

On-Site Water Retention Strategies: Solutions from the Past for Dealing with Jordan's Present Water Crisis

Introduction

A common sight throughout Jordan today is the water truck hauling its life-sustaining contents from pumping stations to agricultural fields and buildings throughout the country. Also hard to miss as one travels throughout the country are the water pipes which criss-cross and dissect villages and the agricultural lands which surround them.

As settlement and plow agriculture has expanded over the past half century in Jordan, so has dependence on deep-drilled wells, water pipes and trucks for obtaining water. *Herein lies a very significant and unprecedented break with the past.* Until this century, it would have been inconceivable to hope to expand settlement and plow agriculture without automatically also expanding on-site facilities for collection and storage of rainwater and surface runoff. Yet, today, this is precisely what has happened!

In light of the fact that, despite modern technology, water supply continues to be one of Jordan's most pressing problems, another look at how previous generations of Jordanian citizens coped with this problem is warranted. Thus, an opportunity has arisen for archaeologists to contribute information which may benefit today's and tomorrow's generations in their search for a solution to this problem. We can contribute information, for example, about how very intensive forms of agriculture were possible during Nabataean and Roman times in the absence of modern technology.

In this paper my goal is to build a case for incorporating archaeological inquiry into the search for solutions to deal with Jordan's current water crisis. I will support my case with four arguments:

First, that the status-quo is not sustainable over long-term.

Second, that archaeological inquiry focuses attention on indigenous time-tested solutions.

Third, that archaeological inquiry can aid in developing solutions that are sustainable over long-term.

And fourth, that yesterday's technology, when wed-

ded to today's technology, may provide a *blended technology* solution for tomorrow.

The Status Quo is not Sustainable

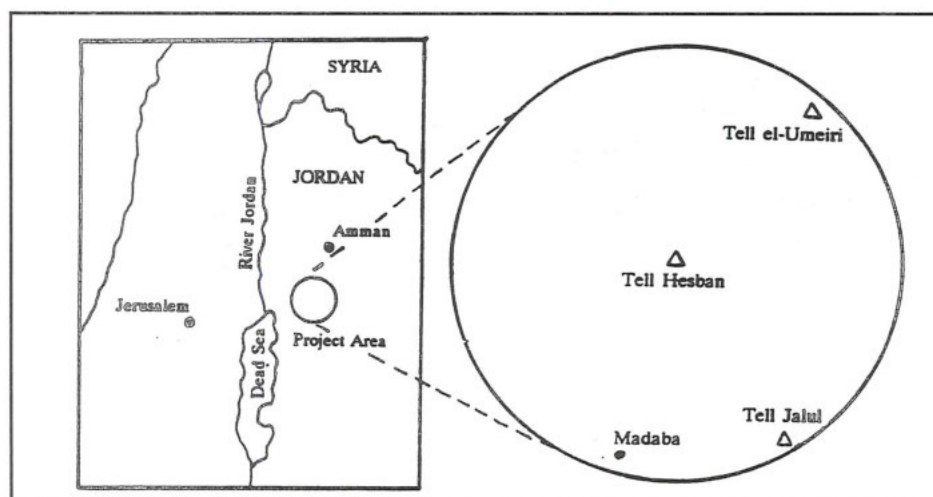
As already indicated, the status-quo in Jordan today as far as water supply is concerned involves reliance on underground sources of water accessed via deep-drilling of wells. This practice was apparently first introduced in the Qaṣr al-Ḥallābāt area circa 1962 by a woman remembered today as "Miss Coats" (Bert De Vries, personal communication). Her purpose in introducing deep well drilling was as a means to help resettle Palestinian refugees from the az-Zarqā' refugee camp.

Since its initial introduction almost three decades ago, deep drilling of groundwater wells has spread to most areas of Jordan. From pumping stations built above the more productive wells, water is transported, as mentioned above, to agricultural fields, villages and towns via water pipes and trucks. The consequences of this practice have only recently begun to be fully comprehended. Among them are the following:

First, it has allowed landuse and settlement to intensify without concomitant grass-roots development of surface water harvesting facilities. As already indicated, in past centuries, this would simply not have been possible.

Second, it has contributed to loss of interest in and widespread devaluation of time-tested indigenous methods of water collection. Thus, today, more and more houses, which do not include in their design the traditional roof catchment structures and sub-basement cisterns which were an integral part of traditional buildings, are being built.

Third, overpumping is making replenishment increasingly impossible in many underground aquifers, making their depletion more imminent. A case in point is the underground "river" which runs from Jabal ad-Drūz to al-Azraq. This aquifer is replenished by precipitation which seeps down between the cracks in the basalt overlayment to pools on the waterproof limestone below. The



1. Location of Tall Hīsbān.



2. Tall Hīsbān with modern village in foreground.

problem today is that the rate at which this aquifer is being replenished by precipitation is not keeping up with the rate at which it is being pumped (Bert De Vries, personal communication).

Fourth, in terms of energy efficiency, reliance on fossil-fuel powered pumps and trucks is much less efficient. There is more loss of water due to evaporation and unmanaged runoff, and water has to be transported much longer distances than was the case with traditional methods.

Fifth, because of the larger quantity of dissolved solids in groundwater, the increasing salinity of soils irrigated with such water is becoming a serious problem.

For these reasons, the status quo is not sustainable over the long-term. What then, can archaeology contribute to the search for new solutions to the present water crisis?

Archaeology Focuses Attention on Time-Tested Indigenous Solutions

A central tenant of twentieth century Western culture has been the belief that "modernity" is the infallible standard against which all other practices, whether past or contemporary, may safely be compared and judged. It has been assumed, for example, that if a technology em-

bodies the most recent techniques, methods and ideas, it is somehow intrinsically superior and therefore represents a worthy goal to be striven after.

A frequent consequence of this striving after modernity has been a contemptuous attitude toward things and practices which are "out of date." Indeed, the very expression "out of date" connotes irrelevance, not useful, not of value any more.

There can be little doubt that the rapid spread of deep drilling and reliance on groundwater in Jordan occurred because this "modern technology" was assumed to be superior to the suddenly out-of-date "indigenous technologies" it replaced. By indigenous technology I mean the techniques and practices which have been developed and perfected over centuries and millennia by the local population, by past inhabitants of Jordan.

Now that the limitations of over-reliance on groundwater sources have begun to come to light, the search is on for new solutions. Surely, the accumulated experience of Jordan's past inhabitants must count for something in this search. As an example, I would like to focus attention on what our excavations at Tall Hīsbān have brought to light in regard to how water was collected and stored throughout three millennia of human occupation at this Central Jordanian site (FIGS. 1 and 2).

Not unlike other villagers in Jordan, the fundamental problem which has challenged those who made Tall Hīsbān their home in the past has been coping with six months of practically no rain during the months of April through September. In the absence of modern techniques for pumping up groundwater, the ancients of Tall Hīsbān had to cope by relying on on-site collection of rainwater and surface runoff. As our excavations have covered all periods of human occupation of this site, from 1200 BC up to the present, we are in a position to study long-term changes in the site's water system as it correlates with cycles of intensification and abatement in occupation of the *tall*. Six findings are of particular interest in this regard:

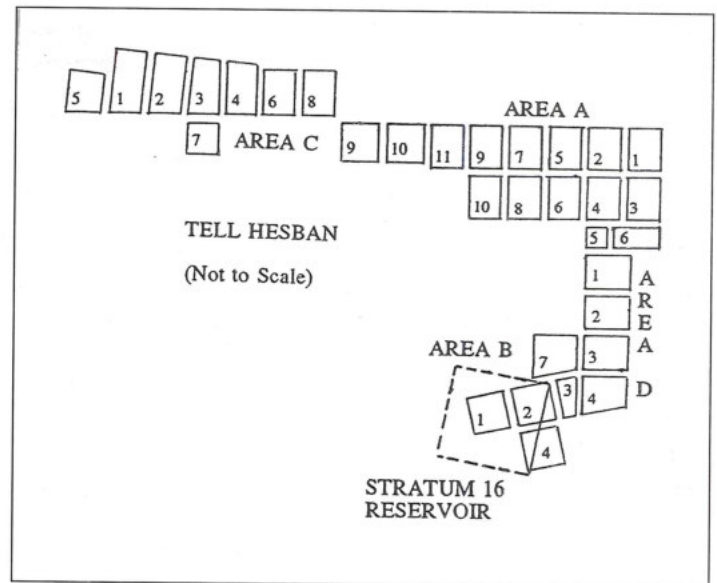
First the use of catchment channels and cisterns for collecting and storing rainwater goes back to the earliest period of occupation of the *tall*, namely to the Iron I period or circa three thousand years ago. Evidence for this is a cistern located in Area D (D.4), and the remains of several water channels (B.2; B.3; D.4), all of which were dated by the excavators to Iron I strata (c. 12th-10th century BC) (FIG. 3).

Second, with intensification of settlement on the *tall* came enlargement of the capacity for collecting and storing rainwater and surface runoff. This is powerfully illustrated in the Iron II period, when the Iron Age occupation cycle reached its highest intensity. During this period a large plaster-lined water tank or reservoir was constructed on the southwestern slope of the *tall* (B.2). The installation measured 7m deep and the distance from its southeastern corner to its northeastern corner was roughly 17m. According to Larry Herr (n.d.), who has computed the tank's capacity on the assumption that it was a square, it would have had a capacity of slightly over 2,000,000 liters. Three layers of plaster were found at the bottom of it and along its sides. Rainwater was fed into it by means of various channels carved out of the bedrock (B.4).

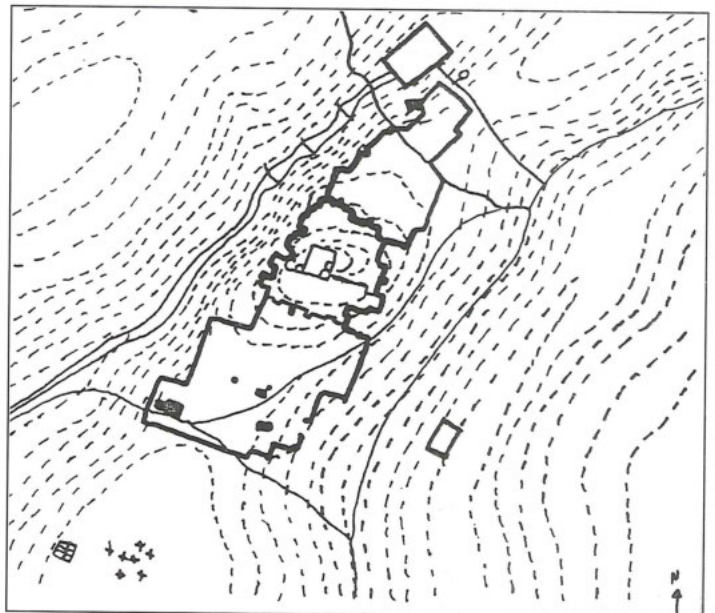
Third, when the *tall* was resettled following periods of occupational abatement, facilities for collecting and storing rainwater built during earlier periods of occupation were as a general rule brought back into use. There are at least two instances of the same two cisterns having been used during all three succeeding millennia of human occupation of the *tall* (D.6 and G.12). In the case of the large number of water channels, cisterns and reservoirs constructed during the Roman period, the majority of them were brought back into use during the Ayyubid-Mamluk period, almost a millennium after they had been originally constructed.

Fourth, during the Roman period, when the greatest expansion of the capacity for harvesting rainwater and surface runoff occurred at Tall Ḥisbān, buildings, courtyards and streets all appear to have been constructed with water catchment in mind. For example, roofs were made so they would catch the rain like a pan. Water thus collected was led via drains to cisterns submerged below the buildings or below adjacent courtyards. Similarly, paved courtyards and streets also doubled as rainwater catchments, as is evidenced by the numerous street level water channels which were built and maintained during this period. Finally, at the base of the *tall* were two large reservoirs, one in Wādī Maj'ar to the west of the *tall* and the other in Wādī Muḥtariqa to the east, each of which no doubt added enormously to the water storage capacity of this Roman town (FIG. 4).

Fifth, the water collected in these large reservoirs was distributed by means of gravity to cultivated fields below



3. Layout of excavated areas (Letters A-D) and their respective squares (numbers).



4. Byzantine Ebus (Hisban) as sketched by Musil in 1902 showing location of two large reservoirs (see LaBianca 1990: 186).

them via diversion dams and terraces. The reservoir in Wādī Maj'ar, for example, had a step-wise series of shelves below it, each shelf being held in place by a retaining wall of stones. In this manner plants were irrigated and soils prevented from eroding away.

Sixth, the basic elements of Tall Ḥisbān's water system as outlined above are by no means unique to this site. They are typical of many other *tall* sites in our project area and of *tall* sites spanning the same millennia throughout all of Jordan. Just to give an idea of how common reservoirs were in the Roman period in this region, we have counted 19 of them within a radius of 10km of Tall Ḥisbān (LaBianca 1990: 189) (FIG. 5). The

largest of these reservoirs is one found in Mādabā, which measures 330 feet long, 312 feet broad and 15 feet deep (Thomson 1880: 637). These reservoirs were either recorded by our own survey (Ibach 1987) or by Conder's survey (1889). No doubt, both surveys missed many others which today have been either destroyed, built upon or otherwise escaped detection.

While our excavations and surveys in the Ḥisbān region have provided a baseline of information about the nature and extent of indigenous Jordanian solutions to the problem of water supply, we have really only just touched the surface of what remains to be learned. There remains a vast variety of practices and technologies which still await documentation and study. This is par-

tainable methods for meeting Jordan's future water needs are two things: First, information about indigenous technologies that have proven to be sustainable over the long-term. And second, information about technologies, policies and practices that have had a destructive effect on the environment. To amplify these two points, I turn again to finding and insights emerging from our research at Tall Ḥisbān and vicinity.

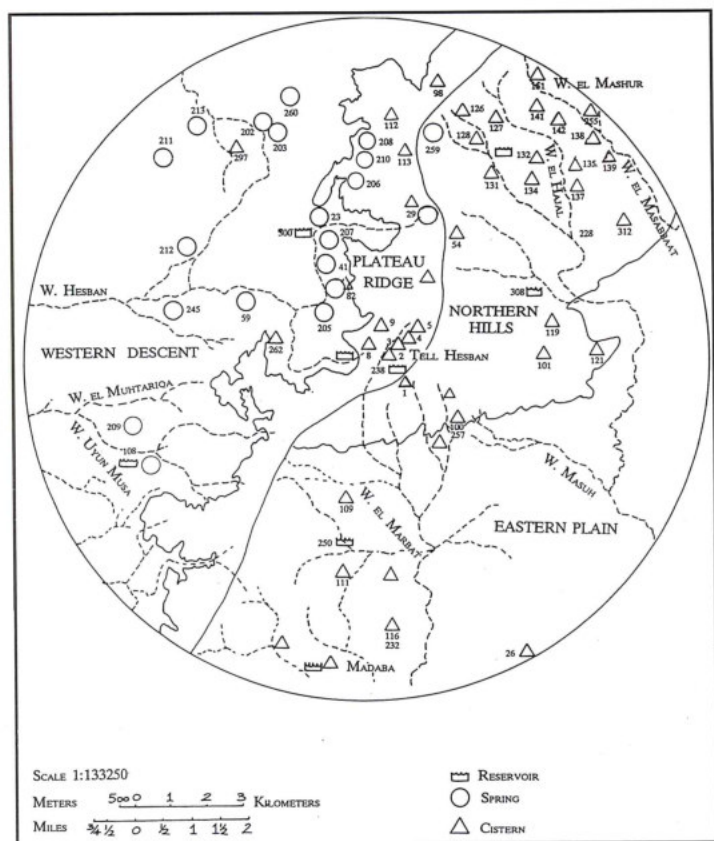
The first point I would like to emphasize in this regard is that the way water was obtained by past inhabitants of this region has always been intimately related to how food was obtained. In other words, arrangements for managing water needs have always been an integral part of arrangements for managing food needs. They constitute an integral part of the same system, namely the *food system*, by which I mean all of the purposive, patterned and interconnected activities carried out by a group of individuals in order to procure, process, distribute, prepare or consume food, and dispose of food remains.

Elsewhere (LaBianca 1990), I have described in some detail how changes in water management arrangements have been tied to changes in patterns of settlement, land use and diet at Ḥisbān and vicinity. A striking feature of the local food system is its resilience. In other words, in response to changing political and economic winds over the past three millennia, it has survived repeated oscillations between low and high levels of intensity. The key to its survival has been the flexibility of Jordan's population, their apparent ability to convert back and forth between sedentary and nomadic lifestyles by means of the processes of sedentarization and nomadization.

A consequence of this is that a very impressive array of variously sustainable indigenous strategies for coping with water needs have been experimented with over the centuries by Jordan's past inhabitants. A measure of the sustainability of these strategies is the extent to which they were utilized under varying food system intensity levels, in other words, their resilience.

On this measure, none surpass the strategy of maintaining cisterns for collecting and storing water (FIG. 6). This strategy appears to have served equally well the sedentary and nomadic phases of the food system cycle for at least the past three thousand years. For example, even during periods when Ḥisbān was abandoned as a year-round settlement, it was used as a seasonal camping ground because, no doubt, of its cisterns.

Another strategy which has stood the test of time is, of course, the practice of maintaining terraces and retention dams to prevent soil erosion and facilitate distribution and retention of rainwater and surface runoff to cultivated hillside shelves. This strategy, I believe, has been utilized more or less continuously in our project area for at least the past four thousand years. Of course,



5. Reservoirs, springs, and cisterns within 10km radius of Tall Ḥisbān (see LaBianca 1990: 188).

ticularly true for other drier and wetter parts of Jordan, for while there are some practices, such as construction and use of cisterns, which can be found almost anywhere, many others exist which represent more specialized adaptations to specific environments and locations. Surely such specialized practices deserve to be studied and to be brought to the awareness of those who are seeking alternative solutions to Jordan's water situation.

Archaeology Can Aid in Developing Sustainable Technologies

What archaeology can contribute to the search for sus-

the areal extent under such management expanded and contracted greatly depending on the cyclic shifts in food system intensity levels over the centuries. By far the greatest expansion occurred during Roman-Byzantine times.

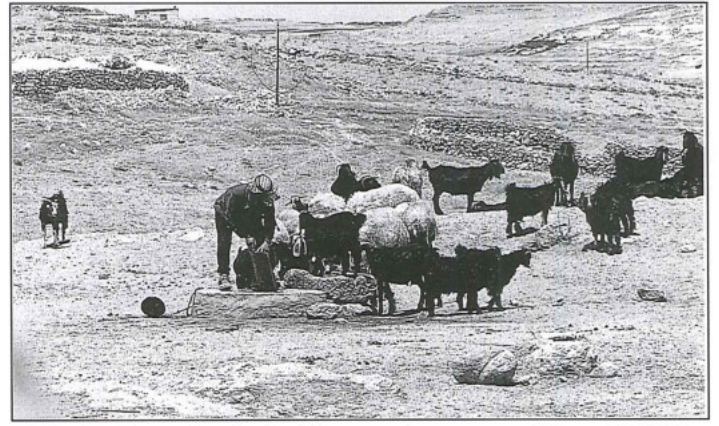
As a method for collecting and storing large quantities of water, the maintenance of reservoirs dates back, as we have seen, nearly three thousand years in our project area. It was not until about two thousand years ago, however, or during the Roman period, that they came into widespread use in this region. Significantly, reservoirs were constructed and maintained primarily during the more intense phases of the food system cycle, such as during the Iron II, Roman, Byzantine and Ayyubid-Mamluk times. This was, no doubt, because they required much more labor and cooperation to maintain and were more difficult to repair in the wake of major earthquakes. Although less resilient than the preceding strategies, their critical role in facilitating intensification of the food system during these periods make them an important strategy to consider today, however.

The above strategies represent only a few examples of the wide array of sustainable methods of water management which our archaeological research has brought to light. Others which have not been touched on include a variety of cooperative arrangements which entailed, on the one hand, strategies involving various forms of kinship-based cooperation, and on the other hand, strategies involving various forms of bureaucratic control. Since our research along these lines is still in its infant stages, I have deliberately limited the discussion here to the consideration of the findings about which we feel the most certain.

As important as what archaeology can tell us about the sustainability of various indigenous methods of water procurement is what it can tell us about the accumulative impact of these methods on the natural environment over the long-term. In other words, while the methods themselves may have stood the test of time, their cumulative impact on the environment is only today beginning to come to light. As an example of this, I would like to end this section by setting forth a proposal regarding the relationship between cycles of food system intensification and abatement and deforestation in our project area.

Briefly stated it is that denudation of the landscape in this region is accelerated in the wake of each intensification phase of the food system cycle. As trees were cleared to open up more land for cultivation during successive intensification phases, soils were initially protected from erosion by terraces and retention dams. Denudation occurred, however, as a result of failure to maintain these terraces and dams during successive abatement phases of the food system cycle.

The reason for this failure, I believe, was increasing



6. Shepherd watering flock of sheep and goats near village of Ḥisbān.

insufficiency of people to do the necessary maintenance work. This, in turn, resulted from a general decline in the population occupying the area during each abatement phase and increasing seasonal migration of the population which did survive.

It is my opinion that the most devastating blow to the environment of our project area came in the wake of the Roman-Byzantine intensification drive, during which most of the forested areas remaining from earlier centuries were cleared and converted to terraced agricultural lands. I base this proposal primarily on the evidence for widespread distribution of agricultural sites and installations all over our project area during this period.

Blended Technologies: Wedding Old and New for Best Results

On the strength of the findings presented above, I would urge that more attention be given to incorporating yesterday's concern with rainwater and surface runoff collection in providing for tomorrow's water needs in Jordan. As an example of this, I will refer briefly to a proposal which we have developed on behalf of ACOR for submission to USAID (United States Agency for International Development).

Entitled "Project Rainkeep" (LaBianca 1992), the proposal entails excavating and restoring cisterns and reservoirs and putting them to use in collecting and storing water for use in irrigating crops. But instead of relying on traditional methods for distributing the water to crops, the proposal entails installation of subsurface microporous tubes for distributing it. To this end, solar powered pumps will be used to lift the water up and push it through the tubing to the plants.

The reason for thus wedding old and new technology is that while yesterday's technology — especially the use of cisterns — reduces significantly the amount of water lost due to unmanaged runoff and evaporation, modern technology assures that the water is distributed and utilized in the most efficient manner possible. The use of

microporous tubes also makes supplying fertilizer and pesticides to the plants much easier.

When compared with the status quo, this blend of old and new technology is vastly more efficient. Whereas the status quo involves relying on large quantities of ground-water being pumped and distributed via fuel-consuming trucks, pumps and pipes to irrigated areas, this *blended technology* relies primarily on on-site collection of rainfall and surface runoff, small solar-powered pumps, and rows of buried plastic tubing for distributing water to the plants.

If Project Rainkeep is funded as a demonstration project, and if it is successful and should lead to widespread implementation throughout Jordan, it will provide an opportunity for archaeologists to work side by side with village farmers and agricultural engineers in addressing one of Jordan's most pressing problems. Their role will include helping to identify possible sites for such installations, surveying and recording them, and, where appropriate, carrying out salvage archaeology as a preliminary to their restoration.

I would like to conclude this paper by coming back to the bigger issue of long-term environmental impact as it related to this blended technology. Even though it would help reduce the current threat of depletion of ground-water sources and help reduce the loss of rainwater to unmanaged runoff, if implemented in the absence of other effects to protect the environment, particularly afforestation efforts, it would be a short-sighted solution.

The reason for this is that, as our long-term scenario involving Ḥisbān's environmental history suggested, deforestation occurred as an unintended consequence of unbridled expansion of intensively managed terrace ag-

riculture. To prevent this from occurring again, it will be important that the momentum already underway, thanks to the visionary leadership of King Hussein, to restore Jordan's forests be continued. Forest, after all, is the ultimate solution not only to storing rainwater and managing surface runoff, but to sustaining indefinitely the process whereby soils, plants and animals are produced on-going for the benefit of future generations of Jordanian citizens.

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