CLIMATE CHANGE & THE ENVIRONMENT

As environmental issues become an increasingly acute concern worldwide, Türkiye 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 Türkiye 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 Türkiye, 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.

doi:10.18866/biaa2023.12

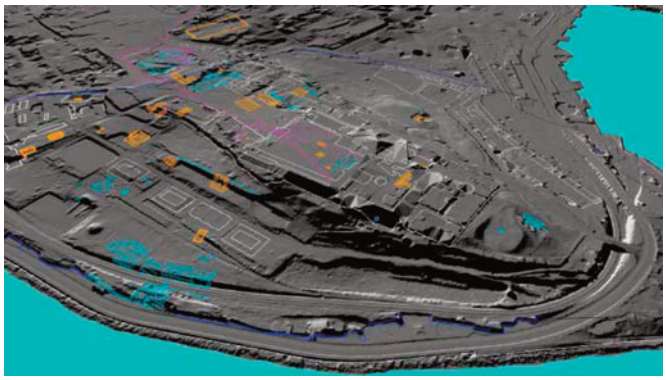
Water in Istanbul and beyond: past, present, future

Stefano Bordoni, Jim Crow | University of Edinburgh
Martin Crapper, Maria Monteleone | Northumbria University
Akgün İlhan, Lutgarde Vandeput, Martyn Weeds | British Institute at Ankara
Caner İmren, Beril Karadöller, Çiğdem Özkan Aygün | Istanbul Technical University
Ender Peker | Middle East Technical University & British Institute at Ankara

The BIAA-led Water in Istanbul: Rising to the Challenge? project brought together archaeologists, social scientists and hydraulic and geophysical engineers from the University of Edinburgh, Northumbria University, Istanbul Technical University (ITU), Middle East Technical University (METU) and the British Institute at Ankara (BIAA) to investigate the past and present water management infrastructure of Istanbul and explore how past practices can inform solutions to contemporary and future water-related challenges.

A major objective of the project was to develop a better understanding of the Ottoman system for supplying water to Istanbul's First Hill, as this presented particular challenges due to its elevation. A survey was conducted around the Topkapı Palace, Ayasofya and Yerebatan Sarayı using Ground Penetrating Radar (GPR) in combination with targeted archaeological fieldwork to acquire precise data on water levels as well as conduit, channel and cistern sizes. The work carried out in the streets around the palace revealed a number of previously unknown water channels, while intensive research around the adjacent Archaeological Museum added considerably to previous knowledge of the water infrastructure in that area. The museum is built on a terrace dating from the Byzantine era, and GPR in the courtyard revealed new cisterns from that period and later, as well as related supply channels.

GPR survey work around the Istanbul Archaeological Museum.

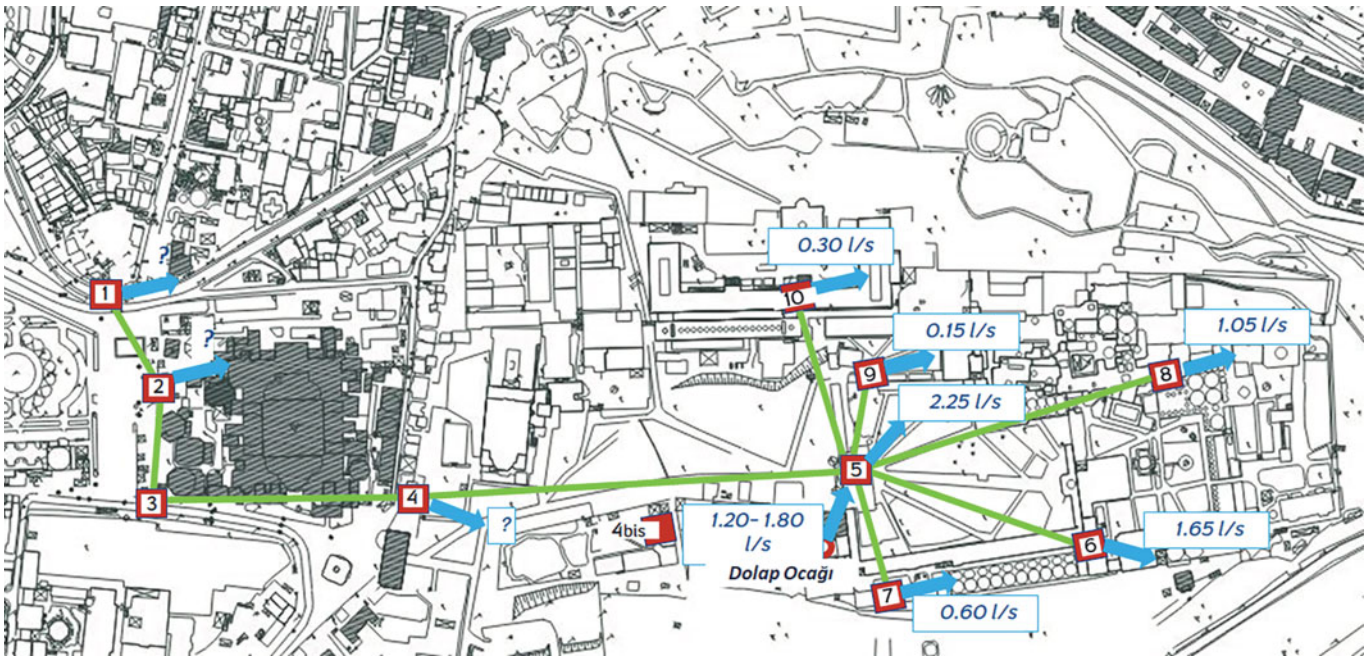


3D model of the First Hill showing the distribution of known cisterns (orange) and the outline of the principal Ottoman buildings.

To complement and inform the fieldwork, archival research brought hitherto unpublished information from earlier excavations around the museum to light, including evidence for channels, pipes and a Byzantine water shaft. This information, as well as results from previously published research, was incorporated into a Geographic Information System (GIS) 3D model of the First Hill and plotted in relation to Byzantine and Ottoman buildings.

The result is that – for the first time – all known remains of water-related infrastructure in the First Hill area have been integrated into a single model, contributing significantly to our understanding of how different elements of the historical water management infrastructure were linked and functioned together as an evolving system. Detailed maps showing modern water supply lines and others dating from prior to the population explosion in the final decades of the 20th century were also integrated into the model to allow comparison between water usage and distribution networks over time.

The results of the GPR survey and GIS modelling informed engineering analysis of the Ottoman water distribution system within the Topkapı Palace and the possible Roman system that supplied the First Hill prior to the Ottoman conquest. There is no definitive archaeological trace of the earlier supply line, so engineering judgement combined with GPR observations and the locations of known cisterns were drawn upon. Previous work by Ward, Crow and Crapper (2017) concluded that the Hadrianic Aqueduct, which is known from contemporary sources to have supplied the Yerebatan Sarayı, approached the First Hill from the south, presumably passing between the cistern and Ayasofya, at which point it must have been no higher than around 33m above sea level (asl). This potentially ties in with the project's GPR investigations, which identified possible subterranean cavities on Osman Hamdi Bey Yokuşu and Soğuk Çeşme Sokak (see *Heritage Turkey* 2021), one or both of which might have been aqueduct channels, these having elevations of around 22–26m and 29m asl respectively. However, careful examination of Tezcan's (1989) data shows that the cistern beneath the Archaeological Museum courtyard has a base level of around 16m asl, so it would be possible for it to have been supplied in this way. The Yerabatan Sarnıcı could have been supplied by a branch leaving the



Hydraulic modelling of the 1509 water supply to the First Hill indicates that the total incoming flowrate (Beylik: 2–3 l/s and Kırkçeşme: 1.2–1.8 l/s) did not provide the amount of water required to operate all the Palace installations at the same time.

View of the current excavations, the Million and the line of the Ottoman pipes (photograph by J.C. Crow).

Hadrianic aqueduct further to the south and traversing the west side of the valley. The only way the First Hill could have been supplied would be by raising water, either from low cisterns or via channels to the bottom of the deep shafts known as the Dolap Ocağı, which although clearly Ottoman in construction likely succeeded a similar Roman structure or structures. A channel following our postulated route at close to ground level would have had a slope of 3 m/km and a capacity of around 0.97 m^3/s if of a cross-section similar to the Fourth Century aqueducts observed in Thrace.

The problem of supplying the rapidly growing city with water is one that also challenges contemporary engineers, policymakers and urban planners, particularly in the context of climate change and increasing water scarcity. Inspired by past practices, discussions with Istanbul's water management authorities and other local stakeholders identified rainwater harvesting as a potential solution to the urgent need for an alternative water source for the city. However, challenges to implementation were found to exist on a number of levels. These challenges, and explorations of possible solutions, formed the main focus for a series of four participatory action research workshops which brought water management experts from Istanbul Metropolitan Administration (IBB), Istanbul Water and Sewerage Administration (ISKI), district municipalities, ministries, academic institutions, private sector organisations and NGOs together for the first time.

As described in *Heritage Turkey* 2021, the first workshop defined the challenges that needed to be overcome in order to implement effective rainwater harvesting systems. The second workshop analysed and developed potential solutions to these challenges, while the third focussed on determining institutional ownership of the audit of the rainwater harvesting systems and on solving problems of ambiguity in methods and techniques. The results of this workshop led to changes in regulations and empowered ISKI to issue approval for rainwater harvesting systems before occupancy. A more detailed summary of the second and third workshops can be found in *Heritage Turkey* 2022.

While the first three workshops and related activities focused on rainwater harvesting systems for individual buildings, the fourth – held in November 2022 – examined how rainwater harvesting could be implemented in public spaces at street, neighbourhood and district levels, as well as how it can be incorporated into spatial planning processes. Eleven types of rainwater collection area (green areas, stream banks, gardens of public buildings, sports

Poster for the final conference, held at ITÜ in March 2023.

grounds, roadsides, public squares, coastal areas, parking lots, disaster assembly and shelter points, private gardens, and marketplaces) were defined. Of these, the first three were identified as the most promising for the implementation of rainwater harvesting systems. Relevant suggestions on legislative implementation tools and the appropriate actors to create and put them into action were incorporated into a report that was presented to all institutions involved.

The project formally concluded with a major conference held at Istanbul Technical University and online in March 2023. The conference attracted an international audience of approximately 250 academics, students, policymakers, municipality representatives and other stakeholders, as well as members of the public.

Based on the results of Water in Istanbul: Rising to the Challenge?, a follow-up project, led by the BIAA and funded by UK International Development, is currently being implemented to develop and deliver an experience-based training programme to equip municipalities in Türkiye with the knowledge, resources and capacities to implement sustainable rainwater harvesting. In addition to the training programme itself, the main outputs of this project will be the initiation of a pilot project in Kadıköy Municipality and an online multimedia toolkit to widen impact to all municipalities in Türkiye (see below).

Running from 2021 to 2023, the Water in Istanbul: Rising to the Challenge? project was funded by the British Academy's Knowledge Frontiers International Interdisciplinary Research Scheme, the Scientific Research Projects Department of Istanbul Technical University, two BIAA research grants and the SFC GCRF Fund of the University of Edinburgh.

doi:10.18866/biaa2023.13

Local climate action: empowering municipalities on rainwater harvesting

Ender Peker | Middle East Technical University & British Institute at Ankara
Akgün İlhan | Bogazici University & British Institute at Ankara

I consider myself fortunate to have an engineer in our department with expertise in rainwater harvesting systems, who is also dedicated to continuous exploration and development in this field. Thanks to him, we have successfully conducted rainwater harvesting implementations in some of our service buildings. However, it's worth noting that there is a noticeable lack of awareness among our municipal staff concerning this issue, as well as climate adaptation in general. Would it be possible for us to collaborate on addressing this matter?
(Director, Kadıköy Municipality, Istanbul)

This was the response we received from one of the key directors at Kadıköy Municipality during a feedback interview as part of the Water in Istanbul: Rising to the Challenge? project (see above), which aimed to draw lessons from past solutions to water-related difficulties that could be applied to contemporary challenges. As one of the pioneering municipalities in Istanbul, Kadıköy has taken some initial measures to address the risk of water scarcity in the face of climate change. To create an alternative water resource, the municipality has implemented rainwater harvesting (RWH) methods in four different public buildings. These initiatives have successfully replaced a portion of the mains water used for street cleaning in the district. The pilot projects were voluntarily designed and implemented by an engineer working under the guidance of the Directorate of Climate Change and Zero Waste. However, as indicated by the quote, city officials working in various departments responsible for local climate action lack technical knowledge of rainwater harvesting systems.

With the support of a small research grant from the British Institute at Ankara, we have been conducting additional research with Kadıköy Municipality to better understand the challenges that emerge due to lack of resources – including staff, knowledge and tools – to implement rainwater harvesting systems. We conducted group interviews with directors and experts from the Directorates of Climate Change and Zero Waste, Strategy Development and Foreign Relations, Zoning and Urbanisation, Technical Works, Parks and Gardens, Plans and Projects, License and Inspection, and Construction Control. In total, we interviewed 23 experts, and the analysis of these interviews helped us identify the most frequently mentioned challenges and needs within these directorates. To share the findings with municipal staff and design the remainder of the process in a way that is meaningful to the municipality, we organised a roundtable meeting with key directors who hold significant responsibilities for rainwater harvesting facilities. They agreed on the need for a training programme where municipal staff could practise collaborative work while attending lectures provided by external experts. Here, a wide range of training needs were described, starting from learning how a simple rainwater collection system works at the building scale, and progressing to how complex systems can be designed at the urban scale.