PERCEIVED BARRIERS TO RAINWATER HARVESTING AS A SOURCE OF WATER SUPPLY IN BOTSWANA: CASE OF GABORONE CITY

Mothusi Selabe[1] and Mutakela K. Minyoi[2]
1. South East District Council, Physical Planning Office
2. University of Botswana, Department of Architecture and Planning
Email: minyoim@ub.ac.bw

Abstract
Water is considered as a finite resource and urban water supply is a growing issue for many cities and towns as they face rapid population growth, spatial growth and diverse urban activities. In most urban areas underground water levels are declining and the Authorities are struggling to meet the current and future urban water demands. As this process unfolds urban water suppliers are forced to search for new and more water sources. Rainwater harvesting is a potential avenue for source of water that has been exploited successfully elsewhere. Rainwater harvesting is gaining relative significance as an effective long term strategy for supplementing urban water sources. In spite of this, urban areas in Botswana are failing to consider and practice rainwater harvesting as a sustainable development strategy. Water demand is increasing but there are little efforts in harvesting and utilizing rainwater which is a decentralized, local and in-situ water source. In light of this the paper seeks to assess the levels of rainwater harvesting uptake in Gaborone, in particular, and to explore the constraints and opportunities of rainwater harvesting as a supplementary source of water. The paper finds that at household levels, rainwater harvesting is in its infancy stage to the extent that it does not augment the current water supply. Most households deal with rainwater by channeling it outside homesteads (plots) as a form of storm water management.

Keywords: ***Rainwater Harvesting, Urban Areas, Perceived Barriers, Conventional Water Supply, Gaborone City***

1. INTRODUCTION

The current water supply situation is very different from what it was in the past. Water has been a plentiful resource in most areas of the world including the urban areas. However, as population of societies continues to increase throughout the years, the water supplies remain constant. Worldwide water consumption is rising at double the rate of the population growth (Lekwot *et al*, 2012). As noted by Gilbert Houngbo (2018), Chair for UN-Water, with a rapidly growing population, demand for water is expected to increase by nearly one-third by 2050. Similarly the urban water consumption is continually rising due to the increased demand for urban water supply as a result of various and diverse urban activities such as construction, manufacturing and farming. Since water is considered as a finite resource, relevant authorities who deal with water provision are striving to maintain and improve the available water quantities and qualities as efficiently as possible by utilizing the available sources that are at our disposal such as rainwater harvesting (hereafter RWH). Rainwater harvesting is a decentralized source that offers a frequently over looked alternative and a supplementary water source. When compared to other sources of water, rainwater produces freshwater at minimal cost provided it is strategically harvested and managed (UN-Habitat, 2000).

In most urban areas, underground water levels are declining and the municipal supplies are struggling to meet the current urban water demands particularly in countries characterized by semi arid climatic conditions such as Botswana. Urban areas are heavily dependent on the conventional water supply system which is facing many challenges. These challenges pose questions about the adequacy and sufficiency of the system both in the short and long run. The supply standard seems unsustainable and extremely high on energy consumption that relevant authorities are spending a lot of money on infrastructure, distribution and management of water as to meet the ever rising water demand in urban areas. This demand is triggered by rapid urbanization as urban areas continue to experience rapid population growth, spatial growth as well as diverse urban activities. As this process continues, urban water suppliers are forced to search for new and more expensive water sources as is the case with Gaborone City, Botswana, which gets some of its water from Letsibogo Dam, in the northern part of Botswana, via the North South Water Carrier.

The main objective of the paper was to investigate the perceived barriers to rainwater harvesting as a supplementary source of water to conventional water supply in urban areas, with specific reference to Gaborone City. Thus, the secondary objective of developing such a paper was to provide feasible recommendations that will lessen the identified barriers that urban areas face in practicing rainwater harvesting. The main results of this paper are based on the information obtained from the survey conducted in selected neighbourhoods of Gaborone City. The study combined a desktop and field survey approach. The desktop survey was undertaken to not only identify but also to ascertain whether or not there were any perceived barriers to rainwater harvesting generally in Botswana. Field survey was conducted through the use of household questionnaires and interview question checklists for key informants. The intention was to collect information on the perceived barriers to rainwater harvesting practices from households, as well as to garner experts' knowledge in rainwater harvesting from key informants.

The paper will firstly discuss rainwater harvesting practices across the world which will be followed by a general discussion of experiences of rainwater harvesting in Botswana. Then this will be followed by the presentation and analysis of findings from the study undertaken in Gaborone City while the last section forms the conclusion of the paper which also outlines the possible solutions to the identified barriers.

2. INTERNATIONAL EXPERIENCES OF RAINWATER HARVESTING

Rainwater harvesting is an ancient practice that has been used around the world for many years and continues to be widely used to this day. The exact origin of rainwater harvesting has not been determined (Gould and Nissen-Peterson, 2005). The oldest known examples are associated with the early civilization of the Middle East and Asia. Many different civilizations have used this technology for agricultural purposes in rural areas. The Philippines have been using rainwater for rice terrace for thousands of years now (Leung, 2008). The Indian history indicates that rain water systems have been used since 3000 BC where simple gutters were used to fill the jars and pots. In the 1960's a new technology of rainwater harvesting was developed where water was stored in wells, that is storage tanks in the form of different sized ponds.

Although rainwater harvesting was a significant and successful design in the past, its popularity has declined over the centuries. During the twentieth century, the use of rainwater techniques declined around the world mainly due to urbanization (Gould and Nissen-Peterson, 2005). Urbanization brought along provision of large, centralized water supply schemes such as dam building projects and piped water distribution systems. However, due to the increasing water demands in the last few decades, there has been an increasing interest in the use of harvested rainwater with an estimated 100 million people worldwide currently utilizing a rainwater system of some description (Heggen, 1995).

International experience with rainwater in urban areas is on a learning curve but growing at a rapid pace. The increasing demand for water in urban areas has accelerated and revived the old system of rainwater harvesting with more advanced technology being adopted. The concept of rainwater harvesting has been accepted by many cities, governments and societies in different countries around the world. According to UN-Habitat (2000) there are many success stories of rainwater harvesting in developing and developed countries.

2.1 Australia

In Australia a study was done through the United Nations Environment Programme (2009) and it came to a conclusion that Australia's urban areas depend much on large surface reservoirs for water supply. It added that these sources are highly overused due to rapid urban growth and severe drought conditions during the current decade. The study also mentioned that to ensure long term sustainability of urban water supply, various alternative water sources including rainwater harvesting, grey water, wastewater and desalination of plants are being examined in Australia. In the previous year, it has been shown that rainwater harvesting in tanks of appropriate size which were installed in detached small dwellings can meet a significant proportion of household water demand.

2.2 France

France has few installed rainwater harvesting systems in its urban areas such as Albi and Beauvais townships (Rahman and Yusaf, 2000). Those that do exist are often simple, inefficient and used mainly for garden irrigation, with the domestic utilization of rainwater for flushing toilets and washing machines being virtually non-existent. This low uptake is attributed primarily to the organization of the French water supply system which is essentially a set of regional monopolies that have no incentive to introduce rainwater harvesting techniques since it would reduce their profits (Koenig, 2003).

2.3 Sweden

In Sweden, increasing urbanization and the widespread use of large-scale centralized treatment has resulted in a water supply system that is vulnerable to shortages and water quality deterioration. In recent years, rainwater harvesting was adopted and it is solely used for non-potable uses in order to reduce the amount of water required from the public supply system for urban developments (Villarreal and Dixon, 2005).

2.4 Tanzania

According to Lekwot *et al* (2012) although in some parts of Africa rapid expansion of rainwater harvesting systems has occurred in recent years, progress has been slower than in Southeast Asia. This is mainly due to the low rainfall pattern experienced and lack of information on rainwater harvesting. That notwithstanding, due to inadequate piped water supplies, the University of Dar es Salaam has effectively applied rainwater harvesting and utilization technology to supplement the piped water supply in Monkira neighbourhood where its staff houses are located. Rainwater is collected from the roofs and channeled into storage tanks. From there it goes to several filtration tanks before being pumped to a distribution tank that is connected to the plumbing system of the staff houses.

2.5 South Africa

The country has well developed water system for formal urban areas. However, there is a considerable evidence of rainwater harvesting schemes being implemented decades ago before the municipal services were available. Urban areas are mainly supplied with conventional water supply systems and there is evidence of an old rainwater harvesting system which is sometimes still used (Kahinda *et al*, 2007). At the time of the first democratic elections, South Africa was very poorly served with water supplies. A severe drought in 1992 highlighted the weaknesses in the operation and maintenance of the conventional water supply system in most of the urban areas in the Eastern Cape Province (ibid). However, there are situations where rainwater harvesting offered at the very least an important supplement to existing or traditional sources. In some parts of the Eastern Cape Province, many householders have installed corrugated iron rainwater tanks of their own accord with no external assistance (ibid).

3. BOTSWANA’S EXPERIENCE ON RAINWATER HARVESTING

In Botswana, the concept of rainwater harvesting has a long history. In literature it has been indicated that domestic rainwater harvesting has been used in Botswana at a small scale for a long time (Botswana Technology Centre, 2006). However the adoption of the traditional knowledge and practices on rainwater harvesting has been abandoned in many parts of Botswana after implementation of conventional water projects (Kamutati, n.d.). That notwithstanding, since the early 1980s, there has been a renewed interest in rainwater harvesting projects in Botswana but it is still at infancy stage (Botswana Technology Centre, 2006). Recently, the Government of Botswana has built rainwater storage tanks at many schools, clinics and administration offices across the country.

Rainwater harvesting has being implemented and utilized successful in some parts of Botswana, like in Shoshong. This village is supplied with mains water via the ‘North South Carrier’, but it experiences seasonal water shortage. As a result, rainwater harvesting has been adopted as a supplementary water source. Several institutions such as Shoshong Senior Secondary School are practicing rainwater harvesting. The collected water is mainly used for maintaining water supplies for sanitation and easing pressure on valuable potable water or mains pipelines for consumptive use (Bolaane and Ikgopoleng, 2011). To combat the problems regarding the conventional water supply, the Water Conservation Unit at the Department of Water Affairs is working diligently on rainwater harvesting projects. The Unit has completed a project on rainwater harvesting in Shoshong Senior Secondary School, which is to be transferred to other areas across the country. The Department is also publicizing rainwater harvesting as a viable source of freshwater when stored properly.

Rainwater harvesting has been identified as a potential avenue for source of water that has been exploited successfully elsewhere and is not new to Botswana. It is an immediate source to augment the conventional water supply system by catching rain water wherever it falls (Lekwot *et al*, 2012). Countries across the globe have started considering and practicing rainwater harvesting as a sustainable development strategy. In spite of this, urban areas in Botswana including Gaborone are failing to take advantage of rainwater that is at our disposal because of some perceived barriers that results in the low uptake of rainwater harvesting. The key indicators of failure to venture into rainwater harvesting include the limited number of households who practice rainwater harvesting at the household level, and the existing water supply and water requirements which seem to provide an impression that water is abundant and readily available. The current method of supplying urban population with water tends to limit people from using other methods, including rainwater harvesting. It appears all water requirements are met by this supply, but this comes at an extra cost which could be greatly reduced by harvesting and utilizing rainwater.

4 IDENTIFIED BARRIERS TO RAINWATER HARVESTING IN GABORONE CITY

The major findings of the paper show that there are five main barriers that deter the implementation of rainwater harvesting in urban areas and there are discussed as follows: the building design, method of rainwater harvesting, acceptability of rainwater, the intensity and amount of rainfall and lack of information and technical knowledge.

4.1 Building Design

The efficiency of rainwater harvesting is dependent on the design of the building (Rahman and Yusaf, 2000). There are some designs that ensure optimal rainwater harvesting and those which are a barrier to rainwater harvesting or enable minimal collection of rainwater. Generally a building design with a regular roof shape is desirable and the most suitable for rainwater harvesting. While irregular or overlapping roofs have a minimal catchment area for rainwater harvesting. Key informants highlighted that this type of house/building design tends to limit the possible amount of rainwater that could be harvested. Furthermore, irregular roof shapes increase the cost of installing rainwater harvesting; hence it is a financial constraint for households to install the rainwater harvesting system. For example, the same house with the same footprint as the house with a regular roof shape will require more rainwater harvesting materials and often skilled personnel to install the system. There is a lot of cutting and joining of gutters thus the developer often reduces the cost of building by leaving out the option of rainwater harvesting.

During the field survey, just over half of the surveyed households (58%) were living predominantly in detached houses. This type of building design is mainly characterized by regular roof shapes and these were the ones that could ensure maximum utilization of the catchment area for rainwater harvesting. It was observed that a third to the whole of the roofs (the catchment area) could be utilized for rainwater harvesting, because the roofs had gutters. However, rainwater harvesting was not practiced by these households because other sides of the roofs either had no gutters or had gutters but were not connected to the storage facility.

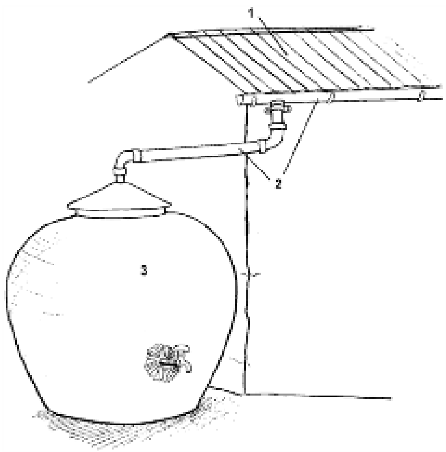
The other 42% of surveyed households had houses with irregular and/or overlapping roofs meaning that the catchment area utilized for rainwater harvesting was less than half of the entire building's roof. These houses were mainly semi-detached townhouses and flats. Because a small catchment area is available in these types of buildings, there is a loss of potential rainwater that could have been harvested, to supplement the conventional source of water supply in the yard.

4.2 Methods of Rainwater Harvesting

There are several methods of rainwater harvesting that are widely used across the world and there are broadly categorized into two; micro and macro rainwater harvesting (Prinz, 2011).

The paper focuses on the micro category because it is the one applicable in urban areas, especially in built up areas. Although the rainwater harvesting methods vary, there have few things in common, namely the catchment area (1), the conveyance system (2) and the storage facility (3) as shown in Figure 1.

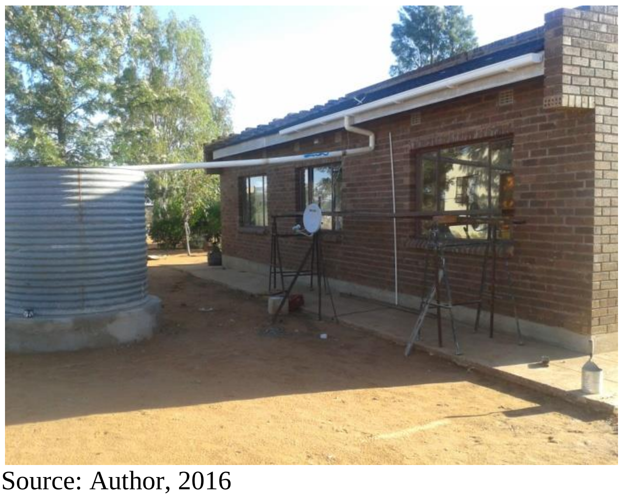
Figure 1: Basic components of a Rainwater Harvesting System.



Source: Sen, 2012

The predominant method of rainwater harvesting is the rooftop system which is commonly used worldwide, even in Gaborone City (see Figure 2). This method provides the water where it is needed and the absolute control of the system lies with the occupant of the building. The quality of the harvested rainwater from the rooftop is usually clean provided proper installation and maintenance is followed (Sen, 2012). After assessing the various methods, the rooftop method was revealed to cost the least among them (ibid). According to Sen (2012) the associated costs of installation, operation and maintenance of the rooftop rainwater harvesting system are relatively low when compared to other methods of rainwater harvesting. In Kimberly, South Africa, it is said that the rooftop method can provide an average of 30 600 litres per year from the rooftop surface of $100m^2$ of a typical 'RDP' house. The amount meets the demand of a household of five for nearly six months and it is cost effective (Baker *et al*, 2007).

Figure 2: A Simple Rainwater Harvesting System (The catchment area, Conveyance system and Storage facility).



Source: Author, 2016

Most of the surveyed households in Gaborone City had a roof surface of more than 100m^2. However, the households were harvesting minimal rainwater or none at all for two main reasons. Firstly, from the field survey, the households perceived the cost of the rainwater harvesting system to be high. This was also reiterated by property developers who are profit orientated. One of the leading property developers pointed out the cost of installing the system as their biggest barrier. That is how many years of water saving in money will it take to pay for the system. Of the cost of installation, this study found out that the storage tank represents the largest investment which can vary between 30% and 45% of the total cost of the system depending on the system size. Secondly, there are some households who indicated that their small storage facilities more especially in the low income neighbourhoods, which have small plot sizes, tends to limit rainwater harvesting such that the system cannot provide water for longer periods.

The other method of rainwater harvesting is the land surface catchment which uses the ground or land surface as the catchment area. It is a less complex method compared to the rooftop rainwater harvesting method (Fai and Lo, 2005). This method provides an opportunity for harvesting rainwater from natural surface areas such as rock outcrops/slopes or man-made surfaces such as concrete surfaces, plastic sheets or treated ground. The harvested rainwater is mainly used for non-potable uses and extra costs are incurred when harvesting the water for potable uses (Appan, 1993). The land surface method was not observed to be used by households in Gaborone City. For it to be used, it needs groups of individual households working together to operate and maintain the surface.

4.3 Acceptability of Rainwater Quality

Rainwater harvesting is an accepted freshwater augmentation technology in many parts of the world (Hartung, 2009). However, the acceptability of the practice is mainly influenced by the quality of the harvested rainwater. In Gaborone City, the quality of rainwater was voiced by 44% of the surveyed households as a major barrier that deterred rainwater harvesting. Households indicated that the harvested rainwater is unhygienic because of bacteriological contamination from bird’s droppings and intrusion of small mammals (rats, bats etc) among other things in the gutters and storage facilities.

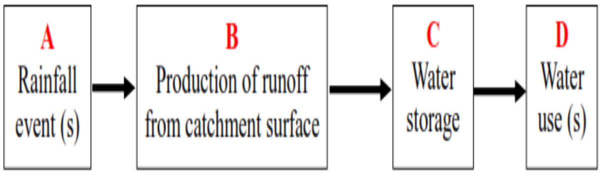
However, key informants who indicated to have been involved in various rainwater harvesting projects are convinced of the exceptional quality of rainwater (or that its quality can be kept high). According to a key informant at Botswana Institute of Technology Research and Innovation (BITRI), there is still a misconception of rainwater getting bad over time when stored. This is actually not true as the research by Arizona Department of Water Resources at the University of Arizona has shown that rainwater quality gets better with time when certain criteria are met (no light into the storage, protection from whatsoever animals, aeration).

4.4 The Intensity and Amount of Rainfall

In general, Gaborone is said to receive 530mm of rainfall per annum. However, both the surveyed households and the interviewed key informants perceived the low rainfall in Gaborone as a barrier to rainwater harvesting. This contributes to a low uptake in rainwater harvesting and households are also reluctant to take the practice on board as most households also have catchment areas of less than 230m^2. During the rainy periods, the households reckon they can harvest minimal rainwater which can only sustain the households for a few weeks. This leaves households relying much on the provision of conventional water supply.

The feasibility of rainwater harvesting in a particular locality is highly dependent on the amount and intensity of rainfall (Heggen, 1995). In ensuring the sustainability of rainwater harvesting, the variables shown in Figure 3 are fundamental in rainwater harvesting. These variables are dependent on each other.

Figure 3: Flowchart demonstrating fundamental rainwater harvesting processes.



Source: Heggen, 1995

The first variable is rainfall event; the amount of rainfall the area receives affects the level/efficiency of rainwater harvesting. The amount of rainfall received is generally categorized into three levels, namely low, medium and high rainfall. Whatever is possible to catch during the rainfall event influences the other variables in the process. The second variable is the catchment area which is dependent on the amount of rainfall received in the area as shown in Table 1. There are other external factors that influence the size of the catchment area such as the building type, household income etc. With the availability of rainfall and the appropriate catchment area, the storage facility which is the third variable comes in place. The amount of rainfall and the catchment area could then determine the size of the storage facility which will in turn, influence the water usage for a set period of time. The other external factors influencing the amount of storage facility is the household water demand, household income and cost of alternative source of water.

For optimal and sustainable rainwater harvesting in areas experiencing low rainfall, the second variable being the catchment surface has to be relatively large though there will be a limited period for uses of the harvested rainwater. In the other scenario where rainfall is high, the catchment area has to range from medium to large areas with a larger water storage facility that will lead to more diverse uses of water over an extend period of usage.

Table 1: Rainwater harvesting variables

Rainfall Event (annual)	**Catchment Area**	**Water Storage**	**Water Use (s)**
Low (350mm or less)	Large (above 500 m^2)	Medium (5000*l* – 7500*l*)	Limited period and limited uses
Medium (351mm – 600mm)	Medium (250–500 m^2)	Medium (5000*l* – 7500*l*)	Limited to diverse uses over moderate periods

High (601 mm or above)	Medium/Large	Large (10 000*l* or above)	Extended period and diverse uses

Source: Heggen, 1995

4.5 Lack of Information and Knowledge.

Despite the fact that rainwater harvesting is not a new practice in Botswana, there is still lack of knowledge on rainwater harvesting more especially in urban areas. Knowledge on rainwater harvesting plays a critical role in creating awareness, influence policy formulation and encourage adoption of various and advanced technologies of modern times (Kahinda *et al*, 2007). However, what was observed during the field survey shows that households have solely transferred the traditional ways of harvesting rainwater from rural areas to urban areas. Households still use simple rainwater harvesting systems that consist of simple utensils namely buckets, large open dishes and 200 litre drums. In this way, households that practice rainwater harvesting use the rainwater mainly for non potable uses (watering the lawn, car washing among others) and rely on conventional water supply for potable uses.

According to key informants in rainwater harvesting, separating the rainwater harvesting system and the conventional water system tends to escalate the cost for the household. For example, there has to be separate plumbing for both the supplies. They also voiced their concern on lack of government support in terms of policies and building regulations that will ensure that rainwater harvesting is made mandatory more especially for new developments. For example, if rainwater harvesting was a mandatory requirement considered when issuing a building and planning permission, a significant portion of households would have been aware of rainwater harvesting and even having the system in their yards. Thus the involvement of the government is key in influencing the implementation of rainwater harvesting strategies (Kahinda *et al*, 2007). Currently, the Department of Water Affairs has a public awareness program that sensitizes the public on rainwater harvesting.

5. CONCLUSION

The paper concludes that although the knowledge of rainwater harvesting has increased, there are some barriers that deter households from installing rainwater harvesting systems even in new houses. It is further acknowledged that the implementation of rainwater harvesting will continue to be limited whilst these barriers remain and unresolved. As a result the efforts to reduce the consumption of potable water from conventional sources that the authorities are spending a lot on will continue to be limited.

The paper also concludes that rainwater harvesting should be considered as a holistic approach for sustainable development management of water resources with great awareness among the urban communities. This will easily disseminate and promote rainwater harvesting that requires user involvement thus eliminate the impact of relying on conventional water supply for urban water demand.

As people increasingly live in urban areas, it is important to promote urban systems that contribute to sustainable development such as rainwater harvesting. A significant portion of the urban areas is built up and can be put to good use by channeling the rainwater surface run-off. This will reduce the loss of potential rainwater which most households deal with by channeling it outside the homesteads as a form of storm water management.

To that effect the following basic measures can begin to address the identified barriers to rainwater harvesting in the study area:

a. The Building Control Act should be amended to incorporate rainwater harvesting systems in all new developments. Specifically, planning permission should be issued when a proposed development has a functional rainwater harvesting system. As it was indicated earlier, newly built houses are not doing enough to harness rainwater although the country at large is facing water challenges.
b. Formulation of rainwater conservation plans and government policies such as tax incentives for households who play a role in water conservation.
c. Institutional mandate - rainwater harvesting should be somebody's responsibilities as opposed to independent, uncoordinated initiatives as is the case now. The government, NGOs and the individuals who are capable should come to aid the households to break the identified barriers to rainwater harvesting.

REFERENCES

[1] Appan A. (1993). The utilization of rainfall in airports for non-potable uses. Proceedings of the 6th International Conference on Rainwater Catchment Systems. Nairobi, Kenya.

[2] Baker S., Grygorcewicz E., Opperman G. and Ward V. (2007) Rainwater Harvesting in Informal Settlements of Kimberly, South Africa. Worcester Polytechnic Institute.

[3] Best R. and De Valence G. (2004). Building in value: pre-design issues. Architectural Press.

[4] Bolaane, B. and Ikgopoleng, H. (2011). Towards Improved Sanitation: Constraints and Opportunities in Accessing Waterborne Sewerage In Major Villages Of Botswana. Habitat International 35(3): 486-493.

[5] Botswana Technology Centre. (2006). Feasibility Study on Rainwater Harvesting. Proceedings of the Workshop on Project. Botswana Technology Centre, Gaborone, Botswana, pp. 8–9, March 2006.

[6] Fai, K. & Lo, A. (2005). Rainwater harvesting – An alternative water resources in Taiwan. Proceedings of the 12th International Conference on Rainwater Catchment Systems. New Delhi, India, pp 89, November 2005.

[7] Gould D. and Nissen-Peterson E. (2005). Rainwater catchment systems for domestic supply: design, construction and implementation. London: Intermediate Technology Publications.

[8] Hartung H. (2009). Domestic rainwater harvesting: Perceptions of water professionals and the way forward. Proceedings of the 15th Rooftop Rainwater Harvesting. Germany, pp. 11–12 October 2009.

[9] Heggen, R. (1995). Rainfall intensity and Rainwater catchment. Proceedings of the 7th International Conference on Rainwater Catchment Systems. Beijing, China, pp. 69, June 1995.

[10] Kahinda J. M., Rockstrom, J., Taigbenu A. E. and Dimes J. (2007). Rainwater harvesting to enhance water productivity of rain fed agriculture in the semi-arid Zimbabwe. Physics and Chemistry of the Earth, Vol 9(6), pp. 68–70.

[11] Kamutati A. (n.d.). Rainwater Harvesting for Rural Supply. Unpuplished report. Gaborone, Botswana.

[12] Koenig, W. K. (2003). Rainwater harvesting: Public need or private pleasure? World Water Forum. Kyoto City, Water Development Board.

[13] Lekwot V. E., Samuel I O., Ifeanyi E. and Olisuemeka O. (2012). Evaluating the potential of rainwater harvesting as a supplementary source of water supply in Kanai (Mali). Global Advanced Research Journal, Vol 1(3), pp. 4–5.

[14] Leung, J. (2008). Rainwater Harvesting 101. New York, GrowNYC.

[15] Prinz D. (2011). The Concept, Component and Methods of Rainwater harvesting. 2nd Arab Water Forum. Cairo, Egypt, pp 10, November 2011.

[16] Rahman, M. and Yusaf, F. (2000). Rainwater harvesting and the reliability concept. ASCE Speciality Conference on Probabilistic Mechanics and Structural Reliability. University of Notre Dame.

[17] Sen P. (2012). Implementing Rainwater Harvesting Methods. Journal of Humanities and Social Science. Vol 5(1), pp. 1 – 5.

[18] Villarreal, E. and Dixon, A. (2005). Analysis of a rainwater collection system for domestic water supply in Ringdansen, Norrköping, Sweden. Building and Environment, 40(16), 1174.

[19] UN-Habitat. (2000). Rainwater Harvesting and Utilisation. Blue Drop Series, 7–8.