International Academic Research Consortium Journals (IARCJ)
International Journal of Agricultural Science and Technology
ISSN: 2360-9888. Volume 8, Number 4
Pages 86-97 (December, 2020)
www.iarcj.org, www.arcnjournals.org

Rainfall Harvesting as Panacea for Domestic Water Supply in Maiduguri

Yahaya Yusuf Shallangwa[1], Mukhtari Mohammed Adamu[2] and Abdullahi Abba Mamman[3]

[1]Department of Agricultural Engineering, School of Engineering, Ramat Polytechnic Maiduguri Borno State Nigeria | Tel: 08036558913 | Email: yyshallangwa@gmail.com

[2]Department of Urban and Regional Planning, School of Environment Studies, Ramat Polytechnic Maiduguri Borno State | Tel: 08036422824, 08095245933 | Email: mukhtarimohammedadamu@gmail.com

[3]Department of Agricultural Engineering, School of Engineering, Ramat Polytechnic Maiduguri Borno State Nigeria | Tel: +2348035822447 | Email: abbamamman@gmail.com

Abstract: *The paper"Rainfall harvesting as panacea for domestic water supply in Maiduguri" examines water supply in Maiduguri with a view to identifying problems associated with it and showcasing rainwater harvesting as a panacea for domestic water supply. This was achieved through examining the various sources of domestic water supply in Maiduguri; explaining the idea of rainfall harvesting, discussing the practice and contribution of rainfall harvesting and suggesting ways of harvesting rainfall for solving problem of domestic water supply in Maiduguri. The study concentrated on literature research that involved consulting written texts such as seminar and conference papers, journals, magazines, books, internet materials among others. The major finding was that water supply in Maiduguri is inadequate in quantity and quality, time and energy consuming in respect to , expensive and unreliable. The paper recommended participation stakeholders that involved the communities, the local government, the state government, community based organizations, other non-governmental organization to work together harmoniously in the provision infrastructure for rainfall harvesting in various communities within and around Maiduguri, Engage of relevant professional in the operation and maintenance of the infrastructure. Regular training and retraining of personnel to enable them handle to update them on modern issues regarding rainfall harvesting. Explore international sources of finance for urban development project for adequate funding in other to make rainfall harvesting effective and efficient in addressing the problem of domestic water supply in Maiduguri.*

Keywords: *Domestic water, Harvesting, Panacea, Rainfall, Water supply*

1.0 INTRODUCTION

Water maintains life, water sustains life and water is life: these are popular slogans in water industries depicting the importance of water in human life. Water is the most important liquid substance in human life, it constitute more than 90% of the human body and essential in physical, social , economic, cultural and psychological development of human society (Yobe water 1992 in Adamu, 2008).

Water can be obtained from the surface (rivers, lakes, oceans), underground (well, boreholes) and from the sky (rain, snow and other forms of precipitation). (Microsoft Encarta, 2009)

Maiduguri town has problem with domestic water supply being a state capital with increasing population and rapid expansion of settlements without water connections. Several efforts made in addressing the problem have been inadequate (Adamu, 2008). These calls for more alternatives in meeting the domestic water supply which is what this paper is trying to do by looking at rainfall harvesting.

According to Wikipedia (2016) Rainfall harvesting is the accumulation and deposition of rainwater for reuse on-site, rather than allowing it to run off. Rainwater can be collected from rivers or roofs, and in many places the water collected is redirected to a deep pit (well, shaft, or borehole), a reservoir with percolation, or collected from dew or fog with nets or other tools." Oluwasanya (2006) described Rainfall or Rainwater harvesting (RWH) as the collection of rainwater where it falls or capturing the runoff in one's village or town. In other words it is defined as gathering and storing of rainwater (Akoh and Oyeyemi, 2009). Rainwater harvesting has been used to provide drinking water, water for livestock and water for irrigation or to fill aquifers through ground water recharge process.

Rainwater collection is one of the oldest means of getting water for domestic purposes that is growing in popularity due to interest in reducing the problems of water supply in our communities. The history of the use of rainwater as a source of water supply date back to 400years (Agarwal and Narrain 1997, Srinivas 2013).

According to Guebaili *et-al* (2011) Rainwater harvesting is an old method used almost anywhere in the world. It is applied in a traditional way in some parts of the world. It attracts more and more attention in several countries as an excellent practice of sustainable water management. In most cases rainwater is stored in à reservoir or a tank constructed using various materials such as concrete, polypropylene, polyethylene, fiberglass, or metal.

Rainwater harvesting has been undertaken successfully throughout Africa and can be implemented cost effectively by residents of high, medium and low income areas. Rainwater harvesting essentially involves the collection, storage and continuous use of captured rainwater, as either a main or alternative source of water (Gebhardt, 2013) . At present in china and Brazil rooftop rainwater harvesting is in practice for providing water for drinking, livestock, irrigation and for replenish of ground water level. Gansu province in china and semi-arid north east brazil have the largest rooftop harvesting project in progress. In Rajasthan, India rainfall harvesting has traditionally been practiced by people of the Thar desert (Agarwal and Narrain, 1997).

Rainwater harvesting system primarily consists of collection and subsequent use of captured rainwater as either the principal or supplementary source of water. All rainwater harvesting systems share a number of common components: a) A catchment's surface from which runoff is collected e.g. roof surface. b) A system for transporting water from the catchment's surface to a storage reservoir, known as the delivery systems. c) A reservoir where water is stored until needed (storage system). d) A device for extracting water from the reservoir (Olaoye, Coker, Sridhar and Adewole, 2013). Various technologies to harvest rainwater have been in use for millennia and new ones are being developed all the time. They include macro-catchment technologies that handle large runoff flows diverted from surfaces such as roads, hillsides, pastures, as well as micro-catchment technologies that collect runoff close to the

growing crop and replenish the soil moisture. Rooftop harvesting structures have the advantage to collect relatively clean water, while weirs and dams on ephemeral watercourses can store relatively larger volumes and for longer period s (RELMA, 2005). Advantages and benefits of rainwater harvesting are numerous . The water is free; the only cost is for collection and use. The end use of harvested water is located close to the source, eliminating the need for complex and costly distribution systems. Rainwater provides a water source when groundwater is unacceptable or unavailable, or it can augment limited groundwater supplies. The zero hardness of rainwater helps prevent scale on appliances, extending their use; rainwater eliminates the need for a water softener and the salts added during the softening process. Rainwater is sodium-free, important for persons on low-sodium diets. Rainwater is superior for landscape irrigation. Rainwater harvesting reduces flow to stormwater drains and also reduces non-point source pollution. Rainwater harvesting helps utilities reduce the summer demand peak and delay expansion of existing water treatment plants. Rainwater harvesting reduces consumers' utility bills. (Krishna,2003 and Ishaku *etal* 2011).

Due to pollution of both groundwater and surface waters, and the overall increased demand for water resources due to population growth, many communities all over the world are approaching the limits of their traditional water resources. Therefore they have to turn to alternative or 'new' resources like rainwater harvesting (RWH). Rainwater harvesting has regained importance as a valuable alternative or supplementary water resource. Utilization of rainwater is now an option along with more 'conventional' water supply technologies, particularly in rural areas, but increasingly in urban areas as well (Worm and Hattum, 2006). Rainwater harvesting yields numerous social and economic benefits, and contributes to poverty alleviation and sustainable development (Bancy, Mati and Oduor, 2006). RWH can augment water supply in all sectors. Rainwater harvesting increases food production and hence forms the foundation of many development projects that promote agriculture and land management (Rigasira *etal* 2002, Lundgren, 1993; Hurni and Tato, 1992; WOCAT, 1997). For instance, according to studies carried out, maize yield can be tripled with RWH through Conservation agriculture. RWH minimizes the risk of crop failure during droughts, intra seasonal droughts and floods (Baron and Rockstrom, 2003); RWH reduces women's burden of collecting water for domestic use, leaving time for other productive activities. RWH gives opportunity for the girl child to attend school and provides a relatively safe and clean source of drinking water, minimizing incidences of water borne diseases. When applied at watershed level, it improves the environment and minimizes the effects of drought and floods. RWH is a decentralized water supply system encouraging community participation and self-reliance. Local communities who have an enormous capacity to invest labour and time can do it; the systems are varied and can therefore be built according to the ecological characteristics of the particular region or locality (Oweis *etal*, 2001; SIWI, 2001). Hatibu and Mahoo (2000) also demonstrated the importance of Rain Water Harvesting to domestic water supplies, livestock watering and crop production using examples and data from Tanzania.

From the above is not out of place to say that rainwater collected from roofs of houses, tents and local institutions or from specifically prepared areas of ground can make an important contribution to domestic water supply in Maiduguri.

1.1 Aim and Objectives

The aim of this paper is to examine water supply in Maiduguri with a view to identifying problems associated with it and showcasing rainwater harvesting as a panacea for domestic water supply.

The Specific objectives are to:

- Examine the various sources of domestic water supply in Maiduguri.
- Explain the idea of rainfall harvesting
- Discuss the practice and contribution of rainfall harvesting.
- Suggest ways of harvesting rainfall for solving problem of domestic water supply in Maiduguri.

1.2 Methodology: the study will concentrate on literature research that will involves consulting written texts such as seminar and conference papers, journals, magazines, books, internet materials among others.

1.3 The study area

Maiduguri town is the capital of Borno state located in the northeastern corner of Nigeria on latitude 11 51' north and longitude 13 05' east based on the fertile soil of the bank of Lake Chad area. It laid strategically on Kano/Jos road as well as Mubi and Port Lome roads. The town covered a total land area of 543 Sqkm, which make it the largest city in the northeastern region of the country.

The city comprises of two (2) local governments; Maiduguri Metropolitan Council (MMC) and Jere, engulfs parts of Konduga and Mafa local governments. It comprised of twenty seven (27) Political wards, fifteen in MMC twelve in Jere. The city is directly administered by the state government with the two municipal local governments and directly supported by the traditional leaders comprising of the Emir (Shehu), the district head (Lawan) and traditional representative of the ward head (Bulama) to execute their constitutional responsibilities.

The projected population of Maiduguri town for 2007 was 1,019,902 with a density of 1878 persons per Sqkm, which makes it the most densely populated city in the northeastern Nigeria. There is rapid increase in population with a growth rate of 3.5 in resent time in the town. This partly accredited to the serious influx of people from Cameroun, Chad, and Niger that the state share international boundary with, from Adamawa, Gombe and Yobe state that the state share national boundary with, from various local government in the state and other state of the nation in lesser degree. The people that move into the state continuously move into Maiduguri town thereby increasing the population and make it the fastest growing city in the region.

With the above situation in the town, the present domestic water supply is inadequate and therefore welcome rainfall harvesting to contribute in bringing remedy.

2.0 SOURCES OF DOMESTIC WATER SUPPLY IN MAIDUGURI

In Maiduguri, drinking water is obtained from boreholes. The annual rainfall range from 500mm to 1000mm and relative humidity of about 49% with evaporation 293mm per year

and temperature range of 38 to 40oC during the hottest month of March and April. These factors together with persistent draught, very short rainfall period and desertification had made the water table very difficult to reach. In addition, the cost of drilling new boreholes and maintenance of the old ones had been on the increase. (Dakwa and Abu, 2004)

The Borno state government in an effort to solve the problem of water in Maiduguri sought the assistance of the World Bank and that led to the initiation of a water project in 1986 to channel water from lake Alau to treatment plant located in Maiduguri for purification and subsequent distribution to the metropolis (Dakwo and Abu, 2004). With the construction of the dam and channeling of the water to the treatment plant, Dammo and Sangodoyin (2014) observed that provision of portable water had proved difficult because of the socioeconomic activities around the dam . There is evidence of improper sanitary management, inadequate proper education on irrigation, indiscriminate waste disposal and some farming practices.

The popular sources of water supply in Maiduguri include the following: Alau dam – completed in 1988 by the federal government of Nigeria managed by Chad basin development. It provides water for human and animal consumption and agricultural purposes ((Dakwa and Abu, 2004). Alau dam is the main source of water supply to Maiduguri which is supported and complemented with some boreholes. At present the alau dam supplies about 10million gallons daily. Generators were provided for the treatment plant and submersible pumps of various capacities for the boreholes (FMHD, 2006).

Boreholes – a number of boreholes were constructed in various settlements within Maiduguri town with the aim of providing domestic water to the people to compliment the Alau dam

Tube wells – Several tube wells have been dug by private individual for commercial, private or both.

However in recent times with the increasing population and human activities the water supply is has become inadequate.

Several Studies have shown that Maiduguri town has a history of water supply problem for long. According to a study conducted by Odihi (1988) Maiduguri's water supply services are both inadequate and unreliable. The water rate irony of higher cost burdens for the low income households generates an inequality pattern of water supply, namely low and relatively insecure supply condition for low income households and wards.

Water supply in Maiduguri is generally inadequate, time and energy consuming, expensive and unreliable. Hence the need of rainfall harvesting to complement the present sources

3.0 THE IDEA OF RAINFALL HARVESTING

Rainwater harvesting is an old method used almost anywhere in the world. It attracts more and more attention in several countries as an excellent practice of sustainable water management (Guebaili et al, 2011).Rainfall harvesting is a technology use for collecting and storing rainwater from rooftops, the land surface or rock catchments using simple technique such as jars and pots as well as more complex techniques such as underground check dams (srinivas, 2013). It is a simple low-cost technique that requires minimum specific expertise or knowledge and offers many benefits. Collected rainwater can supplement other water sources when they become scarce or are of low quality like brackish groundwater or polluted surface water in the rainy season. It also provides a good alternative and replacement in times of

drought or when the water table drops and wells go dry. One should, however, realize that rainfall itself cannot be managed. Particularly in arid or semi-arid areas, the prevailing climatic conditions make it of crucial importance to use the limited amount of rainfall as efficiently as possible. The collected rainwater is a valuable supplement that would otherwise be lost by surface run-off or evaporation.

Rain Water Harvesting has proven to be of great value for arid and semi-arid countries or regions, small coral and volcanic islands, and remote and scattered human settlements.

Rainwater harvesting has been used for ages and examples can be found in all the great civilizations throughout history. The technology can be very simple or complex depending on the specific local circumstances. Traditionally, in Uganda and in Sri Lanka rainwater is collected from trees, using banana leaves or stems as gutters; up to 200 litres may be collected from a large tree in a single rain storm. With the increasing availability of corrugated iron roofing in many developing countries, people often place a small container under their eaves to collect rainwater

The reasons for collecting and using rainwater for domestic use are plentiful and varied the following are among others:

1. Increasing water needs/demands

The increased need for water results in lower groundwater tables and depleted reservoirs. Many piped water supply systems fail. The use of rainwater is a useful alternative.

2. Variations in water availability

The availability of water from sources such as lakes, rivers and shallow groundwater can fluctuate strongly. Collecting and storing rainwater can provide water for domestic use in periods of water shortage. Rainwater may also provide a solution when the water quality is low or varies during the rainy season in rivers and other surface water resources (for example in Bangladesh).

3. Advantageous collection and storage near the place of use

Traditional sources are located at some distance from the community. Collecting and storing water close to households improves the accessibility and convenience of water supplies and has a positive impact on health. It can also strengthen a sense of ownership.

4. Quality of water supplies

Water supplies can become polluted either through industrial or human wastes or by intrusion of minerals such as arsenic, salt (coastal area) or fluoride. Rainwater is generally of good quality.

Broadly there are two ways of harvesting rainfall which are surface runoff harvesting and roof top rain water harvesting (The Constructor 2015) Rainfall harvesting system comes in various shapes and sizes, from simple catchment system under a downspout to large above and or underground cisterns with complex filtration system that can store thousands of gallons of water. Most rainfall harvesting system comprised the same basic components as follows:

i) Catchment surface – hard smooth surface such as metal roofs or concrete areas with reasonable size and good slope.
ii) Distribution system - Gutters and downspouts that channel water from the catchment area to a holding container.
iii) Leaf screens – are panels of shields that remove or catch debris.
iv) Roof washers – a device that diverts the first flush of rain before it enters the storage tank.
v) Storage tanks – they are of numerous types and styles which can be above ground or underground. Made from galvanized steel, wood, concrete, clay plastic, fiberglass, masonry etc.
vi) Delivery systems – pumped or gravity fed to landscape or other end use areas.
vii) Purification or treatment system – filtration to make the water safe for human consumption.

Table 1: The table below shows the advantages and disadvantage of rain water harvesting:

Advantages	Disadvantages
Simple construction: Construction of RWH systems is simple and local people can easily be trained to build these themselves. This reduces costs and encourages more participation, ownership and sustainability at Community level.	High investment costs: The cost of rainwater catchment systems is almost fully Incurred during initial construction. Costs can be reduced by simple construction and the use of local materials.
Good Maintenance: Operation and maintenance of a household catchment system are controlled solely by the tank owner's Family. As such, this is a good alternative to poor maintenance and monitoring of a centralized Piped water supply.	Usage and maintenance: Proper operation and regular maintenance is a very important Factor that is often neglected. Regular inspection, cleaning, and occasional repairs are essential for the success of a system.
Relatively good water quality: Rainwater is better than other available or traditional sources (groundwater may be unusable due to fluoride, salinity or arsenic).	Water quality is vulnerable: Rainwater quality may be affected by air pollution, animal or bird droppings, insects, dirt and organic matter.
Low environmental impact: Rainwater is a renewable resource and no damage is done to the environment.	Supply is sensitive to droughts: Occurrence of long dry spells and droughts can cause water supply problems.
Convenience at household level: It provides water at the point of consumption.	Limited supply: The supply is limited by the amount of rainfall and the size of the catchment area and storage reservoir.
Not affected by local geology or topography: Rainwater collection always provides an alternative wherever rain falls.	
Flexibility and adaptability of systems to suit local circumstances and budgets, including the increased availability of low-cost tanks (e.g. made of Ferro cement, plastics	

or stone/bricks).	

Source: Adopted from Worm and Hattum (2006)

4.0 PRACTICE AND CONTRIBUTION OF RAINFALL HARVESTING

Today many countries in the world engage in large scale rainfall harvesting, particularly in rural areas where the people use it for activities such as farming, fishing, mining etc. The technology is flexible and adaptable to a very wide variety of conditions. It is used in the richest and the poorest societies, as well as in the wettest and the driest regions on our planet (Worm and Hattum 2006). Rainwater harvesting is practiced at individual, household, commercial and occasionally at local or state government level to augment dwindling water supplies to urban centres (Sridhar, Coker and Adegbuyi, (undated), Lade and Oloke, 2015).

In China seventeen provinces have adopted the rainwater utilization technique, building 5.6 million tanks with a total capacity of 1.8 billion m3, supplying drinking water for approximately 15 million people and supplemental irrigation for 1.2 million ha of land.

In South Africa there is a number of rainwater harvesting projects namely: Botlhabela Village Project in Alexandra, Johannesburg; the Cato Manor Green Initiative in Durban and the Indlovu Centre in Khayelitsha, Cape Town. Collectively, these projects assist in supplementing water supply and management in low income communities, as well as improving their quality of life.

In Senegal and Guinea Bissau the houses of Diola people are normally fitted with local brew rainwater harvesters made from local organic material. In Bermuda the law requires that all new construction to include rain water harvesting adequate for the residents. The United States Virgin Island also has similar law. Elephanta and Kalahari caves in Mumbai of indus valley civilization rainwater harvesting alone has been used to supply their requirement.

In Botswana thousands of roof catchment and tank systems have been constructed at a number of primary schools, health clinics and government houses throughout Botswana by the town and district councils under the Ministry of Local Government, Land and Housing (MLGLH)

In Tanzania the principles for the operation of rainfall harvesting system are: (i) only one underground tank should be filled at a time; (ii) while one tank is being filled, water can be consumed from the other tank, (iii) rainwater should not be mixed with tap water; (iv) underground storage tanks must be cleaned thoroughly when they are empty; (v) in order to conserve water, water should only be used from one distribution tank per day. (Hatibu and Mahoo 1999)

In Tokyo Japan rainwater harvesting and utilization is promoted to mitigate water shortages, control floods, and secure water for emergencies.

In Bangladesh, rainwater collection is seen as a viable alternative for providing safe drinking water in arsenic affected areas. About 1000 rainwater harvesting systems have been installed in the country, primarily in rural areas.

In Berlin, Germany rainwater utilization systems were introduced as part of a large scale urban re-development, to control urban flooding, save city water and create a better micro climate.

In Central Texas, more than 400 full scale rainwater harvesting systems have been installed by professional companies, and more than 6,000 rainbarrels have been installed through the City of Austin's incentive program in the past decade. Countless "do-it yourselfers" have installed systems over the same time period (Texas Water Development Board, 2005).

5.0 CONCLUSION AND R ECOMMENDATION

5.1 Conclusion

Potable, fresh and reliable water is very essential in most human activities in life, its availability determines location and development of human settlement. In Maiduguri the supply of water is inadequate, time and energy consuming, expensive and less reliable. For these reasons there is need for rainfall harvesting to address the situation. For it to be effective the following is highly recommended

5.2 Recommendation

- All stakeholders that involved the communities, the local government, the state government, community based organizations, other non-governmental organization to work together harmoniously in the provision of infrastructure for rainfall harvesting in various communities within and around Maiduguri.

- Engagement of relevant professional in the operation and maintenance of the infrastructure.

- Regular training and retraining of personnel to enable them handle and to update them on modern issues regarding rainfall harvesting.

- Exploration of international sources of finance for urban development project for adequate funding.

REFERENCES

Adamu, M.M. (2008) Planning for the Integration of Informal Economic Activities into

Land uses in Maiduguri.MURP Thesis Department of Urban and Regional Planning School of Environmental Sciences Federal University of Technology Yola Adamawa State.

Agarwal, A and Narrain, S. (1997) Dying Wisdom Rise, Fall and Potential of

India's Traditional Water Systems, State of Indian's Environment, a

Citizen's Report, Centre for Science and Environment in India.

Akoh, S. A. (2014) Rainfall Harvesting: Panacea for Domestic Water Supplyin the Peri-

Urban Area of Kaduna Metropolis, Nigeria in the Journal of Nigeria Institute of Town Planners. Volume xxiii number one.

Akoh, S.O andOyeyemi, S. M.(2009). Rainfall Harvesting in Nigeria. Paperpresented at

the 19th Annual Conference/AGM of Nigerian Environmental Society, NICON Luxury Hotel Abuja.

Bancy, M, Mati, M. M and Oduor, A. (2006) Promoting Rainwater Harvesting in Eastern and Southern Africa. Published by the World Agroforestry Centre United Nations Avenue PO Box 30677, GPO 00100 Nairobi, Kenya.

Baron, J. and Rockstrom, J. (2003) Water harvesting to upgrade smallholder farming: Experiences from on-farm research in Kenya and Burkina Faso. RELMA, Nairobi. 20pp.

Dakwa, P.Y. and Abu G.O.(2004) Distribution and Statistical Analysis ofbacteria in Lake Alau in the arid northern Nigeria in journal of applied science and environmental management volume 8 number 1 pages 5-9.

Dammo, M.N. andSangodoyin O.(2014) Socioeconomic activities around Alau dam and the quality of raw water supply to Maiduguri treatment plant Nigeria .at https://www.researchgate Net/.

Federal Ministry of Housing and Urban Development, (2006). Sustainable Urbanization and Urban Development in Nigeria: Challenges and Response. Abuja Nigeria.

Gebhardt, Z. (2013) Rainwater Harvesting. Why What and How.

Guebaili , A. Djebbar , Y. Guedri , A and Boukhari S. (2011) Rainwater Harvesting in North Africa: A novel method for reservoir sizing.Colloque International « Journées des Géosciences de l'Environnement » Oujda, 21, 22 et 23 Juin 2011 « Environnement et développement durable ».www.jmaterenvironsci.com

Hatibu, N. and Mahoo H. (1999) Rainwater harvesting technologies for agricultural production: A case for Dodoma, Tanzania in: Kaumbutho P G and Simalenga T E (eds), 1999. Conservation tillage with animal traction.A resource book of the Animal Traction Network for Eastern and Southern Africa (ATNESA). Harare. Zimbabwe. 173p. A publication supported by French Cooperation, Namibia. At http://www.atnesa.org

Hatibu, N. and Mahoo, H. F, (2000) Rainwater harvesting for natural resources management. A Planning guide for Tanzania.Technical Handbook No. 22. RELMA, Nairobi.

Hurni, H. and Tato, K. (eds). (1992) Erosion, Conservation and small-scale farming. GeographiscaBernesia, Walsworth Publishing Company, Missouri, USA.

Ishaku H.T, Majid, M.R and Johar, F. (2011). Rainwater Harvesting: An Alternative to safe water supply in Nigeria Rural Communities. In Water Resources Management Volume 26 issue 2. At http://activatejavascript.org.

Krishna H. (2003) An Overview of Rainwater Harvesting Systems and Guidelines in the United States.Proceedings of the First American Rainwater Harvesting Conference; 2003 Aug 21-23; Austin (TX).

Lade, O and Oloke, D. (2015) Rainwater Harvesting in Ibadan City , Nigeria: socioeconomic survey and commercial water supply practices. In American Journal of Water Resources Volume 3 Number 3.

Lundgren, L. (1993) Twenty years of soil conservation in eastern Africa. RSCU/Sida. Report No. 9. Nairobi, Kenya.

Odihi, J. O. (1988) Urban water supply response to droughts in Maiduguri, Nigeria in the context of the recent sudano- sahelian droughts 1960-8 5. unpublished dissertation for doctor of philosophy PhD Pennsylvania State university.

Olaoye, R. A.1, Coker, A.O.1, Sridhar, M. K.1 and Adewole, M. (2013) Examining the Effectiveness of Rainwater Collection Systems in a Nigerian Leper Colony using the Behavioural Model in Asian Research Publishing Network (ARPN).Journal of Engineering and Applied Sciences VOL. 8, NO. 1, At www.arpnjournals.com

Oluwasanya, G. O. (2006) Assessment of Rainwater Harvesting in RuralHouseholds Water Supply.A case of Olofure Village, Edo state.Journal of the Nigerian Meteorological Society Volume 6 number1.

Oweis, T., Prinz, P. and Hachum, A. (2001) Water harvesting. Indigenous knowledge for the future of the drier environments. International Centre for Agricultural Research in the Dry Areas (ICARDA). Aleppo, Syria.

RELMA, (2005) Potential for Rainwater Harvesting in Africa: A GIS Overview Volume I. In ICRAF & UNEP

Rigasira,J, Abaru, M. and Winberg,R. (2002). Empowering rural communities; Rainwater

harvesting by women groups in Rakai, Uganda. Technical Report No.29. RELMA, Nairobi.

SIWI. (2001). Water harvesting for upgrading of rain-fed agriculture: Problem analysis and research needs. Report II. Stockholm International Water Institute. Stockholm, Sweden: Stockholm International Water Institute.

Sridhar,M. K. C. Coker A. O. and Adegbuyi S. A.(2011) Rainwater Harvesting in Nigeria: Prospects and Problems. Division of Environmental Health, College of Medicine, Nigeria, email: mkcsridhar@skannet.com

Sriniva, H.(2013) An Introduction to Rainwater Harvesting. At http ://wwwgdrc.org.

Texas Water Development Board, (2005). The Texas Manual on Rainwater Harvesting.Third edition.Austin USA.

The Constructor, (2015) Methods of Rainwater Harvesting. Civil engineering Home. At http// the constructor.org/water resource.

Wikipedia Encyclopedia (2016) Rainwater capture and storage system at the Monterrey Institute of Technology and Higher Education, Mexico City.

WOCAT, (1997). WOCAT, World Overview of Conservation Approaches and Technologies – A Programme overview. May 1997. Bern, Switzerland.

Worm, J. and Hattum, T.V. (2006) Rainwater Harvesting for Domestic Use.First edition Agrodok 43 Agromisa Foundation and CTA, Wageningen.