

Policy Implications of Cistern-based Water Conservation in Jordan

by

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"Now there was no cistern in the city, so I said to all the people, 'Make you every man a cistern in his house.'"

Mesha (King of Moab) Mesha Stele/Moabite Stone, ca. 835 B.C.

This paper treats a subject of vital interest to many rural Jordanian families whose access to water during the summer is limited, expensive and uncertain. To alleviate this distress for some, in 1995 the Adventist Development and Relief Agency in Jordan (ADRA) restored over two dozen cisterns for families to collect rainwater to supplement insufficient piped water or expensive trucked supplies. Based on the results of interviews conducted in June and July 1996, this paper presents a number of implications for public policy and Non-Governmental Organizations (NGOs). Most fundamentally it poses the questions "Should cistern restoration continue?" and "If so, under what conditions?"

A study of the effectiveness of restored cisterns in harvesting rainwater fits poorly into the framework of traditional disciplines. Archival sources, computer models and much else common to either economics or history proved of little value to this study. On the other hand, the process of obtaining primary sources of information aroused the author's envy of some anthropologists' working conditions, whether the pleasures of discussing water supplies over tea in a home, or riding with a tanker truck delivering clean water. Research for this paper proved a delight, and it is presented at MESA in hopes of constructive criticism to improve a continuing project.

I. Background

From time immemorial, each summer's sunshine and heat brought apprehension to those who inhabited the hills and plains of the Jordanian Plateau. Nature provided only a handful of perpetual streams and springs, and few locations rewarded efforts to dig wells. Cisterns at 'Umm al-Bayara above Petra and elsewhere suggest that for over three millennia, the region's inhabitants survived their summers by harvesting runoff from winter rains and storing it in cisterns carved from the subterranean rock.

Over the centuries, trial and error established the characteristic features of such cisterns. Hewn from rock, these storage containers came to resemble a giant egg, pointed end up with an entry large enough to permit descent and cleaning. Though substantial variation existed in size, dimensions could exceed 6 meters in depth and 5-6 across; some later served as shelters for shepherds and flocks. Even if only partially filled, the resulting 90 CM of water could suffice for a household and its flocks for several months.¹

Today thousands of cisterns lie scattered across the landscape, many dug during the

¹If there is a typical level of rural Jordanian household water consumption, my interviews have not obtained it. At one extreme, a family entirely dependent on trucked water reported using less than 6 CM per month, about 33 liters per capita per day (L/C/D), or 8 gallons per day including water for a few animals. A rather wealthier family of similar size (6) with a flock of 120 sheep received piped water weekly into its storage tanks of 4 CM and still might buy 10 - 20 CM monthly. In the Balqa Governorate in 1990, water supply reached 146 L/C/D, but a significant portion was used in irrigation and nationally losses exceed 20% (Bilbeisi 20,20). The lower limit of modern urban domestic water consumption is estimated at 100 L/C/D (Udluft & El-Naser 40), so rural Jordanians do consume very little.

densely populated Roman and Byzantine periods, though the practice continued. When the frontier of permanent settlement moved eastward in the 19th century, pioneers cleaned, repaired and used these cisterns. For example, Raouf Abujaber notes that more than 300 were known in the small settlement of al-Yaduda south of Amman. Some were very effective: during a drought it was not unusual to use water three years old (1989:8). Jordanians raised in the 1920s and 1930s also remember cisterns well, and relate stories of water shortages in years of low rainfall. By the 1940s, however, modern drilling techniques and pumps provided an alternative source of water for wealthier households, and piped water reached many Amman homes. The national government undertook to extend the water system to many smaller towns and villages.

The convenience of piped water discouraged labor-intensive storage of rainfall, and few cisterns remain in use. However, the presence of pipes does not assure constant access. Total demand from agriculture, industry and households exceeds national capacity; moreover over-pumping has lowered the water table.² Recognizing both the contemporary water shortage (National Water Master Plan of Jordan, 1977; Garber and Salameh 1992:115) and widespread evidence of the ancients' solution, Oystein LaBianca, a physical anthropologist with the Andrews University Tal Husban and Madaba Plains Project (MPP) proposed Operation Rainkeep to restore cisterns for household use.

Despite rain-harvesting approaches elsewhere including international organizations, little study had been done on Jordanian practices. According to Kefaya (72-73), the micro-catchment of water for domestic and small-scale agricultural use had received little sustained economic analysis. Moreover, social trends discouraged cistern use. Many had become garbage dumps; given their moisture, insects flourished. Despite government edicts, some remained immediate public health hazards because sheep, children, and even adults walking at night could fall into their uncovered mouths.

During the late 1980s and early 1990s, Dorothy Irvin, an ethnologist with the MPP, gathered information about the traditional uses of cisterns in a series of interviews in homes and tents of the region. Beyond establishing the importance of women's roles in harvesting rainwater, she determined crucial design features of functioning cisterns, and in 1994 supervised restoration of one in a widow's yard (Irvin 1996:1). By 1994 the work of LaBianca and Irvin won publicity and official support when the Water and Irrigation Minister, Saleh Irsheidat and secretary general of the Water Authority of Jordan, Qusai Qteishat, inspected cisterns in Madaba, earning substantial press coverage in the major dailies.

Interviews by Irvin and Russell clearly established significant financial advantages for families that collected rainwater in cisterns. For example, trucked water to supplement inadequate piped supplies typically costs JD 15 - JD 35 per month for 10-25 CM, compared with daily wages as low as JD 4 - JD 5 for unskilled laborers (Russell field notes, 1994).

²Widely quoted estimates suggest that in by 1990 some 10% of Jordan's water usage came from non-renewable sources, and that aquifer depletion was causing evident declines in water quality. A simple visual example is the fate of the famous pools of Azraq. A haven for migrating birds and remembered from T. E. Lawrence's accounts, they have almost completely disappeared.

Equipped with such preliminary evidence and official support, LaBianca and the ADRA sought funds for a demonstration project of cistern storage of rainwater. Though several funding sources declined to consider such small-scale projects, the Canadian International Development Agency, CIDA, eventually provided funds used by ADRA to restore 28 cisterns in July-September 1995.

II. Essential Elements of a Successful Cistern:

Though inherently limited by considerations of scale and the capital costs of (new) construction³, a cistern stores water far better than an open reservoir or above-ground tank. Its depth insulates the water from solar rays and extreme air temperatures, providing cool moisture in summer when common rooftop tanks serve as unintended solar heaters. A cover minimizes evaporation loss, and the dark interior apparently retards bacterial growth and mosquito larva. Though apparently simple in essence--a covered hole in the ground--to harvest rainwater successfully a cistern requires the following features.

II. A. Catchment Area:

The finest cisterns of antiquity are often located mid-slope with the catchment area above typically consisting of barren rock or gravel. Given sparse annual precipitation of some 300-450 mm/yr, the catchment must be quite large, exceeding 150 CM for significant water conservation around Madaba, given typical annual rainfall of 300mm - 450mm.⁴ Traditionally household women sweep the catchment clean before the first rain; additional cleansing results from diverting runoff from the first significant rainfall.

II. B. Settlement Basin, Water Channels and Deflecting Ridges:

Also in evidence from ancient times, the water channels and settlement basin were often hewn directly from the rock. The basin traps sediment before it is washed into the cistern, perhaps improving water purity somewhat and certainly reducing the need to clean sediment from the cistern's bottom.

II. C. Top, including Cover and Intake

Ancient cisterns apparently had a raised rim involving stones, but parts made from less permanent materials disappeared centuries ago. The major function of the top is to cover the cistern and keep out animals and dirt. However, the following constraints must be observed:

- * The mouth and any opening must permit workers and equipment to descend into the cistern for repairs, cleaning, and removing large buckets. According to Irvin, this

³An official in the water authority related the case of a well-to-do family that constructed a cistern to supply water for a swimming pool. He judged its payback period at 50 years.

⁴A cistern with a rocky catchment area provides strong ecological benefits. An estimated 85% of Jordan's rainfall evaporates, and most of the remainder runs off rather than settle into an aquifer.

requires a rectangular lid at least 50 cm x 70 cm.

- * However, if left open, a hole of such size constitutes a safety hazard to animals and children. Beyond leaving the lid locked, the solution, Irvin noticed, is a smaller lid (35 cm x 40 cm) within the first.
- * For convenience and to avoid stressing the hinges, an open lid needs a support.
- * Providing a ground-level intake hole to permit runoff water to enter. Typically this is blocked after the rains; a screen is advantageous but not essential. Though not airtight, such a top cuts off access by insects and animals.

II. D. Storage Reservoir Itself

Often hewn out of the rock, cisterns typically resemble an elongated globe or large egg, with a narrow mouth. Apparently some cistern walls proved relatively watertight, but often waterproof plaster is required to avoid leakage.

II. E. Watering Trough

Even permanently settled families often keep goats and sheep, watering them at a trough near the cistern. Their proximity to the catchment naturally raises questions of cleanliness. Ensuring the watering trough is located substantially below the catchment should prove a useful sanitary precaution.

III. Analysis of the ADRA-Rainkeep Pilot Project

In cooperation with ADRA-Jordan, in June and July 1996 members of the Madaba Plains Project attempted to evaluate the success of the 28 cisterns restored the previous year in 11 villages south of Amman in the vicinity of Madaba. Initial attempts at precision included an interview protocol that asked about local rainfall and the value of water saved. MPP staff visited the operators of 24 of the cisterns, on occasion accompanied by Mr. Basim Aziz, the director of ADRA-Jordan who supplied copies of ADRA's files on each cistern (see Appendix, list of cisterns and "Project Rainkeep Evaluation Sheet"). However, low rainfall the previous winter had reduced rain runoff; many of the cisterns were dry or contained purchased water. In these circumstances qualitative results from repeated visits to individual households probably proved more valuable than precise measurements. In particular, criticisms of the ADRA project proved much more forthcoming on later visits.⁵

⁵Given its orientation to public policy issues, this paper will not address perceived shortcomings of ADRA's restored cisterns. In fact, perceived shortcomings often revolved around ways to cut corners (cheaper sand and cement, thinner metal lids, etc.) and probably resulted from the attempt to save funds and meet deadlines by hiring as the supervising engineer an Iraqi waiting to emigrate, rather than using a firm with a reputation to uphold. On occasion the engineer apparently (and accounts differ) constructed impressive tops to cisterns without ensuring their proper functioning. Other shortcomings--e.g., the selection of badly

III. A. Perceived Importance of Stored Water:

The interviews clearly established that rural Jordanians, many of them settled bedouin, philosophically value water conservation. This is not surprising, for many envisage extra water as providing olive trees, vines, fruit trees and gardens. Moreover, though they treasure water, householders report a tradition of sharing cistern water, even allowing passing flocks to drink. In contrast, they lock tanks or cisterns holding water delivered by tanker truck. Probably the most surprising comments of the interviews, however, were the repeated preferences for drinking cistern water. Several individuals complained of chemicals in tap water; others used phrases like "Rainwater makes the best drinking." One family in the village of Libb reported "We use the tap water for sheep and washing clothes but we save the cistern water for ourselves."

Project Rainkeep had deliberately proposed cisterns to provide additional non-potable water for low income households, seeking both water conservation and a higher quality of life. Several survey questions attempted to measure this. This approach proved useless, because cistern water was considered at least equal to (and usually superior to) tap water.

Because stored runoff is used for drinking, the following issues arise:

III. A. 1. Public Health Implications of Drinking Cistern Water:

In contrast to a standardized product delivered through relatively few means (pipes; tanker trucks), the quality of harvested rainwater will vary with each catchment and cistern. Consequently achieving uniform water purity according to the World Health Organization's "Guidelines for Drinking Water Quality" (WHO, 1984) becomes practically impossible; even measurement is problematic. Village families, their digestive tracts adapted to local bacteria, certainly accept this opportunity cost, but important questions are raised:

- * Even if individuals privately accept risks of impure water, is it in society's interest?
- * What may not be the same thing, are the risks an acceptable cost from the perspective of the water and public health authorities?⁶

III. A. 2. Social Organization of Potable Water--A shift from a macro-focus to micro:

Modernization typically brings economies of scale, industrial norms and standardized goods subject to government regulation. The substantial research carried out on Jordan's water supply and consumption typically fits this pattern and dates back at least as far as Ionides' 1939 report. Other studies concentrate on the international aspects and of the issue and its potential for regional conflict, as Jordanians helplessly watch neighboring countries consume water that might be valued more highly in Jordan, typified by Miriam Lowi's Water and Power: The Politics of a Scarce Resource in the Jordan River Basin.

By contrast, harvesting rainwater in cisterns is inherently small-scale. While a very

sited cisterns--may reflect inexperience, a failure to sense the ultimate uses of the stored water, or a desire for visible projects near roads.

⁶Of possible interest, LaBianca consistently drank from each cistern he visited, with no ill effects. The author, looking forward to a long-anticipated cycling trip after the study, did not.

few stipulations appear obvious (e.g., a solid cover and blocked entrance; perhaps even a license and annual water test), other aspects defy regulation. Regardless of laws, family men will bear responsibility for removing silt from the bottom, and the catchment's cleanliness will be a function of the judgment and efforts of the household's women. Other possible government intervention--e.g., legislation requiring fences around catchment areas to keep out sheep and goats will prove both ineffective and ugly. As a result, two fundamental questions arise:

- * Is it desirable for an NGO to encourage this sense of private responsibility?
- * Even if it is not, is it an acceptable cost in return for the benefits of water saved?

III. A. 3. Costs and Benefits:

The costs of restoring cistern vary widely from ADRA's informal estimate of an average marginal cost (net of overhead expenses) of JD 300. In one case, for example, labor costs for the removal of debris alone exceeded that amount. Similarly, in 1994 Irvin supervised restoration of a relatively small cistern which cost some JD 700. Given larger scale operations and experience, an average cost of JD 600 seems a reasonable cost for a large cistern, with some expenses falling proportionately with smaller size.

Uncertainty also hampers estimating the benefits, which will vary with the quantity of water stored and the source of alternate supplies. Piped water is considerably cheaper than trucked, and the frequency of water flowing through the pipes varied greatly between localities. Because it is not uncommon for trucked water to cost JD 1.5 - JD 2 per CM, a cistern holding 90 CM could save the household roughly JD 150. Accepting JD 600 as the cost of restoration, this suggests a capital/output ratio of 4.00. Furthermore, out-of-pocket operating costs approximate 0, and earthquakes aside there are few moving parts to go wrong. Considered in different terms, given otherwise unused (and often unusable) land and allowing JD 10 for the value of labor to clean the catchment and annual silt, an investment of JD 600 produces average annual savings of JD 140 indefinitely.

Even a rooftop catchment of 150 m² yielding 50 CM would produce savings of roughly JD 65 annually, an average (post-tax) return exceeding 10% even at a restoration cost of JD 600.

Such high benefits raise the obvious question of why they have not provoked the widespread private restoration of cisterns. In fact, restoration has taken place, as a casual walk in the countryside will illustrate. Individuals even dig new ones; there may be specialists today and there certainly were as recently as 20 years ago. When asked why they had not acted on their own, respondents usually considered themselves too poor to hire a contractor, or reported that they lacked the skills (and even the time) to do the work themselves. A possible unstated risk is that the cistern will leak, rendering the entire investment useless. Finally, beyond valid technical reasons, it may be that previously the benefits had not been calculated formally.

III. B. Property Rights:

If the practice is adopted widely, cistern water storage could lead to disputes, e.g., where run-off from one person's land is stored in another's. Other property rights issues might revolve around pollution: what if the runoff from a neighbor's land is polluted, or herders traverse the catchment with flocks?

III. C. Public Health Danger: Potential Mosquito Larva:

Victory over malaria came recently enough in Jordan's history for popular sensitivity over the possibility that cisterns could foster mosquito larva. However, villagers reported that mosquitoes were not found in covered cisterns.

III. D. Technological Aspects:

The ADRA pilot project provided confirmation that Jordanian craftsmen possess design and construction skills necessary for cistern renovation. Flaws in some restorations (e.g., cracked cement, leaks, rusting hinges and lids) apparently resulted from ignoring specifications (Irvin 1996). Possible technical improvements in the use of cisterns include

1). Easily constructed equipment for both restoration and annual cleaning.

This should include a rope ladder and windlass arrangement to enable heavy buckets of sediment to be lifted from the cistern.

2). An electric pump (or alternatively a windlass) to raise water to the surface.

Relatively inexpensive (JD 25), a pump could reduce the toil and drudgery of drawing water. A pump might also aid in the annual cleaning, by permitting the cistern to be emptied and the dried sediment removed.

3). Attached to a pump, a filter to reduce sediment and bacterial contamination.

4). Tubing to permit a watering trough further down the slope.

Greater distance between the catchment area and watering trough can only reduce the quantity of animal droppings in the catchment.

5). Improved detection of leaks:

Some ancient cisterns are plastered; others apparently retained water well enough to avoid the expense. Geologists with the Madaba Plains Project suggest leaks occur most often along seam lines, and that local varieties of rock differ in porousness. ADRA reportedly tested for leaks by filling the cistern with water and measuring to see if the level fell within one week. Such methods are expensive (perhaps 10% of the total cost unless the water can be reused) and hardly foolproof; some recipients claimed the test was not carried out. Is there a cheap method to determine if plastering is needed?

6). Plastic or other non-porous materials for simple, low-cost collection zones.

IV. Policy Issues If Restoration Continues:

IV. A. Organizational Structure:

The local storage of rain runoff will not seriously affect the looming water shortage, either regionally or nationally. In 1990, the Balqa's population of 235,000 consumed 12.5 million CM of water. Were each individual to harvest 10 CM of rainfall annually--a most unlikely event-- it would increase water supply by less than 20%, and only cover half the existing shortage (Bilbeisi 20, 21). Compared to the thirst of Jordan's farms, industries and cities, the domestic water used by villagers pales in significance. Though it may have great

symbolic value, Jordan's self-sufficiency in water will come either from new sources (i.e., a reservoir on the Yarmuk) or from massive changes in agriculture, which consumes most of Jordan's water. Household activities affecting either demand or supply will only play a limited role. Nevertheless, as previous sections of the paper have indicated, the traditional custom of catching rainwater in cisterns offers a valuable financial return to relatively poor members of Jordanian society.

Assuming that water harvesting is desirable, who should coordinate it? Certainly ADRA and other NGOs can readily apply the lessons learned from this evaluation and thus aid Jordanians short of inexpensive water. However, a far more efficient alternative might be the establishment of a charitable society under the patronage of one or more influential individuals, to coordinate restoration activities. Such a society could more easily

- * Provide a central source of information and coordination
- * Standardize specifications for measurements, quality of concrete, metal, etc.
- * Foster cooperative community groups that will undertake restorations locally, possibly aided by teams of experts who train villagers in demonstration projects.
- * Foster the development of local technology and traditional skills, including training for plasterers, deriving appropriate technology for cleaning, etc.
- * Encourage the provision of credit for cistern restoration and equipment.
- * Establish modest, below-market fees for services, presumably waiving them for the particularly needy.
- * Establish standards of cleanliness and care of both catchment and cistern.
- * Perhaps even provide a voluntary annual inspection.

IV. B. Problems of Competing Goals:

Conversations with LaBianca, Irvin and Aziz make plain their desires to assist the particularly unfortunate. They also seek to enhance the supply of water, and several of ADRA's cisterns serve widows. Others facilitate social organizations, including a school and a women's society. Inevitably, however, some of the best cisterns to repair may not belong to the poorest members of the community. Thus attempts to maximize either broad goal requires sacrificing some progress towards the other, creating tension between the two goals. This will be true regardless of form of organization.

IV. C. Possible Negative Impact on the National Water System:

Given the advantages of a cistern in storing water, some householders already seek to use it for storing piped or trucked water. Though hardly the purpose of Operation Rainkeep, such activity is not without merit, for the water stored has better quality than in above-ground units, and cisterns might be cost-effective. Where runoff crosses a road or other polluted location, this might be the only use of such a cistern, and though hardly a priority for charity,

such restorations may be useful for families who would use them. However, given the infrequent availability of water (one or two days weekly), plus relatively low water pressure, conceivably cisterns could provide its owner an unequal advantage in storing water.

IV. E. Minimizing Adverse Selection:

Inevitably some householders who desire restored cisterns will prove unwilling to undertake the necessary labor for their upkeep (cleaning the catchment and cistern). Given the level of poverty, householders given cash may divert it to more immediate needs.

Where there are able-bodied individuals in the home, a reduction in adverse selection might result from requiring sweat equity from the family. If done by paid labor, the cost of cleaning an abandoned cistern may exceed half the total cost. However, this is largely unskilled work, and unpleasant. Were families to undertake this themselves, there is greater likelihood they would ensure the cistern caught all available clean water.

V. Conclusion:

Returning to the two questions posed in the introduction, "Should cistern restoration continue? If so, under what conditions?" it is worth recalling that Jordan's villagers and townspeople use amazingly little water by Western standards. Supplementing their piped supplies will make little direct impact on national supply and demand. It will certainly not change the equations of water availability used in peace negotiations or provide a substitute for supplies from the indefinitely-postponed Unity Dam on the Yarmuk River between Jordan and Syria.

On the other hand, in regions of modest annual rainfall and convenient catchment areas, restored cisterns will provide additional water to relatively poor people cheaply and without environmental harm. Coordinated by a society formed for this purpose, the restoration movement could play a significant role in bettering the lives of many Jordanians. The obvious conclusion of this paper is that restoration should continue, with attention to lessons learned from the ADRA pilot project and possibly with a more specialized organization.⁷

⁷Individuals wishing to contact me may do so at Andrews University, Berrien Springs, MI, 49104-0024, telephone 616-471-3104; Fax 616-471-4280; e-mail russell@andrews.edu

Selected References

Most of the substantial literature about Jordan's water scarcity contributed to this paper only peripherally and hence are not cited. Nor have I cited my individual interviews.

Abujaber, Raouf Sa'd. Pioneers Over Jordan: The Frontier of Settlement in TransJordan, 1850-1914. London: I. B. Tauris & Co, 1989.

Abu-Taleb, Maher F., Jonathan P. Deason, Boulos Kefaya and Elias Salameh. Water Resources Management in Jordan. Washington: Catholic University of America, 1991.

Adventist Development and Relief Agency, Jordan. Cistern Construction Records.

Bilbeisi, Mu'taaz. "Jordan's Water Resources and the Expected Domestic Demand by the Years 2000 and 2010, Detailed According to Area," in Garber & Salameh, Jordan's Water Resources and Their Future Potential, 1992.

Garber, Andra, and Elias Salameh. Jordan's Water Resources and Their Future Potential. Amman: Friedrich Ebert Stiftung, 1992.

Irvin, Dorothy. "Report on 27 Cistern Units Worked on in 1996", Project Rainkeep, 1996.

Kefaya, Boulos. "Meeting the Needs of a Growing Population: Scenario for 2000 and 2010," in Garber & Salameh, Jordan's Water Resources and Their Future Potential, 1992.

LaBianca, Oystein. various proposals, press clippings, and other materials. Project Rainkeep, 1994-1996.

Lowi, Miriam R. Water and Power: The Politics of a Scarce Resource in the Jordan River Basin. Cambridge: University Press, 1993.

Udluft, Peter, and Hazim El-Naser. "Some Aspects of Modern Alternatives and Principles of Water Resources Use," in Garber & Salameh, Jordan's Water Resources and Their Future Potential, 1992.36