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APPRAISAL OF RAINWATER HARVESTING POTENTIAL IN MAIDUGURI, BORNO STATE, NIGERIA

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ABSTRACT

Maiduguri, Borno State's capital has experienced for more than 6 years, increase in population and social activities due to insurgency leading to scarcity of water in the area, notably IDP (internally displaced persons) camps. However, rooftop rainwater harvesting which is regarded as one of the viable alternative sources of water for domestic use was therefore assessed in this study. Hydrological analysis was carried out using rainfall data for 33 years, obtained from the Nigerian Meteorological Agency (NIMET) North East Zonal office, Maiduguri. Results revealed that rain water harvesting was found to be technically feasible based on the prevailing rainfall pattern with many households having a rooftop constructed from technically appropriate materials. This indicate that an average roof of 85 m^2 will collect 38,352 l/yr (15 l/person/day) for a household size of 7, which is close to the WHO recommended minimum requirement of 20 l/person/day. It is recommended that governmental and non-governmental organizations should embark on massive rainwater harvesting with corresponding water reservoir as a way to reduce the effects of the five months dry spell experienced in the region.

1. INTRODUCTION

Water, which is essential to life and necessary for day to day activities, is most times hard to get especially in its pure state. In many parts of the world, people do not have access to clean and reliable water supply for domestic and other uses (Worm and Hattum, 2006). Access to safe water is a universal need and in fact a very important requirement to meet drinking-needs of people (Nashima *et al.,* 2013). Nigeria is endowed with enormous surface and groundwater resources yet the provision of potable and safe drinking water is still inadequate (Orebiyi *et al.,* 2010). At least 68% of all households in Nigeria fetch their drinking water from outside their homes with only three out of ten homes having a regular supply of clean water (Country WID Profile, 1999). Many urban and rural households in Borno State still have to trek long distances in search of water (Ishaku *et al.,* 2013). The rainfall season in Maiduguri, Borno State is usually short, between May to September. With the increase in population of Maiduguri town due to the insurgency, there is more demand for potable water. Population increase is owing to the relocation of victims of Boko Haram insurgency (IDPs) from their communities/local government areas to Maiduguri. However, improvement in water supply service delivery will eventually result in the improvement of the living standard of the people. Access to safe water supply will lead to the amelioration of human suffering and increased productive capacities that will consequently reduce health care cost (Thomas and Martinson, 2007).

Domestic Rainwater harvesting (RWH) is a technology that is flexible and adaptable to a wide variety of conditions. It is being used in the richest and poorest societies on earth as well as the wettest and driest regions of the world (Ishaku *et al.,* 2013). Worm and Hattum (2006) noted that RWH is rarely considered simply due to lack of information on its feasibility both technically and otherwise. However, the design of a RWH system is determined by several factors such as; the number of users and their consumption rate (for the case of multiple uses), local rainfall data, rainfall pattern, user regime of the system (occasional, intermittent, partial or full), roof catchment area (m^2) and the run-off coefficient (this varies between 0.5 and 0.9 depending on roof material and slope). Considering these factors, RWH could be feasible or not. According to Thomas and Martinson (2007), domestic roofwater harvesting can yield adequate quantities of water throughout the humid tropics, but only low quantities in semi-arid zones. Unless the RWH system includes a large and expensive storage tank, the availability of harvested water varies with the seasons.

This paper however, aims to assess the potential amount of rainwater that can be harvested from rooftops in Maiduguri, Borno State, Nigeria. Rainwater harvesting is relatively cheap and pollution-free. More so, it would complement the water treatment plant's supply and minimize the after effect of heavy rainfall event.

2. METHODOLOGY

2.1. Study Area

Maiduguri, the capital of Borno State is situated in the semi – arid climatic zone, comprising of two seasons; dry and wet seasons. The dry season starts around November and ends around March or April, while the wet season starts in May or June and ends in October. The city has an average rainfall of about 600 mm. The temperature generally ranges between 29.4 ^{o}C and 30 ^{o}C. The daily temperature occasionally exceeds 40 ^{o}C. Maiduguri and its surroundings fall within the savannah type vegetation, constituting of a relatively high tree growth. However, the dominant species is the Neem tree, which is drought resistant (Muh'd *et al.,* 2014). Figure 1 shows the map of Maiduguri city, the capital of Borno State.

Survey was carried out to appraise the RWH technologies available locally. Hydrological analysis was also carried out to determine the reliability of rainwater harvesting as an alternative or supplemental water supply in Maiduguri. For the objectives of this study to be accomplished, data on rainfall, household size/needs, roofing material and size were obtained. The choice of Maiduguri city is because it is a residential area which is highly populated and the population is on the increase due to the insurgency. For this study, data on average monthly rainfall for a period of 33 years (1981-2014) were obtained from the Nigerian Metrological Agency, North East Zonal office, Maiduguri.

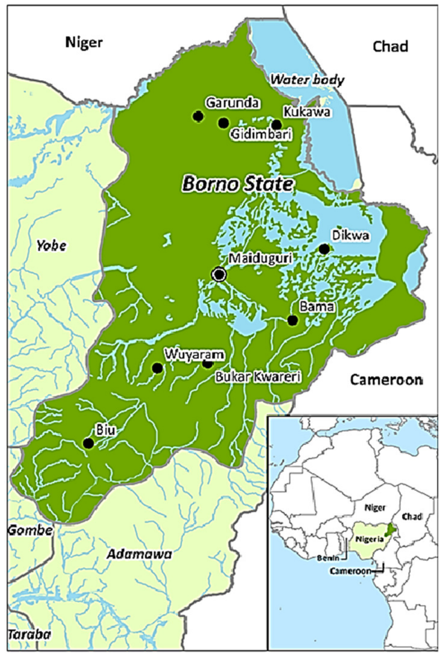

Figure 1: Map of Maiduguri City

2.2. Household Size and Needs

This is related to the total water demand, storage volume and catchment area (roof top). The average household size was taken as 7 (ZOA, 2016) for the calculation of the design storage capacity. However, the amount of water a household needs is very hard to decide (Thomas and Martinson, 2007). If water was cheap and abundantly available all day, a household might use up to 1,000 litres a day – as is common in countries like the USA, and if very scarce and expensive, a household might use as little as 12 litres a day (Thomas and Martinson, 2007). "Each person needs at least 2 litres per day to stay alive in a warm climate and at least 7 litres per day to stay healthy and practice good hygiene. The World Health Organisation recommends 20 litres per person per day as a minimum, but there are many rural communities in the tropics where water consumption is well below this minimum requirement" (Thomas and Martinson, 2007).

2.3. Roofing Material

In Maiduguri, the common roofing materials include cement concrete, aluminum and asbestos sheets. These materials are suitable for rainwater catchments. An area of 85 m^2 was considered for roof area using random selection of households.

2.4. Storage Volume Calculations

In order to determine the storage capacity of tank to be installed, the expected volume of rainfall to be harvested was determined using Equation 1 (Worm and Hattum, 2006).

$$V_{rw} = A_c \times R \times i \qquad (1)$$

Where:
V_{rw}= volume of rainfall expected to be collected
A_c= catchment area collecting the runoff rainwater
R= average annual rainfall
i= runoff coefficient between (0.8 – 0.9) for aluminum sheets

Using the supply side approach of Worm and Hattum (2006), a plot of the monthly and cumulative monthly runoff was produced. A constant demand line was drawn, assuming a constant demand throughout the year. The maximum difference between the demand line and the cumulative rainfall yields the storage capacity required.

2.5. Household Demand

The water demand of a household was obtained from Equation 2 (Worm and Hattum, 2006)).

$$D = AC \times N \times d \qquad (2)$$

Where:
D= water demand in litre
AC= average consumption, (20 litres (WHO 2011))
N= number of people in the household (7 persons)
d= the number of days (365 days for a year)

3. RESULTS AND DISCUSSION

Figure 2 shows the average monthly rainfall distribution of Maiduguri city based on the data obtained from NIMET. The Figure shows that there is rainfall between the months of March and October, with rainfall peaking in August. The rest of the year outside this period is dry. The rainfall received during the rainy season can be stored for use during the dry season, to supplement other water supply sources.

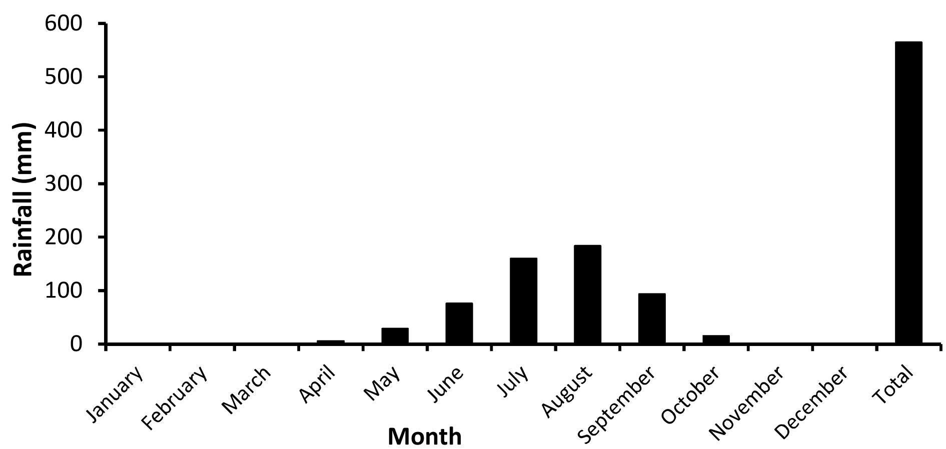

Figure 2: Average monthly rainfall distribution of Maiduguri city (1981 - 2014)

The estimate of the average potential amount of rainwater that can be harvested from rooftop area (85 m^2) per household was obtained as 38352 litre/year. This calculation was based on the annual average total rainfall in Maiduguri for the study period (564 mm). This equals to approximately 15 liter/person/day, which is close to WHO's recommendation of 20 liters/capita/day. However, the demand per household (7 persons) as per WHO's recommendation was obtained to be 51100 litres in a year and 140 litres/day. Table 1, therefore, presents the results obtained for cumulative harvested rainwater.

Table 1: Cumulative harvested rainwater

S/N	Month	Rainfall (mm)	Monthly harvested rainwater (m^3)	Cumulative rainwater harvested (m^3)
1	January	0.0	0.0000	0.000
2	February	0.0	0.0000	0.000
3	March	0.3	0.0204	0.0204
4	April	5.6	0.3808	0.4012
5	May	29.1	1.9788	2.3800
6	June	76.2	5.1816	7.5616
7	July	159.9	10.8732	18.4348
8	August	183.7	12.4916	30.9264
9	September	93.6	6.3648	37.2912
10	October	15.5	1.0540	38.3452
11	November	0.0	0.0000	38.3452
12	December	0.1	0.0068	38.3520

4. CONCLUSION

The city of Maiduguri has tremendous technical potential for rooftop rainwater harvesting, despite being located in the drier north of Sahel Savannah. Most of the households have a rooftop constructed from technically appropriate materials. Results of the study shows that an average roof of 85 m^2 has the potential of harvesting 38,352 l/yr (15 l/capita/day) for a family of seven, which is near the water demand for drinking and cooking purposes recommended by WHO. Based on the estimated results from this study it is envisaged that Maiduguri residents can potentially collect substantial amount of rainwater for usage as an alternative in addition to other sources.

5. ACKNOWLEDGMENT

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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