Environmental Archaeology
The Journal of Human Palaeoecology

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/yenv20

Water as a Strategic Resource in the Western Samaria Region – The Unique Case of Deir Sam'an: The Water System that Has Been Operating for 1,500 Years

Yair Elmakayes, David Ben-Shlomo, Yaakov Anker & Amos Frumkin

To cite this article: Yair Elmakayes, David Ben-Shlomo, Yaakov Anker & Amos Frumkin (2023): Water as a Strategic Resource in the Western Samaria Region – The Unique Case of Deir Sam'an: The Water System that Has Been Operating for 1,500 Years, Environmental Archaeology, DOI: 10.1080/14614103.2023.2213021

To link to this article: https://doi.org/10.1080/14614103.2023.2213021

ENVIRONMENTAL ARCHAEOLOGY
https://doi.org/10.1080/14614103.2023.2213021

Water as a Strategic Resource in the Western Samaria Region – The Unique Case of Deir Sam'an: The Water System that Has Been Operating for 1,500 Years

Yair Elmakayes[a], David Ben-Shlomo[a], Yaakov Anker[b] and Amos Frumkin[c]

[a]Land of Israel Studies and Archaeology Department, Ariel University, Ariel, Israel; [b]Department of Chemical Engineering and the Eastern R&D Center, Ariel University, Ariel, Israel; [c]Institute of Earth Sciences, The Hebrew University of Jerusalem, Jerusalem, Israel

ABSTRACT
Maintaining a proper water supply is a subject of constant concern in arid and semi-arid regions of the world, including the Mediterranean Basin and, more specifically, Western Samaria. Solutions such as cisterns, reservoirs, water tunnels, and springs were developed and perfected throughout history to enable a regular supply of water to the local population. The case of Deir Sam'an is particularly interesting, as it seems the site's water storage capability is much larger than needed during its activity in the Roman-Byzantine period. At the site, located in Western Samaria, several Roman-Byzantine water systems were found including reservoirs and large cisterns. Its main water system, which is still operating, enables a reliable estimate of the available water amount to the site residents in antiquity. In the winter of 2020-2021, the daily precipitation volume and the annual rise in pool levels were measured and compared with the water amount at the end of the summer. The results validated that the water storage capability far exceeds the estimated demand of Deir Sam'an's population. This paper suggests that a large amount of water was utilized by the Byzantine Empire as a strategic management tool of settlement in the area to attract its preferred population to the Western Samaria region.

ARTICLE HISTORY
Received 28 October 2022
Revised 25 April 2023
Accepted 2 May 2023

KEYWORDS
Byzantine period; water management; Justinian; Western Samaria; cisterns; ancient agriculture

Introduction

Essence of the Research

Deir Sam'an is one of the most well-preserved Byzantine monasteries in Western Samaria (205228/664053 on the Israeli Transverse Mercator [ITM]). The site, approximately 10 km southeast of Rosh HaAyin, is located on a spur, 379 m above sea level (asl), rising above Nahal Rabba to the north and the tributaries of Nahal Shiloh to its south (Figure 1). Deir Sam'an, along with other sites, controlled a central road that ascended from the Coastal Plain to Samaria during the Roman and Byzantine periods. Around the site is a large water storage system which seems to have been an important factor in the life and strategic design of the site. It seems that the water storage of the various hydraulic works is much larger than the consumption need. The goal of this research was to measure the water capacity of the site, examine the roofing, location, and plaster quality and quantity of the hydraulic infrastructure, and evaluate the data in relation to the water consumption needs of the population during the Roman-Byzantine period. This paper will discuss these questions in relation to the historical aspects of the Byzantine period in Western Samaria. Additionally, the study will determine the performance of the water system at the site after 1,500 years of abandonment.

Survey of Additional Aspects of the Case Study

Geologically, the Deir Sam'an area is mostly composed of hard limestone and dolomite rocks belonging to the Judea group. Owing to the well-developed karst on the western slopes of Samaria, the area is characterized by high water permeability and a karst landscape with some dolines and caves. Thus, although the region has approximately 500–600 mm of precipitation per year, the rainwater mostly does not accumulate or flow on the surface but rather seeps into the ground and flows as groundwater to the foot of the hills (Itzchaki 1980, 218). As a result, there are almost no stable water sources in the high relief area that were relevant to the population in antiquity. Recent studies demonstrate that the climate in the Byzantine Southern Levant did not drastically differ from the current conditions (Frumkin 2002; Fuks et al. 2017).

The complicated morphotectonic setting of the Samaria hills has influenced its settlements layout and character. In contrast to the continuous ridges of Judea, the Samaria hills are dissected, and each settlement was enclosed between the surrounding mountains. Isolated and independent settlements developed, and each site functioned as a separate social and economic unit (Hirschfeld 2003).

CONTACT Yair Elmakayes yairalmak2@gmail.com Land of Israel Studies and Archaeology Department, Ariel University, Ariel, 4076405, Israel
Supplemental data for this article can be accessed online at https://doi.org/10.1080/14614103.2023.2213021.

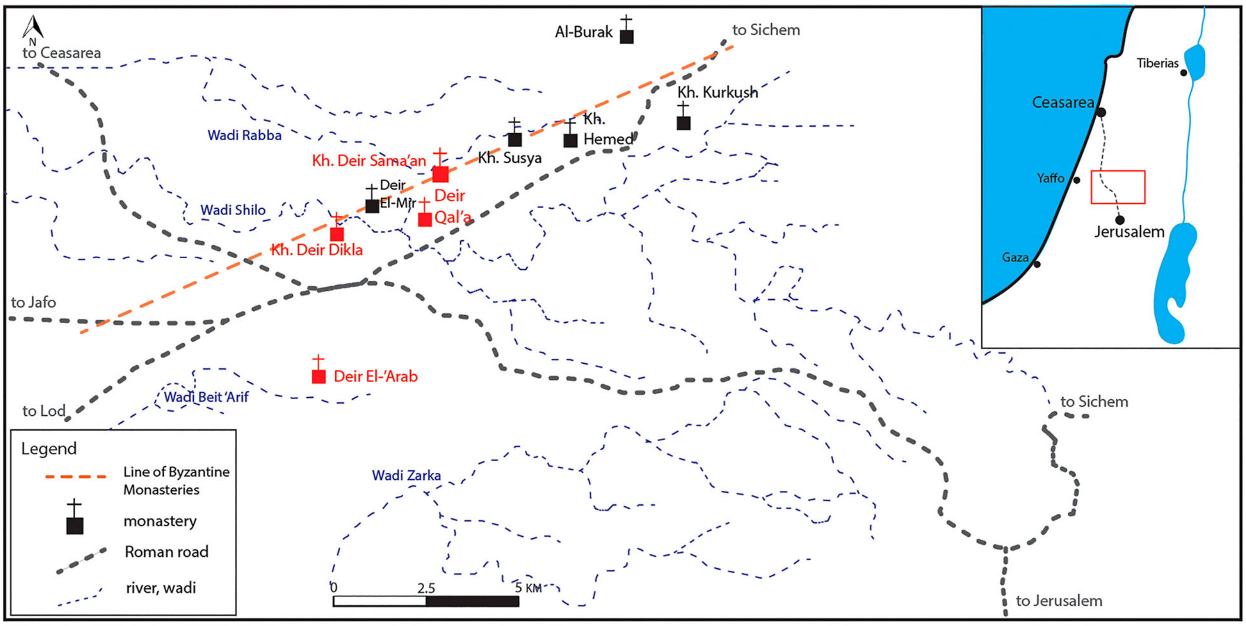

Figure 1. (a) The line of Byzantine monasteries of Western Samaria. (b) General site location map.

The primary modern sources describing Deir Sam'an are Victor Guérin's report (1984 part 2, 86) of his expeditions between 1869 and 1880, the British PEF survey of the nineteenth century (Conder and Kitchener 1878, 1882 part 2, 319), and the Emergency Survey I (Porat 1968, site 148). The site was excavated by Shimon Dar (1982, 45–53) and A more extensive excavation was finally carried out by Yitzchak Magen (2012). Pottery and architectural remains at the site date to the Iron Age as well as the Persian, Roman, Byzantine and Arab periods.

Two watchtowers were found approximately 200 m north of Deir Sam'an. The distance between these compounds is about 100 m and both are located at the same elevation in the upper part of the spur. These complexes control the line of sight on the Nahal Sayif-Rafat streambed, where remains of the road from Antipatris to Nablus were discovered. Deir Sam'an overlooks the central crossroads (see Figure 1 in Hirschfeld 2003):

- **The lateral road:** Antipatris (Tel Afek) – Deir Ballut – Deir Sam'an – Kafr al-Dik – Salfit – Yasuf – Nablus.
- **The longitudinal road:** Azzun – Kafr Thulth – Saniriya – Mas-ha – Al-Lubban – Aboud – Ramallah.

It seems that the Deir Sam'an area became of strategic importance already in the Iron Age II when the early military complexes were established. The earliest pottery from the northern area of Deir Sam'an is dated to the Iron Age II, probably the earliest stage of settlement at the site, established in order to control the road that passed through the streambed. The road continued to exist during the Roman and Byzantine periods as seen in the secondary use of a Roman milestone within a recent agricultural fence at Deir Sam'an (Dar 1982, 45, 52). Although the complexes were allegedly destroyed during the construction of the new settlement Leshem in the early 2000s, the region is still known today for its military importance (Herzog and Gichon 1997).[1]

A Roman citadel was built for protection in the center of Deir Sam'an. Above it is a monastery surrounded by a wall of hewn stones with chiseled margins typical of the Byzantine period in the region (Magen and Aizik 2012, 107). Inside are plastered cisterns, a large olive press, a church, living rooms and tombs. To the north of the monastery is a large complex of wine presses. Below the monastery, there is an arch-roofed reservoir attributed to the Roman citadel,[2] even though canals from the monastery feed the reservoir to this day. Northwest of the monastery are large reservoirs that were filled by canals from the built complex (Figure 2).

Historical and Archaeological Background of the Monasteries

The Byzantine period in the Land of Israel (fourth–seventh centuries CE) is characterized by the general construction of agricultural facilities, particularly related to the production of wine, olive oil and flour (Avalon, Frankel, and Kloner 2012; Dar 2019; Stavi et al. 2018). Deir Sam'an belonged to a group of monasteries in Western Samaria, extraordinary in their wealth and concentration of agricultural facilities relative to their time (Dar 1982, 51–53; Hirschfeld 2003; Stavi et al. 2018).

Figure 2. Aerial site map (photographed from the south, February 2020): 1: The circular installation. T1: The canal leading from the circular installation to reservoirs 2, 3, and 4. 2, 3, 4: The connected reservoirs. T4: The overflow canal, leading from reservoir 4 out to the fields. 5: The western reservoir. T5: The canal leading from reservoir 5 out to the fields. 6: The arch-roofed reservoir. T6: The canals feeding into reservoir 6. 7: The unplastered quarry. A, B, C: The cisterns located inside the monastery. TA, TB,;TC: The canals feeding into the cisterns.

The Western Samaria Monasteries are large cenobitic monasteries[3] with exceptionally high-quality construction. All have the same characteristics, including the existence of a church, a fortified building made of hewn stones and a large water collection system. The monasteries are located about 2–3 km from each other (Figure 1(a)); closest to Deir Sam'an are the monasteries of Deir Qal'a, Khirbet Susya, Deir ʻArab, and Deir el-Mir (Hirschfeld 2003, 241; for a description of the sites see Conder and Kitchener 1882, 311–313; Finkelstein, Lederman, and Bunimovitz 1997, 177–178, 233; Guérin 1874; Kochavi 1972, 233; Magen 2012). Based on architectural resemblance to other monasteries (for example the Mount Gerizim and Saint Catherine monasteries), Deir Sam'an and Deir Qal'a are identified as part of the construction enterprise belonging to the days of Emperor Justinian (Conder and Kitchener 1882, 315; Hirschfeld 2003, 244, and note 58).[4] This period was one of economic prosperity in the Byzantine empire, which could afford, if it saw fit, to invest in the construction of these monasteries (Tsafrir 1998, 255, 265, 274). These monasteries served a dual purpose by providing religious monastic settlement as well as representing the broader interest of the empire in controlling the area, possibly as a religious military force (Hirschfeld 2003). The fact that the monasteries were well fortified, located in a hostile border area, and built against the background of growing security tensions suggests that their inhabitants had some military training. At the end of the Byzantine period, some of the monasteries underwent additional fortification processes, demonstrated by the closing of windows and narrowing of openings that were applied to protect the site from invasions (Hirschfeld, 2003; for more on the phenomenon of the abandonment of monasteries in Israel in the Byzantine period, see Schick 1995, 119–120). The monasteries continued to exist into the early Arab period.

In the Byzantine period, the area became a border between the Christian and Samaritan populations, explaining its establishment as a center of military and agricultural settlement (Di Segni 2012). Magen (2002a) suggested that the area, emptied of its Jewish inhabitants following the Great Revolt and the Bar Kokhba Revolt, was fertile ground for Christian settlement during the Byzantine period (Elitzur and Ben David 2007; Hirschfeld 2003; Magen 2002a, 245, 269–271). The Samaritans, an independent nation who view themselves as the descendants of the northern kingdom of Israel, numbered more than one million during the Byzantine period (Magen 2002b, 223–253). Following the failure of the Bar Kokhba Revolt, the spread of the Samaritans from the mountains of Samaria towards other districts in the Land of Israel began. Despite clashes with Roman authorities and persecutions by the Christian rulers of Byzantium, the Samaritan community became a populous ethnic group among the inhabitants of the region and continued its territorial expansion until the fifth and sixth centuries CE. Harsh events led to a wave of Samaritan rebellions against Christian rulers, resulting from a combination of religious tensions and severe economic damage (Magen 2002b, 213–272).[5]

These rebellions took a heavy toll on the empire's resources and manner of control over the area.[6] At the height of its existence, the empire suppressed the rebellion with great cruelty and determination (Dar 2002, 444–454; Di Segni 2012, 157–160). The military suppression continued for a long time and, even after that, a large Samaritan population remained in the region. This was the main construction phase of the Western Samaria Monasteries (Hirschfeld 2003, 249; for an example of Byzantine activity against the rebellions, see Haddad and Zwiebel 2021).

Archaeological and architectural analysis of the Western Samaria Monasteries shows that they were established deliberately in one period, in contrast to the monasteries of the Judean Desert, which were established sporadically by various individuals and institutions over many years (Dar 2002; Magen 2012, 105). A mosaic inscription found in the northern chapel at Deir Qalʿa mentions Justinian I and is dated to 544–545 CE (Magen and Aizik 2012, 141; Di Segni 2012, 157). It is likely that the construction took place within the restoration framework of the central government to repair the damage caused by the rebellions. Their establishment along strategic roads provided them with the ability to support a garrison in times of war (Dar 1982; Hirschfeld 2003). In this way, the monasteries can be seen as an important instrument in the hands of the empire to establish control over the area.

The Hydraulic Features of Deir Sam'an

The Circular Installation (Figure 3)

To the north of the monastery is a circular installation (1 in Figure 2) connected to the reservoir complex (2, 3 and 4 in Figure 2) by a canal (T2 in Figure 2), and near the opening to the reservoirs there is an additional small hewn area (HA in Figure 2). Several hypotheses have been raised regarding their nature (Dar 1982, 45–46; Tepper 1986). The first theory is that the round installation was used for the washing and processing of wool. This assumption is difficult to accept because the distinct agricultural nature of Deir Sam'an is not consistent with industrial sheep farming (Dar 1982). The second opinion is that the round installation was used as a threshing floor,[7] although this alone does not explain the presence of the canal and the small hewn area (Dar 1982). It seems that the installation had two uses; threshing wheat during the harvest, and water collection to the northern reservoirs during the winter.[8]

On the eastern side of the circular installation, Dar (1982) discovered a sundial located on a vertical wall facing south (SD in Figures 2–4).[9] The sundial, found near reservoirs 2, 3 and 4, is indicative of a functioning economy with a high level of organization and order (Dar 1982, 52; Tepper 1986). Tepper suggested that it was not used to measure the hour of the day but rather to allocate time in the distribution of water for different areas. It is also possible that the clock measured the filling rate of the pools on rainy days, enabling an estimate of the future amount of water in order to manage the monastery's water supply.[10] The secondary usage of agricultural facilities for water harvesting is known from other sites in Western Samaria such as Khirbet Al-Burak (668069/210783) and was recently discovered between the Western Negev and the Hebron Mountains (Stavi et al. 2018). This installation is the first step in the water collection process at Deir Sam'an.[11]

Reservoirs 2, 3 and 4 (Figure 3)

The filling process of these reservoirs was gradual and functioned as a gravitational water system. First, the water was collected on the circular

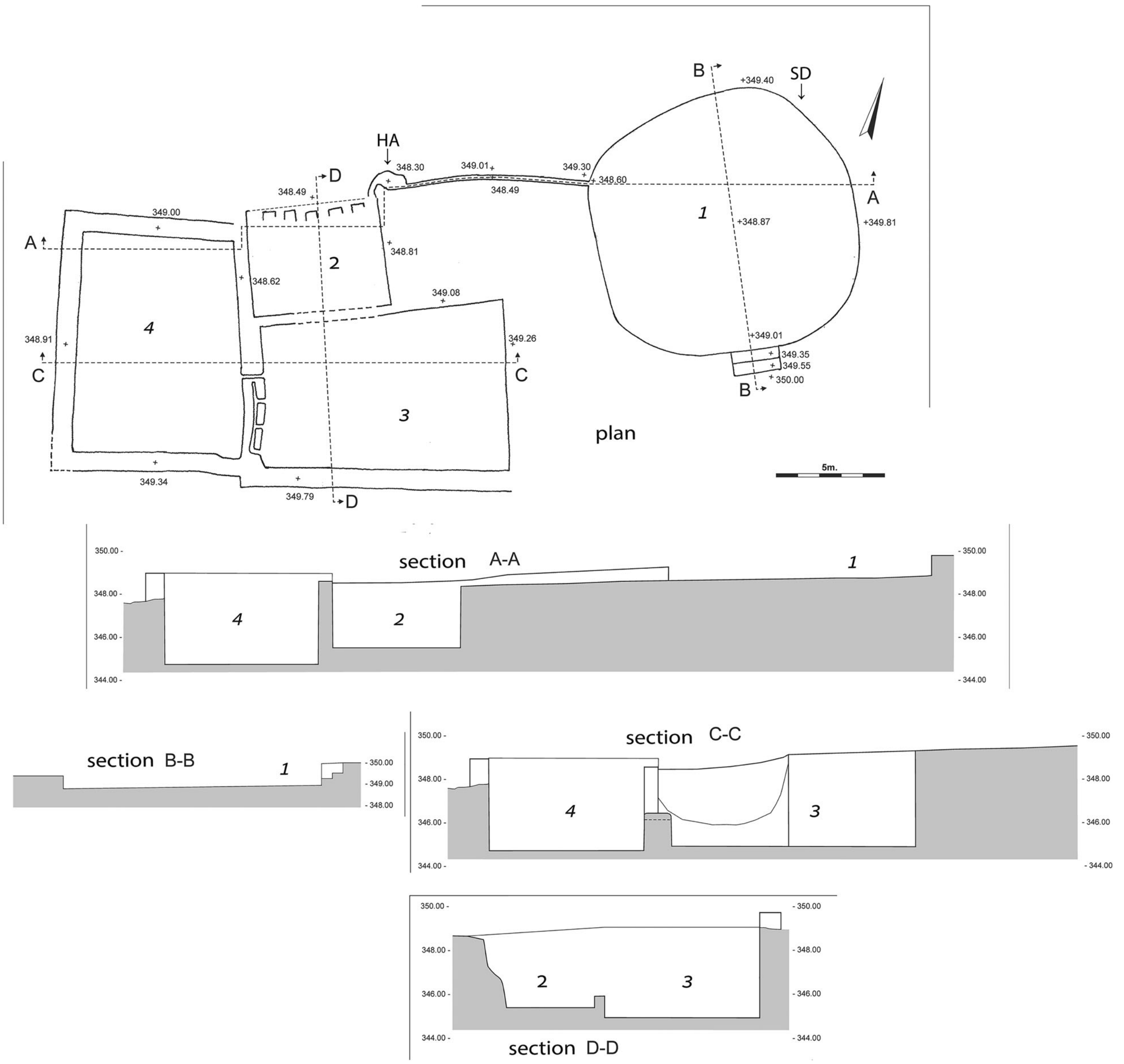

Figure 3. Plan and sections of the circular installation and reservoirs 2, 3, and 4.

installation and then channeled into reservoir 2 ($4m*12.2m*11\ m = 540m^3$), the shallowest of the three pools. When the water reached a depth of 1 m, it began to fill reservoir 3 ($3.5m*5.5m*5.7\ m = 110m^3$), and when it reached a depth of 1.2 m, it began to fill reservoir 4 ($4.2m*10.2m*7.7\ m = 330m^3$). The emptying of the reservoirs occurred in the opposite order (reservoir 4 emptying first, then reservoir 3 and then reservoir 2). On the northwest side of reservoir 4 is an overflow canal (T4 in Figure 2), used to drain water from the reservoir when it reached full capacity (a reconstruction of the site can be seen in Figure 5).

Figure 4. Sundial at the circular installation of Deir Sam'an.

Reservoirs 5 and 6 stand independently, each with its own filling and emptying system.

Reservoir 5 (Figure 6)

Reservoir 5 is adjacent to the western side of the site and is disconnected from reservoirs 2, 3 and 4. Magen (2012) describes a single layer of plaster in this reservoir, with qualities typical of that of the

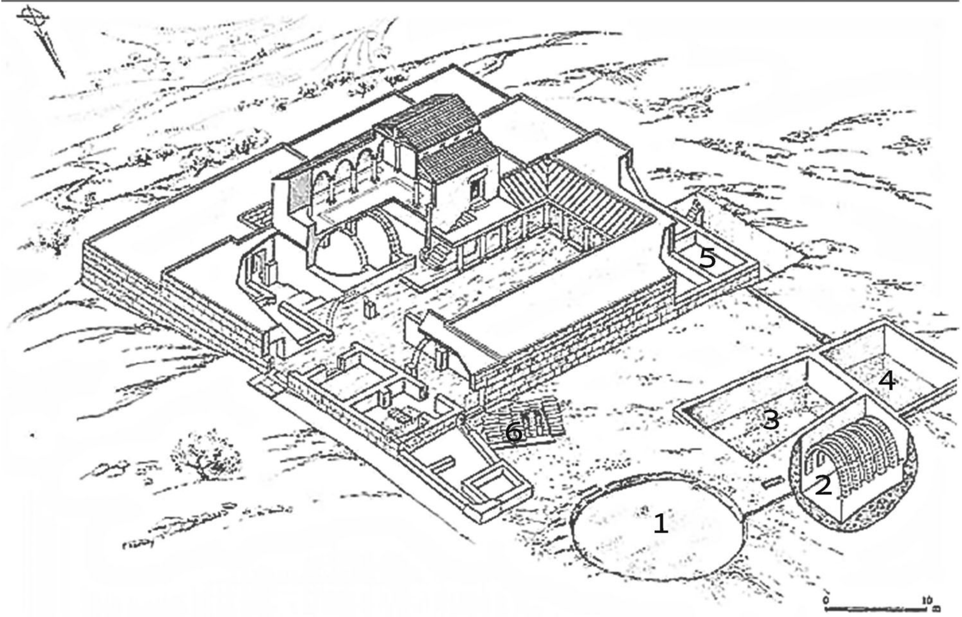

Figure 5. Deir Sam'an monastery reconstruction proposal (adapted from Magen 2012).

Roman era. Hence, Magen's understanding is that this reservoir was not used in subsequent periods. This statement can be challenged as even today water is stored well without an additional layer of plaster. It is also difficult to accept that an asset as important as a water reservoir was not in use when the monastery was inhabited. The absence of plaster from the Byzantine period is probably due to lack of need, as the plaster left in the reservoir allowed for water storage, as can be seen to this day. However, this absence is significant in the analysis of water retention, as will be discussed below.

Reservoir 6 (Figure 7)

Reservoir 6 differs from the others in two aspects:

1. The reservoir is completely covered by ashlar arches – a large investment for this type of reservoir. According to Magen (2012), such a roof also existed over reservoir 2 (Figure 5). Two similar reservoirs were recorded in Western Samaria: one discovered by the authors at Deir Zenar (207315/661895, Figure 8), located about 3 km south of Deir Sam'an, and the other, described by Magen and Aizik (2012) and remeasured by the authors, at Deir Qal'a (204442/662782).
2. The filling of reservoir 6 occurs from a higher elevation area compared with the recharge area of the circular installation. Additionally, the reservoir direction is not congruent with the monastery, which may indicate that the reservoir predated the monastery in its current form.[12]

Due to the reservoir's large and permanent roof, it is completely sealed and there is no infiltration of dirt.

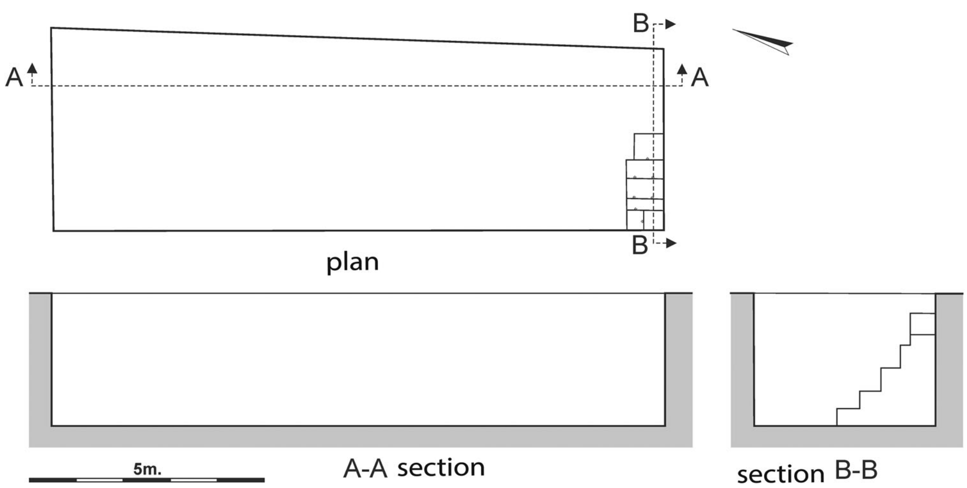

Figure 6. Plan and sections of reservoir 5.

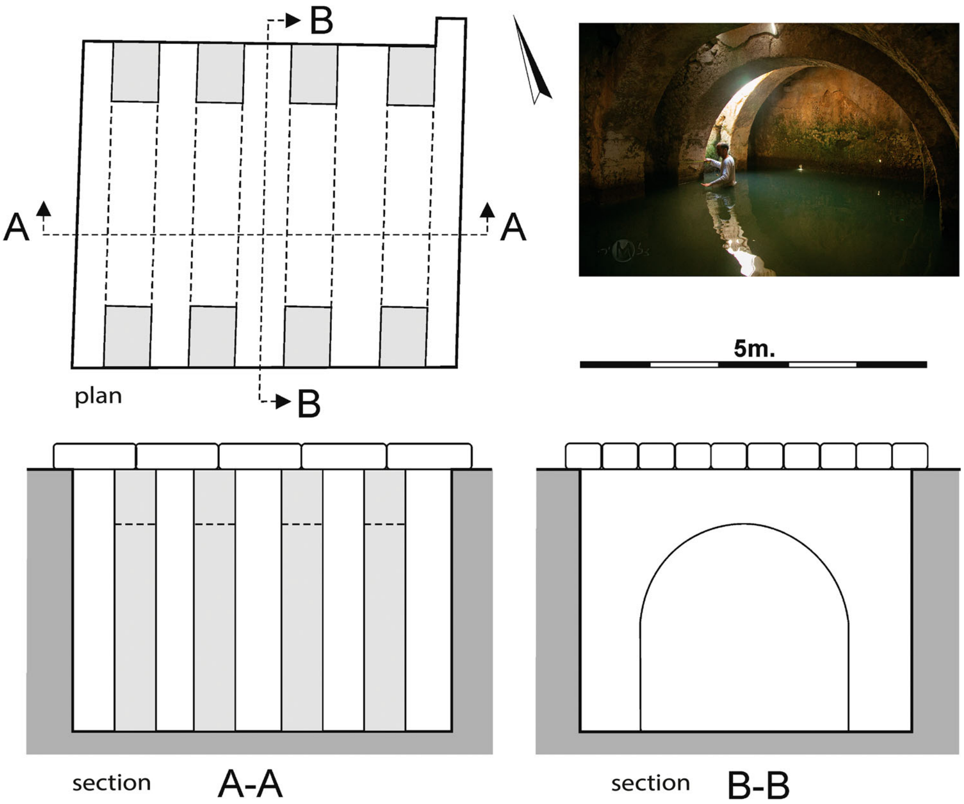

Figure 7. Plan and sections of reservoir 6.

As observed in the framework of this study, the water stored in this reservoir was pure and clean at the end of the summer.[13] In closed reservoirs, such as reservoir 6, the temperature generally remains stable.

Reservoir Roofing

It is difficult to assume that the hydraulic features were exposed to the sun due to the large investment in the construction of the reservoirs and the significant effect of water evaporation. The reservoirs which are not covered today were most probably covered with a light roofing such as leather or wood sheets (Hirschfeld 2003, 215–219). Nonetheless, the water storage provided by the open (light-roofed) reservoirs in the external area (2, 3, 4 and 5) is more substantial than the storage provided by the arch-roofed reservoir in the complex area.[14] This is an indication that even possible evaporation losses in the open reservoirs did not greatly affect the water consumption needs of the inhabitants or the production activities of the monastery.

Cisterns A, B and C (Figure 9)

In contrast to the reservoirs described above, cisterns A, B and C are defined by a distinct pear-shape and storage capacity of less than 50 cubic meters of water each (Tsuk 2011, 42–48). The canals that drain into these cisterns were built to collect water from the roof of the monastery; they enter the building from the roof and come out to fill the cisterns from under the building's floor (TA, TB and TC in Figure 2). The cisterns were opened as needed, after the previously opened cistern was depleted.[15]

Methods

In order to estimate the water storage at Deir Sam'an, the present daily precipitation volume at the site was measured and compared to the annual rise in reservoir levels as well as the water amount left at the end of the summer. The most accurate rainfall measurement on site were taken manually at two points in the adjacent settlement of Pedu'el, 394 m asl (Figure 10, 204664/662913 ITM).[16] The values from the two rain gauges were averaged and compared to those of the meteorological station of the Israeli Ministry of Agriculture, located near Deir Sam'an at the Shacharit agricultural farm (666198/207398, 407 m asl). This rain gauge measures precipitation automatically on an hourly basis (https://www.meteo.co.il/report/SingleStationReport). The results are presented in Figure 11 and Appendices 1–3.

Some of the water canals leading to the reservoirs remain active when it rains today. During the winter of 2021, the absolute depth of the reservoirs was measured in millimeters with a measuring tape. The change in water level was then calculated by measuring from the top of the reservoir to the water level and subtracting the result from the absolute height of the reservoir.

Before conducting the measurements, the canals were cleaned to allow for optimal water flow and collection into the reservoirs. The measurements were

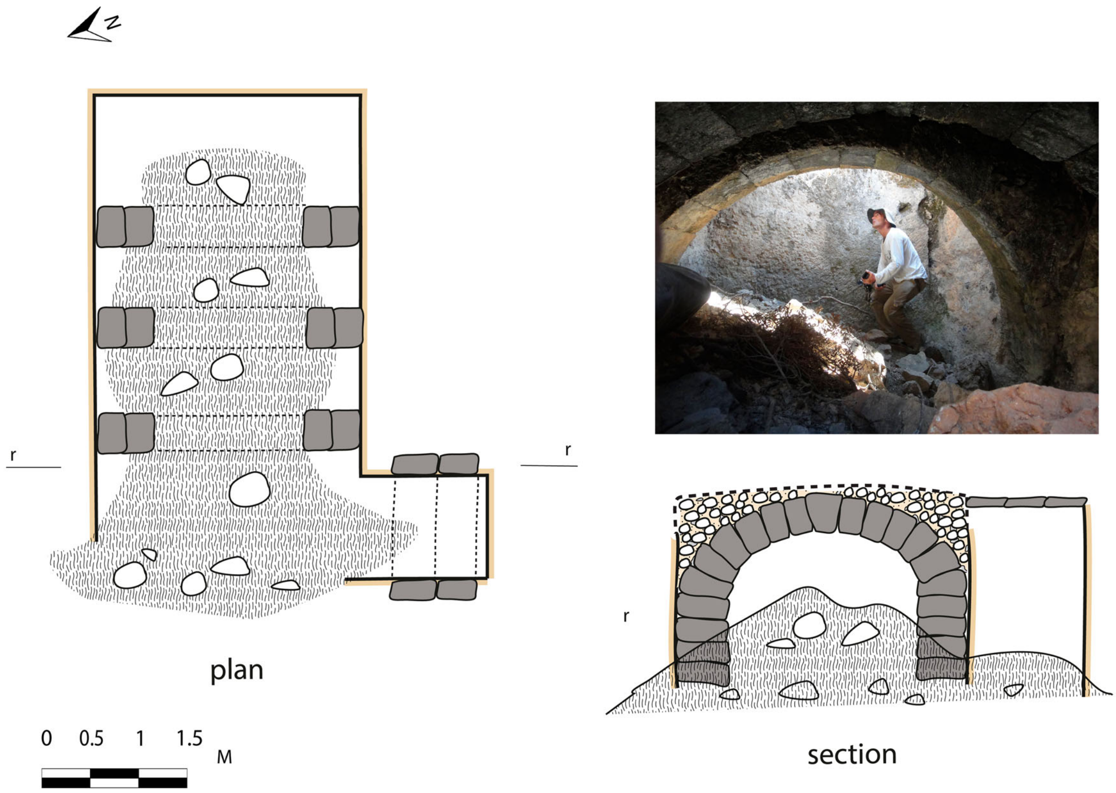

Figure 8. The underground reservoir at Deir Zenar.

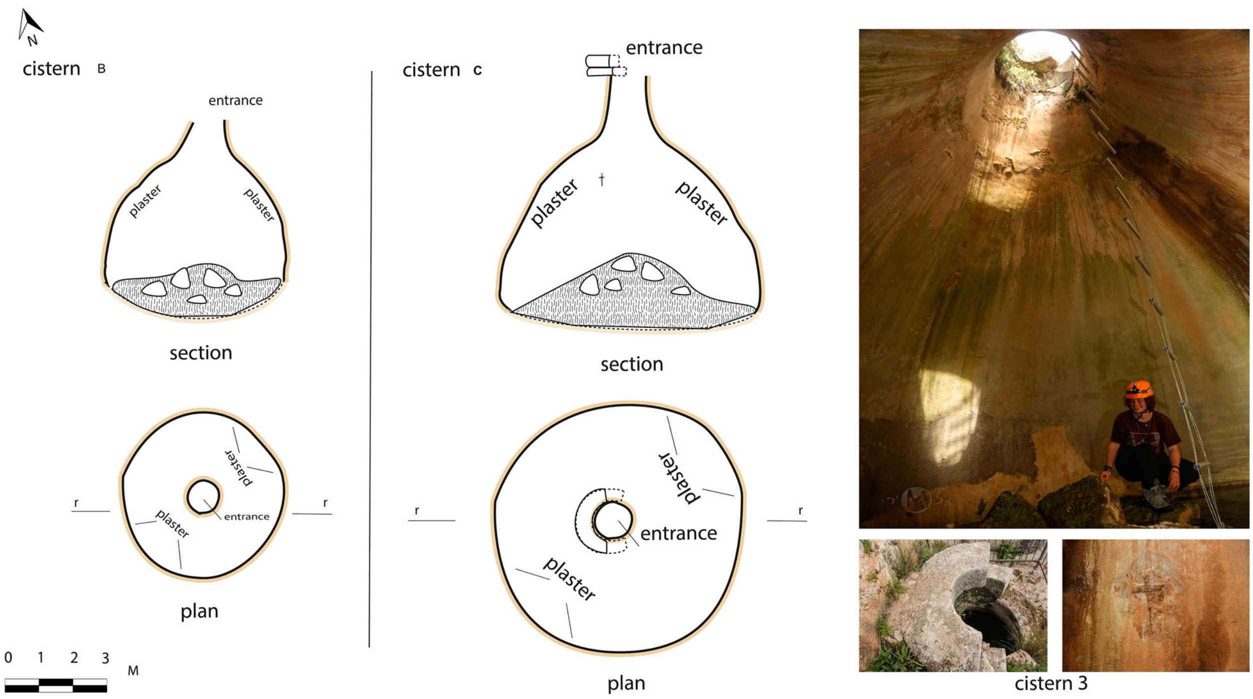

Figure 9. The cisterns inside Deir Sam'an monastery.

conducted once every few weeks between January and March 2021, and the rise in water level of each reservoir was measured separately (Figure 12). A measurement was also taken in October 2021 to record the remaining amount of water in the reservoirs after the summer months. This measurement enabled the calculation of the evaporation rate and of the difference between the covered and the uncovered reservoirs. This data is presented in Figure 12 and in Tables 1–3.[17]

Analysis of the Measurements

Since the monastery is currently roofless, the measurements of this study are somewhat lacking. The size of

Figure 10. Manual rain gauge close to Deir Sam'an.

the monastery is approximately 1,600 square meters, and from every part of it, water drainage canals can be seen running down the side of the building. Remnants of the canals in the northern part of the site drain into the circular installation and reservoir 6, while those in the western part drain into water reservoir 5. Based on the perpendicular gutters, it is reasonable to assume that at least half of the monastery was roofed and that the water flowed from the roof into the water reservoirs, providing the inhabitants with an additional 800 square meters of water drainage area. In a standard winter, when the average precipitation in the area is approximately 650 mm per year, 520 cubic meters of water could have been collected from the roof (650 mm * 800 square meters = 520,000 mm of water).[18]

Additionally, some of the canals are ruined; only the canals which are preserved were cleaned for this study, and still, the results show a rise of 2 m in the reservoirs' water level during a rainy winter. It is reasonable to assume that the reservoirs were filled in every normal winter.[19]

Results

1. **The transport quality of the water system.** Remarkably, the reservoir complex of Deir

Amount of Precipitation (mm)	October	November	December	January	February	March	April	May	Yearly Total
Peduel 2017/2018	29	22	86	197	70	15	33	4	456
Peduel 2018/2019	32	74	331	97	111	108	37	0	790
Peduel 2019/2020	11	5	177	320	100	129	31	6	779
Peduel 2020/2021	0	201	71	145	176	2	0	0	595
Regional Average 2011-2020	20	66	148	162	88	53	23	9	569

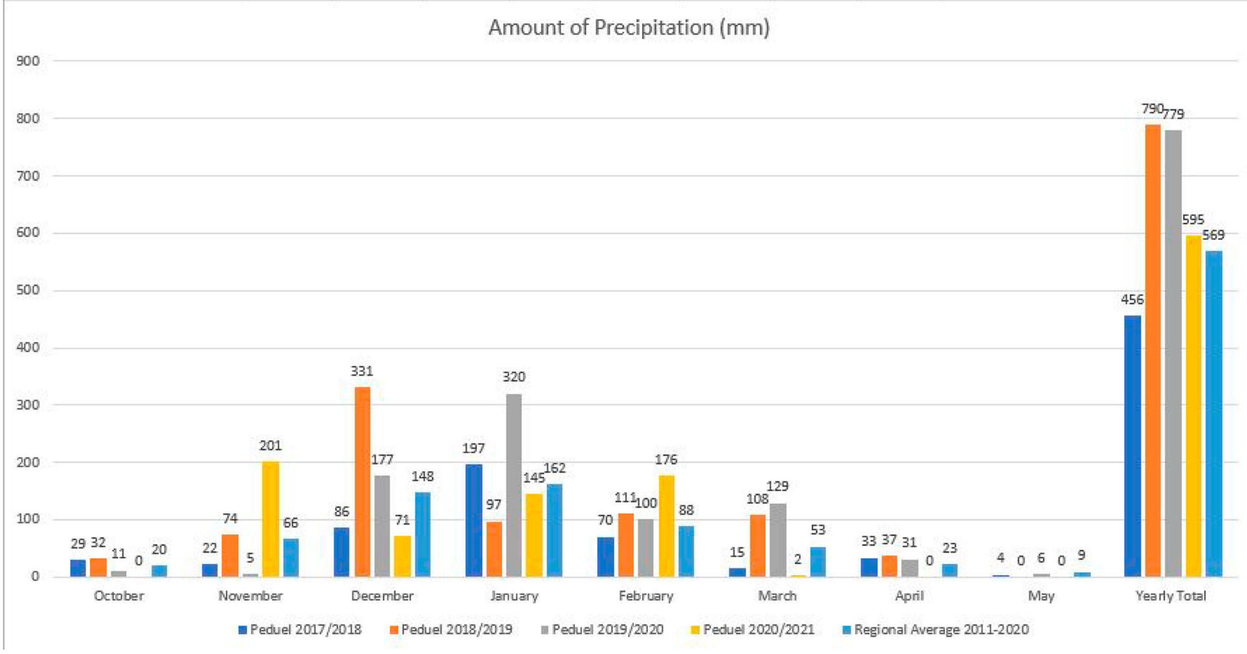

Figure 11. Amount of Precipitation Graph.

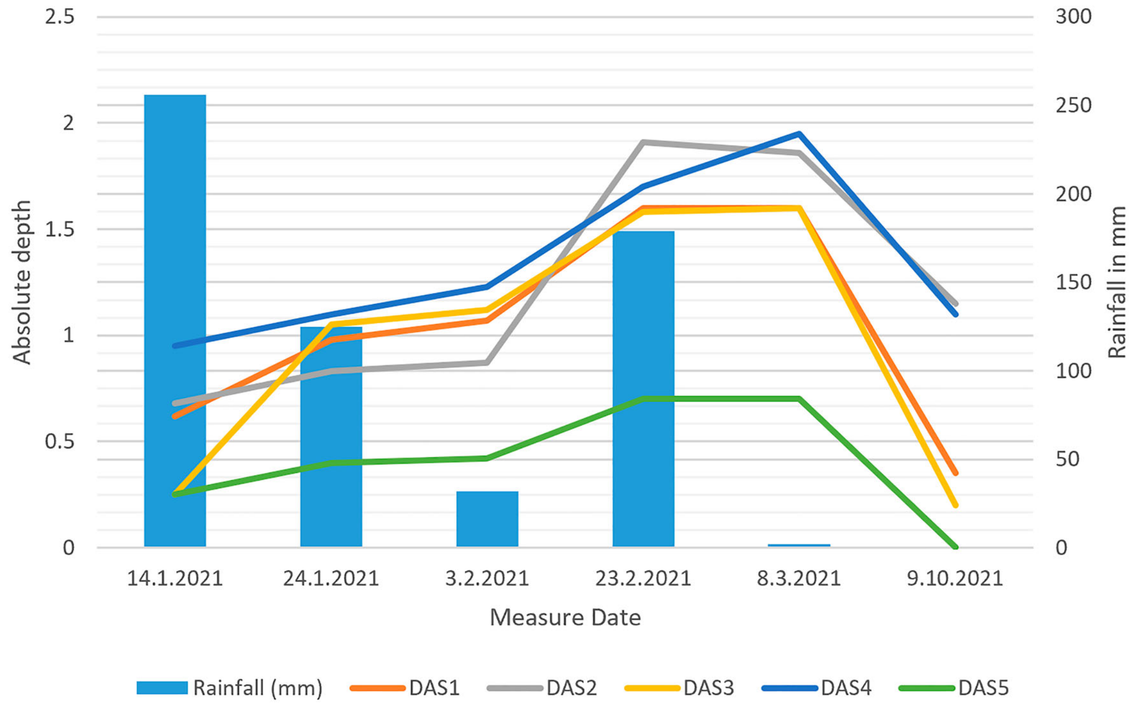

Figure 12. Rainfall vs the Reservoir Water Depth Graph.

Table 1. Size of the Reservoirs[a].

Reservoir Number	Depth (m)	Width (average) (m)	Length (average) (m)	Volume (m^3)
DES 2	4	12.2	11	540
DES 3	3.5	5.5	5.7	110
DES 4	4.2	10.2	7.7	330
DES 5	4.5	4.5	13.4	270
DES 6	4	5.5	4.8	106
Total				(~) 1,400

[a]Throughout the article, number 1 refers to the circular installation. This chart begins with the first reservoir as number 2 to create uniformity.
[b]We added a small amount to the total volume to make up for imperfections in the shape of the reservoirs.

Table 2. Size of the Cisterns (m) (only those located within the site are included).

Cistern Number	Diameter of the Opening	Depth	Maximum Width at the bottom	Volume (approximate m^3)
DES A	1.1	3.5	5.9	21
DES B (sediment buildup)	0.42	2.5 (until the buildup)	2.4	6
DES C	1.3	5.7	7.6	43
Total				70

Table 3. Calculation of excess water storage at Deir Sam'an.

Total volume of water storage (cisterns and reservoirs)		**(~) 1,470 m^3**
Water consumption per person per year	(~) 3 m^3	
Estimated population	(~) 50 m^3	
Estimated water needs of the population		**(~) 150 m^3**
Estimated excess water storage		**(~) 1,300 m^3**

Sam'an is still functional today. Not only does the water system fill, but it also stores water until the next summer, approximately 1,500 years since the site was abandoned. This indicates the efficiency and resilience of the system.

2. **The importance of plaster quality for water retention.** A significant difference in plaster quality is apparent between the various periods. Reservoir 5 (Figure 6) has a single layer of plaster, and its limited prevention of water seepage is clear as it empties first. On the northern side of the site, there is a square quarry (7 in Figure 2) that, after a series of rainstorms, fills to a depth of over a meter. However, the water retention is limited to a week. This quarry is not plastered, and the water seeps out quickly. There seem to be various levels of water storage efficiency: an unplastered reservoir (square quarry) stores water for about a week, a reservoir that is coated with one layer of plaster (reservoir 5) stores water for three to four months, and a reservoir that is coated with two layers of plaster stores water for the entire summer.
3. **The amount of water stored compared to the amount of rainfall.** In the measurement year 2021 The actual water level rise was about 60% of the maximum volume of the pools.[20] Assuming that the structure was completely drained and that the canals were intact, the amount of water in the reservoirs reached 100% capacity.[21]
4. **The total amount of water collected**. The amount of water storage from the cisterns and reservoirs totaled 1,470 cubic meters. According to a presumed consumption of three cubic meters per person per year (Tsuk 2011, 28), the water collected in the various hydraulic works of the monastery was sufficient for the sustenance of 490 people.[22]

However, the size and architectural features of the site are thoroughly unfit to support such a large population.

In summation, Deir Sam'an had a sophisticated collection system with high-quality plastering that preserves water even today. This system contained about 1,400 cubic meters of water storage and may have filled more than once during a single winter. This is in addition to the three water cisterns located within the site that together contain approximately 70 cubic meters of water (A, B and C in Figure 2; Figure 9).

The collection system includes a network of canals from the roof of the monastery and within it (in the exposed parts), the secondary use of agricultural facilities to increase drainage, and a sundial. The reservoirs themselves have depth differences for the benefit of better storage and an optimal understanding of the amount of water available. Based on roofing type and location, the hydraulic features can be grouped into two: those that are closed and located inside or close to the monastery complex, and those that are open and located in the external area of the site. It can be hypothesized that the closed features provided for the daily consumption needs of the population while the open reservoirs were used for productive activities such as agriculture and food production.

Discussion

We have shown that during the Byzantine period, Deir Sam'an collected a large quantity of excess water, an amount that cannot be justified by the site's estimated population.[23] The question of population size in Samaria during the Byzantine period and the density of settlement sites according to the percentage of construction per square meter has been discussed earlier (Broshi and Finkelstein 1990). Based on a study conducted in the Judean Desert (Hirschfeld 2002, 189) and the size of the site, we can estimate that a few dozen to fifty people lived as permanent residents of Deir Sam'an in the Roman-Byzantine period. A population of fifty monks would need 150 cubic meters of water; such a population could have easily survived on the water stored by the monastery's roofed features, cisterns (A, B and C) and reservoir 6 (together totaling approximately 175 cubic meters, as displayed in Tables 1 and 2). With a population of fifty, it can be estimated that during an average winter the site had an excess of over 1,200 cubic meters of water, provided by the open (lightly roofed) reservoirs. The large amount of water contained in the elaborately built reservoirs raises questions, the answers to which lie in the historical aspects of the site.

In addition to the military and religious aspects expressed in the monasteries, the importance of water and agriculture must be considered. The T4 and T5 overflow channels (Figure 2) continue beyond the monastery complex and irrigate the fields below. Organized agricultural terracing is observed on the slopes below the monastery. Evidence of stone fences is spread over hundreds of meters of strategic agricultural land, marking the agricultural areas occupied by these monasteries (mapped by Hirschfeld 2003, 213; Dar 1982, 50–53). According to the proposal detailed below, the impressive water storage facilities at these sites were used to establish regional agriculture, controlled by the monasteries, in the areas up to and beyond the stone fences. The amount of water available to Deir Sam'an affected the extent of its control and its distance from the other monasteries, as the range of control of each monastery resulted from the amount of water it had at its disposal.[24] The central government built these sites (or encouraged their construction) when the main tool in their control of the territory and their economic independence was the construction of a developed agricultural system between the monasteries and strategic open spaces. It is also probable that during wartime, the excess served as a water source for troops traversing the roads.[25] This effectively created a protective ring of monasteries and agriculture around the roads leading to Samaria.

We propose that the excess water collected in the reservoirs of Deir Sam'an was used by the monastery to sustain agriculture in two ways:

1. Irrigated agriculture for the monastery's consumption – for this purpose, irrigation canals (T4 and T5) were constructed from the monastery to the land plots adjacent to it. We assume that annual crops such as vegetables and grains were grown using this form of irrigation (Tzaferis 1996, 22). These are seasonal crops, suitable for the size of the plots and the consumption of the monastery residents (Dar 2019).
2. Dryland farming (non-irrigated cultivation of crops), which relies on initial irrigation – the main amount of water was intended for perennial crops such as fruit trees with a profitable agricultural yield. Initial irrigation is needed to increase the chances of these trees taking root in their first years. For this purpose, a large amount of water must be stored in addition to local consumption.[26]

Although there seems to have been a variety of fruit trees, the main crops were olives and grapes. This is evidenced by the many olive and wine presses scattered throughout Samaria.[27] These crops have two distinct advantages; the produce is of great economic value, and it can be preserved for a long time. At the site of Al-Burak (Figure 1), the largest winepress in the region and one of the largest in Israel was found, with a capacity of 40,000 liters (40 cubic meters)

(Dar 1982, 82–131; see Figure 3 in Kohn-Tavor et al. 2021).

The cultivation of grapevines in Western Samaria had already reached importance in the Hellenistic period, when John Hyrcanus conquered Samaria and settled senior officials and military veterans within it by distributing agricultural land on behalf of the government. This is expressed in the archaeological finds, mentions of Jewish towns and magnificent tombs of officials in the region (Raviv 2013; Shahar 2000), and a reference to the best wine of Western Samaria that reached the Temple – '*Alpha LaYayin*' (Tractate Menachot 8, 6).[28]

Viticulture requires skill and large initial investment: surface clearing, row planting, trellising, pruning, harvesting, winepress construction and optimal storage conditions. However, the return is high. It is notable that, after a relatively short time, the vines adapt themselves to the hard limestone rock of Western Samaria. Grape cultivation is especially worthwhile if there is initial investment capacity in the construction of agricultural infrastructure (Liphschitz and Biger 1998, 139–143; Netzer et al. 2009).

Considering these advantages, we believe that these agricultural crops were planted by the inhabitants of Deir Sam'an monastery during the Byzantine period to occupy land in a strategic area vital to the empire, with an emphasis on grape cultivation as an economically profitable crop. It is reasonable to propose, following conversations with local farmers who have plots without irrigation systems, that a new grove was planted every year according to the excess amount of water (more than 1,000 cubic meters) and irrigated manually in the first few years to increase the chance of its survival. Once the grove no longer required irrigation, new trees were planted and irrigated, occupying previously uncultivated areas around the monastery.

Conclusions

The initial stage of Deir Sam'an was probably a Roman military enterprise that was strengthened and received religious markings when the Roman Empire converted to Christianity. The reason for the establishment of this site as part of the Western Samaria Monasteries lies both in the geographical aspect of the Byzantine roads that cross through the monastery cluster and in the local historical events of the Samaritan rebellions during this period. Due to the importance of the site, settlement there continued into the early Muslim period until it waned and ceased (Dar 1982, 50; Magen 2012).[29]

Deir Sam'an's impressive hydraulic storage system seems to far exceed the sustenance requirements of its inhabitants. The population in the Roman-Byzantine period can be estimated to be about fifty monks, with a consumption need of approximately 150 cubic meters of water. The results of the field research validated that the water storage capability of at least 1,470 cubic meters far exceeds the water needed for consumption by the estimated population of fifty. Drinking water was provided by the 175 cubic meters of water within roofed and internal hydraulic features, while more than 1,200 cubic meters remained in the open and external reservoirs for monastic productive activities. Such activities predominantly included irrigated agriculture for the monastery's consumption and dryland farming of perennial crops, specifically olives and grapes (Dar 2019).

Throughout history, water has played a crucial role in determining the layout of settlements, even before the formation of complex societies (Braemer et al. 2009; Mantellini 2015; Wilkinson and Rayne 2010). It is therefore not surprising that water was used as a strategic factor in the establishment of the Western Samaria region. We suggest that the excess water found at Deir Sam'an was used by its inhabitants to rule, through the use of crop cultivation, up to the line of contact with Deir Qal'a towards the southwest and up to Khirbet Susya towards the northeast (Figure 2(a)). In this way, with the help of efficient water management and agriculture, a relatively small site succeeded in occupying a strategic area for the Byzantine Empire.

Notes

1. The ancient part of the site is not found today, but demonstrates the site's importance. Here the Ottoman and British armies faced each other in the First World War.
2. Although the construction style of the reservoir looks similar to that of the monastery complex, the reservoir is asymmetrical to the monastery. It seems that the monastery was built above it in a later stage of construction. This was discussed at the site with Dr. Tsvika Tsuk.
3. Monasteries where monks live, study, pray and eat while taking part in a communal lifestyle.
4. For more about imperial construction in the days of Justinian, see Hirschfeld (2003, 242, note 60).
5. One of the most significant economic legislations by the central government against the Samaritans, decreed in 529 CE by Emperor Justinian, prohibited Samaritans from gifting their property or bequeathing it to a non-Christian.
6. Of the three main Samaritan rebellions against the Byzantine Empire, the most significant occurred in 529 CE.
7. The location of the round installation outside the monastery is reasonable. Similar logic appears in Rabbinic literature: 'One must distance a permanent threshing floor fifty cubits from the city. A person should not establish a permanent threshing floor [even] on his own [property] unless he has fifty cubits [of open space] in every direction. One must distance [a threshing floor] from the plantings of another and

from [another's] plowed field enough that it does not cause damage' (Baba Batra 2:8).

8. In this context, the second hewn area may be an installation where the water can be filtered by a net of thorns before passing into the reservoirs. Perhaps the circular installation had a third usage as an industrial winepress during the grape harvest, with the second hewn area used as a collection pit.
9. In one of the Villas in Boscoreale near Pompeii, a threshing floor was found adjacent to a farmhouse, and a rock surface drained the rainwater into a pit at its end. A similar sundial was also found there (White, Press, and Scullard 1970).
10. Another opinion is that it was used by monks to determine the order of their day in the monastery (Hirschfeld 2003, note 66).
11. The filling of the reservoirs is only possible due to the existence of this installation, as was noted by the authors during a tour of the site with Dr. Tsvika Tsuk.
12. Magen (2012) reported two layers of plaster. It is possible that the upper layer dates to the late Roman and Early Byzantine periods (characterization of this type of plaster appears in Hirschfeld 2003). If this assessment is correct, it attests to the fact that the reservoirs were quarried in the Early Roman period and replastered in the Byzantine period (except for reservoir 6). This opinion was expressed in a conversation with Dr. Tsvika Tsuk.
13. The water quality of Deir Sam'an's various hydraulic works has been scientifically tested by Ella Ben-Uleil in an independent study. The analysis concludes that the water quality in reservoir 6 is superior to that of the rest of the reservoirs (for more on the analysis of Deir Sam'an's water quality, see Ben-Uleil 2022, 65).
14. As mentioned above, Magen reconstructs reservoir 2 as covered with ashlar arches alongside reservoir 6 (Figure 5).
15. The order in which the cisterns were opened is not known.
16. The measurements were taken daily between 14 January and 9 October 2021 (Figure 12).
17. DES2 – Deir Sam'an reservoir 2, and so on.
18. A standard winter in Israel is from December to March.
19. For comparison, in the winter of 2021–2022, 690 mm of rain fell in the area and the reservoirs reached a depth of 3 m (this is not included in the measurement graph).
20. Due to the relatively rainy winter of 2022, the water depth in the pools reached about 3 m.
21. An overflow canal (T4 in Figure 2) leads from reservoir 4 to the western fields of Deir Sama'an. It is probable that when the reservoirs reached full capacity, the canal drained the excess water out to the agricultural fields.
22. According to Tsuk (2011, 28), a family of six as well as two camels, a donkey, ten sheep/goats and two dogs would total a consumption need of 18 cubic meters of water per year or three cubic meters per person including livestock.
23. The excess of water storage at Deir Sam'an, as seen by the present paper, characterizes all the monasteries in the area. This is part of an ongoing survey conducted by the authors.
24. For more about the influence of ancient cultures on their environment in the Byzantine period, see Pîrnău et al. (2022).
25. This was suggested by Magen during a tour of the site.
26. From conversations with farmers who have traditional plots without irrigation systems in the area, the author (YE) was told that during the first two years of an olive tree or grapevine they are irrigated sparingly in the summer months (two or three times a season) so that they develop roots and learn to manage on their own. Irrigation is done manually (in the past with beasts of burden, today with tractors and water tankers). The planting is carried out during the rainy season, around the end of February or the beginning of March.
27. Winepresses were established far from settlements due to the sensitivity of the fruit. After harvest, the grape begins to ferment, and transporting it may crush the fruit. The solution was to quarry winepresses near the fields and squeeze the grapes there. The must was then taken elsewhere for further processing and storage (Eitam 1980, 70; Dar 1982, 230–268; 2019).
28. 'From where would they bring the wine? Kerutim and Attulin are the primary [sources] for wine. Secondary to them, Beit Rima and Beit Lavan in the mountains, and the village of Signa in the valley. All the regions were valid [sources for wine]; but it was from here that they would bring the wine' (Tractate Menachot 8, 6). Kerutim, Attulin, Beit Rima and Beit Lavan are identified with present day sites and have preserved their names in Western Samaria, in close proximity to the sites described in this study.
29. Dar (1982, 2019) claims that the abandonment of the site was a result of the Muslim ban on drinking alcohol. The cultivation of grapes in the area was stopped, cutting off the most important source of income of the site. His suggestion strengthens our claim regarding the centrality of the vineyard to the economy of the region.

Acknowledgments

Thank you to Naomi Hadad for help in drafting this paper and preparing it for publication.

Disclosure Statement

No potential conflict of interest was reported by the author(s).

Funding

This research was funded by Ariel University.

Notes on contributors

Yair Elmakayes is a PhD student in the Department of Archeology at the Ariel University Center of Samaria. Within this framework, he conducted a comprehensive study about water storage at key sites in Samaria in general and in Western Samaria in particular, including a thorough field survey mapping the water reservoirs in Western Samaria.

Professor David Ben Shlomo is a professor at the Department of Land of Israel Studies and Archeology at Ariel

University with a specialty in Bronze and Iron Age archaeology and petrography. He is currently the director of the ongoing excavations at the biblical city of ʿAuja el Foqa.

Dr. Yaakov Anker is an environmental research coordinator at the Samaria and Jordan Valley R&D Center and the Department of Chemical Engineering at Ariel University Center of Samaria.

Professor Amos Frumkin is a professor emeritus at the Institute of Earth Sciences at The Hebrew University of Jerusalem, and the head of Israel Cave Research Center. Among his research fields are ancient water systems, hydrogeology and geoarchaeology of Israel.

References

Maps
Sheet 8-I
Issue 14

Avalon, E., R. Frankel, and A. Kloner. 2012. "Wine Production in Eretz Israel in Antiquity: Advancement in Research or a Completely New Approach?" *Qatedrah le-Tôldôt Eres Yísra'el we-Yîššûbah* 145.

Ben-Uleil, E. 2022. "Hydrological Application of Archeological Water Management Systems," Master's Thesis, Ariel University (Hebrew).

Braemer, F., D. Genequand, C. Maridat, P. Blanc, J. Dentzer, D. Gazagne, and P. Wech. 2009. "Long-term Management of Water in the Central Levant: The Hawran Case (Syria)." *World Archaeology* 41 (1): 36–57. doi:10.1080/00438240802666424.

Broshi, M., and I. Finkelstein. 1990. "The Population of Palestine in 734 BCE." *Cathedra: For the History of Eretz Israel and Its Yishuv* 58: 3–24 (Hebrew).

Conder, C.R. and H.H. Kitchener. 1878. *Palestine Exploration Fund Map, Sheet XIV*. 1:63,360, London.

Conder, C. R., and H. H. Kitchener. 1882. "The Survey of Western Palestine, Memoirs of the Topography, Orography, Hydrography and Archaeology." Samaria, Vol. II, London.

Dar, S. 1982. *The Settlement Pattern of Western Samaria*. Tel Aviv (Hebrew).

Dar, S. 2002. "Samaritan Rebellions in the Byzantine Period – The Archaeological Evidence." In *The Samaritans, Jerusalem*, edited by E. Stern, and H. Eshel, 444–454 (Hebrew).

Dar, S. 2019. "The Rural Economy of Samaria in Ancient Times." *Judea and Samaria Research Studies* 28 (1): 5–44 (Hebrew).

Di Segni, L. 2012. "Greek Inscription from Deir Qal'a." In Christians and Christianity, Jerusalem, Vol. 3, edited by N. Carmin, 157–160.

Eitam, D. 1980. "Oil and Wine Production in Mount Ephraim During the Iron Age." Master's thesis, Tel Aviv University.

Elitzur, Y., and C. Ben David. 2007. "Deir in Hebrew, Aramaic, and Arabic and Toponyms of the "Deir-X" Type." *Cathedra: For the History of Eretz Israel and Its Yishuv* 123: 13–38. http://www.jstor.org/stable/23407580.

Finkelstein, I., Z. Lederman, and S. Bunimovitz. 1997. "A Highland of Many Culture." *The Southern Samaria Survey, the Sites*, Tel Aviv.

Frumkin, A. 2002. "The Hydrogeology of Israel and the Problem of Water Supply in Antiquity." *JAR* 46: 21–24.

Fuks, D., O. Ackermann, A. Ayalon, M. Bar-Matthews, G. Bar-Oz, Y. Levi, A. M. Maeir, E. Weiss, T. Zilberman, and Z. Safrai. 2017. "Dust Clouds, Climate Change and Coins: Consiliences of Palaeoclimate and Economy in the Late Antique Southern Levant." *Levant* 49 (2): 205–223. doi:10.1080/00758914.2017.1379181.

Guérin, V. 1874. *Description Géographique Historique et Archéologique de la Palestine, Part 2: Samarie, Vol. 2.* Paris: Impr. impériale (French).

Haddad, E., and E. Zwiebel. 2021. "Khirbat Amagar - Archaeological Evidence of Retaliatory Action by the Byzantine Government Following the Samaritan Rebellions." *Judea and Samaria Research Studies* 30 (2): 153–188 (Hebrew). doi:10.26351/JSRS/30-2/1.

Herzog, C., and M. Gichon. 1997. *Battles of the Bible.* London: Greenhill Books.

Hirschfeld, Y. 2002. *The Desert of the Holy City - The Judean Desert Monasteries in the Byzantine Period.* Jerusalem: Yad Ben Tzvi (Hebrew).

Hirschfeld, Y. 2003. "Deir Qalʿa and the Monasteries of Western Samaria." In *Studies in the History of Eretz Israel, Presented to Yehuda Ben Porat. Jerusalem*, edited by Y. Ben-Arieh, and E. Reiner, 452–493. Jerusalem: Yad Ben Zvi (Hebrew).

Itzchaki, Arieh. 1980. *Israel Guide - A Useful Encyclopedia for the Knowledge of the Country*. Tel Aviv: Keter Publishing House. In affiliation with the Israel Ministry of Defense (Hebrew).

Kochavi, Moshe. 1972. *Judea, Samaria and the Golan: Archaeological Survey 1967-1968*. Jerusalem: Carta (Hebrew).

Kohn-Tavor, A., O. Lavenda, M. Rotschild, E. Zichlinski, and D. Ben-Shlomo. 2021. "Educational Archaeological Excavations at the Barkan Wine Presses Site." *Judea and Samaria Research Studies* 30 (1): 91–125 (Hebrew). doi:10.26351/JSRS/30-1/4.

Liphschitz, N., and G. Biger. 1998. *Trees of Eretz Israel: Characteristics, History and Uses*, 139–147. Jerusalem: Ariel (Hebrew).

Magen, Y. 2002a. "The Areas of Samaritan Settlement During the Roman-Byzantine Period." In *The Samaritans, Jerusalem*, edited by E. Stern, and H. Eshel, 245–271. Jerusalem.

Magen, Y. 2002b. "The Samaritans During the Roman-Byzantine Period." In *The Samaritans, Jerusalem*, edited by E. Stern, and H. Eshel, 213–244. Jerusalem (Hebrew).

Magen, Y. 2012. "A Roman Fortress and Byzantine Monastery at Khirbet Deir Sam'an," *Churches and Monasteries in Samaria and Northern Judea,* 9–106.

Magen, Y., and N. Aizik. 2012. "A Late Roman Fortress and a Byzantine Monastery at Deir Qal'a." In *Christians and Christianity, Jerusalem, 3*, edited by N. Carmin, 107–156. Jerusalem.

Mantellini, S. 2015. "The Implications of Water Storage for Human Settlement in Mediterranean Waterless Islands: The Example of Pantelleria." *Environmental Archaeology* 20 (4): 406–424. doi:10.1179/1749631415Y.0000000005.

Netzer, Y., C. Yao, M. Shenker, B. A. Bravdo, and A. Schwartz. 2009. "Water use and the Development of Seasonal Crop Coefficients for Superior Seedless Grapevines Trained to an Open-Gable Trellis System." *Irrigation Science* 27 (2): 109–120. doi:10.1007/s00271-008-0124-1.

Pîrnău, R. G., S. M. Stanc, B. Roşca, L. Bejenaru, and M. Danu. 2022. "A Multidisciplinary Approach to Human–Environmental Interactions at the Roman-Byzantine

Ibida Fortress (Dobrogea, South-Eastern Romania)." *Environmental Archaeology*, 1–15. doi:10.1080/14614103.2022.2058685.

Porat, Y. 1968. *Inventory of Archaeological Sites in Samaria Survey II*. Unpublished (Hebrew).

Raviv, D. 2013. "Magnificent Tombs from the Second Temple Period in Western Samaria - New Insights." In the *Highland's Depth - Ephraim Range and Binyamin Research Studies*, Vol. 3, 109–142. Ariel-Talmon (Hebrew).

Schick, R. 1995. *Christian Communities of Palestine from Byzantine to Islamic Rule*, 20. Princeton: Darwin Press.

Shahar, Y. 2000. "Har Hamelekh — A New Solution to an Old Puzzle." *Zion* 65: 275–306 (Hebrew).

Stavi, I., M. Chocron, S. Filin, R. Arav, O. Ackermann, and B. Zissu. 2018. "Intentional, Dual Purpose of Ancient Wine Presses as Cisterns for Runoff Water Harvesting in Drylands." *The Holocene* 28 (7): 1107–1112. doi:10.1177/0959683618761550.

Tepper, Y. 1986. "The Sundial at Deir Sam'an." In *Samaria Studies*, edited by S. Dar, and Z. Safrai, 217–207. Ariel.

Tsafrir, Y. 1998. *Eretz Israel from the Destruction of the Second Temple to the Muslim Conquest*. Jerusalem: Yad Ben Tzvi (Hebrew).

Tsuk, T. 2011. *Water at the End of the Tunnel*. Jerusalem: Yad Ben Tzvi (Hebrew).

Tzaferis, V. 1996. *Monks and Monasteries in the Land of Israel in the Byzantine Period*, 9–32. Jerusalem: Ariel (Hebrew)

White, K. D., C. U. Press, and H. H. Scullard. 1970. *Roman Farming*, 428. London: Cornell University.

Wilkinson, T. J., and L. Rayne. 2010. "Hydraulic Landscapes and Imperial Power in the Near East." *Water History* 2 (2): 115–144. doi:10.1007/s12685-010-0024-1.