1 Introduction: an interdisciplinary approach to Water, Life and Civilisation

Steven Mithen and Emily Black

This volume is an outcome of a five-year research project (2005–2009) based at the University of Reading, UK, entitled Water, Life and Civilisation. This project's aim was:

> to assess the changes in the hydrological climate of the Middle East and North Africa (MENA) region and their impact on human communities between 20,000 BP and AD 2100, with a case study of the Jordan Valley.

The project arose from a decision by the Leverhulme Trust to fund one or more projects under the heading 'Water, Life and Civilisation', each funded by an award of up to £1.25 million, advertising for applications in October 2003. Quite why the Leverhulme Trust selected this theme is unknown, but it was one that provided an ideal fit to research interests within the School of Human and Environmental Sciences at the University of Reading. The School had been formed in August 2003 from the previous Departments of Archaeology, Geography, and Soil Science, and the Postgraduate Research Institute for Sedimentology, with the avowed aim of developing interdisciplinary research. There was already research collaboration between Archaeology and the Department of Meteorology, exploring the impact of Pleistocene climate change on hominin dispersals from Africa (Hughes and Smith, 2008; Smith *et al*., in press). In light of expertise within Geography regarding hydrology and development studies, and within Archaeology regarding the emergence of complex society, the Leverhulme Trust's request provided an excellent opportunity to realise the potential for interdisciplinary research provided by the new School; moreover it would be able to do so by addressing a research theme of global significance.

1.1 WATER, LIFE AND CIVILISATION

The planet is facing a water crisis: one billion people do not have access to safe drinking water. Two billion people have inadequate sanitation. By 2025 almost one-fifth of the global population is likely to be living in countries or regions with absolute water scarcity while two-thirds of the population will most probably live under conditions of water stress (UNWater, 2007). Excessive extractions of ground- and surface-water are causing rivers to run dry and wetlands to shrink; freshwater supplies are becoming polluted. Throughout the world, political tension is rife within and between countries over access to precious and dwindling water supplies, tensions that hinder peace processes and threaten to erupt into armed conflict (Gleick, 2006; Barlow, 2007). Population growth, economic development and urbanisation place unrelenting pressure on the planet's water resources. Ongoing, human-induced, climatic change is likely to have a further detrimental impact on water supplies to large sectors of the global population: precipitation is forecast to decrease and evaporation to increase in precisely those areas that are already suffering from water stress (Parry *et al*., 2007; UNEP, 2007).

So if the term 'civilisation' is taken to mean a society in which people live and act in a civil manner to each other, 'Water, Life and Civilisation' is a phrase that encapsulates the immense challenge we face in securing a future for the planet in which all life, human and otherwise, has an adequate and uncontested water supply – or at least one in which drought-induced starvation, inadequate sanitation and water-based conflict are minimised. Research contributing towards that end must necessarily come from a wide array of disciplines ranging from climate science to development studies, achieving an integration that goes beyond mere multi-disciplinary or even interdisciplinary approaches: the challenge of 'Water, Life and Civilisation' epitomises the post-disciplinary academic world towards which we must strive.

One mark of a civilised society is knowledge about the past, both for its practical value – the challenges of the future cannot be resolved unless one understands how they have arisen – and for its own inherent value. The term 'civilisation' can also be used in a historical sense to refer to those ancient societies that

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reached high levels of social complexity, economic development and/or cultural attainment, as in the 'Mayan', 'Sumerian', Egyptian', 'Indus' and 'Inca' civilisations. Key attributes are high degrees of centralised authority and social stratification, extensive craft specialisation and trade networks, writing, art and monumental architecture (Trigger, 2003). While such attributes are shared, there is nevertheless immense social, economic and cultural variability, and quite different historical trajectories of development for such 'civilisations', making the term of limited academic value.

One further attribute that appears to have been shared by all of those ancient societies designated as 'civilisations' is sophisticated systems of water management to provide water for drinking, irrigation and, in some cases, social display. There has been a long history of archaeological study exploring and debating the relationship between water availability, water management and the 'rise of civilisation', or more generally the emergence of social complexity. The 'oasis theory' originally proposed by Pumpelly in 1908 and developed by Childe (1928) suggested that during a period of aridity immediately after the end of the ice age in the Near East, people, animals and plants were forced to cluster around oases, which led to domestication. While this particular proposition is no longer supported, changes in the overall quantity and annual distribution of precipitation between the Late Pleistocene and early Holocene epochs remain central to debates about the origin of farming, not only in the Near East but also in other regions of the Old and New Worlds (see the review in Mithen, 2003). The role of water management has been a key issue in theories about how small-scale farming communities grew into towns and ultimately state societies. Karl Wittfogel's monumental 1957 volume entitled *Oriental Despotism: A Comparative Study of Total Power* proposed that state societies in Asia were dependent upon the building of large-scale irrigation works. Wittfogel's 'hydraulic hypothesis' argued that such works required forced labour and a large, complex bureaucracy, both of which provided the basis for what he termed 'despotic' rule (Wittfogel, 1957). The anthropologist Julian Steward made a similar argument in his 1955 volume *Irrigation Civilization: A Comparative Study*, claiming that irrigation was the catalyst for state formation (Steward, 1955).

Robert McCormick Adams attempted to test the hydraulic hypothesis with regard to the rise of Mesopotamian civilisation (Adams, 1966; Adams, 1978) and found that complex systems of canals and irrigation came after the appearance of cities and the indicators of bureaucratic statehood, rather than before as Wittfogel had proposed. The same was found for the emergence of the Mesoamerican archaic state (Scarborough, 2003). Moreover, it soon became evident that societies throughout history have developed sophisticated techniques of water management but did not evolve into states, and that some of the most complex water management systems concerned reservoir management rather than irrigation. Indeed, what has emerged during the past few decades of archaeological research is a far more complex and diverse association between water and society than Wittfogel, Steward or anyone else had ever imagined, one that defeats the construction of a single grand theory such as the hydraulic hypothesis. Cross-cultural studies now emphasise the astonishing variety of methods of water management, and the even greater variety of relationships to land, labour and power (Scarborough, 2003). So we can use the phrase 'Water, Life and Civilisation' to encapsulate one of the key themes of archaeological research: understanding the complex relationships between water availability, water management and the emergence of social complexity.

1.2 THE IMPACT OF CLIMATE CHANGE: PAST, PRESENT AND FUTURE

There is an overlap between our concerns for the future and studies of the past: the extent to which securing a water supply has been in the past, and will be in the future, a driver for social and economic change. Another overlap is with the impact of climate change and how this might be assessed. The Intergovernmental Panel on Climate Change (IPCC Core Writing Team *et al.*, 2007) predicted a rise of global temperatures of 2.0–5.4 K by 2100 under a 'business as usual' (A2) scenario, one in which greenhouse gas emissions continue at their ongoing rate to the end of the century; even with a substantial reduction in emissions (for example under a B1 scenario), temperatures are predicted to rise by 1.1–2.9 K by 2100. The impact of such climate change on human communities will primarily be reductions in available water in some vulnerable regions, caused by changing patterns of precipitation allied with increased evaporation, which in turn influence food security. Furthermore, some climate models project increases in the frequencies of extreme precipitation and temperature events (e.g. Gao *et al.*, 2006), leading to more floods and droughts, with potentially catastrophic consequences. As such, there is a need to refine the spatial resolution of climate models to make them relevant to those charged with devising policy and plans to both mitigate and adapt to climate change. This has motivated the development of global climate models (GCMs), which have resolutions in the order of 20 km; Kitoh *et al.* (2008) describes the application of such a model to the Middle East. An alternative approach, which avoids the computational expense of running global high-resolution models, is to implement a Regional Climate Model (RCM) for the area of interest. Even when high resolution, state-of-the-art climate models are used, some form of statistical bias correction and downscaling is usually required, if the output is to be used to drive quantitative impacts models.

Studies of the past and current climate can inform projections for the future. At one level, comparison between the output of model integrations and observations of the recent and distant past is a test of how well a climate model can capture both large-scale climate processes and finer-scale variability. In particular, comparison with proxy observations of the past (e.g. the past 12,000 years) is an opportunity to assess how well models can simulate the response of the regional climate to substantially perturbed global forcings through time. This is highly relevant to future scenarios, in which the global forcings, such as net radiation, are substantially different from the present day and recent past. At another level, when used in conjunction, climate models and proxy data can deepen our understanding of large- and small-scale responses to strongly perturbed forcings, enabling us to interpret future climate projections. For example, the aridification that occurred in the Middle East during the Holocene has some parallels with the decrease in rainfall projected for the region over the next century under some future scenarios.

While archaeologists have always had an interest in the potential impact of climate change on the development of human society (Lubbock, 1865; Childe, 1928), this new level of understanding has allowed questions to be asked about the relationship between specific climatic events and cultural change; geologists and hydrologists are also increasingly associating changes in the palaeoclimatic record to changes in the nature of human society (e.g. Cullen *et al*., 2000; deMenocal, 2001; Issar and Zohar, 2004). For instance, the onset of markedly more humid conditions in Africa 70 kyr ago (ka) has been proposed as the reason for the dispersal of modern humans (Scholz *et al*., 2007), while the impacts of the 8.2 ka and 4.2 ka events have been proposed as playing a causal role in cultural change of society in the Near East (Cullen *et al*., 2000; deMenocal, 2001; Rosen, 2007). Perhaps one of the key findings of recent years leading to this concern with the impact of climate change on human communities is the rapidity with which such change can occur: on some occasions, abrupt and dramatic changes in temperature and rainfall happened within the span of human memory and potentially individual human lifetimes (Alley *et al*., 2003).

While it is appropriate to ask about the impact of these 'events', archaeologists and others have rarely gone beyond subjectively identifying a supposed chronological match between a particular spike or trough in a climate curve and a particular cultural event, followed by speculative claims that the former caused the latter. Insufficient attention has been paid to how the supposed global climatic event might have been environmentally manifest at the regional or local level and how that in turn affected the relevant economy and society. Just as is the case for the future, the past impacts would have been mediated by changing levels of precipitation, affecting the water supply and ultimately the provision of food. And just as we need Regional Climate Models to predict what may happen in the future, we need the same type of models to explore how the global climatic events detected in the marine and ice cores might have been manifested at a spatial and temporal scale relevant for past communities. Moreover, we also need an understanding of the society, economy and technology of those communities to assess how resilient and/or adaptable they might have been to such environmental change.

Archaeologists today are fortunate to be working at a time when the threat of future climate change has generated an investment in climate modelling research which they can exploit for their own interests in the past. Climate modellers are also fortunate to be working at a time when archaeologists and geologists have made significant progress in reconstructing past environments and relating changes in the terrestrial record to the climatic events detected in the more continuous ice core and marine records: how else can climate modellers verify their models other than by testing their ability to predict not future but past climate change, in other words against what actually happened in the past? The archaeological and geological records now provide a multitude of proxies for changing temperature and rainfall and their environmental consequences, such as changing patterns of vegetation. So the question arises whether the RCMs are able to draw on the known levels of greenhouse gases and patterns of solar radiation in the past to predict those changes in temperature and precipitation that are known to have happened: if they cannot, how can we have confidence that those same models provide valid predictions of future climate change?

1.3 THE WORLD, MIDDLE EAST AND NORTH AFRICA AND THE JORDAN VALLEY

The issues concerning water availability in the past, present and future are of global significance: they are relevant to all geographical areas of the planet and all human communities. There are, however, regions where the potential impacts of climate change are more pressing than others, partly because of existing problems of population pressure, environmental degradation and/or conflict: sub-Saharan Africa, Bangladesh and Mexico City are notable examples. But the Middle East is perhaps the pre-eminent region where the availability and management of water is most inextricably linked to society and economy.

Ownership and access to water sources has been central to the ongoing Arab–Israeli dispute, both as a cause of conflict and as one of the areas in which cooperation has been achieved (Allan, 2001). The water sources within this region have no respect for political boundaries, the watersheds and aquifers being trans-national in their extent – although it might be argued that through its land annexations and construction of its wall, Israel has been attempting to adjust its national boundaries to encompass the extent of aquifers. Population growth, agricultural development, industrialisation and tourism are placing ever greater demands on water availability, at a time when rainfall is projected to decrease and evaporation to increase during the next century (Mariotti *et al*., 2008; Evans, 2009). Ambitious plans involving vast financial investment are under way to transport water over long distances, epitomised by the Red Sea–Dead Sea pipeline (Glausiusz, 2010).

While the future, present and recent past of the Middle East cannot be understood without reference to the role of water, neither can its distant past. This is the region where both the earliest farming communities and ancient civilisations emerged; it has been the focus for archaeological theories relating water availability and management to major social and economic change. The access that archaeologists now have to climate, hydrological and palaeoenvironmental research should enable significant progress to be made on why farming, urbanisation and civilisation emerged in this region of the world.

In October 2003, when the Leverhulme Trust requested applications for projects on the theme of 'Water, Life and Civilisation', the Department of Archaeology at the University of Reading was already engaged in a long-term project exploring the origin of farming within Jordan, undertaking excavations at the early Neolithic site of WF16 in Wadi Faynan in collaboration with the Council for British Research in the Levant (CBRL), specifically between Steven Mithen at the University of Reading and Bill Finlayson, the Director of the CBRL (Finlayson and Mithen, 2007). That wadi, semi-arid today, also provided dramatic archaeological evidence for the role of water management in the Roman/Byzantine period in the form of a ruined aqueduct, reservoir and field system, and in rural economic development in the expansion of tomato and melon farming using irrigation by recently settled Bedouin following the formation of a cooperative in 2003 (Barker *et al*., 2007).

1.4 THE SCOPE OF THE WATER, LIFE AND CIVILISATION (WLC) PROJECT

In light of the ongoing archaeological research interests in the Jordan Valley, collaboration with the CBRL, the overall significance of the Middle East, and the potential for interdisciplinary research provided by the mix of disciplines represented in the School of Human and Environmental Sciences and Department of Meteorology, a proposal was submitted to the Leverhulme Trust to fund a University of Reading project on Water, Life and Civilisation. The aim outlined at the outset of this chapter was, of course, enormously broad. It has the potential to encompass a vast range of studies covering not only climate modelling, hydrology and archaeological studies, but also history, politics and international relations. Even with the relatively large sum of £1.25m that was available, the extent of research that could be undertaken was constrained, partly by resources and partly by the range of expertise available at the University of Reading. Some of these limits were identified at the start of the project – such as a decision not to address the recent history and politics of water. Others arose during the course of the research as time and resources became gradually exhausted or initial research opportunities were unable to be developed. For instance, there were plans to undertake a study of water usage within a Roman city, such as Jerash, and within the Islamic sugar industry of the Jordan Valley. Neither proved possible with the available time and funding.

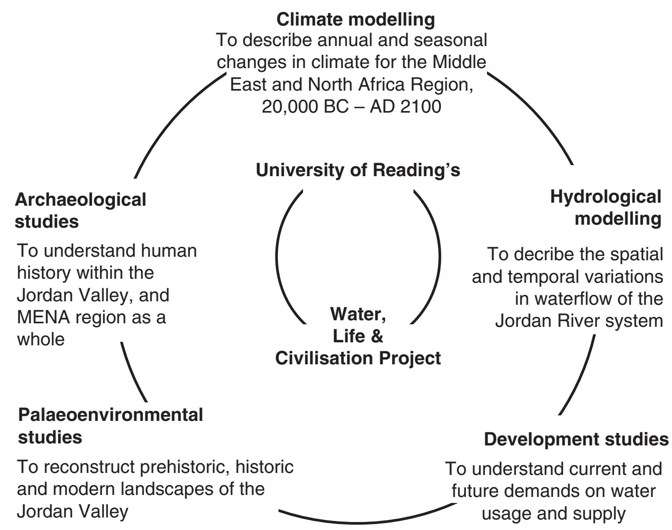

Figure 1.1. Disciplinary aims and interdisciplinary interactions of the Water, Life and Civilisation Project.

One of the over-riding intentions of the project was to develop the interdisciplinarity that is widely recognised as essential for the study of water. This is difficult to realise in practice because of the manner in which academic institutions are structured by departments and faculties, often competing with each other for resource from the same institution. External pressures also serve to maintain disciplinary-based research, such as the Research Assessment Exercise in the United Kingdom. While the development of interdisciplinarity was a key objective, the WLC project also recognised that it needed to make substantive contributions to the core disciplines around which it was structured if the interdisciplinarity was to avoid becoming a superficial sharing of ideas and data. In this light, and to make the best of the available funding and expertise, the WLC project was structured around five sub-projects, each with their own Principal Investigators, aims and project-funded staff: Meteorology, Palaeoenvironments, Archaeology, Hydrology and Development Studies (Figure 1.1, Table 1.1).

The aim was to achieve the interdisciplinarity both informally, simply by regular discussions and seminars between the

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More information

Table 1.1 *Water, Life and Civilisation: project members*

Sub-project	Principal investigators	Post-doctoral research assistants	PhD students	MSc/BSc students	Other collaborators
Meteorology	Brian Hoskins Julia Slingo	Emily Black David Brayshaw			
Palaeoenvironmental studies	Stuart Black Bruce Sellwood	Stuart Robinson Claire Rambeau	Richard Fitton	Robyn Inglis Rachel Goodship	Paul Valdes
Archaeology	Steven Mithen Bill Finlayson	Emma Jenkins Sam Smith Andrew Bradley Rebecca Foote	Michela Sandias	Ambroise Baker Sarah Elliott Helen Stokes	Jaimie Lovell Gundula Mueldner Sameer Numait Khalil Jamjoum John Oleson
Hydrology	Paul Whitehead	Andrew Wade Nicola Flynn Dan Butterfield		Joshua Guest	Paul Holmes Ron Manley David Plinston Mohammed El Bastawesy
Development studies	Rob Potter Stephen Nortcliff	Khadija Darmame	Gemma Carr		Sameer Numait Khalil Jamjoum Nasim Barham

participants to make each other aware of the issues, language, methods and data sources of each discipline, and by formal integration of research. Figure 1.2 illustrates how this was envisaged in terms of a chain of models: a global circulation model would inform a regional circulation model for the study region; the RCM would generate input into a hydrological model for a localised area that would predict water availability, whether for a specified time period in the past or the future. This would, in turn, inform a study of either archaeological remains or a contemporary community. In this regard, the hydrology was identified as the key link between changing patterns of climate and human society – the link that has been most evidently missing from previous research.

Further forms of interdisciplinary engagement were envisaged. We aimed to undertake one or more direct comparisons of the environmental projections from an RCM for a specified region at a specified date in the past and the reconstruction of those environments by using a variety of geochemical proxies to evaluate the veracity of the RCM. We also aimed to make use of palaeoenvironmental reconstructions to inform the interpretation of archaeological sites within the study region and the study of contemporary water use, in terms of day-to-day household strategies to cope with limited water supply, to help formulate proposals for how water may have been managed at this level in the past.

The geographical scope of the climate modelling was chosen to include the whole Mediterranean and some of the eastern Atlantic, so as to allow the RCM to capture the eastward passage

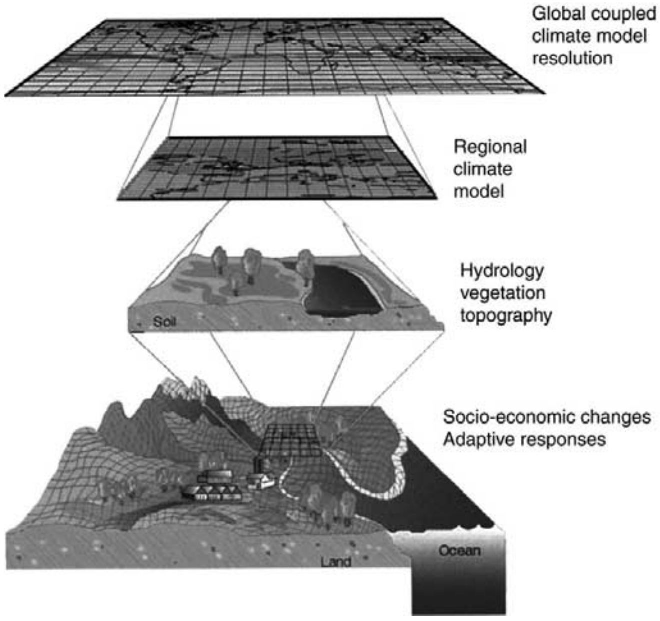

Figure 1.2. Hierarchical modelling from global circulation models to socio-economic impacts (courtesy of David Viner). See colour plate section.

of cyclones over the Mediterranean. The region had an eastward coverage from Portugal to Iraq and a southward coverage from southern Europe to North Africa (Figure 1.3). The model used was HadRM3, a derivative of HadAM3, an atmosphere-only GCM, which is widely used by the climate research community.

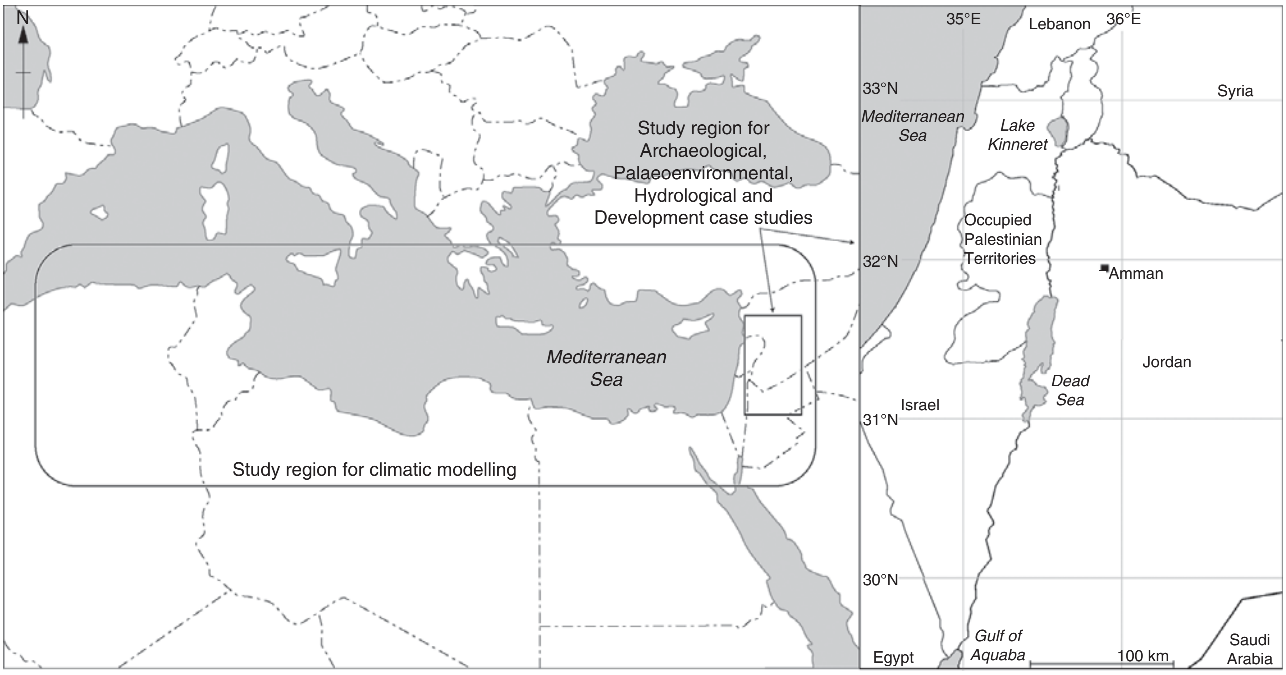

Figure 1.3. The geographical scope of the climate modelling within the Water, Life and Civilisation project and the case study region, indicating the key research localities.

The version of HadRM3 used in these studies has a resolution of 0.44° × 0.44°. The model was informed by lateral boundary conditions derived by the fully coupled model HadCM3 for the future climate integrations, and the slab model HadSM3 for the palaeoclimate integrations. While the Palaeoenvironmental, Hydrological, Archaeological and Developmental studies could feasibly have been undertaken anywhere within this region, the decision was taken to concentrate these in Jordan, and more specifically (but not exclusively) in the Jordan Valley and Wadi Araba regions, broadly between Amman and Aqaba – the southern reaches of the southern Levant and the western arm of the 'fertile crescent' (Figure 1.3). This was partly for pragmatic reasons in terms of the existing research activity in this region, the support of the Council for British Research in the Levant (CBRL) with regard to securing research permits and logistical help in the field, and political stability. More importantly, however, these were identified as the regions with the greatest potential for making substantive contributions towards our disciplinary and interdisciplinary research goals.

1.5 PROJECT DEVELOPMENT

Some elements of the research to be undertaken by each of the sub-projects were clearly defined from the start of the project as a whole. The initial work of the Meteorology sub-project was to provide a study of the present, past and future climates of the Middle East and North Africa region (Chapters 2, 3 and 4). Such work would provide the foundation for the interdisciplinary studies, the specific nature of which had to develop during the course of the project. Similarly, it was clear from the start of the project that the Palaeoenvironmental sub-project had to undertake a review of the evidence for past climates and environments in the study region to provide a framework for any case studies that would follow (Chapters 6 and 7). Those reviews involved some comparison between the output of GCMs/RCMs and the palaeoenvironmental data, but a more explicit comparison became necessary for which a study of changing precipitation in the eastern Mediterranean during the middle Holocene was developed (Chapter 8). It was also evident from the start of the project that further geochemical studies of the Lisan sediments from the former extent of the Dead Sea would be beneficial, especially because these would be on the eastern exposures (i.e. in Jordan), the majority of previous studies having been undertaken on the western bank (Chapter 9). During the course of the project, the potential for palaeoenvironmental reconstruction for the environs of the Neolithic site of Beidha by the analysis of carbonate deposits was identified and pursued (Chapter 16); following some success with that research, the same method was applied to carbonate deposits within Wadi Faynan. In addition, peaty deposits dating from at least 7,000 BP were identified within artesian springs in the vicinity of the Dead Sea, resulting in the extraction of cores for pollen and geochemical analysis.

The changing level of the Dead Sea, both of the past and projected into the future, was also an immediate target for the Hydrology sub-project, as this allowed an engagement between the hydrology and the palaeoenvironmental studies (Chapter 11), along with a broader understanding of the impact of climate change on the River Jordan (Chapter 10). This project then undertook a hydrological study of two of the major wadis in Jordan, Wadi Faynan (Chapter 12) and Wadi Hasa (Chapter 13), with the first of these providing the basis for an interdisciplinary study of long-term human settlement.

In the Archaeology sub-project, there was a clear need to review the existing evidence for water management especially prior to the historic periods (Chapter 14). Such evidence comes in the form of structures – dams, cisterns, aqueducts – and in the character of plant remains that could only have been grown under conditions of irrigation. The latter are critically important because structures such as irrigation channels may have been relatively ephemeral and left no archaeological trace. Rosen and Weiner (1994) and Araus *et al*. (1997) had claimed that the use of irrigation can be identified from the character of phytolith assemblages and the isotopic composition of charred grain, respectively. It was immediately apparent in the WLC project that the methodology they proposed required rigorous testing, and consequently a plant growing experiment was established to support the subsequent analysis of archaeological materials (Chapters 21, 22 and 23). The isotopic analysis of human and animal bone for the reconstruction of past diet and herd management strategies, and how these may have been influenced by changing water availability, was also identified as a priority, although a specific question to be addressed could not be defined until the availability of skeletal samples was determined (Chapter 20).

The Archaeology sub-project was also the main driver in identifying case studies for the interdisciplinary research in terms of developing and applying a chained set of climate and hydrological models to facilitate the interpretation of archaeological remains. During the development of the required methodology to link the climate and hydrological models, it became evident that an explicit description of the critical role of a 'weather generator' that provides the link from one to another was required (Chapter 5). Numerous potential case studies of archaeological sites were initially identified and evaluated, resulting in three being chosen: a multi-period study in Wadi Faynan from the Neolithic to the Byzantine period (Chapter 15), a study of the Bronze Age site of Jawa in northern Jordan (Chapter 18) and a study of the Nabataean–Islamic settlement of Humayma in southern Jordan (Chapter 19). Jawa and Humayma were selected because of pre-existing surveys and interpretations of their water management structures (Helms, 1981; Oleson, 1992; Oleson, in press) that were ripe for further interpretation by our interdisciplinary approach. For these studies a landscape analysis of Chalcolithic/Early Bronze Age settlement was undertaken, covering Jordan, Israel and the Occupied Palestinian Territories, exploring how the distribution of settlement may have been influenced by the availability of water (Chapter 17).

Figure 1.4. Water, Life and Civilisation team members during an orientation visit to Jordan in October 2004, here seen at the Iron Age tell of Deir 'Alla. See colour plate section.

Finally, the Development sub-project began with a clear need to review the overall situation regarding water usage in contemporary Jordan (Chapters 24 and 28) and the potential impact of future climate change. This formed the overarching background for a suite of studies concerning contemporary patterns and processes of water usage in urban and rural areas (Chapters 25, 26 and 27). These included detailed analysis of the use of treated waste-water in the agricultural realm (with a particular emphasis on both farmers and policy decision-makers), and the examination of social variations in the storage and use of water in the primate capital city of Greater Amman. A further line of research provided a detailed assessment of the development impacts of irrigated agriculture in Wadi Faynan.

The need to develop research within core disciplines prior to undertaking the interdisciplinary studies meant that during the first two years of the WLC project (2005, 2006), the extent of formal interaction between the sub-projects was relatively limited. Informally, however, this was achieved by a joint field trip to the Jordan Valley at the start of the project for group orientation (Figure 1.4), most critical for the meteorologists who would not be undertaking field work. It was subsequently met by means of an annual review meeting where each sub-project presented its ongoing work. To give this a self-critical edge we invited Professor Neil Roberts (Physical Geography, Plymouth University), Professor Richard Bradley (Archaeology, University of Reading), Professor Tony Wilkinson (Archaeology, Durham University) and Professor Robert Gurney (Meteorology, University of Reading) to attend these meetings and provide critical comment and advice regarding progress of each sub-project and the WLC project as a whole. Field work in Jordan was conducted by each of the sub-projects (except for Meteorology) combining field trips by staff from different sub-projects whenever possible. Small-scale excavations were undertaken in Wadi Faynan and at Humayma to secure sediment samples from Nabataean/Roman/Byzantine fields for phytolith analysis. As from the start of the third year of the project, the sub-project structure began to dissipate, as the boundaries between what was archaeology, hydrology, meteorology and so forth effectively became so blurred as to be of little value. As well as regular conference presentations by individual members of the project, an annual presentation of its ongoing research was made at the British Association for Near Eastern Archaeology. In November 2009 the WLC project organised a joint discussion meeting of the British Academy and Royal Society on the theme of Water and Society: Past, Present and Future, inviting participants from comparable interdisciplinary research projects based in Germany (GLOWA) and the United States (Mediterranean Landscapes Project).

1.6 THIS VOLUME

This volume provides reports on approximately 80% of the research that was undertaken between 2005 and 2010 by the Water, Life and Civilisation project. Some of this has already been published as journal articles but is brought together here to provide a near-comprehensive coverage of the research and its outcomes. The volume is broadly structured by the sub-projects, with the majority of the interdisciplinary studies being included in Part IV, the section entitled Human Settlement, Climate Change, Hydrology and Water Management. The WLC research not included within this volume is that which was started within the timeframe and with funding of the project, but which has extended beyond 2010. Most notable of this is the analysis of Dead Sea peat deposits and Wadi Faynan travertine deposits, both currently being undertaken by Dr Claire Rambeau, the multivariate analysis of data from the crop growing experiments by Dr Emma Jenkins and a review of water management technology of the Roman, Byzantine and Islamic periods by Dr Rebecca Foote. An attempt has been made to produce individual chapters and sections that can be read as stand-alone products but which also contribute to a single integrated volume. The final chapter (Chapter 29) of this volume seeks to draw the various research strands together to address the overall contribution of the project to our understanding of Water, Life and Civilisation.

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Part I
Past, present and future climate