

CLIMATE CHANGE & THE ENVIRONMENT

As environmental issues become an increasingly acute concern worldwide, Turkey is a country of prime interest in the field of climate studies. Due to its location, it presents an ideal opportunity to explore and understand climate development and the history of global environmental change within the context of contemporary international relations. Lake sediments, tree-rings, speleothems and peat deposits represent valuable natural ‘archives’ of environmental change that have been under-explored in both Turkey and the wider Black Sea region. This programme of research into the vegetation and climate history of the region focuses on changes in vegetation, water resources, landscape stability and hazards in Turkey, the Black Sea area and much of the wider Middle East over time. It also provides a key context of interaction concerning human use of the landscape from prehistory to the present day.

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The water management infrastructure of Istanbul

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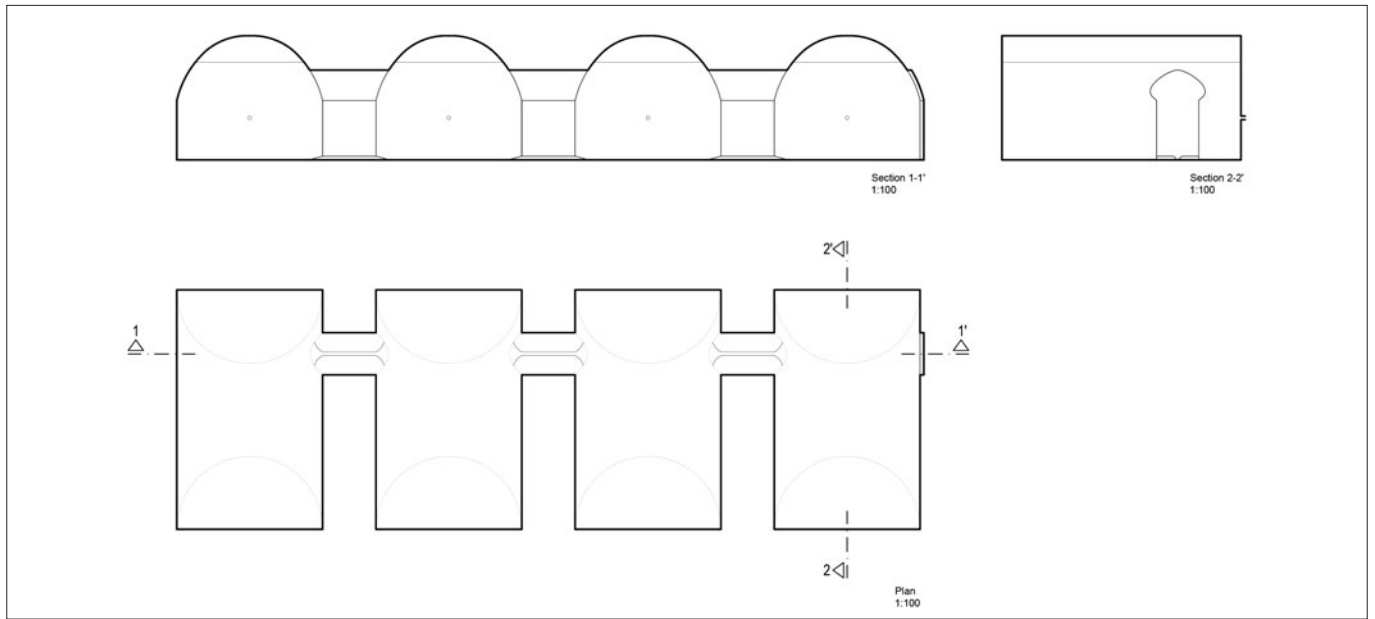
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The ‘Water in Istanbul: Rising to the Challenge?’ project brings archaeologists, engineers, social scientists and historians from the University of Edinburgh, Northumbria University, Istanbul Technical University (ITU) and the British Institute at Ankara (BIAA) together to investigate the water management infrastructure of Istanbul at two key phases in the city’s life – the transition from Byzantine to Ottoman rule and the period of massive population explosion beginning ca 1980 – and explore how past practices can inform solutions to contemporary water-related challenges. It is funded by the British Academy’s Knowledge Frontiers International Interdisciplinary Research Scheme, two BIAA Research Grants, the Scientific Research Projects Department of Istanbul Technical University and the SFC GCRF Fund of the University of Edinburgh.

Over the last year, considerable progress has been made on creating a GIS model of the complex systems that supplied water to Istanbul’s First Hill, an area of 70 ha. Using data from a range of sources – notably Hülya Tezcan’s catalogue of Byzantine remains within the Topkapı palace area and previous fieldwork led by Çiğdem Özkan Aygün – 28 underground cisterns of various sizes along with several connecting channels have been plotted. The distribution of these features was contextualised in relation to known Byzantine and Ottoman buildings and analysed using GIS tools to identify areas for further investigation with GPR and to provide a digital platform for use in hydraulic modelling.

In the process of generating the GIS model, previously neglected findings were reassessed, including the largely unpublished evidence for two cisterns, baths and a street with associated channels and drains uncovered by Nezih Firatlı prior to the construction of a new annexe on the east side of Istanbul Archaeology Museum in 1969. Documents from these excavations were examined in the museum archives, and a new survey was conducted to inform the production of plans of a previously unpublished cistern comprising four parallel halls connected to each other with horseshoe-shaped arches (see drawing, page 26).

By taking the elevation of known structures into account, the GIS model facilitates reconstruction of the water supply network around the First Hill and investigation of how water flowed through it. Of particular interest is a late Roman cistern, documented by Tezcan, located below the courtyard of the Archaeology Museum. From its elevation, this cistern may have been sourced from the Yerebatan Saray. GPR survey revealed subsurface traces consistent with the known features of the cistern, as well as previously undocumented channels leading to and from it. In the next phase of the project, a further survey will be conducted using a 100 MHz antenna to collect additional data and determine the cistern’s precise boundaries. GPR results also indicate a possible, undocumented cistern to the northeast of Çinili Kiosk, one of the earliest Ottoman structures on the First Hill; this will also be investigated further in the next phase of the project.



Plan of a small, previously unpublished cistern in the vicinity of Istanbul Archaeology Museum, comprising four parallel halls connected via horseshoe-shaped arches (drawing by Ece Uysal Engüdar based on measurements by Çiğdem Özkan Aygün, Ece Uysal Engüdar and Ahsen Karagöl).

Through cooperation with Istanbul Water and Sewerage Administration (ISKI), a range of maps showing the modern water supply lines, and others dating to 1961 – prior to the recent population explosion – have been integrated into the GIS model. This allows for direct comparison between water usage and distribution networks over time and adds significant value to the model in terms of future research potential.

The initial phase of the hydraulic analysis involved reviewing previous studies, notably the work of Kazim Çeçen, and examining historical documents relating to Ottoman water structures such as distribution chambers and water towers.

Water originally seems to have been supplied to the First Hill via an underground system of channels and pipes leading to deep wells including the Dolap Ocağı in the first courtyard of the palace. Ottoman maps dating to 1607 and 1748 show a sequence of later towers that were able to maintain sufficient pressure to transport water to the high ground of the Topkapı area via a system of distribution pipes and compartments fed by ‘lüle’ (nozzles). Data was gathered on the geometry of the extant water towers near the Milion and Imperial Gate, as well as those present inside the second palace courtyard. A document dating to 1509, analysed by Gülru Necipoğlu, provides vital information on the amount of water delivered via these towers, allowing hydraulic calculations to be made.

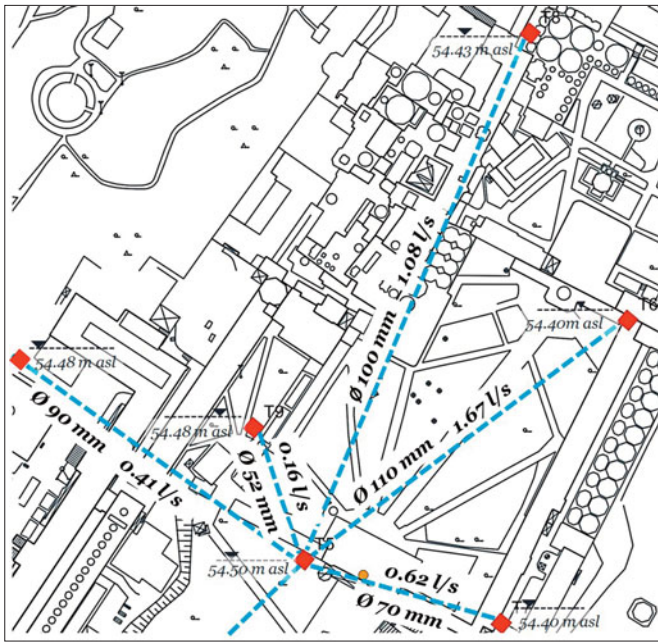
The figure on page 27 shows some of the results of the hydraulic analysis conducted on the water tower system in the second courtyard. The elevation of the water surface in the towers (m asl), the diameters of the pipes (mm) and the flowrates (l/s) required to supply the palace’s fountains, pools, baths and other features in the most favourable hydraulic

conditions (pipes with few encrustations and having the minimum required length) are shown; other conditions are under evaluation.

An additional source of water, supplied by waterwheels and wells connected to the Kırkçeşme line, will be examined in the next phase of the project, and information from the GPR investigations integrated in order to build a more complete hydraulic model. Once this is done, the capacity of known systems can be calculated and compared to estimates



A 1748 map in Topkapı Palace Museum showing a sequence of water towers supplying the palace (Istanbul, Topkapı Palace Museum Library (TSMK) H. 1815).



Hydraulic analysis of water distribution between towers in the second courtyard of Topkapı palace (produced by Maria Monteleone and Martin Crapper based on a 1509 document analysed by Gülru Necipoğlu).

of the amount of water needed to supply the palace. Following this, the location and nature of lost water towers and other features can be postulated.

One of the main ways in which learning from past practices is informing responses to contemporary challenges is through engagement with stakeholders responsible for the modern water management infrastructure of Istanbul to share insight from the archaeological fieldwork and hydraulic analysis, identify current challenges and discuss potential solutions. The aspect of the historic water management infrastructure found to be of most interest to these stakeholders was rainwater harvesting, and three participatory knowledge-generation workshops – attended by more than 70 representatives from the Ministry of

Agriculture and Forestry; Istanbul Metropolitan Municipality; ISKI; Kadıköy, Pendik and Ümraniye Municipalities; universities; NGOs and the private sector – have so far been organised to explore this topic.

As reported in *Heritage Turkey* 11, the first workshop presented features of the historic water management infrastructure, explored current needs and examined rainwater harvesting and water storage from legal, technical and social perspectives.

The second workshop, held in March 2022, invited participants to propose solutions to the problems identified in the first workshop, experienced to date, and likely to be encountered as rainwater harvesting systems become more widespread. Issues at all phases of the process of implementing a rainwater harvesting system – including planning, project design, obtaining construction permits, construction, obtaining occupancy permits, sustainable use, and monitoring and auditing – were examined, with suggested solutions clustering under five main headings: (1) regulatory change; (2) finance and incentives; (3) governance structures; (4) technical solutions; and (5) cultural and attitudinal change.

In response to feedback received following the second workshop, the third participatory workshop, held in July 2022, focused on the components of rainwater harvesting systems in buildings and auditing mechanisms. Participants agreed on the need for comprehensive legal regulation, which should include detail on how district municipalities and ISKI should work together with the Chamber of Mechanical Engineers, the private sector and other stakeholders to implement sustainable rainwater harvesting.

In the final participatory workshop, experts from the Ministry of the Environment, Urbanisation and Climate Change; the Ministry of Agriculture and Forestry; Istanbul Metropolitan Municipality; ISKI; and district municipalities will come together to discuss rainwater harvesting on a neighbourhood scale as a means to create new water supplies for common public use; for example, for park irrigation and street washing.



Participatory workshops with stakeholders involved in Istanbul's present-day water supply system (photographs by Lutgarde Vandepuit).