LEARNING FROM TRADITIONAL WATER HARVESTERS IN THE NEGEV AND SONORAN DESERTS

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The harvesting of rainwater is an essential component of life for many people living in semi-arid and arid ecosystems. These water-harvesting systems are particularly impressive when used for the cultivation of food crops. Studying traditional agricultural sites and the water-harvesting systems associated with these sites enables natural resource managers to gain insight into land management practices that promote healthy ecosystems. Both the Negev Desert of Israel and the Sonoran Desert of southern Arizona and northwestern Mexico are arid areas of the world where for centuries people have practiced traditional agriculture using water-harvesting systems; therefore, the traditional dryland agricultural sites found within these deserts are worthy of attention, especially for researchers working in hydrology and related fields. This paper introduces rainwater-harvesting technologies and presents five main categories that aid in the comparison of these technologies.

LEARNING EXPERIENCE

This last winter I traveled to Israel to learn from people working on a project titled "Ancient Desert Agricultural Systems Revived." The Nabatean people living in the Negev Desert from 200 BC to 640 AD created unique agricultural systems that captured rainwater runoff in the desert environment for household and agricultural uses (Evenari and Koller 1956). Remains of these systems are scattered throughout the southern half of Israel and Palestine, and archeologists, anthropologists, and agriculturalists are working together to understand and learn from them. Also, small communities of people, including Bedouins, Jews, and Palestinians, are currently adapting and utilizing these ancient agricultural and water-saving techniques.

Learning about ancient Middle Eastern culture and the traditional agricultural systems of the Negev Desert helped me to see the Sonoran Desert with a new perspective. Therefore, with a new appreciation for water-harvesting technology, I returned to Arizona with a desire to learn more about traditional agriculturalists and their relationship with the limited resources in the Sonoran Desert. To help remember and compare various water-harvesting technologies, I created five categories beginning with the letter S to represent the basic components of most systems: structure, system, source, scale, and soils.

WATER HARVESTING DEFINED

While approaches for augmenting water supplies have existed for centuries, the term "water harvesting" was introduced in 1963 and defined at that time as "the collection and storage of any farm water, either runoff or creekflow, for irrigation use" (Myers 1975). Since then, water harvesting has become an umbrella term describing a variety of methods for collecting and concentrating various forms of runoff (rooftop runoff, overland flow, streamflow) from various sources (precipitation, dew, perennial streams) for various agricultural and domestic purposes (Reij et al. 1988). The application of water-harvesting technology is most often found in arid and semi-arid regions where rainfall is not sufficient to sustain a good crop and pasture growth or where the risk of crop failure is very high due to the erratic nature of precipitation (Prinz 1996).

Structure of Water-Harvesting Systems

Water-harvesting systems are generally local and small scale, and they consist of three main components: the collection area, the conveyance system, and the storage facility (Prinz 1996; Oweis and Hachum 2003). The geometric structure of the system largely depends upon site-specific characteristics such as topography, the intended use, and the designer's personal preference (Brooks et al. 1997). Tanks, cisterns, or reservoirs might be used for storage of the collected water, or the soil itself

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can serve as a reservoir for a certain period of time (Finkel and Finkel 1986). Furthermore, the collection area and the conveyance system might be the same. For example, hillsides can serve as both the collection area and the conveyance system when rainwater is harvested off a downward-sloping hillside and channeled onto an agricultural field.

System of Production

As I mentioned in the introduction, water harvesting is a technology that people have used for millennia, not only in the Middle East but worldwide. Moreover, it continues to be applied worldwide. Of the numerous forms currently in existence, according to Prinz (1996) there are six generally recognized categories: rooftop water harvesting, water harvesting for animal consumption, inter-row water harvesting, microcatchment water harvesting, medium-sized-catchment water harvesting, and large-catchment water harvesing. Within each of these categories is an associated production system that provides a more stable, secure water supply for household drinking consumption, livestock watering, and/or the growing of agricultural crops. For example, rooftop water harvesting can be a smaller-scale technology used to collect rainwater for human consumption or watering household garden plants. On the other side of the size spectrum, farmers can construct large agricultural terraces, irrigated by hillside rainwater runoff, for growing fruit and nut trees. Many "in-between systems" are also used, ranging from small water-catchment areas that are channeled into reservoirs for livestock watering to the construction of mounds surrounding garden plants and trees to concentrate rainwater around root zones.

Source of Water

The amount, distribution, and variability of seasonal or annual rainfall in arid and semi-arid regions are key factors to consider when evaluating and applying water-harvesting technologies (Brooks et al. 1997). For example, in terms of agricultural production, part of the rainfall may be lost as surface runoff before reaching the root zone of the crops even where the amount of rainfall is sufficient for crop production (Reij et al. 1988). Therefore, it is important to investigate the rainfall patterns in the area, the locations of ephemeral and perennial water-courses, and the quantity and quality of ground water resources of the site. The availability of these water sources will greatly determine the structure and scale of a water-harvesting system.

Scale Suitable for a Specific Site

The amount of rainwater runoff collected on individual farm units in the Negev Desert is directly related to the size of the catchment area surrounding the agricultural fields (Evenari et al. 1982). Therefore, the larger the catchment area, the greater its total water yield. Each farm has its own well-defined catchment area that constitutes its water rights, along with drop structures, spillways, ditches, and dividing boxes, giving the farmer control over the distribution of the water on the farm (Evenari et al. 1982). These agricultural production systems are feasible only where large areas of sloping land and labor input to construct the system are available. Many smaller-scale water-harvesting technologies can be used, ranging from microcatchments for tree crops to garden systems where soil is built up around individual plants in a waffle-like pattern (Anschutz et al. 1997).

Soils of an Area

The absorption capacity of a soil type is its infiltration capacity, which is expressed as the quantity of water depth in millimeters per hour. Runoff is produced when the rainfall intensity is greater than the infiltration rate of the soil (Anschutz et al. 1997). Since surface runoff is the primary component of water-harvesting systems, an understanding of site-specific soil characteristics is necessary. For example, the loess soils typically found in the Negev Desert form a characteristic crust when wet. This crust becomes impermeable with rainfall; therefore, water runoff occurs even with light rains. Heavy, short-duration rainfall causes flash floods. The characteristics of the loess soil thus enable farmers to harvest water from hillsides even under low-rainfall desert conditions (Evenari et al. 1982). Furthermore, on sites where the soil type is sandy, water infiltrates more easily compared to clay soils. Therefore, on these sites, a rainwater conveyance system other than the soil (i.e., rooftop) might be more applicable.

The biological component of the soil crusts is also important. Microphytic communities composed of cyanobacteria, green algae, fungi, mosses, and lichens are found in the sand dunes of the northern Negev, where they stabilize the sand surface against wind and water erosion. Free-living symbiotic cyanobacteria are capable of nitrogen fixation and are important nitrogen sources in the desert sand dunes. These biological crusts not only enhance surface water runoff, making them a key component of a rainwater-harvesting system, but they also combat desertification of arid and semiarid ecosystems (Veste et al. 2001).

APPLICABILITY OF WATER-HARVESTING TECHNOLOGIES

The United Nations (UN) designated 2006 as the International Year of Deserts and Desertification. With this issuance, the UN hopes to raise global public awareness of deserts, disseminate methods for protecting the biological diversity of arid lands, and safeguard the knowledge and traditions of the 2 billion people affected by desertification (UN News Service 2006). The harvesting of rainwater is one such traditional practice which has the potential for improving the lives of many people living in dryland ecosystems by reducing the costs associated with raising animals and growing food (Oweis and Hachum 2003). To make traditional methods more applicable to current social and environmental needs, more information is required on agricultural crop phenology and water requirements. There is also a growing need for demonstration projects that present universal prescriptions and develop specifications for various economic, social, and climatological conditions (Brooks et al. 1997).

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REFERENCES CITED

Anschutz, J., A. Kome, M. Nederlof, R. de Neef, and T. de Ven. 1997. Waterharvesting and Soil Moisture Retention. Agrodok-series No. 13.

Brooks, K. N., P. F. Ffolliott, H. M. Gregersen, and L. F. DeBano. 1997. Hydrology and the Management of Watersheds. Iowa State University, Ames.

Evenari, M., and D. Koller. 1956. Ancient masters of the desert. Scientific American 194 (4): 39–45.

Evenari, M., L. Shanan, and N. Tadmor. 1982. The Negev: The Challenge of a Desert. Harvard University Press, Cambridge, Massachusetts.

Finkel, H. J., and M. Finkel. 1986. Engineering measures: Water harvesting. In Semi-Arid Soil and Water Conservation, by H. J. Finkel, M. Finkel, and Z. Naveh, pp. 93–101. CRC Press, Boca Raton, Florida.

Myers, L. E. 1975. Water harvesting and management for food and fiber production in the semi-arid tropics. ARS/USDA, Berkeley, California.

Oweis, T. Y., and A. Y. Hachum. 2003. Farming where there's no water. LEISA Magazine. June.

Prinz, D. 1996. Water harvesting: Past and future. In Sustainability of Irrigated Agriculture, edited by L. S. Pereira, pp. 135–144. Proceedings of the NATO Advanced Research Workshop, Vimeiro, Balkema, Rotterdam.

Reij, C., P. Mulder, and L. Begemann. 1988. Water Harvesting for Plant Production. The World Bank, Washington, D.C.

UN News Service. 2006. UN Lanches International Year of Deserts and Desertification. UN News Centre. http://www.un.org/apps/news.

Veste, M., T. Littmann, S. W. Breckle, and A. Yair. 2001. The role of biological soil crusts on desert sand dunes in northern Negev, Israel. In Sustainable Land Use in Deserts, edited by S. W. Breckle, M. Veste, and W. Wuchere. Springer, Berlin.