DEsertification and ancient Desert farming systems

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Summary

The Negev, in the south of Israel, is an arid area where the natural conditions do not allow for subsistence agriculture. Nevertheless, numerous remnants of well preserved ancient agricultural systems are scattered over thousands of sq. km in the region. These form a tremendous network of terraced wadis and a special system of runoff water harvested from slopes and wadi floods. This type of desert agriculture has been the subject of several studies in the past, with a special focus on the functioning of the system and its dating in the Nabatean period (2\textsuperscript{nd} century B.C. – 2\textsuperscript{nd} Century A.D.).

According to recent studies, these agricultural settlements reflect two waves of occupation. A first one might be dated in the Byzantine period (4-7\textsuperscript{th} centuries A.D.), while the second should correspond to the Early Islamic period (7-8\textsuperscript{th} centuries A.D.). The establishment of these large-scale desert settlements can be attributed to the policy of the Byzantine and the Umayyad empires, which encouraged agricultural settlements in the frontier regions as a barrier against nomadic invasions.

1. Introduction

The Negev is a desert in the southern part of Israel (Figure 1) covering an approximate area of 10,000 sq. km. It is part of a continuous desert region extending from the Sinai Peninsula in western Egypt (60,000 sq. km) to the south Jordan desert. The average annual rainfall is less than 100 mm, and this does not permit any crop production. There are very few natural water sources and agricultural land is restricted to the borders of the wadi banks. The potential for herding is minimal and allows only for small herds, which are not sufficient to make a living off.
Figure 1. Location map of the Negev, with the situation of sites mentioned in the text. (Line A-A marks the limit of the Byzantine settlement; line B-B marks the expansion of the agricultural settlement in the Umayyad period)
The Bedouins, the nomadic population of that desert, engage in goat husbandry and in poor seasonal agriculture in the wadi beds. This type of farming is totally dependent on the unpredictable floods in the wadis, but it is only of secondary importance in the Bedouin economy which depends primarily on close relations with sedentary population for its food supply. The areas where this is best achieved, and which allow for some limited and meager subsistence, are located either north of Beer Sheva or in a narrow strip along the sea shore of the northern Sinai. These areas constitute also a natural boundary between the desert and the agricultural areas; their average annual rainfall is 200 mm, and this permits to harvest a crop yield once in every second or third year.

Despite these adverse natural conditions, there exists an array of ancient agricultural systems scattered over the desert. Due to the excellent state of preservation - a characteristic of many desert areas - the ancient systems constitute a dominant feature in the present-day landscape. The main elements in that system refer to an extensive network of thousands km of terraced wadis, numerous farmhouses and various agricultural structures. These terraced wadis change totally the limited agricultural potential of the area, and provide large surfaces of man-made fields, created by the accumulation of alluvial and colluvial soil material retained behind terrace walls in the valley.

The ancient systems cover extensive surfaces, estimated at approximately 3,000 sq. km. in the Negev Highlands, 2,000 sq. km. in the northern Negev around Beer Sheva, and 2,000 sq. km. in the north-eastern part of the Sinai Peninsula, south of El-Arish; their extension in southern Jordan is still unknown.

2. History of Research

The existence of ancient agriculture systems in the desert has attracted considerable attention since the beginning of modern archaeological research. Palmer (1870) and Woolley and Lawrence (1915) were among the first to conduct field surveys and describe the systems. In this period, Huntington (1911) attributed the existence of agriculture systems in the desert to climatic changes.

In the 1930s, excavations at Tel Nitzana, an ancient city in the Negev (Figure 1), led to the discovery of papyri documenting daily life scenes and the ancient agriculture systems in the Negev in the 5th to 7th centuries A.D. The papyri provided clear evidence that the residents of the area engaged in farming and in the cultivation of vineyards. They paid taxes as well, being an indication of an economy beyond subsistence level.

In the 1950s and early 1960s, Glueck surveyed the Negev on a much larger scale. Though his research did not focus specifically on agriculture systems, he mentioned their extensive distribution and the intensity of the findings. Glueck’s work in the Negev had a long-term impact by relating the agricultural systems to the Nabatean period (2nd century B.C. - 2nd century A.D.), with continued existence in the Roman and Byzantine periods, up to the 7th century A.D. Glueck (1959) attributed the existence of ancient farming systems in the Negev to the ability of the Nabateans to adapt successfully to the harsh environment.
A scientific breakthrough in the study of ancient agriculture systems took place in the mid-1950s, when a research team headed by Evenari set up a research station near Avdat (Figure 1). Evenari and co-workers focused on the relevance of runoff rainwater management in explaining the mechanism of the ancient agricultural structures, such as: terraced wadis, conduct for collecting runoff rain water, and the enigmatic phenomenon of Tuleilat el-Anab (see below). Evenari et al. (1971) showed that the runoff collection systems concentrated rain water from an area that was five times larger than the area actually drained. Thus, the average of 80 mm. annual rainfall, which is not sufficient for agriculture, expands to 400 mm, creating conditions like those of common farmland.

Evenari disregarded however the large number of well-preserved farmhouses, built near agriculture systems, and a key element to the chronological aspect. His dating of the systems was in accordance with the general trend to attribute them to the Nabateans. Among the contributions of Evenari’s work are his active attempts to grow trees and plants in a reconstructed farm near Avdat, as well as his suggestions about applying ancient methods for contemporary use. The conditions at that time, unfortunately, did not allow Evenari to put his suggestions into practice.

The research mentioned above initiated many other studies. In 1957 Kedar focused on the soil management aspects of the ancient agriculture systems, and he believed that they were intended to increase the accumulation of loess in wadis and create an infrastructure for agricultural activity. In a study conducted at the same time in the area of Nitzana, that investigated the archaeological aspect of the ancient agricultural remains, the systems were dated to the Byzantine period, later than the common dating to the Nabatean period (Mayerson, 1994).

As of the 1960s and 1970s, research on the environmental aspects of the ancient agriculture was accompanied by comprehensive archaeological-historical research, focusing on the ancient towns of Aydat, Shivta, Halutza and Rehovot in the Negev. These studies examined the role of the Nabateans and their descendents in settling the Negev from the second century B.C. to the seventh century A.D., with emphasis on the aspect of material culture, architecture, and analysis of historical sources (Negev 1986; Tsafrir 1986).

Some of the later studies emphasized also on geopolitical aspects, and attributed the establishment of agricultural systems to the policy of the Byzantine Empire to stabilize the frontier and the periphery by encouraging agricultural settlement. State-sponsored peripheral settlements would explain the establishment of such large-scale systems, i.e. state subsidies made it possible for these systems to exist during the frequent drought years characterizing this harsh type of environment.

In the mid-1960s, teams of the Archaeological Survey of Israel began working in the Negev. The survey aimed to systematically document remains, and represents progress in the mapping of ancient agriculture systems, and in the analysis and dating of the remains of structures located in the vicinity of agriculture systems. In this respect the absence of Nabatean findings linked to ancient agriculture systems is particularly noteworthy.
Significant progress in the documentation of agriculture systems, including archaeological excavations, was made in the frame of the Negev Emergency Survey, conducted from 1979 to 1990. Ten teams worked on the project, and systematically surveyed about 5,000 sq. km of the area. About 12,000 archaeological sites were documented (Haiman 1995). The survey results revealed no link between ancient Negev agriculture and the Nabateans.

In the light of the findings of the Negev Emergency Survey, which include documentation of many hundreds of farm houses and excavations in some of those houses, it appears that the agricultural systems should be dated to the 5th-8th centuries A.D., up to the end of the Umayyad period (ca. 750 A.D.). These structures should be viewed as peripheral Mediterranean agricultural settlements during the Byzantine Empire (Haiman 1995), of the type that was known in North Africa as early as the Roman period (Barker 1996).

From the 1970s onwards, further progress was made in studies on the environmental aspect of ancient agriculture systems, as researchers examined the flow of runoff rain water and conducted geomorphological tests of agricultural terraces. One of the important conclusions reached in these studies, is that the systems were intended to function with a rain load that is similar to that of today. Another study, by contrast, dealt with fluctuations of reservoirs in Israel during the ancient period. According to that study, the climate during classic periods was more humid, and allowed for the existence of ancient agriculture in the Negev (Bruins 1985).

Surveys and excavations carried out over the past three years, under the auspices of the Israel Antiquities Authority, indicate that the sedentary land in the north of the Negev Highlands, e.g. the Beer Sheva Valley, contains abundant remains of ancient agriculture systems of the type found in the Negev Highlands. These discoveries, which are only at the early stages of the study, have a decisive impact on some conclusions of previous studies.

3. The Agricultural Systems

Surveys and excavations conducted in the above mentioned agricultural remains shows two waves of settlements: the first in the Byzantine period (4-7th centuries A.D.) and the second in the Early Islamic period (7-8th centuries A.D.).

3.1. The Byzantine Period

The remains of agricultural settlements in the south of Israel, dated to that period, spans an area of approximately 5,000 sq. km in the Northern Negev and the Negev Lowland, about 50 km south to Beer Sheva. The settlement included also six towns in the southern distribution area: Halutza, Shivta, Nitzana, Rehovot, Avdat and Mamshit, which used to be important caravan stations and military camps in earlier periods, occupied by the Nabataeans and the Roman army. The towns in the northern distribution area included Beer Sheva, Malhata, Maon and many others. The area between the towns is scattered with agricultural remains of the type described below.
3.1.1. Farmhouses

The farmhouses of the Byzantine period are high quality of constructions. Two main types were found. One type, the most prevalent, is a square one-room building, measuring 4-5 m by 4-5 m and build of large hewn stones. It prevails in the areas in the neighborhood of the towns and could not have been a family residential dwelling. The square structure probably served as a watchtower in agricultural fields belonging to residents of the towns. The second type is a more complex farmhouse and may be indicative of an actual residence in the peripheral areas. It includes several rooms each measuring 3-4 m to 3-6 m., and resembles the dwelling structures in the cities.

Both types are built of large hewn stones and included ornamented and carved architectonic elements such as lintels, door jambs capitals and pillars. Many of the farmhouses of both types contained arches and flat slabs indicative of stone roofs. These types of structures are prevalent in the close periphery of the Negev cities such as Shivta, Avdat, Nitzana and Beer Sheva.

Figure 2. Byzantine one-room farmhouse near Shivta
(Photo P. Fabian courtesy of Israel Antiquities Authority).

3.1.2. Terraced Wadis

A tremendous network of terraced wadis over several thousands of km long can be attributed to the Byzantine period. The agricultural terraces are in fact artificial fields totally depending on the unstable rainfall regime. The system intended to harvest every drop of rain - runoff from the slopes or floods from the wadis - and functioned efficiently as proven in many studies. However, one must bear in mind that the drought frequency in the area amounts to 2-3 years out of 4 in which the field could not yield any crops.

Two types of wadi terracing are found. One type, in tributary wadis, consists of terraces built across the wadi. The dimensions of the stonework is remarkable; the width of the
terraces extends sometimes to 5 m; the dept is approximately 3 m and the length extends over several dozens of m, reflecting the intention to resist strong floods. Long water conducts directed the runoff water from the slopes in addition to the flood stream in the wadi channel. The second type, observed in the main wadis, is even more gigantically constructed since the walls were supposed to resist substantial volumes of strong flood waters, and thus had to be significantly stronger than in the tributary wadis.

Figure 3. Terraced Wadi south to Avdat (Photo M. Haiman, courtesy of Israel Antiquities Authority).

The agricultural fields, marked by huge stone frames, were built on the banks of the main wadis, slightly above the streambed. Strong dams were built across the wadi in order to elevate the height of the flood and to divert the stream to the fields. Both types of terracing prevail mainly around the towns of Avdat, Shivta and Nitzana.

3.1.3. Tuleilat el Anab

These correspond to large areas (sometimes several sq. km) covered with small stone heaps (1 m. diameter and 0.5 m high), called by the Bedouins Tuleilat el Anab which means vine heaps. Their function has been a subject to several studies and is still a matter of debate. Some experts believe they are a result of digging holes where vines were planted. Others pretend they are a result of exposing the stony slopes in order to improve the runoff flow from the hill slopes to the terraced wadis below.
3.1.4. Water Cisterns

Hundreds of cisterns were found near towns and farms. The typical cistern is a big rock cut, shaped in a square format and measuring 3-5 m by 4-10 m, and up to 4 m deep. The roofs, supported by square pillars, are about 2 m thick. Runoff conduits (up to hundreds meters long) channeled the rainwater from the slopes to the cistern. Most of the farms contained several cisterns, reflecting the collection of a water volume much above the usual consumption, and probably used as a reserve for drought years. In several places, as for example near Avdat, dozens of water cisterns were found concentrated in a relatively small area. In Nitzana, where wells were dug next to the city, no cisterns were found.

3.1.5. Industrial Wine Presses

Several big wine presses were found in the Negev towns of Avdat, Shivta and Halutza, and those are indicative of the importance of that economic activity, not only in the frontier settlements but in the entire area. The latter refers also to Gaza that gained a reputation of export quality to Europe and the Mediterranean, mentioned in ancient literary sources (Mayerson, 1994). The existence of winepresses of substantial proportions in the Negev towns supports the possibility that agricultural settlements in the desert were engaged in a large scale wine production.

One of those extraordinary winepresses was discovered near Halutza. It measured 29 m by 29 m., and the walls were built of finely carved stones, while the treading floor was
paved with slabs; a drainpipe led to two vats, 2 m in diameter each. Similar huge and fine quality winepresses were uncovered at Avdat and Shivta. The capacity of the treading floors (ca. 20 m$^3$) and the volumes of the vats (up 9,000 liter) indicate a prosperous wine production.

Figure 5. Industrial winepress at Avdat, ca. 20 m x 20 m in size (Photo M. Haiman, courtesy of Israel Nature and Parks Authority).

3.2. The Early Islamic Period

The settlement process identified in the Early Islamic period is an extension of agricultural settlements to non-populated areas; this includes in particular the south which was the domain of the nomads. A new type of farmhouse appears, different from those of the Byzantine period. This new farmhouse not only extends in new areas but also in the areas previously occupied by the Byzantine farmhouses. The new settlement was accompanied by extensive terracing of wadis to allow large scale agriculture.

3.2.1. Farmhouses

The farmhouses were built in a distinctive architectonic style, with walls that were constructed of two rows of small roughly hewn stones. The width of the wall was about 0.70 m and the roofs were constructed with light materials; no arches intended to support stone roofs were identified in the Early Islamic farms in the Negev. The significant difference from the Byzantine farmhouse is the size. The Early Islamic farmhouse is much larger and consists of several rooms and courts, which reflect actual dwellings, unlike the Byzantine one-room farmhouses which were only watchtowers.

Early Islamic farmhouses are combinations of “nucleus units” which are square buildings measuring 100 to 150 sq. m., and they consist of one to three rooms and a small courtyard, reflecting a family dwelling unit. In some cases the farmhouses consist of only one nucleus unit; in other cases they contained two to six nucleus units built as a
single block or as separate, adjacent structures.

Figure 6. Early Islamic complex farmhouse, 30 km south of Nitzana (Photo M. Haiman, courtesy of Israel Antiquities Authority).

3.2.2. Terraced Wadis

As in the Byzantine period, the network of terraced wadis constitutes the basic frame for agriculture. However, the construction quality in this period is less than in the previous period; it consists of terraces in small wadis, based on rain water harvesting only. The sophisticated systems aimed to channel the floods into large wadis probably continued to exist, but no new systems of that type were identified. The terraces in the Early Islamic farms were built across the wadi channels; some were constructed in a very solid way and reached a height up to 2 m and a width of 1 m. It is noteworthy to remind that, as in the previous period, the terraces span thousands km. of wadi channels.

3.2.3. Stone Walls

Hundreds of stone walls, of various lengths, and demarcating sections of the terraced wadis were found. The walls were 1 m wide and 0.5 m high, and were built on both sides of the wadi. Most walls delineate 1-4 dunam of farmland in the terraced wadis (1 ha = 10 dunam). The walls, as in the Byzantine period, may play a role in regulating the water flowing into the wadi from the slopes.

3.2.4. Cisterns

Hundred of cisterns were found near the farms. Most of them are a simple rock cut
cistern, 1-3 m in diameter and up to 5 m deep. Only few cisterns possess a roof supporting pillar of the type found in the Byzantine farms. The volume of the cisterns found in any of the farms could contain much more than the minimal consumption of approximately 20 m$^3$ per annum for a family. It was found, mainly in the Early Islamic period, that the distribution of the cisterns reveals a virtual absence of cisterns in farms located up to 4 km from a natural water source; their number increases as the distance from the water source grows.

3.2.5. Threshing Floors

Numerous threshing floors were found on shallow slopes and low hilltops near terraced wadis. The threshing floors consist of a round stone circle (8-20 m in diameter) surrounding a beaten earth floor. The extensive distribution of the threshing floors reflects the importance of cereal cultivation in the farms.

![Figure 7. Bedouins threshing barley in an Early Islamic threshing floor (Photo M. Haiman, courtesy of Israel Antiquities Authority).](image)

3.2.6. Silos

It is assumed that specific areas in the farmhouses were designated for the storage of seeds. In many excavated farmhouses, as well as in many other well preserved structures, rooms without openings were found. The entrance to those rooms may have been through a small opening at a higher part of the walls.

3.2.7. Wine Presses

Very few small wine presses were found, reflecting the decline of that flourishing
economic activity of the Byzantine period. The few wine presses found in the Early Islamic farms measured 1-2 m by 2-3 m. They consisted of a wall surrounding a smoothed rock. The inner side of the walls was coated with a thick layer of white plaster.

3.2.8. Watch-posts

These were structures found on the higher parts of the slope. They overlook the terraced wadi and the farmhouse and may therefore have been used to guard the cropped area during the harvest period. The watch-posts characterizing the Early Islamic farms have a one-room oval shape structure, and measure 1-2 m by 3-5 m.

3.2.9. Tuleilat el Anab

Only one field of this structure, most prevalent in the Byzantine period (see above), was identified in the distribution area of the Early Islamic farms in the Negev Highlands. If that still enigmatic structure would have been used as a vinery, its absence reflects the disappearance of the big winepresses and the decline of the wine industry in general.

3.2.10. Cult Installations - Matzevot and Open Mosques

Rows of flat stones (up to 0.80 m high), fastened upright (Matzevot), prevailed in the desert during earlier periods; they were found in some of the farms, as well as in nomad settlements south to the agricultural areas. The same is with open mosques, indicative of the introduction of Islam; these were found both in farms and in nomad’s sites. At one occasion, in a site related to nomads in south Jordan, Matzevot were installed in a mosque; one of the stones contained an inscription mentioning the date the mosque was built.

4. Conclusions

It appears from recent investigations that during the Byzantine period, the town and the agricultural periphery constituted an organic unit, as is evidenced by the frequency of the one-room farmhouses, and by the location of industrial winepresses and public buildings, like churches, in the towns only.

In the areas south to the agricultural settlements, many poorly built round structures, being temporary nomad dwellings, were found. Most of the sites contained large enclosures, evidence of animal husbandry. Most of the enclosures measure 40-80 m² reflecting small herds of 20-40 heads of small animals, probably goats. Many of those nomad dwelling sites correspond to primitive agricultural terraces built on wadi banks, which are inferior to the complexity of the agricultural settlement described above; they reflect a seasonal exploitation of the poor environment. The temporary sites of the Byzantine period constitute a kind of strip attached to the southern periphery of the agricultural settlement, extending up to 70 km to the south.

The picture is different in the Early Islamic period. The uniform shapes of the farmhouses, as well as the considerable efforts required to build a network of terraced
wadis, suggest that this phase of settlement intended to settle the nomads. In the Negev, it is possible to identify a strip of Early Islamic farms, up to 30 km south to the former Byzantine settlement. South to this zone there is a substantial increase in the number of the nomad sites, as well as in the distribution area which includes the entire southern areas of the Negev. In this period new farm were also established in some of the oasis of the Aravah valley as argued by Evenari and co-workers (1971).

Unlike the close contact between the town and the periphery in the Byzantine period, the distribution of the farms in the Early Islamic period, their size, as well as the existence of a large variety of buildings, including open mosques in many farms, indicates an independent periphery. The growth of the periphery on the account of the towns, some of which suffered a decline, raise the possibility that the periphery received direct support from a higher level authority than the local city, e.g. a support that allowed further expansion of the settlement beyond the periphery of the Byzantine period.

Unlike the differences between the material culture of the nomads and the settlers in the Byzantine period, the findings in the Early Islamic period confirm the link between the residents of the farms and the nomads, indicative of a possible ethnic identity. It seems that the initial objectives of the foundation of agricultural farms were related to the settlement of a part of the nomadic population, while other sectors of that same population were allowed to maintain their nomadic life style.

The question arises as to what extent the agricultural settlement, as a state enterprise, was cost effective for the population. Taking into account the frequent droughts, the economic aspect alone cannot be the only reason for such a huge settlement program. It seems that the establishment of an agricultural barrier along the frontier might be considered in the light of the security interest of the state. This points to the existence of a “frontier policy” to stabilize the borders by settling the nomads. This settlement, initiated by the Byzantine Empire and maintained by the Umayyad Empire could only have existed as long as it was in the state’s interest to support it during drought years.

The rise of the Abbasid dynasty in the mid 8th century A.D. and the transfer of the capital from Damascus to Baghdad, marked a change in the priority of the state to support the frontier. Large agricultural areas, including the desert frontier of the south Levant, were abandoned.

Glossary

**Ancient Negev Towns:** Six well preserved ancient sites in the Negev Desert in the south of Israel: Mamshit, Halutza, Nitzana, Rehovot, Shivta and Avdat. The towns were subject of many studies concerning their dating and the circumstances that allowed urbanization in the desert.

**Farm:** A small settlement unit consisting of a farmhouse, agricultural land and agricultural installations. The farms constitute the dominant settlement element in the desert frontier areas.

**Nabatean period:** 2nd century B.C. – 2nd century A.D.; the general frame of a
kingdom that dominated the South Levant desert, characterized by special material culture.

**Byzantine Period:** 4th-7th centuries A.D.; the general chronological frame of Byzantine Empire rule in the Levant, characterized mainly by the Christianization of the population and settlement initiatives.

**Umayyad Period:** 7th-8th centuries A.D.; an Islamic Empire that followed the Byzantine Empire in the Levant. This was the first stage of the Early Islamic Period (7th-10th centuries A.D.) and marked the beginning of the Levant Islamization.

**Wadi:**
Arabic word meaning dry river, adopted as a professional term in other languages.

**Terraced Wadi:**
Stone dams built across the wadi to trap agricultural soil. It is still a question whether the terraces intent to accumulate the soil or to stabilize existing soil.

**Runoff water:**
The portion of precipitation (or irrigation) discharged from a sloping area, often resulting in strong temporary floods.

**Threshing floor:**
A floor used for separating the seeds from the stem of cereals.

**Matzevot:**
Biblical term for cult installation consisting of upright stones. Appears in all ancient periods.

**Open mosque:**
An archaeological feature found in many Early Islamic sites in the Levant deserts. The mosques are designed by one or two courses of stones only and were not built at full height, as ordinary mosques.

**Bibliography**


survey of the Nabatean history, culture, social structure, and material culture, based on 30 years of research].


Biographical Sketches

Moti (Mordechai) Haiman is a research archaeologist in the Israel Antiquities Authority and teaches at the Department of Land of Israel Studies at Bar Ilan University. He holds a Ph. D. in Archaeology (1992). His expertise is archaeological surveys and multi-disciplinary studies on ancient settlements in the deserts. He participated in projects as head of a survey team in the Negev Emergency Survey (1980-1990), and as head of the survey section in the Israel Antiquities Authority. His current research involves the participation in a multidisciplinary study (archaeology, geomorphology, micromorphology and botany) of ancient desert farming in the Negev desert with a focus on environmental protection.

Peter Fabian is a research archaeologist in the Israel Antiquities Authority and teaches at Ben-Gurion University. He is Ph. D. candidate at Ben Gurion University. His main expertise is on Roman and Byzantine archaeology, and in this context he conducted excavation work in various sites in South Israel, such as Beer Sheva and Avdat.