Rain Water Roof Catchment systems as means to partially alleviate water shortage in the West Bank

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Abstract

In contradiction to widely held views, water not oil is the most invaluable strategic asset in the Middle East. Many observes go as far as speculating that future armed conflicts would be instigated by some water related ambitions. In the West Bank and Gaza strip the water situation is particularly critical and odd due to the presence of a number of military orders barring Palestinians from freely managing their water resources. The present study is an attempt to focus attention and explore the traditional methods of collecting and storing rainwater for subsequent use.

Through the collection of field data and rational analysis it is shown that RWRCS are effective in partially alleviating water shortage hence are promoted specially in rural areas. Practical recommendations are given.

Introduction: Geopolitical Setting-

The Middle East is currently facing a severe water shortage problem. Many observers see this as inherent potential for inviting future armed conflicts in the region. This matter is widely known and much has been written about. In brief, water resources, so important for growth and development are scarce in quantity. Furthermore, the region is embarking upon an era characterized by industrialization and economic growth coupled with a sharp increase in population.

Water resources in general, whether surface or underground are never influenced by political boundaries which in the Middle East are either not defined or poorly defined. This fact does not contribute in any positive manner to easing tensions among the politically belligerent parties. In the West Bank and Gaza strip which have been under an Israeli Military Occupation for a little under three decades, the water situation is particularly odd. Here the Palestinian people are prevented by a number of Israeli military orders, from exploring and drilling new water wells or from maintaining and managing existing ones. This is a forced schism between the indigenous people and a natural resources so vital to life and in the very land on which they live. All done under the pretence of security.

The Zionist movement ever since its inception looked at water resources in Palestine as an esoteric criteria for delimiting the boundaries of their envisaged "state of Israel" although overtly they referred to this as historic and biblical boundaries.

In the Peace Conference at Paris following World War I, Weizman, the first president of the state of Israel clearly described the desired boundaries of the state of Israel to include the headwaters of the Jordan River, the lower Litani and the lower Yarmouk. In his speech he said "Palestine must have its natural outlets to the seas and the control of its rivers and their headwater ... . It is therefore of vital importance not only to secure all water resources already feeding the country, but also to be able to conserve them at their sources". It is perhaps ironic that the first military action of Fatah in January 1965 (Palestinian National Liberation Movement) was targeted against the Israeli national water carrier while in 1966 Israeli air force hit Arab water works on the tributaries of the Jordan River (Za'rour and Issac, 1991 and 1993).

It is very much worth mentioning that the Israeli presence in South Lebanon occupied since 1982 raises many valid questions about Israel's hydrological ambitions in that area and brings back to mind the words of Moshe Sharett made in 1950 "... the only thing that's necessary is to find an officer, even just a major. We should either win his heart or buy him with money, to make him agree to declare himself the saviour of the Maronite population. Then the Israeli army will enter Lebanon, will occupy the necessary territory, and will create a Christian regime that will ally itself with Israel. The territory from the Litani southwards will be totally annexed to Israel and every thing will be all right" (Za'rour and Issac, 1991 and 1993).

In principle rainwater harvesting may be achieved through a number of means which range from the very primitive e.g. a barrel and a tap to the most sophisticated requiring state of the art Engineering skills. The present paper addresses the Rain Water Roof Catchment System (RWRCS) as a method of water harvesting and as a means to partially alleviate the water crisis.

Water situation in the Palestinian occupied territories: General Overview-

Since the onset of the Israeli Military Occupation of the West Bank and Gaza in 1967, the military authorities abolished the prevailing laws pertaining to water and introduced instead new military laws and regulations. The new laws effectively stripped the Palestinians from any control of water resources. This actually included exploration, distribution, planning and management of both ground water and surface water. The task of complete control of the water resources was delegated to the Israeli water company (Mekorot) and to the water planning company (Tahal).

As a direct consequence of the Israeli water policy in the occupied territories, the agriculture sector suffered tremendously. Actually, this vital sector deteriorated with the suspension of the five-year agricultural development plan of 1964. This plan was designed for the West Bank and intended to double rain-fed farming to 220 dunums and to increase the irrigated land by some 40%. Palestinian agriculture did not witness any development since 1967 until the present time. Furthermore, by the military orders No. 1025 and 1039 of 1983 the authorities restricted the planting of new fruit trees in Gaza and the West Bank under the pretence of controlling and limiting water consumption. On the other hand the Israeli settlers were allowed to drill new and deep wells and were given facilitation and subsidies for rain-fed farming (in Za'rour and Issac, 1991 and 1993).

The Israeli policy in the occupied territories is that of "faite accompli" because with its acquisition of 63% of the West Bank land and about 43% of Gaza, Israel in effect is controlling all water resources.

As an example of Israeli practices one dares to mention that Mekorot issued licenses for the drilling of 35 wells that pumps 52mcm/year for the benefit of the settlers while only 23 licenses for new wells were given to Palestinians; only 3 of them are intended for irrigation. Arab wells range in depth from 60m to 150m, while the wells drilled by settlers reach about 300m and sometimes go down as far as 800m specially in the hilly areas.

Finally, water was used at times by the Israeli military authorities as a means to punish people who show a tendency to resist occupation. This punishment was actually exercised in April 1989 against the Jalazone refugee camp and in June 1990 against Jiftlik.

With such a policy in practice the idea of water conservation and rain water harvesting - the subject matter of this paper - become imperative alternatives.

Rain water roof catchment system (RWRCS)

For many purposes Rain Water Harvesting using Roof Catchment System (RWRCS) have been used historically in a number of places around the world e.g. in Europe, in Africa, in Atlantic Bermuda and Australia. The components of the RWRCS are itemized below (Fig. 1) (Schiller and Latham, 1986):

a. A catchment area.
b. A storage tank.
c. A filter or a sediment trap for removing undesired solids.
d. A pump may be needed if the storage tank is below the ground surface.
e. Conduits.

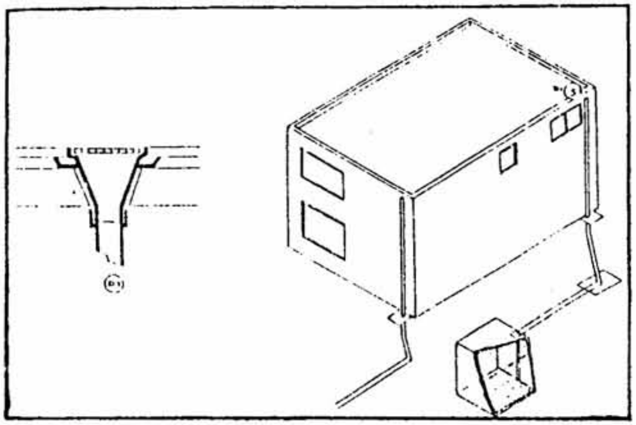

Fig. 1: Roof catchment system

Similar to other engineering systems RWRCS has both advantages and disadvantages. However the following advantages outweigh the disadvantages:

1. The quality of rainwater is usually adequate.
2. The system is independent and therefore suitable for scattered communities.
3. No energy costs are needed to run the system.
4. Ease of maintenance by the owner or user.
5. Convenience and accessibility of water.

The disadvantages can be abbreviated as follows:

1. High initial cost.
2. Water availability is limited by rainfall and catchment area.
3. Mineral free water has a flat taste and may cause nutrition deficient diets.

Furthermore, there are situations similar to the ones summarized below in which RWRCS become imperative (Schiller and Latham, 1987). The water situation in the West Bank and Gaza is one such situation i.e.:

a. When no safe centralized water system is available.
b. When consumers are located in isolated areas or in areas where resources needed for a full-scale water system are unavailable (scattered habitats).
c. When well-water is contaminated, chemically hard, difficult to obtain or unreliable.
d. When ground water tables are low or when the well-water is poor in quality.

Rain water harvesting in the West Bank

The idea of harvesting rain water from roofs of building is not new. For a long time Palestinians have been building cistern wells to collect the rainfall from the roofs of their houses. Those cistern wells are still present in many Palestinian villages in which water is collected during winter and used for domestic purposes throughout the year.

For the purpose of this study and to evaluate the practices of using RWRCS in the West Bank, data from different villages in the districts of Nablus, Tulkarm, Jenin and Hebron where collected using a prepared questionair. The villages together with some general information are tabulated below (Table 1) and shown in Fig. (2) which shows also the lines of equal annual average precipitation computed during the years from 1931 to 1960.

The data from Yutma village were used in a preliminary study by two students for their undergraduate graduation project under the direction of the authors of this paper (Al-Hudhud and Najjar, 1993). These data along with the data from the other villages form the base for this study. It is worth mentioning that most of the land in these villages is agricultural land and the people are farmers.

Table 1: List of villages included in this study

District Name	Village Name	Water Distribution System	Inhabitants Number	Data Sample Number
Nablus	Yutma	No	2300	20
	Beit Wazen	No	1000	[illegible]
	Beit Imrin	Yes	1500	10
	Salfit	Yes	4000	12
	Azmout	Yes	2000	10
	Til	No	3500	11
	Sabstey	Yes	4000	6
Tulkarm	Kufr Zibad	Yes	1200	9
	Der El-Gsson	Yes	10000	5
	Farha	No	800	5
Jenin	Meythalon	No	5000	10
	Tubas	Yes	20000	10
Hebron	Dura	Yes	30000	15
	Beit Kahel	No	4000	10

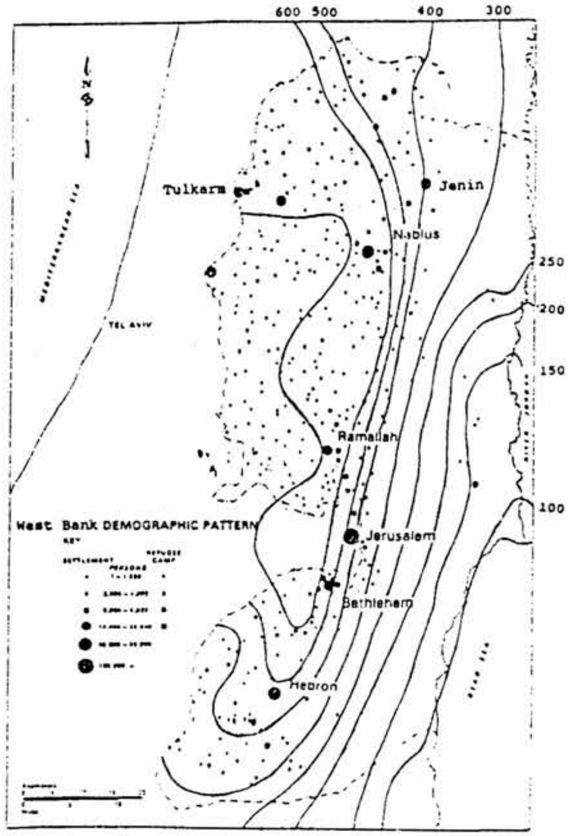

Fig. 2: The demographic build up of the West Bank and the lines of annual average precipitation

Some of the practices using RWRCS in the West Bank are:

1. Many underground storage tanks, especially those that were constructed more than 20 years ago had a pear shape (Fig. 3) or a cistern with dimensions 4x4x4 m. This kind of storage has the following advantages:

   a. The cistern can collect water from ground level catchments.
   b. A cistern of a pear shape usually needs less materials to build, excavations can be done manually and this is usually done by the owner and his family.
   c. The temperature of the cistern and its contents are more stable.
   d. Soil contributes significantly in supporting the cistern's walls.

2. Most of the water stored is used for domestic purposes, livestock and patch-irrigation.

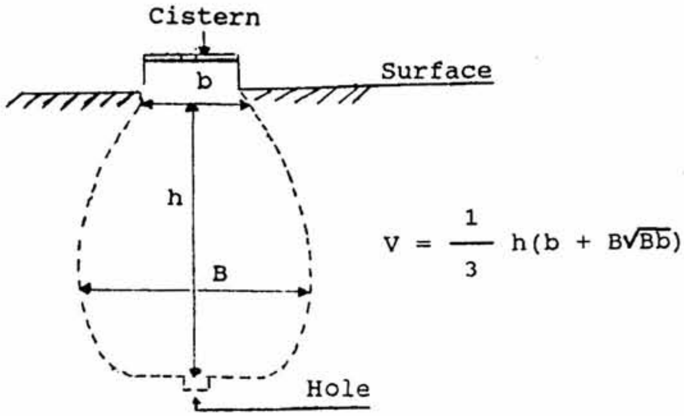

Fig. 3: The traditional pear shape of cistern used in the West Bank

3. The first rainfall storm in a season is usually not directed towards the cistern. It is assumed that this storm would clean the catchment basin. This flush water in addition to leak slashes form most of the water losses.

4. In the case, when the rain water does not cover a household's demand for the whole year, water would be either purchased from vehicle tanks or brought from the spring and stored in the cistern, to cover dry period. This is especially true in areas where there exist no distribution system.

5. In villages with electricity, a small electric pump is usually used to pump water from a cistern to a small metallic reservoir on the roof of the house. Otherwise a rope with a bucket at the end is used.

6. The cleaning of the cistern is done once a year, at the beginning of the winter season. To facilitate the cleaning process, a small hole is made at the bottom of the cistern especially those of pear shape (Fig. 3).

Table (2) shows the result of basic calculations done using the gathered data. The stored volume is the available storage capacity per person resulted from dividing the excavated volume of the cistern through the number of family members. The average period through which the stored water was used is given as a percentage from the whole year in column number (3). Column number (4) gives the daily water consumption in liter/capita resulting from dividing the used volume of water through the period of usage. The possible volume of rainwater which can be stored per unit catchment area is given in column number (5). These values are computed using the values of the annual average precipitation falling in the villages (Fig. 2) and a runoff coefficient of 0,8 which is usually used for RWRCS (Institute for Rural Water, 1982). The last column gives the catchment area per capita required to store the amount of water needed to satisfy the yearly consumption. These values are computed using the daily consumption (column number 4) and the possible storage volume of rainwater (column number 5).

Table 2. Basic calculations of stored water usage in the villages under consideration

(1) Village Name	(2) Storage Volume m^3/c	(3) Yearly Coverage %	(4) Daily Consumption l/c	(5) Possible Storage mm	(6) Catchment Area m^2/c
Yutma	9,6	73%	36	320	41
Beit Wazen	16,0	76%	58	480	44
Beit Imrin	10,8	85%	35	500	25
Salfit	8,5	58%	40	520	28
Azmout	4,8	33%	40	500	29
Til	9,7	57%	47	480	35
Sabstey	9,3	42%	60	480	45
Kufr Zibad	7,1	50%	39	510	28
Der El-Gsson	19,0	87%	60	520	42
Farha	8,8	67%	36	510	25
Meythalon	10,5	47%	45	460	35
Tubas	18,7	89%	58	300	70
Dura	6,7	48%	39	350	40
Beit Kahel	7,7	47%	45	360	45

The period in which the water harvested is used to partially alleviate water shortage is between 30 and 90% of the whole year (Table 2). This figure is appreciable in satisfying the domestic needs for water keeping in mind that other water resources are controlled by the Israeli military authority and beyond reach to the Palestinian population.

Feasibility of using RWRCS in the West Bank

Feasibility of using a RWRCS can be investigated by computing the minimum catchment area for a specified demand and determining whether the existing roof can provide this catchment area (Schiller 1982). RWRCS will be feasible if enough rainwater can be collected and stored (Mahmood, 1986). Historical rainfall data can be used to determine whether enough rainwater can be collected, and the tank's size needed to store the rainwater (Institute for Rural Water, 1982). An accurate method for sizing a tank involves an analysis of data using the mass curve technique. As an example this technique is applied here to the data from Meythalon village (Table 3). The annual monthly average precipitation of Meythalon area used in this analysis are taken from Meythalon Meteorological Station.

In Table 3 the monthly average rainfall are given in column number (2). The monthly supply which results from multiplying the monthly rainfall with the runoff coefficient and the catchment area are given in column number (4). The catchment area and the runoff coefficient used are 48m² and 0,8 respectively. The 48m² catchment area is necessary to collect the possible storage that satisfies the annual consumption for one person based on a daily consumption of 60l/c. The 60l/c/d is taken as the average water consumption in the West Bank (Haddad and Abu-Eishe, 1992). The variation of the consumption during the different months of the year is accounted for by considering three different values. 1,33 of the average consumption is assumed for the four summer months May through August and 0,67 of the average consumption for the months November through February. For the other four months the average value is assumed to be valid (column number 4). The difference between the monthly supply and the monthly demand gives the amount of water that can be stored (column number 5). The total storage in column number (6) is the accumulation of the amount stored.

Table 3: The sizing of the storage tank using the mass curve analysis and the data of Meythalon village

(1) Months	(2) Monthly Rainfall mm	(3) Monthly Supply m^3	(4) Monthly Demand m^3/c	(5) Amount Stored m^3/c	(6) Total Storage m^3/c
November	65	2,50	1,2	1,30	1,30
December	120	4,61	1,2	3,41	4,71
January	138	5,31	1,2	4,10	8,81
February	105	4,03	1,2	2,83	11,64
March	89	3,42	1,8	1,62	13,26 *
April	27	1,04	1,8	-0,76	12,50
May	5	0,19	2,4	-2,21	10,29
June	0	0,00	2,4	-2,40	7,89
July	0	0,00	2,4	-2,40	5,49
August	0	0,00	2,4	-2,40	3,09
September	0	0,00	1,8	-1,80	1,29
October	27	1,04	1,8	-0,76	0,53 *

From Table (3) the storage volume required to satisfy the annual consumption per capita of Meythalon area based on the West Bank average of 60l/c/d is the difference between the maximum value of total storage and the minimum value. This gives a storage volume of about 13m³/c coupled with the 48m² catchment area which would optimally satisfy the annual average consumption of 22m³/c. This means that a household with five persons in Meythalon village may take all its domestic water needs from rainfall using RWRCS that has a catchment area of 240m² and a storage tank of 65m³.

Quality and Economic Consideration.

Quality and quantity of water are considered to be the two main factors in developing any water supply schemes in an efficient and economical manner. The benefit of the maximum available water supply is mainly determined by its quality. Rainwater in general has less impurities than surface or groundwater. Furthermore, due to the fact that air polluting industry in the West Bank is absent, rainwater is considered clean and adequate for drinking. The diversion of the first runoff of rainwater out of the cistern is sufficient to getting rid of the dust and dirt which may have accumulated on the catchment during dry season.

However, with regard to the economical aspects, the cost of constructing a cistern depends on the property of the soil and the type of the cistern. In many cases, this may be far less economical than buying water from the municipality or bringing it from a spring. Nevertheless, the use of RWRCS as a mean to partially alleviate water shortage in the West Bank is feasible and recommended to overcome the shortage and the prevailing political restrictions induced by the Israeli occupation authorities. The initial cost is an obstacle that can be overcome by some innovative technology.

Conclusions and Recommendations

In this Paper the feasibility of using RWRCS as a mean to partially alleviate water shortage in the West Bank has been investigated. The practices of using RWRCS were studied using field data which were collected by students of the Civil Engineering department of An-Najah National University under the direction of the authors. The following are conclusions and recommendations:

1. The alleviation of water shortage using RWRCS is better than 40 to 90% of the whole year. This percentage is appreciable and provides a promising complimentary water resource.

2. Using RWRCS in the West Bank is feasible and recommended although in many cases it seems less economic than buying the water. The prevailing political consideration add to the necessity of having RWRCS for each household in the West Bank and Gaza.

3. Due to the exorbitant initial cost incurred if the RWRCS is built in a conventional manner, every effort should be made to lower this cost by innovative engineering design. e.g. using prefabricated cisterns made of either precast concrete, segmental steel shell units or fiberglass. Standard engineering designs do also contribute to lowering the initial cost.

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