, 1981; Macumber, 2009; Macumber, 2014) and regional archaeological surveys (e.g. Walmsley et al, eds, 2012). Undoubtedly the deepest insight on the pre-modern water presence across Qatar comes from Lorimer (1908) in his listings and descriptions of places in the Gazeteer of the Persian Gulf, Oman and Central Arabia. In addition there is a documentation of pre-existing Native Wells obtained from the 1938 and 1958 (pre-modern) list in the FAO/UNDP 1974 hydro-agricultural resources survey. An account of water availability and usage in the Doha area comes from the *Origins of the Doha Project, Season 1* (Carter and Eddisford, 2013).

The position of the freshwater lens in northern Qatar is controlled by geology, and is associated with a calcium carbonate facies of the Rus Formation limestone aquifer shown as the calcareous and extended calcareous zones in Figure 2. Groundwater in the lens recharges in the hinterlands and flows coastward to discharge into hyper-saline coastal sabkha, which formed following the retreat of the mid-Holocene transgression commencing at ca 4,000 year BP. Between Al Zubarah and Fuwayrit in northern Qatar, the freshwater lens has supplied a number of coastal settlements including those along the north-western coast at Al Zubarah, Furayah, Al Jumayl, Al Arish, Ain Mahomed, Al Nabaah, Al Khuwayr and the Ruwayda Fort. In the north it supplied Al Shamal and Al Ruwais, and Al Mafjar, Al Ghariyah, Fuwayrit and Huwaila in the north-east (Figure. 2). While many of the towns were described as abandoned by Lorimer (1908), those coastal towns still extant in the early 20th century went into rapid decline with the partial destruction of the coastal freshwater lens, and consequent intrusion of seawater in the mid-late 20th century.

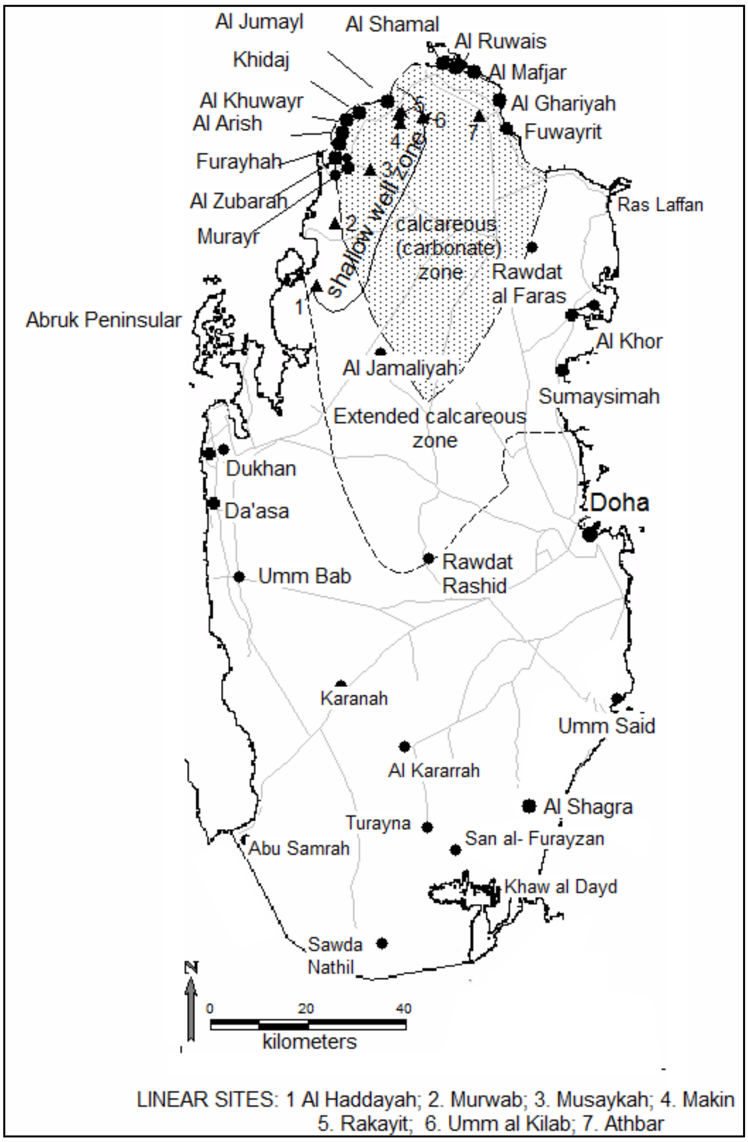

Figure 2. The locations of selected towns and early Islamic linear sites (numbered) (P. G. Macumber, 2014)

Of special significance for early occupation was a *zone of shallow wells* (Eccleston, 1981; Taylor, 1836) tapping the freshwater lens along the northwest coast. The wide time range for archaeological sites since Neolithic times within the zone of shallow wells indicates that favourable conditions for settlement were present along the north western coastline for perhaps as long as there has been occupation of Qatar; these conditions persisted throughout Islamic times up to the modern era. Taylor (1836) in Thomas (1856) comments "...*on the coast, half a day south-east of (Ojair), is a tract of land inhabited by the Beni Khalid Arabs in the spring and autumn, and containing shallow wells, or springs of water*". The area includes a number of Abbasid linear sites such as the ruins of Murwab, Al Haddayah, Musaykah , Makin, Rakayit and Umm Al Kilab (Macumber, 2014). Between Murwab and Al Haddayah are the sites of Jogbi and Umm Ma (Geurin and Al Naimi, 2009). Of the known early Islamic linear sites only Al Athbar lies outside the zone of shallow wells. All the linear sites have much the same alignment, being roughly at right angles to the *shamal* and approximately aligned towards Mecca (Figure 3). The linear villages are located inland at elevations close to the 10 m asl contour and alongside rawdha depressions where they obtained their water supplies; their low elevation guaranteeing ready access to shallow fresh water (Figure 3). The ruins and the associated rawdha are closely linked and must be considered as a composite site. Groundwater mounding beneath the rawdha following storm events, brought water tables close to the surface for lengthy periods.

Figure 3. Umm al Kilab linear village - length 410 m (direction of Kaaba, Mecca - 248°) on the edge of a rawdha. The 'rawdha association' includes trees, well(s), former settlements (ruins) and/or modern farm(s) (P. G. Macumber, 2014)

The linear sites consist of a number of aligned stone houses having parallel NE-SW orientations, ranging from ca 235° to 245°, which approximates the direction of the Ka'aba. This is seen in the case of Umm Al Kilab (Figure 4). However, the sites also lie at right angles to the predominant NW-SE wind direction, which is the preferred orientation adopted for tent lines to minimize the impact of the shamal winds in the hotter months (Macumber 2014).

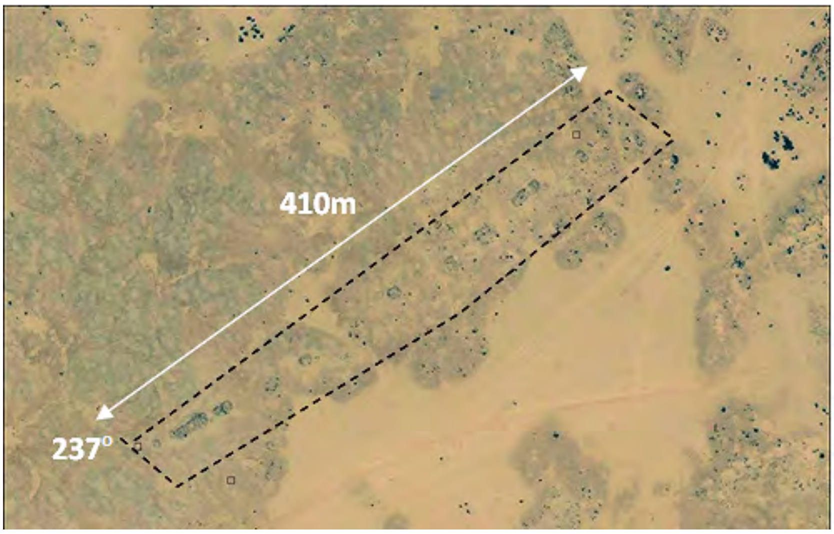

Figure 4. The location of early Islamic linear villages in relation to landscape and the zone of shallow wells. The sites lie close to the 10 m contour where the depth to groundwater in adjacent rawdha depressions would have been minimal (P. G. Macumber, 2014)

At Al Haddayah, a linear village located about 17 km to the north of Jamaliyah (locality Figure 2; Figure 3), a small outdoor mosque consisting of a qibla wall and mihrab niche lies at the SW end of the settlement (Macumber, 2014). The qibla wall lies at right angles to the line of the village. There were several graves adjacent to the houses, and coarse grained pottery and turquoise glazed pottery were present. The village lies on a ridge overlooking two treed rawdha depressions on the northern and southern sides, the likely sites for the water supply at the time. This is the most southerly of the early Islamic linear villages so far identified in northern Qatar, and the mosque firmly establishes an Islamic identity for the village.

Wells, were commonly present in towns bordering the sea, but were underlain at shallow depth by seawater, and were mostly brackish and non-potable, and instead used for domestic purposes such as cleaning and bathing. One example is a well in the mosque at Al Jumayl on the northern coast (Figure 12). Wells providing the water supplies for the coastal towns were located further inland beyond the coastal sabkha zone, where they intercepted the coastward flowing groundwater prior to its becoming hyper-saline. Unlike Bahrain, where large coastal and near and off-shore freshwater springs were/are present, this is not the case in Qatar. In a comprehensive list of Native Wells covering the immediate pre-modern period, created from the 1938 and 1958 groundwater surveys, only one mention was made of a pre-modern spring, that being near Al Khor, the one area where reference to springs span the ca 7,000 years of Qatar occupation. In some instances the terms 'springs' and 'wells' are mistakenly interchanged in usage and this seems to be the case with references to water from the same sites near Doha, being deemed to be from both wells and springs.

Southwards, beyond the limits of the freshwater lens, potable groundwater becomes increasingly less available, and was found as small localized occurrences wherever run-off and recharge has been concentrated in closed depressions or *wadis* (stream courses), sufficient to establish a small localized lens in the underlying sandy shoe-string aquifer. The fresh water in such cases may directly overlie brackish to saline groundwater, or be 'perched' on a less permeable layer above the otherwise saline to brackish water table.

The northern freshwater lens also overlies more saline regional groundwater. The lens is a remnant of an earlier lens formed during the wetter period of the *hydrological optimum* from about 7,500 yr BP until 6,000 yr BP (Macumber, 2011), and maintained by modern day storm-fed recharge, which passes into the groundwater system by means of the *rawdha*.. They are the principal areas of groundwater recharge, which occurs mostly during storm events when the rawdha are flooded. Recharge occurs through coarse-grained sediments around the rawdha margins, and thence downwards via high permeability zones associated with peripheral collapse-induced fractures in the limestone (Eccleston et al, 1981).

Figure 5. Flooding of Helwan — winter 2014 (picture courtesy of Sandra Rosendhal)

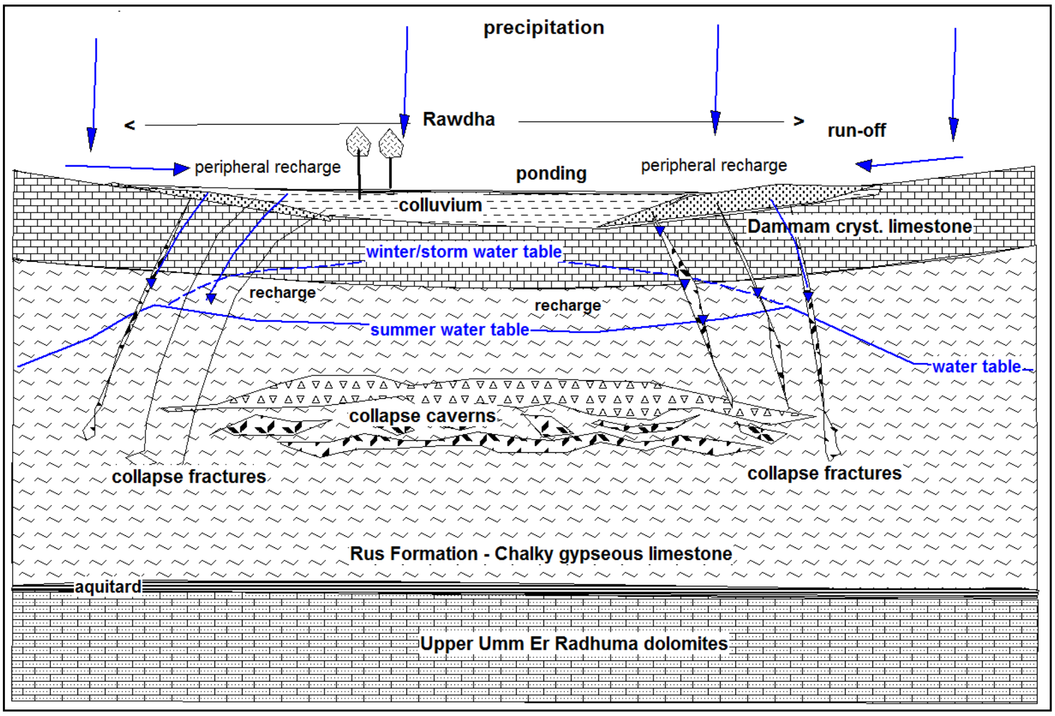

Figure 6. Development of rawdha in response to collapse following gypsum dissolution in the Rus Formation

Overall there are about 1000 rawdha which make up less than 3% of Qatar, covering an area of ~ 33,500 ha, and ranging in size from a few metres across up to 60 ha. In the north of Qatar, the depressions occupy terminal positions in small basins of internal drainage with localized catchments, ranging in area from 0.25 to 45 km^2. They collect surface water from direct rainfall and from storm run-off from bare bedrock areas via an incipient natural internal drainage system. Colluvial soils made up of calcareous loam, sandy loam and sandy clay loam have accumulated in the rawdha to depths ranging from 30 to 150 cm, overlying limestone fragments and bedrock. They provide the main agricultural soils of the country. The rawdha are a crucial feature of the hydrology, without which no freshwater lens could be maintained in the arid, flat landscape. They are grassed in winter, and are the focus for hand-dug wells for drinking water, stock, domestic and agricultural purposes. Date palms have been variously described growing in the rawdha, and were irrigated from shallow wells. In modern Qatar, farms are commonly established on or adjacent to the rawdha, as were most inland settlements during pre-modern times, including the early Islamic linear villages.

Being the focus of recharge, the rawdha depressions are commonly underlain by a groundwater mound, a feature described as 'depression groundwater' of Le Grande, 1959 (FAO/UNDP 1974). Groundwater mounding in response to recharge during storm events at Rawdat Al Faras and Musaykah located 34 and 11 km southeast of Al Zubarah, was documented in Eccleston et al., (1981). At Rawdat al Faras rain over several days in January 1977 caused a 4 m rise in the water table, bringing it within 4 m of the surface (Figure 7). Given more prolonged and perhaps larger storm events, such as those shown for Musaykah in 1976 (Figure 7), it is likely that groundwater levels would rise to the surface. In such instances, the presence of surface water on the rawdha is not simply a relatively brief ponding effect of rainfall and runoff following wet events, but is an artefact of the length of time that artesian conditions exist in the groundwater system. This response is likely to have been more pronounced in the past given that the freshwater lens had been somewhat depleted by the mid 1970's, especially in the vicinity of pumping wells. Whatever the individual circumstances, storm-induced groundwater mounding beneath the rawdha enables a greater certainty and predictability of water availability, than would otherwise be the case with the erratic rainfall in the arid and hyper-arid settings.

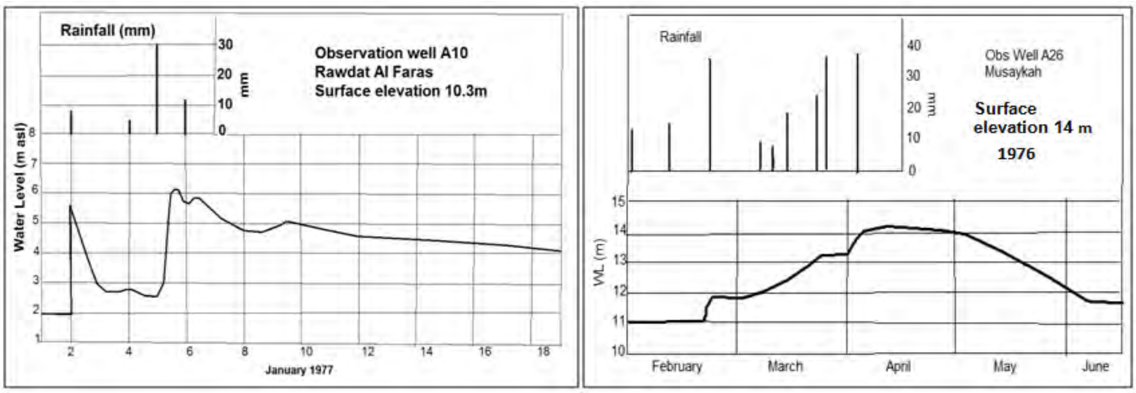

Figure 7. Groundwater mounding beneath Rawdat al Faras (left) and Musaykah (right) after storms - (redrawn, Macumber, 2014, after Eccleston et al, 1981)

The floors of the silty rawdha depressions, which are often treed, reflecting the presence of fresh shallow groundwater, commonly display fine meandrine/dendritic stream patterns ('playettes' of Macumber, 1968; 2011). These fine erosional features are developed as a consequence of both radial flow outwards from the centre towards the recharge areas at the periphery of the rawdha when wet, and a reversed flow towards the rawdha centre during discharge events at times of high mounded water tables (Figure 8).

The occurrence of rawdha, trees, playettes, wells and settlements, present an association across northern Qatar - referred to as the *rawdha association* (Macumber, 2012). Rawdha with such features provide a focus, when uncovering early sites, as was the case with Al Haddayah and Umm al Kilab.

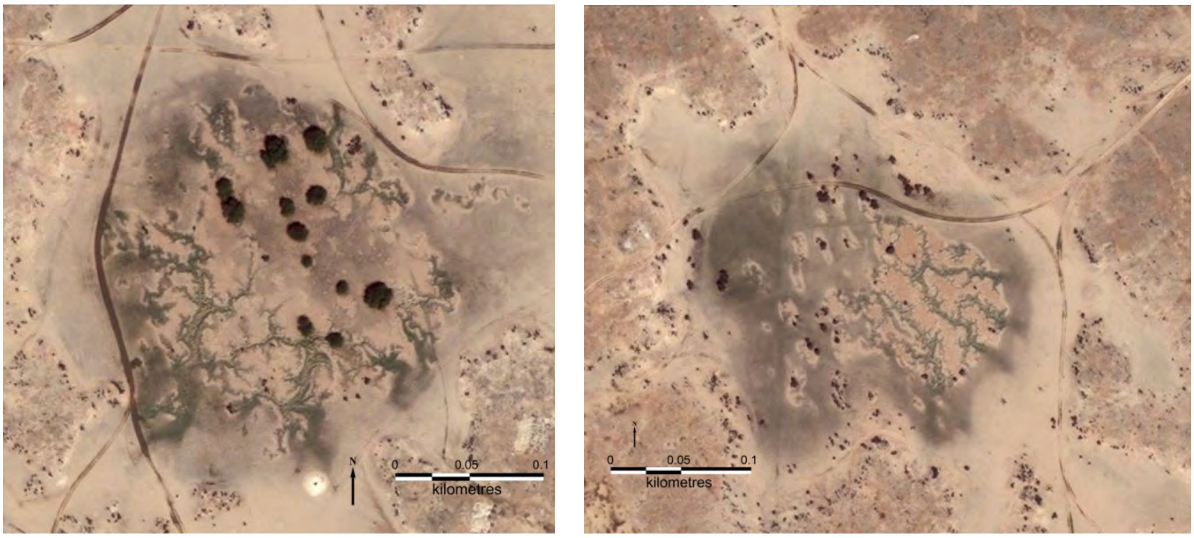

Figure 8. Small rawdha with playette pattern and large trees (shallow water) adjacent to early Islamic (Abbasid?) sites (1) at Makin, and (2) Umm al Kilab. Radial streamlets are both to and from the rawdha sides where groundwater both recharges and outflows into the depression. The Makin and Umm al Kilab rawdha have nearby modern farms. Note the well at the southern end of Makin playette (P. G. Macumber, 2014)

In more recent times, the use of modern drilling techniques has enabled water to be exploited from deep within the aquifer, whatever its depth. This was not the case in the past, when two principal factors dictated the location of past settlement - the presence of fresh groundwater, and its accessibility by hand dug wells. The latter was in turn controlled by relief. Since Qatar is an elongated peninsular with low relief and low rainfall, the elevation of the water table is relatively flat and lies deep beneath the peninsular and graded to sea level. Even in the hinterland its elevation rises at most to about 9 m above that of sea level. For much of southern Qatar and inland parts of the north, the depth to the water table was normally beyond reach by hand-dug wells, and readily accessible groundwater was restricted to lower areas, thereby causing settlements to be concentrated closer to the coast (Figure 2). For this reason, many of the wells and settlements lie at about 10 m above sea level, often established on small rawdha or on the surrounding Tertiary limestone surface (Figure 4 and Figure 9).

Coastal towns are commonly located on palaeo-shoreline ridges backed on their inland side by coastal sabkha. The towns were centres for exploitation of the rich pearl banks and trading, while the remains of stone fish traps dot the coastline. They are commonly underlain by saline groundwater, and having no local water source, obtained their potable water from further inland, beyond the influence of seawater intrusion. This led to the development in Qatar of 'twin-towns', one coastal and the other inland, in a symbiotic relationship linked by trade and produce, each providing different resources with fish and trade goods from the coastal towns, and water and agricultural produce from the corresponding non-coastal settlement. This was the case for the World Heritage site of Al Zubarah on the coast and Murayr further inland (Figure 10). Al Zubarah had a relatively short, albeit important history which lasted through parts of the 18th and 19th centuries. While perhaps less historically significant than the more transient coastal settlements such as Al Zubarah, Fuwayrit and Al Khuwayr (Khor Hassan), further inland set back from the coast, are found some of the longest extant settlements such as Al Athbar and Musaykah, whose wells were an important source of potable water. Both have a heritage of occupation dating back to earliest Islamic times. By contrast, Al Zubarah, built on a Holocene beach ridge had no immediate water source, and instead received water from nearby settlements at Al Muraya and Umm Al Shuwayl, and perhaps Ain Mahomed and Musaykha, the latter being one of seven known early (?Abbasid) linear village sites dotted across northern Qatar (Figure 4).

Similarly, Fuwayrit and Al Ghariyah on the northeast coast received their water supply from Ain Sanan, Fililah, and Al Adhbar further inland (Figure 2 and Figure 9). As was the case with Murayr and Al-Zubarah, the towns existed as 'twin-towns' - one coastal and one inland – each providing different resources with seafood and trade goods from the coastal towns, and water and agricultural produce from the corresponding non-coastal settlements.

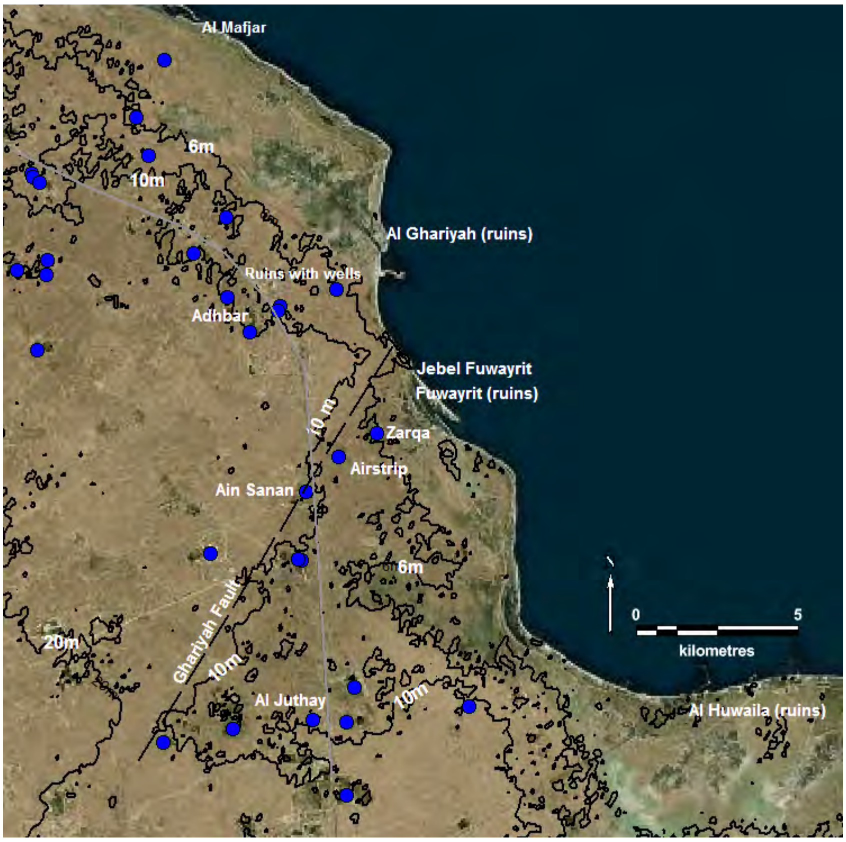

Figure 9. Well distribution in the Fuwayrit - al-Ghariyah area, inland of coastal sabkha. Major well sites are found at Al Adhbar and Ain Sanan, and smaller sites nearer the coastal towns. The map shows the preferred location of wells in the vicinity of the 10 m contour where the water table was readily accessible by shallow hand-dug wells - P.G. Macumber, 2014. Embayment marked by the 6m contour (P. G. Macumber, 2014)

Al Adhbar, southwest of Al-Ghariyah, and Ain Sinan, southwest of Fuwayrit, are set well back from the coast beyond the influence of any seawater intrusion or hyper-saline water present beneath the coastal sabkha. Between Ain Sanan and Fuwayrit is the site of Zarqa, deemed by Lorimer (1908) to have brackish ('indifferent') water. The broad transition from saline to brackish to fresh water in wells on passing inland from the coast was a measure of the extent of seawater intrusion into a coastal plain having low relief.

The supply wells are most commonly found in or alongside areas of rawdha, where the water table is shallow and rapidly recharged during storm events. Lorimer (1908) notes that the Ain Sanan well was protected by a fort built by the Ma'ahid, but was at the time occupied by the Al Bu Kuwarah, attesting to the permanency of the well and the transient nature of its users. Nearby, Al Adhbar is developed on the site(s) of early Islamic linear villages, and the wells have clearly been used over a considerable time period.

Al Zubarah, was a walled city that flourished as a pearling and trading centre for a short period of some fifty years in the late 18th and early 19th centuries. Its prosperity related to its involvement in trade of high value commodities, most notably the export of pearls. It is the only undisturbed pre-modern pearling and trading city in the Arabian Gulf, and as such is of very great importance to an understanding of the way of life in the 18th and 19th centuries. Having no potable water source, it was obliged to access water and agricultural needs from the nearby wells and fields at Murayr and Umm Al Shuwayl, which are located inland of the sabkha, towards the centre of the 'zone of shallow wells' on the northwestern coast. It was also able to obtain produce from small but intensive irrigation areas such as that of the Muhayriqat irrigation settlement, located a few kilometres to the south, and small irrigated areas such as that at Murayr, where date palms were recorded. A constructed canal passes from the tidal zone towards Murayr. Lorimer (1908) suggested that the canal enabled sailing boats to discharge their cargoes at the gates of Murayr, but it was silted with sand. It is difficult to see how any entrance could remain open across the sandy tidal flat, and its use was probably opportunistic, occurring at times when the supra-tidal zone was flooded. This implies that the entrance to the canal was navigable only to those boats with a shallow draught capable of crossing the tidal zone.

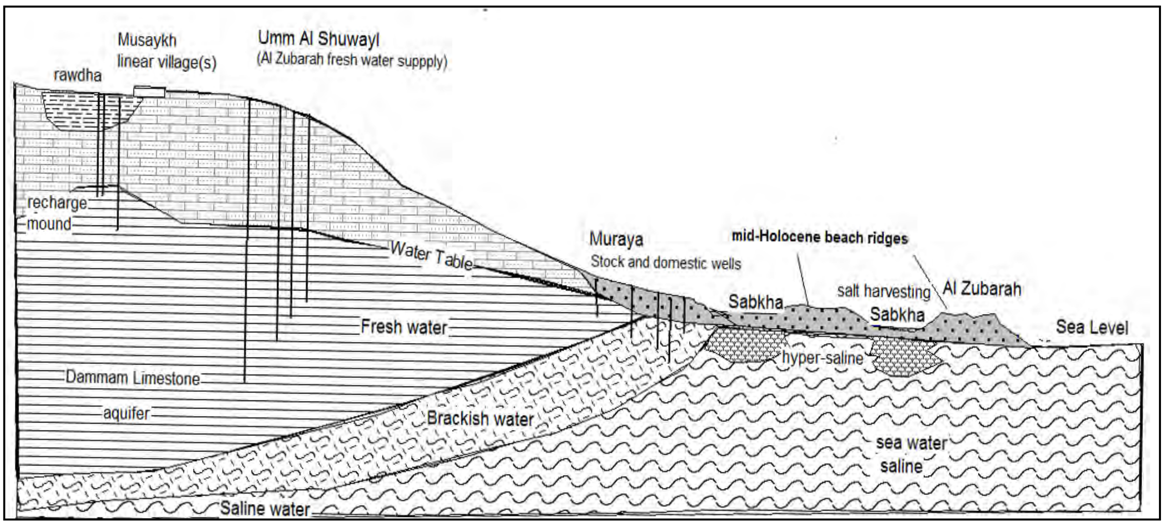

Figure 10. Groundwater distribution and salinity between Musaykah and Al Zubarah showing settlement and well field locations (diagrammatic) in a coastal setting (P. G. Macumber, 2014)

At Murayr are the remains of the Qal'at Murayr fort, provided protection for the scarce water. The present fort was constructed in 1938. Further inland, the settlement of Um Al Shuwayl, also had a fort. The importance of the supplier wellfields to prominent coastal towns is underlined by the presence of associated forts such as those near Umm al Jumayl, near Fuwayrit at Zarqa and near Al Zubarah at Umm al Shuwayl and Murayr. Lorimer (1908) notes that at Mushairib, one of the water supply sources for Doha, '*there is a military outpost of 8 men in a tower to watch the wells*". Peterson et al.(2010) notes the presence of forts at Al Thaqab and Al Rakiyat in the vicinity of Al Ruwaydah. Both were important sources of water, probably from early Islamic times given the presence of the linear site of Al- Rakiyat. Peterson et al, (2010) comment that forts are a ubiquitous feature of Islamic settlement in Qatar, possibly indicating a lack of security or perhaps some form of communal or tribal identity. However the widespread dual presence of both wells and forts, even at small sites such as Zarqa near Fuwayrit, suggest that the primary purpose of the forts was more functional, and designed to protect the wells which provided the crucial water source.

In coastal aquifers, seawater intrudes inland, underlying coastward flowing fresh groundwater. Between Al Zubarah and Murayr are sabkha (Figure 10). Outside the walls of Al Zubarah, small shallow pits were dug in the sabkha floor intersecting the hyper-saline groundwater. Salt (halite) crystallized in the pits and was harvested. Beyond the inland edge of the sabkha, there are about 10-12 wells in two groups at Murayr. Because of the underlying saline water, the wells were relatively shallow, and used for drinking, stock and domestic purposes. Potable water would have been obtained from those wells furthest from the sabkha, while those nearer the sabkha would have served for stock and domestic purposes. Freshwater would have been taken from the top using the process of "skimming", in order to avoid the underlying saline water. The Murayr wells are mostly large shallow square pits (box wells) up to 7m x 7m in area, and several metres deep. Their shape and size suggests that in some cases they were entered from one side. The skimming of water is carried out by manually removing the upper layers of fresher water from the well without drawing in more saline water, which would otherwise pollute the well. In more recent times it is achieved by low pumping rates to achieve the same result.

At Umm Al Shuwayl, there are 3 wells, a small ruined settlement and a nearby fort, alongside which is a further well. The site was recorded by Beatrice de Cardi (Site 13b). While it was recorded as suplying potable water for Al Zubarah, the salinity of the wells when measured in 2009 was ca 3,700 mg/L and too saline for this purpose, reflecting the impacts of recent groundwaterpumping on the freshwater lens. Umm Al Shuwayl is a rawdha site, and within the depression are two large pits which filled whenever the rawdha was flooded. The water level is about 5 m down, but when water tables rose after prolonged wet periods or major storms, the pits could have become small groundwater- fed dams, which held water for prolonged periods, as long as the groundwater levels remained close to the surface. The water from the wells was used on adjacent fields, as shown in Figure 11, or transported by animals/humans to where it was utilized as a potable water supply. There is no evidence, as yet, of canals or pipes, and these only appear in the modern period of mechanically drilled wells and whole farm layouts.

Linked to the coastal towns were a limited number of irrigation settlements, such as that at Al Jifarah, inland of the towns of Al Jumayl, Al Khuwayr, Naba'ah and the Ruaydah Fort.

Figure 11. Abandoned irrigation area near Al Jifarah to the south of Al Jumayl, lies within the 6 m contour on a coastal terrace developed within a former marine embayment. Small farms now border the embayment. Nearby settlements were the Ruwaydah Fort and Al Naba'ah, near where outseepage occurs in a small embayment marked by the 6m contour (P.G. Macumber, 2014)

The now abandoned irrigation area at Al Jifarah, was established on a remnant of a late Pleistocene marine terrace delineated by the 6 m contour (Figure 11). The Al Jifarah irrigation area, although small, was perhaps the most intensely developed of any irrigation area on the northern coast. The 6 m contour marks the approximate upper limits of the late Pleistocene (Eemian?) transgression, which formed shallow marine embayments at Al Thaqab and Al Jifarah. The sandier sediments deposited during the marine transgression provide permeable soils suitable for irrigation. By contrast, the surrounding limestone was often bare and the soils were poorly developed skeletal soils. At Al Jifarah, the water table is within several meters of the surface. Nearer the coast, groundwater outseepage is present, being concentrated in the small embayments as in the vicinity of Naba'ah, where there are a small number of shallow wells (Figure 11).

Al Jifarah was clearly chosen for irrigation because of the better soils, and the ready availability of shallow groundwater, which is still evidenced by trees scattered across the area. A feature of the Jifarah irrigation area is the large number of small plots and shallow wells, there appearing to be almost one well for each plot (Macumber, 2011). The depth of the wells, as at Murayr, was limited by the presence beneath the fresh water of an underlying brackish transition zone to deeper saline water. As a consequence, the large number of small wells tapping the shallow water table enabled just sufficient water for the adjacent fields while not significantly lowering the water table, thereby retaining a flat cone of depression. This approach only skims the fresh water from the top of the transition zone above the freshwater-saltwater interface with a minimum of mixing, and without causing a significant up-flow of saline water from deeper in the aquifer. The overall farm layout and irrigation practice in earlier small irrigation settlements, guaranteed sustainable agriculture while maintaining the freshwater lens on which the coastal towns relied. The presence of palms is indicated by their common presence in abandoned irrigation areas such as Jifarah and villages such as Murayr (Warden (1865: 368). The extant small scale near-coastal irrigation areas were abandoned as a consequence of salinization and/or seawater intrusion after the shift to new techniques following the introduction of large scale groundwater extraction from the 1950's onwards. It parallels the abandonment of near coastal settlements previously dependant on groundwater (see below).

4 Southern Qatar - water heritage in a nomadic regime

Southern Qatar is markedly different from northern Qatar by dent of its thick sand sheets and dunes, which influence the nature of the rawdha and associated vegetation. In southern, central and western Qatar, a deeply eroded central plateau mostly lies at elevations between 40 m and 60 m above sea level, but reaches a height of 103m.The water table is commensurably deeper than in the north. Driven by the north-westerly winds, sand dunes and sand sheets are prevalent, presumed to have migrated southwards from exposed northern shorelines following the fall in sea levels after 4,000 yr BP. Across the region the landscape is subject to intense sandblasting during the seasonal sandstorms, which has resulted in scalloped and fluted limestone surfaces. While rawdha-like depressions occur in the south, they are fewer, and are small and isolated, with a sandy infill and sandy floors; the scattered vegetation utilizes the infiltration and limits groundwater recharge. Larger rimmed structural depressions are present, however the floors are well above the water table. The southern groundwater is mostly brackish to saline fossil water and small freshwater lenses are limited in extent. Even where potable water exists beneath the major depressions, it remained largely beyond reach by hand-dug wells. As a consequence settlements were rare, and located on small locally recharged freshwater lenses as near San Al Furayah near Turayna (Figure 12).

Reflecting a largely nomadic population, the architectural feature most symbolic of southern Qatar are small open mosques, which are scattered as mostly isolated structures across the landscape (Macumber, 2014); they were at times constructed in lightly vegetated areas but were mostly not associated with wells. They consist only of a qibla wall laid out in stones and a mihrab niche. There are a small number of existing towns such as Al Karanah, Al Karrara and Turayna, but even abandoned settlements are few. One such site is the ruins of a small village to the north of Khor Al Dayd near San Al Fuzayrah. The site is located on the floor of a small sandy wadi, and owes its existence to a well, located over a small freshwater lens fed by runoff from the surrounding bare limestone slopes. A small open mosque lies within the village, however an unusually large open mosque is present on the limestone hill overlooking the settlement. The qibla wall is 17 m long and terminates against a rectangular shaped open 13 m square, demarked by stones (Figure 12). The area was clearly a major meeting place and its presence reflects the significance, perhaps rarity of the small well in an area where such wells were uncommon.

Despite the inhospitable conditions, the prevalence of small open mosques indicate that nomadic people visited southern Qatar regularly on passage to and from the north, usually during favourable seasons, when storm water temporarily ponded in the rawdha or accumulated in basins in the limestone. Despite its scarcity in the south, fresh water was not essential for travel, since camels are able to drink brackish to moderately saline water and produce (fresh) milk. In this respect, they may be considered as early versions of portable desalination plants. Camel wells, established where groundwater was too saline for human consumption, enabled movement through those areas where little potable groundwater existed, as was the case for much of southern Qatar. The remaining brackish camel wells represent an important part of the water heritage of Qatar (Figure 13).

Figure 12. Open mosques with mihrab and qibla wall (left) on a low hill above ruins near San Al Fuzayrah. The settlement was established around the now abandoned walled well (right) in a nearby sandy wadi, fed by runoff from the surrounding bare hills (P.G. Macumber, 2014)

Figure 13. Camel well in southeastern Qatar near Shagra

5 Modern changes bearing on the viability of the groundwater system and the water heritage.

The last major hydrological change was ushered in with the development of modern Qatar in response to the oil/gas discoveries. Upto1958, a steady state existed in the groundwater system such that coastal outflow including extractions by hand dug wells was balanced by inflow (recharge and down basin flow), and water levels and salinity remained static (Eccleston, et al., 1981). Villages and towns were dependent on hand-dug wells to provide fresh water, thus greatly limiting extractions, and consequently preserving the northern freshwater lens.

However with gradually increasing abstractions from 1958 onwards, water levels fell markedly but only across north and central Qatar, reflecting the insignificant amount of pumping in the south due to the higher groundwater salinity. High, post-development groundwater abstractions using modern drilling and pumping techniques rapidly depleted the freshwater lens, thereby

impacting upon the aquifer quality and its availability (Eccleston et al., 1981, and Lloyd et al., 1981). This saw a significant reduction in groundwater flow to the sea, required to counter seawater intrusion. In response to the lowered groundwater levels, seawater intrusion migrated into the coastal aquifers, which led to abandonment of coastal and near-coastal towns. Nearer the coast, water tables were very shallow and often only a few metres from the surface, the use of very large pits/wells in conjunction with high yielding pumps greatly exacerbated the decline in groundwater levels. This is seen at Al Thaqab, a traditional water supply site, where the newly established wells were little more than broad shallow trenches cutting the water table (Figure 15). Groundwater modeling results were consistent with the observations showing the replacement of freshwater by saline water in the aquifer (Lloyd et al., 1987). On the basis of the modeling, it was calculated that for the Rus Formation, the annual rate of advance of sea water intrusion was 90 metre/year but where active well fields occurred close to the coast, this rose to 1000 metre/year.
Further inland, on newly established farms, bores were drilled and linked to a number of pumps providing for extensive irrigation layouts. The freshwater lens, a relic of the earlier higher rainfall of the early Holocene period but maintained by rawdha recharge in an otherwise arid climate, was seriously impacted. There was an inevitable up-coning of saline groundwater into the bores which in turn caused salinization of the soils, thus making this approach to irrigation unsustainable (Figure 15). Saline water now occupies much of the coastal aquifer, where it was known that freshwater was previously present, and the towns have been abandoned (Figure 14). Many wells which once were town supply wells are now brackish or saline and no longer capable of providing potable water. The small irrigation settlements located on the more permeable late Pleistocene marine terraces were equally impacted, and are now abandoned (Figure 11). In the case of the Helwan well, the salinity changed from 400 mg/L in the 1960s to 4,000 mg/L in 2010. While most seriously impacted nearer the coast, the freshwater lens remains varyingly present further inland where extractions have been significantly reduced to ensure its protection.

Figure 14. Abandoned town of Al Jumayl (north-west coast) in response to salt water intrusion (P.G. Macumber, 2014)

Figure 15. Abandoned pump house (left) near Al Thaqab on an irrigation pit showing the present a high water table. It was constructed for irrigation purposes, but rapidly become saline. Nearby dead date palms (right) attesting to the salinization of the groundwater in large nearby pumped pit-wells. (P.G. Macumber, 2014)

6 Conclusion

The cultural heritage of water lies in the recognition by the inhabitants of Qatar of the physical constraints of water availability, and the adaption of successive generations to an innately hostile environment, the key to which was an understanding of the nature of groundwater occurrence. In this sense it is of necessity a narrative of landscape and the physical processes surrounding groundwater, its distribution, usage, and protection. Once the protective role weakened in the post-modern era of intensive extractions, the freshwater lens contracted at the coast to be replaced by seawater. With the loss of their groundwater supply the remaining traditional coastal settlements supported by pearling and trade, largely died out. With the switch to desalination as the principle water source, the cultural heritage of groundwater location and usage in Qatar virtually became itself a part of the archaeological record as did many of the settlements dependant on it. In the south of Qatar, where water availability was significantly more limited, the link between a traditional nomadic lifestyles and the implied water heritage remains less impacted.

Protection of the water heritage commences with the recognition that the groundwater and wells, so crucial to occupation, did not exist in isolation, but were part of a broader landscape association centred on the rawdha, a relationship clearly recognized during the early occupation of Qatar.

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Sub-region H: Iran

Overview on Technical and Cultural Heritage of Qanats in Bam Region (Iran)

Case study – Shushtar Historical Hydraulic System (Iran)

Overview on Technical and Cultural Heritage of *Qanats* in Bam Region (Iran)

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1 Introduction

The city of Bam is located 193 kilometers south-east of its provisional center, Kerman. This city is 940 meters above the sea level and has an arid climate. The people of Bam are mainly farmers and date palms play a crucial role in their lives with the help of irrigation. Groundwater is the most reliable source of water supply. Nineteen Qanats irrigate Bam, all originate from the west and the north-west. These Qanats are called: Abbas-Abad, Hafez- Abad, Salsabil, Najmieh, Mohamad-Abad, Asad-Abad, Rahmanieh, Masumieh, Pakom, Deh-Shotor, Kakh, Fakhr-Abad, Lengi-Fakhr-Abad, Ghanbar-Abad, Sheikhi, Sobhan-Abad, Akbar-Abad, Ameri, Mahdi-Abad, Hassan-Abad and Hossein-Abad.

The 2003 earthquake not only struck Bam and Baravat and reduced the region to rubble, but also deeply changed some social structures which used to lie behind such traditional techniques as the qanat. The word "Bam" gives us an insight into the seismic ruination of the unique fortification in 2003. However this castle and the archaic civilization of the area are widely rooted in concealed qanats symbolizing arteries conveying life and prosperity to this ancient city.

Qanats have both cultural and economic value in Bam. The Bam-Narmashir plain has always suffered from arid climatic conditions with an average annual precipitation rarely exceeding 60 millimeters which is hardly enough for any settlements. Qanats originating from alluvial fans have made this region habitable, so a precise survey of these historic hydraulic structures with respect to their great antiquity seems inevitable.

The Qanats of Bam are also important from an economic viewpoint. Irrigation consumption of Bam-Narmashir plain is thoroughly fulfilled by qanats mining more that 400 million cubic meters of groundwater annually whose rate is considerable bearing in mind the area of the cultivated lands. Therefore it seems that the technical characteristics of the qanats of Bam can be enumerated as the most sustainable ecological knowhow being widely applicable to arid zones not disturbing the aquifers.

In fact qanats in Iran have created and supported life and all elements of human ecosystems from millenniums, and are influenced by those elements. Without qanats, simply, thousands of villages and towns in Iran may not be able to continue flourishing in the future, or even to have been there at all.

The site of “Bam and its cultural landscapes” has been inscribed on the World Heritage List since 2004 on the basis of criteria (ii) (ii) (iv) and (v). The short account of its Outstanding Universal Value recognized by UNESCO underlines the role of qanats throughout its history:

> “Bam is situated in a desert environment on the southern edge of the Iranian high plateau. The origins of Bam can be traced back to the Achaemenid period (6th to 4th centuries BC). Its heyday was from the 7th to 11th centuries, being at the crossroads of important trade

routes and known for the production of silk and cotton garments. The existence of life in the oasis was based on the underground irrigation canals, the qanāts, of which Bam has preserved some of the earliest evidence in Iran. etc..”

2 A glance at the Qanats in Bam

The Bam Basin presents suitable conditions for the digging of Qanats, its topography and aquifer characteristic being the main ones. This plain comprises alluvial layers of more than 150 meters thick, which preserves a considerable amount of water in the form of a water table. Drainage forms 50% of the basin where no mining activities are carried out and this equation between the plain and the drainage basin is one of the advantages this region benefits from. Extensive alluvial fans in the west, south and southwest and a convenient hydraulic gradient have caused very suitable conditions for Qanats. Northern mountains also are the focal point of the aquifer recharge. There are four major faults in the region, which divide the groundwater into five hydraulic units so that every group of qanats is discharged by means of an independent unit.

These faults along impermeable layers have brought about the relative stability of the aquifer. So the advance of a group of Qanats towards the other group with different hydraulic unit causes no problem. The following picture indicates this fact.

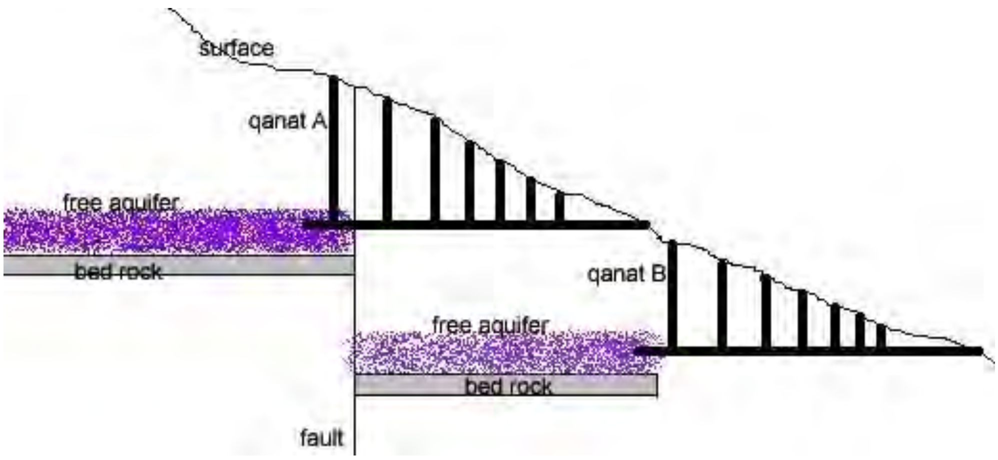


Figure 1. General position of Qanats in Bam (International Center on Qanats and Historic Hydraulic Structures)

To have a picture of Qanats in Bam, the ranges of specifications of Qanats are as follow: the lengthiest Qanat in Bam is the Qanat of Badr-Abad whit the length of 18, 300 meters, and the shortest is the Qanat of Tidumich, with some 32 meters of length. The Ferdows-Gombaki Qanat with mother well being 5 meters deep has the lowest depth, and the well of Hossein-Abad-Abaraq with some 132 meters of depth is the deepest in the region. The range of discharge is between 1 liter per second in the Qanat of Morad-Abad-, and Qanat of Deh-Shotor with some 275 liters of water per second. Qanat of Dolat-Abad-degombaki has the minimum of EC of 297, and of Jahr-Saadat-Abad has the maximum with 4,940 EC.

The mentioned hydrological units are drained by Qanats and their water is partially recharged through farmlands and orchards. Qanats, therefore, do not inflict any damage on the water table. However, accessible statistics bode ill for the future of this sustainable system but herald the booming of tube wells in the face of the legal ban on drilling such wells across the region. Overexploitation of groundwater led to a dramatic drawdown in it each year. That is why the qanats have to be continuously extended into the aquifer some 250 meters a year. As a result about 170 Qanats have been abandoned by 2002. The stockholders of these Qanats have applied for permits for deep wells and some have received permits so far. Therefore, the Qanat discharge of 456,408,788 million cubic meters per year decreased to 338,384,657 in 2002. The average discharge of Qanats in Bam is 37.6 liters per second while it enjoys considerable fluctuations owing to the aquifer recharge. The following chart illustrates this change from 1970 till 2001.

There is varying statistical data concerning the number of Qanats in Bam. In 1973 they were estimated to be 283 whereas in 1993 451 Qanats were announced. This increase seems not to be reliable since a considerable number of Qanats dried up during these years. The statistical increase concerning the number of Qanats is based on two following evidences:

1 In 1973 the mountainous Qanats had not been statistically included because they did not affect the basin water table very much (according to the concerned officials),
2 All the Qanats in Rayen were then added to this list.

3 2002 earthquake and its impact on Bam's aquifer

This region has experienced many earthquakes, like many other parts of Iran. Though no earthquakes had been reported in Bam city before, southwestern Iran has always been subject to many earthquakes. The Bam earthquake struck at 5:26 am and was preceded by 4 foreshocks at 8:00 am and 12.00 the previous day, at 10:30 pm the night before and at 4:30 am, one hour before the catastrophe. All 4 foreshocks accompanied frightening earthquake sounds.

The center of this quake measuring 6.5 on the Richter scale occurred at the depth of 8 km. The worst destructions were from adjacent up to 3 km from the fault so that the areas 4 km from it were not considerably damaged. The number of the Qanats damaged by the earthquake is rather small compared to the buildings and houses destructed. Out of 60 Qanats in the cities of Bam and Baravat 5 were totally destructed. The rest were damaged partially suffered from partial collapse along the canals. This was because the main destruction was along the fault (north-south), whereas the direction of the Qanats is usually east-west. Qanats, therefore, located at the main spots were ruined by the earthquake. The Baravat Qanats were the most damaged by the earthquake, as all Qanats passed major earthquake spots. Mother Wells and ventilation wells of these Qanats collapsed. Structure and morphology of the region played a significant role in the extent of damage to qanats. The east-west direction of the Baravat qanats, located at both sides of the fault running through hard rock, lifted the ancient terraces of Pleistocene, due to the function of the fault. This phenomenon caused qanats wall and shafts to be more resistant where crossing the faults. The farther from the fault to the west, the more damage younger alluviums do to qanat galleries.

Considering the extent of casualty and destruction, studying the impact of earthquake on the aquifer and monitoring the observation wells was not feasible for a long time. Nevertheless, since observation wells in the area were equipped with automatic water level control devices, surveying changes was possible later on.

4 Techniques of Qanat Digging in Bam

Although techniques of digging Qanats by practitioners in Bam have a lot in common in comparison to other parts of Iran, this region enjoys some unique techniques of its own due to its special hydro-geological features. The following is a brief description of methods of digging Qanats in Bam. Qanat diggers are called "moqani", and the master practitioners are "ostad moqani" in Kerman region.

4.1 Leveling

Qanat diggers in Bam utilize the same traditional tools for leveling to be able to estimate the depth of a shaft to determine the location and direction of Qanats. To construct a new qanat, practitioners dig a well and then initiate the leveling process.

Leveling tool comprises two metal poles each including a square pedestal to be placed vertically on and a thin string tied to the poles in the middle of a leveler. To determine where the second well should be dug someone holds one pole near the first well, while another person places other pole where the location of the second well is identified, tying the string to poles and then stretching it. A spirit leveler identifies the slope, as the person by the first well lowers the string to the horizontal level in order to determine the height difference between the two wells. Diggers follow the procedure of leveling in order to have an almost horizontal gallery of around 2-3 % slope. In other words, if a borehole is dug 30 meters deep and the string is lowered one meter, the next shaft should be dug 29 meters deep.

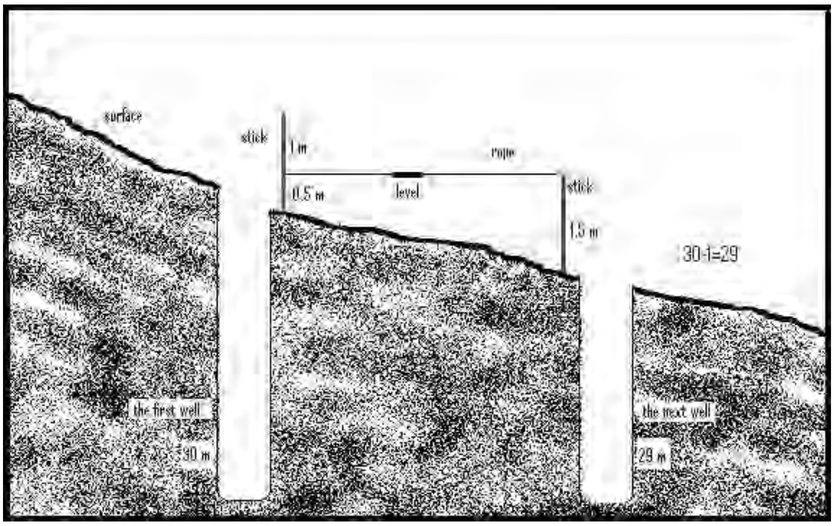


Figure 2. Leveling (International Center on Qanats and Historic Hydraulic Structures)

Leveling is used in Qanat area restriction (Harim) as well. For example, across the Baravat basin 23 parallel Qanats are stretched west-east close to each other. If a new Qanat is to be constructed among the old or anextension is added to the existing qanats, the depth of mother wells or shafts should not exceed the operational qanats.

4.2 Qanat Galleries

To use the force of gravity for water to flow from mother well to water appearance, a leveling process continues from mother well to the appearance. The water appearance is usually an open trench, 1 to 4 meters deep, locally named "Kush". Then, the depth is gradually reduced till eventually water flows to the surface at the outlet. From this point on, a ditch, locally named "Ju", conveys water to the field or the place of use.

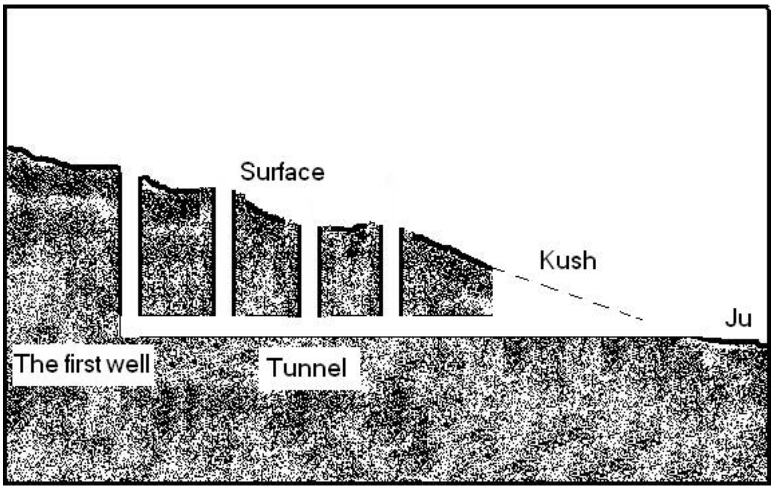


Figure 3. The appearance of Qanat (International Center on Qanats and Historic Hydraulic Structures)

Where Qanats are deep, usually two wells are dug nearby, to provide proper ventilation, known locally as "Joft-e-Badu" meaning twin ventilator. This innovation is also used to facilitate the work of digging, since two diggers and their workers can work in opposite directions, requiring extreme skill of measurement and practice. Double wells are joined at the gallery as well as half way through depending on the depth of wells. This speeds up the duration of digging. Qanat of Ghasem-Abad has this type of double shafting. The ceiling of a Qanat canal is mainly cut semi-arched. Galleries are dug in the wet zone, where water seeps into the tunnel, or in the dry zone, which is the water passage.

To construct walls and floor of the gallery in dry and wet zones, the slope is kept even, again depending on the length of tunnel and gradient of the ground. In cases where the tunnel of another Qanat passes underneath, to prevent the penetration of water into the lower canal, the floor of the upper one is well insulated with cement. To do this, a paste of clay, lime and egg white is spread on the floor and walls, where water is flowing. This phenomenon exists in the qanat of Sharik-Abad running above Hasan-Abad's tunnel.

4.3 Construction of tunnel in the wet zone

Tunnels in the wet zone pass through the water table where water seeps into the tunnel from the floor, walls and ceiling. Digging this section is locally called "Tarah-kar" or "Tarvan". As the tunnel goes deeper into the aquifer, the amount of water increases. The longer and richer the wet zone, the more water discharge is expected from the qanat. Therefore, the length of the wet zone of qanats in Baravat region is mentioned for the water table and the impact of paralleled qanats on each other. In Baravat and Bam, extension of qanats are dug 100 to 200 meters each year, and the close coordination by owners of all qanats should be closely observed.

The shape of ceilings of canals in wet zones in Bam looks like the letter V upside down, locally named Mekenayi, which is usual in Yazd too. This type of sharp arch prevents water from dripping down and the ceiling from collapsing; but it makes the drops slide down on the walls instead. To construct a tunnel in the wet zone, the Master practitioner begins with the ceiling first, then the walls and finally digging the floor so that water level does not raise above the knees; this also is to use the water flow for keeping the slope constant along the tunnel.

In central parts of Iran where water is scarce, a qanat's tunnel must be supervised all the time to prevent any blockage. In Bam region, however, water flows in galleries easily due to rich aquifers. There are sometimes occasions for the diggers in Bam to encounter hidden temporary natural reservoirs of water while digging, known as "Benow". As practitioners say, these small sources, which are located anywhere in the walls or floor, are cooler or warmer than the usual flow and stop flowing after some months or years. Shafts are needed along the wet-zone but not deeper than the water table since working is not probable in water filled spots. Therefore, they apply a method called "Devil-Kani" to construct shafts and tunnel in wet zones.

4.4 Devil-Kani' technique

This special technique and innovation is frequently used in Bam. The practice of Davil-kani is simple in description, tremendously complicated in planning, and extremely difficult in practice. The principle of devil-kani is to dig into the water table from the tunnel upward, not from the well downward, as it is the normal practice for digging or extending qanats. The moqani digs the well until it reaches the upper strata of water table, and water starts to fill up the bottom of the well. Work continues till water seeps into the well to the extent that the digging cannot be continued anymore; yet the tunnel, which should normally be reached from the well, is many meters down below. Ostad moqani then goes into the tunnel, and continues to extend the tunnel, using the old well as the access and ventilation well. When the tunnel reaches below the well, digging upwards begins, which is called "devil-kani". This requires an extremely skilful mathematical and measuring practice, as well as working in dark with not enough air. When one well digger approaches the new well, another practitioner ties a piece of stone to the end of a rope and throws it down into the well and pulls the rope and throws the stone repeatedly before his friend can find out where to connect the Devil to the well. The citizens of Bam call this procedure "Tavar". Many Devils can be witnessed in Behjat-Abad, Sheikh and Fakhr-Abad qanats. Devils in Behjat-Abad qanats are up to 15 meters long.

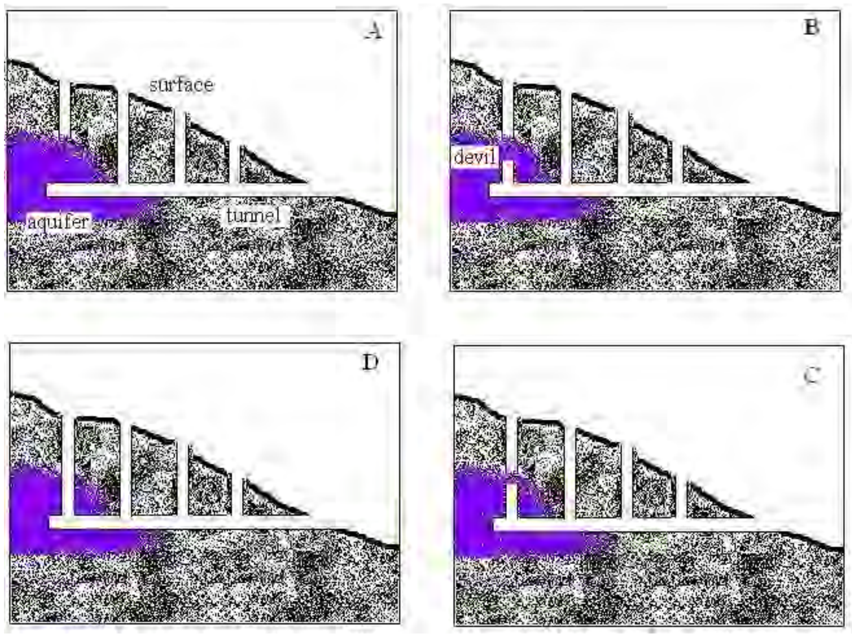


Figure 4. Digging a Devil (International Center on Qanats and Historic Hydraulic Structures)

4.5 Navigation in qanat galleries

Practitioners used simple, yet accurate equipment in Bam to determine the digging direction from one shaft to another. Any negligence could deviate the route tens of meters inflicting huge costs and time, moreover no water would be found. A Tool used, named a "Rasse", includes: a piece of wood, two ropes tied to it in the middle of it some 25cm apart. Two pieces of stones are tied to the ends of ropes. Piece of wood is placed on the mouth of the well in the next wells direction. The hanging stones indicate direction towards the next well. While digging a tunnel, a well digger leaves a light behind in the gallery to follow the direct route, and cure sign of deviation. A light at one end of qanat Khajeh-Asgar tunnel, is claimed, is seen from one kilometer of distance.

Now a compass is also used, where it is placed by the first well so the direction of the next well is identified. The direction should be determined and repeated by adjusting the compass at the bottom of the well. Obviously, moqanis make mistakes when navigating along the tunnel. In case they deviate from the main direction, they have to create a diverging course to reach the other well. This procedures is locally named "pistooyi well" and includes waste of time, money and energy. More pistooyi Qanats are witnessed in the area in recent years. The following figures illustrate the utilization of "Rasse" and a pistooyi well's characteristics.

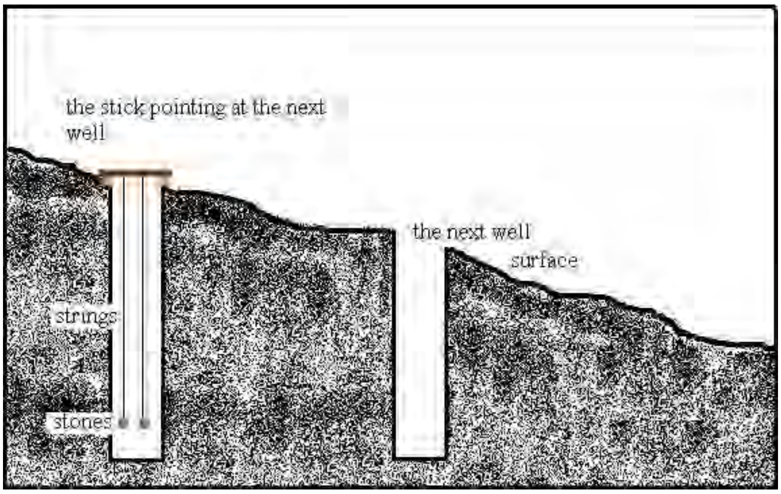


Figure 5. The utilization of rasse (International Center on Qanats and Historic Hydraulic Structures)

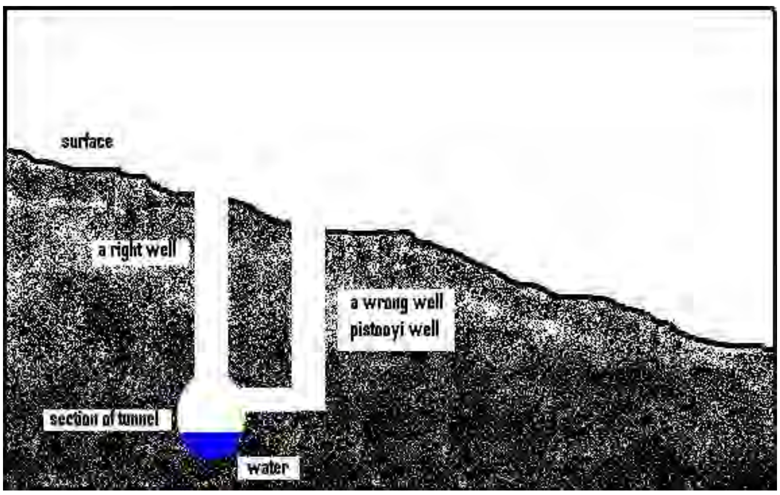


Figure 6. Pistooyi well (International Center on Qanats and Historic Hydraulic Structures)

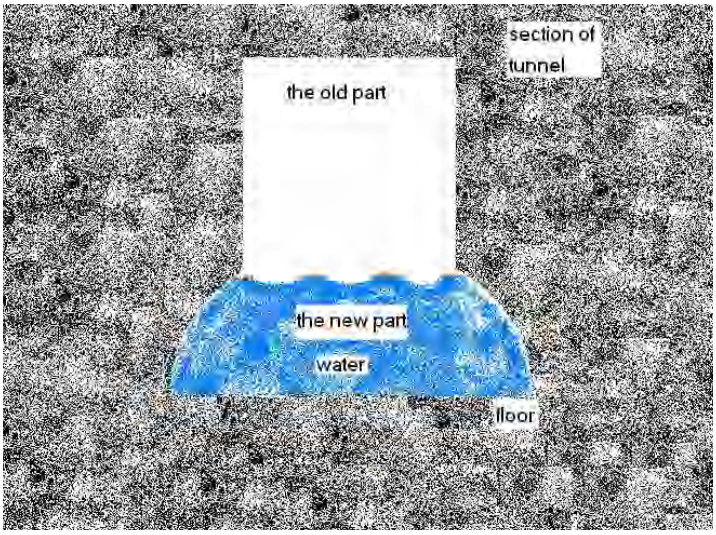


Figure 7. Widening the bottom of the gallery (International Center on Qanats and Historic Hydraulic Structures)

5 Qanat repair and restoration; problems and remedies

Moqanis may face obstacles when constructing, repairing or renovating qanats. These problems are mainly due to geological and aquifer characteristics of the basin, including:

1. A very large amount of water in the wet zone
2. Lack of ventilation
3. Collapsing soft layers
4. Collapse of tunnels and wells
5. Big pieces of rocks along the course of tunnel
6. Hard ground

High flow of water is a major problem for those working in qanats. Due to working continuously in wet and hot conditions with no current of air, workers suffer from painful skin diseases locally named "Ab-gaz". To cure this sickness well-diggers soak some pomegranate skin overnight and put some on sore spots. Another issue concerns existence of gas underground causing respiratory problems and make the light stop burning. Carbon dioxide is more present where there is hard ground since the Neocene sediments producing this gas. Nowadays, air is compressed into the well to supply the needed oxygen. However, in old days digging twin wells was used for ventilation. Another innovation was construction of chimney-like structures along the wall of shafts so that well diggers could enjoy air circulation. Moqanis also put some vinegar in the well beside them while working. Pouring wet sand into the well is believed to refresh by sending down fresh air and send up gases.

Soft and unsecure layers of soil are another problem that causes collapse, and the well-diggers have to line the tunnels with oval lining locally called "Nay" or "Keval". To fill the gap between the linings, they use pieces of rock and mud. Oval linings are 110 cm tall each.

In the case that a tunnel collapses, soil has to be brought up to the surface, and in some situation lining again has to be used for the final repair. Five hundred meters of Ghonad Qanat, partly damaged by the Bam earthquake, were repaired by unskilled workers. The renovations were not satisfactory, collapsing four times because no lining was used and workers could not carry out the task properly.

Bed rocks and big pieces of rocks are obstacles while digging or repairing qanats, which should be removed, buried or bypassed which, is more practical. In some cases there is no other option but to dig into rocks or break it into pieces.

The Qanats of Barevat run through faults and rocks structures at one point or another. The thickness of the rocks is more important in the south. If a new qanat is to be constructed, moqanis can anticipate difficult task of going through rocks, judging by the existing qanats.

6 Qanats in Baravat

As mentioned in 2.3, the Qanats in Baravat, parallel to each other, convey water from aquifer in the western side of the plain to the fields and human settlements in the east of the fault. Digging into the water table of each qanat is coordinated with others, and is a continuous task. Even deep qanats should be extended to compensate reduction in discharge. In Bam, a shallow qanat is called "Borz" and a deep one "Jahr". When people refer to a qanat as being more "Jahr" than the other, they do not mean the depth of the well, but because it is dug deeper into the aquifer. For example, the mother well of Hossein-Abad Borz Qanat is 80 meters deep and Hossein-Abad Jahr benefits from a mother well of 40 meters. People know the Hossein Abad Jahr's mother well goes more into the water table although has half of the other’s depth in total.

Names of 23 qanats of Baravat are as follow: Nartij, Seyed-Abad, Dodung-o-Nim, Ghasem-Abad, Akbar-Abad, Nouruz-Abad, Mohamad-Abad, Ghonad-Kohneh, Hossein-Abad-Barz, Hossein-Abad-Jahr, Ferdows, Gorgen, Rashidi, Vakil-Abad, Allah-Abad, Kenaru, Seyed-Ahmadi, Doulat-Abad, Mirzaie, Lotf-Abad, Yazdan-Abad and Jannat.

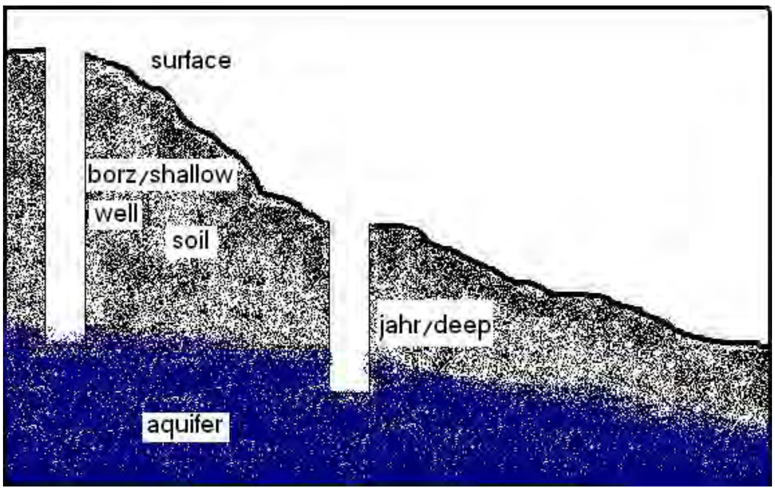


Figure 8. Deep and shallow wells in the Bam practitioners’ jargon (International Center on Qanats and Historic Hydraulic Structures)

7 Qanat construction knowledge in Bam

The Qanat digging technique is an ancient and important innovation in Iran. Knowing its social, technical, operational, managerial and cultural dimensions is vital in understanding of the system. Qanat digging in the past was done by two groups of workers:

1. Hiring unskilled diggers by landowners,
2. Hiring professional qanat diggers.

Prior to the National Land Reform of 1961, most lands in the areas were owned by major landowners who at the same time owned and sponsored construction of qanats. Qanat diggers had to start from the low level of workmanship, and gradually attain more skill to become Ostad Moqani, after some years of hard work and intellectual conducts. Yazdi moqanis are well known to be highly professional practitioners, and wise planners. Nearly all Ostad moqanis who constructed or did major works on the qanats of Bam were from Yazd. Some names are: Haj-Mohamad Sedighi, Seyed-Mostafa Rashti, Haj-Ali Rashti, Haj-Ali Taherian, Haj-Hossein Taherian and Hassan Joukar. The tradition was for the Yazdi moqanis to work in Bam seasonally. They used to come to Bam in autumn and winter to work on the qanats of Bam, when their presence was not required in their own home farms and town; weather in Bam also was more suitable for working.

Yazdi moqanis used to pass down the professional skill, planning ability and engineering ingenuity from fathers to sons, making it traditionally a hereditary skill in families. This is different in Bam for those who have learned the profession from Yazdi moqanis. Below is the family tree of a known moqani of Bam, Mr Avaz-Karimi, whose ancestors had no relations to this profession.

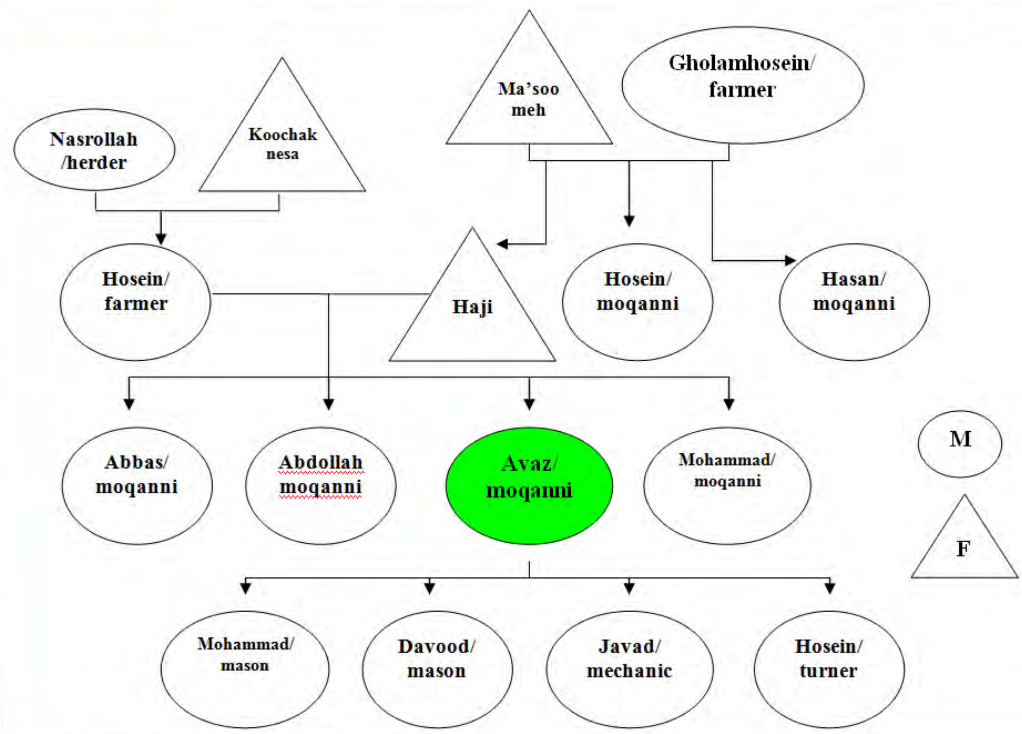


Figure 9. Family tree of Mr. Avaz-Karimi a local qanat master (International Center on Qanats and Historic Hydraulic Structures)

In order to dig a qanat, like executing any project, a contract is made between the owners' representative (Qanat board of trustee or landowners) and the contractor, who consists of groups of 4 persons. For deeper wells and longer tunnels more people may be added to the group: Each person of the group has to perform a specific task:

1. Moqani, the digger, who actually does the digging.
2. Mud collector, who fills up the bucket with soil.
3. Bucket removers, who pulls the bucket along the tunnel and hangs it on the hook to be lifted up. In case they have to carry the soil a long distance, 2 persons must do the job.
4. Soil extractor, who works with a Persian wheel to pulls up the bucket tied to a rope.

Learning the skill starts from working as bucket removers at a younger age of around 15, slim enough to move easily along the tunnel, before moving up to become professional moqanis after many years. Groups of moqanis are always supervised by a Master Digger or "Ostad Moqani" who knows the advanced techniques of identifying place and direction for digging new qanats, or planning repair, conducting measurements and carrying out more complicated works.

Working hours is another issue in Bam. In old days workers used to work from sunrise to sunset, while now workers change shifts every 4 hours in order to distribute the hardship of work evenly.

The application of new technologies and modern facilities have contributed a great deal to better and more efficient ways of digging qanats. When workers use drills, sledgehammers, crowbar and chisel, they surely dig and repair faster and better. Concrete linings have also replaced old clay rings and made the tunnels much stronger than before, and the installation of these linings is much easier. Using drills allow making tunnels larger, and new electric lifts allow more soil to be brought up to the surface much easier. Yet it should be emphasized that there is still a long way to go to taking much better advantages of the new technology in qanat digging and developing other tools and equipments where required. Old qanat have tunnels of some 50cm width and 125cm height, whereas new ones are 75cm wide and 175cm high, because the new technologies allow the workers to move a bigger mass of soil. Moreover nowadays no family in the region consent to sending their little boys to drag the heavy soil buckets in a qanat tunnel, so the adults have to be hired for this job that entails a bigger tunnel.

8 Characteristics, regulation and threats for the qanats in Bam

1. The water table fluctuates a lot in different regions in Bam. The discharge from qanats, therefore, varies greatly in different areas. As the practitioners living in Bam claim, this distinct feature has divided the Qanats in Bam into two groups:

    a. qanats with shallow wells, short galleries and considerable discharge, and
    b. those with long galleries, deep wells and little discharge.

For example, the mother well of Ghanbar-Abad Sheikhi Qanat is 71m deep or the gallery of Deh-Shotor qanat doesn't exceed 3,500 m with considerable discharge while another qanat named Sobhan-Abad with 130 meters depth of mother well has very little discharge and it has a considerable discharge while the mother well of the qanat of Sobhan-Abad is 130m deep but has very little discharge.

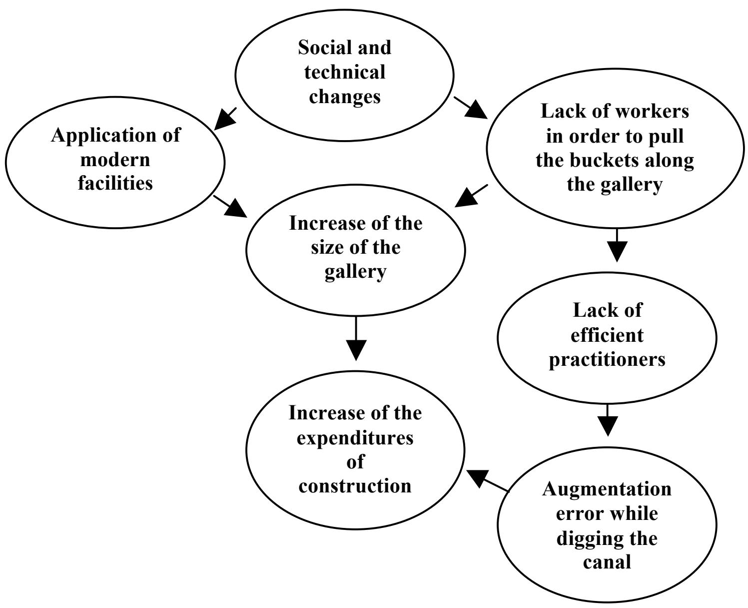
2. Initiations of some modern industries in Bam have affected qanats traditional uses. For example, a company has purchased all the water rights of the qanat from the Late Hossein Ameri's heirs to consume its water which formerly irrigated some lands in Bam. On the other hand, digging some tube wells dried some Qanats in this area. In fact, these industries have deprived the agriculture in Bam of water.

3. Deep wells have damaged Qanats a lot and caused some of them to dry up. The first deep well of the area was dug by Mr. Sekhavat in return for his 50% ownership of a village qanat which had dried. Digging of next deep-wells affected some Qanats which previously had considerable discharge. However, ownership of qanats in Bam has prevented digging of deep wells in the region. According to the 1960s land reform law, landowners were to sell their agricultural lands to the farmers under government's supervision, which led to their dissatisfaction. However, the law had two main exceptions: The lands benefiting from a mechanized system of agriculture and Gardens and orchards.

   Major land owners managed to dig deep wells eluding the land reform law. On the pretext of mechanized agriculture, deep wells were dug one after another causing water table to drop and qanats to dry up. Larger land owners did not need to dig deep wells, as water from qanats was sufficient for their gardens and palm groves, which were exempted from the land reform law, anyhow. More wells were dug, more water table dropped, and more qanats had their water discharge to reduced or dried up.

4. Another important characteristic of qanats in Bam is that water is used in four seasons due to their convenient climatic conditions for all the year cultivation. So, no water is practically wasted in winters.

5. There are some Qanats in Bam with more than 300 liters of discharge per second. So, abundance of water is one of the other characteristics of qanats in Bam. It should be noted that the qanats with high discharge are fed directly by Bam fault. Fortunately, dry years do not affect these Qanats' discharge much. The considerable amount of water in the qanats of Bam has not necessitated a precise and complicated water division system to ration water among the farmers as seen in the other arid regions of Iran. That is why the productive-social structures in the region are different from that of the central plateau of Iran.



9 The impact of the earthquake on Bam

The earthquake of 2003 caused blockage and collapse in a number of Qanats in Bam, and on the other hand the discharge increased in some others. Blockage in some qanats caused water to seep into other qanats like Ghasem-Abad Baravet. Some qanats have already been reconstructed and some others were repaired later. Repair and restoration of qanats running underneath houses were put off until the debris was removed. The earthquake has affected qanats in Bam, mainly on the following dimensions:

Structural deviations: In the past, qanat blockage was removed by moqanis, removing collapsed soil by shovel and bucket to the surface. But after the earthquake machinery was used to remove the obstructions. The relatively shallow qanats of Bam made it possible to dig open some parts of gallery like an open trench in order to remove blockages. The open trench is not necessarily dug just in the same direction as that of the relevant underground gallery, but the earth surface features dictate where to dig the trench. That is why there occurred some dramatic changes in the traditional direction of qanats such as the Abbas Abad qanat. It is, however sometimes necessary to dig a bypass to divert the tunnel altogether. It might be possible to remove all the soil on the surface of tunnel and turn the tunnel to an open deep ditch.

The ditch may have to be covered by concrete and the trench filled up to the surface. In some cases unskilled workers may cause problems. For instance, some 120 meters of canal was dug for Ghanbar- Abad Sheikhi qanat at a place named Bagh-Abbas-Khan Ameri, in order to unblock the tunnel. The new section was dug one meter higher than the original tunnel at the very beginning. Water sat back along the gallery, causing collapse of the ceiling and walls. Considering the topographic conditions of the area, bulldozers cannot be used in some spots. Therefore traditional tools must be used.

There is a case of the repair of another qanat worth considering. The costs of reconstruction of qanats of Baravat, have been proportioned among owners based on an eight-day cycle of 192 hours. In 2005, the water right of this qanat was estimated to be around two million Tomans or 2212 USD per hour of water use. The earthquake caused considerable collapses and blockages along the gallery of this qanat. Clearing of debris and unblocking the tunnel started after the earthquake. The work started by digging a ten meter deep trench from the point of water appearance along a stretch of 100 meters towards the first shaft.

Yazdi professional moqanis continued the task, passing 4 shafts up to the building of Bam City Council. Then another collapse was encountered near the city water reservoir. This blockage had occurred in two successive spots in the distance between the two shafts. Diggers dug another well in the middle, excavated and brought up the soil from both sides. No other collapse was there until Golestan Ice-House, where more blockages were cleared. Eight shafts from this point to the wet zone needed repair before the reconstruction was completed. Avaz Karimi was the contractor of the repair supervised by Haj Hassan Shayan who is one of the share-holders, the representative of qanat owners.

Managerial changes: All qanats had a Board of Trustees to supervise management and the traditional water distribution system prior to the earthquake. For example, Gholam-Reza Biglari had been head of the Board of Ghanbar-Abad Sheikhi qanat, keeping records and documents some of which were lost in the earthquake. Agriculture Organization suddenly became the custodian of the qanats after the earthquake. This sudden change of management created confusion and insufficiencies which require more evaluation.

Labor costs for repair of qanats increased because of an immediate high demand for moqanis and workers. Avaz Karimi, for example, receives 20,000 Tomans (approximately 904 Tomans being 1 USD, in 2005) for unblocking one meter of gallery, for all costs including workers wage. Workers digging into and drilling into rocks receive 12,000 Tomans a day, the one who collects mud in wet zones receives 7,000, those who drag the buckets of mud and soil along the tunnel to the bottom of the well to be lifted up receive 5,000 Tomans, workers pulling up the buckets by tractors are paid 20,000 and those who grabs and empties buckets on the surface receive 7,000 Tomans of wage per day. At the time of our field work in December 2004, qanats reconstruction, repair and restoration cost between 75,000 to 500,000 Tomans (85-572 USD) for every 175cm of tunnel digging, depending on soil hardness.

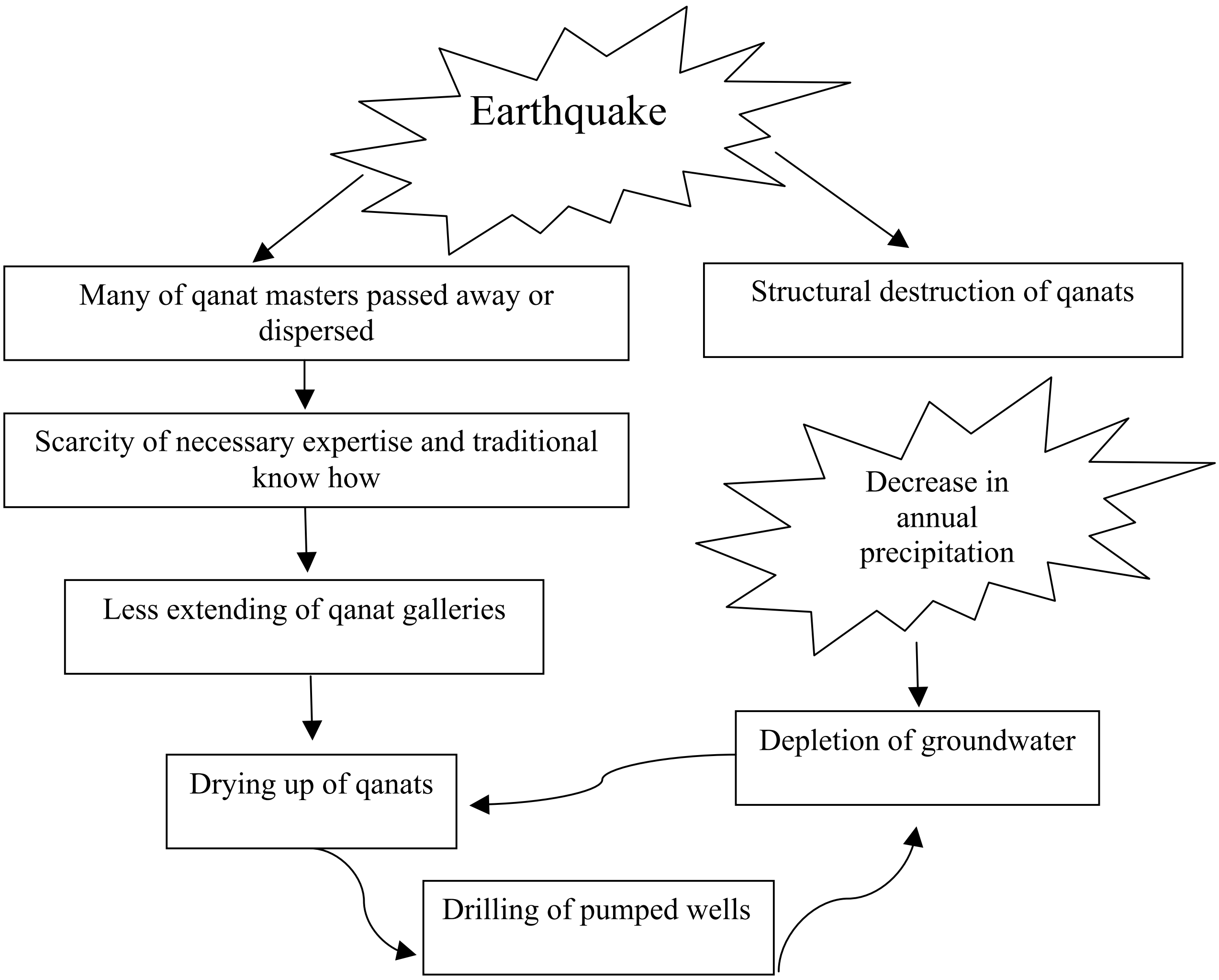
One of the indirect impacts of the earthquake was associated with the efforts of government and NGOs in Bam to restore blocked qanats, which led to some changes in technique, technologies, tools and equipment used in qanats. Even, the traditional measurement unit of "baqal" (about 175 cm) which was once used for measuring the length in qanats was changed to the metric unit of meter.

10 Conclusion

Bam is a suitable area for digging qanats because of its hydro-geological and topographical features. Water from qanats is not wasted in winter because cultivation is done throughout the year. As such, Bam can be considered a region of sustainable agriculture practice in arid and semi arid zones; due to its qanat system of water supply. Nevertheless the qanats in the Bam region are still suffering from the natural and social consequences of the earthquake, which do not bode well for the future of this ancient technology.

In Bam and Baravat, the main reason for the annihilation of qanats is groundwater depletion which has something to do with a considerable decrease in precipitation as well as a boom in pumped well drilling. In most cases, those qanats which are longer and whose water production section is relatively short are more subject to drying up, because groundwater evades their gallery easier.

The Ministry of agriculture has invested a large amount of money on the qanats that were about to dry up, by cleaning their gallery all the way or constructing concrete canals. Nevertheless those qanats dried up and all the energy and money invested was squandered. In a traditional context, it is normal for a qanat to lose a part of its discharge because of periodic decrease in annual precipitation. Annual precipitation in the Bam region has been estimated to be 60 millimeters on average, but it has dropped to some 10 millimeters over the past five years. Traditional response to such a decrease was to extend the qanat gallery into aquifer in order to keep the qanat discharge steady. Before the 2003 earthquake, it was normal for the qanat shareholders in Bam and Baravat to dig the gallery forward up to 200 meters a year. The long qanats like Zarch whose length exceeds 60 kilometers were not built at once in short time, but they were dug gradually in response to groundwater depletion. It seems that the earthquake has changed the traditional context, and the local people have lost their logical relationship with their environment. Most of the measures taken by the ministry of agriculture were focused on cleaning the galley and building concrete canals, and extending the qanat tunnel makes up less than 5 percent of their projects. As a result, groundwater depletion ended up in annihilation of qanats. So they sought an alternative means to make up for their qanats drying. According to the fair water distribution law of Iran, it is legal to replace a drying qanat by a pumped well. So the qanat owners resorted to drilling a well and abandoned their qanat which could still be refurbished by extending its gallery. Thus the pumped well flourished in the region drying up the qanats. The earthquake disturbed the social structure revolving around qanats. Many of the qanat masters passed away or dispersed in the wake of earthquake, and the scarcity of skilful manpower is something that aggravates the situation of this precious cultural and technical heritage.



Case study

Shushtar Historical Hydraulic System (Iran)

From the ICOMOS evaluation for the 33th World Heritage Committee Session, 2009

Basic data

State Party: Iran (Islamic Republic of)
Location*: Khuzestan Province*
WH Listing*:* 2009 (WH property n° 1315)
Criteria*:* (i) (ii) (v)

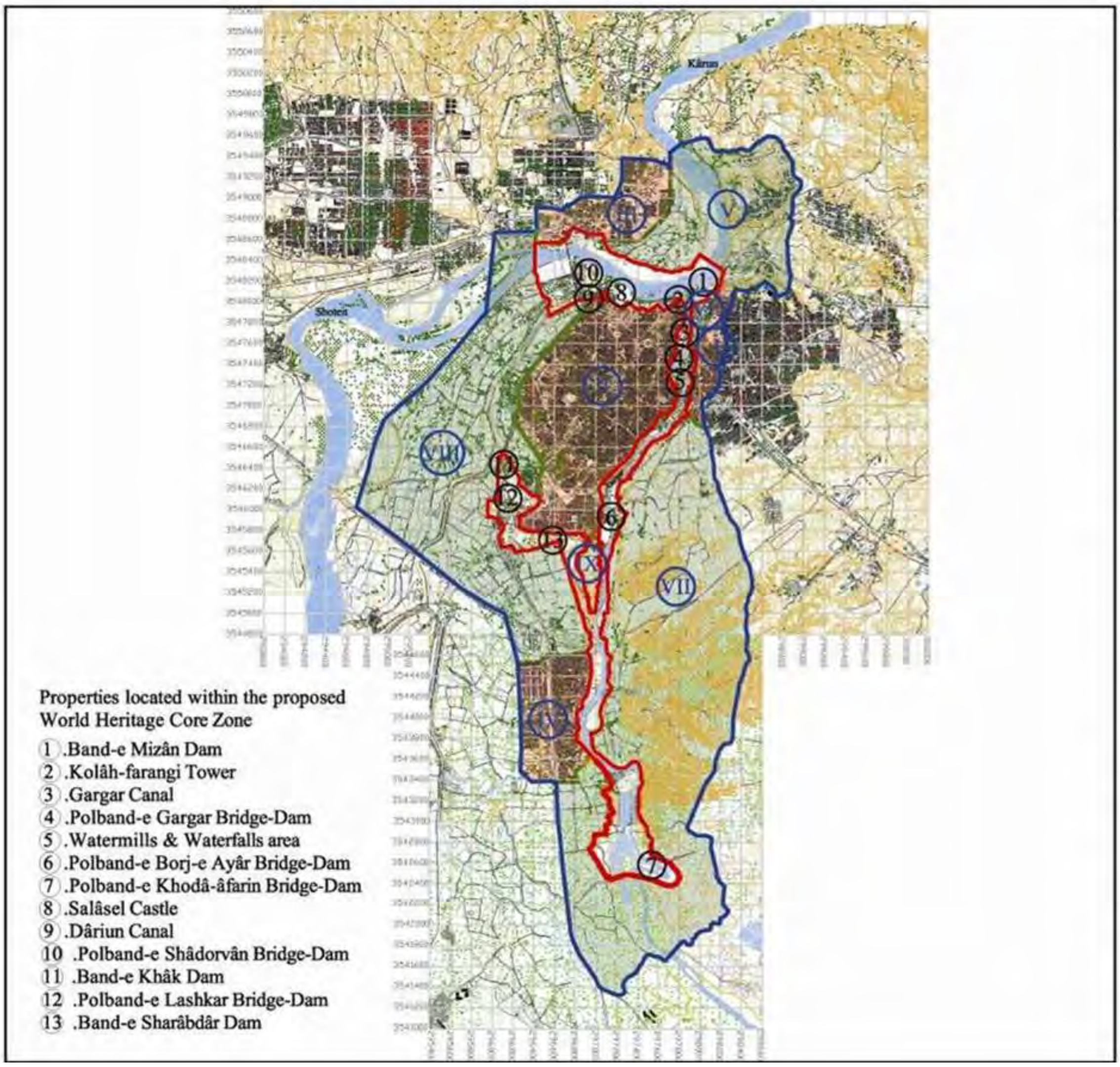


Figure 1. General map of the WH property, red line is for the core zone and blue line for the Buffer zone (nomination file, SP of Iran, ICHHTO)

Description of the property

The Shushtar Historical Hydraulic System (SHHS) comprises a vast ensemble of flow control structures, canals, some of which are dug into the rock, and numerous water uses, which form a perfectly coherent ensemble. Its installation required major civil engineering works, based on the design of a global water system established in ancient times. It provided the material bases for the economic and social development of a human community for many centuries from irrigated agriculture, fish farming, water mills, town water supply, the role of the ditches in the town's defence system, and navigation. The Gargar canal hydraulic system is still in use; only remains of the older Dâriun system are left, but it was partially rebuilt in the 20th century to maintain its function for irrigation.

The initial project involved controlling the powerful river Kârun with the Shâdorvân weir-dam, which raised and stabilised the water level by forming an impounding reservoir. It was then possible to divert a significant part of the river's water to the Dâriun canal via tunnels, and to the Gargar canal, under the control of the monumental Mizân water intake at the exit from a bend in the river Kârun. The Gargar forms a veritable artificial river, diverted from the main Kârun River.

Figure 2. The eye-bird view of the historical hydraulic system derived from the Kârun River and through the city of Shustar (nomination file, SP of Iran, ICHHTO)

The Gargar canal first crosses the rocky bank adjacent to the city of Shushtar. After a further flow control dam, it continues downstream via a series of tunnels that operate mills and supply water to the city. The site forms a spectacular cliff and the water falls in cascades into the downstream basin. The Gargar canal then enters the plain south of the city, at the foot of the mountains, where for almost two millennia its water enabled the planting of orchards and fertile farmland called the Mianâb (literally 'The Paradise'), which covers approximately 40,000ha.

The nominated property forms a continuous territory along the various waterways, the river itself, and the canals. It extends to the north and to the west at the centre and the south of the city of Shushtar. Today it includes an ensemble of remarkable sites, hydraulic structures, and monuments.

Figure 3. An impressive Gargar dam view during a flood at the outlet of a series artificial tunnels (nomination file, SP of Iran, ICHHTO)

History and development, intangible attributes

The first confirmed water irrigation systems from canals in the region date back to the Elamite civilisation, notably in the 13th century BCE. They were probably influenced by the large-scale irrigation work undertaken in Mesopotamia by the Sumerians from the 4^{th} millennium BCE.

Darius the Great, the Achaemenid king from the start of the 5th century BCE, had the Elamite irrigation systems repaired, and he is attributed with the creation of the Dâriun canal, to the west of the current site of Shushtar. Archaeological remains near the canal would tend to confirm this.

Roman civil engineering influence would seem to be borne out by certain aspects of the hydraulic system installed at the time. It is also probable that the hydraulic works in Petra carried out by the Nabateans in the 1st century CE influenced the project to divert a river in a rocky site using a dam and boring a tunnel. The construction of the large Shâdorvân weir dammed and provided a passage across the river Kârun. The second Sassanid emperor, Shapur, in the middle of the 3rd century CE, performed this audacious construction.

With the addition of the monumental Mizân water intake upstream from Shâdorvân and the Gargar canal, the hydraulic ensemble as then reworked and extended was designed to supply water to the new city of Tustar, later called Chouster or Shushtar, and to irrigate the vast semidesert plain to the south, along the last of the mountain foothills, for the systematic development of agriculture, notably the planting of orchards.

During the Islamic period, the various Iranian dynasties carefully maintained the Shushtar Hydraulic System as an essential component in the country's development. They carried out significant maintenance work, and sometimes additional work, such as during the Safavid (1500–1700) and then the Qadjar (1779–1925) dynasties for the Gargar bridge-dam and the Shâdorvân Grand Weir.

Figure 4. Mizân water intake dam at the entrance of the artificial Gargar River (nomination file, SP of Iran, ICHHTO)

Outstanding Universal Value

Justification
Shushtar, Historical Hydraulic System, inscribed as a masterpiece of creative genius, can be traced back to Darius the Great in the 5th century B.C. It involved the creation of two main diversion canals on the river Kârun one of which, Gargar canal, is still in use providing water to the city of Shushtar via a series of tunnels that supply water to mills. It forms a spectacular cliff from which water cascades into a downstream basin. It then enters the plain situated south of the city where it has enabled the planting of orchards and farming over an area of 40,000 ha. known as Mianâb (Paradise). The property has an ensemble of remarkable sites including the Salâsel Castel, the operation centre of the entire hydraulic system, the tower where the water level is measured, damns, bridges, basins and mills. It bears witness to the know-how of the Elamites and Mesopotamians as well as more recent Nabatean expertise and Roman building influence.

Criterion (i)
The Shushtar Hydraulic System is testimony to a remarkably accomplished and early overall vision of the possibilities afforded by diversion canals and large weir-dams for land development. It was designed and completed in the 3rd century CE for sustainable operation and is still in use today. It is a unique and exceptional ensemble in terms of its technical diversity and its completeness that testifies to the human creative genius.

Criterion (ii)
The Shushtar Historical Hydraulic System is a synthesis of diverse techniques brought together to form a remarkably complete and large-scale ensemble. It has benefited from the ancient expertise of the Elamites and Mesopotamians in canal irrigation, and then that of the Nabateans; Roman technicians also influenced its construction. Its many visitors marvelled at it and were in turn inspired. It testifies to the exchange of considerable influences in hydraulic engineering and its application throughout antiquity and the Islamic period under the various Iranian dynasties.

Criterion (v)
Shushtar is a unique and exceptionally complete example of hydraulic techniques developed during ancient times to aid the occupation of semi-desert lands. By diverting a river flowing down the mountains, using large-scale civil engineering structures and the creation of canals, it made possible multiple uses for the water across a vast territory: urban water supply, agricultural irrigation, fish farming, mills, transport, defence system, etc. It testifies to a technical culture dating back eighteen centuries serving the sustainable development of a human society, in harmony with its natural and urban environment.

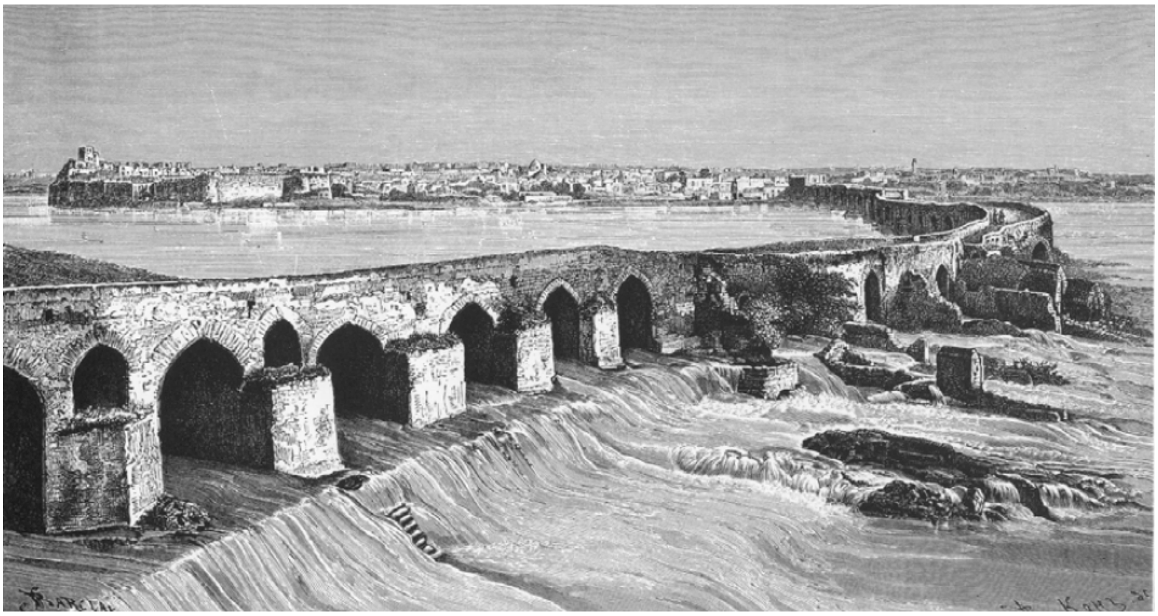


Figure 5. Bridge-dam of Shâdorvân in 1880s, (Dieu la Foie and from the nomination file, SP of Iran)

Authenticity- integrity

The hydraulic functional integrity is maintained through the use of the Mizân water intake, which diverts part of the river Kârun to feed the Gargar canal. Still in use, it continues to fulfil the role of town water supply (4, 5) and irrigation for the plain downstream from Shushtar.

Among the historic structures, the Mizân dam intake (1) and the nearby Gargar bridge-dam (4), with its tunnels, are still in use; they have retained their original function, at the cost of more or less extensive modifications. The other structures are today monumental testimonies or sometimes mere archaeological remains, notably the Shâdorvân weir-dam, which was the masterpiece of the project in ancient times.

In addition to changes due to the passage of time or sometimes abandonment, the component parts of the property have undergone alteration to their original built structure in several important places. Otherwise, the maintenance of the structures over the centuries has been carried out with due respect for the initial constructions, with similar materials and binders and using construction traditions that have persisted throughout its long history. Nonetheless, most of the hydraulic structures have not been maintained for many years, in some cases since ancient times, nor have they been restored using modern technical techniques, which contributes to their authenticity as remains, although they no longer have any functional purpose.

Comparative analysis

The Shushtar Historical Hydraulic System appears to be comparable with the best hydraulic engineering achievements of antiquity, by diverting a river and creating an artificial river, and by a remarkable and diversified ensemble of technical structures. It is a very complete overall system, endowed with all the functions associated with the simultaneous control of water and the land. In this respect, it is exceptional. It is one of the most extensive still conserved, and it is one of the rare hydraulic systems of ancient times still in use. It also provides an important example of the meeting of hydraulic techniques linked to Mesopotamian antiquity, and more broadly to the Middle East and those of the Roman world. Among the many hydraulic systems dating from the ancient and medieval periods, Shushtar is one of the most complete and one of the most important.

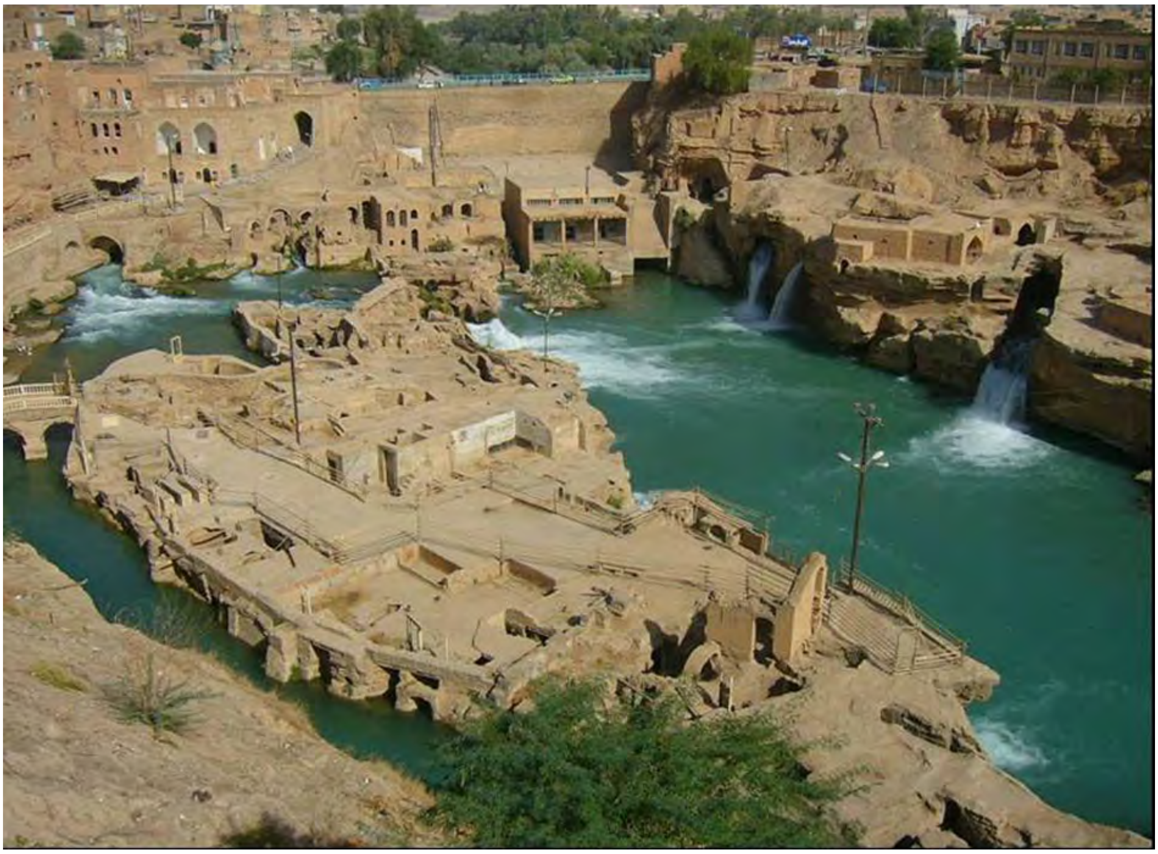


Figure 6. Gargar Dam and the areas of mills (nomination file, SP of Iran, ICHHTO)

Threats

Development

The development of automobile traffic directly affects the Mizân and Gargar dams, which are also used as bridges. There are plans to limit traffic. A road has been built in the city on the western bank of the canal. The very friable sandstone of the canal banks is affected long-term by chemical pollution in the air and water.

The surroundings of the property have often been altered by rapid urban growth, in the form of constructions that are inappropriate in terms of their form and the materials used. Modern bridges have also been built over the canals and roads near the property, made necessary by urban growth.

Visitors – Tourism

Tourism generally does not pose a problem for the property.

Environmental pressures

The river Kârun has already reduced the Shâdorvân weir-dam to a ruined state. The Mizân water intake dam and its dyke, through to the Kolâh- Farangi tower included, are particularly exposed to erosion by the river over time.

At times, plants may colonise the dam structures and some species can alter the canal's natural banks. More particularly, in the urban zone of the Gargar canal and in the mill zone, the natural cliffs reveal areas subject to erosion, which could collapse.

Climate change
Climate change could increase the level and frequency of the river Kârun's high water.

Figure 7. Bridge-dam of Lashkar (nomination file, SP of Iran, ICHHTO)

Protection and management

Legal provision
The Islamic Republic of Iran owns the property nominated for inscription with the exception of the private dwellings included in the property and the South Garagar ponds.
The thirteen monumental elements or remarkable sites of the nominated property are inscribed on the National Heritage List, in accordance with the Conservation of Monument and National Sites Act (1930). The property and its buffer zone also come under a series of the State Party's general laws (Civil Code, Islamic Penal Code, National Economy Act, Public Land Development Act, National Security Decree, and Five-Year Development Plan). It also falls under texts specifically dealing with the protection of cultural heritage.

Conservation and management
The issue of the conservation of the property looks like appropriately raised. However, particular attention needs to be paid to consolidating the archaeological remains, monitoring and studying the underground elements, and renovating the old houses linked to the property and its landscapes.
The Iran Cultural Heritage, Handicrafts and Tourism Organisation (ICHHTO), the Municipality of Shushtar, and religious organisations do public management of the property jointly. All the plans and programmes concerning the property nominated for inscription must be approved by the ICHHTO Technical High Council. At the executive level, ICHHTO appoints a director in charge of the database and the implementation of the Conservation Plan. This executive body is called the SHHS.

Documentation

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- "Shushtar New Town, Iran", *Mimar* (17), Concept Media, Singapore, 1985. p. 49-53.
- Viollet, P.-L., *L'hydraulique dans les civilisations anciennes*, Presses de l'ENPC, Paris, 2004, trad. : *Water Engineering in Ancient Civilizations*, Madrid, 2007.
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- Documentation UNESCO http://whc.unesco.org/en/list/1315


Figure 8. Ponds and fisheries along the South Gargar River (nomination file, SP of Iran, ICHHTO)

Conclusion

Prof. Michel Cotte

This first edition of an ICOMOS thematic study on **"The cultural heritages of water in the Middle East and Maghreb"** has benefited from the participation of numerous researchers and professionals working in the combined field of water and heritage, and also in archaeology, history, civil engineering and anthropology. All of them have demonstrated great commitment, and deserve our warmest thanks, particularly as it is always a little problematic and time-consuming working in different locations, with no opportunity to meet face-to-face. Furthermore, it is not easy finding colleagues ready to spend time on this kind of topic, as it is almost impossible (apart from exceptional cases) to find water heritage specialists able to span the various scientific and cultural dimensions of the subject. Almost all the authors work in a related field, and have thus made a special effort to take on board what may be described as a new type of heritage that is resolutely multi-disciplinary. The different tones and emphases from the various authors clearly illustrate the diversity of the fields considered.

Finally, the idea for the group and the search for people with the necessary competencies, followed by the constitution of the network and its coordination, have been carried out largely thanks to the international secretariat of ICOMOS, and Ms Regina Durighello in particular. We would like to thank her on behalf of all the authors.

We use the term "first edition" because texts have been brought together for the first time on a specific and clearly demarcated subject (water heritage)[1], that is however huge in scope; and we hope, before we finalise the definitive printed edition, to obtain complementary material. It is also a first edition in the sense that we are hoping to continue these regional approaches to water heritage in various parts of the world.

The first result (and perhaps the most important one) is the passionate interest in the subject taken by those confronted by water heritage: from the catchment of water to its storage, its material management and its symbolic values, and to the history of its uses and its legends. This is a major cultural heritage bequeathed by the civilisations of the past, particularly those sustainably and largely established on territories where water was in short supply, as is often the case in the Arab-Islamic world.

This heritage issue is very directly linked to the concerns of today, particularly those related to "sustainable development." Several of the texts in this thematic study throw light on to the continuity between past and present, and on to the history of breaks with the past that are sometimes extremely brutal. Technical means that are apparently simple, but whose uses have been refined by centuries of practical experience, have enabled many successive generations to live in harmony with their natural environment. Over recent times, and particularly since the oil boom, a series of factors have combined to exponentially increase the difficulties faced in the field of water and its uses: population growth, an increase in needs linked to changing lifestyles, the increase in consumption for agricultural purposes, the impact of climate change, and so on.

[1] We have not however forgotten, and are delighted to mention, the general work on water heritage edited by our colleagues from ICOMOS Netherlands: Willem J.H. Willems & Henk P.J. van Schaik (eds.), *Water and Heritage - Material, conceptual and spiritual connections*, Sidestone Press, Leiden, 2015.

As often happens in the history of techniques, the search for innovations and new solutions has caused a revolution that has changed the existing heritage in an exceptionally powerful and rapid way. As a result of pressure from the development of human societies, traditional hydraulic facilities have undergone changes that can be very broadly divided into three categories:

- the rebuilding and complete reformatting of existing systems by the use of mechanical and industrial technology, sometimes on a very large scale;
- adaptation and small-scale conversion, particularly in regions that are somewhat isolated or have no major technical facilities, or when the hydraulic facilities' intrinsic heritage value has been recognised and deliberately preserved;
- pure and simple abandonment in favour of new supplies (exploitation of deep fossil groundwater systems, desalination of sea water, long-distance transport of water).

In each of the three cases, "heritage" is generated, but they are very different types of heritage, both in terms of their tangible components (water objects and systems) and their social and intangible components (organisation of society and its new values in water use).

Many of our authors have focused on the description of the most ancient, emblematic and instructive heritage consisting of historic technical systems used for the catchment, management and use of water, and this is of fundamental importance. The study clearly shows that their state of conservation is only really satisfactory if the hydraulic systems are still in use, which means that adaptations are necessary, or sometimes, but rarely, a more or less powerful will to preserve the heritage and its traditions. Today, the authors are interested in providing us with examples of water heritage that is sustainable, over a period of several centuries or even millennia. This is a value in itself, of course, but also provides a fundamental cultural reference when it comes to the modern development of fresh water production and its uses in arid or semi-arid regions.

Other characteristics have emerged from this study that will need to be refined, if possibly collectively with the group of authors of this work, and we hope it will be possible to organise shortly a symposium on the cultural heritage of water in the Middle East and Maghreb. Note for example the continuing existence and the very widespread existence of underground water catchment systems at the foot of a hill, which have led to many oases and fertilised plains. The name changes depending on the region: *falaj* in Oman and in the Persian Gulf, *qanat* in Iran and *foggara* in the western part of the Maghreb, etc., but not the technical conception and the general architecture, which are the same. Although it is not always easy to trace their origins back to a specific date, the age of systems of this type is usually counted in centuries. The strong and long-established cultural unity of the region has favoured the spread of proven technical models. The knowhow required for maintaining the systems still exists in several of these countries. What is of course more fragile and has often disappeared, generally to be replaced by modern mechanical means (mechanical pumps, valves and pipes, etc.), are the ancient hydraulic devices: animal power for wells, norias, etc. Today these devices are studied more in the history of technology rather than as heritage, but reconstitutions make it possible to bring this past knowhow back to life for educational purposes. Another lesson learnt from the study is that abandoning this heritage for whatever reason (weakening of water table, natural accident, technical change, impact of a war, etc.), leads to a situation of non-use after which the heritage is very quickly transformed into archaeological vestiges, which are sometimes buried by desert sand. Still another, finally, is to show us the presence of a great deal of water heritage in towns and villages.

We hope that this volume will help to raise awareness of the importance of this heritage and what is at stake here. Some of the heritage is on a very large scale, and clearly has significance as a monument, while other heritage has vernacular and repetitive aspects. From the World Heritage viewpoint, some of the properties have received recognition, and others will doubtless do so over the coming years, but two other points are crystal-clear: 1) the necessity of reconsidering the importance of the attributes of water heritage, both tangible and intangible, in its contribution to the Outstanding Universal Value of properties already inscribed on the List; 2) a growing awareness of the presence of a huge vernacular water heritage, which is either unrecognised or insufficiently recognised, and which is therefore in an extremely fragile situation if nothing is done to take it into consideration.

Conclusion

Pr. Michel Cotte

Cette première édition d'une étude thématique de l'ICOMOS sur le sujet : « **Les patrimoines culturels de l'eau au Moyen-Orient et au Maghreb** », a bénéficié de la participation de nombreux chercheurs et professionnels dans le domaine conjugué de l'eau et du patrimoine, mais aussi de l'archéologie, de l'histoire, du génie civil ou encore de l'anthropologie. Tous se sont impliqués de belle manière et il faut les en remercier, d'autant qu'il est toujours un peu délicat, pour le moins long, de travailler à distance et sans avoir l'occasion de se rencontrer. Par ailleurs, il n'est pas facile de trouver des collègues prêts à consacrer du temps à un tel sujet, car il n'y a pas, à proprement parler ou de manière très exceptionnelle, de spécialistes des patrimoines de l'eau dans ses différentes dimensions scientifiques et culturelles ! Presque tous les auteurs sont venu d'un champ voisin et ont donc fait un effort envers ce qu'il convient d'appeler un nouveau type de patrimoine, à caractère résolument pluridisciplinaire. Les tonalités différentes et les accents mis par tel ou tel de nos auteurs montrent bien la diversité des champs abordés.

Enfin, l'idée de ce groupe et la recherche de personnes compétentes, puis sa constitution en réseau et sa coordination, doivent beaucoup au secrétariat international d'ICOMOS, à Mme Regina Durighello tout particulièrement. Nous la remercions au nom de tous les auteurs.

Nous parlons de première édition car il s'agit de textes rassemblés pour la première fois sur un sujet précis et bien délimité des patrimoines de l'eau[1], mais fort vaste ; et nous espérons, avant d'en fixer l'édition définitive imprimée, obtenir des compléments. Première édition aussi dans le sens où nous espérons poursuivre ces approches régionales des patrimoines de l'eau dans différentes parties du monde.

Le premier résultat, et peut être le plus important, est de constater combien la question des patrimoines de l'eau passionne ceux qui s'y confrontent, de sa captation à son stockage, de sa gestion matérielle à ses valeurs symboliques, ou encore de l'histoire de ses usages jusqu'à ses légendes. C'est un héritage culturel majeur légué par les civilisations du passé, notamment celles qui se sont durablement et largement installées sur des territoires où l'eau était rare, comme c'est tout particulièrement le cas dans l'espace du monde arabo-islamique.

Ce sujet patrimonial rejoint très directement les préoccupations d'aujourd'hui, en particulier celles dites du « développement durable ». Dans plusieurs des textes de cette étude thématique, la continuité entre passé et présent, mais aussi l'histoire de ruptures parfois très brutales, sont mises en lumière. Des moyens techniques apparemment simples, mais aux usages raffinés par des siècles de pratique, ont permis à de nombreuses générations successives de vivre en harmonie avec leur milieu naturel. Durant ces dernières années, notamment depuis le boom pétrolier, une série de facteurs se sont conjugués pour accroître de manière exponentielle la difficile question de l'eau et de ses usages : croissance démographique, augmentation des besoins liés au changement des modes de vie, accroissement des consommations agricoles, effets du changement climatique, etc.

Comme souvent dans l'histoire des techniques, la recherche d'innovations, de solutions nouvelles, est venue chambouler les données patrimoniales initiales, ici d'une manière exceptionnellement forte et

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[1] Nous n'oublions pas et citons avec un grand plaisir l'ouvrage général réalisé sur le sujet des patrimoines de l'eau par nos collègues d'ICOMOS Pays-Bas : Willem J.H. Willems et Henk P.J. van Schaik (éd.), *Water and Heritage, material, conceptual and spiritual connections*, Sidestone Press, Leiden, 2015.

rapide. Face à ces pressions du développement des sociétés humaines, le sort des installations hydrauliques traditionnelles a, en première approche, connu trois types d'évolution :

- la reconstruction et le reformatage en profondeur des systèmes existants par l'usage de moyens mécaniques et industriels, parfois à grande échelle ;
- l'adaptation et la reconversion artisanale, notamment dans des régions un peu isolées ou sans grandes moyens techniques ou bien quand leur valeur patrimoniale intrinsèque a été reconnue et volontairement préservée ;
- l'abandon pur et simple au profit des nouveaux approvisionnements (exploitation de nappes fossiles profondes, désalinisation des eaux de mer, transport de l'eau à grande distance).

Les trois cas sont générateurs de « patrimoines », mais de nature bien différente, tant dans leurs composantes matérielles (les objets et les réseaux de l'eau) que sociales et immatérielles (l'organisation de la société et ses nouvelles valeurs dans l'usage de l'eau).

Beaucoup de nos auteurs s'attachent, et c'est fondamental, à décrire les patrimoines les plus anciens, les plus emblématiques et les plus instructifs des systèmes techniques historiques visant à la captation, à la gestion et à l'usage de l'eau. L'étude montre clairement que leur état de conservation n'est vraiment satisfaisant que dans le cas d'ensembles hydrauliques encore en usage, ce qui signifie donc des adaptations ou parfois, mais c'est rare, une volonté plus ou moins affirmée de préserver un patrimoine et ses traditions. Leur intérêt, aujourd'hui, est de nous donner des exemples de patrimoines durables de l'eau, à l'échelle de plusieurs siècles, voire de millénaires. C'est une valeur en soi, bien entendu, mais aussi une référence culturelle fondamentale en face du développement moderne de la production d'eau douce et de ses usages en régions arides ou semi-arides.
D'autres caractéristiques se dégagent de cette étude, qu'il conviendra d'affiner, si possible collectivement avec le groupe des auteurs de cet ouvrage, en espérant pourvoir organiser prochainement un symposium sur le thème des patrimoines culturels de l'eau au Moyen-Orient et au Maghreb. Notons par exemple la permanence et la très large diffusion du captage souterrain de l'eau en piémont d'un relief, à l'origine de nombreuses oasis ou de plaines fertilisées. Le nom change suivant la région : *aflaj* en Oman et sur les bords du Golfe, *qanât* en Iran ou *foggara* dans la partie orientale du Magreb, etc., mais pas la conception technique et l'architecture générale qui sont les mêmes. Sans qu'il soit toujours facile de dater précisément leurs origines, l'ancienneté de tels systèmes se compte généralement en siècles ! La longue et forte unité culturelle de la région a favorisé la diffusion de modèles techniques éprouvés. Le savoir-faire lié à l'entretien de ces systèmes existe toujours, dans plusieurs de ces pays. Ce qui est bien entendu plus fragile et qui a souvent disparu, généralement remplacé par des moyens mécaniques modernes (pompes, vannes et tuyauteries mécaniques, etc.), ce sont les dispositifs hydrauliques anciens : la traction animale pour les puits, les norias, etc. Il s'agit plus aujourd'hui de sujets d'histoire des techniques que de patrimoine ; mais la voie des restitutions offre une possibilité de valorisation pédagogique de ces savoirs du passé. Un autre enseignement de cette étude est de constater que l'abandon de ces patrimoines, pour une raison donnée (affaiblissement de la nappe souterraine, accident naturel, changement technique, effet d'une guerre,…), conduit à une situation de non usage et à un basculement très rapide dans le vestige archéologique, parfois recouvert par les sables du désert. Un autre, enfin, est de nous montrer la présence de nombreux patrimoines de l'eau au sein des villes et des villages.

Espérons donc que cet ouvrage aidera à une prise de conscience de l'importance et des enjeux de ces patrimoines, parfois à grande échelle et aux aspects incontestablement monumentaux, parfois vernaculaires et répétitifs. Du point de vue du Patrimoine mondial, certains de ces biens sont reconnus, et d'autre le seront sans doute dans les années à venir, mais deux autres éléments se dégagent avec force : 1) la nécessité de reconsidérer l'importance des attributs du patrimoine de l'eau, tant matériels qu'immatériels, dans leur contribution à la Valeur Universelle Exceptionnelle de biens déjà inscrits sur la Liste ; 2) la prise de conscience de la présence d'un vaste patrimoine vernaculaire de l'eau, mais mal reconnu ou non reconnu, donc en situation de grande fragilité si rien est fait pour le prendre en considération.

Appendix 1 | Annexe 1

Cartographie introductive au thème des patrimoines culturels de l’eau dans les régions arides et sèches

Cartographie introductive au thème des patrimoines culturels de l'eau dans les régions arides et sèches

Sabrina Suaud

Cette étude est principalement centrée sur les zones situées dans les régions tropicales et subtropicales (approximativement de 20° à 40° de latitude). Nous envisageons tout d'abord les définitions climatiques et leurs critères, puis nous proposons une typologie et une cartographie introductive à l'étude thématique, enfin quelques références bibliographiques générales à propos des questions climatiques et des ressources en eau.

1 Définitions

Un climat aride se présente dans les régions où la faiblesse des précipitations limite le développement des organismes vivants. Celles-ci sont communément réunies sous le nom de "déserts" qui se situent pour la plupart dans des régions tropicales ou subtropicales. La pluviométrie annuelle peut atteindre 100 à 150 mm en moyenne et reste inférieure à la quantité d'eau évaporée où transpirée par les plantes (Evapotranspiration potentielle). Les précipitations sont réparties de manière saisonnière en averses. Les amplitudes thermiques diurnes y sont importantes, fréquemment de l'ordre de 35°.

Un climat de type semi-aride se définit par sa situation le plus souvent en zone subdésertique et la présence d'une longue saison sèche et d'une saison humide avec de faibles précipitations, entre 150 et 500 mm par an. Il peut être chaud ou froid. On l'appelle aussi climat de steppe. Ce climat permet la présence de certains types de cultures et l'herbe constitue un élément important de la végétation naturelle.

Un climat méditerranéen se caractérise par un rythme saisonnier avec un été chaud et sec d'une durée minimale de 3 mois et un hiver doux et humide. Les précipitations ont surtout lieu en automne et au printemps atteignant 400 à 800mm en moyenne annuelle. On le retrouve au nord du climat subtropical ainsi qu'au sud de la zone tempérée (zone tempérée chaude).

2 Les critères d'identification des zones climatiques arides et semi-arides

Plusieurs critères peuvent être choisis pour délimiter des espaces à caractère aride ou semi-aride.

Les précipitations : La quantité de pluie tombée constitue un facteur essentiel qui détermine en partie la présence de végétation mais elle ne peut constituer le seul facteur de délimitation des zones arides et semi-arides. Cette pluie peut s'évaporer plus ou moins rapidement après être tombée et elle peut rester plus ou moins longtemps à disposition des végétaux.

Les températures : La température est l'un des facteurs climatiques qui conditionne le plus le taux d'évapotranspiration. Il est donc indispensable de prendre en compte ce critère avec celui des précipitations pour parvenir à localiser les zones sèches.

Les indices : Il existe plusieurs types de classification des zones arides et semi-arides. Certaines peuvent se baser uniquement sur les facteurs climatiques cités précédemment comme celle de

Köppen-Geiger qui prend en compte trois critères ; le type de climat, le régime pluviométrique et les variations de températures. D'autres utilisent des indices comme celui de l'aridité de Martonne, l'indice d'humidité de Thornthwaite basé sur la quantité d'eau nécessaire aux plantes, ou encore celui utilisé par l'UNESCO (rapport Précipitation/Evapotranspiration). Ils permettent de définir en une formule les éléments du climat et certains se rapportent à une région limitée.

Les zones climatiques : Les zones climatiques peuvent se définir à plusieurs échelles en fonction de paramètres divers et variés. On distingue les climats généraux où zonaux, les climats régionaux ou macroclimats, les climats locaux ou méso-climats et enfin les microclimats.

- Les climats généraux où zonaux : ils dépendent de facteurs cosmiques et planétaires généraux comme la latitude ou la circulation de l'atmosphère. Ex. : zone intertropicale, zone tempérée...
- Les climats régionaux ou macroclimats : ils dépendent également de leur situation géographique mais ils se caractérisent surtout en fonction de facteurs géographiques plus localisés comme la proximité d'un océan ou l'influence d'une chaine de montagne.
- Les climats locaux ou méso-climats : ils se déterminent par la configuration géomorphologique locale (vallée, colline...) et par une situation à caractère particulier (zone d'étangs, agglomérations, massif boisé...)
- Les microclimats : il s'agit de données qui interviennent à plus petite échelle et qui dépendent de l'ensemble des caractères topographiques, édaphiques (type de sol) et biotiques (influence des être vivants sur leur milieu) propres à un site donné ou station.

Compte-tenu de notre échelle d'étude, nous délimiterons les zones arides et semi-arides en fonction des climats de type régionaux.

3 Proposition d'une typologie géo-climatique

Nous proposons donc la classification ci-dessous. Elle se base sur l'étude des facteurs climatiques précédemment cités à partir des travaux de Köppen Geiger, sur l'indice de l'aridité élaboré par l'Unesco, sur la répartition des formations végétales caractéristiques des climats arides et semi arides, ainsi que sur les éléments géographiques régionaux ayant une influence sur la présence de ces espaces.

Ainsi, le climat aride se caractérise par différents types de déserts dont la présence est conditionnée aussi bien par des éléments de climatologie générale (ex. : présence d'Anticyclones Subtropicaux) que par une situation géographique particulière (ex. : proximité des courants marins d'eau froide pour les déserts d'abri en région côtière).

Le climat semi-aride, quant à lui, regroupe des espaces définis par des facteurs climatiques et par le type de végétation en présence.

Cette classification intègre les éléments suivants :

Le climat aride, est marqué par la présence quasi permanente d'air sec, le plus souvent provoquée par les anticyclones, notamment subtropicaux, qui maintiennent une atmosphère à haute presque tout au long de l'année. Les zones nuageuses associées aux perturbations sont rares et la pluviométrie est faible, ne dépassant pas 150 mm par an. Suivant la nature des sols, la végétation est soit carrément absente, soit éparse, faite de plantes vivaces éphémères ou annuelles. Le mode de vie est le nomadisme pastoral à grande échelle, appuyé sur des puits et des oasis qui se regroupent le long de zones favorables contenant des nappes phréatiques accessibles.

Le climat aride lui-même se subdivise de la manière suivante :

- Les *déserts chauds* à caractère continental se situent en dehors de l'aire d'influence des sources principales de précipitation ; celles-ci peuvent être carrément absentes certaines années.
- Les *déserts à courte saison de pluies* ; ils entourent les grands déserts continentaux d'Afrique et d'Arabie ou bien ils sont au centre des régions propices au climat aride mais dans des zones moins continentales.
- Les *déserts à hivers froids* sont souvent en position d'abri, c'est à dire isolés des influences humides océaniques par des barrières montagneuses. Celles-ci agissent en provoquant des effets de foehn, qui assèchent et réchauffent les vents.
- Les *déserts côtiers* sont à la conjonction d'une vaste cellule anticyclonique, de courants froids côtiers et d'une remontée d'eau froide océanique profonde (upwelling). Les masses d'air abordant le continent sont ainsi refroidies et stables.

Les **climats semi-arides** ont une pluviométrie annuelle comprise entre 100-200 mm et 400-500 mm d'eau. En fonction des sols et des conditions hydrologiques et pluviométriques régionales, les couverts végétaux sont différents et ils forment deux groupes principaux :

- Les *steppes* ont une végétation clairsemée de graminées xérophiles vivaces ou annuelles.
- Les *savanes herbeuses ou arbustives* comprennent des formations denses de hautes herbes vivaces, ou d'arbustes.
- La *forêt tropicale sèche et claire* comportant un couvert végétal ouvert et assez élevé mais dont le sol est largement ensoleillé.

Un nomadisme de steppe est possible, d'échelle généralement plus réduite que dans les déserts, ainsi qu'un élevage intensif dans la savane ou la forêt tropicale sèche. Une agriculture pluviale est aussi possible, mais elle demeure aléatoire en raison de l'irrégularité de la pluviométrie d'une année sur l'autre.

Le climat méditerranéen ne fait en général pas l'objet d'une division en plusieurs espaces distincts du fait de ses caractéristiques déjà bien définies. On distingue toutefois suivant leur localisation :

- Les zones de *climat méditerranéen* présentes dans le sud des zones tempérées, comme le pourtour de la mer Méditerranée qui lui a donné son nom.
- Les *climats de type méditerranéen* situés en position intermédiaire entre le climat océanique et le climat de désert chaud.

Cartographie : Situation des zones climatiques sèches et arides dans les régions tropicales et subtropicales

Suaud Sabrina, décembre 2010

Carte 1 : Amérique du Sud

Climat aride

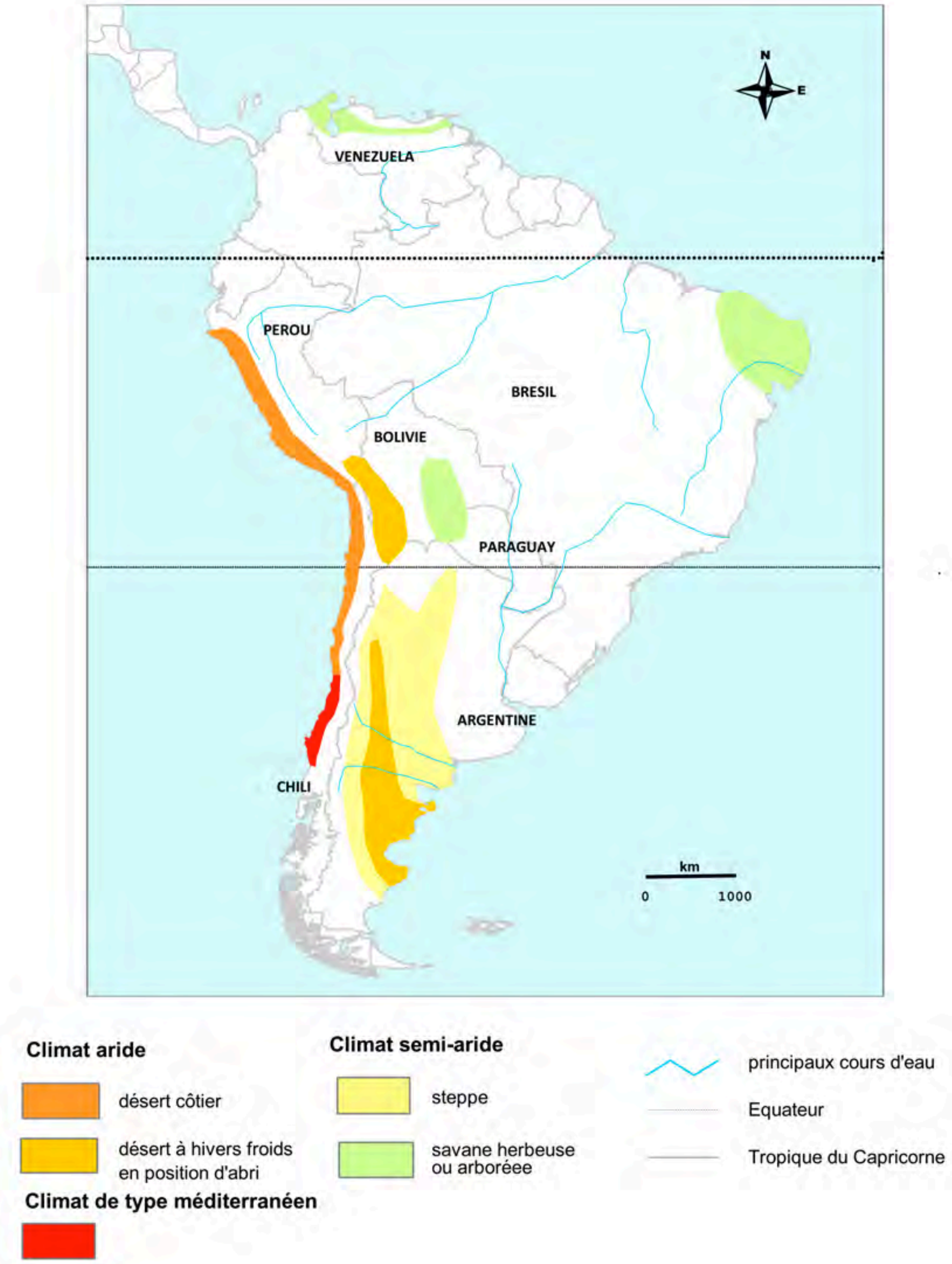
- désert à hiver froids, souvent en position d'abri : altiplano, Patagonie argentine
- désert côtier : chilo-péruvien et Atacama

Climat semi-aride

- steppe
- savane herbeuse ou arbustive (Chaco, Caatinga)

Climat Méditerranéen

- région autour de Santiago du Chili



Carte 2 : Amérique du Nord

Climat aride

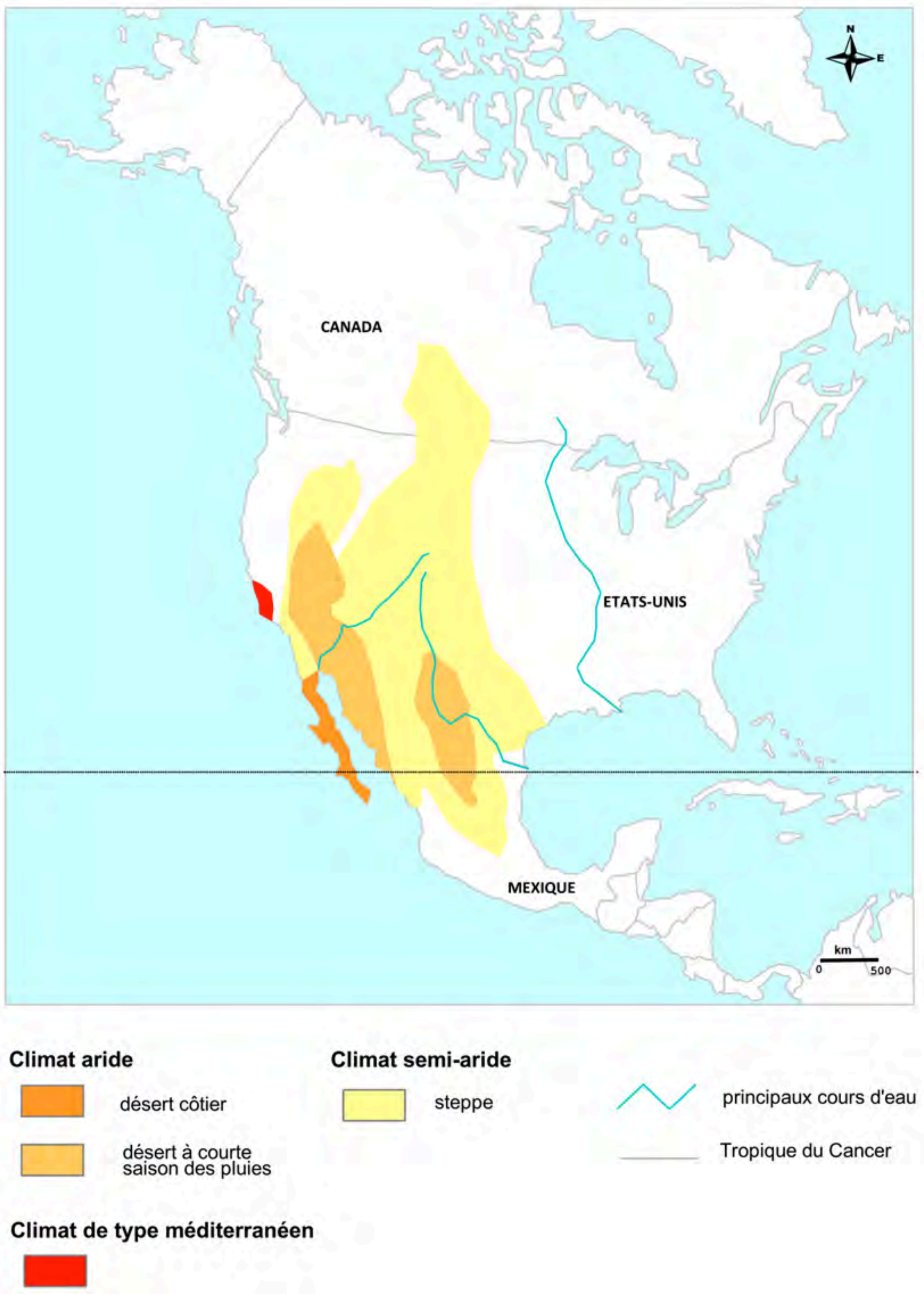
- désert côtier (Basse Californie)
- désert à hiver froid, souvent en position d'abri (Montagnes rocheuses nord-américaines)
- désert à courte saison des pluies (Grand Bassin, Mojaves, Sonora, Colorado)

Climat semi-aride

- steppe

Climat Méditerranéen

- Sud de San Francisco



Carte 3 : De l’Afrique sahélienne au monde méditerranéen

Climat aride

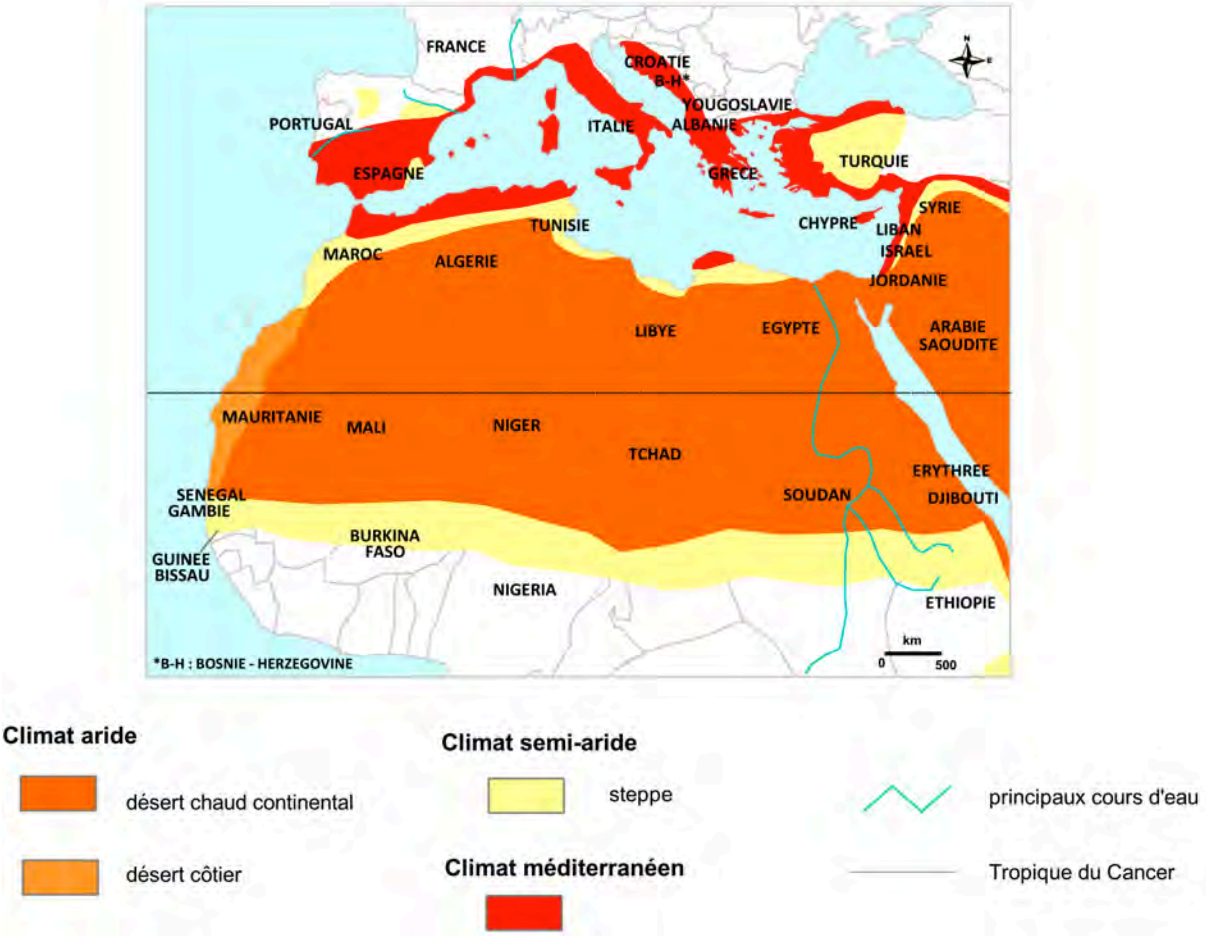
- désert chaud continental (Sahara)
- désert côtier (côte Sud Maroc)

Climat semi-aride

- steppe (Sahel, sud de l’Atlas, Almeria, Anatolie, Aragon)

Climat Méditerranéen

- pourtour Méditerranée : Maghreb, Espagne jusqu’au Sud d’Israël, Benghazi (Lybie)



Carte 4 : Afrique méridionale

Climat aride

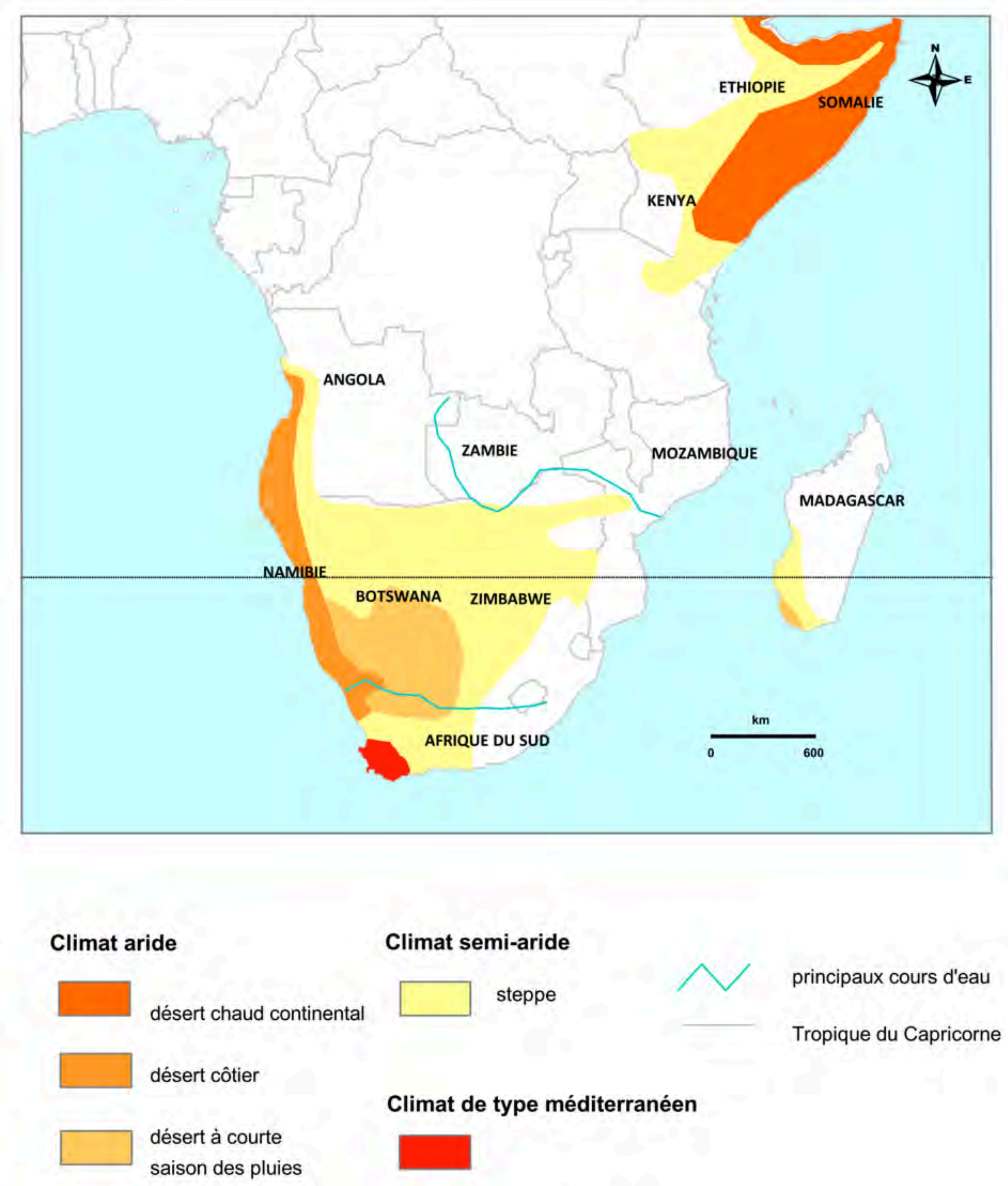
- désert côtier (Namib)
- désert à courte saison des pluies (Kalahari, l'extrême sud-ouest de Madagascar)

Climat semi-aride

- climat steppique (autour de la corne somalienne, sud-ouest Madagascar)

Climat Méditerranéen

- Afrique du Sud (autour du Cap)



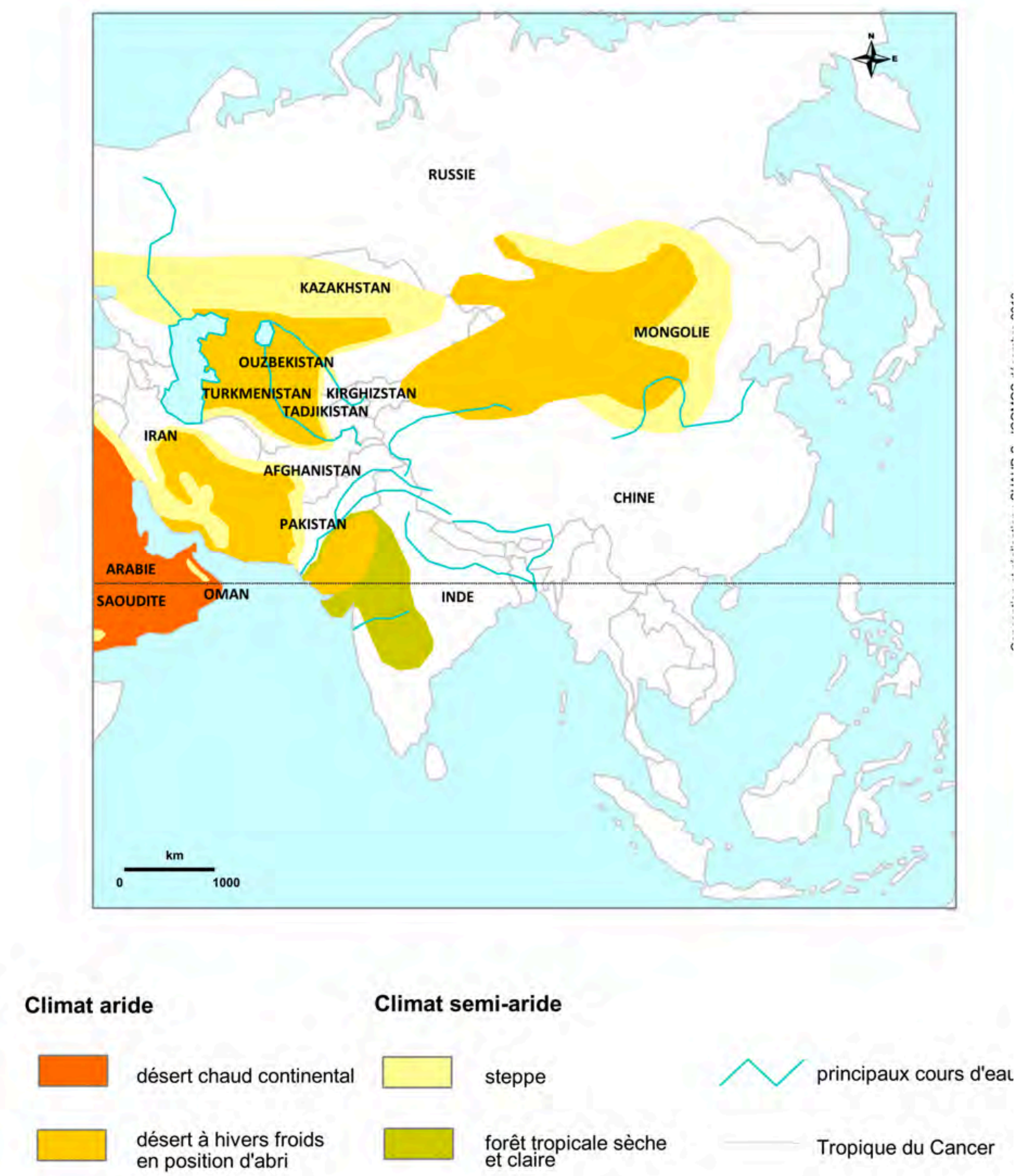
Carte 5 : Asie centrale et extrême-orientale

Climat aride

- désert à hiver froid souvent en position d'abri (Karakoum, Kizilkoum, Taklamakan (Bassin du Tarim), Gobi, Thar (Inde), plateau Afghan

Climat semi-aride

- steppe : nord du Caucase, steppes kazakhes et mongoles
- forêt sèche et claire : nord-ouest et une partie du centre de l'Inde



Carte 6 : Le Moyen-Orient

Climat aride

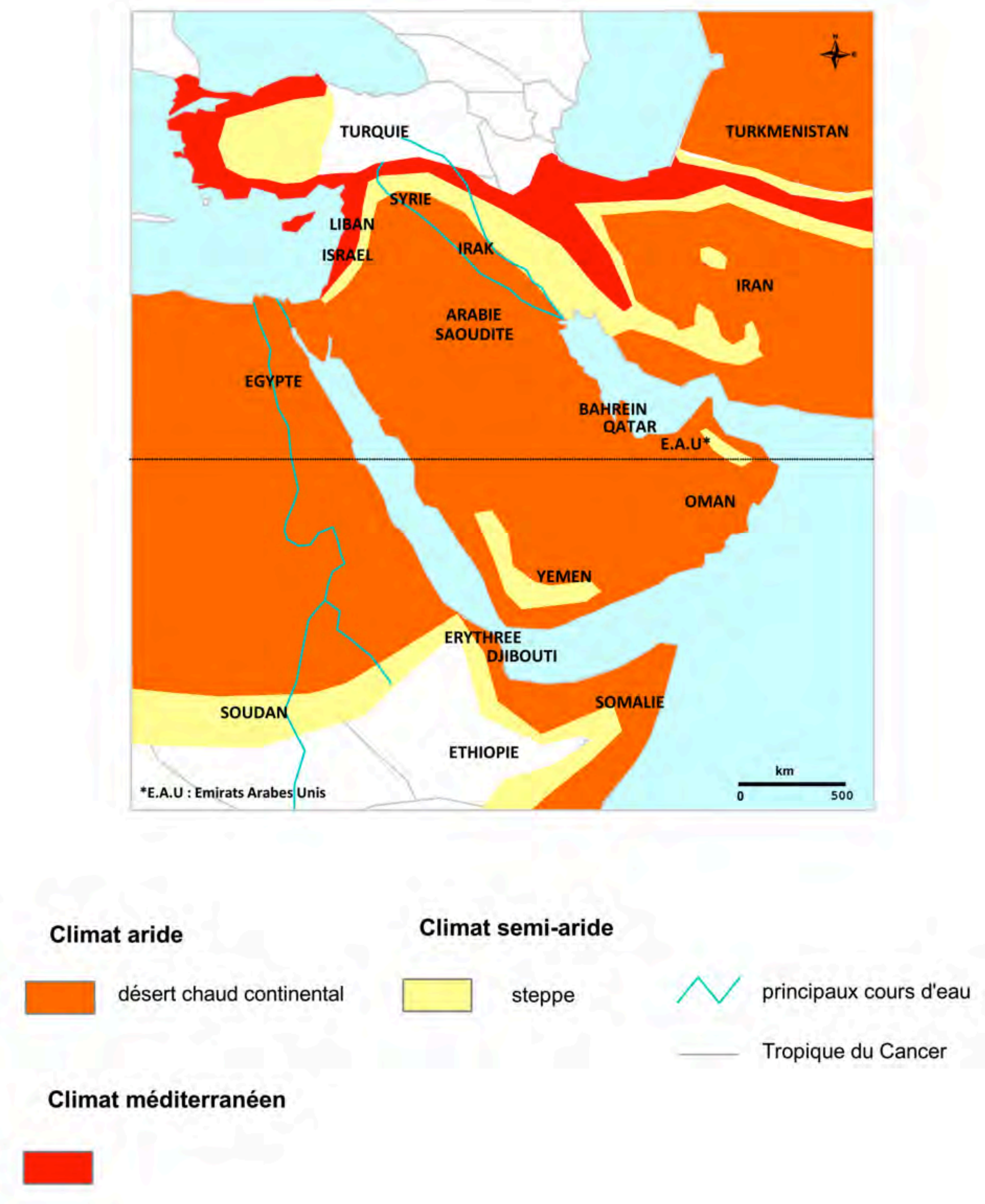
- désert chaud continental (désert de Lybie, péninsule Arabique)
- désert à hivers froids souvent en position d'abri (plateaux iraniens ou afghans)

Climat semi-aride

- climat steppique (Anatolie, nord péninsule Arabique, autour plateau d'Iran, nord Mer Noire)

Climat Méditerranéen

- côtes turques, Israël, Palestine, sud de la Caspienne



Carte 7 : L'Océanie

Climat aride

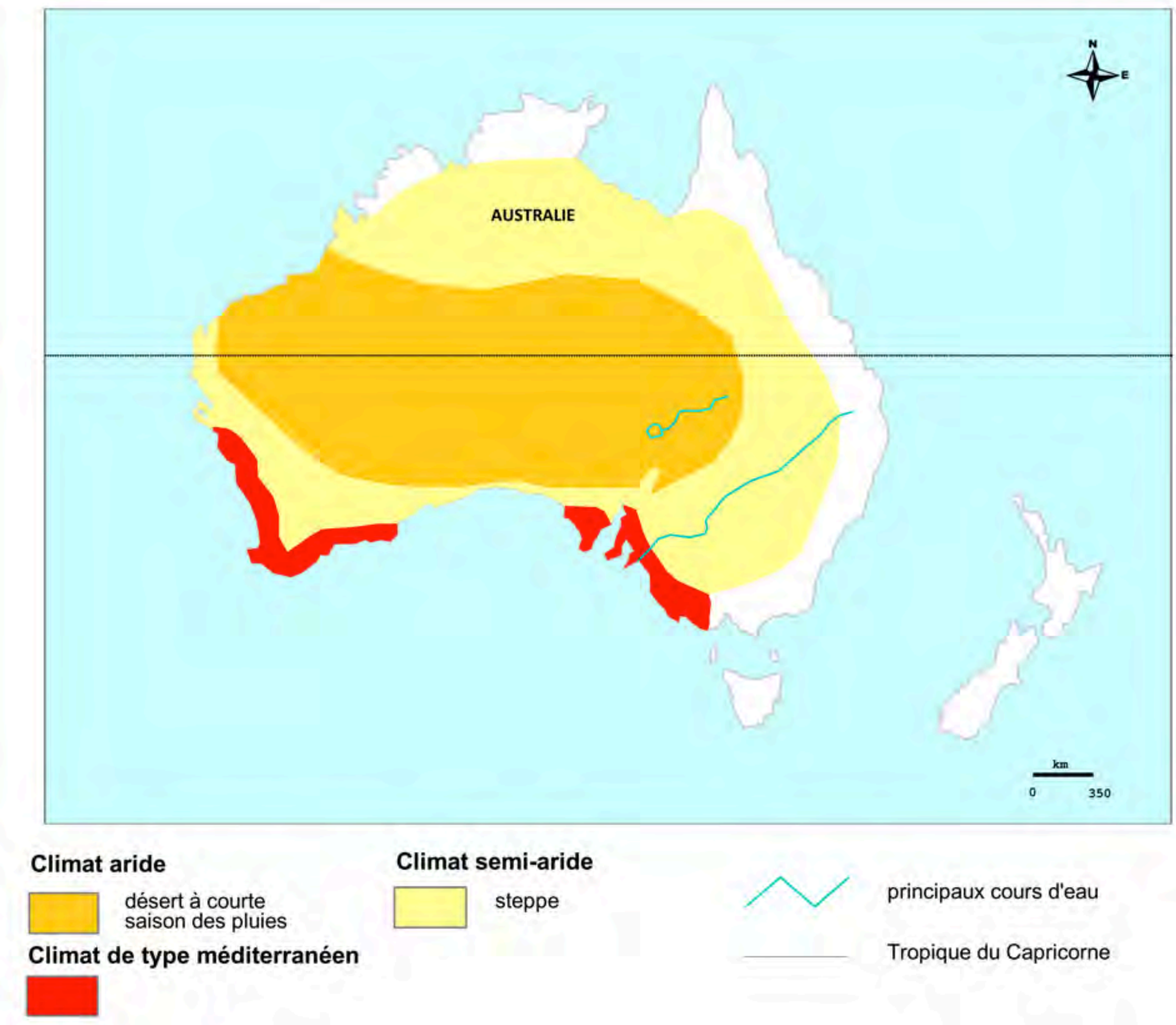
- désert à courte saison des pluies (centre de l'Australie)

Climat semi-aride

- steppe : autour du désert continental australien

Climat Méditerranéen

- région de Perth (SO Australie) et d'Adélaïde (SE de l'Australie)



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Appendix 2 | Annexe 2

Les patrimoines culturels de l'eau au Moyen-Orient et au Maghreb dans la Liste du patrimoine mondial et les listes indicatives

Les patrimoines culturels de l'eau au Moyen-Orient et au Maghreb

Cléménce Grimal, mars 2014

Country	Property	Status	Ref.	Criteria	Period	Evolving continuing heritage	Evolving relict heritage	Short description for properties on tentative list	Comments on inscribed properties
Algeria	Timgad	Inscribed in 1982	194	(ii) (iii) (iv)	AD 100	no	yes		The importance of baths is underlined in the all description. The **criterion (iv)** talks about "public conveniences" we could link to baths : "Criterion (iv): Timgad possesses a rich architectural inventory comprising numerous and diversified typologies, relating to the different historical stages of its construction: the defensive system, **buildings for the public conveniences** and spectacles, and a religious complex. Timgad illustrates a living image of Roman colonisation in North Africa over three centuries.".
Algeria	Djémila	Inscription in 1982	191	(iii) (iv)	96/98AD	no	yes		As all the Roman cities, water was brought to supply public buildings as baths : "They comprise private dwellings and public buildings such as the Arch of Caracalla (216), the Temple of Gens Septimia (229), a theatre with a capacity of 3,000 places, **baths**, basilicas and other cult buildings". But the OUV is not based on it.
Algeria	Tipasa	Inscription in 1982	193	(iii) (iv)	From the 6th century BC to the 6th century AD	no	yes		As all the Roman cities, water was brought to supply public buildings as baths : "Within this enclosure there are important buildings situated both in the original core of the city and in its new quarters: the forum, the curia, the capitolium, two temples, an amphitheatre, a nymphaeum, a theatre and **baths**." But the OUV is not based on it.
Algeria	Sites, lieux et itinéraires augustiniens du Maghreb central	Tentative list 30/12/2002	1773	(ii) (iii) (iv) (vi)	Roman Times	yes ?	yes	The Augustinian itinerary goes through Roman towns with baths in particular : example : "-Thagura (Taoura) vestiges romains sur 20 ha, **thermes**, basilique chrétienne et forteresse byzantine."	
Algeria	Les oasis à foggaras et les ksour du Grand Erg Occidental	Tentative list, 30/12/2002	1772	(ii) (iii) (iv) (v)	?	yes	no	**Oasis, wells. "**Les oasis à foggaras et les ksour du Grand Erg Occidental et de la vallée de la Saoura la stratification dans le temps de l'action anthropique a donné lieu à un modèle original d'implantation d'oasis où le cadre naturel et les interventions dues à l'homme concourent à la formation de l'écosystème."	
Algeria	Nedroma et les Trara	Tentative list, 30/12/2002	1774	(ii) (iii) (iv) (v)	12th century	yes	no	"C'est une ville étagée sur les flancs du djebel Filaoussène entre 400 et 500 m d'altitude sur un site verdoyant arrosé par **des sources d'eau importantes** où les maisons bleues, blanches, vertes et brunes forment un cadre enchanteur." => **a water management system may exist**.	
Algeria	Oued Souf	Tentative list, 30/12/2002	1775	(ii) (iii) (iv) (v)	?	yes	no	**Artificial oasis.** "Ensemble d'oasis unique implanté en plein erg imposant un mode particulier de mise en valeur (technique du Ghout) et un système de culture originale: les palmiers sont plantés directement au dessus de la nappe au fond de vastes **entonnoirs** creusés dans le sable. [...] L'existence des oasis s'avère une **création complètement artificielle** dont chaque pouce de terrain est directement disputé aux dunes."	
Algeria	Parc des Aurès avec les établissements oasiens des gorges du Rhoufi et d'El Kantara	Tentative list, 30/12/2002	1777	(ii) (iii) (iv) (v) (vii) (x)	?	yes	no	**Oasis with palm trees**.	
Bahrain	Qal'at al-Bahrain – Ancient Harbour and Capital of Dilmun	Inscription in 2005, minor modification in 2008	1192bis	(ii) (iii) (iv)	From 2300BC to the 16th century	no	yes		**Palm groves** (3rd century BC) surround the site showing the commande of water by this civilisation. It is mentioned in the Criterion (iv) : "The palaces of Dilmun are unique examples of public architecture of this culture, which had an impact on architecture in general in the region. The different fortifications are the best examples of defence works from the 3rd century B.C to the 16th century AD, all on one site. **The protected palm groves surrounding the site are an illustration of the typical landscape and agriculture of the region, since the 3rd century BC."**
Bahrain	Barbar Temple	Tentative list, 25/09/2011	1570	?	3rd and 2nd millenium BC	no	yes	The water management system is described : "From the central terrace a ceremonial stairway led to the subterranean shrine where water cult ceremonies took place. Halfway down the stair was a portal, and from there the stair was roofed. The rich natural spring which filled the **pool** probably accounts for the siting of the temple at Barbar. **Water poured from a perforated stone jar** beside a semicircular stone font at the threshold of a dry chamber near **the basin**. From the comers of the shrine deep stone built **channels led the water to the surrounding fields and gardens.**"	

Egypt	Raoudha nilometre in Cairo	Tentative list, 28/07/2003	1826	(i) (iv)	Antiquity ?	yes	yes	Egypt, the gift of the Nile Egypt would not exist without the river and its periodical flooding which regulated life, work in the fields, religious and civil feastdays. The banks flooded by the river when it was in spate were transformed into arable lands. Before the great modern dams were built, the average width of these banks varied between 100 m in Sudanese Nubia and 1000 m in Egypt. ar. The nilometre according to StraboStrabo (about 58 BC 21/25 AD) gave the following definition of a nilometre: "the nilometre is a well built of squarred stones in which are marks indicating the flooding of the Nile.	
Egypt	Abu Mena	Inscribed in 1979	90	(iv)	AD 296	no	yes		"Built in the 5th century to accommodate the increasing number of Christian pilgrims, the Thermal Basilica used to **store the curative waters used for the heated baths and pools surrounding the basilica.**" No information about criteria.
Egypt	Saint Catherine Area	Inscription in 2002	954	(i) (iii) (iv) (vi)	6th century	yes	no ?		The water system management is not expressed in the approved criteria but is described : "**A constant supply of fresh water is provided by the Fountain of Moses**, which taps an underground spring. The monks' cells are disposed along the inner faces of the walls. Outside the walls is the triangular monastery garden, created over many years by the monks, who brought soil here and made thanks to **store water for irrigation**. Adjoining the garden are the cemetery and charnel house."
Egypt	Southern and Smaller Oases, the Western Desert	Tentative list, 12/06/2003	1808	(vii) (viii) (ix) (x) ==> natural property	?	yes	no	The water management system makes **agriculture** possible : "This vegetation type is most pronounced around ditches, rice fields, **wells**, and in **drains and pools**." for example.	
Egypt	Oasis of Fayoum, hydraulic remains and ancient cultural landscapes	Tentative list, 28/07/2003	1830	(i) (iv) (v)	2nd millenium BC	no	yes	"The work was started by Senusert II (1872-1854) and completed by his grandson Amenemhat III (1853-1809); the Bahar Youssef was **channelled and a network of irrigation canals** was set up. […] Strabo in 24 BC described how the water of the Nile was channelled and distributed and already in his time the system had been greatly improved by the Ptolemies, who, in their turn, undertook **great drainage and further development works**.[...] Thanks to the works completed under the Mameluke Sultans in the XIIIth century then under Mohamed Ali in the XIXth century, the Fayoum became once more the "**garden of Egypt**"."	
Egypt	Wadi Feiran	Tentative list, 01/11/1994	195	?	5th century	no	yes ?	"It is an **oasis** with old monasteries between El-Banat monastery the old and hill El-Mhered and El-Tahona mount and all these remains date to 5th century during the Sinai meede of the many monks."	
Egypt	Two citadels in Sinai from the Saladin period (Al-Gundi and Phataoh's island)	Tentative list, 28/07/2003	1828	(iv) (vi)	12th century	?	?	"It was supplied with drinking water from the Ayn Sadr source which was at a distance of 5 km or through run-off waters (there was a **small dam** to the north) or through the **big cisterns dug in the ground**. The building material was basically limestone which was easy to work in the area and a kind of mortar, found near the run-off waters. [,,,] 3 **cisterns** [...] -a **hammam** with three rooms and a **water supply system** -"	
Egypt	The monasteries of the Arab Desert and Wadi Natrun	Tentative list, 28/07/2003	1827	(ii) (iv) (v)	3-4th century BC	no ?	yes ?	"Water supplied through an **underground canal** from the **monastery's well**."	
Egypt	The An-Nakhl fortress, a stage on the pilgrimage route to Mecca	Tentative list, 28/07/2003	1829	(iii) (iv) (vi)	From the 7th century to the 19th century	no	yes	"A **22 m canal** situated below the eastern tower brought water in from the outside towards Qalaa where **three underground reservoirs** had been dug to store the water. Other **cisterns** had been built outside for the pilgrims and their animals. It was **in use until the middle of the XIXth century**."	
Egypt	Newibah Castle	Tentative list, 01/11/1994	199	?	19th century	yes	no	"The castle includes a **shaft**, which is still used and some chambers."	
Egypt	Historic quarters and monuments of Rosetta/Rachid	Tentative list, 28/07/2003	1831	(ii) (iv) (v)	Since the 9th century	yes	no	"There were new territorial conquests, a denser population, better and more urban equipment (oukalas, fondouks, factories, workshops, souks, **public water fountains, reservoirs**)"	
Egypt	El Gendi Fortress	Tentative list, 01/11/1994	193	?	12th century	yes ?	no ?	Evocation of **cisterns**.	
Iran, Republic Islamic of	Bam and its cultural landscape	Inscribed in 2004, minor modification in 2007	1208bis	(ii) (iii) (iv) (v)	Antiquity	no	yes		The qanats are mentioned all along the description. **Criterion (v):** The cultural landscape of Bam is an outstanding representation of the interaction of man and nature in a desert environment, using **the qanats**. The system is based on a strict social system with precise tasks and responsibilities, which have been maintained in use until the present, but has now become vulnerable to irreversible change.

Iran, Republic Islamic of	Shushtar Historical Hydraulic System	Inscribed in 2009	1315	(i) (ii) (v)	Antiquity (5th century BC)	yes	yes		**Criterion (i):** The Shushtar Hydraulic System is testimony to a remarkably accomplished and early overall vision of the possibilities afforded by diversion canals and large weir-dams for land development. […] **Criterion (ii)**: The Shushtar Historical Hydraulic System is a synthesis of diverse techniques brought together to form a remarkably complete and large-scale ensemble. [...] **Criterion (v)**: Shushtar is a unique and exceptionally complete example of hydraulic techniques developed during ancient times to aid the occupation of semi-desert lands. [...]
Iran, Republic Islamic of	The Persian Garden	Inscribed in 2011	1372	(i) (ii) (iii) (iv) (vi)	Since the 6th century	yes	no		The water management system is mentioned in 2 criterion**. Criterion (i):** [...] The creation of the Persian Garden was made possible due to intelligent and innovative engineering solutions and **a sophisticated water-management system**, as well as the appropriate choice of flora and its location in the garden layout. [...] **Criterion (ii)**: [...]It is the geometry and symmetry of the architecture, together with the **complex water management system**, that seem to have influenced design in all these gardens. [...] In the **criterion (vi)**, it is indirectly said that it reflects the importance of the natural element "water"
Iran, Republic Islamic of	Tchogha Zanbil	Inscribed in 1979	113	(iii) (iv)	1250BC-640BC	no	yes		The water management system is explained in the description : "**To supply the population of the city with water, Untash-Napirisha made a channel of about 50 km long**, leading to a **reservoir** outside the northern rampart; from there, nine **conduits** carried the filtered water to a **basin** arranged inside the rampart. " The approved criteria are not developed.
Iran, Republic Islamic of	The Zandiyeh Ensemble of Fars Province	Tentative list, 05/02/2008	5270	(vi)	?	?	?	Evocation of **a water reservoirs**,	
Iran, Republic Islamic of	The Historical–Cultural Axis of Fin, Sialk, Kashan	Tentative list, 09/08/2007	5187	(i) (ii) (iii) (iv) (vi)	From the 6th millenium BC	yes	yes	"**Soleymanieh Spring** in Fin (Kashan) is the origin of life in this region and generated **civilizations** like Sialk that belong to 6th millennium BC and other instances onward. This spring generated **Garden of Fin**, the most prominent Iranian garden."	
Iran, Republic Islamic of	Qanats of Gonabad	Tentative list, 09/08/2007	5207	(ii) (iii) (iv) (vi) (vi)	?	?	?	"The property contains of **427 water wells** with a length of 33113 meters and has been constructed based on different sciences like **physics, geology and hydraulics** and made it possible for the inhabitants to live in such a dry land that it rains there scarcely."	
Iran, Republic Islamic of	Damavand	Tentative list, 05/02/2008	5278	(vii) (viii) (ix) (x) ==> natural property	?	yes	no	"Mount Damavand is the highest elevation about 5628m a. l. s. in Iran. It is an inactive volcanic mountain which was activated in Quaternary Period. It has numerous **thermal springs."**	
Iraq	Erbil Citadel	Tentative list, 08/01/2010 / Nomination record received, 17/01/2013	5479	(i) (ii) (iii) (iv) (v)	Since the 5th millenium BC	yes	no	"A **public bath (Hammam)"** involves a water management system	
Israel	Biblical Tels - Meggido, Hazor, Beer Sheba	Incribed in 2005	1108	(ii) (iii) (iv) (v)	Antiquity	no	yes		The underground water-collecting system is mentioned in the short description and in the **Criterion (iii)**: The three tels are a testimony to a civilization that has disappeared - that of the Cananean cities of the Bronze Age and the biblical cities of the Iron Age - manifests in their expressions of creativity: town planning, fortifications, palaces, and **water collection technologies.**
Israel	Incense Route - Desert Cities in the Negev	Inscribed in 2005	1107rev	(iii) (v)	Antiquity	no	yes		Just as Petra and Al-Hijr, those towns with a complex water system were made by Nabateans. It is mentioned in the **Criterion (v)**: The almost fossilized remains of towns, forts, caravanserais and **sophisticated agricultural systems** strung out along the Incense Route in the Negev desert, display an outstanding response to a hostile desert environment and one that flourished for five centuries.
Israel	Masada	Inscribed in 2001	1040	(iii) (iv) (vi)	Until 73AD	no	yes		The water system management is largely explained but the OUV is not based on it. "The palace on the northern face of the dramatic mountain site consists of an exceptional group of classical Roman Imperial buildings. **The water system was particularly sophisticated**, collecting run-off water from a single day's rain to sustain life for a thousand people over a period of two to three years. This achievement allowed the transformation of a barren, isolated, arid hilltop into a **lavish royal retreat.** [...] During the main phase two rows of **cisterns** were dug beneath the hilltop. Water was delivered through **a network of dams and channels** during the winter floods in the wadis to the west of Masada."
Israel	Degania & Nahalal	Tentative list, 30/06/2000	1478	(v) (vi)	20th century	yes	no	A "**water tower**" implies a water management system.	
Israel	Region of the Caves & Hiding: bet Guvrin-Maresha	Tentative list, 30/06/2000 / Nomination record "Caves of Maresha and Bet-Guvrin in the Judean Lowlands as a Microcosm of the Land of the Caves" 1370 received on the 24tth january 2013	1484 (Mixte)	(iii) (v) (vi)	Antiquity	no	yes	A water system was managed during Roman times : "**Two aqueducts** brought water from afar, and together with local **waterworks**, supplied the needs of the residents. ".	
Israel	Jerusalem : This concerns the property entitled "Jerusalem - the Old City and Ramparts to include Mount Zion" proposed by Israel as an extension to the "Old City of Jerusalem and its Walls" inscribed on the World Heritage List in 1981, upon proposal by Jordan.	Tentative List, 20/06/2000	1483	(i) (ii) (iii) (iv) (v) (vi)	Since Antiquity	yes	yes	"**The water source** of Jerusalem is the Gihon Spring/Mary's Well that has proven over the generations to be the focal point for the city and its development, including **water installations and aqueducts** bearing evidence to the changing sociopolitical patterns of the area."	

Israel	Caesarea	Tentative list, 30/06/2006	1480	(ii) (iv) (v) (vi)	Antiquity (since Phoenician times)	no	yes	Since Caesarea had no rivers or springs, drinking water for the prospering Roman and Byzantine city was brought via a **unique high-level aqueduct**, originating at the nearby Shuni springs, some 7.5 km northeast of Caesarea. The aqueduct consists of thrce **canals**, two of which were added in the course of its use. In low lying areas, sections of the aqueduct were carried on **arches** (arcadiha).	
Israel	Bet She'an	Tentative list, 30/06/2006 / Nomination record "Bet Shean Archaelogical Site" 1120, july 31 2003, incomplete	1479	(ii) (iv) (v) (vi)	Since the 5th millenium BC	yes	no	Evocation of **baths,**	
Jordan	Petra	Inscribed in 1985	326	(i) (iii) (iv)	Antiquity	no	yes		The water management system is mentioned in the short description and **in all the criteria approved.**
Jordan	Um er-Rasas (Kastrom Mefa'a)	Inscribed in 2004	1093	(i) (iv) (vi)	From the 3rd to the 9th century AD	no	yes		The water system management is not expressed in the approved criteria but appears in the description : "Um er-Rasas is surrounded and dotted with remains of ancient agricultural cultivation, from **water reservoirs to terracing, water channels, dams and cisterns**."
Jordan	Quseir Amra	Inscription in 1985	327	(i) (iii) (iv)	8th century	no ?	no		**The water management system and the baths (hammam) are mentioned in Criterion (iv)**: Together with the remains of the fort/garrison buildings several hundred metres to the north and traces of agricultural water catchment works, the fresco-painted bath building with its reception hall and adjacent well, tank and water-lifting hydraulic system, drainage pipes and cesspool represent an outstanding example of an Umayyad desert establishment.
Jordan	Abila City (Modern Qweilbeh)	Tentative list, 18/06/2001	1557	(i) (iii) (iv)	Antiquity	no	yes	"The site was supplied with a **water system** while additional water was brought to the area by the **Khureibah aqueduct**. From the spring, **two aqueducts** traveled along the west side of the Wadi Qweilbeh and **brought water into the center of the city**"	
Jordan	Al-Qastal Settlement	Tentative List, 18/06/2001	1550	(i) (iii) (iv)	Umayyad Period	no	yes	"Over a kilometre to the east, across the airport highway, is the **400-metre-long, 4.3-metre-thick stone dam** built by the Umayyad inhabitants of Qastal to store nearly **two million cubic metres of rainwater for irrigation**. About a kilometre north-west of the palace, at the edge of the modern village of Qastal, is the **large reservoir** measuring 30x22 metres and 6.5 metres deep, with **a capacity of 4,000 cubic metres**. It was formed from the quarry which supplied Qastal's building stones for the palace, mosque and dam. In the centre of the reservoir is the lower section of its **original water gauge**. Over **70 smaller cisterns** within two square kilometres of the palace provided the settlement's year-round water needs. West of the palace are some faint remains of **Qastal's Umayyad baths."**	
Kuwait	Sa'ad and Sae'ed Area in Failaka Island	Tentative list, 27/02/2013	5800	(iii)	3rd millenium			Evocation of wells : "Outside the houses, many **shallow water wells** were found."	
Lebanon	Anjar	Inscription in 1984	293	(iii) (iv)	8th century	no	yes		**The baths are not mentioned in the criteria but in the description** : "The **baths** are located in the North-East quarter to facilitate the functioning and evacuation of waste waters […] More evidence of the Umayyad dependence on the architectural traditions of other cultures appears in the Umayyad baths, which contain the three classical sections of the Roman bath: the vestiary where patrons changed clothing before their bath and rested afterwards, and three rooms for cold, warm and hot water. The size of the vestiary indicates the bath was more than a source of physical well-being but also a centre of social interaction."
Lebanon	Centre historique de Saida	Tentative List, 01/07/1996	398	(iv)	Since Prehistoric tmes	yes	yes	Evocation of **Hammams**	
Libya	Old Town of Gadamès	Inscription in 1986	362	(v)	Roman times	yes	no		Description : "Ghadamès, known as 'the pearl of the desert', stands in an **oasis**." Advisory Body Evaluation : "management of the oasis, whose survival is necessary for an understanding of the history of the site and for the ecological equilibrium of the city. Special attention should be paid to **traditional systems for the irrigation of the palm tree grove. "**
Libya	Archaelogical site of Cyrene	Inscribed in 1982	190	(ii) (iii) (vi)	Hellenistic times	no	yes		**Presence of baths and fountains** in the ancient town : "To the north, the sanctuary and sacred fountain of Apollo, the fountain celebrated by Pindar, Herodotus and Callimachus, regroups the temples of Apollo (7th-4th centuries BC) and Artemis (7th-6th centuries BC), the sacella of Persephone, Hades and Hecate, votive monuments and treasuries. This cultic zone was completed, during the Roman period, by extremely large buildings of which the most important are the Baths of Trajan, restored in the 2nd century"
Libya	Archaelogical site of Leptis Magna	Inscribed in 1982	183	(ii) (iii) (vi)	Phoenician times	no	yes		There was a water management system : **baths, canal, barrage**… "The ancient port, with its artificial basin of some 102,000 m2, still exists with its quays, jetties, fortifications, storage areas and temples. Dug under Nero and organized under Septimius Severus, it is one of the chefs d'oeuvre of Roman technology with its barrage dam and its canal designed to regulate the course of Wadi Lebda, the dangerous torrent that empties into the Mediterranean to the west. "

Mauritania	Paysage culturel d'Azougui	Tentative list, 14/06/2001	1545	(iii) (iv) (v) (vi)	Since Middle Ages	yes	yes	"**Oasis**. [...] Cette **palmeraie**, la plus ancienne de la région, compte maintenant plus de **vingt mille palmiers** et conserve encore le système traditionnel de **canalisation et d'exploitation**. Ce dernier constitue un véritable métier traditionnel qui risque de disparaître sous l'effet de la modernisation. "	
Morocco	Medina of Fez	Inscribed in 1981	170	(ii) (v)	Middle Ages	yes	no		The property is not inscribed thanks to its water management system which is not even mentioned neither in the description of the property, nor in the criterion, nor in the ICOMOS recommendation.
Morocco	M'Zab Valley	Inscribed in 1982	188	(ii) (iii) (v)	Middle Ages	yes	no		The palm groves are mentioned in the description**. Criterion (v):** The elements constituting the M'Zab Valley are an outstanding example of a traditional human settlement, representative of the Ibadis culture that, through the **ingenious system for the capture and distribution of water and the creation of palm groves**, demonstrates the extremely efficient human interaction with a semi-desert environment.
Morocco	Medina of Marrakesh	Inscribed in 1985	331	(i) (ii) (iv) (v)	11th century	yes	no		Menara with palm groves and gardens are part of the **Criterion (i)** : Marrakesh contains an impressive number of masterpieces of architecture and art (ramparts and monumental gates, Koutoubia Mosque, Saâdians tombs, ruins of the Badiâ Palace, Bahia Palace, **Ménara water feature and pavilion**) each one of which could justify, alone, a recognition of Outstanding Universal Value."
Morocco	Historic City of Meknes	Inscribed in 1996	793	(iv)	11th century	yes	no		The specificity of the water management is not directly specified in the criterion (iv) but is mentioned in the description : "Water from the Tagma spring was brought to the town to serve the **various fountains**, **baths and mosques**. At that time there were **four sets of baths (hammam)**, the location of which indicates how the town had spread. [...] Within are the palace with its enormous stables, a military academy, vast granaries and water **storage cisterns**."
Morocco	Archaeological Site of Volubilis	Inscribed in 1997, minor modification in 2008	836bis	(ii) (iii) (iv) (vi)	3rd century BC	no	yes		Only a **broken aqueduct** is mentioned.
Morocco	Medina of Tétouan (formerly known as Titawin)	Inscribed in 1997	837	(ii) (iv) (v)	8th century	yes	no		**Fountains and hammans** are briefly mentioned in the description.
Morocco	Medina of Essaouira (formerly Mogador)	Inscribed in 2001	753rev	(ii) (iv)	18th century	yes	no		There is only the mention of a "**water gate**".
Morocco	Portuguese City of Mazagan (El Jadida)	Inscribed in 2004	1058rev	(ii) (iv)	16th century	yes	no		The water management system is mentioned in the description : "The **waters** are conducted to the **cistern** through a **system of channel**s from the citadel.".
Morocco	Rabat, Modern Capital and Historic City: a Shared Heritage	Inscribed in 2012	1401	(ii) (iv)	12th century	yes	no		The water management system is not mentioned but the gardens, the "**vegetation**" prove its existence. Moreover, all the other Moroccan inscribed towns can manage waters.
Morocco	Oasis de Figuig	Tentative List, 30/05/2011	5625	(iii) (iv) (v)	Middle Ages ?	yes	no	"La **palmeraie en jardin étagé**, avec une diversité de cultures et de variétés de palmiers, et son **système d'irrigation** : **foggaras, bassins, échangeurs et canaux** avec leurs savoir-faire et pratiques sociales constituent un ensemble étroitement imbriqué de patrimoine matériel et immatériel à préserver dans leur cohérence. "	
Oman	Aflaj Irrigation System of Oman	Inscription in 2006	1207	(v)	2500BC	yes	no		**Criterion (v)**: The collection of Aflaj **irrigation systems represents some 3,000 still functioning systems in Oman.** Ancient engineering technologies demonstrate long standing, sustainable use of water resources for the cultivation of palms and other produce in extremely arid desert lands. Such systems reflect the former total dependence of communities on this irrigation and a time-honoured, fair and effective management and sharing of water resources, underpinned by mutual dependence and communal values.
Oman	Bahla Fort	Inscribed in 1987	433	(iv)	Middle Ages	yes	no		The water management system is described but does not appear in the criterion (iv) which underlines the military component of the site : "The **oasis is watered by the falaj system of wells and underground channels** bringing groundwater from distant springs, and by management of the seasonal flow of water. Bahla is an outstanding example of a **fortified oasis settlement** of the medieval Islamic period, exhibiting **the water engineering skill** of the early inhabitants for agricultural and domestic purposes." The OUV is not based on it.
Oman	Land of Frankincense	Inscribed in 2000	1010	(iii) (iv)	The 1st and 2nd centuries BC	no	yes		The OUV is not based on the water management system. We only learn the existence of **the caravan oasis of Shisr/Wubar** : "There is a number of Neolithic sites in the immediate vicinity of Shisr. This **agricultural oasi**s and caravan site on the route along which frankincense was brought from the Nejd to the port of Sumhuram was dominated by an Iron Age fortress of the 2nd century BCE. "
Oman	Prehistoric Settlements in Bisya & Salut	Tentative List, 23/05/2013	5831	(ii) (iii) (iv) (v)	from the late 4th millennium BC down to Islamic times	no ?	yes	"Site has experienced a history of settlement shift which has been influenced by the alignment of **the groundwater pathways** on which settlement and **irrigatio**n have depended from the introduction of agriculture to the present day."	
Oman	Qahlat	Tentative List, 23/05/2013	5830	(ii) (iii) (iv) (v)	Since Middle Ages	no	yes	"Therefore, the main structures in the historic city of Qalhat are coupled with the architectural features of Hormuz, as well as the architectural type of certain **water cisterns** in the city of Qalhat are coupled with **water system** at Hawra Bargha in Sohar in the Sultanate of Oman since the Nabahina ruling reign (1624-1744).[...] **cisterns**"	

Oman	The forts of Rostaq and al-Hazm	Tentative list, 07/07/1988	497	?	Since Persian Times	yes	no ?	"The impresive fort of Rostaq is in the middle of a **large oasis,** […] Three towers were later added with living quarters at various levels and the construction includes an elaborate access to **the falaj system**."	
Palestine	Tell Umm Amer	Tentative list, 04/02/2012	5716	(ii) (iii) (vi)	Roman Times	no	yes	"The monastery was provided with good infrastructure facilities, including **water cisterns**, clay-ovens and **drainage channels**. […] In addition, the monastery was equipped with **baths, consisting of Frigedarium, Tepidarium and Caldarium halls**."	
Palestine	QUMRAN: Caves and Monastery of the Dead Sea Scrolls	Tentative List, 02/04/2012	5707	(iii) (iv) (vi)	Greco-Roman Period	no	yes	"The excavated site is composed by a large complex of buildings, including communal facilities, **a sophisticated water system**, a library and a large cemetery."	
Palestine	Palestine: Land of olives and vines. Cultural Landscape of Southern Jerusalem, Battir	Tentative List, 25/05/2012	5748	(ii) (iii) (iv) (v)	Since Roman Times ?	yes	no	"Criterion (iv): **The traditional systems of irrigated terraces** within the nominated property are an outstanding example of technological ensemble, which today constitute an integral part of the cultural landscape."	
Palestine	El-Bariyah: wilderness with monasteries	Tentative List, 02/04/2012	5708	(i) (ii) (iii)	Roman Times	yes ?	yes	"The complex was built on a conical hill shaped and secured by the erection of massive retaining walls. This artificial mound was equipped with **a sophisticated fortification system, including an elaborate water supply**."	
Qatar									There is a mention of the water management system but there is no explanation about how it works : "A short distance away are the remains of the fort of Qal'at Murair, with evidence of **how the desert's supplies of water were managed and protected**, and a further fort constructed in 1938."
Saudi Arabia	Al-Hijr Archaeological Site (Madâin Sâlih)	Inscription in 2008	1293	(ii) (iii)	Antiquity	no	yes		Wells are mentioned all along the description. **Criterion (iii):** […] The site includes a set of **wells**, most of which were sunk into the rock, demonstrating the Nabataeans' mastery of hydraulic techniques for agricultural purposes.
Saudi Arabia	At-Turaif District in ad-Dir'iyah	Inscribed in 2010	1329	(iv) (v) (vi)	Modern Times and 18th-19th centuries	no	yes		Urban settlements and military facts are more developped than the water heritage. The OUV is not based on it : "Criterion (iv): The citadel of at-Turaif is representative of a **diversified and fortified urban ensemble within an oasis**. It comprises many palaces and is an outstanding example of the Najdi architectural and decorative style characteristic of the centre of the Arabian Peninsula".
Sudan	Archaeological Sites of the Island of Meroe	Inscribed in 2011	1336	(ii) (iii) (iv) (v)	8th century BC	no	yes		(not in the criteria): "It was the seat of the rulers who occupied Egypt for close to a century and features, among other vestiges, pyramids, temples and domestic buildings as well as **major installations connected to water management**. [,,,]The water reservoirs in addition contribute to the understanding of the palaeoclimate and
Syrian Arab Republic	Site of Palmyra	Inscribed in 1980	23	(i) (ii) (iv)	From the 1st to the 2nd century	no	yes		The OUV si not based on the water management system (there is not a criterion about it) but we learn in the description that there was an aqueduct to transport water.
Syrian Arab Republic	Ancient City of Aleppo	Inscribed in 1986	21	(iii) (iv)	Since the 2nd millenium (water management system : Middle Ages ?)	yes	no		There is no mention of the water management system except for **hammans**. Moreover, we can see **basins** on the pictures. The OUV is based on the all urbanism.
Syrian Arab Republic	Ancient City of Damascus	Inscribed in 1979, minor modification in 2011	20bis	(i) (ii) (iii) (iv) (vi)	Since the 3rd millenium (water management system : Middle Ages ?)	yes	no		Mention of the **public baths** in the description + pictures of **basins.** OUV: urbanism

Syrian Arab Republic	Un Château du désert : Qasr al-Hayr ach-Charqi	Tentative List, 08/06/1999	1298	(iv)	Umayyad Period	no	yes	**"Une canalisation d'environ 5,7 km apporte l'eau d'une région lointaine."**		
Syrian Arab Republic	Noréas de Hama	Tentative List, 08/06/1999	1291	(i) (iv)	Middle Ages	yes	no	"La **noréa** est en effet un mécanisme qui permet d'**élever l'eau de la rivière** grâce à une roue en bois plus ou moins grande installée au bord de la rivière et dôtée de caissons en bois qui se remplissent d'eau chaque fois que la roue s'enfonce dans le liquide et qui se vident quand ils se trouvent au sommet, en déversant leur contenu dans un **bassin ou un acqueduc** qui véhicule l'eau aux endroits désirés. A Hama les noréas ont un diamètre qui varie entre 10 et 12 mètres; certaines peuvent atteindre les 22 mètres. "		
Syrian Arab Republic	Mari (Tell Hariri)	Tentative List, 08/06/1999	1294	(iii) (vi)	2900BC	no	yes	"Expression d'une volonté politique la première cité de Mari avait un plan strictement circulaire d'un diamètre de 1900 métres . Elle était **entourée par une digue et un canal directement relié à l' Euphrate, assurant son approvisionnement en eau** tout en permettant, sans doute, aux bâteaux de venir s'arrêter dans le port. "		
Tunisia	Kairouan	Inscribed in 1988 (minor modification in 2010)	499bis	(i) (ii) (iii) (v) (vi)	Middle Ages	yes	no		The Basin of the Aghlabids and the aqueduct are mentioned in the description. **Criterion (iii)**: With the Great Mosque, the Mosque of the Three Doors, and the **Basin of the Aghlabids**, not to mention the numerous archaeological vestiges, Kairouan bears exceptional witness to the civilisation of the first centuries of the Hegira in Ifrîqiya.	
Tunisia	Archaeological Site of Carthage	Inscribed in 1979	37	(ii) (iii) (vi)	9th century BC	no	yes		The water management system is briefly mentioned : "**the Antonin baths, Malaga cistern**s" but they represent major components of the site.	
Tunisia	Punic Town of Kerkuane and its Necropolis	Inscribed in 1985, extension in 1986	332bis	(iii)	Phoenician times	no	yes		There was a sophisticated **water management system revealed by the excavations of the town** : " In proving the repetitive nature of this particular plan, which was taken to be a typical plan, the excavation made it possible to confirm the existence of an authentic town-planning programme that gave considerable importance to hydraulics and hygiene."	
Tunisia	Dougga / Thugga	Inscribed in 1997	794	(ii) (iii)	Roman times for the water management system	no	yes		The water management can be seen through the public buildings : "Thugga possesses a remarkable assemblage of public buildings - temples and sanctuaries, forum, **public baths**, theatre, amphitheatre, circus, market, **public cisterns** and **fountains**, etc.".	
Tunisia	Le complexe hydraulique romain de Zaghouan-Carthage	Tentative list, 1702/2012	5685	(i) (iv)	2nd century	no	yes	"Il s'agit du plus grand complexe du genre jamais réalisé. Il associe trois composantes : **les captages de quatre sources principales** avec dotation d'un cadre monumental, le nymphée connu couramment sous l'appellation de « **temple des eaux** », d'une grande valeur archéologique, **un aqueduc de 132 km** courant en général à fleur de terre ou en parcours souterrain et dont de nombreux tronçons marquent à ce jour le paysage en de nombreux endroits avec des arcades de plus de 20 m de hauteur, et les **citernes de stockage** de la Maalga à Carthage, auxquelles il faut ajouter les **grands thermes publics** de Carthage, dits thermes d'Antonin, situés en bord de mer et qui constituaient le but ultime et l'aboutissement de l'ensemble."		
Tunisia	Oasis de Gabès	Tentative List, 28/05/2008	5386	(iv) (vii) (x)	?	yes	no	"L'oasis: systèmes et paysages intimement liés à l'action de l'homme. Les oasis en Tunisie constituent une forme très élaborée d'**irrigation collective** et dont la conception est très ancienne. En effet l'ensemble de ces systèmes d'irrigation est basé sur **la mise en commun et le partage des eaux des différentes source**s entre les parcelles par un réseau complexe de **canaux d'irrigation**. C'est ce **système d'irrigation collectif et**		
Turkey	Hierapolis-Pamukkale	Inscribed in 1988	485	(iii) (iv) (vii)	2nd century BC	no	yes		The system of the thermal town is expressed in the description and in the **Criterion (iii):** Hierapolis is an exceptional example of a **Greco-Roman thermal** installation established on an extraordinary natural site. The therapeutic virtues of the waters were exploited at the various thermal installations, which included immense **hot basins and pools** for swimming. Hydrotherapy was accompanied by religious practices, which developed in relation to local cults.	

Turkey	Archaeological site of Laodikeia	Tnetative List, 15/04/2013	5823	(ii) (iii) (iv)	Hellenistic period	no	yes	**Criterion (iii)**: Laodikeia is the home of unique and magnificent structures dating from the Hellenistic, Roman Imperial and Early Byzantine Periods. These structures were supplied by **a system that brought water from springs** located in the valleys of the Salbakos Mountain eight km south of the city. **A water line** made of double rows of **travertine pipes** as well as clay pipes utilized in the first and second water distribution terminals, demonstrate its **excellent hydraulic design**. This **siphon system** is unique in Anatolia.		
Turkey	Archaeological Site of Perge	Tentative List, 06/09/2009	5411	(ii)	Antiquity	no	yes	"**The water channel** which crosses the Colonnaded Street from one end to another is another important design of the city. Supported with the **four monumental fountain**s and **two baths** give the city the impression of a water city for this time period."		
Turkey	Archaeological Site of Sagalassos	Tentative List, 06/09/2009	5409	(ii) (iii)	Antiquity	no	yes	"**The use of natural water resources was also carefully planned**. In fact only few towns in the region show such an abundant water display in Roman times as Sagalassos. **Water was collected, distributed, displayed and recycled** within **a complex network** which is being further documented and studied at the moment."		
Turkey	Bursa and Cumalikizik Early Ottoman urban and rural settlements	Tentative list, 25/02/2000	1407	(i) (iii) (iv)	Antiquity	no	yes	"**37 public bath house**s"		
Turkey	Güllük Dagi-Termessos National Park	Tentative list, 25/02/2000	1412	?	Antiquity	no	yes	"**cisterns and drainage system**"		
Turkey	Historic City of Ani	Tentative list, 13/04/2012	5725	(ii) (iii) (iv)	Middle Ages	?	?	"There are also a great amount of dwellings and other civic buildings such as public **baths**, stores, **aqueducts**, bridges and roads as Ani was one of the unique medieval cities densely populated."		
Turkey	Historic Town of Birgi	Tentative list, 13/04/2012	5728	(ii) (iv)	Ottoman period	no ?	yes	"There are still remains of the many civilisations that Birgi hosted; such as many tombs, madrasa, dar-ül hadis, mosques, **fountains**, **baths"**		
Turkey	Seljuk Caravanserais on the route from Denizli to Dogubeyazit	Tentative list, 25/02/2000	1403	(ii) (iii) (iv)	Middle Ages	no	yes	"There were certain to be **bath**s, a masjid, **a cistern or fountain**, an infirmary, a cookshop, a place for the storage of provisions, and shops."		
Turkey	The Ancient City of Sardis and the Lydian Tumuli of Bin Tepe	Tentative list, 15/04/2007	5829	(i) (ii) (iii)	Roman Times	no	yes	"**A Roman Bath-Gymnasium complex** with its monumental columned Marble Court"		
Turkey	Alanya	Tentative list, 25/02/2000 / Nomination record "Historic city of Alanya" 2012 withdrawn	1405	(iii) (iv)	Middle Ages	no	yes	Evocation of "the ruins of a **Seljuk bath**"		
United Arab Emirate	Cultural Sites of Al Ain (Hafit, Hili, Bidaa Bint Saud and Oases Areas)	Inscription in 2011	1343	(iii) (iv) (v)	Since Neolithic times	yes	no		The water management system and the wells are mentioned in the description and in the criteria (iv) and (v) : **Criterion (iv)** : […]**The aflaj system**, introduced as early as the 1st millennium BC, is testimony to the management of water in desert regions. **Criterion (v)**: The remains and landscapes of the **oases** of Al Ain appear to testify, over a very long period of history, to the capacity of the	
Yemen	Historic Town of Zabid	Inscribed in 1993	611	(ii) (iv) (vi)	Middle Ages	yes	no		The water management system appears in the description but not in the criteria : "Its development is due to the founder of the Ziyadite dynasty, Ibn Ziyad, who was sent to the region by the Caliph al-Mamun in 820 to quell a rebellion. He gave it its circular plan, built the fortifications, and brought water to it through a network of canals.". The OUV is not based on this water system.	
Yemen	Old Walled City of Shibam	Inscribed in 1982	192	(iii) (iv) (v)	19th century for the water system management	yes	no		The modern water management system : "Abandonment of the old agricultural flood management system in the wadi, the overloading of the traditional sanitary systems by the introduction of modern water supply combined with **inadequate drainage**, together with changes in the livestock management have all contributed to the decay of the city."	
Yemen	Old City of Sana'a	Inscribed in 1986	385	(iv) (v) (vi)	Before the 11th century	yes	no		**12 (or 12?) hammans testifying of the heritage of Islam. Gardens**. No more information.	

Yemen	Historic City of Saada	Tentative List 08/07/2002	1718	(i) (iv) (v)	Middle Ages	no	yes	Evocation of **"ancient cisterns"**		
Yemen	Historic City of Thula	Tentative List 08/07/2002	1719	(i) (iii) (iv)	15th century	yes	no	" Le vieux suq traditionnel de 110 échoppes avec ses **points d'eau** et caravansé-rails complete cette cite médiévale bien conservée. **L'eau** est encore présente avec **deux grands bassins** et son **énorme hammam** qui remonterait au 15eme siècle."		
Yemen	The Madrasa Amiriya of Rada	Tentative List, 08/07/2002	1720	(i) (iv)	16th century	yes	no	Evocation of **basins**		
Yemen	Jibla and its surroundings	Tentative List, 08/07/2002	1721	(ii) (iv) (v)	Middle Ages	yes	no	"**L'aqueduc** construit sous le règne de la reine Arwa **apporte toujours l'eau des montagnes**."		
Yemen	Sharma/Jethmun coastal area	Tentative List, 08/07/2002, Natural property	1727	?	Since Antiquity ?	yes	no	Evocation of **hot spring baths (thermal cures)**		