CURA AQUARUM IN GREECE

Proceedings of the 16th International Conference
on the History of Water Management and Hydraulic Engineering
in the Mediterranean Region

Athens, Greece
28 - 30 March 2015

Siegburg 2017

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Preface of the Editor

The Deutsche Wasserhistorische Gesellschaft (DWhG), or German Water History Association, is a non-commercial organisation that fosters knowledge and awareness of the history of water management and hydraulics. To do so, DWhG organises conferences and publishes books and proceedings on related topics. DWhG has roughly 400 members worldwide, all interested in the history of water, and representing all scientific fields, from engineering and hydrology to archaeology and history, as well as humanistic studies. This interdisciplinary convergence often triggers new ideas, insights, and solutions for particular problems or questions. Since its foundation in 2002, the DWhG has published 26 volumes, most of which cover a special regional or temporal aspect. Additionally, 16 special volumes – mostly monographs – have been published. This enormous coverage indicates the need for scientific literature dealing with water history at the interface of the sciences and humanities.

This volume contains the proceedings of the 16th *Cura Aquarum* International Conference on the History of Water Management and Hydraulic Engineering in the Mediterranean Region, held in Athens, Greece, from the 28th to 30th of March 2015. This conference was organised jointly by Anna Androvitsanea and Henning Fahlbusch, who recruited participants conducting research on various aspects of ancient water management in Greece.

Consequently, the evolution of water management in Greece is subject of most of the contributions, which cover all phases from the Minoan and Mycenean periods to recent water supply systems. Five papers deal with the water management of particular parts of Athens, allowing for a better understanding of the development of that city's infrastructure. Case studies from Corinth, Olympia, Naxos, Megara, and Piraeus complement this coverage. As pointed out by Henning Fahlbusch, in both his keynote lecture in Athens and in his contribution to the proceedings, Greece can be regarded as the cradle of water management in Europe. The other reports within this volume certainly support this hypothesis.

This volume is completed by case studies from across the Mediterranean region (e.g., Israel) as well as a compilation of hydraulic structures used for sewage and water supply systems in Egypt. Further contributions focus on special topics like ancient water clocks, Roman lead pipes, qanats, and other hydraulic features. This broad variety of topics reflects the importance of water-studies in very diverse disciplines across engineering, the natural and social sciences, and the humanities.

This is the first time that the conference proceedings published by DWhG have not been not edited by Christoph Ohlig. It was my great honour to work with him to learn how to do the editorial work. He taught me his diligent and

thorough way of working. Editing this volume, I have gained new appreciation for how much labour and time he invested in more than 15 years of publishing the more than 40 volumes that precede this one. It is due to his dedication that the published series of DWhG has become such a success. And it is due to the handing over of this editorship, that authors and colleagues had to wait quite a long time until these proceedings were finally finished.

Kai Wellbrock

Siegburg, December 2017

Preface of the Conference Organisers

It was our great pleasure to be able to organise the sixteenth *Cura Aquarum* conference in Athens. When the first meeting on water supply in antiquity was held at Koblenz, Germany, in 1975, at the initiative of Bernd Haberey (Cologne) and on behalf of the Leichtweiss-Institute for Hydraulic Research of the TU Brunswig, as well as of engineers from the Studienkreis für die Geschichte des Wasserbaus, der Wasserwirtschaft und der Hydrologie, none of the participants could have imagined that it would be the beginning of a such a great series of conferences. Yet, here in Athens, we celebrate its 40th anniversary. The first conference abroad already took place in 1977, in Lyon (France). All subsequent events have been carried out in countries around the Mediterranean Sea. In 1991 our colleagues from the Netherlands, the "Dutch nymphs" who organised two conferences, came up with the title *Cura Aquarum*, which we keep up to this day.

The main organiser has, however, changed. Today the Deutsche Wasserhistorische Gesellschaft (DWhG), or German Water History Association, serves as a successor of the aforementioned group of engineers. During its 12 years of existence, the DWhG has organized 25 conferences on various aspects of the history of water management.

It would be more or less impossible to plan a conference in a foreign country without a local partner. For this reason, we were delighted that the German Archaeological Institute in Athens (DAI Athens) helped us with words and deeds, as they also had done in 1981. We are grateful to Katja Sporn and Reinhard Senff for this support. Their assistance was essential, not only for compiling an interesting programme of lectures, but also for the excursions to the Kerameikos and Olympia. We also take this opportunity to thank all of the speakers for the presentation of their research. Meanwhile, we must apologise for any mistakes in the translation of the various abstracts. Unfortunately, English is not our mother tongue, and we admit that we do not qualify as professional translators. At the very least, we hope that we were able to preserve the meaning of the original texts.

Since the meeting in Koblenz, an excursion to view ancient projects of hydraulic engineering has become an integral part of every conference. We have mostly chosen destinations which one cannot visit as "a regular tourist", and we observed this tradition here again in Greece. Needless to say, visiting the places of interest would not have been possible without the support of the people who care for them. We would therefore like to extend a heartfelt thank you to the Ephorates of Athens, East Attica, West Attica & Piraeus, and Corinth, and representatives of the various excavation sites for their understanding and support, most notably Eleni Banou, Anastasia Lazaridou, Stella Chrisoulaki and Konstantinos Kissas.

The goal of the conference, including the lectures and excursions, is to bring scientists from various disciplines together for a fruitful exchange of ideas. One of the excursions during the fourth *Cura Aquarum* in 1981 included the Kopais project, which was presented at that time by Siegfrid Lauffer (University Munich). That visit would inspire Jost Knauss (TU Munich) to get involved in the history of the Kopais plain and, later, in the Mycenaean hydraulic engineering of Greece, in general. It is with particular pleasure that we include at least four projects that he investigated among this year's destinations. Naturally, we hope that similar initiatives might spring from this meeting.

Seldom do participants of such a large congress like the sixteenth *Cura Aquarum* imagine the amount of preparatory work "behind the curtain". The organisers would have been hopelessly overwhelmed if our friend Stefania Kostourou of Marine Tours had not supported us in a professional and reliable way. We thank her wholeheartedly for her contributions to our endeavour.

Anna Androvitsanea — Henning Fahlbusch

Athens, March 2015 — *Ratzeburg, March 2015*

Preface of the Co-Organiser

Es ist eine besondere Freude, dass die Deutsche Wasserhistorische Gesellschaft (DWhG) nach einigen Jahrzehnten nun Athen wieder als Tagungsort für ihre Tagung gewählt hat. Das letzte Mal, im Jahr 1981, bildete die Tagung einen wichtigen Impuls für einige neue Kooperationen in Griechenland, etwa mit dem Deutschen Archäologischen Institut in Samos. Aber auch die Forschungen von Jost Knauss zur Melioriation des Kopais-Beckens in Böotien wurden durch die von der Tagung angebotene Exkursion in dieses Gebiet angestoßen. Das Projekt war für die folgenden Jahre eines der wichtigsten wasserkundlichen Forschungsprojekte zum antiken Griechenland. Es war auch daher so wichtig, da die Untersuchung der über Jahrtausende andauernden Bemühungen zur Entwässerung des Kopais-Sees Einblicke in wesentliche technische Erneuerungen bereits im prähistorischen, besonders im mykenischen Griechenland gewährten.

Bei der ersten Tagung in Griechenland war der damalige wissenschaftliche Direktor der Abteilung Athen des Deutschen Archäologischen Instituts, Hermann Kienast, der Kooperationspartner des Instituts. Er hatte damals auch einen Vortrag über Bauelemente griechische Wasserversorgungen gehalten, der Eingang in die Tagungsakten fand. Auch der jetzige wissenschaftliche Direktor unserer Abteilung, Reinhard Senff, Leiter der Olympia-Grabung, hat sich wieder sehr für die Entstehung der Tagung eingesetzt, ebenso wie Jutta Stroszeck, Leiterin der Kerameikos-Grabung. Beide stellen Vorträge über ihre laufenden Forschungen zu Wassermanagement im Heiligtum von Olympia bzw. dem Kerameikos von Athen vor. Zum Zeitpunkt der Tagung war das Institut zudem auf dem Weg, auch an einem anderen Grabungsort des DAI, im Heraion von Samos unter der Leitung von Joachim Heiden und Christoph Külls von der FH Lübeck ein neues Kooperationsprojekt zu fixieren. Es ist mittlerweile mit dem Titel „Wasser und Kult im Heraion von Samos“, finanziert von der Deutschen Forschungsgemeinschaft (DFG) und mit Mitarbeit von Anna Androvitsanea, Johanna Fuchs und Henning Fahlbusch erfolgreich angelaufen.

Verschiedene Fragestellungen zur physischen wie anthropogenen Wasserzufuhr und -regulation, deren Nutzung und deren Folgen sind mittlerweile an allen Projektorten des Deutschen Archäologischen Instituts in Athen von Bedeutung. So ergaben geoarchäologische Untersuchungen in der Umgebung des Heiligtums von Olympia auch für das Heiligtum folgenreiche Tsunami-Szenarien in der Antike. Zuletzt wurden zudem in Tiryns neue Untersuchungen zur Regulierung des Flussverlaufs in der Unterstadt und deren Zusammenhang mit der Entstehung der nachpalastzeitlichen Siedlung am Fuß der Burg durchgeführt. Selbst im Heiligtum von Kalapodi regt die ungewöhnliche

Existenz eines Brunnens in der Peristasis des Nordtempels zu Hypothesen an.
Es ist zu erwarten, dass zukünftig weitere Forschungen zu diesem Themenschwerpunkt in Griechenland stattfinden. Die zahlreiche Beteiligung von in Griechenland tätigen Kolleginnen und Kollegen an der Tagung 2015 mit unterschiedlichen Fragen und Präsentationen neuer Ergebnisse spricht für sich. Es bleibt zu hoffen, dass die nächste fachspezifische Tagung zu diesem Thema in Griechenland nicht erst mit einem so großen zeitlichen Abstand stattfinden wird wie diese Tagung zur letzten!

Katja Sporn

Athen, Dezember 2017

The history of the *Cura Aquarum* conferences

1st	1975	Koblenz, Germany
2nd	1977	Lyon, France
3rd	1979	Istanbul, Turkey
4th	1981	Athens, Greece
5th	1983	Jerusalem, Israel
6th	1985	Cairo, Egypt
7th	1988	Rome, Italy
8th	1991	Merida, Spain
9th	1994	Pompeii, Italy
10th	1998	Syracuse, Italy
11th	2001	Jerusalem, Israel
12th	2004	Ephesus, Turkey
13th	2007	Petra, Jordan
14th	2009	Toledo, Spain
15th	2012	Jerusalem, Israel
16th	2015	Athens, Greece

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The Water Supply of Athens through the Centuries

Demetris Koutsoyiannis and Nikos Mamassis

Abstract

The sites where major ancient civilizations were developed had similar climatological and hydrological conditions. All sites have in common warm and dry climate but also abundance of water from a large river crossing the area. However, the sites of ancient Greek civilizations, while they also have warm and dry climate, are located in water deficient areas without large rives.
The city of Athens played an important role to the Greek civilization and in general to the ancient world. It has been the cradle of democracy, the system of government in which all citizens are equally involved in taking decisions and actions. The natural environment of the Athens territory has been warm and dry, and the nearby Kephisos river has had ephemeral flow. The water scarcity of the area has been mentioned in many legends and ancient texts. Several aqueducts were constructed in several periods of the antiquity forming a network of pipelines.
The modern water supply system of Athens is an admirable hydraulic work. It includes four reservoirs in areas with different climates and geomorphological conditions, a complex aqueduct system and several water uses. The longest path of the water is about 217 km from Evinos Dam to Athens. The ancient Greek values and perspectives have been useful in the modern system design and management and have equal potential for modern problem solving. Several ancient Greek legacies are relevant in modern problem solving, including: (a) the creation of philosophy and episteme, (b) the conception of the principle of Orthos Logos (Right Reason), and (c) the creation of democracy.

1 Introduction

The water supply of ancient settlements was strongly depended on natural environment. During the Neolithic period and after the last Glacial Age, groups of people concentrated at a zone of hills extended from Syria-Palestine to the foot of Taurus and Zagros mountains. In these areas the winter rainfalls favoured the natural growth of wild grains, such as barley and wheat. About 9,000 BC, when the climate was stabilized, these communities developed the first agricultural methods and animal domestication, and constructed the first small hydraulic works. During the period from 7,500 to 4,500 BC (known as Neolithic revolution) the increased population was

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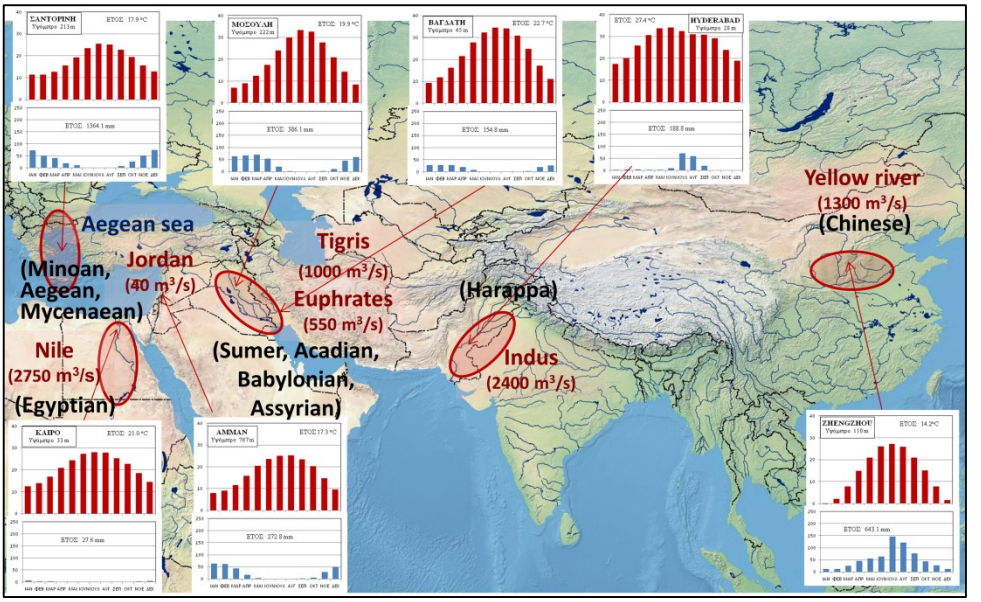

Fig. 1. Climatological and hydrological conditions in sites where ancient civilizations were developed.

spread to alluvial valleys adjacent to large rivers and established the first civilizations. That was the era when the first cities were developed.

The main sites where ancient civilizations were developed are depicted in Fig. 1. For each site the climatograms (monthly distribution of mean monthly temperature and precipitation) and the mean annual discharge of the rivers are displayed. The climatological and hydrological conditions of the sites are similar. All sites have in common warm and dry climate but also abundance of water from a large river crossing the area. Likewise, the sites of ancient Greek civilizations (Minoan, Aegean, Mycenaean) have the same warm and dry climate (Aegean islands, southern continental Greece). The big difference is that the Greek sites are located in water deficient areas without large rives.

The city of Athens was most influential on the Greek civilization and in the ancient world. The natural environment of the Athens territory has been warm and dry and the nearby Kephisos river has had ephemeral flow. The water scarcity of the area was vividly portrayed in an important legend of the Hellenic mythology, *the competition of Athena and Poseidon*. According to that, for choosing their patron god, Athenians organized a competition for two candidates: Athena, the goddess of wisdom, and Poseidon, the god of waters. Poseidon offered abundant spring water and Athena offered the olive tree and an explanation why it would be wiser to choose her gift. Athenians opted for Athena, which reflects the idea that scarcity may not be a punishment but a choice and that wisdom may be more powerful than abundance.

During the classical period, Thucydides, the father of "scientific history", asserted that scarcity of resources and poverty triggered progress in Athens:

> *"The richest soils were always most subject to this change of masters; such as the district now called Thessaly, Boeotia, most of the Peloponnese, Arcadia excepted, and the most fertile parts of the rest of Hellas. The goodness of the land favoured the aggrandizement of particular individuals, and thus created faction which proved a fertile source of ruin. It also invited invasion. Accordingly Attica, from the poverty of its soil enjoying from a very remote period freedom from faction, never changed its inhabitants. And here is no inconsiderable exemplification of my assertion that the migrations were the cause of there being no correspondent growth in other parts. The most powerful victims of war or faction from the rest of Hellas took refuge with the Athenians as a safe retreat; and at an early period, becoming naturalized, swelled the already large population of the city to such a height that Attica became at last too small to hold them, and they had to send out colonies to Ionia."*[1]

2 Water supply in ancient Athens

Indeed, scarcity of water triggered institutional and technological advances from the early stages of the Athenian state, which were able to ensure the supply of Athenians with fresh water. One of the earliest measures of this type appears in Solon's legislation, in the beginning of the 6th century BC:

> *"Since the area is not sufficiently supplied with water, either from continuous flow rivers, or lakes or rich springs, but most people used artificial wells, Solon made a law, that, where there was a public well within a hippicon, that is, four stadia* [710 m]*, all should use that; but when it was farther off, they should try and procure water of their own; and if they had dug ten fathoms* [18.3 m] *deep and could find no water, they had liberty to fetch a hydria (pitcher) of six choae* [20 L] *twice a day from their neighbours; for he thought it prudent to make provision against need, but not to supply laziness."*[2]

[1] from: Thucydides, The Peloponnesian War, 1.2.3-6. English translation: Richard Crawley, www.gutenberg.org/files/7142/7142-h/7142-h.htm.

[2] from: Plutarch, Solon, 23. Translation by John Dryden (http://classics.mit.edu/ Plutarch/solon.html) after adaptation.

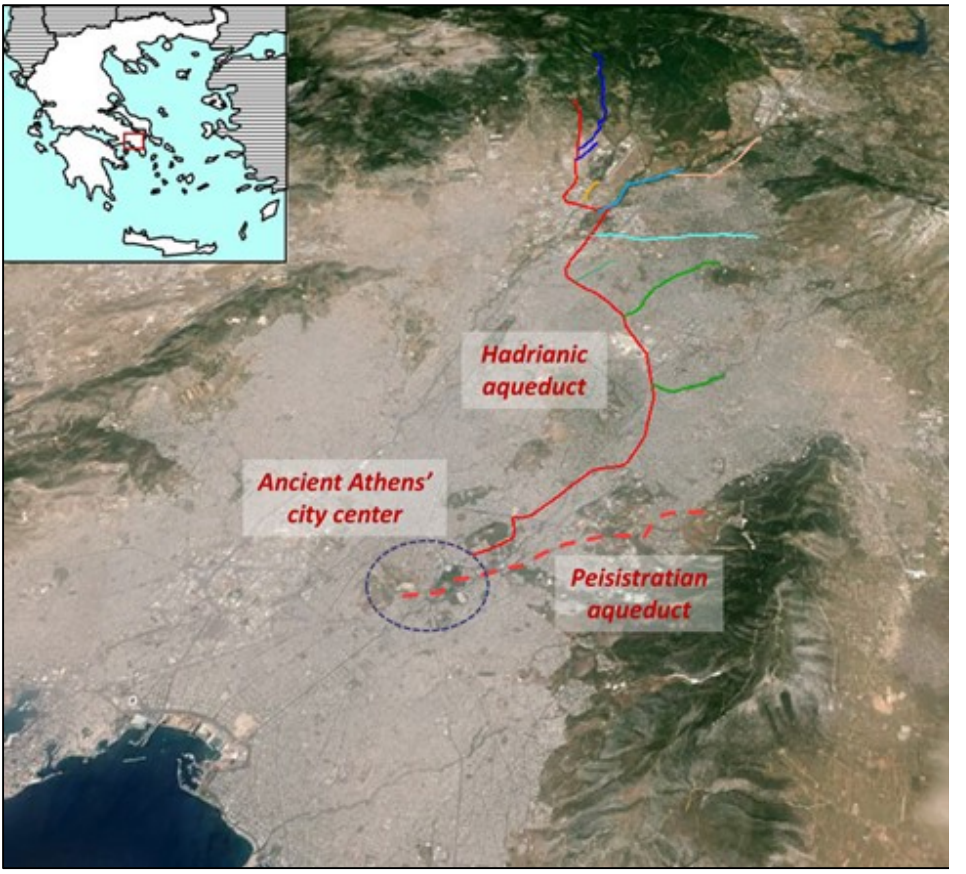

Fig. 2. Ancient aqueducts of Athens: Peisistratian (dashed line) and Hadrianic (solid line).

Important elements of that law are (a) the priority given to public wells and their protection, (b) the balance of the public and private interests for the construction and operation of wells, (c) the regulation of relationships among individuals in order to cover water needs of all citizens, and (d) the provision against need, while discouraging laziness.

The first major hydraulic project in Athens was an aqueduct constructed under the tyrant Peisistratos (in power between 546-527 BC) and his sons. The Peisistratean aqueduct has a length of about 8 km (Fig. 2 – dashed line). Its largest part was carved as a tunnel at depth reaching 14 m. Other aqueducts were also constructed in several phases (as thoroughly presented in Chiotis - Chioti 2012) forming a network of pipelines; one of them, the Hymettus aqueduct, follows a route parallel to the Peisistratean. In contrast to later Roman aqueducts, the Greek hydraulic constructions were mostly underground for security reasons (e.g. in case of war; Koutsoyiannis *et al.* 2008).

In addition to wells and large-scale aqueducts, Athenians advanced a technology of storing rainwater from roofs in underground cisterns. In several cases, small-scale constructions, *i.e.* wells and cisterns, were interconnected forming complex systems storing ground and rain water. The rationale behind such connections must have been (a) to recharge aquifers with excess rainwater, (b) to use the tunnels as extra storage, and (c) to facilitate water distribution, exploiting the principles of hydraulics.

In Athens a distinguished public administrator, called «*κρουνῶν ἐπιμελητής*», (Superintendent of Fountains), was appointed to operate and maintain the city's water system, to monitor enforcement of the regulations and to ensure the fair distribution of water. This officer was one of the few that were elected by vote whereas other officers were chosen by lot[3]. This must be related to the high importance of this particular position, in which even Themistocles had served. Generally, private sponsoring of public hydraulic systems was encouraged; *e.g.* in 333 BC the Athenians awarded a gold wreath to the Superintendent of Fountains Pytheus because he restored and maintained several fountains and aqueducts.

The rationale behind the complexity of the Athens water supply system is the fact that using many sources of water, *i.e.* ground, rain and spring water, makes the system more reliable than relying on a single source. Also, using and maintaining large-scale public works (aqueducts) can provide more water at lower cost. However, the private small-scale constructions (wells and cisterns), provide security and safety, particularly in times of war and crisis.

The last and longest ancient aqueduct, the Hadrianic aqueduct, was constructed during Roman times (Fig. 2 - solid line). Its length is 25 km and, as all earlier ones, it is subterranean at typical depths of 20-30 m.

3 The modern water supply system and its links to the past

Up to the early 20th cent., the water supply of modern Athens fully relied on the ancient hydraulic works. The Hadrianic aqueduct was repaired and its cistern in Lycabettus was reconstructed in 1870 and was used to provide drinking water up to the mid-20th cent. The Peisistratian aqueduct is still in operation providing irrigation water to the National Garden (Panagoulia - Zarris 2009). However, as the identification has not been conclusive yet this could be the Hymettus aqueduct parallel to the Peisistratean (Chiotis - Chi-

[3] "*All the officials concerned with the regular administration are appointed by lot, except a Treasurer of Military Funds, the Controllers of the Spectacle Fund, and the Superintendent of Fountains; these officers are elected by show of hands, and their term of office runs from one Panathenaic Festival to the next. All military officers also are elected by show of hands*" from: Aristotle, Athenaion Politeia, 43.1. Translation by H. Rackham. Cambridge, MA, Harvard University Press; London, William Heinemann Ltd. 1952.

oti 2012). In the course of the 20th cent., a huge modern water supply system (Fig. 3) has been gradually developed in Athens.

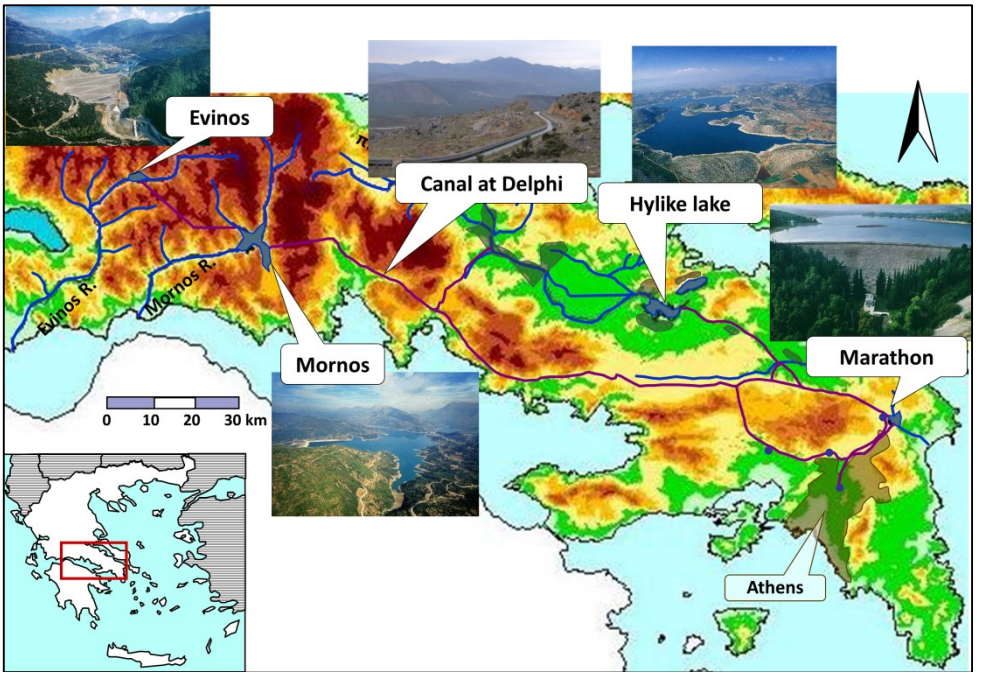

Fig. 3: The modern water supply system of Athens.

The first modern project for the Athens water supply was constructed between 1926 and 1929 by Ulen & Co. from New York. The project included (a) the *Marathon Dam* which is a 54 m tall concrete dam, the only in the world with a marble coating, (b) a 21.5 km aqueduct (with a tunnel), and (c) a water treatment plant. In the late 1950s, the *Lake Hylike* became part of the Athens hydrosystem, as an aqueduct (with parts under pressure) was built to transfer the water to the city. In the 1970s the *Mornos Dam and aqueduct* were constructed in western Greece about 180 km from Athens.

In the late 1980s, a persistent (seven-year) drought occurred and, subsequently, a new large-scale project, namely the *Evinos Dam and tunnel*, were studied and constructed. The tunnel, which conveys water to the Mornos reservoir, was completed in record short time (less than three years). During the drought period, several aquifers were intensively exploited with new boreholes and pumping stations. Also individuals and municipalities searched for alternative local water sources, mostly groundwater from lower quality local aquifers, to irrigate private and public gardens, to wash roads and cars and to use it in industry. Additionally, water demand control was

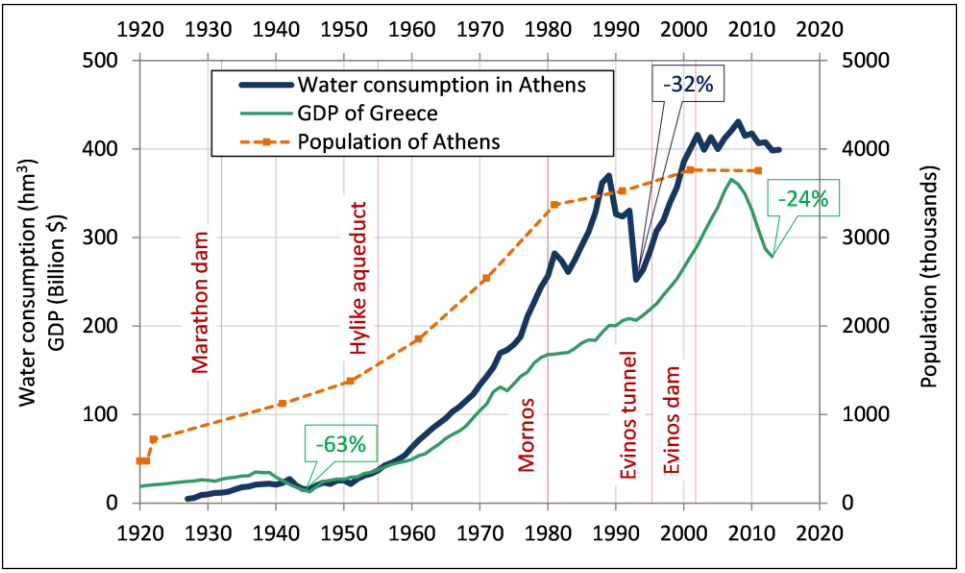

Fig. 4: Evolution of (a) water consumption of Athens (b) GPD of Greece (data from gapminder.org), and (c) population of Athens; time stamps of major water supply works for the Athens hydrosystem are also shown.

performed including (a) two drastic increases in water price, with increasing block tariffs and discount for significant water conservation, (b) severe restrictive regulations, including prohibiting and fining the use of treated water for irrigation, car and road wash, and swimming pools, and (c) a massive public information campaign (via press, TV, school programs). With these actions all people had been aware of the problem and its real causes, and had actively participated to the problem solution.

The success in dealing with the persistent drought is also illustrated in Fig. 4, which depicts the temporal evolution of water consumption in Athens. Indeed, the measures during the drought period had a significant effect to water consumption, as a decrease of about 32% was achieved without leading the water system to failure.

In parallel to the evolution of water consumption, Fig. 4 also depicts the evolution of the population of Athens and the Gross Domestic product (GPD) of Greece. It is obvious that water consumption is correlated to both the population and the GDP. Also we can conclude that increase of water availability (with the construction of hydraulic works at the years indicated in the figure) results in increase of water consumption.

Modern Athenians are capable to combine the convenient and healthy way of living in dry climate and the water sufficiency of the wet western part of Greece. The modern water supply system of Athens is an admirable hydraulic

Fig. 5. Marathon dam (upper), the end of the bottom outlet of the dam (lower left) and the replica of the Athenian Treasury at Delphi (lower right).

work. Its longest path from Evinos to Athens (Acharnae Water Treatment Plant) is about 217 km (not counting the path across the Mornos reservoir). The aqueduct is comparable to some of the world's most famous aqueducts such as: (a) Los Angeles First Aqueduct, 375 km; (b) Los Angeles Second Aqueduct, 220 km; (c) Thirlmere Aqueduct, Manchester, 154.3 km; (d) Delaware Aqueduct, New York (the world's longest continuous underground tunnel), 137 km; (e) National Water Carrier of Israel, 130 km; and (f) Päijänne Water Tunnel, Helsinki, 120 km.

The management of the Athens hydrosystem, which comprises four reservoirs in areas with different climates and geomorphological conditions, a complex aqueduct system and several water uses, is also challenging. The simulation and the management of the hydrosystem using a Decision Support System (DSS) and the operational rules are thoroughly discussed by Koutsoyiannis *et al.* (2002, 2003) and Efstratiadis *et al.* (2004). The mathematical framework of the methodology is presented in Nalbantis - Koutsoyiannis (1997), and Koutsoyiannis - Economou (2003), while a more general setting of the management problem and its logical connotations can be found in Koutsoyiannis (2011a).

Several links between the modern hydrosystem of Athens and the Greek antiquity may be interesting to notice. The structure at the end of the bottom outlet of Marathon dam (Fig. 5) is a replica of the Athenian Treasury at Delphi that was built for the victory in the Battle of Marathon (490 BC). The replica symbolizes the victory of modern Athenians against drought. Furthermore, the lake Hylike receives waters from the former lake Copais, which was drained in the beginning of the 20th cent. AD. During the Mycenaean period (12th cent. BC), the inhabitants (Minyans) drained part of the lake Copais and reclaimed land for agriculture. A channel and a levee diverted two rivers to natural sinkholes (Mamassis *et al.* 2015). Later, a drainage tunnel was attempted but never completed. Finally, to exploit the water of the Mornos River, the ancient city of Kallipolis was sacrificed, along with the modern village of Kallion. They are now submerged in the Mornos reservoir.

4 From ancient to modern water problems

In a significant part of the world the current water supply level is inferior to that in ancient Athens (Koutsoyiannis 2011b). From Fig. 6, which depicts the domestic water use for each country, it becomes obvious that currently there are a lot of problems to solve in the world.

Could ancient Greek values and perspectives be useful to modern problem solving? We believe that the following three important contributions of ancient Greeks are quite relevant in modern problem solving and that revisiting these legacies in their original form would be quite useful.

Episteme (*i.e.* science) was created to explain nature and history based on reason and in parallel to philosophy[4]. The two had very strong links to each other. In our time, science has spectacularly progressed, but has departed from its foundation, that is, philosophy, while, in many cases, science-based propaganda (else known as sophistry) has prevailed over scientific inquiry.

[4] Thales of Miletus (640-546 BC) was the father of philosophy and of science. Thucydides was the father of scientific history (based on evidence and analysis in terms of cause and effect).

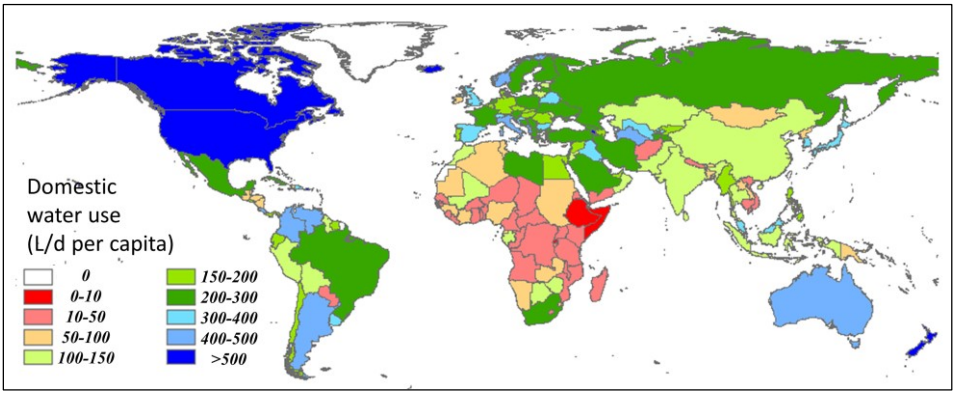

Fig. 6: Domestic water use in each country (L/d per capita).

Athens is also the birth place of the principle of *orthos logos* (*i.e. recta ratio*, or right reason) in guiding human decisions and actions. Aristotle (384-328 BC) was perhaps the first to formulate this principle[5]. Unfortunately, in our postmodern era, paralogism or irrationality is not uncommon, while doctrines and stereotypes often prevail over *orthos logos*.

Athenians also created democracy, the system of government in which all people are equally involved in taking decisions and actions. The original definition of democracy was formulated by Pericles in his Epitaph, quoted by Thucydides[6]. Many admit that the Athenian democracy has been the most advanced and radical in history. Others criticized it because it excluded a large part of the population. But it is important to note that the principle of inclusion was simple and clear: the rights arise from the fulfilment of obligations. It is a pity that this principle is forgotten in modern states, including in Greece. It is also a pity that the functioning of the Athenian democracy was unknown during the establishment of modern republics. For, Aristotle's book *Αθηναίων Πολιτεία* (*Constitution of the Athenians*) had been lost until the end of the 19th cent. Currently, the synergy of economic powers and high technology lead modern societies to oligarchy and it is a big challenge to re-establish democracy by studying its principles as originally formulated. Otherwise, that synergy could lead to a locked cockpit.

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[5] "*It is a common principle which must be accepted that we must act in accord with orthos logos*" from: Aristotle, Nicomachean Ethics, 1103b (translation by authors).

[6] "*καὶ ὄνομα μὲν διὰ τὸ μὴ ἐς ὀλίγους ἀλλ' ἐς πλείονας οἰκεῖν δημοκρατία κέκληται· μέτεστι δὲ κατὰ μὲν τοὺς νόμους πρὸς τὰ ἴδια διάφορα πᾶσι τὸ ἴσον, κατὰ δὲ τὴν ἀξίωσιν, ὡς ἕκαστος ἔν τῳ εὐδοκιμεῖ, οὐκ ἀπὸ μέρους τὸ πλέον ἐς τὰ κοινὰ ἢ ἀπ' ἀρετῆς προτιμᾶται".* Translation: "[The Athenian] *administration is called democracy because it is the responsibility of the many instead of the few; the laws ensure equal justice to all in their private differences, but with respect to public interests, each citizen is preferable to public office not by class considerations but by merit."* from: Thucydides, The Peloponnesian War, 2.37 (translation by authors).

5 Conclusions

Overall, from the above discourse we may draw the following conclusions.

- The study of history is a good advisor for problem solving. This applies to water problems too.
- Ancient Athens was equipped with several hydraulic works which operated as a hydrosystem. Legislation, institutions and public awareness about water strongly supported hydrosystem's operation.
- The implemented technology has been related to socio-economical characteristics of the societies. In Athens during some periods, the political situation favoured the construction of large public works (such as the Peisistratean aqueduct). On the other hand, the democracy favoured the balance between small scale, safe and cost efficient management structures, on the one hand, and large scale technological systems on the other hand; between structural measures and institutional arrangements; between interests of the private and the public sectors; and between technological progress and sustainability. All this, in a framework of resilience, particularly in periods of crisis, and durability, as exemplified by the fact that we still have in operation ancient aqueducts.
- Technology developing is guided by necessity and can modify poor natural conditions.
- Technology is not enough. It should be combined by episteme (science), orthologism (rationalism) and democracy. Technology, episteme, orthologism and democracy are all legacies of ancient Greeks.
- Modern Athenians do not claim exclusiveness of these legacies. Sharing material things may sometimes be *division*. But sharing intellectual values is always *multiplication*.

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