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Rain Water Harvesting in Jos, Nigeria: A means To Compliment Domestic Water Supply

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ABSTRACT

Plateau state despite its ground and surface water potential and rainfall availability, is faced with the utmost challenge of meeting water needs to its citizens in some specific areas. This study in two areas of Jos determined the water per capita use, examined water sources and estimated the amount of water that can be harvested by households. The study used scheduled interview with a total of 100 households interviewed; a total of 89% rely on water from shallow wells, streams, and local water vendors while 11% rely on bore holes. Jos had a mean annual rainfall of 1330.2mm from 2000 to 2014 and it was estimated that 102.41m^3/month can be harvested as the rainwater harvesting potential. Although 95% of the population are aware of rainwater harvesting; only 32% actually practice the technology. This is due to lack of storage facilities that can last them months or even the entire dry season. There is therefore the need to embark on massive rainwater harvesting with corresponding water reservoirs as a means to eradicate water scarcity and reduce the prevalence of water borne diseases and also fight climate change in the region.

Keywords: Domestic Water Supply, Rain Water Harvesting, Water Demand, Water scarcity.

1.0 Introduction

Almost three-forth (72%) of the earth's surface is covered with water (Rao 2010, Rao, 2004) out of which 97% is salt water with only 3% being fresh water found in rivers, lakes and seas (Shiklomanov 2000, Rao 2004). Water has always been an important and life-sustaining drink to humans and is essential to the survival of all organisms (Antipas et al., 2015, Rao 2010, Greenhalgh 2001). Drinking water or portable water is water of sufficient high quality that can be consumed or used with a very low risk of immediate or long lasting harm (Greenhalgh 2001, BBC, 2001). The quality of drinking water is a powerful environmental determinant of health. Drinking water quality management has a key pillar of primary prevention for over one and a half century and it continues to be the foundation for the prevention and control of water borne diseases (WHO, 2010). Water is essential for life but it can and does transmit diseases, therefore water must be "wholesome"; and this is defined in law by standards for a wide range of substances, organisms and properties of water in regulation (DWI, 2010). The standards are set to be protective of public health and this reflects the importance of ensuring that water quality is acceptable to consumers (WHO, 2010). The story of water is fascinating, complex, with roots as deep as civilization. Despite its profound, life-giving role in our planet's history, what we hear about it today is mostly bad news; the world's supply is severely at risk. We're reminded of this daily, with word of another drought, or alarming statistics about pollution, population growth, and climate changes; which together threaten to make water, even more than oil, the cause of war within our life time (BBC, 2001). Why have we allowed something so elemental to our existence to drift into such a precarious state? And what can we do to change the course were on?

According to Gleick, 1998 between 20-50 litres of safe water is needed on daily basis by each individual for basic human domestic needs. However, water use and pattern of use differs from place to place and also purpose of use (White et al., 1972). The water required for the various activities varies from place to place and more specifically life style, tradition, culture, prevailing climatic condition, wealth and technology in use. According to Hassan et al., 2013, Antipas et al., 2015, the vital role of sufficient quantity of water supply for human well-being has been recognised for a very long time. There have been heated arguments by Cairn-cross 1990 and Eserey et al., 1991 on the significant importance of the quantity of water required by individual. Besides this argument, there has not been a universal yardstick for minimum quantities that water agency board should provide. While the target 10 of the Millennium Development Goals is to reduce by 50% the population of persons that do not have access to safe drinking water by 2015 (UN, 2000), it did not however state the quantity of water to be provided.

2.0 The hydrological cycle

As the nations concern over water resource and the environment increases, the importance of considering the water cycle as a single resource has become increasingly evident (Rao, 2010). Water is termed the most widespread substance in nature. It occurs in the solid state (ice), Liquid state (rainwater or precipitation), and gaseous state (vapour). The transformation of water from one state to the other is best described in the hydrologic cycle. According to the US Geological survey circular presented by Thomas et al., 1998 the hydrologic cycle describes the continuous movement of water above, on and below the surface of the earth. The hydrologic cycle is mostly referred to as a recurring consequence of different forms of movement of water and changes of its physical state in the nature on a given area of the earth (Thomas et al., 1998, Lev 2004). Lev 2004 further added that the movement of water in the hydrological cycle extends through the four parts of the total earth systems-Atmosphere, Hydrosphere, Lithosphere and Biosphere- and strongly depends on the local peculiarities of these systems. The hydrological cycles consist of; precipitation, infiltration, runoff, evaporation, transpiration and ground water flow.

2.1 Rain water harvesting

Rainwater is the ultimate source of fresh water (Rao 2010). Where there is no surface water, where groundwater is deep or inaccessible due to hard ground conditions, or where it is too salty, acidic or otherwise unpleasant or unfit to drink, another source must be sought (Saidan et al., 2015, Rain 2005). In areas that have regular rainfall, the most appropriate alternative is the collection of rainwater, called 'rainwater harvesting' (Water Aid 2013). According to Water Aid 2013, Hari and Krishna 2005, rainwater harvesting is a technology used in collecting, conveying and storing rain water from relatively clean surfaces such as a roof, land surface or rock catchment for later use. John 2004 and Koske et al., 2016 further defines rain water harvesting as the redirection and productive use of rainfall. Therefore, the term rainwater harvesting can be said to mean the immediate collection of rainwater running off surfaces upon which it falls directly. The harvesting of rainwater simply involves the collection of water from surfaces on which rain falls, and subsequently storing this water for later use. Normally water is collected from the roofs of buildings and stored in rainwater tanks. Water can also be collected in dams from rain falling on the ground and producing runoff.

Rainwater harvesting is an option which has been adopted in many areas of the world where conventional water supply systems have failed to meet the needs of the people. In many cases, rain water harvesting has been introduced as part of an integrated water supply system where the town supply is un reliable or where local water sources dry up for a part of the year (Hassan et al., 2013). Falling rain can provide some of the cleanest naturally occurring water that is available anywhere (Lev 2004). This is not surprising, as it is a result of a natural distillation process that is at risk only from airborne particles and from man-made pollution caused by the smoke and ash of fires and industrial processes, particularly those that burn fossil fuels (Rao, 2010). According to Water Aid 2013, most modern technologies for obtaining drinking water are related to the exploitation of surface water from rivers, streams and lakes, and groundwater from wells and boreholes. However, these sources account for only 40% of total precipitation (Rao, 2004, Water Aid 2013). It is evident, therefore, that there is considerable scope for the collection of rainwater when it falls, before huge losses occur due to evaporation and transpiration and before it becomes contaminated by natural means or man-made activities.

The United Nation Environment Programme (1982) article on Rainwater Harvesting described an outline of commonly used systems which are constructed of three principal components; namely, the catchment area, the collection device, and the conveyance system. The catchment areas consist of rooftop areas or land surface or rock surface catchments. The collection devices consist of storage tanks and water containers, dams and reservoirs etc. While the conveyance system is used to transfer the rainwater collected on the rooftops to the storage device or tanks.

2.2 The need for rain water harvesting

There are some major parts of the country that have been facing continuous failure and shortage of rainfall over the past few years. Furthermore, due to ever increasing population, the use of ground water has increased drastically leading to constant depletion of ground water level (Letwot et al., 2012, Hattum and Worm 2006). It is therefore imperative to take adequate measure to meet the drinking water needs as well as other domestic water needs of the people in those affected communities. Nigeria as a nation has adequate surface and ground water resource to meet its current demands. However, according to Koske et al., 2016, UNDP 2016, Otti and Ezenwaji 2013, temporal and spatial distribution of water resources has led to scarcity in some areas especially northern Nigeria. Hassan et al., 2013 added that this disparity has increased rapid depletion of ground water. Millions have been spent on the provision of portable water to meet basic needs but yet most communities still don't have access to portable water. Rain water harvesting reduces the amount of money spent on water consumption and at the same time save natural resources and over dependence on ground and surface water supply (Water Aid 2013, Russell et al., 2008). This water that would otherwise have gone down the drainage system, into ground or been lost to atmosphere through evaporation can be collected and stored in rain water tanks or directed into mechanism that can recharge ground water (Baguma et al., 2012). Rain water harvesting can to a degree of extent meet up domestic water demands which in turn can reduce water bills. It is a technology that is flexible and adaptable and can be used both in urban and rural communities respectively.

In light of this, there is a great need for massive collection and use of rain water in order to help mitigate the problems of water scarcity and to also reduce the prevalence of water borne diseases.

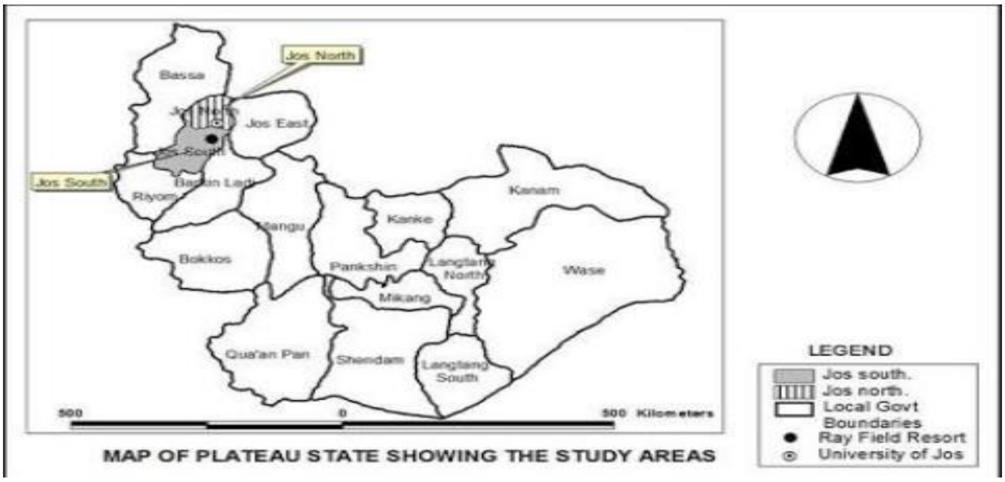
This however cannot be achieved without the communities actively involved in their water supply process right from the onset of the water supply project (Koska et al., 2016, Opare 2012, Efe 2006). If rain water is collected effectively, it can reduce the likelihood of flood, soil erosion and the spread of diseases through surface runoff (Roy 2015, Azo 2008) and also help in the fight against climate change by serving as an adaptation strategy (Joshua and Sherry 2015, Yunana et al., 2017).

3.0 Methodology

Study area

This study was conducted in Jos North Local Government Area of Plateau State. The study area falls within the savannah region of Nigeria with great potential of rain fall. The rainy period is usually between April and October and the average annual rainfall is between 1100 - 1400mm spreading over an average of between 120-150 days annually. The study area was chosen because of non-availability of public or private water mains in some parts of the area, the major source of water for domestic use are from rain, hand dug wells and boreholes. Unfortunately, majority of the wells dry up during the dry season when the rain ceases while the borehole water is sold at a rate relatively high for the ordinary man (farmers/retirees). The community relies extensively on the available rainwater because it is cheap, accessible in the raining season and it is believed to be safe for drinking.

Figure 1: Map of Plateau showing Jos North Local Government Area



Source: Antipas et al., 2015

4.0 Result and Discussion

A total of 100 questionnaires were distributed to 100 house hold representatives in Jos North Local government area and the areas covered were Tudun-Wada and Rukuba road respectively. Both areas are situated in rocky terrains and this makes it very difficult to access pipe borne water from the state water board. This therefore makes those areas in dire need for an alternative water supply especially during the dry season.

4.1 Profile of respondents

From the survey carried out in the two areas covered, it was revealed that 52% of the respondents are female while 48% are male heads of households in which approximately 60% are government employees, 22% are into one form of business, 10% are farmers (both livestock and crops) and 8% are retirees who depend on their pension. The family size range from 1-8 accounts for 68% while those above 9 accounts for 32%. On the average, 39% of the respondents earn below N15000 monthly which is below the N18000 Federal Government minimum wage for its work force. Furthermore, 79% of the population interviewed had one form of formal education while 21% did not attend formal education.

4.2 Water per capita use

Water use depends on season i.e. either rainy or dry season. From the result obtained, water use in both Tudun wada and Rukuba area was found to have an average of 75l/p/d during raining season and less than 50l/p/d during dry season. The figure below shows the assessment of water use by activity in the two wards surveyed. The figure reveals that water for bathing was ranked the highest at 26l/p/d during the rainy season; this was due to the availability of water during the rainy season. However, during the dry season, because of water shortages, water for bathing dropped to 18l/p/d. Next was water for cooking which accounts for 18l/p/d followed by water for washing clothes and dishes. Water for drinking stood at 2.5l/p/d during the rainy season and increased to 4l/p/d during the dry season. The Increase in drinking water is due to the increase in temperature and humidity which is accompanied during the dry season.

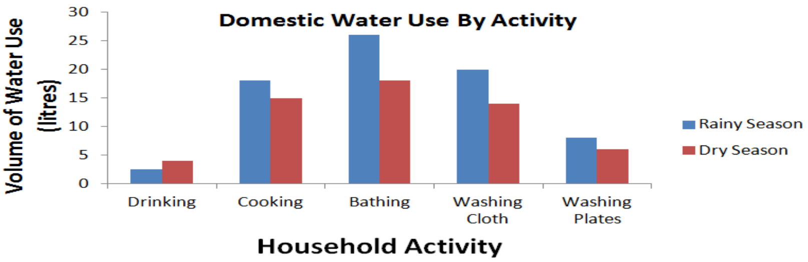


Figure 2: domestic water use by activity for both rainy and dry season in tudun wada and rukuba road of jos plateau state

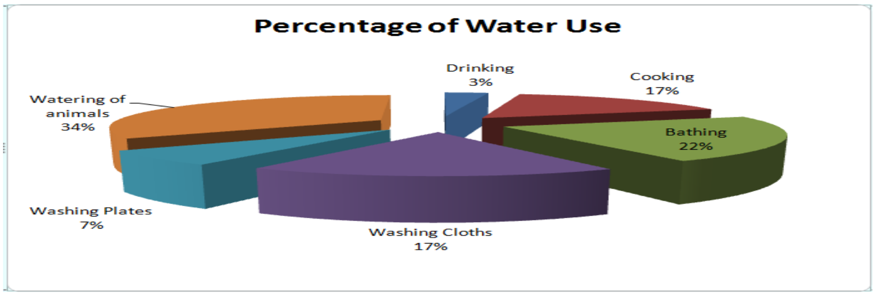


Figure 3: a chart showing the percentage of average water use by activity

4.3 Source of water supply and distance

Hand dug wells are the most widely used source of water supply in the two areas surveyed. 65% depend solely on water from wells, 17% harvest rain water, 5% ephemeral streams, 9% buy water from water vendors and 4% use boreholes. Responses on the negative effect of lack of access to portable water supply shows that health related issues accounts for over 60%, higher expenditure 22% and delay in doing normal house chores 18%. Over 65% use up to 30l/p/d and this confirms with the stipulated daily water requirements given by World Bank 2000 and Gleick 1998. Distance covered shows that during the intense dry season (March – May) about 40% walk a distance of about half a mile (0.804 km) to get water, 10% rely on personal boreholes while 50% have to buy from water vendors whose source of supply are mostly unknown. Majority of the households surveyed shows that 43% store water in drums of 100 Litres, 28% in Jerry cans of 25 to 30 litres, 18% in tanks of 1000 litre capacity and 11% in buckets that last only few days. Water storage facilities indicate one of the greatest obstacles to rain water harvesting in these areas.

4.4 Rainwater harvesting awareness

Rain water harvesting awareness is rapid in most of the areas in Jos with over 95% of the population being aware but only 32% of the population actually practice the technology. Despite the fact that most of the people are aware of rain water harvesting, most household heads complained of lack of storage facilities that will last them long to be the reason for its poor patronage. Although majority of the respondents are aware of rain water harvesting; only 32% harvest and use rain water. 15% of the harvested water is used for drinking, 48% for cooking and other domestic works, 37% is used for poultry and watering of animals. The result shows that most of their household activities are being catered for by water and not minding where it comes from. Therefore, rainwater remains one of the best options to compliment water supply for these communities in Jos.

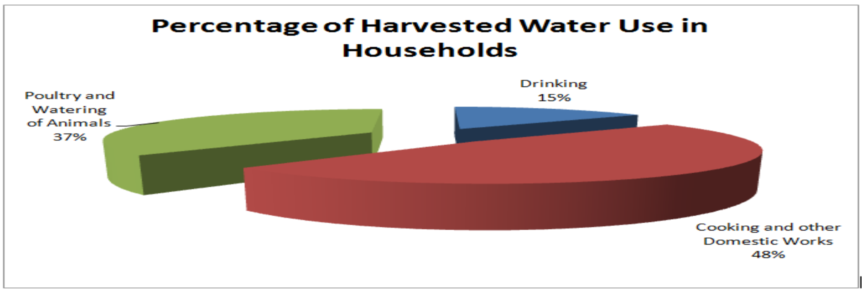


Figure 4: percentage of harvested water use

4.5 Potential for rainwater harvesting

For rain water to effectively be harvested, stored and used adequately, the availability of rainfall needs to be known since it's the key climatic variable. According to the data collected at the MET observation unit in the University of Jos between the year 2000 and 2014, an average of 1330.2mm of rainfall was recorded in the state. This amount of rainfall is absolutely very good and can guarantee rain water harvesting. The data (secondary data) was analysed in order to determine the average monthly rainfall, average annual rainfall and wet and dry months of the year under consideration. Intra annual variability of rainfall and inter annual variability determination were obtained from Hassan et al., 2013. The inter annual variability was determined using cumulative rainfall. Coefficient of variation is thus expressed as;

$$CV = \frac{S}{X} \qquad (1)$$

Where;
CV = Coefficient of Variation of the monthly rainfall
S = standard deviation of the monthly or annual rainfall (mm)
X = Mean of the monthly or annual rainfall (mm)

Rain water can be harvested through both surface runoff or from roof tops. This study focuses on roof top harvesting therefore the quantity of water to be harvested depends on the roof top area, intensity of rainfall, storage and runoff coefficient. The equation used by Ghisi et al., 2006 is adopted in order to calculate the amount of rain water that can be collected per House hold. The equation is thus given as;

$$VR = \frac{R \times HRA \times RC}{1000} \qquad (2)$$

Where;
VR = monthly volume of water harvested per house hold (M^3),
R = monthly rainfall (mm)

HRA = House roof Area (M^2)

RC = Runoff coefficient (dimensionless)

Monthly rainfall data were taken as average monthly rainfall from 2000 to 2014 and house roof area per dwelling was estimated during field observation to be around 100m^2. Coefficient of runoff is taken to be 0.85.

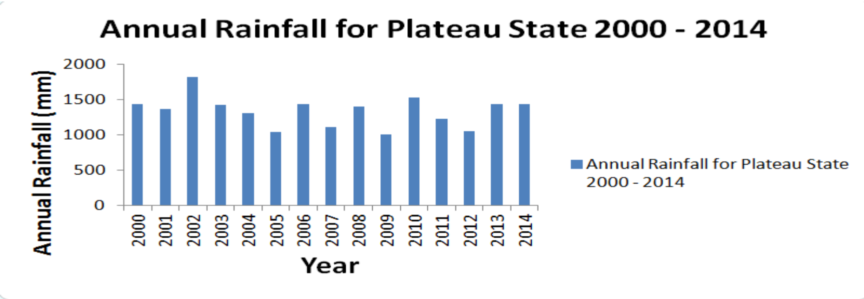


Figure 5: annual rainfall for plateau state 2000 -2014

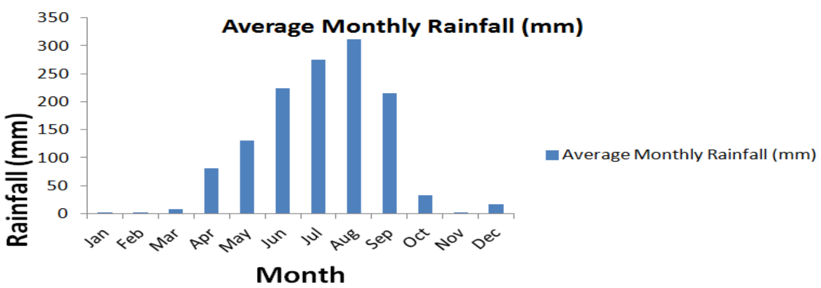


Figure 6: monthly rainfall from 2000-2014

4.6 Monthly rainwater to be harvested by households

From the monthly rainfall data collected, it can be noted that rainfall begins to fall as early as February and last up to October. However, the most wet periods that can actually guarantee rainwater harvesting in Jos will be from the months of June to September which records an average of about 200mm and above of rainfall. Annual rainwater harvesting potential per house hold stood at 102.41m^3/month for Jos Plateau State. This amount clearly shows that the harvested water can effectively supplements domestic water supply for both Tudun-Wada and Rukuba Road areas of the State having an average water demand of 100.2m^3.

Table 1: household rain water harvested and monthly water balance for Tudun wada and Rukuba

Month	Average Monthly Rainfall (mm)	Anticipated Water to be Harvested (m^3/month)	Monthly Water demand (m^3)		Monthly Water Balance (m^3))	
			Tudun Wada	Rukuba	Tudun Wada	Rukuba
Oct	33.42	2.67	8.5	8.2	-5.83	-5.53
Nov	0.05	0.002	8.5	8.2	-8.49	-8.19
Dec	2.26	0.18	8.5	8.2	-8.32	-8.02
Jan	0.01	0.00	8.5	8.2	-8.50	-8.20
Feb	0.14	0.01	8.5	8.2	-8.49	-8.19
Mar	8.26	0.66	8.5	8.2	-7.84	-7.54
Apr	81.1	6.48	8.5	8.2	-2.02	-1.72
May	130.8	10.46	8.5	8.2	1.96	2.26
Jun	223.6	17.88	8.5	8.2	9.38	9.68
Jul	274.9	21.99	8.5	8.2	13.49	13.79
Aug	311.3	24.90	8.5	8.2	16.40	16.70
Sep	214.87	17.18	8.5	8.2	8.68	8.98
Total	**1280.70**	**102.41**	**102**	**98.4**	**0.41**	**4.01**
Average	106.72	8.53	8.5	8.2	0.03	0.33

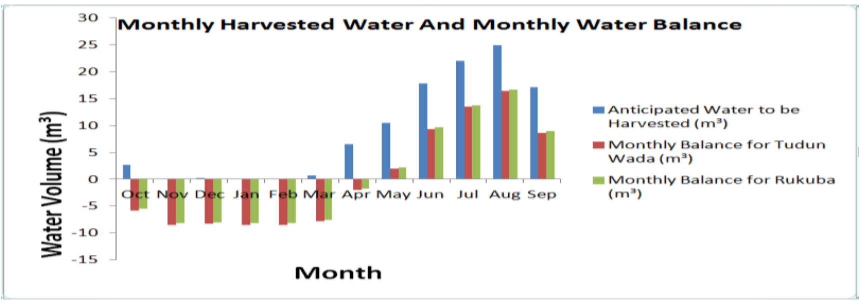


Figure 7: House hold Monthly Harvested Water and Monthly Water Balance

5.0 Conclusion

Rainwater harvesting is one of the easiest means of collecting rain water and storing for future use. Plateau State having a mean annual rainfall of 1300mm over the past 15 years shows that it has the potential to harvest and store rain water for use during the 5 month dry season. This will help eradicate the prevalence of water related diseases and ease of difficulties in walking distances to get water for domestic use. Furthermore, it is recommended that households embark on a massive sensitisation on rainwater harvesting and its importance and the government through water related agencies to provide water storage facilities so as to enable massive harvesting of rainwater for future use. Communities should as a matter of concern, team up to help build locally; reservoirs that will hold water during the wet season for use during the dry season.

Plate 1: Tudun Wada Stream during the Dry Season

Source: Site Visit

Plate 2: Tudun Wada Rocky Terrain

Source: Site Visit

Reference

Antipas G. R, Agbubata K .A, Lekwot V.E, Ali A. Y, Danjuma A. K and Abdulrahman A. S (2015). Population Increase and Water Supply in Nigerian Cities: Case Study of Jos in Plateau State, Nigeria. *International Journal of Multidisciplinary and Current Research, vol 3, (2015) 23-31*

Azo Cleantech (2008): 'What is Rainwater Harvesting and the Importance of Harvesting Rainwater' Accessed online on the 20th of May 2014 via http://www.azocleantech.com/article.aspx?ArticleID=65

Baguma D, Loiskandl W, and Jung H (2010): Water Management, Rainwater Harvesting and Predictive Variables in Rural Households. *Water Resource Management 2010, 24, No.13, 3333-3348.* http://doi:10.1007/s11269-010-9609-9

BBC NEWS (2001): BBC Health news on "Healthy living-water". Accessed online on the 8th of December 2014 via http://www.bbc.co.uk/health/treatments/healthy_living/nutrition/healthy_water.shtml

Cairn-cross A.M (1990): Health Impacts in Developing Countries: New Evidence and New Prospects, *Journal of the Institution of Water and Environmental Management 1990, 4, No. 6, 572-577*

Drinking Water Inspectorate (DWI) 2010: guardians of drinking water quality; what are the drinking water standards? Accessed on line on 6th August 2014 via http://www.dwi.gov.uk/consumer/advice-leaflet/stamdards.pdf

Efe S.I (2006): Quality of Rainwater Harvesting for Rural Communities of Delta State, Nigeria. *The Enviromentalist 2006, 26, No 3, 175-181.* http://doi:10.1007/s10669-006-7829-6

Eserey S.A, Potash J.B, Roberts L, and Shiff C (1991): Effects of Improved Water Supply and Sanitation on Ascariasis, Diarrheoea, Hookworm Infection, Schitomiasis, and Trachoma, *Bulletin of World Health Organization, Vol. 69, No. 5, pp 609-621*

Greenhalgh, A (2001): drinking water quality. Accessed on line on the 14th of August 2014 via http://www.iwawaterwiki.org/xwiki/bin/view/Articles/DrinkingWaterQuality

Ghisi E, Montibeller A, and Schmidt R.W, (2006): "potential for Portable Water Savings by Using Rainwater. An Analysis Over 62 Cities in Southern Brazil". *Building and Environment 2006, 14, No 2, 204-210.*

Gleick P.H (1998): Basic Water Requirement for Human Activities: Meeting the basic needs. *Water International 1998, 21, 83-92.* http://doi:10.1080/02508069608686494

Hari J and Krishna P.E (2005): "Texas Manual on Rainwater Harvesting", *3rd Edition, Austin 2005.*

Hattum T.V and Worm J, (2006): Rainwater Harvesting for Domestic Use. *Agromisa Foundation and CTA Wageningen. The Netherlands*

Hassan Tsenbeya Ishaku, Ajayi Peters Abayomi, Abdulrahman Ahmed Sahabo. Fabian Mazawuje Dama (2013): Complementing Water Supply through Rain Water Harvesting in Some Selected Villages of Sahel Savannah Ecological Zone in Borno state North eastern Nigeria journal of water resource and protection, 2013, 5, 200-207 http://dx.doi.org/10.4236/jwarp.2013.52021

John Palmbach (2004): 'Traditional Water Harvesting' Part of Water is Life a class website on water privatization and commodification, produced by students of Geography *378 (International Environmental Problems & Policy) at the University of Wisconsin-Eau Claire, USA.*

Joshua W.K and Sherry W.A-P (2015): The Combined Effect of Human Influence and Climate Variability on Water Bodies. A case study of receding Lake Chad in Sub-Saharan Africa. *International Journal of Advanced Research (2015), Volume 3, Issue 6, 800-808*

Koske E.C, Jackson J.K, Recha C.W (2016): Adoption of Rainwater Harvesting Technologies as an adaptation Strategy to Climate Variability in Baringo County, Kenya. *J. Arts. Humanit. Soc. Sci, 2016; 4(5B):583-592*

Letwot V.E, Ikomomi S, Ifeanyi E, Onyemelukwe O (2012): Evaluating the Potential of Rainwater Harvesting as a supplementary Source of Water Supply in Kanai district of Zangon-Kataf Local Government Area of Kaduna State Nigeria. *Adv-Res J. Environ.Sci.Toxcol 1(3)2012 pp 38-45*

Lev. S. K (2004): THE HYDROLOGICAL CYCLE AND HUMAN IMPACT ON IT. Water Resource Mnangement. [Eds. Arjen Y. Hoekstra, and Hubert H.G Savenije] In Encyclopedia of Life Support Systems (EOLSS), Developed Under the Auspices of the UNESCO, Eolss Publishers, Oxford UK.

Otti V.I, and Ezenwaji E.E (2013): Enhancing Community-Driven Initiative in Rainwater Harvesting in Nigeria. *International Journal of engineering and Technology Vol 3 No. 1 (2013). Pp 73-79*

Opare S (2012): Rainwater Harvesting: An Option for Sustainable Rural Water Supply in Ghana. *Geo Journal, 2012, 77, 695-705*

Rain Barrel (2005): 'Rainwater Collection-The History of Rainwater Collection'. Accessed online on the 20th of August 2015 via http://www.rain-barrel.net/rainwater-collection.html

Rao, P. V. (2010). *Principles of Environmental Science and Engineering.* New Delhi: PHI Learning Private Limited.

Rao, P. V. (2004). *TextBook of Environmental Engineering.* New Delhi: Prentice Hall of India Private Limited.

Roy Omna, (2015): 'Brief Note on Importance of Rainwater Harvesting'. Accessed online on the 7th of June 2014 via: http://www.importantindia.com/15567/brief-note-on-importance-of-rainwater-harvesting/

Russell A.P, Porter D, and Silvy V (2008): Rainwater Harvesting Capturing Natures Best for Your

Landscape. Accessed online on the 3rd of July 2014 via http://texaswater.tamu.edu/conservation.rainwater.html

Saidan M. N, Radwan A. Al-w, and Ibrahim O (2015). 'Potential Rainwater Harvesting: An Adaptation Measure for Urban Areas in Jordan'. Accessed online on the 12th July 2014 via: http://dx.doi.org/10.5942/jawwa.2015.107.0154

Shiklomanov I (2000): Appraisal and assessment of World Water Resources. Water international 25(1); 11-32 (2000).

Thomas C. Winter, Judson W Harvey, O. Lehn Franke, William M, Alley (1998): Ground Water and Surface Water; A Single Resource. US Geological Survey Circular 1139 Denves Colorado 1998.

United Nations Environment Programme UNEP (1982): Rain and Storm Water Harvesting in Rural Areas. Dublin: Tycooly International publishing Limited.

United Nation Development Programme (UNDP), (2016): Adaptation to Climate Change in Arid and Semi-Arid Lands, 2016. Accessed online on the 15th of July 2016 via http://www.ke.undp.org/content/kenya/en /home/operations/projects/environment_and_energy/Adaptation_to_Climate_Change.html

United Nations (2000): In Larger Freedom: Towards Development, Security and Human Right for All. United Nations, Geneva 2000

Water Aid (2013): 'Rainwater Harvesting'. Accessed online on the 20th August 2014 via: http://www.wateraid.org/~/media/Publications/Rainwater-harvesting.pdf

White G.F, Bradley D.J, and White A.U, (1972): Drawers of Water, Domestic use in East Africa, University of Chicago Press. Chicago , 1972

World Bank (2000): "Sector Report on Water Resource Strategy Paper on Effective Management of Water Resource in Africa". Effective Management of Water Resource in Africa, Washington DC, 2000

World Health Organisation (WHO) 2010: WATER FOR HEALTH; WHO Guidelines for drinking-water quality. Accessed online on 30th August 2014 via http://www.who.int/water_sanitation_health/WHS_WWO2010_guidelines_2010_6_en.pdf

Yunana D.A, Shittu A.A, Ayuba S, Bassah E.J, Joshua W.K (2017): Climate Change and Lake Water Resources in Sub-Saharan Africa: Case Study of Lake Chad and Lake Victoria. *Nigerian Journal of Technology (2017) Volume 36 No.2, 648-654*