Print ISSN: 2671-4981 / Online ISSN: 2671-499X
JBEES website: http://www.jbees.or.kr/
Doi: 10.13106/jbees.2020.vol10.no4.29

Rainwater for Water Scarcity Management: An Experience of Woldia University (Ethiopia)

Venkatesh ANDAVAR[1], Bayad Jamal ALI[2], Sazan Ahmed ALI[3]

Received: April 15, 2020. Revised: May 14, 2020. Accepted: October 05, 2020.

Abstract

Purpose: Town of Woldia, a semi-arid region in the Northern Wollo region of Ethiopia, faces water supply shortage in general, though the town possesses a running stream of clean water throughout the year. This study is aimed at analyzing the possibility of using rainwater for water scarcity and non-potable water needs of the Woldia University. A careful study and analysis have been made to assess the feasibility of using rainwater in place of the tap water supply. **Research design and methodology:** This study was done inside the main campus of Woldia University located in Woldia town. The runoff water from the roof of buildings was studied, by the time of rainfall in the town. Also, the budget needed for implementing a rainwater harvesting system was calculated. **Results:** The findings of the study clearly indicates that the requirements of the water to use for flushing, cleaning, and washing toilets in the administrative buildings and classrooms can be satisfied by using rainwater as an alternative to tap water. **Conclusion:** Based on the results the study finds it is benefitable for the Woldia University to install the rainwater harvesting system at the earliest to solve the water problems prevailing in the current situation.

Keywords: Rainwater, water scarcity, water supply, scarcity management, Ethiopia

JEL Classification Code: M10, M14, M19, Q25

1. Introduction

Water is one of the major resources of Ethiopia due to its large amount of annual rainfall. However, the people of Ethiopia still have a long way to go in satisfying their daily water needs for both drinking and sanitation; especially in rural regions of Ethiopia. Though rural water supply has improved in supplying water for 35 million people between the periods of 1994 to 2015; (WASH. World Bank 2018), the demand for water is still beyond capacity. In Woldia, water that are available on surface are mostly seasonal and permanent streams (Semaw 2018) and are pumped, purified, and chlorinated for the households of the town. The inception of Woldia University in the year 2011 has increased the number of population by bringing approximately 12,000 regular and weekend students, summer class students, and staff community into the town. With it, the demand for water kept increasing, but the supply remained the same. As a result of such an increase in demand the water is supplied only on specific days in a week for the residents in the Woldia town. Even with three different water supply connections from the Woldia water supply and sewer authority, the university faces a severe water shortage to satisfy the needs of the students in the dormitory, for the staff in the administrative buildings and for both teachers & students in class rooms and lecture hall buildings. As such, the use of rainwater to eradicate this water shortage is proposed to Woldia University, where

1Corresponding author: Assistant professor, Business Administration Department, College of Business, Komar University of Science and Technology, Sulaimani city, Kurdistan Region-Iraq. Email: venkatesh.andavar@komar.edu.iq
2Lecturer, Business Administration Department College of Business, Komar University of Science and Technology, Sulaimani city, Kurdistan Region-Iraq.
Email: bayad.jamal@komar.edu.iq
3 Business Administration Department, College of Business, Komar University of Science and Technology, Sulaimani city, Kurdistan Region-Iraq - Email: sazan.ahmed@komar.edu.iq

there are approximately 69 buildings with similar lengths and widths that are very suitable for collecting rainwater from its roof catchment area. Every building with the roof area of 640^{m2} is able to collect 5, 72,544 liters of rainwater with the given average rainfall of 99.4cm (in the months of June, July, August and September). By doing so, the university can make water available for sanitation and washing; and can solve conflicts in sharing of resources. Most importantly, this cost-effective system would save a huge amount of money that can be invested in improving the water supply capacity on the main campus of Woldia University.

1.1. Study area

This study focuses on Woldia University located in the town of Woldia in North Wollo Amhara region of Ethiopia. Operating with 24 departments under 6 faculties; the university covers a total area of 196 hectares of land. Woldia University as a non-profit higher education institution, which hosts regular, weekend and summer class students from all over the country, work throughout the year. Water supply is not always available from the tap water connections that are found inside the toilets of the buildings and also from the taps found in the open areas of the university. As a result, the students and working community population generally face the problem of lack of enough water to wash hands, and to use in toilets. Due to lack of trees, except for a few, and remote location, the university has little or almost no debris deposit on the roof of its buildings, and this makes them very suitable for rainwater harvesting from the roof catchment. Hence, the study has been conducted on the Faculty of Business and Economics building to calculate the potential of roof catchment from the annual rainfall.

Source: Collected from Google Maps

Figure 1: Aerial View of Woldia University Main Campus in Woldia Town

1.2. Objectives of the study

The main objectives of this study are as follows:

i. Find out the possibility of collecting, storing and using rainwater from roofs of the buildings in Woldia University
ii. Provide solution to the problem of water scarcity for non-potable needs in the main campus of Woldia University
iii. Make rainwater available to the community of Woldia University on a daily basis for sanitation and washing–
iv. Calculate the cost of rainwater harvesting and storing in Woldia University

2. Literature review

A study by T. Thomas (1998) states that where surface water is absent, ground water is polluted and pipe supply is unaffordable, domestic water demand can be met partially or whole by collecting roof water from rain. This study gives a strong recommendation to use rainwater based on facts. In another study by Alem (1999) various facts were surfaced out with respect to suitability, need, justification and cost effectiveness of using rain water for daily use in households as an alternative for tap water supply. He also points out the suitability of the rainwater harvesting system in rural areas where centralized water supply is nearly impossible and could be expensive. It can be noticed from this study that, cost of installing a rainwater harvesting system is not expensive in all the times i.e. from past to present. Meanwhile, the results of the research that was done by Qiang (2003) I n China; recommends that rainwater is the most easy-to-use water source with a high potential, and it is reasonable to mainstream rain water harvesting in integrated water resources management.

Based on the study of 50 households by Dwivedi and Bhadauria (2006) in Dhule town of India, rainwater can be used for drinking water for the domestic users and the excess water can be used to recharge the groundwater to increase the ground water table. They also argued that the cost benefit of rainwater harvesting system is very much favorable for households as rainwater harvesting is beneficial based on the given rainfall data. Research conducted by Dakua et al. (2013) in Dhaka city in Bangladesh has mentioned that rainwater harvesting could be the low cost technique to reduce dependency on the water suppliers. It is also mentioned that, rainwater harvesting can help in reducing ground water extraction and costs associated to it. Later on, Hajani and Rahman (2014) had found that; in all the ten locations they investigated in peri-urban regions of Greater Sydney, Australia, 96%-99%

of water needed for toilet and laundry use has been met with harvested Rainwater in 5 Kiloliters tank and that the same tank can meet 69% to 99% of water needed for toilet and laundry uses even in the driest years.

A transformation story of "His Grace Primary School" in the village of Kkona, Uganda, states that the installation of simple rainwater harvesting system in December 2016, with a Polyethylene tank on a cement base, had changed the routine of kids by saving time from fetching water from a well of 2 kilometers away. Moreover the money spent on fetching water was reinvested in planting maize and beans, which provided lunch to the students (UWP project, 303, 2017). Ojha, and Gupta, (2016) in their research, states that, the effectiveness of rainwater collection will depend on the appropriate design of the system, or it would lead to rise in operational and maintenance cost. Further, a research that was concluded by Mandloi, et al (2016) in Indore city of India, where the ground water supply was over utilized, the rainwater harvesting and storing it underground was found to be a good and effective water management solution, as it has proved to be of low running costs as compared to its benefits

A study by Dismas, et al. (2018) in Kinondoni municipality of Dar es Salaam city in Tanzania has revealed that, the collection of rooftop rain water can provide better quality water than other sources. But the initial investment cost and lack of knowledge about the rainwater harvesting system hinder the use and installation of rainwater harvesting system. Another research was made by Adugna, et al. (2018) to investigate the feasibility and potential of rainwater harvesting in public institutions located in Addis Ababa city of Ethiopia, where the tap water supply is estimated to be 94 liters per person a day. And the findings also revealed that the alternative supply capacity of rainwater to tap water can be low at a city level. The visible challenge is the cost of the water tanks to be installed with the rainwater harvesting system.

All the above research and studies seem to be supporting the collection of rainwater using any simple method to resolve the scarcity of water for daily use under various conditions and environment irrespective of the geographic locations. With a great amount of annual rainfall, harvesting rainfall could give an optimum solution for the water scarcity in Woldia University.

3. Research Methodology

The study was done as an exploratory research by using literature review and collection of first hand information from the Woldia University. The University has 69 buildings of similar design and size which are perfectly suitable for harvesting rainwater from the roof top. The sizes of the roofs were measured manually and were found that they were within the measurement of 640m^2, and all of them were made of corrugated iron sheets. The rainfall data were collected from the, "Water Resources and Irrigation Engineering" department of Woldia University for calculation of average rainfall and were verified with the online sources- https://en.climate-data.org/. With the average rainfall of 99.4 cm in Woldia, in general, the roof of one single building will collect 5, 72,544liters of rainwater on average.

3.1. Hypotheses of the study

Collecting and using rainwater as a substitute to the tap water, where it is not available in sufficient amount, is a known practice in Ethiopia, and dates back as early as 560 BC, during the Axumite kingdom (Seyoum 2003). Hence it is evident that the alternative for tap water could be the rainwater, which can be used directly after collecting it from rain storm, especially for non-potable needs by the residents in a town or city or a specific location. Since such a practice is overlooked- in a place like Ethiopia, which receives a heavy rainfall in most of its landscape, the practice of rainwater harvesting should be reminded and suggested wherever it is found to be possible. After considering those facts, the hypotheses were made for this study. The main hypotheses of this study are as follows:

H_{A1} Using rainwater in place of tap water for non-potable water needs like washing and toilet uses will solve the problem of water scarcity in Woldia University Main Campus

H_{A2} Collecting and storing rainwater in 20000 liter polyethylene tank can provide water for non-potable needs of 6000 liters per month, in Woldia University Main Campus

3.2 Roof Catchment Capacity:

The roof area of the selected building for rainwater harvesting is 640 m^2. So the amount of water to be collected with the given average rainfall could be calculated as given below:

Roof surface area x mean annual rainfall x runoff coefficient
Roof surface area is 640m2
Mean annual rainfall is 994 millimeters
Runoff coefficient for iron roof is 0.90

640 x 994x 0.90 = 5, 72,544liters of water in average

Heavy annual rainfall in Woldia last from June to

September, but there will be rainfall in different measures all through the year. With the given amount of rainwater runoff, the 20,000 liter polyethylene water tank will be filled in 12 minutes, which can provide water for non-potable water needs for atleast next three months of the rainwater harvesting.

3.3. Demand for water in the university

Woldia University consists of employees working inside identical building blocks of ground plus two buildings and usually has approximately 20 staff members, including teaching faculties, administration staff and secretaries, on every floor. Those staff members of the university use water only in the toilets located in the respective floors of the buildings. The three floor buildings contain three toilets, with one on each floor. The water is usually filled in a 100 liter plastic drum kept inside the washrooms, and a plastic container of about 3 liters (reusable paint container made of plastic) is used to flush the toilet and to wash hands. Those water drums are refilled manually from the tap water connections inside the washrooms in all of the three floors, because the water from tap is not always available. At the present time, the cleaning staffs fetch the water from the tap connection inside the toilet and fill the plastic drum every day. When there is no water from the taps inside the toilets, they carry water in buckets from the nearby taps in the garden ground next to the buildings to fill the plastic drum. (Water tap inside the toilet and the taps on the ground garden area are from different water supply connections).
The teaching faculty members usually do not present themselves regularly in all the work days from Monday to Friday, but they would be available in the office for research guidance and teaching classes in an average of three days in a week. As such, the average number of individuals present in a day would be more or less 10 persons in a floor. Based on this, the per capita need for water in the buildings is calculated as follows:

Average water needed in an 8 hour working day in a building:

Water needed per individual = 30 liters
So, 10 individuals x3 floor = 300 liters per day for a building
And for a 20 days working day in a month, the water need would be;
300x20=6000 liters per building for a month

By fixing a 20,000 liter water tank next to the buildings and connecting the gutter pipes from the roof of the buildings to the tank with a T-valve pipe for first flush, rainwater can be directly collected into the tank. The tap fixed to the bottom of the tank will be used to collect water and to fill it manually into the 100 liter-plastic drum in all three floors of the building.

4. Results and Discussion

With the given amount of annual rainfall and runoff from the roof of the selected buildings in Woldia University, the water scarcity can be easily solved by collecting the rainwater and using it for non-potable needs. From among the non-potable needs, 85% of the water needed is for toilet use, and it can be fully satisfied with the help of harvesting and storing of rainwater in the 20,000 liter plastic tanks in every building. Since the 20000 liter tank will supply water for three months of daily usage from the time of rainwater harvesting, the water can be used as per the needs. Also the occasional rainfall which falls in different periods of the year can supply rainwater to recharge the water tanks. The numbers of water users in all of the buildings are calculated as follows: 60 individuals in a building x 69 identical buildings = 4140.Therefore all the 69 buildings of similar size hosts 4140 individuals inside Woldia University.

The above calculations of rainwater harvesting potential, daily water need of the users in the 69 identical buildings and their counts in number 4140 clearly gives evidence that the water needs for non-potable toilet use can be fully met by investing on and harvesting rainwater from the roofs. All of the 69 buildings with the similar size can be installed with the rainwater harvesting system and can be used for collecting the enormous amount of water from the seasonal rainfall at the main campus of Woldia University. The cost of installing such a rain water harvesting system in one single building is calculated and presented below:

4.1. Cost calculation for system installation per building

4.1.1. 20,000 liter Polyethylene plastic storage tank – 38000 Birr (Ethiopian currency)

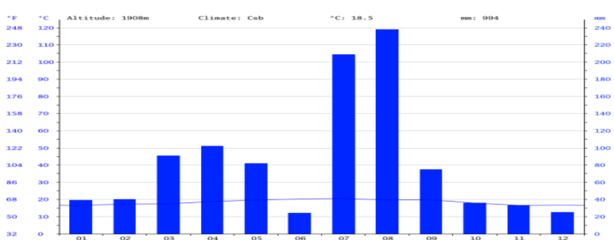
i. PVC pipes of 5 inches 10 meters – 280 Birr
ii. Metal tap to fit in the storage tank – 150 Birr
iii. T- valve with flush facility – 760 Birr
iv. Connecters and fixtures – 270 Birr
v. Sealer – 150 Birr
vi. Metal filter piece (mesh net) - 35
vii. Plastic bucket with jug -- 1(price 150 Birr)
viii. Metal lock -------------- 2(price 200 Birr)
ix. Broom ------------------- 1piece – 60 Birr
x. Building materials cost break down
   a. Bricks 15 cm size each 9 birr… 50x9=450 birr

b. Cement 10 kilograms …. 4 birr per kg – 4x10 = 40 birr
c. Sand 100 birr for 25 kg sack – for 3 bags 3x100=300 birr
d. Wages to mason and a helper =250+150=400
1. Cost of labor to clean the roof before first flush –300Birr
2. Cost of labor for installation of the system – 250 Birr

4.1.2. Total cost = 41795Birr (1290 USD)

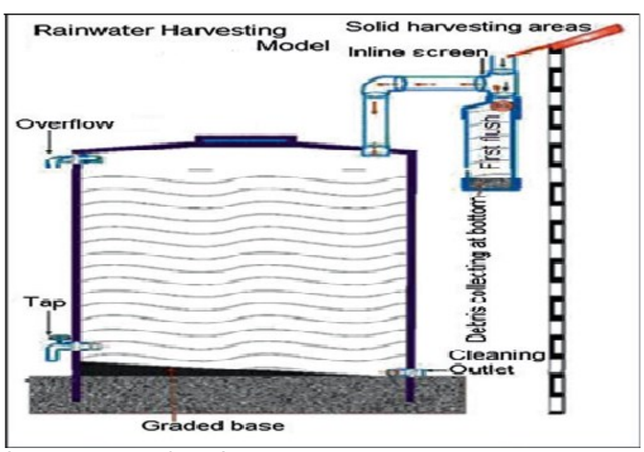
Therefore, the cost to be invested on one single building is calculated as 41795 Ethiopian Birr, which includes the cost of labor, polyethylene tank, pipes, fittings and cement base. The gutter pipes are already available in the buildings to drain the rainwater from roof into the ditches beside of the buildings. If all the buildings in the main campus of Woldia University are to be installed with the system, then the cost of installation would be:

41795 X 69 = 2883855(88,827 USD) birr, which is the total cost for the university to install the rainwater harvesting system in all of the 69 similar buildings inside the Woldia University main campus



Source:https://en.climate-data.org/africa/ethiopia/amhara/weldiya-55331/#climate-graph

Figure 2: Woldia climate information



Source: Adopted from Google Images

Figure 3: Rainwater Harvesting Model

4.2 Conclusion and Findings

The hypothesis H_{A1} and H_{A2} are proved by the study, which means that the use of rainwater in place of tap water for non-potable water needs like washing and toilet use will solve the problem of water scarcity in Woldia University Main Campus. Collecting and storing of rainwater in 20,000 liter polyethylene tank can supply water to the non-potable water needs on daily basis in main campus of Woldia University. Therefore, based on the study made, the findings are as follows:

1. The water for non-potable needs can be easily met with the help of an installation of simple rainwater harvesting system in the Woldia university buildings.
2. Since Woldia University is suffering with lack of water supply all through the year, investing on the rainwater harvesting seems very cost effective.
3. Major cost in the rainwater harvesting system is from buying the readymade 20,000 liter plastic tank which is 91% of the total cost. When the purchase is made in bulk quantity of 69 tanks, the purchase would have a sales discount of up to 15% of its price, making the activity more economical. It can be concluded that the installation of rainwater harvesting system to meet the non-potable water needs at Woldia University is highly suitable and recommended than any other way of obtaining water to satisfy the needs of water inside the main campus of Woldia University.

References

Adugna, D., Jensen, M., Lemma, B., & Gebie, G. (2018). Assessing the potential for rooftop rainwater harvesting from large public institutions. *International journal of environmental research and public health, 15(2),* 336 https://doi.org/10.3390/ijerph15020336

Alem, G. (1999). Rainwater harvesting in Ethiopia: An overview *WEDC Conference, Addis Ababa/Ethiopia*.

Dakua, M., Akhter, F., Biswas, P. P., Siddique, M. L. R., & Shihab, R. M. (2013). Potential of rainwater harvesting in buildings to reduce over extraction of groundwater in urban areas of Bangladesh. *European Scientific Journal*, 3

Dismas, J., Mulungu, D. M., & Mtalo, F. W. (2018). Advancing rainwater harvesting as a strategy to improve water access in Kinondoni municipality, Tanzania. *Water Science and Technology: Water supply,* 18(3), 745-753. https://doi.org/10.2166/ws.2018.007

Dwivedi, A. K., & Bhadauria, S. S. (2006) Domestic Rooftop Water Harvesting-a case study, ARPN *Journal of Engineering and Applied Sciences*, *4*(6), 31-38.

Hajani, E., & Rahman, A. (2014). “Reliability and cost analysis of a rainwater harvesting system in peri-urban regions of Greater Sydney, Australia.*” Water, 6*(4), 945-960. https://doi:10.3390/w6040945

Mandloi, D., Khare, D., & Pareek, T. (2011). Rain water harvesting in Indore city: A demanding need for sustainable development. *Journal of Chemical, Biological, and Physical Sciences (JCBPS), 1* (1), 88.

Ojha, A., & Gupta, L. (2016). “Design of Rainwater harvesting system at SPSU Udaipur *International journal of engineering sciences & research technology*. 5(6), 54-59. https://doi:10.5281/zenodo.54654

Qiang, Z. (2003). Rainwater harvesting and poverty alleviation: A case study in Gansu, China. *Water Resources Development*, *19*(4), 569–578. https://doi:10.1080/0790062032000161373

Semaw, F. (2018). The Problem of Solid Waste site selection in Woldia town, *Journal of Remote Sensing and GIS*, *7*(3), 246. https://doi.org/10.4172/2469-4134.1000246

Seyoum, M. (2003). Overview of the Ethiopian rainwater harvesting association (ERHA). *Integrated water and land management research and capacity building priorities for Ethiopia, 155*

Thomas, T. (1998). Domestic water supply using rain water harvesting. *Building Research & information, 26* (2), 94 –101. https://doi:10.1080/096132198370010

Ugandanwaterproject.com/2017 /11/his-grace/

World Bank (2018) Maintaining the Momentum while Addressing Service Quality and Equity: A Diagnostic of Water Supply, Sanitation, Hygiene, and Poverty in Ethiopia WASH Poverty Diagnostic. Washington, DC: World Bank.