Potential of rainwater harvesting in urban Zambia

Lubinga Handia [a,*], James Madalitso Tembo [a], Caroline Mwiindwa [b]

[a] *Department of Civil and Environmental Engineering, School of Engineering, University of Zambia,*
P.O. Box 32379, Lusaka, Zambia
[b] *SCOPE-OVC, Care International, P.O. Box 36238, Lusaka, Zambia*

Abstract

This paper was associated with a WARFSA funded research project "Potential of rainwater harvesting in urban Zambia". The general objective of the research was to investigate the applicability of rainwater harvesting in urban Zambia. This paper presents the results obtained at the time of writing the paper. Rainwater harvesting was not new to Zambia and there had been installations which were mainly confined to rural areas. Laboratory analysis of water samples from one such system showed that the water was suitable for drinking purposes. Two peri-urban areas of Lusaka were selected mainly based on the water stress in the areas. The socio-cultural survey conducted in the two areas indicated that water ranked among the top two priorities by the Residential Development Committee. Design of the systems was based on the mass curve analysis for storage and rational formula for the gutters. However, a maximum storage of 10 cubic meters was chosen due to budgetary limitation. Construction of five systems was in progress.
© 2003 Elsevier Ltd. All rights reserved.

Keywords: Rainwater harvesting; Water demand; Drainage networks

1. Background

According to the "Social sector rehabilitation and development programme, 1993–1996", only 43% of the urban population of Zambia had access to safe water and sanitation structures. The situation in Lusaka was similar to most other cities and towns in the whole country and about one-fifth of the country's population lived in the city. Therefore, Lusaka was used as an example of water and sanitation. Estimates by the JICA study team showed that the safe water coverage in Lusaka was 57% in 1995. Estimates in 2002 for the service level in Lusaka was 80%. The current supply to the city fell short of demand. It had been projected that at the 2002 supply of 200,000 m³/day, the city would have deficits of 302,100 and 522,300 m³/day in 2005 and 2015, respectively (Yachiyo Engineering Co. Ltd., 1995).

The factors that had led to the lack of safe water to the majority of city dwellers were lack of financial resources to increase the water supply system and rural to urban migration. Others were lack of services (water and sanitation) to certain areas, inability to pay water bills due to high poverty levels and insufficient knowledge about health. Possible solutions to this problem were to manage the water demand, expand the current supply from Kafue River, increase exploitation of groundwater and start rainwater harvesting.

Rainwater harvesting (RWH) is an option which has been adopted in many parts of the world where conventional water supply systems have failed to meet the needs of the people. Rainwater collection and utilisation schemes are said to be optimal when implemented in conjunction with water demand management, as well as measures to enhance aquifer recharge (Session reports, 1999). Lusaka Water and Sewerage Company (LWSC) had started a water demand management project concentrating at reducing leakage, installation of meters, etc.

The city's poor drainage network had made residents believe rainwater was a nuisance as it could not be quickly disposed of through the system. Rainwater had been ignored as a resource. But the piped water consumed in the city during one year which was about 73 million cubic meters was exceeded by the 306 million cubic meters of rain that fell over the city. This rain should be harnessed and used. Reclaiming the city's rainwater as a resource, and the importance of securing water by changing from "off-site" to "on-site" sources is a significant exercise (Murase, 1999).

---

* Corresponding author.
E-mail address: handia@eng.unza.zm (L. Handia).

There was need to investigate what style of rainwater harvesting was suitable, the quality of harvested water, affordability of the system by utilising local materials and skill, and economic and socio-cultural aspects. Demonstration projects should be undertaken to improve public acceptance and assist in removing institutional barriers (Session reports, 1999).

1.1. General objective

The general objective of this study was to investigate the applicability of rainwater harvesting in Zambia.

2. Methodology

Investigating rain collection system technology in existence in Zambia was done by conducting interviews and physical visits. Organisations and institutions which were expected to be involved in rainwater harvesting were contacted. These included Ministry of Agriculture, Livingstone Sustainable Food Programme, Africare, Ministry of Local Government and Housing and Rainwater Harvesting Association of Zambia. A visit was made by the Research team to the Southern Province of Zambia.

Pilot stations (five) were selected in Lusaka based mainly on catchment/collecting area material (roof), number of users, alternative water sources and affluence or density of residential area. It was decided that communities with severe water problems be given priority. Consultations were made with stakeholders on identifying such areas. The organisations consulted were Ministry of Local Government and Housing, National Water and Sanitation Council (NWASCO), Care International and Community Based Organisations (CBOs).

In each community, there were both focus group discussions with the Resident Development Committee and individual interviews using questionnaires for the socio-cultural survey.

The RWH system that was used in the research for the pilot system was the roof harvesting system. This comprised a collection surface (roof), guttering, storage tanks and first flush. The gutters were designed using the Rational and Mannings formulas. Design of the storage tanks was based on the mass curve analysis.

The CBOs played a crucial role of being a link with the community, facilitating installation of the RWH systems and building capacity of the local communities in RWH technology. Some women groups existed in the communities and were active. Some women had already been trained by a Non-Governmental Organisations (NGO) to maintain hand pumps. Women were key players in the implementation of the systems. Their role was to participate in building the tanks and other components, control the use of water and maintain the system. Training was given to the women and the rest of the community on RWH technology in order to build capacity within the communities.

3. Presentation of results and discussion

3.1. Investigating RWH in Zambia

Rainwater harvesting is a technology which is traditional in some parts of Zambia. It is done on an ad hoc, very low tech basis usually by placing buckets under the eaves to catch rain during storms/storing the water in containers such as old 210 l oil drums. Very few RWH systems had been installed, mainly at schools, but this was not widespread. These were roof harvesting systems consisting of a roof catchment, gutters and tank. The water was drawn through a tap from the tank. The water was used for drinking and washing by pupils, teachers and nearby communities. The Ministry of Agriculture had constructed a number of different rainwater harvesting systems for rural areas especially in the Eastern Province. Some of these were roofwater harvesting systems with ferrocement and brick tanks. Some of the installations were at schools whilst others were at individual houses. Livingstone Sustainable Food Programme had also worked with the rural communities. The structures constructed were mainly dams, weirs and boreholes. The local government, with support from UNICEF was planning to start piloting in 10 districts of 2 provinces. A RWH Association of Zambia had been formed to promote RWH in the country.

3.2. Physical visits and collection of relevant data

Rainwater harvesting systems were found at Batoka Basic School in Choma district (Southern Province of Zambia). It was a roof type and harvests rainwater from two classroom blocks with only half of the roof (of iron sheets) being used. One of the tanks was constructed of concrete (10 m^3) whilst the other was made of burnt bricks in cement mortar (75 m^3). Both tanks were covered with iron sheets supported by timber members. The systems did not have any first flush, filter nor treatment facilities.

Water samples were collected once from the tanks and the results are presented in the table below. Results show that the collected water for Tank B is good for drinking as it meets the WHO guidelines. Tank A water fails to meet the guidelines in terms of bacteriological quality but it can be used for drinking after it has been boiled (Table 1).

3.3. Selecting pilot stations

Areas with critical water shortages were located in high density poor communities. These areas were visited by the research team to have a feel of the situation and investigate the feasibility of RWH in these areas. Two

Table 1
Harvested rainwater quality at Batoka, Zambia

Parameter	Tank A (concrete)	Tank B (brick)	WHO guideline (maximum value)
pH	7.3	7.0	6.5–8.5
Total dissolved solids (mg/l)	12.6	8.50	1000
Sulphates (mg/l)	1.66	1.69	250
Turbidity (NTU)	0.42	0.56	5
Lead (mg/l)	<0.01	<0.01	0.01
Zinc (mg/l)	0.62	0.67	3.0
Chlorides (mg/l)	6.0	5.0	250
Nitrates (as NO_3–N mg/l)	5.11	4.15	10
Total coliform (#/100 ml)	8	0	0
Faecal coliform (#/100 ml)	7	0	0

areas, Chazanga and Linda compounds, were selected based mainly on the good quality of buildings which would ease the fixing of gutters.

Pilot stations were to be preferably chosen where buildings have a roof and guttering in good condition in order to reduce the cost of the system. Recently built schools were likely pilot stations. However, these schools were found to have no roof gutters. Some had storm drains on the ground. One school was chosen as a pilot station while the remaining four were to be built at houses.

3.4. Socio-cultural survey

The population in the selected communities was estimated at 29,000 and 18,000 in Chazanga and Linda, respectively. The water situation in both communities was considered to be very poor. Most of the community obtained its water from shallow hand-dug wells while residents who could afford to pay got water from boreholes sunk by NGOs and the LWSC. In Linda compound, a stream running through the area was also used as a source of water.

Residents covered an average distance of 800 m from their homes to the water sources. Plastic containers of 20-l capacity were used to carry and store water. Women and children (both girls and boys) were the ones involved in drawing water for all households. Men only participated in cases where they stayed alone.

Households payed an average K3000 (US$0.7) per month for water with the amount restricted to 100 l per household per day which was not adequate. Although the amount was small, most of them had difficulties in paying.

Over 90% of the respondents had harvested and utilised rainwater on an ad hoc basis. Those that had never harvested rainwater before expressed interest in doing so. All the respondents expressed interest in harvesting rainwater using proper systems but expressed concern about its taste and debris in the collected water.

3.5. Design and construction of RWH systems

The size of storage tank chosen was 10 and 20 m³ for house and school installations, respectively. At the

school, two tanks were being constructed and would be operated in series. It was decided that a tank with a maximum size of 10 m³ be built. Since the tank size was fixed for different roof and family sizes, the amount of water drawn would be varied so that the water was available for the whole year. With 10 m³ of storage for a catchment of 120 m², the supply was 10 l per capita per day for the whole year for a household of six.

The Meteorological Department was still in the process of developing intensity duration frequency (IDF) curves. However, some IDF curves were available in some literature for one of the stations in Lusaka. The design rainfall used was 15 mm/h (Ettrick, 1990) and a gutter size of 100 mm height and 100 mm wide folded iron sheets was found adequate. Downpipe size of 75 mm PVC was used.

Ferrocement tanks which had been estimated to cost the least at US$470 for 10 m³ size in Zambia were selected. The tank were constructed using local labour and material. Shuttering alone accounted for one-third of the cost. By reusing the shuttering, the cost of the tanks could be reduced. The cost of plastic and steel tanks of the same volume was US$950 and 1150, respectively. Guttering was made from folded metal sheet. The other remaining components (pipework and first flush) were made of PVC.

3.6. Community participation

Local skills were used in the construction of the RWH systems. In Chazanga, where three systems were being constructed, 14 people were engaged in the work comprising 2 builders, 2 carpenters and 11 helpers, 6 of whom were women. Ten people were constructing systems in Linda consisting of 2 builders, 2 carpenters and 6 helpers, 5 of whom were women. More helpers than required were recruited in order to increase the number of people involved in learning the skills of constructing RWH.

4. Conclusions

Rainwater harvesting was a technology which existed in some parts of Zambia but it was not widespread.

Samples from a roofwater system showed that the water can be used for drinking. Although one can not draw conclusions on the water quality based on one sampling, the indication was that the water which would be harvested from the pilot stations could be used for drinking purposes. Construction of the RWH system chosen was possible using local skills, materials and equipment. Most of the residents expressed interest in harvesting rainwater but were concerned with its taste and debris in collected water.

References

Ettrick, T.M., 1990. An introduction to hydrology. Course Textbook CE 463. University of Zambia, pp. 70.

Murase, M., 1999. Creating a rainwater utilisation based society for sustainable development. In: Proceedings of the International Symposium on Efficient Water Use in Urban Areas, pp. 107–120.

Yachiyo Engineering Co. Ltd., 1995. The Study on the National Water Resources Master Plan in the Republic of Zambia.

Session reports, 1999. In: Proceedings of the International Symposium on Efficient Water Use in urban Areas, pp. 7–25.