People have always been clever enough to manage in difficult conditions. They have discovered reasonable methods for utilizing their environments. History of cultivation practices offers many illustrative examples of this. In this paper, will be discussed the methods of researching dry cultivation. The empiric material illustrates how water installations can be used for promoting the growth of crops and fruits in semi-arid environment. The example is an environment on the W side of the ancient city of Petra in southern Jordan, on the edge of Wadi Araba. Today only some trees and small flock of sheep remind us of the fact that this environment has once been fertile for agriculture (Fig. 1).

Figure 1. The contemporary view of the Jabal Harûn. Photo: Paula Kouki

My empiric material was collected in the archaeological survey of the area around the historical Aaron’s Mountain (=Jabal Harûn) ca 5 km from the Ancient city of Petra. In the
field seasons from 1998 to 2005 I took part in the Finnish Jabal Harûn project as the leader of the survey group. To the group belonged seven archaeologists and two land-surveyors from Helsinki University of Technology. Also geomorphology and macrofossils of the material were researched. The basic research method was the intensive survey in combination with the detailed cartographic measurement of the sites and structures. The intensive survey included field walking in tracts cross the area of ca 7 km², small test excavations, and soundings at the selected sites (Fig. 2). The structures were measured with total station and documented by stereo-photographing. One essential aim of the project was to reconstruct the computer-aided 3D-model of the dry cultivation system. Dating the phases of cultivation was essential, too.

Figure 2. The intensive survey area around the Jabal Harûn. Map: Katri Koistinen
In the last survey year in 2005, the research area was ca 20 km² and the method was more extensive. In other words, the documentation of the discovered sites was not as detailed as in the previous years. The survey in 2005 was carried out on the S and W side of the intensive survey area. The main idea was then to understand the settlement history of a larger area. In this latter case the locations of the sites were measured with GPS only and structures were shortly described and photographed. Any soundings were not made. Locations of ancient water installations were observed but details of the constructions were not measured. The purpose was to test two different strategies for comparing and developing survey methodology.

The flourishing time of Petra was the last century B.C. and the first centuries A.D. The city was the crossroads for caravans arriving from Egypt, the Persian region, the Mediterranean, and Silk Road from the Far East. In spite of the Roman conquest in 64 A.D., the wealth and prosperity continued. However, during the Byzantine period after 395 A.D. and after the Arab conquest in 635 A.D., in particular, the importance of the city began to decline.

The successful cultivation in the semi-aridic areas in the Petra region needs understanding how to utilise the small amount of rainwater. Today the number of expected rainy days in the year varies between one and four although small changes in climate have taken place during Holocene. When rain comes, the water flush is heavy. This is a problem because the topography in the region is mostly steep bedrock not keeping water in the soil. Gullies and wadis promote the flowing of water quickly away. The water technology is necessary for hindering the soil from moving and keeping the soil moist. If the water technology works successfully, the cultivation of wheat, barley, legumes and vegetables is possible in a four-year rotation (Evenari 1971, 179-189).

In the most clever way, the environment was utilised by Nabaeans, who lived in Petra region from the first century B.C. to the Byzantine period. Our hypothesis is that the genius water collecting was essential for the subsistence of the city itself. Even today a number of remains of these constructions are at least partly visible. Cisterns and open pools kept water in reservoirs. The water catching in them took place through the channels or chutes of different dimensions and lengths. Water was kept in soil and cultivation became possible because of the terrace walls and barrages.

In the cisterns, water was available for people and animals all year long. Cisterns which are used today are often the remains of Nabataean water installations. The largest of them can be over 15 m in length and 8 m in width. The constructions can be in the caves, they
can be open pools or they have been quarried in the sandstone or limestone bedrock. (Fig. 3)
Cisterns are often rebuilt by constructing the roof for hindering evaporation. Building the
cesterns was an adequate means to store drinking water even close to the summits of the
mountains. For instance, the Byzantine Monastic complex of St. Aaron, at the height of over
1250 m a.s.l. three cisterns were enough for tens of people living there permanently.

![Figure 3. A small cistern found during the 2005 survey. Photo: Paula Kouki](image)

The purpose of the water collecting was to store all drops of water. Water was also led into
temporary reservoirs by a complicated net of small channels cut in the bedrock. In some
cases, the channels and pipes were built with mortar. The remains of both are still visible
indicating how carefully the systems were constructed.

Another way to use water was necessary for ensuring the cultivation of the small
terraces in the valleys and slopes. Considerable effort was put in constructing barrages and
terrace walls which kept the eroding soil stable. The barrages were built of stones across the
wadis and tributaries (Lavento et al. 2004).
In the places, the pressure of the running water and soil was the strongest walls were necessary to strengthen by manifold stone settings. The barrage may include several and many times rebuilt walls. Sometimes the thickness of a barrage exceeds two metres. In the largest wadis, the water could be kept in pools but the abrupt excess of it water was necessary to lead further to the lower terraces. The terraces in the wadis and tributaries are descending and they form a system with the help of which the water excess was possible to control. Examples of these can be found in many regions in the Near East (Brunner 2004). The remains of the structures of these kinds were visible in the Jabal Harûn survey. (Fig. 4)

Figure 4. The barrages in Wadi as-Saddath. Photo: Paula Kouki

In the deepest wadis, the largest barrages are over 5 m in height and more than 30 m in length their thickness being even 2 m. The shortest barrages in tributaries are only 3 m in length and less than 0.5 in height. In the area of intensive survey over 500 barrages were registered and measured during the field seasons.
Another manner to keep soil and water in the lower part of the mountains and hill slopes was to build terrace walls following the orientation of the wadis. The terrace walls kept soil from moving and water in soil. The stone walls are today worn out because they have not been rebuilt actively. The longest terrace walls found are over 100 m in length their height being ca 0.5 m. Their original dimensions are difficult to estimate because most of them are in ruins. The number of terrace walls is higher than barrages.

A complicated challenge for the surveyor is that many barrages had their function as terrace walls, too. One part of single structure may have been in the function of a barrage while another part of the same construction may have been a terrace wall. This comes visible because the directions of the structures may change. In tributaries there are barrage-terraces which have served these two functions.

The water installations are usually very difficult to date. After their first building, they have been repaired several times because water has damaged their structures. Absolute dating methods like 14C or thermoluminescence methods are excluded because the sediments are eroded and mixed. For this reason neither geomorphology nor geoarchaeological research of terraces and stratigraphy do not help in dating. The dating is almost solely based on the Nabataean ceramics of the 1st and 2nd centuries A.D. (Lavento & Huotari 2002) which was found on the surface or in the test excavations. So, it is not evident that the building tradition began during the Nabataean period.

The system to collect water with cisterns and temporary reservoirs, channels and pipes was an effective way to control and save drinking water as well as carry out agriculture (see Meyerson 1962). The intensive survey together with the interdisciplinary work gives possibilities to research the water systems of the history of dry cultivation. The missing macrofossiles and complicated chronology makes the work difficult. Despite the difficulties the documentation of the barrages and terraces carried out in the Jabal Harûn area is detailed and it makes it possible to construct a hypothetical model of the water controlling system (Fig. 5). It elucidates how people may have utilised the semi-arid desert at least for two thousand years.
Figure 5. A part of the 3D-model illustrating the wadi and terrace systems.
Model: Aaro Söderlund

References


