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HISTORY AND ARCHAEOLOGY OF WATER MANAGEMENT IN JORDAN THROUGH AGES

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ABSTRACT

In the absence of any comprehensive article of water management in long-term perspective, this paper attempts to draw together the evidence and arguments as they currently stand, for early and late periods, on the basis of both archaeological and textual sources, in order to broadly situate the Nabataean and Roman-Byzantine period within the context of what came before and afterwards. In Jordan, the water management problem can be characterized by water shortages, environmental quality issues, and supply distribution concerns. Two major factors influence water availability; the semi-arid climate and the high population growth. In this paper chronological overview of water management from the Prehistoric to the Islamic periods will be demonstrated.

KEYWORDS: Jordan, Water management, Prehistoric, Nabataean, Roman-Byzantine, Islamic, Climate.

1. INTRODUCTION

Human beings need approximately one and a half pints of water per day to survive (Hill 1984: 25; Smith 1975: 69); other than oxygen, it is the most important requirement for life. Since ancient times humans had noticed that rainfall accumulated naturally in pockets of rock and hence they were inspired to carve in rock to accumulate water to be used as needed. Then, an aqueduct system for carrying water was developed. Many forms of water construction such as: wells, canals and storehouses from antiquity onwards. Water plays a vital role in the development of human society as it subjected to use for various purposes, among which the domestic use deserves more attention in arid and semi arid regions.

The basic cultural-chronological sequence for Jordan has recently been usefully summarized in the 2001 volume *The Archaeology of Jordan* (MacDonald, Adams and Bienkowski, 2001), though none of the individual authors consider water management as a central theme and the majority of them hardly mention it; the subject is effectively left to a thematic chapter by John Peter Oleson, 'Water supply in Jordan through the ages', which provides a useful, if rather short, outline, especially using site data from Humayma in southern Jordan to extrapolate and compare in a general way with evidence from other Nabataean sites (Oleson, 2001). In the absence of any comprehensive article of water management in long-term perspective, this paper attempts to draw together the evidence and arguments as they currently stand, for early and late periods, on the basis of both archaeological and textual sources, in order to broadly situate the Nabataean and Roman-Byzantine period within the context of what came before and afterwards.

There follows a chronologically ordered outline review of water management development and issues in an inter-regional and broad cultural context as currently understood by archaeologists. Here, the research coverσ the Neolithic to Iron Age and Hellenistic periods and then the Roman and Byzantine periods through to the Islamic and historical periods. **(Fig.1)**

Figure 1. Geographical location of Jordan with surrounding regions of interest mentioned in the text (see: http://theancientcityofpetra.blogspot.com/2012/07/where-ancient-city-of-petra.html)

2. THE TRANSITION TO FARMING (NEOLITHIC PERIOD) 8000-4500 BC

During the Neolithic period (8500-4500 BC), three great shifts took place in Jordan. First, people settled down to community life in small villages. This corresponded to the introduction of new food sources-such as cereal agriculture, domesticated peas and lentils, and the newly widespread practice of goat herding, into the diet of Neolithic

man. The combination of settled life and food security prompted a rise in population which reached the tens of thousands. In this period, specifically the 9th millennium BC, hunter-gatherers started to occupy permanent shelters and then established agricultural settlements. This is a vital phase to study because it embodies a critical change in humanity's way of life, socially and economy. Since that time agriculture has supplanted hunting as the essential source of food (Kafafi, 1992: 28).

As with much Jordanian archaeology, ongoing research initiatives mean that the current picture is changing rapidly. Rollefson, for example, writes that "*the concentration on later Neolithic development is only about 10 years old, and the revelations of work in Wadi Ziqlab and Jabal Abu Thawwab have shown the directions that continued research should take. The tantalising scatters of as yet under-researched ceramic Neolithic sites in the southern part of Jordan have some indications that the social patterns of the country - and the Levant in general - were much more complex than was imagined in the early 1980s*." (Rollefson, 2001: 97).

Research, on archaeological sites dating back to the Neolithic period has concentrated on valleys around which humans lived and established agricultural settlements; the most advanced of these were established on abundant water resources, especially springs (Rollefson 1992: 123, 1985). Springs have played a major part in the establishment of many archaeological sites, such as Ain Ghazal. Located to the north of Amman and extending over an area of 12 hectares, Ain Ghazal, established near the Ain Ghazal spring, was seen not only as one of the most important sites dating to the Neolithic period, but also as one of the greatest settlements dating to that age in the ancient Orient (Rollefson, 1992: 125; 1985). Other similar sites are at Ain Al-Jammam near modern Ma'an city, named after the adjacent spring, Basta located south of the town of Wadi Musa in the vicinity of Petra (Gebel 1988: 67), and Beidha northwest of Basta (Kirkbride, 1960: 123). People were beginning to live together in permanent settlement.

There is evidence of ancient floodwater farming systems at the pre-pottery Neolithic site at Beidha (Jordan), in the Edom Mountains of southern Jordan (dating to the eighth to the early seventh millennium BC), and these are thought to have been in use during the Neolithic age, nearly 9,000 years ago. Today, the area receives a low annual precipitation of around 170mm. The earliest example of ancient farmers taking advantage of rainfall runoff is at Beidha (Kirkbride, 1966: 5-17; 19; Haebaek, 1966). In other parts of the Jordanian desert, in particular north of the Azraq Oasis, ancient barrages crossed wadi walls and wadi walls controlled and directed floodwater to irrigate cereal and barley fields (Gilbertson and Kennedy 1984).

Water management systems of Jordan are considered to be integral to the study the emergence and development of civilisation. Human beings settled in Jordan in many varied locations, such as Ain Ghazal, Beidha, Rum Valley and Abu Sowwan Hill, where an abundance of the water sources (springs, rivers and lakes), is largely unavailable (La Bianca, 1995: 266).

In the arid regions outside the Nile and Tigris-Euphrates river valleys, irrigation technology depended mostly upon the exploitation of natural springs and groundwater and the collection of water runoff. The Neolithic settlement at Jericho, the earliest known urban site, relied on a perennial spring that produced enough water for irrigation and consumption by humans and animals. The approach to the spring was guarded by a defensive wall and tower, an indication of the spring's value to the inhabitants of Jericho (Kenyon, 1979: 25).

Socially, according to Gary Rollefson (2001), an "*element of change during the existence of the town phenomenon undoubtedly had to do with social relationships between neighbours and not-so-close neighbours. As permanent populations grew, a new surprise was in store: for the first time a resident of a town could encounter another resident who may have been more or less a stranger. As competition for farm land become keener, older methods from MPPNB times may not have been effective in settling conflicting claims for fields and resources; and these conflicts may have arisen within and not just between kin groups….".* (Rollefson, 2001).

Wells are difficult to find in the archaeological record and highlight the fact that the recognition of wells is not always as simple as it might seem. At the site of Beidha, Miller notes that there may have been similar, temporary well pits dug into the wadi floor (Miller 1980: 331), although Kirkbride and Byrd only refer to the present-day, local springs (Byrd 1989: 17; Kirkbride 1966: 71; 1968: 264).

3. CHALCOLITHIC AND BRONZE AGES

The oldest house-cisterns found in Palestine are claimed to belong to the Chalcolithic, before 3000 BC (Evenari *et al*., 1971: 171). However, at the later site of Jawa, in the black lava desert of northeastern Jordan, a sophisticated water-collecting system was planned and built before 3000 BC which did not involve man-made cisterns: a natural cave was utilised – considered by Helms to be a natural prototype for later, artificial structures (Helms 1971: 160-177).

The first cisterns were dug in the Middle and Late Bronze Age (2200-1200 BC). The rainwater that collected in them during the short rainy season would be enough for at least one dry season. In some parts of Palestine cisterns were the main (sometimes even the only) source of drinking water in peace time as well as in war time. It has been argued that it was in the early Iron Age (1200-1000BC) that the sides of cisterns began to be covered with watertight plaster, which considerably prolonged the time for which water could be stored – an important innovation that made it possible to extend the areas of settlement into the mountainous parts of the country (Negev 1986a: 332; Shqiarat at el., 2011). However, other scholars consider that the pits/wells at the Chalcolithic site of Teleilat Ghassul in Jordan were also lined with plaster, as they also were in the Chalcolithic/Early Bronze Age phases at Tell Brak in Syria (Oates and McDonald, 2001: 26).

The Chalcolithic period (4500-3200 BC), saw copper smelted for the first time. It was put to use in making axes, arrowheads and hooks, although flint tools also continued to be used for a long time. Chalcolithic people relied less on hunting than in Neolithic times, focusing instead on sheep and goat-breeding and the cultivation of wheat, barley, dates, olives and lentils. In the desert areas the lifestyle was probably very similar to that of modern Bedouins. As with the Neolithic, recent research presents a constantly changing picture. Bourke (2001) notes that "*much has been written on the nature of social organization in the Chalcolithic period in the southern Levant over in the last 15 years. Arguments over the archaeological correlates of social transformation have intensified as the sophisticated field projects of the 1980s move from preliminary description to final publication*" (Bourke 2001: 150).

In the Chalcolithic, copper implements were used on larger scale; permanent streams become seasonal; wadis as forests disappear and erosion increases. Around 2300 BC there was an invasion of nomads. Every town in Palestine and Jordan was destroyed and abandoned for centuries, probably due to a destruction of the balance between people and resources.

In the Chalcolithic, agricultural villages expanded widely and vegetation developed intensely in Jordan, especially on mountain slopes, which resulted in the prevention of soil erosion (Abu-Jaber 1995: 737). Sites that represent this age in Jordan are Teleilat Ghassul, northeast of the Dead Sea, where buildings supported by more than one line of stones to prevent rainfall seeping into them were found. Similarly, in religious-styled architecture, water basins found amidst temple courtyards are most likely to have been used for washing by people who intended to (Hennessy 1969: 1). Bourke writes that "*All evidence currently available suggests that the Ghassulian Chalcolithic had its origins in the small village societies that grew up along the northeastern shores of the Dead Sea early in the Chalcolithic period*" (Bourke, 2001: 152-53).

Bourke considers that "*it may be that Jordanian late Chalcolithic society can be viewed as one in which the traditional symbolic religious ruling elite gradually came into competition with an emerging elite based on the control of agricultural surpluses…*" (Bourke, 2001: 152-53). If this is true, then the association of these new elites with an understanding of water-management issues should be expected. Structures connected with water management are clearly observable at Jawa in the Black Desert, one of the most important sites of the Chalcolithic and early Bronze Age - a prosperous village with plenty of forest around to prevent erosion was built in the eastern desert of Jordan at the end of the 4th millennium BC. The settlement has an elaborate hydraulic system. Remnants of stone barriers used to reduce soil erosion were discovered; this is a good indication that people were dependent mainly on rainfall due to lack of underground water (Helms, 1981: 156).

Many reservoirs and tanks seemingly used for accumulating rainfall were discovered in the Black Desert region. Connected with these are networked channels for channelling water to houses; farming channels built in Jawa were made from a double dry-stone wall. The development of the city of Jawa required complex social organisation and technology, including a large dam and other harvesting constructions (Helms, 1981). Before the establishment of Jawa, people dwelt in caves spread out around the area and acquired water from adjacent dispersed natural ponds emerging after rainfall, for example a pond close to Burqu' Palace near Jawa (Helms, 1981: 157; Shqiarat, 2014). The Wadi Rajil, in the Jabal Druze, provided the catchment for this water harvesting system. Storms in the Wadi Rajil produce over 500mm of rainfall annually; high in comparison to Jawa, which has an average annual rainfall of 150mm (Helms, 1981).

Jawa was reliant on the drainage that flowed from the Jabal Druze. Snowmelt water in the Jabal Druze also supplied a small amount of runoff to the Wadi Rajil (Helms, 1981). It has been calculated that the Jawa system could process an estimated 75,000 cubic metres annually; the total runoff has been estimated at 2,000,000 cubic metres per year and it would only have been required to work at an efficiency level of four per cent to sustain the Jawan population (Helms, 1981:135-98). However, this would only

have occurred if there had been snow during the winter months on the nearby Jabal al-Arab massif, the source of the flood spates, which lies twenty kilometres or so to the northwest. If snowfall failed to appear over a number of years, then the settlement positioned deep within a semi-arid environment, would have had trouble surviving.

By the early Bronze Age, from around 3000 BC, metal manufacturing expanded greatly as result of the discovery of bronze. In the later phases of this age there was an ecological imbalance produced by deforestation resulting from excessive tree-cut. Consequently, soil erosion emerged and valleys and permanent rivers became seasonal (Franken, 1979: 3). Because of a severe natural shortage of water along with a postulated invasion of Bedouin tribes requiring water and food, who may have made the situation even more critical, many agricultural towns and villages in Jordan and Palestine were abandoned, leading to increased social insecurity and instability (Yassin, 1991: 20).

Cisterns have at least in the Near East become the preferred method for capturing and storing water. At the emerging early town of Arad in the third millennium BC, systematic efforts were made by the town folk to acquire and utilise the maximum amount of water potentially available to them (Miller, 1980). The inhabitants of Ai in Israel (2700-2550 BC) went one stage further, channelling water from the town to the surrounding fortification walls, using drains lined with stone slabs and sealed with clay (Calloway, 1978: 51). In this way, the reservoirs at Arad and Ai could provide a useful secondary role as a line of defence. In the time of third and fourth Dynasty Egypt (2700-2500 BC), societies had acquired the organisational skills to construct large-scale dams, far larger than earlier examples such as at Jawa. Therefore, although almost impossible to date precisely, the impressive dam at Wadi Gerrawi in Egypt (116) metres long by ten metres high could plausibly only have been built to supply water to the workers in the nearby quarry, which has been dated to the early Dynastic period (Murray, 1955).

Examples of patronage and beneficence can be found as early as the third millennium BC, with the construction of the Wadi el-Garawi dam south of Cairo to provide drinking water for workers at a nearby alabaster quarry (Murray, 1955: 171-181; Biswas 1970: 5-7). Another example comes from the second millennium BC Sumerian poem "*Gilgamesh and Agga*" (Pritchard, 1950: 45, 5-7, 11-13, and 20-22). The poem mentions Gilgamesh's completion of wells, having dug them and fastened ropes. Pritchard notes that the exact meaning of the poem is obscure, but that it is probably linked to Gilgamesh's plea to fight rather than to submit to Kish, which records Gilgamesh's well construction as an incentive.

An underground tunnel system of unknown date is found below the Early Bronze Age II-III (2950-2350 BC) site of Khirbet ez-Zeraqon, situated 13km northeast of Irbid on the western edge of Wadi Shellalah. In the south-eastern part of the city, three shafts have been found, which provide access to an ancient tunnel system, extending approximately 60m below the surface. This system could have been entered through an entrance shaft on the western slopes of the Wadi Shellalah., the date of the tunnels is still debated and ranges from the Early Bronze Age to Roman times. Furthermore, tunnels of a similar system have been found near Tell el-Fuhhar in the eastern part of Wadi Shellalah (Ibrahim and Mittmann, 1987: 6).

Philip (2001:166) believes that the early Bronze Age in Jordan may be characterized by so-called 'middle-range' societies. He writes that the idea of these, developed by Feinman and Neitzel (1984) on the basis of ethnographic data, was "designed to conceptualize a spectrum of organizational forms intermediate between mobile hunter-gather groups and bureaucratic states, and thus subsumes the chiefdom." He goes on to say that, "*Recent work in western Asia and elsewhere indicates that significant areas of economic activity could exist outside the operational arena of political power (Stein and Blackman, 1993; Wattenmaker, 1994; Potter and King 1995; Levy 1995), and there is now a trend towards approaches that seek to 'unpack' the various components of complexity, political and economic structures in particular (Netting, 1990). Given the variety of organisational forms characteristic of middle-range societies, Feinman and Neitzel (1984) suggest that the model can be best employed as a means to explore the interrelationships between different aspects of the given society, by using the archaeological data to investigate key dimensions of social organization.*" (Philip, 2001: 166).

Ebla in Syria (2350-2200 BC) displays an early example of water provision as an integral part of the design plan, revealing a system of wells and cisterns placed around a courtyard. In the middle Bronze Age, 1800-1650 BC, examples of domestic water storage can be found in the dwellings of Hazor in Palestine, which have adjacent to them underground plaster lined cisterns which appear to have collected precipitation runoff from the house roofs (Miller, 1980). In addition, the town exhibits one large underground cistern hacked out of the limestone bedrock, although the date of its construction is difficult to assess accurately. Underground rock-cut cisterns of all shapes and sizes are to be encountered

everywhere in the Near East, but are less common in Egypt (Murray, 1955: 175).

Irrigation technology varied from region to region depending on the nature of the major water source: river, perennial spring or runoff. The ancient societies that evolved along the great rivers of Mesopotamia and Egypt planned their crops around the annual floods and built canals and dikes to control the distribution of water to their fields (Butzer, 1976, 1961, 1963; Adams, 1981; Endesfelder, 1982). The excavation, use and maintenance of the canals dictated a strong, centralised authority that played an important role in the unification of Egypt (Hodges, 1970: 91; Bonneau, 1986) and in the evolution of city-states and territorial empires in Mesopotamia (Adams, 1955, 1974a, 1981).

Of the later part of the Early Bronze Age (EB IV), Palumbo (2001) writes that "*There is no doubt that trade may have played an important role in the in the development of the new urban civilisation, but certainly not as a single, or even the main factor. Social and cultural change at the beginning of the second millennium BC can be seen as the results of the influence of political, climatic, economic and technological factors on a economic (the rural/domestic mode of production) and social base (where the beginnings of social stratification can be seen) that were ready to receive and develop the new trends" (Palumbo 2001: 261). These social changes, starting from around 2000 BC, are said by Falconer (2001: 271) to be characterized by "the rapid rejuvenation of towns and cities atop the stratified tells of the southern Levant."*

Falconer says that "*while some communities were founded anew, many sites that had lain abandoned during the collapse of urbanism in the last centuries of the Early The Bronze Age were now reoccupied, expanded and refortified*." (Falconer 2001: 271).

The Late Bronze Age is more enigmatic and: "*very little is known about the social and political organisation*" (Strange, 2001: 304). Jordan was at this time under Egyptian rule, but the degree of domination is hard to assess (Strange, 2001: 294). On balance, Strange, also, believes that the city-state organization survived, but there is some evidence for the emergence of the territorial states that are thought of as typically Iron Age (Strange, 2001: 304).

4. THE IRON AGE AND START OF THE HISTORICAL PERIODS

This section details the period from the inception of iron technology to the beginning of the Byzantine period researcher will not dell in any detail on the Hellenistic or Roman-Byzantine periods in detail at this point.

During this 'proto-historical' era, Jordan witnessed the emergence of three monarchies: Ammon, Moab and Adoum. The relationship between these monarchies was characterised by warfare and conflicts (Fan Zeal, 1990: 128). The Iron Age saw development and consolidation throughout in the Iron Age between 918-332 BC and extended into Transjordan (Yassin 1979: 30). Fan Zeal argues that during the Iron Age control of water led to competition, and there was extensive re-use of previous water management systems, first developed in the Bronze Age, or earlier (Fan Zeal 1990: 130).

Archaeological excavation of sites dating back to the 1st and 2nd phases of the Iron period (1200-918 BC), for example Hisban, Amman and Sahab, revealed very few architectural elements relating to water systems. In Hisban a ruined water channel carved in rock has been found, along with reservoirs roofed by arches; one of these has a capacity of 8000 m^3, a length of 17m ranging from 12-14m with a pear shape (Bikai and Daily, 1996: 26). At other early settlements in Syro-Palestine, dating from the early Bronze Age through the Iron Age II**,** wells and tunnels were dug to access underground water sources. Such water tunnels became an important feature of fortified cities such as Megiddo, Hazor, and Jerusalem, by securing a constant supply of water within the walls of the cities (Tsuk 1997: 130). The most impressive access-route to a well, however, is the Iron Age stone staircase at Tell Es-Sa'idiyyeh in Jordan (Miller, 1988).

Around 830-805 BC, Mesha, king of Moab pointed out on his obelisk the importance of water in the inscription which said: "*I am he who carved both water pools inside the city, since it was void from any well. That day I said to people: everyman must dig a well [make a cistern] in his own home…"* (translation from Assyrian adapted from Fan Zeal 1990: 182; cf Abu-Jaber 1995: 737). This text clearly shows how important the technique of accumulating and reserving water was for the Moabites.

The Iron Age appears to show the first extensive construction of cisterns in Jordan. La Bianca writes that at Hisban "already in the Iron I (1200-1150 BC) village we encounter a significant water management complex consisting of at least one, and probably many (had our excavations been more extensive) cisterns, and an overflow tank, which possibly also served as a channel for leading water to a yet-to-be-discovered reservoir" (La Bianca 1990: 149). In the Negev, cisterns from the Iron II period were dug into loess soil and lined with large stones to ensure the stability of their walls. Also in the Negev, rock-cut cisterns began to appear in Nabataean times (Evenari et al., 1971: 14-17, 159). However, as with other water-storage and control

structures that will shortly be discussed, there are theoretical and methodological problems with these sorts of broad chronological comparative statements. It seems that the preferred type of cistern at this time was the rock-cut 'bottle cistern'. As the name suggests, these were shaped like a bottle with a small neck but widening out below the lip to an interior wide of three to four metres in diameter (Oleson 1995: 709).

During the Iron Age, water systems were widely developed and expanded. In sites dating to this period we find wells and tank-reservoirs with plaster in order to keep the water fresh and to stop water percolating through the stone and being lost to evaporation (Albright 1969: 30). In fact, although the use of plastered cisterns for the collection and storage of water seems to have been first introduced in the Chalcolithic or Bronze Age (discussed above), it is generally thought that it did not become common until Iron Age II (Tsuk, 1997: 130). Albright believes that the increasing number of reservoirs and wells discovered in sites dating back to the 1st and 2nd phases of the Iron Age, indicates a sharp increase in population (Albright, 1969: 30). The logic of the arguments and interpretations of Albright and Tsuk, and broader problems associated with them are discussedlatter, which deals with theory and methodology.

According to Herr and Najjar (2001), "*…. it is from the Iron IIC finds [dating to the 7th and 6th centuries BC] that we have the best evidence for the separation of nationalities based on material culture. As national awareness of the political, social and ideological/religious levels rose, so did its expression in the archaeological record, especially in terms of writing, language, religious are and pottery. In Jordan, the material culture of Iron IIC seems to continue into the early Persian period, perhaps as late as the fifth century BC*" (Herr and Najjar, 2001: 335).

The expansion of the Achaemenid Empire brought the area of modern Jordan under Persian control by later 6th century BC. It is clear that the Persians had advanced engineering skill for water management. From the 6th century BC, settlements on the Iranian plateau used qanats (a combination of vertical shafts linked by underground tunnels) to transport groundwater from higher elevations to agricultural fields on the plains (English, 1968; Spooner, 1974: 694-8; Landels, 1978: 38-40; see Wilson, 2003 for useful information about qanats).

The Persians introduced this subterranean irrigation system into Oman where it is known as Aflaj (Wilkinson, 1977; Neely and Wright, 1994). However, their contribution to the development of the water-management infrastructure in Jordan remains unclear. Bienkowski (2001) notes that "*Until recently the evidence for Persian–period occupation in Jordan was sparse and stratigraphically unclear, allowing even the latest commentators to conclude that sedentary life had disappeared from large parts of the country … there is no evidence for the status of Edom or Moab within the Persian empire, and no basis for the bald statement that Busayra and Tall al-Khalayfi were integrated into the Persian administrative system […]*" (Bienkowski, 2001: 361). This remains a problematic period and designation for Jordan, and matters continue to be confused terminologically in the subsequent period, which can be referred to both as Greek/Hellenistic and as Nabataean.

Nearly 200 years of the Persian rule of Transjordan came to an end in 332BC with the coming of Alexander the Great (Meyers, 1997). The majority of the following historical background is from *The Oxford Encyclopaedia of Archaeology in the Near East* (Meyers, 1997).

Between 400 BC and 160 AD, the armies of Alexander the Great conquered much of the Near East, and introduced Hellenistic culture to the area, especially influencing the arts and architecture, with the Greek language becoming the official language throughout the region (Harding, 1963: 114). On Alexander's death in 323 BC, the Greek Empire was divided between two of his generals. The origin of Greek colonies in the region has been attributed either to Alexander or to those who ruled the territories after him.

Jordan, Palestine and Egypt were given to Ptolemy and there followed a period of stability during which Jordanian communities such as Pella, Cerasa, Gadara, Abila, and Esbus prospered and witnessed a florescence of Greek culture. The Ptolemies ruled Transjordan until ca. 200 BC when the Seleucids took control of the area. Jordan (or Transjordan) remained part of the Roman Empire between 63 and 324 AD. A league of ten cities, known as the Decapolis, was established at this time to facilitate trade and commerce. Four cities in Jordan - Jerash, Philadelphia, Umm Qais and Pella - formed part of the Decapolis, however, Freeman concludes that "*in its strictest sense, the Roman era in Jordan is relatively short*" (Freeman, 2001: 427).

The Roman conquest of northern Jordan was part of a process that resulted in the incorporation of the entire eastern Mediterranean under a single government. Starting in 133 BC with the conquest of the western portion of Anatolia (province of Asia), the Roman armies advanced eastward taking Syria in 63 BC, Egypt in 30 BC, Judaea (later designated Syria Palestine) in 70 AD, Arabia in 106 AD and Mesopotamia in 198 AD. During this process of

eastward expansion, in 27 BC, the Roman Republic was replaced by the monarchy of Augustus (27 BC-14 AD).

Governors were appointed to these new eastern provinces and given responsibility for the collection of taxes, providing military security against external threats and providing law and order within the province. No doubt some changes in daily life were observed in these newly conquered lands, but the effect of Roman governance is not thought to have brought about radical change. However, Roman control of such a large area, stretching from the British Isles to Mesopotamia, facilitated the easy flow of ideas and existing technology in such fields as agriculture and architecture over great distances. This process was assisted by the construction of new roads and the upgrading of pre-existing roads into major transportation routes that connected northern Jordan with the rest of the Roman Empire. The major effect would have been the relative peace and stability provided by coming under the control of such a widespread empire (Meyers, 1997).

Though not actually occupied during the Sassanian invasion of 260 AD, Transjordan suffered as a result of the defeat of the Roman army. Arab tribes took advantage of the disorder and increased their raiding along the desert frontier. Emperor Diocletian (284-305 AD) retook the eastern provinces and began to fortify the desert frontier region by the construction of fortified *limes Arabicus* (Meyers, 1997).

The term *limes* has been defined in a number of ways. Tacitus, writing in the first century AD, used it to denote the current extent of the Empire. It was later used in reference to the transportation and military system on the frontier of the Empire (Schutz, 1985). The purpose of this additional security was to check raiding by nomadic Arab tribes. The growth seen in the Byzantine period has been largely credited to the stability and order imposed by Diocletian (Meyers, 1997).

5. THE NABATAEAN PERIOD

The sophisticated water supply system they built up led to a flourishing agriculture; the remains of walls built in terraced fields can still be seen in the areas surrounding Petra (Browning, 1989: 49). Strabo noted that within the rock circle of Petra, plentiful springs supplied both the needs of households and the irrigation of gardens.

This was true only up to a point. In the early stages of Nabataean settlement, supplies from such sources as the Wadi Siyagh would have been adequate, the water being taken, we can assume, by donkey, to cisterns for storage, much as in modern times.

The Nabataeans engineered an impressive system of pipes, tunnels and channels that carried drinking water into the city and reduced the chance of flash floods (Hammond, 1973: 53).

The most prominent characteristic of the Nabataeans was their dexterity in developing methods of collecting rainwater in barren dry areas by building and carving dams, cisterns, well and channels. The nature of the geographic location provided an incentive for devising different methods of collecting rainwater and using it. This took place in Petra and other Nabataean cities (Negev, 1986: 5).

They followed two systems: the first is based on the principle of collecting water and taking it to selected areas. Excess water was reserved to be used when needed. The second system is called terracing of hillsides (graphs hills in Arabic), which are heaps of stones paved on the hillsides in an overlapping manner that contributes to the system of controlling water. This development in engineering led to an expansion in cultivation (Shqiarat 2008, 2005). .

Many of the hills in the Nabataean area preserve traces of walls running across the slope which function to catch water running of from higher up and which have gradient carefully judged so as to channel the water in a controlled way down to cisterns. The Nabataeans did not suffer from scarcity of water. They could supply trade caravans and passengers with water (Shqiarat, 2008).

As the Nabataeans gained more wealth and prospered, their increased standard of living and settlements needs more water. To meet the need, they increased the use of the traditional water harvesting techniques of the area. They also started using new techniques learned from their contacts, noticeably the Hellenistic world (Oleson 1995: 708; Shqiarat, 2005).

Of the traditional water harvesting techniques, the terracing of hillsides is perhaps the most noticeable. Heavy stone walls were built across the slope of a hill to capture rainwater and soil that the water carried with it. Crops were planted on the resulting flat surfaces and benefited from the accumulated moisture (Mattingly, 1998: 335; Oleson, 1995: 709).

A variant of this technique was to build barriers across wadis and streambeds. These were more vulnerable, since they could get damaged by flash floods that carry the concentrated runoff from a whole catchment area, but on the other hand, more water collected when the barriers held. There is a difference between these smaller barriers and those that are called containment dams.

Containment dams are large barriers that are designed to trap and hold a large body of water, creating a pool, for example at the entrance of Petra (Siq). They have to be constructed with the utmost care since they have to resist the sudden influx of water, as well as the erosion that takes place when water flows over the spill way, and percolation. There is also the problem of high precipitation and the low water quality caused by organic material falling into the open pool. Natural pools easily from in soft stone and have been used from antiquity to the present (Oleson, 1995: 709; Shqiarat 2008).

The Nabataeans could control scarce seasonal rains when they realised the importance of making use of rain, impelled by their desire to survive, in spite of the hard conditions surrounding them. The most important indicator of the Nabataeans' ability in preserving water is that their cisterns and pools are still being used.

The Nabataeans experimented with the use of roofed reservoirs and at some point realised that the maximum effective span they could achieve was six to seven metres (Oleson, 1995: 717). For private use, some Nabataean residences had circular cisterns up to five metres in diameter placed underneath their houses to collect rainwater from the roof. In this way, the development of earlier roof collection systems was continued and many examples of these later cistern types have been recorded throughout the Near East (Rubin, 1988: 233).

According to papyri found at Nessana in the Negev, the Nabataean water system permitted the successful cultivation of barley, wheat, legumes, grapes, figs and dates (Evenari and Koller, 1956: 45). Many of the ancient channels and terraces are still extant and some continue in use by the local population. Also, they are still using the water from Muse spring: everyone has two hours to irrigate his field. They manage this between them, depending on the size of the land, sometimes allowing more than two hours.

7. THE BYZANTINE PERIOD

In Levantine archaeology, the term 'Byzantine' is used to describe an archaeological period that begins with the reign of Constantine I in 324 AD and ends with the loss of the Roman provinces of Arabia, Syria and Palestinian during the Islamic conquest of the later 630s AD. It is further broken down into Early (324-491 AD) and Late (491-640 AD) (Grauer and Armelagos, 1998).

The Empire of Byzantium or new Rome was a continuation of the Roman Empire. It began with the establishment of Constantinople as the new imperial capital in 330 AD, on the site of the previous Greek colony named Byzantium (modern-day Istanbul). It lasted until the Ottoman Turks took that city in 1453 AD. The emergence of Byzantine civilisation as something unique compared to what went before and what came after was a process that took the entire 1000-year period, but was typified through the 7th to 11th centuries (Hendy 1985).

The Byzantine period most commonly coincides with the reign of Constantine and, more specifically, his establishment of Christianity as the state religion, and the founding of Constantinople as the capital of New Rome in 330 AD. As the Byzantine period does not signify the beginning of something new and different, there are other events that have been chosen to mark the beginning of the Byzantine period for various purposes of the study. Numismatic sources concerning the Byzantine Empire begin with the reign of Anastasius I (491-518 AD) and specifically with the copper coinage reform of John the Paphlagonian, then comes sacrarum largitionum, in 498 AD. The dates given for the emperors' reigns are taken from Vasiliev (1952), except for those reigning prior to 324 AD, which are taken from Stuart Jones (1908).

According to scholars, the economic practices and governance that exemplify the early Byzantine period became distinct during the reign of Diocletian (284-305). The division of the empire into eastern and western halves in 395/396 AD under Arcadius (395-408 AD) and Honorius (395-423 AD) is another point that has been chosen to mark the beginning of the Byzantine period (Hendy 1985). The period between the reign of Emperor Constantine and the Muslim conquest in the Mid-7th century AD is identified in the Near East as Byzantine but Late Roman in other regions.

Until recent years, the Byzantine period was largely neglected by archaeologists and the majority of research was by religious scholars and art historians. During the last thirty years more attention has been given to the continuation of occupation of the Near East from the Roman through Islamic periods, (that is the Byzantine period). This period has been investigated through careful excavation and with an increased interest in social history (Meyers 1997). The history of the Byzantine period in the Near East has often been viewed as the history of the Christian Church, since most written sources are ecclesiastical in nature, or as part of the declining Roman Empire.

Both of these approaches fail to provide information concerning everyday life. Through an examination of material culture, archaeology can potentially demonstrate a reconstruction of regional

economics and individual daily life (Avi-Yonah, 1958; 1976).

An archaeological assessment of the Byzantine period is difficult. Pottery types that are considered Byzantine do not appear until the middle of the 4th century and do not become distinctive from earlier Late Roman products until the 5th and 6th centuries AD. The generally more delicate Roman pottery decreases during the 4th century and is gradually replaced by coarser, thicker pottery. Adding to the confusion is the presence of Byzantine type pottery in otherwise Late Roman contexts (Meyers 1982; Shqiarat 1999).

During roughly 300 years of the Byzantine period in the Near East, only gradual changes can be seen in the material culture. What changes did occur were probably due to the gradual conversion of the population to Christianity and administrative changes that took place in the region. Building techniques and are indistinguishable from early Islamic pottery until a distinctive Umayyad pattern emerges (Meyers 1997; Zeyadeh 1988: 117). During Roman-Byzantine era (64 B.C to 660 A.D), large numbers of qanats were constructed in Syria and Jordan. The Romans also used qanats as subterranean parts of aquaducts , as witnessed.

Of the Abbasids, Whitcomb writes (2001: 510) that "The late ninth and tenth centuries witnessed transformation in religion and culture not unlike those seen in the sixth and early seventh centuries". Access to well water can be crucial during civil defence (Miller 1980: 337), as can be seen by the extraordinary efforts made to secure the water at Megiddo, where Lamon argues " a supply of water inside the city wall was very nearly as important as the wall itself " (Lamon 1935: 1). In terms of water control outside urban defences in this period we may note that fortified water stations, wells and cisterns on the Hajj route from Damascus to Mecca were jealously guarded and no Bedu was allowed to draw water from them (Doughty, 1936 [1888]: 47). Access to water along the Darb Zubayda on the main Hajj route from Iraq was, according to Tim Insoll (Insoll, 1999: 111) easier. Under the management of the Abbasids, it had 1300 wells, but only 54 guard stations.

Social transformation continued in the successive Fatimid, Ayyubid and Mamluk periods, and Walmsley depicts "a society in the throes of major cultural and economic transformation . . . progressively integrated, in uneven stages, into the Arab-Muslim world of Egypt and ash-Sham,". (Walmsley, 2001: 516; Caponera,1954). Archaeologically, the succeeding Ottoman period is an archaeological puzzle. McQuitty describes the evidence as "*both inconclusive and invisible*" (2001: 561) and concludes that while "*The material culture may not itself be well dated . . . too often the distinctions become the basis for identifying chronological divisions when differences may be reflecting social divisions, for example, between pastoral and village sites, and between urban and village sites*" (McQuitty, 2001: 577).

The early development evolved gradually with time and provide the foundations for toddy's water technologies not only in the Jordan but throughout the world. The historic heritage and the lessons learned provide a wealth of experience for the sustainable management of water resources today and in future generations.

The codification of Islamic Law began under the auspices of the Ottoman Empire (1300 to 1922). In 1839 the Ottomans began a process of reform (tazimat).there remained initial problems of reconciling Muslim and non-Muslim institutions and the internal relationships between Muslim and non-Muslim populations and the outside

World. A second period of reform was initiated in 1854 and the civil law was codified into the Mejelle Code. The law itself was split between a framework based on the Napoleonic Code, which was selected to comply and easily adapt to the Hanafi law, and *Shari'ah* that continued to govern personal status law, inheritance, and *waqf*. Many of the laws in regard to water, remained quite similar in spirit(see Shqiarat 2011; Caponera 1954).

As water law came to be codified throughout the Muslim world it is possible to view a pattern of change. Caponera best identifies the four major trends as follows:

- All waters were declared as vested in the state, Crown or incorporated in the public Domain. The state thus took the place of the Moslem Community.
- Every use of water (other than for drinking or animal watering purposes) left free under the colonial legislation and *Shari'a* was placed under government control.
- Water commissions were set-up to survey and recognize established water rights.
- Land registers were complied in order to keep a written record of duly recognised land and water rights (Caponera, 1954 :37).

The countries themselves that emerged from the Ottoman Empire, including Jordan, retained many of the principles found in the Mejelle Code.

8. CONCLUSION

This paper outlines the basic culture-chronological and historical sequence in Jordan, in relation to water resources, and indicated problems with dating

evidence to particular time periods. The issues relate to the initial construction, phasing of re-use and abandonment of water-management structures, are part of a broader set of methodological problems with ascribing particular structures to particular periods. The widespread use of dry-stone construction techniques and the lack of significant processes for the creation of deep soil deposits, implies the often very little scope for directly dating a structure that could have been in use over centuries or millennia. The technological development over time resulted to current level of knowledge and should not be ignored. It is shown here also the modern management neglect of lessons learned from the wisdom of managing natural resources developed and accumulated by our ancestors.

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