No planet B: comparative reflections on hydraulic engineering and zoonotic epidemics in the Jordan Valley in early Neolithic time and twenty first century

Não há planeta B: reflexões comparativas sobre engenharia hidráulica e epidemias zoonóticas no Vale do Jordão no Neolítico antigo e século XXI

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Abstract This article focuses on the critical importance of knowledge, a key trait of human culture, in multi-species environmental coadaptation and niche co-construction in human evolutionary history. It draws upon two cases of hydraulic engineering and associated zoonotic epidemics in the Jordan Valley, which has been part of the planetary crossroads of human migration and cultural exchange (including the exchange of knowledge) since prehistoric times. The first case is based on existing archaeological studies of the Neolithic town of Jericho as it was 10,000 years ago in today's Palestine, and the second is based on our ethnographic fieldwork on a Pumped-Storage Hydropower (PSH) project under construction since 2017, 110 km away from Jericho, located in today's Israel. Following recent observations by ecologists that the Earth is becoming one single ecosys-

Resumo Este artigo debruça-se sobre a importância crítica do conhecimento, um traço fundamental da cultura humana, na coadaptação ambiental multiespécie e na coconstrução de nichos na história evolutiva humana. Baseia-se em dois casos de engenharia hidráulica e epidemias zoonóticas associadas no Vale do Jordão, que tem feito parte da encruzilhada planetária da migração humana e do intercâmbio cultural (incluindo o intercâmbio de conhecimentos) desde tempos pré-históricos. O primeiro caso tem por base estudos arqueológicos da cidade neolítica de Jericó, tal como era há 10.000 anos, no que hoje conhecemos por Palestina, e o segundo baseia-se em trabalho de campo etnográfico por nós realizado num projeto de armazenamento hidroelétrico bombeado (PSH do inglês *Pumped-Storage Hydropower*) em construção desde 2017, a 110 km de distância de Jericó, localizado onde hoje se

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tem and our only ecological niche, this article undertakes a comparative analysis of human knowledge and its part in niche construction at local and planetary scales. The neolithic people of Jericho eventually left their town due to ecological crises and dispersed into small agro-pastoral communities for survival and re-adaptation. Today, as we can infer from the PSH case study, human beings have no Plan(et) B and must adapt to the changing environment through knowledge innovation and exchange. We call for cross-disciplinary approaches to studying social-cultural processes of sharing and innovating knowledge that are adaptive to today's ecological changes at a planetary level.

Keywords: Planetary ecosystem; human knowledge; adaptation; niche construction; energy transition.

situa o Estado de Israel. Após observações recentes por parte de ecologistas de que a Terra se está a tornar num ecossistema único e no único nicho ecológico do ser humano, este artigo analisa comparativamente o conhecimento e o seu papel na construção de nichos às escalas local e planetária. Os habitantes neolíticos de Jericó eventualmente abandonaram a sua cidade devido a crises ecológicas e dispersaram-se em pequenas comunidades agro-pastoris para sobrevivência e readaptação. Hoje, como demonstrado no caso do PSH, os seres humanos não têm Plano(eta) B e devem adaptar-se a um ambiente em constante mudança através da inovação e da troca de conhecimentos. Apelamos para abordagens interdisciplinares no estudo de processos socioculturais de partilha e inovação de conhecimento que sejam adaptáveis às mudanças ecológicas atuais a nível planetário.

Palavras-chave: Ecossistema planetário; conhecimento humano; adaptação; construção de nicho; transição energética.

Introduction

Human adaptation to environmental changes involves two strategies: migration to a new environment, and development or adoption of new knowledge for continuing local life. This article focuses on two cases of hydraulic engineering as respective examples of these two adaptation strategies and associated human knowledge practices amid climate change and environmental crisis at different moments in human evolution. Although about 10,000 years apart, both cases are located in the Jordan Valley, a small region that illustrates the human history of adaptive evolution. The Jordan Valley is a critical part of the planetary crossroads of prehistoric humans' migration from Africa to Eurasia and the rest of the world. Based on existing archaeological studies, the first case is about the flood-control walls of the Neolithic town, Jericho, that date back to about 10,000 years and were located in today's Palestine. This hydraulic engineering project was associated with environmental challenges and zoonotic diseases that made Jericho residents abandon the town and disperse into small agro-pastoral communities after about one and half millennia. Based on ethnographic research, the second case is about a pumped-storage hydropower (PSH) project that has been under construction in Israel since 2017. This project, designed by and being carried out collaboratively by a group of multinational engineers, can be viewed as part of our ongoing transition to renewable energy amid global climate change. A critical difference between the two cases is the respective geographical scales of the ecological niches of the people involved and the knowledge needed to achieve their goals. The Neolithic Jerichoans were lucky to have new environments available and accessible for them to re-adapt to and in which they could co-construct new niches. In contrast, amid global environmental change and zoonotic disease pandemics today, human beings all over the world are becoming part of one shared ecological niche, i.e., the ecosphere of the Earth, or also increasingly called the planetary ecosystem. Abandonment of and emigration from the Earth is not yet a viable option, i.e. for the moment, there is no Plan(et) B. Therefore, human beings necessarily have to follow the other major strategy: adaptation, namely knowledge innovation and exchange for adapting to the changing environment.

We draw inspiration from the recent attempts of (re-)articulating archaeological and ethnographic research for a comparative analysis in a historical framework (e.g. Goody, 2006; Binford, 2019; Graeber and Wengrow, 2021). More specifically, for a comparative analysis of human knowledge in niche construction and in ecological crises, we draw upon existing archaeological research and our own ethnographic fieldwork on the prehistoric and the current hydraulic engineering projects in the Jordan Valley. Our comparative approach is firstly based on this small valley's special geographical location and environmental-ecological conditions that made it a key part of the planetary crossroads during the prehistoric migration of human groups out of Africa, and the continuous exchange of knowledge that resulted, including the knowledge of epidemic diseases.

We compare two unprecedented moments of human adaptation: the historical move into the world's very first sedentary farming town and contemporary efforts to adapt to the new realities of earth's ongoing transformation into a single ecosystem.

Unlike recent archaeological-ethnographic comparative work aimed at archaeological goals (Binford, 2019) or at modern history (Borsch, 2004), our comparative approach is future-oriented: it pulls together recent developments in multiple fields including anthropology, ecology, and STS to encourage urgently needed cross-disciplinary exploration of human adaptation to the emerging planetary ecosystem.

Our comparative approach highlights the predicament of contemporary human adaptation and its challenges. We look at the implications from Neolithic times for the development of a nonlinear understanding and how this might play a part in current technological knowledge as it is applied to present-day strategies for adapting to environmental challenges. We appreciate archaeologists' and cultural anthropologists' recent warning against the continuing emphasis — driven, as it is, by ideas of technological progress — on unilineal evolutionary theories despite multidisciplinary critiques and the 19th century rejection of unilinealism (e.g. Graeber and Wengrow, 2021). Likewise, our case studies, especially the Neolithic case, demonstrate that the advancement of technological knowledge in itself is not the decisive factor in processes of human adaptation to changing environmental conditions. Our comparative analysis focuses on the urgent need for cross-cultural exchange and knowledge innovation that would contribute to a timely adaptation to changing environments, and a rejection of the continuous hegemony of dominant models of knowledge, such as unilineal evolutionism and fossil fuel engineering. We also reject the hostile separation of human groups such as in today's Jordan Valley.

Section 1 below draws upon theories of human evolution and human ecology to guide the comparative approach for this study. Section 2 presents the research methods and focal sites of this study. Sections 3 and 4 introduce, respectively, the flood-control walls of Neolithic Jericho and the Pumped-Storage Hydropower project under construction in the Jordan Valley. Section 5 provides a comparative analysis of these two cases focusing on knowledge variety and innovation in evolutionary adaptation. Section 6 briefly concludes this article and suggests further ways of thinking about human knowledge and niche construction in the emerging planetary ecosystem today.

1. Human knowledge in niche construction at local and planetary scales

As a human practice and a variety of knowledge, hydraulic engineering, a subset of civil engineering, is concerned with the flow and conveyance of fluids and has been deployed from Early Neolithic times to protect settlements, enhance farming practices, and provide energy. The walls of Jericho are a textbook example (e.g., Lavenda and Schultz, 2007: 215-217) of the earliest example of large scale hydraulically engineered project designed to protect sedentary human settlement and animal domestication from flooding. However, as with many subsequent cases in a variety of locations throughout history (e.g., Borsch, 2004), zoonotic epidemics turned out to be one of the main causes of the eventual abandonment of Jericho.

Based on Jericho and other early cases, a simplistic and long held paleo epidemiological theory has associated infectious zoonotic diseases with the agricultural transition and animal domestication. Scholars in bioarcheology, paleoepidemiology and related fields have recently called for a broader framework of multispecies coevolution that would employ multi-disciplinary approaches to investigating human, animal and ecosystem health with a more extensive historical view covering a wider range of human-animal-environment interactions (e.g., Bendrey and Martin, 2022; Schug and Halcrow, 2022). This framework helps to examine zoonotic disease outbreaks beyond just settlements that are associated with changing environments due to human mobility in hunting-gathering societies (Vlok et al., 2022). This article deploys such a framework to encompass humans' ongoing adaptation to global climate changes in a single planetary ecosystem, and to consider niche construction activities beyond agricultural, including such activities as hydraulic engineering and energy transition.

Even if not yet fully supported across all disciplines, scholars in ecology and neighboring fields have been warning us for some twenty-five years now that accumulated anthropogenic impacts are turning the whole Earth into a single ecosystem, and that this is the only and last ecological niche available to us and must be shared by all human and other living beings (Cohen, 1995; Lovelock, 2000; Ellis, 2015; Chase-Dunn and Lerro, 2016; Bohle and Marone, 2019). Given the limits of human knowledge and technologies available currently, there is still no other accessible planet which would provide the stage for another "Great Discovery" in the form of human colonization (Nowotny, 2019). Sourcing highly condensed (nuclear) energy is still beyond our grasp (Sinyavsky, 2018; Campioni, 2020), despite ongoing attempts by the likes of Elon Musk and other billionaires (Musk, 2017; Szolucha, 2022). The human race finds itself facing a historically unprecedented moment full of uncertainties. One critical issue that urgently needs updating is our knowledge of the geographical scale of our ecological niche. Recent multidisciplinary studies on global climate change adaptation have often fallen back on local or community scale (Jones et al., 2021). These ill-defined and limited geographical scales are insufficient or even misleading as indicators of the success of recent climate change adaptation projects. For example, thanks to monetary donations and supposedly advanced knowledge of developed countries, local flood-control walls to fight climate change and rising sea levels have once again been built along the shorelines of Pacific islands, only to have failed after just a few years (Nunn, 2009; Dean et al., 2016; Piggott-McKellar, 2020), much faster, indeed, than the Neolithic walls of Jericho. However, since before the recognition of the Anthropocene or planetary ecosystem, anthropological studies have challenged the conventional multidisciplinary approach that treats local human settlements or groups as isolated systems

(Vayda and McCay, 1975; Moran and Lees, 2019; Jones et al., 2021). Moreover, based on recent studies of global environmental changes and adaptation efforts, a few anthropologists have begun to suggest an upgraded approach to the research of planetary ethnography that has a larger geographical scale and a longer historical scope (e.g., Calkins, 2020; Sullivan, 2021; Szolucha, 2022).

The COVID-19 pandemic reminded us again that all humans are part of the same planetary ecosystem. Multidisciplinary researchers have confirmed that global climate changes increase the emergence and transmission of zoonotic diseases, including COVID-19, a phenomenon that occurs during ecological crises called "zoonotic spillover" (Wilson et al., 2021; Carlson et al., 2022). This pandemic was special also for the historically unprecedented speed at which transmission and global coverage occurred (Brinkworth and Rusen, 2022). Since late last century, scholars have warned of the rapid and extensive transmission of pathogens in a globalized world. The disease ecology of a globalized world in which infectious diseases can be quickly spread between continents contrasts with that which Paleolithic populations were subjected to. The infectious diseases of prehistory had little impact on relatively isolated populations (Armelagos and Harper, 2005). Unfortunately, the COVID-19 pandemic has unambiguously illustrated the disease ecology of a globalized world. Multidisciplinary scholars, especially anthropologists, have started to explore upgraded perspectives for rethinking human adaptation to environmental changes and associated epidemics as they once occurred in small and isolated ecological niches and as they have begun to emerge on a much larger scale in our own planetary ecological niche (e.g., Rival, 2021; Toraldo et al., 2021; Brinkworth and Rusen, 2022; Schug and Halcrow, 2022).

In a broadened theoretical framework of multispecies co-evolution at a planetary scale, we must focus on knowledge as a key part of ecological adaptation and niche construction. In earlier theories, adaptation among organisms is a passive process for continuing fitness and survival carried out in response to environmental changes. In niche construction theory — increasingly integrated into related fields including biology, ecology, and anthropology since the late 20th century — organisms can also be active in shaping their environments (Day et al., 2003; Ellison, 2004; Laland et al., 2016). In this view, various organisms are seen as being engaged in "ecosystem engineering" (Jones et al., 1994; Wright and Jones, 2006; Erwin, 2008; Spengler, 2014). This is true, for example, of various fungi at both micro and macro-levels (Tsing, 2015; Zotti et al., 2020) and beavers (*Castor canadensis*) as non-human experts in hydraulic engineering and the social transmission of knowledge (Laland and O'Brien, 2011; Brazier et al., 2021). An extreme example would the human race "as a global force…transforming the ecology of an entire planet" (Ellis, 2015: 287). Socially transmitted knowledge has been identified as the key trait of human culture that leads to almost all the transformative human impacts on the Earth (Laland et al., 2000; Odling-Smee and Laland, 2011; Jones et al., 2021). For example, use of fossil fuels in the energy sector since the beginning of industrial capitalism has been the major contributor to ever-accelerating climate change and other environmental crises (Falkowski et al., 2000; Page, 2007; Murphy et al., 2021; Persson et al., 2022). To clarify, in this article, knowledge refers not only to that of modern science and technologies but also to (pre-) historic technologies and tools (Alland, 1967), of which the principal example offered here is the knowledge of emerging agriculture and hydraulic engineering in Neolithic Jericho.

Scholars in multiple fields further suggested developing more integrative theories that can explain the transformative impacts of human sociocultural processes on ecological niches in human evolution, one of which would be the theory of "human sociocultural niche construction" or simply "anthroecology" proposed by ecologist Erle Ellis (2015). Such suggestions remobilize evolutionary theory's critical emphases on variance or diversity as the driver of adaptive evolution. "At its heart, evolutionary adaptation is a story of variance: the greater the variance in a trait, the greater opportunity for adaptation and the faster adaptation will take place" (Jones et al., 2021: 2). More specifically, as a key trait of human culture, the knowledge of some human subpopulations or groups can be more adaptive and constructive to their local niche, or to the planetary niche, and the knowledge of some others could be insufficient or even maladaptive and destructive. Fortunately, human knowledge can be socially transmitted for wider use and further innovation which increases the potential rate of adaptive cultural evolution (e.g., Sousa and Luz, 2018). As recent works remind us (e.g., Bunce and McElreath, 2018; Centola and Lord, 2018), adaptive knowledge often arises from peripheral groups and can spread to the core, but unfortunately, peripheral groups and their knowledge are often overpowered by those with pre-established dominant positions. To achieve human adaptation for the first time at the planetary scale, we need to turn to more innovative and adaptive forms of knowledge rather than to established knowledge, such as that derived from fossil fuel energy engineering in the Western-led industrial-capitalist setting, which has led to today's environmental changes and planetary crises (Falkowski et al., 2000; Page, 2007; Murphy et al., 2021; Persson et al., 2022). In the evolutionary framework, multidisciplinary scholars have called for climate change adaptation to "focus on the sources of innovation and social structures that nurture innovations and allow them to spread" (Jones et al., 2021: 1). This article, especially when we discuss the case of intellectual collaboration between multinational engineers in the context of pumped-storage hydropower, will engage this call to action through a comparative analysis of knowledge in historical local and contemporary planetary niche construction.

2. Methods and research sites

This study combines archaeological data and ethnographic fieldwork for historical comparison and also reflects critically on the (in-)accessibility of research sites in the Jordan Valley. The Jordan Valley is a geographically small, historically rich, and politically charged area. It is located on the lower course of the Jordan River which exits the Sea of Galilee in the north and ends at the Dead Sea in the south (see Figure 1). It is only 105 km long and, on average, 10 km wide. Located between the deserts on the east and the Mediterranean Sea on the west, the valley has been part of the Levantine Corridor for the migration of and exchange between multiple *Homo* species moving from Africa to Eurasia dating back to the period preceding modern *Homo sapiens* (Luis et al., 2004). Thanks to the year-round warm climate, fertile soils and water supply, the valley has hosted human agriculture (Henry, 1989) as well as water management and hydraulic engineering (Mithen, 2010) for over 10,000 years as part of the "Fertile Crescent."

More specifically, we focus on two cases in Jordan Valley, the flood-control walls of the Neolithic town of Jericho and a Pumped-Storage Hydropower (PSH) project currently under construction. The Neolithic town of Jericho, built at an elevation of 258 meters, is located at the Ein es-Sultan Spring in the southern part of the valley, about 40 km north of the Dead Sea. It is part of today's city of Jericho in the West Bank of Palestine. For this case, we reexamine existing archaeological records and also combine historical records, geomorphological evidence, and climatological modeling for further analyses. We synthesize existing studies of the flood-control walls of Jericho and historical local ecological changes, including environmental deterioration and zoonotic epidemics, for re-analysis in our broadened theoretical framework. The analysis of this case is oriented towards a critical (re-)examination of knowledge exchange, development and insufficiency in niche construction, factors which are then compared with the other case.

Located in the northern part of the valley (see Figure 2), the PSH project[1] was initiated in 2017 with its completion planned for late 2021 but postponed to 2023 due to COVID-19. About 160 engineers work on the site on a regular basis. These engineers come from different national and professional backgrounds, including local engineers from the Israeli government, which is the project's developer; German and British engineers from the banks financing the project; as well as Chinese, French, Italian, and local engineers from contracted construction companies (Chen et al., 2022). The second author conducted ethnographic fieldwork at the project site for several months in 2019 and 2022 that included participant observation at engineers' work meetings and after-work activities, and in-depth interviews of thirty-five engineers. We adopted a quota sampling method (Bernard, 2017) so that the nationality of engineers in the sample roughly matched that of the overall population of 160 engineers working on the project: about 83% Chinese, 10% Israeli, and 7% European. The study participants were all male (Chen et al., 2022). In this article, we focus on the project engineers' knowledge exchange and conflicts across their multi-national and cross-cultural backgrounds and their intellectual collaboration and innovation in adapting to the local environmental and geological conditions, and to the broader energy transition needs. We coded and analyzed observation notes and interview transcripts in original languages (Saldaña, 2015; Bernard et al., 2017).

The Jordan Valley hosts a long and continuous history of human development and adoption of new hydraulic knowledge for adapting to the changing environment. There are various kinds and sites of hydraulic engineering work built during the Neolithic Period (including Jericho), the Bronze Ages (e.g., in today's Caesarea National Park), the Roman Period (in the Zippori National Park), the early twentieth century (e.g., The Rutenberg Hydropower plant) and, finally, the 21st century (e.g., the PSH project) (see Figure 2). We had considered conducting fieldwork in a few historical sites of hydraulic engineering including Jericho, but we were hindered in our attempt to do so due to political borders and military checkpoints between Israel, Palestine, and Jordan in today's Jordan Valley between. In this critical study of knowledge sharing and innovation, we also submit the common difficulty in accessing hydraulic engineering sites in the Jordan Valley to a comparative analysis of knowledge exchange and transmission.

3. The town walls of Neolithic Jericho 10,000 years ago

The camp sites of Neanderthals in the Jordan Valley from around 250,000 years ago and those of the first *Homo sapiens* to arrive there about 40,000 years ago were located adjacent to springs and lakes, allowing access to fresh water, although they didn't do much water management or engineering at this early date (Mithen, 2010: 5256). Not surprisingly, all the early Neolithic settlements in the Jordan Valley are also close to water courses or springs. Among them, Jericho directly relied on the artesian spring of Ein es-Sultan and on the wetlands of the Wadi Qelt stream in particular (Kenyon, 1981; Bar-Yosef, 1986). The Jordan Valley has its special ecological diversity and historical environmental changes. Geomorphological evidence and climatological modeling indicate that the climate in this region was much wetter in the 7th millennium BC than today (Bar-Yosef, 1986; Robinson et al. 2006; Mithen,

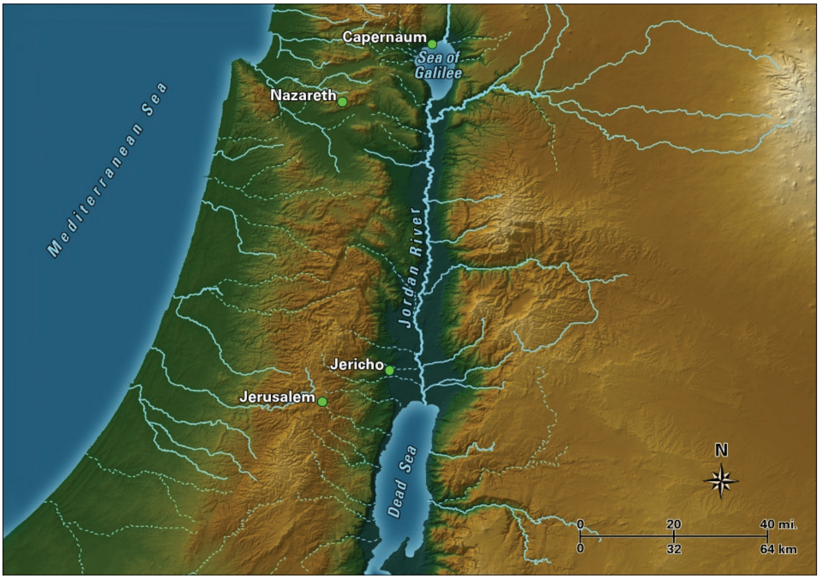

Figure 1. Map of the Jordan Valley. (Source: Bible Odyssey, accessed at: https://ww.bibleodyssey.org/map-gallery/jordan-river-map/).

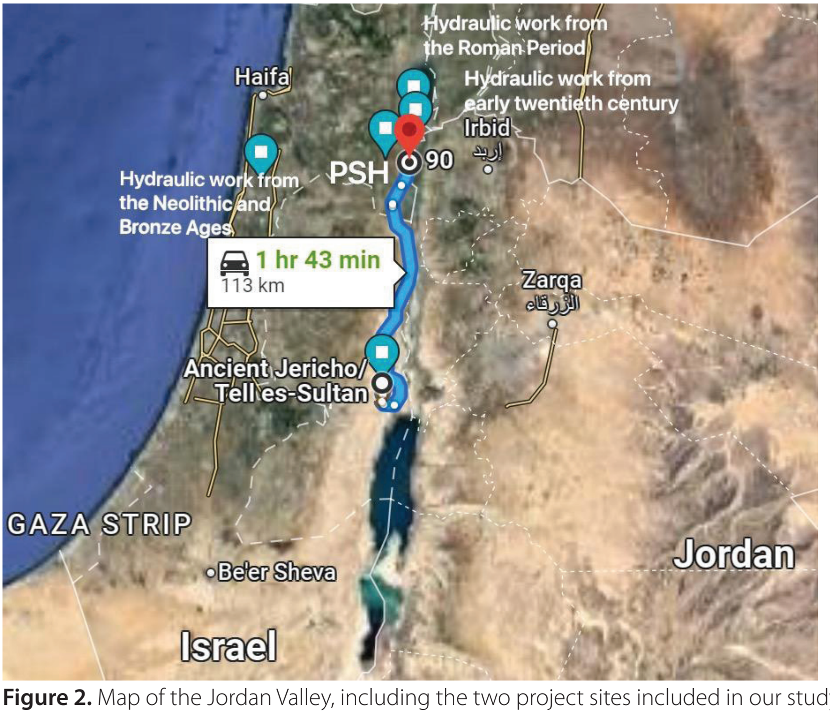

Figure 2. Map of the Jordan Valley, including the two project sites included in our study and other historical hydraulic engineering sites. (Source: Google Maps).

2010; Nigro, 2014). The wetter climate was more favorable for water access and for lower average annual temperatures, but it also brought risks of more frequent and destructive flooding, mudslides, and soil erosion than occur today (Bar-Yosef, 1986; Robinson et al., 2006; Mithen, 2010). The environmental and geographical conditions set the stage for prehistoric Jerichoans' efforts in niche construction, which included water management and hydraulic engineering.

The town walls and towers of Neolithic Jericho represent the first known large-scale hydraulic engineering work in human history in archaeological findings to date. The first perimeter wall of Jericho was 3.6 meters high and 1.8 to 1.1 meters thick from its base to its preserved top. Some walls built later were even higher and thicker. The whole circumference is about 700 meters long. The main walls are a mud-brick construction on a stone foundation. In addition, slanting walls were built of large, undressed stones for retaining the earlier levels. The tower placed inside the perimeter of the first wall was 8.2 meters high and about 9 to 7 meters in diameter from its base to its preserved top. Later carbon-14 dating indicated that the construction occurred between 8300 BC and 7800 BC, with the earliest section of town wall built 8300 ± 200 BC (Bar-Yosef, 1986: 157). That means the construction of the free-standing walls and towers was subsequent to the initial occupation of the Jericho settlement. The perimeter walls enclosed an oval mound, an area of about 2.5 hectares (Kenyon, 1981; Smith, 1995: 3). Archaeologists estimate that the population of Neolithic Jericho was as high as 3,000–4,000 (Kenyon, 1981) and as low as 400–900 (Kramer, 1982). Similar engineering constructions are found at other Neolithic sites in the Valley due to the "pervasive problem" of flooding and mudslide (Mithen, 2010: 5266), however, all other projects discovered so far are not as elaborate or well preserved as the walls of Jericho (Bar-Yosef, 1989; Bar-Yosef and Kislev, 2014).

The walls served as fundamental infrastructure for the very first town built by humans, who were increasingly engaged in sedentary farming and animal domestication. The town of Jericho was much larger, both in population and settlement area, than the previous camp of the hunting-gathering-based Natufian culture in this location, as people from nearby small hamlets increasingly settled there to take advantage of the fertile arable land and year-round water source for plant and animal domestication (Henry, 1989). Archaeologist Bar-Yosef concluded that the walls were a system of defense against floods and mudflows (1986), an interpretation supported by later studies and widely recognized (e.g., Mithen, 2010; Nigro, 2014). Geomorphological evidence shows aggradational deposits in the alluvial fans in the Jordan Valley, including on the sloping plain where the Neolithic Jericho is located. It means that the annual flooding in Neolithic times provided new veneers of brown soil which was essential back then to continuous cultivation of legumes and grains. While good for sedentary farming, this kind of regular sheetwash and mudflow basically "required" effective protection for human settlements like Jericho built in the middle of farming fields (Bar-Yosef, 1986: 161). In this engineering system, walls and towers are built to raise the settlement from the surrounding landscape, using trenches and ditches outside the walls to divert the water flows for town safety and possibly also for "simple irrigation" (Bar-Yosef, 1986: 160). The thickness of the different sections of the walls varies, indicating the builders' sophisticated knowledge of the varying levels of protection needed along the whole perimeter, with the wester side, for instance, requiring a high level of protection (Bar-Yosef, 1986: 160).

Agriculture emerged and succeeded as a new subsistence strategy in the Jordan Valley about 10,500 years ago (often called the Late Natufian period) thanks to human inhabitants' adaptation to the local environment and construction of the local niche, well exemplified in Jericho. Agricultural pioneers started to cultivate plants, including pulses and cereals (wheat and barley), and to domesticate animals, first dogs and soon sheep and goats as well, while continuing to hunt (Bar-Yosef, 1986; Horwitz and Smith, 2000; Nigro, 2014). With its special location, fertile land and water resources, the Jordan Valley hosted the world's earliest human innovation in agriculture and neolithization, concentration of population and rise of long-term communities at town scale. Recent comparative studies argue that the agricultural, technological, and sociocultural heights attained in the Neolithic Jordan Valley were not replicated until much later during the Early Bronze Age (3200-1950 BCE) (Goring-Morris and Belfer-Cohen, 2010; Nigro, 2014). But, from a more critical and longer-term perspective, this success was only a short-term one (Bar-Yosef, 1986; 1989; Horwitz and Smith, 2000; Goring-Morris and Belfer-Cohen, 2010): the town of Jericho was eventually abandoned by the inhabitants due to multiple problems, including epidemics of zoonotic disease — outbreaks that were precisely associated with sedentary farming settlement and its accompanying hydraulic engineering project.

Despite the protection provided by the perimeter walls, sedentary farming in the Neolithic Jordan Valley led to devastating environmental changes and zoonotic epidemics, problems especially "common to large groups" such as the town of Jericho (Bar-Yosef, 1989: 60). Concentrated populations' continuous intensive farming in a small area resulted in ecological deterioration, including deforestation, soil salinization, and land infertility (Bar-Yosef, 1989; Goring-Morris and Belfer-Cohen, 2010). Such anthropogenic ecological deterioration worsened around the large settlement communities due to heavier over-farming and overgrazing. Moreover, early sedentary farming raised fatal threats to human inhabitants' health at community scale, especially via the transmission of zoonotic diseases from domesticated and commensal animals. Due to increased human sedentism and food storage, Neolithic communities in the Jordan Valley also experienced a marked increase in the population of commensal animals such as the house mouse (*Mus musculus*), spiny mouse (*Acomys cahirinus*), and house sparrow (*Passer domesticus*) (Horwitz and Smith, 2000: 79). The daily proximity of domesticated and commensal animals and multi-species crowding were immediate causes of new and repetitive contagious zoonotic diseases. Definite evidence of a specific zoonotic disease in the late Neolithic period was first found at the site of 'Ain Ghazal in the Jordan Valley, where the remains of two individuals were diagnosed with tuberculosis (El Najjar et al., 1997; Horwitz and Smith, 2000). Moreover, the community streams and irrigation ditches in and around the settlements were ideal homes for pathogens and creatures that carried them. Therefore, open sewage and poor hygiene from waste disposal in the immediate environs of living quarters and farming land further facilitated the emergence and transmission of infectious diseases, such as malaria, sleeping sickness, encephalitis and Schistosoma worms (Horwitz and Smith, 2000; Goring-Morris and Belfer-Cohen, 2010).

The early sedentary agriculturalists' "newly created living environment" in the Neolithic Jordan Valley (Goring-Morris and Belfer-Cohen, 2010: 70) eventually turned out to be unfit for human health and survival and thus was abandoned. Also, ecological deterioration overwhelmed the settlement communities, leading some into the gradual decline and others into total abandonment in the late Neolithic period. As a historical icon, the perimeter walls of Jericho were heavily damaged and entirely buried by severe flooding around 7400-7300 BC (Bar-Yosef, 1986: 157). Infectious diseases were one of major causes for the decline and abandonment of the Neolithic settlements in Jordan Valley (Lavenda and Schultz, 2007: 215-217; Goring-Morris and Belfer-Cohen, 2010; Nigro, 2014). Inhabitants of these settlements including Jericho (re-) dispersed into small agro-pastoral communities, in which farming and herding continued but at smaller scale and where hunting and gathering was redeveloped (Lavenda and Schultz, 2007: 215-217; Goring-Morris and Belfer-Cohen, 2010).

Overall, the exchange of knowledge and development was of critical importance to the environmental adaptation and niche construction in Neolithic Jericho. The Jordan Valley has been part of the planetary crossroads not only for human migration and material exchanges but also for sociocultural information and knowledge sharing between human groups, and it provided the historical arena for innovations in early agriculture, urban settlement, and water management (Bar-Yosef, 1986: 159; Henry, 1989).

Thanks to its special location, which became a natural center for knowledge sharing and innovation, Neolithic Jericho can be seen as the historical landmark of the origin of water management and hydraulic engineering (Bar-Yosef, 1986). The strategic design of the walls and the continuous work of construction, repair and enhancement demonstrates the Neolithic Jerichoan inhabitants' accumulated and tested knowledge in architecture and engineering geared toward niche construction. The eventual abandonment of the Neolithic town of Jericho is worth rethinking. Archaeologists argued that the overexploitation of resources, ecological deterioration and zoonotic epidemics in Neolithic Jericho were all due to beginner agriculturalists' lack of ecological knowledge about sedentary farming and animal co-living, a fact which compares negatively with earlier mobile hunter-gathers' long-term experiences and knowledge in adaptation to the dynamics between people, game animals, plants, and the environment (Goring-Morris and Belfer-Cohen, 2010: 70). From a broader evolutionary perspective, the then "newly created living environment" best represented by Neolithic Jericho might be more aptly called *a multi-species co-constructed ecological niche*: which started mainly with human engineering practice and knowledge, but eventually became unfit for human survival due to early agriculturalists' lack of necessary knowledge of multispecies coadaptation.

4. The pumped-storage hydropower project today

As new arrivals to the planetary ecosystem — our newly created living environment —, there have been many emerging projects oriented towards systematic transition from fossil fuels to renewable and sustainable energy, all of them working under the premise of reducing anthropogenic greenhouse gas emissions and mitigating global climate change. One example is the pumped-storage hydropower project in the Jordan Valley, which has mobilized and updated hydraulic engineering knowledge from different parts of the world during the COVID-19 pandemic over the last few years.

Pumped-storage hydropower (PSH) is a type of renewable hydroelectric energy storage. Electric power systems use it for "load balancing." Put simply, a hydrologic battery allows energy from other renewable but intermittent sources (e.g., solar and wind) to be saved for periods of high demand. PSH functions by building two reservoirs at different elevations. Water moves downward through a turbine, generating power at high-demand (and high-price) times, and is pumped back up at low-demand (low-price) times. Compared to conventional hydroelectric dams of similar productive capacity, PSH reservoirs are much smaller, but require a rarer convergence of geomorphological conditions that include both water availability and geographical height difference (Rehman et al., 2015). In our case, the reservoirs draw water from a freshwater lake nearby. The typical negative effects of aquatic migration found in conventional hydroelectric dams have been avoided in this case.

As a modern hydraulic engineering technology first developed almost in the same historical era as the emergence of petroleum energy (both in late nineteenth century, first PSH 1882, first modern oil well 1859; Botterud et al., 2014), PSH came into use worldwide at a much later time. The first wave of PSH project constructions was around the 1970s to help utilize (or load-balance) excess energy generated by nuclear power plants, while the second wave started in the early 21st century in conjunction with large-scale wind and solar power production. In general, PSH has always played a supporting role in energy technology, and has remained underutilized outside of these periods, at least from a dominant fossil energy perspective (Antal, 2014; Petrescu and Petrescu, 2015). However, it is increasingly used worldwide for energy storage in the transition toward renewable energy, which has been, to a large extent, driven by the fossil energy crisis and global climate change (Lovins, 1977; Solomon and Krishna, 2011). PSH projects are thus expected to see the highest decadal growth in history as they come online to address the worldwide demand for greater system flexibility and stability in wind and solar energy capacity and storage (International Energy Agency, 2021). As an illustration, near the PSH project in Jordan Valley, there are solar, wind, and garbage power plants already built or under construction. In addition, PSH is also a backup energy source in Israel, making up over 50% of the country's emergency power, crucial for Israel's power grid stability and national security.

The PSH project focused on here has far-reaching significance for human knowledge exchange and innovation. It represents a new frontier in terms of group collaboration in which the application, practice and reproduction of hydraulic engineering knowledge is being applied to our adaptation to environmental changes, and it should be seen as creating an example for energy transition at national and global scales. The diversity of the project engineers' national and professional backgrounds creates a context in which the engineering knowledge and practice on this particular PSH is seen to be more innovative and adaptive than similar projects developed by engineers based only in Western countries. The multinational engineers themselves emphasized the fact that this was a "mutual learning process", and suggested that knowledge, experience, and technology not only flowed from the core (developed countries) to the periphery (less developed countries), as argued in classic theories of globalization (e.g., the World Systems Theory, Wallerstein, 1989), but also flowed in the other direction. For instance, because of the geopolitical location of the project and the multi-national character of its personnel, engineers routinely debated whether to apply European, American, Israeli, or Chinese standards in design and construction and demonstrated a great capacity for multicultural innovation and adaptation to the specific locale. "No particular set of standards was superior to others," said a Chinese mechanical engineer, whose Israeli counterpart added that "it was up to the on-site engineers to apply the right standards to a particular problem." When none of the published standards were applicable, engineers discussed and evaluated the particular situation, which was often comprehensively affected by local geological, hydrological, technological, and human conditions, and then creatively applied and re-developed standards from other areas — for example, South Africa — to solve a given problem. New engineering patents have also been applied accordingly.

Knowledge innovation as such benefited from the engineers' rich working experiences. About 70 percent of the interviewed engineers had significant experience working in other countries, including Thailand, Vietnam, Morocco, Sudan, South Africa, France, Italy, and Switzerland. Engineering experience and knowledge transcended the physical location of this particular project and the boundaries of nation states and benefited from the global mobilization behind the formation of its technical staff. As a result, engineering standards employed on the ground no longer reflect a Western-driven singularity but are rather plural in nature, subject to dialogue, negotiation, and adaptability to the local environment. As the epitome of knowledge innovation in this project, the new patents that engineers have obtained are ready to be applied to future projects, engaging, and evolving with local environments in and beyond Israel. This continuous and recursive knowledge production process as part of the global renewable energy transition could be considered as the newest example in human history of strategic environmental adaptation and collaborative niche construction (Ellis, 2015; Jones et al., 2021).

This productive exchange and collaboration didn't come about easily. Moments of friction and conflict regularly arose partly due to the variance in the engineers' backgrounds, and it took time and effort to get accustomed to each other's professional practices. For example, engineers once argued about the proper value of a certain parameter called "bend radius," which specifies the minimum amount a given material can be bent without damaging it. While the exact amount of the "bend radius" varies according to European, Israeli, and Chinese standards, the engineers attributed the seemingly technical-based conflicts mostly to their national and professional-training differences. They had to admit that "bend radius" wasn't just a mathematical conundrum with a single correct answer but rather a complicated situation requiring them to be patient and understand each other's "logic" and "reasoning" to reach a consensus. Through a hard but fruitful process, the engineers on the PSH established a new working procedure accepted by each party instead of falling back on a fixed value for "bend radius." Knowledge innovation rose out of conflict-management, out the heterogeneity of the engineers on the ground, out of the dynamics of the successive problems to be solved, and out of a willingness among the engineers themselves to exchange ideas. Like the patents, this newly established cross-cultural working procedure was an end result of a previously uncodified procedure: a particularly human, social, and intellectual bi-product of the willingness to innovate in solving the problems of renewable energy's application and growth in a complex geopolitical and sociotechnical environment — and it should serve as a model for similar projects worldwide.

The ongoing collaborative construction of the PSH plant was delayed but not suspended by the Covid-19 pandemic. The frequent travel of the project engineers from 20 countries and their concentration at the project site exemplifies the intense human movement and contact in our globalized world. This kind of frequent travel worldwide has contributed to the rapid and global transmission of the COVID-19 virus (Armelagos and Harper, 2005; Brinkworth and Rusen, 2022). However, the project engineers and the project itself survived the pandemic. For one thing, when the pandemic started there was absolutely no discrimination against the Chinese engineers at the PSH site, this in contrast to many other locations around the world (Bollyky et al., 2021). When a Chinese engineer came down with Covid, his Israeli colleague called him and said, "you got Covid? Take a rest, I'll invite you to lunch next week!" The Chinese engineer told the second author with a surprised but happy face, "Ha-ha, he (the Israeli engineer) invited me to lunch next week. Brave guy, isn't he afraid of being infected?!" The friendliness went much further than the individual level. The open and collaborative dynamics between the project engineers encouraged some of them, especially the Chinese, to take early precautionary measures, letting other team members know that from their experience of what was happening in China, this was, indeed, a fast-spreading pandemic, thus contributing to the knowledge base of the project's COVID policy from very early on in the pandemic. Based on this early knowledge shared remotely by their families, the Chinese engineers took the lead in wearing masks and taking vaccine shots; meanwhile, following the local experience of European public policy, the engineers implemented flexible quarantine-based schedules to guarantee everyone's health and the project's progress. The whole group of multinational engineers followed the project's Covid "policy package" in support of each other. In contrast to what happened in prehistoric Jericho, this time around the zoonotic spillover from ecological crises neither destroyed the hydraulic engineering project (see

Figure 3) nor killed or disbanded the human group on site, thanks at least partly to the multinational engineers' open and dynamically collaborative approach to knowledge exchange and sharing.

5. Knowledge variety and innovation for evolutionary adaptation

While the neolithic people of Jericho eventually abandoned their town due to ecological crises and dispersed into small agro-pastoral communities in order to survive and re-adapt, human beings today so far have no Plan(et) B and thus have to adapt to the changing environment through knowledge innovation and exchange. So, what kind of knowledge are we talking about, knowledge that is more technologically advanced or that which is more environmentally adaptive? And how to develop and share it?

Recalling the recent theories of adaptive evolution and niche construction introduced earlier, development or adoption of new knowledge that is adaptive to the changing environment works better for human evolution. Technological knowledge advancement in itself, either in sedentary farming or in hydraulic engineering, was not as decisive as social organization for knowledge practice and environmental adaptation in human development (Nigro, 2014: 59; Graeber and

Figure 3. A photo of the completed lower reservoir of the PSH in 2023. (Source: Interviewees).

Wengrow, 2021). After all, knowledge itself, along with social organization and other features, is only part of how human culture developed in and for human adaptation, a classical premise in anthropology (e.g., Alland, 1967; Jones et al., 2021). This notion is finally receiving wider recognition in other fields such as ecology (Laland et al., 2000; Odling-Smee and Laland, 2011; Ellis, 2015). According to the unilineal evolutionary theories in Western scholarship since the 19th century, large-group sedentary farming in Neolithic Jordan Valley has been considered as the most advanced human culture across the world around 10,000 years ago. However, as we have seen above, in the case of Jericho, human evolution in Neolithic Jordan Valley went from small-group hunting-gathering to large-group sedentary farming and (back) to small-group mixture of agro-pastoralism and hunting-gathering. Recent archaeologists have pointed out that the development of sedentary farming in this region was indeed early and pristine, but "nonlinear and undirected" with unpredictable outcomes and implications (Goring-Morris and Belfer-Cohen, 2010: 77; Graeber and Wengrow, 2021). We suggest applying these multidisciplinary insights of non-unilinear evolution to modern technologies as well. This is because however advanced fossil fuel technologies have become, they have turned out to be — with all the knowledge we have now gained vis-à-vis the climate and its inability continue absorbing carbon — maladaptive. They are destroying the only niche left us. The message of accelerating global climate change is as clear as day. And, however advanced Elon Musk's SpaceX Starships are becoming, they are still not ready (and not even intended for) the removal of all 8 billion *Homo sapiens* to another livable planet. In comparison, renewable energy technologies could be more promising in exploring adaptive ways of continuing human life on this changing planet.

Recent evolutionary theorists have stressed the transformative powers of sociocultural processes in human beings' niche construction and adaptive evolution (Ellis, 2015), including the development of knowledge as a key cultural trait (Jones et al., 2021). The PSH project in the Jordan Valley today turned out to be well aligned with this long tradition of sociocultural openness to exchange and collaboration which is of fundamental importance to engineering practice and innovation for and likely beyond this project. Engineers of different ethnicities including Jewish and Arab and from a variety of countries, including Israel, China, European countries, and the U.S. joined and collaborated with each other, bringing together their unique training and professional experiences from across the world and integrating this diverse knowledge in a collaborative and innovatively novel approach to civil construction. Significantly, the project team has more Chinese and Arab engineers than engineers from developed countries. Based on their training and experiences from developing countries, such as China, Thailand, and South Africa, and on their more widely and freshly tested knowledge, they have often complimented and at times challenged the engineering standards long established as standard practice by Euro-American engineers.

Upon reflection, the development of the latest PSH technology, shows that in comparison to its peak in the 1970s, when most PSH projects were carried out in the U.S. and European countries, the current surge in PSH construction is occurring in more developing countries including China, in countries in Southeast Asia, and in the Middle East (Deane et al., 2010; IEA, 2021; Bernardi and Wu, 2023). The Jordan valley project not only illustrates that PSH, as a renewable energy technology now more active on the periphery, may be more adaptive than the still dominant petroleum energy technology, but that it also demonstrates that in terms of the development of PSH technology itself, innovative and collaborative knowledge from the global periphery is reshaping the knowledge from the global north, thereby making PSH's position in the energy transition quite significant. As recent works in anthropology and ecology have highlighted, adaptive knowledge often originates from the periphery and has the potential to permeate to the core, contributing to human evolutionary adaptation (Bunce and McElreath, 2018; Centola and Lord, 2018).

However, peering over the fence of the PSH project site, we see right away the brutal reality of political-military divisions among human groups and their knowledge bases in this small valley. While on sight, some international engineers from the PSH project also wanted to visit historical hydraulic engineering sites in the Jordan Valley, but, like us, failed to receive permission to do so. On Google Maps, the trip from Jericho to the PSH project is only an hour and forty-three-minute drive; but in reality it's extremely difficult, and probably not even possible for most people to move freely across strictly controlled militarized zones. As a result, the rich spectrum of human knowledge and experience in hydraulic engineering in the Jordan Valley is off limits. And many of the sights are significantly destroyed by historical and contemporary political-military segregation and conflicts (Vaknin et al., 2022). This represents a terrible loss of knowledge and also impedes knowledge innovation. Today, the Jordan Valley typifies segregation, conflict, and war.

6. Conclusion

The history of human evolution is a history of multispecies co-adaptation to environmental and ecological changes as well as to the associated consequences of zoonotic diseases. The shift from mobile hunting and gathering to sedentary agricultural, as it occurred in Neolithic Jericho, was one of the most significant milestones in human history. However, archaeological studies of the Jordan Valley have concluded that technological advancement in itself was never going to be as sufficient or decisive as human diversity and social dynamics for human beings' continuous adaptation and development — in other words, for human civilization (Alland, 1967; Nigro, 2014). Even with the earliest hydraulic engineering infrastructure, Neolithic Jericho eventually failed, and the town residents moved out of the town to (re-)adapt to new environments and mixed lifeways. As we enter into a new planetary ecosystem as the only and shared ecological niche with no plan(et) B, contemporary humans will be obliged to adapt once again. This can only happen through knowledge innovation and exchange, a strategy also developed in the history of evolution and especially well-represented in the hydraulic engineering projects in the Jordan Valley. The PSH project focused on in this paper provides a good example of a development of knowledge that facilitates the balancing and systematization of renewable energy generation and use, and no less importantly, serves as an opportune example of cross-cultural collaboration and knowledge exchange for niche construction. The sociocultural and intellectual dynamics in the special human group at the PSH project, open and collaborative even during the Covid-19 pandemic, corroborates and updates evolutionary theorists' observation of how knowledge exchange, diffusion, and innovation comes to the fore in certain settings. It is more than obvious that human cultural diversity and especially marginal subpopulations can and do contribute when environmental changes demand knowledge innovation for niche (re-)construction and (re-)adaptation (Jones et al., 2021).

Taken together, the political and militarized brutality in today's Jordan Valley and the crisis unfolding in the emerging planetary ecosystem are a call to study the sociocultural processes in human knowledge innovation and adaptation. Such a study calls for a more engaged dialogue, comparative approaches, and collaboration between academic disciplines such as anthropology, ecology, Science and Technology Studies (STS), and more (e.g., Ellis, 2015; Jones et al., 2021). In practical terms, the Neolithic town of Jericho provides early lessons on engineering innovation, environmental adaptation and niche construction that are still meaningful today; and the PSH project, still an open-ended story, demonstrates possible trajectories of collaboration, exchange, and innovation for hydraulic engineering, energy transition and environmental adaptation even in the most challenging and brutal environments.

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