
Sustainable Water Management: Learning from the Past to Inform the Future



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Abstracts

 **BIRI**

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9.45-10.05 Lancelotti, C. and S. Biagetti, Archaeology's unfulfilled potential:
Bridging disciplinary gaps for sustainable development

10.05-10.25 Morabito, L., M. H. Velasco, J. Thompson, T. Stambouli, S. Ghattas, R. Foote and
C. Cone, Towards water resilience through synergy: the role of archaeology,
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management in AIUla

10.25-10.45 (online) Wellbrook, K., H. Hayajneh, A. Alsouliman, P. Keilholz and H. G. K. Gebel,
Applied Archaeohydrology. Traditional water management in Jordan's
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2. Water Management in Past Urban Contexts – Insights for the Future

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11.15-11.35 Crow, J. and L. Vandeput, Water in Istanbul: Rising to the challenges, lessons from
the Byzantine/Ottoman transition

11.35-11.55 Peker, E. and A. Ilhan, A participatory methodological framework for reviving
lost culture: rainwater harvesting in Istanbul

11.55-12.15 Alam, I. and C. A. Petrie, Learnings from a Mughal waterscape:
Modelling & evaluating Shahjahanabad's hydrological landscape

12.15-12.35 Motta, D., M. Crapper, D. Keenan-Jones, M. Monteleone and E. Poehler,
Ancient Roman water infrastructure and long-term adaptation: insights from
interdisciplinary research

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3. Rural Water Management Practices

Chair: Jim Crow

- 14.00-14.20 Massa, M., J. Wainwright, D. Motta and E. Peker, Fragile landscapes: The past, present and future of water use in the Konya Plain, Türkiye
- 14.20-14.40 Şenkul, Ç. et al., Water security in Türkiye: lessons from the past to enhance socio-ecological resilience to future challenges
- 14.40-15.00 Stump, D., Why allowing water to erode soils is not always a bad idea: How farmers in Konso, Ethiopia, and Engaruka, Tanzania, managed soils and water for centuries, and what these practices teach us about soil and water conservation today
- 15.00-15.30 BREAK

4. Water Governance and Infrastructure Histories

Chair: Martin Crapper

- 15.30-15.50 Moradi, H., Harnessing water resources in arid landscapes: A case study of the Neyriz Plain, Fars Province, Iran
- 15.50-16:10 Vetter, Th. and A. - K. Rieger, Ancient water harvesting in the Marmarica as a model for sustainable and adapted management of scarce natural resources
- 16.10-16.30 Davies, M., W. Kipkore and S. Lunn-Rockliffe, Unintended consequences, conflict and resilience in a small-scale irrigation development, Marakwet, Kenya

Day 2

5. Heritage Water

Chair: Paul Lane

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- 9.50-10.10 Yegen, G., ALPHA: Water management games
- 10.10-10.30 Dessane, D., A. Makaratzis, E. Kaçel and Y. Kurşun, Water heritage of Ayvalık: Understanding sustainable solutions of the past
- 10.30-11.00 BREAK

6. Italian Rivers: Historical Ecologies, Management and Water Harvesting

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- 11.00-11.20 Parolini, C., The river Aniene (Latium, Italy) from the Roman era to today: a paradigm of water management
- 11.20-11.40 Campopiano, M., The Po Valley and water management in the Middle Ages: The long road to unsustainability (9th-early 16th centuries)
- 11.40-12.00 Bannon, C., Sustainability on Roman rivers
- 12.00-13.30 LUNCH

7. Indigenous knowledge and Technologies

Chair: Lutgarde Vandeput

- 13.30-13.50 Altaiee, Th. M., Ground water harvesting using ancient water transfer systems in arid regions in the context of climate change
- 13.50-14.10 (online) Khorrami, N., A. Camiz and M. Abaee, Water and urban tissues: The Qanat system and the formation process of Yazd, Iran
- 14.10-14.30 Gateri, C., Water Scarcity response strategies among women residents of semi-arid regions of Kajiado, Kenya
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8. **Water Catchments Across Space and Time**

Chair: Maurits Ertsen

- 15.00-15.20 Polinskaya, I. and K. Velentza, Lessons from a thirsty island: Water shortage and technological solutions in ancient and modern Aigina
- 15.20-15.40 (online) Kelly, A., Securing the Knossos-Iraklio water supply over two millennia, a case study
- 15.40-16.00 (online) Purdue, L., Oases in Arabia: The challenges of long-term water management. Proposal for an integrated approach of these waterscapes
- 16.00-16.20 Gitu, K., Rethinking water use: Calling on the past to solve present challenges in the Ewaso Ng'iro Basin Kenya
- 16.20-17.00 **Discussion**
led by
M. Ertsen, D. Keenan-Jones, P. Lane and C. Petrie

Abstracts

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Archaeology's unfulfilled potential: bridging disciplinary gaps for sustainable development

Undoubtedly, given the inherent uncertainty in predicting the future, archaeological data offer an avenue for comprehending the historical repercussions of climate and environmental changes on societies. Recent scholarly works have consistently highlighted the potential of archaeology and deep historical insights to contribute to the attainment of the United Nations Sustainable Development Goals. However, paradoxically, while proponents praise the utility of archaeological data, it remains apparent that these insights are minimally embraced by other academic disciplines and inadequately integrated into policymaking processes.

One of the areas where archaeology can offer impactful insights is on the resilience of livelihood practices in the face of climate-driven uncertainty. This paper focuses specifically on cultivation in arid and hyper arid drylands and the efficient use of traditional rainfed cultivation systems. We will showcase the results of the ERC-funded project RAINDROPS, which has generated new data on contemporary traditional practices of rainfed cultivation of drought-tolerant cereals (millets and sorghum), successfully tracing their roots back to antiquity. Results from RAINDROPS have highlighted a profound nexus between traditional agricultural practices and archaeological evidence, paving the way for an alternative interpretation of past dynamics and offering a new perspective on sustainable agrifood systems.

Towards water resilience through synergy: the role of archaeology, agriculture and sustainability for a holistic approach to sustainable water management in AIUla.

This paper will introduce the interdisciplinary work undertaken by the Heritage, Agriculture, Planning and Sustainability Departments of the Royal Commission for AIUla (RCU) to (re)introduce integrated sustainable water management practices in the County through a holistic approach which includes proper planning, community engagement, archaeological and environmental aspects, regulations and policy-making, taking into account successful lessons learnt from the past in order to solve current and future challenges.

Nestled in the arid mountains of north-western Saudi Arabia, AIUla has been a crossroads of ancient travel routes and civilizations since prehistory. The geographic characteristics of the valley facilitated movement and cultural interaction from the Paleolithic onwards, while the presence of groundwater and springs connected to the Saq and Alluvial aquifers contributed to the establishment of settlements and an oasis from (at least) the second millennium BCE. Despite the arid climate, the valley has been inhabited since then, new oases have been established north and south of the central part of the valley, and the main oasis has flourished up to the present day. Therefore, AIUla constitutes a *longue durée* palimpsest of sustainable water management in a particularly challenging arid environment.

The archaeological signature of ancient water management includes wells, dams, and a complex system of shafts and underground channels that routed water to irrigate the alluvial soils of the valley floors (qanat). The traditional prudent use of water and the community managed limitations on the extent of irrigated agriculture proved sustainable over the centuries, but the introduction of boreholes, pumps and pipelines to serve the continuous urban growth alongside the agricultural purposes in the 20th century is rapidly leading to the water quality deterioration and tangible risk of exhaustion of aquifers. Considering the arid climate of AIUla, the quantity and quality deterioration of both aquifers and the global challenges related to climate change, the need to build a resilient and sustainable water balance has been a central focus for the RCU.

Sustainability and heritage safeguarding goals converged in the efforts to revitalise AIUla's traditional multi-strata oasis farming systems a local farming community with renewed confidence in a thriving economy based on high quality products and sustainable agri-tourism experiences. This holistic virtuous circle of heritage, community and environment, centered on water, is therefore contributing to reviving the historic role of AIUla as a sustainable travel destination and a thriving oasis, which is what AIUla has represented for millennia in the past.

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Applied archaeohydrology. Traditional water management in Jordan's Southeastern badia – Potentials of rehabilitation

A multi-disciplinary project group under the current umbrella of the Eastern Jafr Joint Archaeohydrological Project (EJJAHP) has been documenting and evaluating traditional and sustainable water management in northern Arabia (hydrology, geomorphology, environmental sciences, archaeology, "ethnological anthropology", epigraphy and others). The sub-recent hydraulic development of the desert areas shows an astonishing technological diversity of water harvesting (e.g. mšāš, muġur, ḥabrat, miḥfār, ṭamāyil, sadd, sawāqī systems as well as qā' and ṣabḥa uses) that existed alongside the tapping of aquifers and intermediate flows by wells (qulbān)/ ābār, all mostly connected with canals and trough systems. The former were mainly used for the maximum possible exploitation of the surface run-off for humans and animals as well as for the manipulation of vegetation. The hydraulic safeguarding of sites was particularly important, especially in rain deficit years, to secure stations of the pastoral migration routes. By integrating remaining local Bedouin expertise, the functioning of the systems is analysed, and their capacities are modelled. Parallel, the documentation and evaluation of the traditional hydraulic and environmental knowledge, issues of water hygiene etc. as well as their sociodemographic, socio-hydraulic and cognitive foundations and competencies are followed. The evaluations intend to examine, in the true sense of a sustainable applied archaeohydrology, the feasibility, practice, potential and need for the rehabilitation of traditional water systems, jointly with the local expertise and interested stakeholders. The first examples are presented.

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Water in Istanbul, rising to the challenges, lessons from the Byzantine/Ottoman transition

Since its dedication as a mega-city in 330 AD Constantinople/Istanbul has benefited from its geographical position as a nodal centre for the expression of power and commerce, yet from the outset, it was vulnerable to water stress with restricted local water resources for the expanding urban population. The recent project “Water in Istanbul: Rising to the Challenge” addressed two periods of radical urban transition, the Ottoman conquest of 1453 and the rapid population expansion over the past four decades. The former theme has focused on the challenges of water supply for the city’s First Hill, the site of the Ottoman palace, Topkapı Saray. Through a detailed assessment of extensive previous studies and recent observations including GPR survey of discrete areas, it was possible to document the Byzantine water supply and storage systems including over 33 cisterns, and by using GIS to set these where possible in their urban setting and to define how water management evolved over time responding to changing resources. A key factor was the increase of rainwater harvesting apparent in a number of cisterns revealing a hybrid approach to water storage in the later Byzantine periods.

Six years after the great siege of 1453 Sultan Mehmet II chose to develop the new Saray on the First Hill defining a walled and gated 55-hectare precinct and to utilize and adapt the extant Byzantine hydraulic infrastructure as well implement new supply lines replicating the earlier system. A number of written texts and surviving structures attest to the inheritance of a spectrum of continuing practices and regulations associated with the former water provision of the new city. The results of this new synthesis were a valuable element of the knowledge generation workshops attended by the stakeholders responsible for the water management of Istanbul. In this way, the knowledge of past practice informed and motivated new responses and especially successfully started implementation of rainwater harvesting.

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A participatory methodological framework for reviving lost culture: rainwater harvesting in Istanbul

This study presents a methodological framework for reviving the lost culture of rainwater harvesting (RWH) in Istanbul. It builds upon insights from previous research and participatory engagement with key stakeholders. Istanbul, facing chronic water supply challenges since its inception, has historical evidence of RWH systems as effective solutions, but their contemporary adoption has been relatively recent, primarily driven by the recognition of climate change challenges.

To address this issue, this research develops a participatory action research (PAR) methodology, collaborating with water management actors. Through in-depth interviews, workshops, and group meetings with representatives from water management and urban planning institutions, we identify challenges related to planning, legislation, governance, financing, societal adaptation, infrastructure, and system operation. These challenges underscore the need for a comprehensive governance mechanism to foster collective action among relevant stakeholders. By focusing on Istanbul, the largest metropolis in Türkiye, we showcase the feasibility of collaboration among public and private institutions at local, regional, and national levels. Our participatory methodology generates valuable knowledge for urban planning and water management institutions involved in RWH system implementation. It underscores the importance of a decentralised governance mechanism involving all stakeholders and offers a roadmap for reviving the culture of rainwater harvesting in Istanbul.

Learnings from a Mughal waterscape: modelling & evaluating Shahjahanabad's hydrological landscape

Water. This symbol of life and prosperity, sacrament, cleanser and healer, devastator, and destroyer is one of the most revered and feared elements in the South Asian landscape. It does not merely govern the banalities of everyday life but directs the forms of traditions, rituals, trade, defence, recreation, and infrastructure. In modern urban India, the water-settlement relationship has taken a form and function where the haphazard growth and unplanned resource exploitation coupled with a population boom has led to serious water-stressed districts. India is currently on the brink of an acute water crisis. The government has declared 255 of its districts water stressed. The study of a deteriorated historic waterscape is significant both locally and as an instantiation of urban-regional hydrological model, inspired and influenced by multiple regions and empires. Water is essential to urbanism and has the potential to be sustainable when it is part of an ecologically sensitive land management intervention. Learning from the success and failure of a historic model can provide a blueprint for the adoption and adaptation of the model, both on utilitarian and aesthetic grounds, across the parched landscape of South and Central Asia. The study can also inform urban conservation models and provide insights into the evolving urbanization patterns in the region.

This paper will focus on presenting the Mughal system of waterworks through a study of the hydrological landscape of Shahjahanabad, the last capital of the Mughal Empire (1639-1857), to help build a comprehensive social and environmental approach to water conservation in medieval and Early Modern cities of South Asia, which can further inform a resilience approach to watershed management and regulation of land resources. Shahjahanabad is a powerful iteration of the water architecture practices of the region and their continuities re-imagined in the context of the subcontinent.

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Ancient Roman water infrastructure and long-term adaptation: insights from interdisciplinary research

Ancient Roman water infrastructure included aqueducts, water distribution and drainage systems that were designed, built, and operated for the long term. Across their history, they were adapted to respond to changes in water availability and demand, a situation that is analogous to the present-day challenge of managing water resources in a sustainable way while facing the effects of climate change and growing populations.

We present in this paper a few significant examples of ancient Roman water infrastructure adaptation, where the interdisciplinary collaboration of hydraulic engineers, archaeologists and environmental scientists has allowed to unlock information on such adaptation and interpret it.

The marks left by the ancient flows in aqueducts, as calcium carbonate (travertine) accumulation, contain information on those ancient flows and their variation in response to climate or usage changes. The design and construction practices of aqueducts and water distribution systems display signs of adaptation to ensure sustained system operation and to meet a varying water demand driven by urbanisation. Stormwater drainage systems included solutions implemented progressively for storing or draining water and managing its impact on cities and their inhabitants.

These examples illustrate how interdisciplinary collaboration can represent a step change in the understanding of ancient water systems and attest the continuing value of infrastructure for society.

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Fragile landscapes: the past, present and future of water use in the Konya Plain, Türkiye

Fragile Landscapes (2021-2023) is a transdisciplinary project funded by the British Academy's Global Challenges Research Fund. Its aim was to consider the entangled relations between the past, present and future uses of water in the Konya Plain (Türkiye), a semi-arid dryland, with an emphasis on the development of sustainable practices between the Ottoman period (16th century CE) and today. Archaeological data from surveys and remote sensing were coupled with detailed analyses of historical tax registers and court documents to understand the extent and nature of land and water use through time up to the present day. The area has seen significant changes in the 20th and 21st centuries, and high-resolution analysis of the surface water network evolution has been used to evaluate these changes. Hydrological modelling has further investigated scenarios of water use in the 16th century and the present day to compare with projected changes relating to climate and land-use change over the coming century. The Ottoman scenario suggests water use matching water availability. This landscape was based on local, subsistence agriculture with relatively little export trade. However, subsequent social change and climate variability may have meant it was subject to instabilities, as seen in settlement abandonment in the 17th-19th centuries. The modern landscape is, by contrast, tied into agricultural production systems at national and international scales and water use by far outstrips supply, despite governmental controls and policies. As a consequence, groundwater levels have been dropping significantly over recent decades, and are likely to become critical in the near future. Future water deficits will be exacerbated by climate change, but defining effective policy to support behavioural change is the key to developing sustainable futures for the region. An ethnographic approach is helping us understand the motivations and behaviours of farmers and other stakeholders in the modern landscape. The Fragile Landscapes project has been effective in engaging end-users with research from a wide range of academic perspectives and provided a springboard for opening the dialogue further with relevant groups, and for understanding deeper time perspectives on water management.

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Water security in Türkiye: lessons from the past to enhance socio-ecological resilience to future challenges

Challenges surrounding increasing water demand in Türkiye have been intensified by climatic change and intensified agricultural irrigation in recent decades. Evidence from the past can be informative about environmental resilience to drought events that predate the memory of recent generations. Exploring environmental change over multi-centennial to millennial timescales captures information about ecological system behaviour, offering valuable information for maintaining environmental stability and building resilience to future challenges. Within this research, we aim to understand why modern water resource use and management overlooks past experiences of drought and to explore how scientific information and knowledge of the vulnerabilities of past societies can aid sustainable future water resource use. We investigate socio-ecological resilience to water resource challenges in the Konya Basin (Türkiye) using an interdisciplinary approach, combining natural and social science methods. Lake sediment archives, once scientifically analysed using paleolimnological techniques, provide information about past environmental, climatic and water resource change. Long-term past water availability, climate trends, land-use and landscape data are being integrated with socio-cultural and environmental knowledge. We seek to understand how past climate and land use has shaped the trajectories of landscape change in the Konya Basin. Elemental analyses (ITRAX data) reveal cyclic patterns of drier and wetter periods through the last few thousand years while vegetation patterns inferred from fossil pollen data do not always respond to shifts in water availability with changes in agricultural practices evident during drier periods reflecting cultural transitions. Historic records corroborate evidence of land-use changes and irrigation practices in recent centuries. The study area contains a rich repository of palaeo-environmental and archaeological data that has potential to enable us to draw lessons from the past by linking behaviours with processes. This new knowledge has potential to inform future water resource management, which requires a holistic approach that takes into account not only the trajectories of environmental changes, but also the complexities of cultural and social factors.

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Why allowing water to erode soils is not always a bad idea: how farmers in Konso, Ethiopia, and Engaruka, Tanzania, managed soils and water for centuries, and what these practices teach us about soil and water conservation today

The management of water frequently goes hand-in-hand with the management of soils, particularly in the tropics where high levels of evapotranspiration can lead to soil salinization under prolonged irrigation, and where comparatively rapid soil development means that with careful management soils can be treated as a renewable resource. This paper presents archaeological research from two agricultural landscapes in Eastern Africa, both of which were created in part by using water to transport eroded soils to create sediment traps for crop production. One of these – Konso in southern Ethiopia – remains in use today after a period of cultivation and landscape modification lasting at least 500 years, and whilst the other – Engaruka in Northeast Tanzania – is still farmed through irrigation, the process of artificially capturing eroded soils ceased when the site was first abandoned, likely sometime in the 18th or early 19th century. Both sites provide lessons for sustainable soil and water management today, and indeed although the abandonment of Engaruka suggests that the system was not sustainable indefinitely, the cultivation of this area for at least three centuries is an order of magnitude longer than many modern agricultural development projects in the Global South, and the legacy of deep fine-grained soils in irrigable locations continues to benefit the farmers who cultivate this landscape.

Harnessing water resources in arid landscapes: a case study of the Neyriz Plain, Fars Province, Iran

Effective water resource management and utilization are crucial for agricultural success in arid and semi-arid regions of western Asia and the Mediterranean. Traditional methods of water management in these regions provide valuable insights into the relationship between humans and the environment over the long term. This research focuses on the Neyriz plain in Fars province, serving as a case study to explore the strategies employed in harnessing water resources in arid landscapes.

The Neyriz plain heavily relies on aquifers as fundamental water sources. The ecological conditions and archaeological findings of the region indicate that the historical development and settlement patterns of human communities have been closely tied to the development and management of traditional water systems, particularly qanats. This research aims to identify the factors influencing the pattern of water utilization, which plays a vital role in shaping the way of life and settlement patterns in the Neyriz plain. The geological characteristics of the area significantly influence the water resources of the Neyriz plain. The Tarbur limestone formation in the eastern mountains serves as a reliable underground water source, nourishing the most abundant and flourishing qanats in the city of Neyriz, the largest settlement center in the plain. Other geological units, such as the Sanandaj-Sirjan and Jahrom formations, form limited aquifers in the foothills and the plain, which require the construction of canals and reservoirs to utilize these resources effectively.

By examining the traditional water management practices in the Neyriz plain, this research offers valuable insights into sustainable water utilization in arid landscapes. The findings have implications for resource management and can inform similar regions facing water scarcity challenges. Understanding the historical context and traditional methods of harnessing water resources can contribute to more effective and sustainable water management practices in arid and semi-arid environments.

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Ancient water harvesting in the Marmarica as a model for sustainable and adapted management of scarce natural resources

The contribution is based on landscape archaeological research at the Northwestern Coast of Egypt and focusses on ancient sustainable water resources management and its comparison with contemporary practices.

The marginal region, ancient Marmarica, is characterised by scarce natural resources and vast tablelands with short, incised valleys draining to the sea. The arid climate, ca. 100-150 mm of seasonal wintery rainfalls, declining towards the South, and poor soils inhibit rainfed agriculture. Sedentarized Bedouins sparsely populate the rural regions and live on runoff agriculture and livestock breeding.

The past practise Marmarican resource management system was based on

- detailed knowledge of local runoff processes, hydraulics and their controls,
- optimizing minimum intervention measures for maximum durability and maximum effects,
- watershed wide consideration of single structures and sub-systems,
- partial cultivation of tableland runoff areas.

Marmarican water management systems, dating back 3500 years, consisted mainly of a combination of dry-stone check dams in wadis, lateral terraces parallel to the slopes, feeder bunds and channels in a way of construction optimised for hydraulic conditions and maintenance. On the plains, water and soil were harvested resulting in complex systems of flat terraced fields (kurum) with feeder bunds, channels and distribution facilities. The rationale of reducing the effective runoff generating areas of valleys strongly suggests that low frequency high magnitude events were perceived rather as a threat that needed to be averted than a benefit.

The skills for sustainable and adapted water management have been lost. However, plenty of remains persisted and enabled reconstructing the former rationale as well as the functionalities. They were based on thorough observation, trial and error, and manual work. The blossoming of the sophisticated Marmarican system ended between 4th and 7th c. CE.

Today, there is a conflict of interests between the two main population groups: Bedouin farmers living in the rural areas, receiving subsidies (seeds, fuel etc.) and ethnic Egyptians in the administrative bodies in the towns along the coast (e.g. Marsa Matruh, el Daba'a). Commonly, the modern implementations are poorly adapted to climate, relief and social conditions. Growing barley on random parts of the tableland without water harvesting support is one example. The modern management results in high cost and little return.

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Unintended consequences, conflict and resilience in a small-scale irrigation development, Marakwet, Kenya

This paper examines the development, early operation, and subsequent failure of the Tot-Kolowa Red Cross irrigation scheme in Kenya's Kerio Valley. Initially conceived as a technical solution to address regional food insecurity, the scheme aimed to scale up food production through the implementation of a fixed pipe irrigation system and the provision of agricultural inputs for cash cropping. A series of unfolding circumstances, however, necessitated numerous modifications to the original design as the project became increasingly entangled with deep and complex histories of land use patterns, resource allocation and conflict. Failure to understand the complexity of these dynamics ultimately led to project's collapse as the region spiralled into a period of significant unrest. In tracing these events, we aim to foreground the lived realities of imposed development, including both positive and negative responses to the scheme's participatory obligations, and its wider impact on community resilience.

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Water infrastructure and public space: exploring the enduring legacy of drinking fountains as place making devices in Rome

The ubiquitous cast iron drinking fountains or *nasone* of Rome, installed from 1874, persist to offer a seemingly egalitarian access to clean drinking water across the city. These points are ingrained within the urban fabric, configured upon a system of hydraulic infrastructure that has been predicated on ancient water supply and drainage networks. The *nasone* were initially installed to provide access to clean water where individual domestic connections were missing, and at their most prolific, approximately 5000 points were located on street edges and in squares in Rome. The presence of the *nasone* in the city has dwindled as domestic water supply has become common place with the remaining drinking fountains often overlooked as urban remnants or guidebook novelties.

The contemporary importance of these points as a key public infrastructure has been recently underscored by the pressures of consecutive heatwaves in Italy as they have done much to support day to day life. This paper explores the drinking fountains as more than relics and argues that their location and development offer a lens through which to understand the layered and changing urban morphology of Rome. This research puts forth that by examining Rome through its water infrastructure we can gain an understanding of urban form which can highlight the specific features and histories of neighbourhoods as well as aid in explaining the growth trajectory and pressures of city development. Further, through in-situ observation focused on select points, this research unpacks the role of drinking fountains within a city facing climate change, details the contemporaneous stresses on this infrastructure and aims to understand the extent to which water infrastructure continues to support the public life of Rome.

ALPHA – Water management games

The ALPHA (Active Learning Protects Heritage and Archaeology) project develops innovative educational games for classroom use that support children to develop their own understandings of the ancient past and how to protect the archaeology and heritage around them. In the third and final year of our project, we are focussing on how heritage education can support cross-curricular learning in Science Technology, Engineering and Maths (STEMS) subjects, specifically how water resources can be sustainably managed and conserved using examples from archaeological sites in Türkiye. Children are then asked to reflect on how what they have learned about ancient water management strategies can inform the design of contemporary houses, city-planning and the personal choices we make to conserve water – thereby raising their awareness of Global Citizenship.

In this paper we will discuss the pedagogical principles behind the design of the games, present qualitative and quantitative feedback from teachers who piloted the ALPHA Water Management games in their classrooms and suggest ways in which these educational approaches and resources might usefully be rolled out in future.

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Water heritage of Ayvalık: understanding sustainable solutions of the past

Water use and management were essential to the urban identity of Ayvalık, formerly Kydonia, on the northeast coast of the Aegean. Settlement began with the Turks during the Oriental invasions of Anatolia in the 13th-14th centuries, followed by the Greeks from Lesbos in the 16th century. This coastal town was located on the banks of a seasonal river, the Potamos. In the following four centuries, the city experienced economic prosperity, despite several disasters: the destruction of the city by fire during the Greek Revolution in 1821, the deportation of the Christian population in 1917 and the final expulsion of all Christian inhabitants in 1922. The settlement remained densely populated, despite limited water availability.

Ayvalık depended on the rain for all its needs: sanitation, street cleaning, sewage system, industry and the church. Water was mostly harvested from the roofs of houses and stored in underground cisterns or collected in wells in the valley bottoms. A complex network of cisterns connected the houses and provided a communal example of traditional water management. Two dozen fountains with a water tank are distributed throughout the city and are available to the public. A network of underground watercourses, similar to qanats, still exists today.

In this paper we examine the city's water management heritage through topographical studies, travelogues, official documents, artistic approaches, and local oral traditions. Starting with the social and political implications of sustainable water management in the past, we highlight the technical solutions of the 20th century (e.g. the Madra Dam of 1991) and the inadequacies of today's water management system in a climate increasingly prone to drought. Mapping the traditional cistern network of Ayvalık will allow us to propose a revival of this network. While old houses are renewed and rebuilt today, the water management heritage deserves better attention. Fountains, cisterns, wells and waterways should be registered as cultural assets and kept in working order as the city approaches its UNESCO World Heritage candidacy today.

The river Aniene (Latium, Italy) from the Roman era to today: a paradigm of water management system

What happens when in an area there is continuity between past and present in the choices, places and technologies of water management? This question can be answered by telling the history of the water exploitation of the Aniene river, one of the main tributaries of the Tiber and a strategic river channel since Roman times for the water supply of the city of Rome. Since the river stop to be a passive geographical object and dynamically it harmonized itself with the local context, the control of waterway became a focal point of the valley and as a result, the river and his hydrographic basin constantly became the object of territorial policies and interventions. If in the Roman times the river supplied the four greater aqueducts of Rome, its power continued to be exploited in the next centuries in areas already subject to intervention in roman times, starting from the same Roman features, often with different purposes but re-proposing the ancient model of water management.

It is proposed to focus on the sequence of "landscapes" shaped over time near the most exploited areas of the river and to understand the co-penetration of the signs of the past landscapes in the present one. Therefore, only thanks to an integrated analysis and an interdisciplinary historical-geographical study of the river channel in space and time is it possible to have a comprehensive framework of the impressive project of exploitation of its water. In fact, only a cross-reading of geomorphological, archaeological, geographic and historic data led to a better understanding of the management of the river in different times.

This research highlights how over time there has been a transmission of knowledge that led human activities to structure themselves around the "river" space and had an impact on the use and transformation of the territory in next eras; it highlights some analogies between the republican and imperial project to supply water to Rome and the project to use the Aniene water to supply electricity to Rome since the end of the 19th century.

These considerations leads us to ask some questions necessary to answer to today's challenges in the management of water resources: what was the impact of the water exploitation over time on the river ecosystem and on the landscape? Was it a sustainable exploitation? What are replicable strengths of the model offered by the Aniene valley?

The Po Valley and water management in the Middle Ages: the long road to unsustainability (9th-early 16th centuries)

The Po Valley was one of the most economically significant regions in medieval Italy. It is a vast flat area defined by the water basin of the Po River, Italy's longest river. It was the subject of a process of transformation and land clearance that began as early as the end of the ninth century under the impetus of large landowners, who reduced the wooded and marshy areas (often inextricably intertwined) to make way for cultivated land, which was made possible by an intensive network of canals and drainage ditches. Embankments, intended to 'protect' the cultivated areas, increasingly constricted the course of the Po and its tributaries. This created a complex water network, which over time, particularly with the economic and political expansion of the weight of urban centres from the 12th century onwards, had to fulfil other roles such as navigation, providing energy for the mills etc. The sustainability of Po Valley societies essentially depended on the sustainability of this increasingly complex water system. Embankments constrained rivers in somewhat non-sustainable flows and contributed to the aggradation of riverbeds, an effect that would have been worsened by the increase in the number of canals discharging their water into rivers, leading to an increase in the magnitude of floods.

The transformation of hydrogeological structures combined in the 14th century with a period of intense meteorological and climatic instability. This led to an increase in the frequency and extent of floods, which reached a peak in the 14th century. The cities of the Po Valley had to pay close attention to the renewed risks of flooding, establishing officers to maintain the embankments and regulate the waterways. However, the effects of such endeavours were limited, as shown by the commissions of inquiry that the Po Valley cities established to verify the effects of flooding in the 15th and early 16th centuries. This contribution hypothesises that these unsustainable conditions were due to the difficulty of establishing coordination among different economic and political actors who claimed different uses of the water network (irrigation, energy provision, drainage, etc.). My contribution will focus in particular on the area south of the Po, both because of the presence of various cities along the southern axis of the Po, all of which were very active in the management of water resources (for example Piacenza, Parma, Reggio Emilia, Modena) and also because water flow rates of the tributaries coming from the south, hence from the Apennine Mountain chain, played an essential role in the great floods of the Po. It can be assumed that the great land reclamation and water management consortia of the late 16th century transformed the management conditions and stability of the Po Valley water system. However, the hydrogeological fragility of this area has also been shown by the numerous disastrous floods of recent decades. Reflecting on the medieval millennium and the conflicts that characterised it will help us understand how conflict management is a key aspect in achieving sustainable water management even today.

Cynthia Bannon

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Sustainability on Roman rivers

Sustainability involves balancing environmental and economic goals, a challenge that the Romans faced already in antiquity. The Roman experience of managing rivers illustrates this dynamic and offers lessons for the modern world. In the Roman world, as today, both law and technology were applied to rivers; and as today, they were not always coordinated effectively. Taking the Po in northern Italy as a case study, this paper evaluates Roman strategies for sustainable river management from the second century BCE through the first century CE.

The Romans intervened in the riverine environment with both law and engineering. On the Po, archaeological evidence shows that the Romans built embankments to control flooding in the upper basin and canals in the delta to facilitate navigation starting. Roman law regulated rivers to support economic activities such as transportation and irrigation, as documented in the *Corpus Iuris Civilis*, Justinian's sixth century CE compilation of Roman law. The Romans also understood environmental systems, such as sedimentation caused by erosion and the brackish conditions necessary to raise oysters in the Po delta. At least one legal expert knew conditions on the Po: Cassius Longinus described the Po as he explained how to apply the law when violent flooding transforms the riverine landscape. And yet the Romans were unable to sustain the ecological environments critical for their economic wellbeing. Flooding was managed to some extent in the Po's upper basin, but oyster beds suffered after the construction of canals in the delta.

Roman problems with sustainability arose from policy and structural issues. Engineering and legal strategies were not coordinated, as Cassius Longinus' writings show. Strategic concerns motivated emperors to focus on transportation in the Po basin to serve the naval base at Ravenna. Comparison with Roman management of the Tiber shows that the problems on the Po resulted not only from its distance from the capital but from cultural, social, and institutional practices. Comparison with the Nile reveals the fiscal priorities that put tax collection ahead of sustainable river management. Understanding the Roman experience of rivers helps us to build on the legacy of Roman law, which informs contemporary environmental law, without making the same mistakes.

Ground water harvesting using ancient water transfer systems in arid regions in the context of climate change

Global warming over the past decades has led to climate change in large parts of the world, illustrated by increased floods, heavy rains, hurricanes, declining snowfall and/or severe drought conditions. In the case of the severe drought conditions, a recession of surface water resources was recorded. This water declination also resulted in the transformation of permanent streams into seasonal ones and seasonal streams into dry streams, especially in conjunction with the increasing demand for water due to increasing population and economic growth in the world. As a result of these conditions, the residents of semi-arid and arid areas tend to dig wells and pump up groundwater to cover their daily needs. This in turn leads to a drop in groundwater levels often without the option of renewing the water levels. This is what is happening in many arid and semi-arid regions of the world, including the Middle East.

In past centuries, these regions have withdrawn and transferred ground water by establishing subsurface channels called Kahrez in Iraq and Pakistan, Qanat in Iran, or Aflaj in some of the Gulf Cooperation Council countries. These sustainable ancient water supply systems consisted of an underground water transfer system that transported ground water from the aquifers of mountainous areas to points of re-emergence such as an oasis through one or more underground tunnels. This system was created by digging vertical tunnels to reach the groundwater levels and linking them with a horizontal tunnels dug with a slight slope (1-2)% to withdraw this groundwater by gravity, without negative environmental effects or loss of water by evaporation or leakage. UNESCO recognized the value of these traditional groundwater management techniques in dry rural areas.

The aim of the present research is to review groundwater harvesting systems represented by Kahrezes, Qnanats, and Aflajs in arid and semi-arid regions, and to reveal their structure, construction methods and operational characteristics and benefits. The work highlights the sustainability of these systems in comparison to the technology of the current technique of digging wells and pumping up groundwater. The research focuses on areas where the population resorted to depleting groundwater through excessive pumping, which may lead to the destruction of these resources contrary to the past practise systems which provided sustainability. Past practises may therefore offer solutions for the present and the future.

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The Qanat system and the architectural structures of Yazd, Iran

This research has analysed the Qanat system to discern its profound influence on the architectural landscape of Yazd, Iran. In arid regions where agricultural sustainability depends on effective irrigation, the imperative to address water scarcity has led to innovations such as the underground watercourse, referred to as the Qanat system. This system has played an important role in sustaining and advancing civilization on the Iranian plateau (Bouzarjomehri and Khatami, 2018). In Yazd, there are twenty-two Qanats, with only two among them, the Zarch Qanat and the Firozabad Qanat, presently retaining water. Regrettably, the remaining twenty Qanats have succumbed to gradual desiccation over time (Arse Architectural and Urban Consulting Engineers, 2007). The research has been structured into two primary phases. In the first phase, the study focused on identifying and characterizing the Qanat system. Subsequently, in the second phase, the research delved into a comprehensive exploration of architectural structures associated with underground watercourses such as cisterns, watermills, and Payabs. The main aim of the research is to recognize and document the impacts of the Qanat system on the architectural characteristics of Yazd. This research has exposed the significant attributes of the Qanat system and illuminated their complex interaction with the architecture of Yazd, Iran.

Water scarcity response strategies among women residents of semi-arid regions of Kajiado, Kenya

"Beyond the focus of public attention, an unseen emergency continues to unfold. It does not fall dozens all at once, like a bomb, or carry away whole towns in the blink of an eye, like a flood. Rather, it kills its victims – mostly infants and small children – largely unnoticed, spiriting them away one by one from rural villages and urban slums in every corner of the developing world."

Water scarcity is a slow – onset disaster that does not usually obtain rapid humanitarian intervention, and the group mostly affected is women. Kajiado County is an Arid and Semi-Arid Land characterized by an acute shortage of clean and safe water. Most of the rivers are seasonal. Ground water is salty and not adequate. Some rural populations cover about 20km one way to access water. The number of households with access to piped and portable water is about 36.8 percent of the total population. Due to their role in the society, women are the most affected by water scarcity and thus most committed to ensuring that water resources are sustainably managed.

Using multi-disciplinary research methods of literature study, ethnographic research design, questionnaires and focus group discussion, this study focuses on experiences and coping strategies of rural women in Kajiado with regards to water scarcity. The study seeks to answer the following research questions: What are the traditional methods practiced by women in water resources management in Kajiado County?, What are the changes in the traditional system practiced by women in water resources management in the Kajiado County?, What are the social economic challenges hindering women from participating effectively in the management of water resources in Kajiado County?, and What policy measures can be adopted to enhance women's participation in water resources management in Kajiado County? The findings of this study will inform decision-makers to consider the challenges which have been established and address them through policy reforms thus improving access to safe drinking water, alleviate poverty, and improve the general wellbeing of the general population in the County.

Irene Polinskaya

King's College London, UK

Katerina Velentza

Energy and Environmental Institute, University of Hull, UK

Sophia Michalopoulou

Ephorate of Peiraeus, Greece

Lessons from a thirsty island: water shortage and technological solutions in ancient and modern Aigina

Water crisis is acquiring acute dimensions on global scale today, due to palpable climate changes, but in many parts of the world, water shortage has been a constant concern for millennia, forcing human inhabitants to seek and find sustainable solutions that can still be of value to modern communities.

In one pocket of the Aegean Sea, on the Greek island of Aegina, where evidence for human presence goes back at least to the 4th millennium BCE, water management strategies are evident in the archaeological record since the Bronze Age, and advances in engineering offered lasting solutions for water extraction and channelling since the Archaic period. An aqueduct, or perhaps several, were constructed on the island in the 6th century BCE and stayed in use apparently until the 1970s when human interference led to damages and stoppage in the functioning of the aqueduct.

Today, the island of Aegina is still one of the driest in the Aegean Sea. With a population of around 13,000, it has no usable fresh water sources. Since 2013, it has been receiving water from the mainland (Athens) through a pipeline laid on the bottom of the Saronic Gulf. Before then, for decades, since the loss of the local aqueduct, potable water was brought to the island in tankers from Athens and deposited in large containers from which it was piped into the local water mains. Absence of local sources of fresh water is still a major environmental challenge faced by the island residents. Yet, it did not and does not have to be reliant on this costly and environmentally questionable solution.

The paper will present modern and ancient challenges to fresh water supply on the island of Aegina in Greece, seeking to derive practical lessons from the comparison between modern-day problems and ancient sustainable solutions that saw construction of an underground aqueduct and development of an underground network of water cisterns for long-term storage. The paper will be based on the analysis of ancient textual sources, archaeological evidence, and modern sustainable development studies of the island.

Amanda Kelly

School of Archaeology, University College Dublin

Securing the Knossos-Iraklio water supply over two millennia, a case study

Water has long constituted one of the most important factors determining the landscape of settlement on Crete, but, in the Roman period, securing the necessary height at which water entered the city became an important consideration for civic development. With the civic adoption of the Roman custom of daily bathing, the operation of the baths became a key contender for civic expression, and with this development, the ensuing hydraulic considerations shaped urban blueprints, often shifting civic focus, leading to the expansion of Roman cities into their lowlands. In this talk, I will present the Aqueducts of the Greater Iraklio Area (AGIA) as a diachronic study on civic water supply showcasing the Roman aqueduct of Knossos, the 17th-century aqueduct of Candia, and Mehmet Ali's 1838 aqueduct supplying Kandiye.

Oases in Arabia: the challenges of long-term water management. Proposal for an integrated approach of these waterscapes

Water in arid environments is and has been a key resource for the development of agricultural communities. Water landscapes, mainly oases, are currently threatened by climatic, socio-economic and demographic mutations. Studies have developed in the Arab World to raise awareness on their gradual disappearance. Yet, archaeological and paleo-environmental studies have revealed that some of the oldest agricultural oases in Arabia have been exploited for at least the last 5 millennia. This entails that specific strategies have been deployed to cope with climatic and socio-economic constraints through time. In order to properly contribute to the debate on the preservation of these oases, it is necessary to change our perspective and consider them as dynamic socio-ecosystems, archives of environmental and social changes. A holistic and diachronic approach of these waterscapes will allow us to decipher the long-term driving factors of change and consequent human adaptations (e.g. shifts in water resources and hydraulic technology as a result of hydro-climatic constraints, population migrations). I propose in this talk a diachronic and multiscale approach based on hydraulic geoarchaeology, agronomy, (paleo)ecology, chronology, geophysics, spatial analysis, archaeology and modelling.

Case studies from the Southeast and Northwest Arabia (UAE, Oman, Saudi Arabia) will be presented, where diverse hydro-climatic conditions and/or socio-economic frameworks have led to different adaptations and strategies of water management through time. Our observations reveal that oases are structured around repeated cycles of development, shifts and abandonment. There is a clear link between increased demography, economic growth and technological innovation. Moreover, we have identified a broad trend of decreasing biodiversity and a higher specialization of hydro-agricultural activities through time with the temporary use of durable strategies (e.g. runoff water channelling) and increased mobility in the face of climatic constraints. These observations provide a basis of discussion with local farmers, associations or scientific institutions in order to preserve, rehabilitate or rebuild hydraulic systems.

Rethinking water use: calling on the past to solve present challenges in the Ewaso Ng'iro Basin Kenya

Ewaso Ng'iro River basin covers an area of more than 200,000 km², representing 36% of Kenya's drainage area, forming the principal source of water for wildlife and domestic utilization. Climate change and water use practices are jeopardizing the ability for the river to support the millions of people and wildlife who depend on it. Variations in seasonality, attributable to climate change, uncontrolled/ unregulated water abstraction for commercial farming and industries upstream particularly on the Ewaso Narok and Naro Moru sub-catchment areas, population growth and unsustainable practices such as sand harvesting for a booming construction industry have reduced the flow to downstream users. This has increased conflict between user communities, led to migration of wildlife and compromised mechanisms of survival within the basin. Historically, communities within the basin had developed seasonal mechanisms of water exploitation that worked in synch with the cycles, and it is these practices that need to be revisited and enhanced. The use of Specificells on dry riverbeds, incorporation of sand dams and other interventionist undertakings such as wells, dams are some of the practices that can be borrowed from the past. Cultural activities such as water access and user protocols infused within the legal frameworks of governance can reduce conflicts. Thus, this study aims at addressing the following main question: how can indigenous water management practices inform sustainable practices of water use and access in the basin? The study will depend on ongoing ethnographic research on resource-based conflict in the basin, precipitation and water abstraction data and the use of Google Earth to map settlement and land use practices to answer pertinent questions including the historical methods of water access and storage, and possible interventionist practices that can be employed to tackle the inherent problems.

Bio-Blurbs

Mazyar Abaee

Mazyar Abaee is Research and Education Department Director at the Urban Planning and Architecture Research Centre of Iran (UARC), as well as Assistant Professor at the Faculty of Architecture and Urban Planning, University of Art, Tehran. He is Project Manager at Gozineh Consulting Co., and president of ISUF Iran (Iranian Network of Urban Morphology) under the supervision of ISUF (International Seminar of Urban Form).

Iqtedar Alam

Iqtedar Alam is an architect by training. Presently a doctoral student in the Department of Archaeology, University of Cambridge, Iqtedar was previously involved with the Aga Khan Trust for Culture and thereafter taught at the Department of Architecture at Jamia Millia Islamia, New Delhi. His ongoing research explores the system of Mughal waterworks in Shahjahanabad. He also designs and curates works on cultural landscapes and socio-religious ephemera.

Amer Alsouliman

Amer Alsouliman is a Jordanian geoarchaeologist. He is Deputy Co-Director of the Eastern Jafr Projects and the Saudi-German Rajajil Joint Archaeological Project. He is currently a PhD student at the University of Catania.

Thair Mahmood Altaiee

Thair Mahmood Altaiee graduated with an MSc in Water Resources Engineering in 1985. Since 1994, he has worked as an academic and researcher at Mosul University in Iraq, where he is an Assistant Professor. He has published many scientific reports in the water resources field and participated in several conferences and workshops outside Iraq. He has capability in decision making, planning, time management

and collaboration, and skills in negotiating, team working and coordination.

Gianna Ayala

Gianna Ayala is a Senior Lecturer in geoarchaeology, currently based in the Archaeology Department at the University of Sheffield. Her research interests are focussed on investigating the human footprint through geoarchaeological applications and landscape archaeology. Her recent projects include excavations at Knossos, Crete and palaeoenvironmental reconstruction in the Konya Basin, central Türkiye.

Cynthia Bannon

Cynthia Bannon is a Professor of Classical Studies at Indiana University, Bloomington. Her research focuses on Roman law, history, and literature, especially in relation to water resources. Her publications include *A Casebook on Roman Water Law* (2020), and 'Fresh-Water in Roman Law: Property and Policy' *Journal of Roman Studies* (2017).

Stefano Biagetti

Stefano Biagetti (PhD in Archaeology, UCL 2012) is Professor of Archaeology with the Culture, Archaeology and Socio-Ecological Dynamics Research Group (CASEs) at the Department of Humanities, Universitat Pompeu Fabra in Spain. He is the principal investigator of an ERC-funded project focusing on the study of pastoralism in drylands. His research focuses on land use and food-producing strategies in arid environments, both in the present and past.

Stefano Bordoni

Stefano holds a PhD in Archaeology from the School of History, Classics and Archaeology of the University of Edinburgh. He is interested

in archaeological science and GIS-based research. He was involved in the project 'Water in Istanbul: rising to the Challenge' (<https://www.thebritishacademy.ac.uk/projects/knowledge-frontiers-2021-water-in-istanbul-rising-to-the-challenge/>) as data manager and GIS specialist.

Alessandro Camiz

Alessandro Camiz is an Associate Professor in the Department of Architecture of Università degli Studi "G. d'Annunzio" Chieti, Pescara. He taught in the School of Architecture, University of Miami, and in the Faculty of Architecture, Design and Fine Arts at Girne American University, Cyprus, where he directed the International Centre for Heritage Studies and the Department of Interior Architecture. He is Editor of *FORMA CIVITATIS*, and a Council Member of the Society for Post-Medieval Archaeology, UK. Until February 2024, he was Director of the Laboratory of Dynamic Research on Urban Morphology at the Faculty of Architecture and Design of Özyeğin University, Istanbul.

Michele Campopiano

Michele Campopiano teaches at the University of York. His research interests include the history of historiography and memory, and medieval environmental history, with a focus on water management in Italy, Germany and the Middle East. He implemented, for instance, the von Humboldt Foundation-funded 'Cities and Rivers in the Middle Ages: Water Management in the Po and Rhine River areas (1300-1550)' project.

Catherine Cone

Catherine Cone is the Director of Environment and Sustainability at The Royal Commission (RCU) for AIUla in North-West Saudi Arabia. RCU is embarking on a long-term plan to develop and deliver a sensitive, sustainable transformation of the region, reaffirming it as one of country's most important archaeological and cultural destinations.

Martin Crapper

Martin Crapper is Professor of Civil Engineering at Northumbria University, Newcastle upon Tyne, UK. With a long background in civil engineering hydraulics, both in industry and academia, he has sought to understand civil engineering heritage, using modern techniques to interpret the achievements of the past. He was co-investigator on the Leverhulme-funded project 'Engineering the Byzantine Water Supply', and on the British Academy-funded 'Water in Istanbul: Rising to the Challenge?' project. He has published widely on the operation of Roman water systems.

James Crow

Jim Crow is the Chair of the British Institute at Ankara and Professor Emeritus of Roman and Byzantine Archaeology at the University of Edinburgh. His research concerns ancient and medieval infrastructure and landscapes in times of transition and crisis. In the eastern Mediterranean, this has focused especially on the water supply and defences of the city of Constantinople and the early medieval landscapes of the Aegean islands including Naxos.

Matthew Davies

Dr Matthew Davies is the Deputy Director of the McDonald Institute for Archaeological Research at the University of Cambridge. His research focuses on the contemporary and historical management of landscapes, ecological diversity, climate, and questions of sustainability, resilience and regeneration.

Damien Dessane

Damien Dessane is an agriculture specialist who graduated from Wageningen University, and currently lives in Ayvalık (Türkiye). He specialises in energy efficiency and life cycle analysis of organic and conventional olive groves. Since 2018, he has initiated and developed the 'Cultural Route' project with the Ayvalık UNESCO office, completing the itinerary and detailed descriptions of 36 sites.

Maurits Ertsen

Maurits studies how longer-term water practices emerge from short-term actions of human and non-human agents in current, historical, and archaeological periods in diverse settings. He combines (environmental) history, engineering and archaeology. Another major aspect of his work concerns education. Maurits develops active classroom settings in courses and is Director of Studies of the MSc programme in Environmental Engineering in Delft.

Rebecca Foote

Dr Rebecca Foote is the Director of Archaeology & Cultural Heritage Research for the Royal Commission for AlUla (Saudi Arabia). She brings more than 30 years' experience in archaeology, in particular on water management in semi-arid regions of the Levant and NW Arabia in the 2nd–8th centuries CE, thanks to research conducted while Co-Director of Humayma Excavation Project (Jordan) and in Aga Khan and National Endowment for the Humanities Fellowships.

Catherine Gateri

Catherine Gateri is a Senior Research Fellow at the British Institute in Eastern Africa, attached to the research project 'Regional Futures in Kajiado County', working with the Maasai Community. She has participated in research activities in land administration, land management, urban and regional planning, livelihoods and governance. Catherine holds a PhD in Urban and Regional Planning, an MA in Planning, and a BA in Land Economics.

Hans Georg K. Gebel

Dr Hans Georg K. Gebel is a German prehistorian with a focus on archaeo-hydrology. He has more than 40 years' experience directing excavations in Baja, Qulban Beni Murra (Eastern Jafr Archaeological Project), Rajajil (Saudi-German Rajajil Joint Archaeological Project), and others, as well as in the Emirates and Oman. He has conducted Bedouin ethnological research, and advocates for Embedded Archaeology. He

is the Vice-President of the recently founded International Academy of Prehistory and Protohistory in Paris.

Samar Ghattas

Samar Ghattas is an accomplished environmental engineer with over a decade of hands-on experience. Samar excels in crafting sustainable strategies for mega developments. With extensive expertise in wet infrastructure and a focus on research-driven environmental solutions, Samar is dedicated to building resilience against emerging global warming threats. As a proficient project management practitioner, Samar excels in managing stakeholders and surpassing challenging client expectations.

Kennedy Gitu

Kennedy Gitu is a population historian with an archaeological background based at the British Institute in Eastern Africa, Nairobi. His main research interests are pastoral demography, mobility and settlement, and climate change adaptation. He is particularly interested in the intersection between environment, population, and human security. He has worked mainly in northern Kenya, but has been involved with projects in Kenya, Ethiopia, South Sudan, and Tanzania.

Hani Hayajneh

Hani Hayajneh is a Professor of Ancient Arabian and Levantine Languages and Cultures at the Faculty of Archaeology and Anthropology, Yarmouk University, Jordan. He is a member of the global capacity building team of the UNESCO 2003 Convention for the Safeguarding of Intangible Cultural Heritage and represents Jordan on the UNESCO Intergovernmental Committee. He is the Co-Director of the East Jafr Joint Archaeohydrological Project.

Manuel Hidalgo Velasco

Manuel Hidalgo Velasco is a chartered MSc in Chemistry and MSc in Environmental Management and Control with over 35 years of

experience, particularly in the water sector. His experience spans the full value chain and life project cycle in the water industry: desalination, water and wastewater treatment, and reuse and recycling projects in compliance with environmental and sustainability regulations. He is currently employed by the Royal Commission for AlUla as Sustainability Compliance Manager.

Akgün İlhan

Dr Akgün İlhan earned her PhD in Water Management from Universitat Autònoma de Barcelona in 2010, with financial support from the Catalan Government. Since 2017, she has been teaching undergraduate courses at Boğaziçi University, specializing in environment, sustainability, and water. Since 2022, she has been a postdoctoral researcher at the British Institute at Ankara, focusing on participatory and climate-adaptive water management projects.

Caner İmren

Dr Caner İmren is an Assistant Professor in the Department of Geophysical Engineering of Istanbul Technical University, Türkiye. His interests focus on applied geophysics, tectonics and marine geophysics, more specifically related to acoustic methods. He is also interested in archaeo-geophysical research and has been working with several archaeological fieldwork teams, including the project 'Water in Istanbul: Rising to the Challenge' for which he led the geophysical research.

Ela Kaçel

Ela Kaçel studied architecture at YTU (Istanbul) and at the AA (London), receiving her PhD in History of Architecture from Cornell University in 2009. Her research focuses on post-war modern architecture, photography, visual urban research, migration and memoryscapes. She is an Associate Professor in the Faculty of Architecture of Mimar Sinan Fine Arts University in Istanbul.

Beril Karadöller

Beril Karadöller is a research assistant at in the Department of Geophysical Engineering of Istanbul Technical University, Türkiye while finalizing her PhD. Her research focuses on applied geophysics, tectonics, near-surface geophysics, and archaeo-geophysical research. She was involved in the project 'Water in Istanbul: Rising to the Challenge' as a member of the geophysical research team.

Duncan Keenan-Jones

Duncan's research focuses on the relationship between environment, technology and society, especially in the ancient Mediterranean and in Australia, and how past and Indigenous practices can help us today. Duncan has current projects on the climate, flooding and water management in ancient Italy, floodplain management and carbon storage in Australia's channel country and the development and durability of Roman mortar.

Patrick Keilholz

Patrick Keilholz is Professor of Hydrology and Water Management at Nuremberg Technical University. He has almost 20 years of experience in archaeo-hydrological projects, including in Gadara / Umm Qais (Jordan), Tayma (KSA), and Jabal Haroun. He has a PhD in groundwater hydrology from the Technical University of Munich.

Amanda Kelly

Amanda Kelly is Assistant Professor at UCD School of Archaeology, Dublin. She is an archaeologist specialising in Roman aqueducts and baths, with a focus on Crete. She leads the project 'Aqueducts in the Greater Iraklio Area (AGIA)', funded by the Gerda Henkel Foundation (2021-2024). Amanda was recently the recipient of a Stanley J. Seeger Visiting Research Fellowship at Princeton University, where she worked on her book *The Venetian Aqueduct of Candia (Iraklio), Crete*.

Claire Kelly

Dr Claire Kelly holds a PhD in Geography. She has been Lecturer in Quality Management and Research at the Peninsula Medical School and Senior Research Fellow at the School of Geography, Earth and Environmental Sciences, at the University of Plymouth. Her expertise spans resilience; participatory co-design for sustainable solutions to complex challenges; partnership working, governance and public engagement with science.

Nahal Khorrami

Nahal Khorrami received her BA in Architectural Engineering from Tehran University of Art and an MA in Architecture at Özyeğin University. She currently serves as a tutor and member of the Dynamic Research on Urban Morphology (DRUM) Research Group at Özyeğin University. In 2018, Nahal founded the Tile Design Studio, specializing in Iranian ancient architectural decoration. She co-founded Done, an architecture and construction studio, in 2023.

Wilson Kipkore

Dr Wilson Kipkore is a Senior Lecturer and manager in natural resource management at the University of Eldoret, Kenya. He has a range of experience working with leading East African environmental NGOs, and as the Chief Executive of the Permanent Presidential Commission on Soil Conservation and Afforestation, Kenyan government.

Yücel Kurşun

Yücel Kurşun, born in Istanbul in 1982, graduated from Istanbul University, Faculty of Forestry, Department of Forest Industry Engineering. After working in different business sectors, he became a professional photographer in 2012. In addition to commercial photographs and videos, he produces documentary works. Street animals, cultural heritage, ecological destruction, and daily life are his subjects.

Carla Lancelotti

Carla Lancelotti is an ICREA Research Professor with the Culture, Archaeology and Socio-Ecological Dynamics Research Group (CASEs) at the Department of Humanities, Universitat Pompeu Fabra in Spain. She holds a PhD in Archaeobotany from the University of Cambridge. Her research interests include long-term traditional knowledge, drylands agriculture, past agricultural strategies, modelling and ethnoarchaeology. She has worked extensively in Asia and Africa.

Paul Lane

Paul Lane is the Jennifer Ward Oppenheimer Professor of the Deep History & Archaeology of Africa at the University of Cambridge. His research interests include the historical ecology of African landscapes and the archaeology of East African pastoralism. A former Director of the British Institute in Eastern Africa (1998-2006), he currently directs the "Mapping Africa's Endangered Archaeological Sites and Monuments" project.

Samuel Lunn-Rockliffe

Dr Samuel Lunn-Rockliffe is an Early Career Research Fellow at the McDonald Institute for Archaeological Research, University of Cambridge. His research draws upon historical ecology, contemporary archaeology and post development thinking to reconceptualise smallholder innovation in Kenya as an iterative historic process to be harnessed as a mechanism for future agricultural design.

Apostolos Makaratzis

Apostolos Makaratzis holds a BA in Environmental Cartography (2004) and a MA in Cultural Technology and Communication (2007) from the University of the Aegean, Greece. He has extensive experience in fieldwork and in collecting field data, but also in data visualisation and map design. He has been involved in many mapping works and publications.

Michele Massa

Michele Massa is Assistant Professor at Bilkent University's Department of Archaeology and previously held a postdoctoral fellowship at the University of Chicago. His primary area of interest is the prehistoric eastern Mediterranean and Near East, and he specialises in landscape archaeology and different aspects of state formation processes, including water management, warfare, long-distance exchange networks, administration and elite behaviours.

Maria C Monteleone

Dr Maria C Monteleone is a civil hydraulic engineer specialising in the application of reverse engineering-hydraulic analysis to the operation of historical and ancient water structures. Recently, she has been working with archaeologists on the site of Pompeii to verify the operation of Roman laundries and study the water demand of private residences.

Laura Morabito

Dr Laura Morabito is a landscape archaeologist with a strong background in archaeology and digital humanities. She specialises in interdisciplinary approaches to identify, understand, protect and celebrate ancient landscapes. She currently works as Archaeological Survey Manager for the Royal Commission for AlUla (Saudi Arabia), coordinating international survey projects and providing heritage input for the regional planning and multi-scale development of the area.

Hassan Moradi

Dr Hassan Moradi specialises in Islamic archaeology. His research primarily revolves around the typology and classification of ceramics and landscape archaeology. He obtained his doctorate from the University of Tehran, where his studies centred on the landscape archaeology of the Neyriz Plain during the Islamic Era. Currently, he is a curator at the Iran National Museum and contributes to the preservation and promotion of Iran's rich cultural heritage.

Davide Motta

Davide Motta (PhD, CEng MICE, FHEA) is a civil/hydraulic and environmental engineer and Assistant Professor of Civil Engineering at Northumbria University. His research focuses on archaeohydrology, sustainable water management and infrastructure-water-environment interaction, with the goal of informing sustainable infrastructure engineering through interdisciplinary frameworks. His latest projects are on water scarcity in the Konya Plain (Türkiye) and the hydraulics of ancient Roman infrastructure.

Çiğdem Özkan-Aygün

Dr. Çiğdem Özkan Aygün is a lecturer in the Department of Humanities and Social Sciences at İstanbul Technical University, Türkiye. She specializes in underwater archaeology (certificated by Conisma and NAS) and holds an MBA from the Institute of Social Sciences from Marmara University, Türkiye. An important point of focus of her research is the history of water management infrastructure of the Byzantine and Ottoman era, including the remains that are currently submerged.

Cecilia Parolini

Cecilia Parolini (PhD, Sapienza University of Rome, 2012) is an independent researcher. She trained on the ancient topography of the Tiber Valley and the city of Rome. Her current research focuses on ancient hydraulic engineering and water management in Roman times. Her interests include water supply systems, the building of dams, and the exploitation of rivers. She studies the interaction between natural landscapes and human actions with an integrated approach combining landscape analysis and geology, geography and history.

Ender Peker

Dr Ender Peker, an urbanist specialising in climate-responsive urbanism, holds a degree in Urban Planning and an MSc in Urban Design from Middle East Technical University (METU). With a

PhD from the University of Reading, he worked as a postdoctoral researcher at the British Institute at Ankara and Istanbul Policy Center, Sabanci University. Currently an Associate Professor at METU, his teaching and research encompass climate-responsive design, participatory planning, and water management.

Cameron Petrie

Cameron Petrie's research primarily focuses on the investigation of complex societies - particularly the rise of complexity, state formation, the impact of imperial expansion, and the relationships between humans and the environment. He has extensive field and research experience at archaeological sites dating from the Neolithic up to the medieval period in India, Pakistan and Iran, and has co-directed projects in each of these countries.

Eric Poehler

Eric Poehler is a Professor of Classics at the University of Massachusetts Amherst. His work focuses on Roman urbanism, infrastructure, and digital humanities. His major digital projects include the Pompeii Bibliography and Mapping Project and the Pompeii Artistic Landscape Project, co-directed with Sebastian Heath.

Irene Polinskaya

Irene Polinskaya is a Reader in Ancient History at the Department of Classics, King's College London. Her research focuses on the social and religious history of ancient Greece and the wider Mediterranean and Black Sea regions.

Louise Purdue

Louise Purdue is a CNRS researcher at the CEPAM laboratory and the University Côte d'Azur in Nice, France. She is a geoarchaeologist and an engineer in agronomy, specialized in the history of agriculture and water management. She has worked in a variety of locations but has dedicated the last 15 years to the study of oases in the Arabian Peninsula as PI of international projects in the Emirates, Oman and Saudi Arabia.

Based on an interdisciplinary approach, she and her team aim at understanding the origin, evolution and mutations of oases for the last five millennia, the socio-environmental driving factors of change, and the adaptation of ancient agricultural communities to climate change.

Anna-Katharina Rieger

Dr Anna-Katharina Rieger is a classical archaeologist based at the University of Graz. From 2013-2017, she was a Postdoctoral Researcher on the 'Lived Ancient Religion' project based at the Max Weber Centre, University of Erfurt. She directed the Eastern Marmarica Survey from 2004-2011, and has held positions at the Universities of Göttingen, Halle – Wittenberg and Berlin, as well as the German Archaeological Institute and Bavarian Academy of Science. She has held fellowships from the Gerda Henkel Foundation, the Alexander von Humboldt Foundation, and the Excellence Initiative of the University of Warsaw.

Çetin Şenkul

Çetin Şenkul is an Associate Professor and Director of the Anatolia Quaternary Research Center at the Süleyman Demirel University in Isparta, Türkiye. He is specialised in Quaternary palaeoecology and biogeography. His main scientific interest lies in exploring microscopic biological remains (especially pollen) in all kinds of sediments all over Anatolia for the reconstruction of environmental settings, natural versus human-induced vegetation changes, and climate dynamics in the past.

Mehmet Şeremet

Dr Mehmet Şeremet is an Associate Professor in Human Geography at Van Van Yüzüncü Yıl University, Türkiye. His wide interests include social sciences and humanities, human geography, tourism and hotel management, education, city information systems, regional planning, urban planning and development and multi-criteria decision-making analysis.

Talel Stambouli

Talel Stambouli is an agricultural engineer and irrigation expert based in Saudi Arabia. He received his PhD from the University of Zaragoza, Spain. Dr Stambouli has over 15 years' experience working in irrigation, water management, geospatial and agriculture practices. He is currently the Manager of Irrigation and Agriculture Infrastructure at the Royal Commission for AIUla.

Daryl Stump

Daryl Stump holds a joint appointment with the Department of Archaeology and the Department of Environment and Geography, University of York, reflecting his research interests in the use of archaeological techniques to assess the sustainability of human-environment interactions, with a particular focus on historic agricultural systems in eastern Africa.

Amy Thompson

Amy Thompson is a Landscape Architect and Urban Designer based in Cape Town. She is the director of Yes And Studio, an experimental design office specialising in public realm interventions and co-creation. Amy was the 2021 recipient of the Scholar's Prize in Architecture from the British School at Rome, where she focused on understanding the city's water infrastructure and its relationship to public space.

James Thompson

Currently leading the planning for the Agriculture Sector for the Royal Commission for AIUla, James Thompson is an ecological agriculture management specialist with 40 years of experience in conventional and organic production, natural resource management, climate smart agriculture systems in arid, tropical and temperate climate zones in many international locations. He holds a BA in Land Management (Ecological Agriculture) from the University of Sydney, and a MSc in International Ecological Agriculture from the University of Kassel, Witzenhasuen, Germany.

Lutgarde Vandepuit

Lutgarde Vandepuit holds a PhD in classical archaeology from the KU Leuven in Belgium. She has been the Director of the British Institute at Ankara (BIAA) since 2006. Whereas she originally specialised in the study of monumental architecture and urban development, as well as in survey archaeology, her recent work focused on cultural heritage management and on sustainable water management.

Katerina Velentza

Katerina Velentza is a maritime archaeologist and postdoctoral research associate in Environmental Humanities at the University of Hull. As an archaeologist, she has conducted research in several archaeological projects and museums of the Mediterranean, the UK and the Baltic Sea. Since 2020, she has been working on the interrelationships between archaeology, heritage, climate change and sustainability.

Thomas Vetter

Dr Thomas Vetter is a lecturer in the Department of Physical Geography at Greifswald University. He is a Senior Advisor for Water Diplomacy at the German Federal Foreign Office, and Project Manager for ancient, adapted water management in the Northwestern Egyptian drylands. He has held assistant professorships at Greifswald and Leipzig universities and was a research assistant at Halle University as well as a project advisor in Egypt for the Deutsche Gesellschaft für Technische Zusammenarbeit.

John Wainwright

John Wainwright is Professor of Physical Geography in the Department of Geography, Durham University, specialising in geoarchaeology and geomorphology. His research focusses on human-environment interactions at a range of scales, with an emphasis on water management and land degradation using inter- and trans-disciplinary approaches.

Kai Wellbrock

Dr Kai Wellbrock is a Research Associate in the Laboratory for Urban Water Management and spokesman for the Archaeohydrology Group at the Technical University of Lübeck. He completed his engineering doctoral thesis in archaeohydrology at the BTU Cottbus-Senftenberg on the ancient water management system of Pergamon, Turkey, and has many years' experience in archaeological field projects including Tayma, the Saudi-German Rajajil Joint Archaeological Project, and Eastern Jafr Joint Archaeohydrological Project.

Jessie Woodbridge

Dr Jessie Woodbridge is a lecturer in Ecosystem Resilience at the School of Geography, Earth and Environmental Sciences (Faculty of Science and Engineering) of the University of Plymouth. Her research interests focus on interdisciplinary approaches to address modern environmental challenges that integrate long-term environmental perspectives. She has worked on projects related to the UK, such as 'Biodiversity and land-use change in the British Isles' as well as the Mediterranean and specifically on Türkiye.

Gülşen Yegen

In 2012, Gülşen Yegen retired from her position as a lecturer at Abant İzzet Baysal University. She has a master's degree in creative Drama and Curriculum, and has completed the Anadolu University Cultural Heritage Programme, the Safeguarding Archaeological Assets of Turkey Certificate Program, and AKMED Antalya History Certificate Programme. In 2017, she started working with Dr Alan Greaves from Liverpool University's Archaeology department. She continues to work as the Education Coordinator of the Carved in Stone and ALPHA projects.

