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Full Length Research

Planning for a sustainable water supply through improved rainwater harvesting system in Hong Local Government Area of Adamawa State, Nigeria

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ABSTRACT: This paper examined water supply and demand in Hong Local Government Area (LGA) with a view to planning a sustainable rainwater harvesting system. The plan projected population in the area is 223,176 with an average of 5 persons per household. Similarly, there are 1,038 existing water supply infrastructures in form of wells and boreholes in seven (7) districts where 2,135 households out of 42,729 households in the LGA were sampled randomly to ascertain their level of access to water supply so as to provide strong basis for the planning activity. Results of the research indicated that 50.0% of the households are water-stressed, 40.6% are partially water-stressed while only 9.4% are not water-stressed. This therefore calls for a drastic planning action through rainwater harvesting system. The objectives of the plan are to provide more water supply to augment the shortfall in domestic water requirement, reduce the effects of domestic water stress on the socio-economic indicators in the area and optimise the use of water to avoid wastage and ensure sustainability. Design standards for rainwater collection, conveyance and storage are spelt out to ensure efficiency and viability of the project with materials are in conformity with the existing standards.

Keywords: Domestic water stress, planning, rainwater harvesting system, water supply.

INTRODUCTION

“Water is life” so goes a popular adage. This assertion goes to express the importance of water which is evident in every activity in the human society today. As important as water is, its availability in a sustainable manner is not guaranteed (Joshua, 2018). Sullivan et al. (2003) examined water stress in terms of its physical availability observing that simple distance is not enough an indicator but that queuing time is the main issue. Similarly, Idogho and Yahaya (2012) looked at the water scarcity in relation to distance to sources of water. None of them had examined water stress in relation to the standards provided for in the United Nation water supply guidelines and National Water Supply and Sanitation Policy 2000. Studies conducted on water stress index and water poverty index by Gleick et al. (2003) and Sullivan et al. (2003) have not observed water stress at domestic level, they only emphasised physical availability of water in relation to per capita annual consumption pattern at international and national levels without looking at local domestic water use, requirement and availability. Their study did not include the way out of water supply problem. Planning for sustainable through rainwater harvesting system is necessary. The task is then placed on planners to use their skills to ensure a sustainable supply of water to the end users in urban and rural areas. This paper therefore seeks to provide a planning solution to the dwindling supply of water for all uses in Hong Local Government Area where domestic water stress is

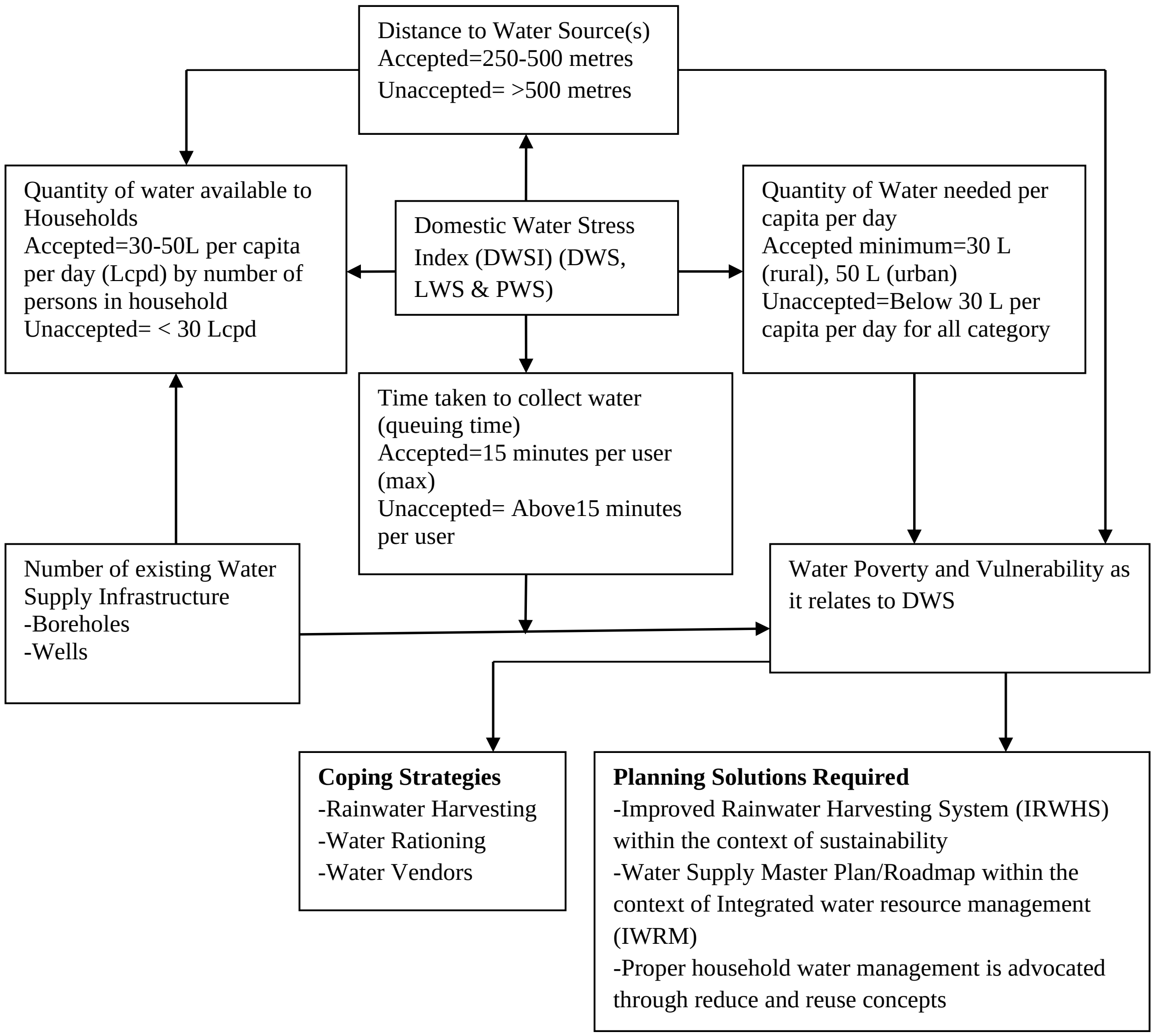

Figure 1. Conceptual framework for the Study.
Source: Adapted from Joshua (2018).

prevalence as stated by Joshua et al. (2017).

Conceptual framework

The concepts of planning and sustainability are utilized for this paper within the context of water supply. Domestic water stress which is a shortage of water to households or individuals is as a result of some indicators such as number of existing water supply infrastructure, distance to water sources and queuing time. Other issues water resources vulnerability and water poverty were also examined. The quantity of water available to households is measured against their water requirement using existing policy standards of minimum of 50 litres per capita day to assess their level of domestic water stress, hence the need to plan for a sustainable water supply through improved rainwater harvesting system. The concept of planning is seen as multi-faceted as it is applied to every aspect of human endeavour (Joshua and Ilesanmi, 2016). Glasson (1974) in Roberts (1977) defined planning as a future oriented problem solving process by making choices from options that appear open. Planning is aimed at finding solutions to tomorrow's problems today. Sustainability on the other hand applies to the usage of resource(s) in such a way that the future generation's use of the same resource(s) is not jeopardized by the current generation (Joshua, 2015). The idea comes from the definition provided by the Brundtlands' Commission on sustainable development in 1987 (Brundtland Commission/WCED, 1987). These concepts as relates to water supply is hinged on organizing (planning) the existing water supply system in Hong LGA in order to ensure that it is maintained (sustainability) for the future generation to use as well. Proper and judicious use of stored water should be imbibed by members of households through reduce and reuse concepts. Figure 1 indicates the framework for the study describing all the concepts used for the research.

METHODOLOGY

Study area

Hong Local Government Area (LGA) is located between latitudes 10°00'00'' and 10°35'00''N and longitudes 12°35'00'' and 13°20'00''E. It has a total land area of 2,419.11 km^2 (Bashir and Raji, 1999). Hong is one of the 21 Local Government Areas of Adamawa State created in 1987 during the defunct Gongola State. Its headquarters is in Hong town being the largest settlement and is classified by Ilesanmi (1999) as a third order core urban settlement in Adamawa state. Hong LGA consists of seven (7) districts namely; Hong, Dugwaba, Pella, Kulinyi, Hildi, Gaya and Uba districts. Figures 2 and 3 provide the geographical detail of the study area. According to the 2006 census conducted, the population of Hong LGA stood at about 169,183 people with 83,736 males and 85,447 females (NPC, 2013). The population has been projected to be 213,360 people in 2014, then 218,268 in 2015 and projected to 223,176 people in 2016.

Methods

The method of planning adopted for this study is the multiple water sources strategy which includes surface water, groundwater and rainwater to ensure sustainability of water supply in Hong LGA. Population threshold vis-à-vis the existing water supply and future demand due to increasing population is also considered. The proposed rainwater harvesting system and provision of wells and boreholes in the area is a multiple water supply planning strategy to provide more sources and more quantity required for domestic uses. A total of 2,135 households were selected randomly and used as sample drawn from the 42,729 households in 126 communities across all the districts namely Dugwaba, Gaya, Hildi, Hong, Kulinyi, Pella and Uba (Joshua et al., 2017).

RESULTS AND DISCUSSION

Existing water supply situation and infrastructure in Hong LGA

Hong LGA has different existing sources of water and water supply infrastructure. This is the basis for the planning. Residents of Hong LGA usually source water from rivers/streams, ponds, wells, rainfall, earth dams and boreholes for different uses. However, most communities across the LGA depend on water from wells and boreholes for domestic uses. There are 1,038 wells and boreholes in the area irrespective of their functionality. This spreads across the seven districts in the LGA. The details of the number of these infrastructures are presented in Table 1, while the functionality or their status is presented in Table 2.

Unsustainable practices in the face of dwindling water supply

Research conducted by Joshua (2018) has shown that there are several unsustainable practices, such as rationing of water, buying water from vendors and small scale rainwater harvest among the people in the area which has to be tactically handled to pave way for achieving the sustainable water supply for all domestic uses in the area. Prominent among these unsustainable practices is the abandonment of wells as soon as boreholes are provided in some communities. Table 2 indicates the condition of the existing infrastructures meant to provide water for the people in the area. The abandoned wells become contaminated from activities of children who throw debris and other unwholesome wastes into them thereby making the water unfit for even washing and bathing. Similarly, some communities neglect their water pools and ponds rather than develop them for other domestic uses to augment the shortfall in supply. The spatial distribution of the existing water supply infrastructure in the area is displayed in Figure 4.

Water supply situation in Hong LGA

Water supply is inadequate in Hong LGA considering the threshold of population and the existing infrastructure for supplying the water. A study conducted by Joshua (2018) has shown that of the 1,038 wells and boreholes, only 460 of them are functional and therefore have to provide for 223,176 people giving a rough threshold of approximately 485 persons per water point. This situation is responsible for the high percentage (90.6%) of domestic water-stressed households as against the 9.4% who are not water-stressed in the area. The detail of the water supply and deficiency described as domestic water stress (DWS) is presented in Table 3.

Planning for improved rainwater harvesting system in Hong LGA

Rainwater harvesting system is practiced globally for different purposes such as washing, water the lawn, bathing and even drinking depending on the level of treatment technology involved. Rainwater harvesting is practiced in Hong LGA at a small scale where rainwater is captured from the roofs of buildings into containers such as buckets, basins, and pots among others for domestic uses such as drinking, washing, cooking and bathing among others (Joshua, 2018).

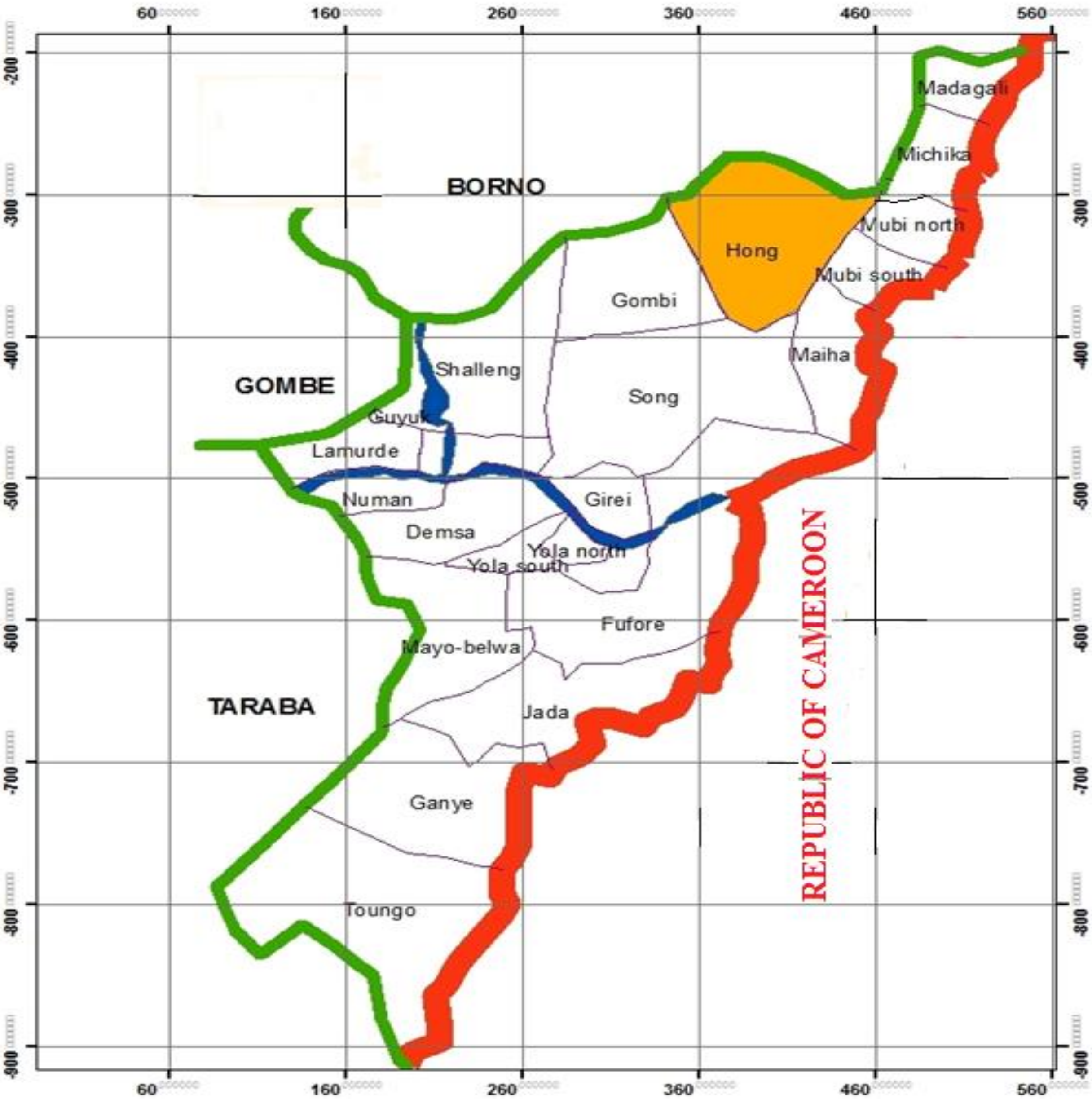

Figure 2. Adamawa State showing Hong LGA (Study Area).
Source: Joshua et al., 2017.

Existing situation of RWH in Hong LGA

The existing practice of rainwater harvesting (RWH) during the rainy season in Hong LGA indicates that it is the most widely practiced coping strategy used in the area as 90.7% of the households in the area practice it. Rainwater harvesting is done in Hong LGA by diversion of rainwater through locally fabricated gutters hanging and attached to the end of the slanted roofs made from corrugated sheets which are common in the area. The harvested rainwater is stored in small containers such as jerry cans, clay pots, and buckets for domestic uses including drinking. Generally, RWH is carried out on a small scale in the area. It is not clear how much water is harvested on the average in various households but the rainfall data in Figure 5 can guarantee a good yield/harvest for domestic uses with proper planning.

Improved rainwater harvesting system (RWHS)

Rainwater harvesting (RWH) in its broadest sense can be defined as the collection of run-off rainwater for domestic water supply, agriculture and environmental management

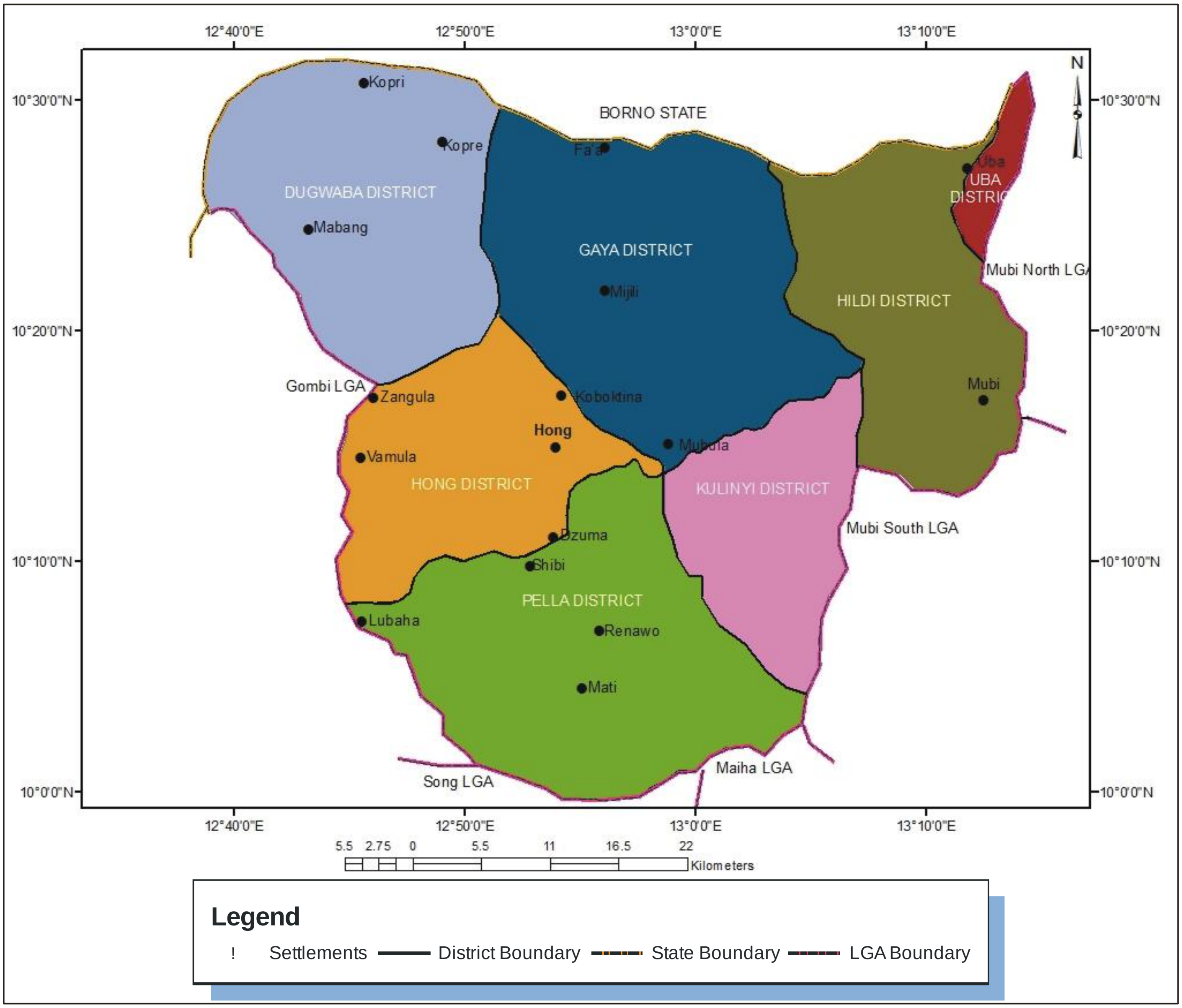

Figure 3. The Districts of Hong LGA.
Source: Joshua et al., 2017.

Table 1. Existing water supply infrastructure in Hong LGA.

Districts	Solar BH	Electric BH	Hand-pump BH	Concrete Wells	Earthen Wells	Total (Districts)
Dugwaba	1	0	16	20	1	38
Gaya	4	0	68	127	0	199
Hildi	4	2	85	106	1	198
Hong	5	2	68	83	5	163
Kulinyi	12	3	68	179	1	263
Pella	6	1	57	90	0	154
Uba	1	0	15	7	0	23
Total	33	08	377	612	08	1,038

Source: Joshua, 2018.

Table 2. Functionality of Existing Water Supply Infrastructure in Hong LGA.

District	Infrastructure					Total
	Functional	Not Functional	Seasonal	Abandoned	Epileptic	
Dugwaba						
Electric BH	-	-	-	-	-	0
Solar BH	-	1	-	-	-	1
Hand-pump BH	3	8	-	-	5	16
Concrete Well	9	7	4	-	-	20
Earthen Well	-	-	1	-	-	1
Gaya						
Electric BH	-	-	-	-	-	0
Solar BH	3	1	-	-	-	4
Hand-pump BH	40	25	-	-	3	68
Concrete well	47	30	48	2	-	127
Earthen Well	-	-	-	-	-	0
Hildi						
Electric BH	-	2	-	-	-	2
Solar BH	1	3	-	-	-	4
Hand-pump BH	60	24	-	-	1	85
Concrete Well	3	29	55	19	-	106
Earthen Well	-	-	1	-	-	1
Hong						
Electric BH	-	2	-	-	-	2
Solar BH	2	3	-	-	-	5
Hand-pump BH	51	17	-	-	-	68
Concrete Well	38	4	34	7	-	83
Earthen Well	-	-	5	-	-	5
Kulinyi						
Electric BH	2	1	-	-	-	3
Solar BH	4	8	-	-	-	12
Hand-pump BH	48	17	-	-	3	68
Concrete Well	49	29	80	21	-	179
Earthen Well	-	-	1	-	-	1
Pella						
Electric BH	-	1	-	-	-	1
Solar BH	3	3	-	-	-	6
Hand-pump BH	30	27	-	-	-	57
Concrete Well	55	-	29	6	-	90
Earthen Well	-	-	-	-	-	0
Uba						
Electric BH	-	-	-	-	-	0
Solar BH	-	1	-	-	-	1
Hand-pump BH	11	4	-	-	-	15
Concrete Well	1	2	1	3	-	7
Earthen Well	-	-	-	-	-	0
Total	460	249	259	58	12	1,038

Source: Joshua, 2018.

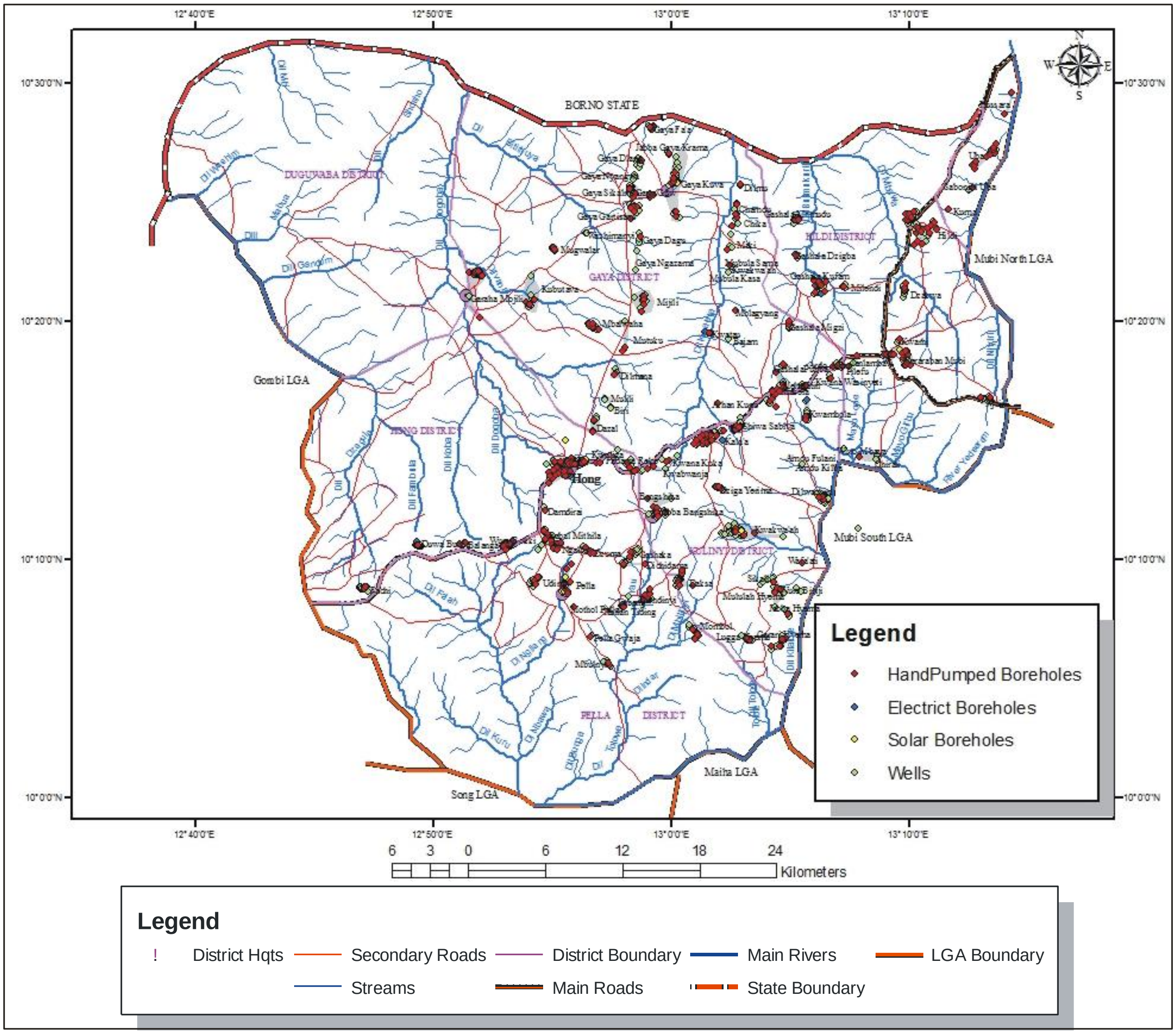

Figure 4. Spatial Distribution of existing Water Supply Infrastructure in Hong LGA.
Source: Joshua, 2018.

Table 3. Pattern and Level of DWS in Hong LGA.

Type of DWS	Quantity available (l/c/d)	Quantity Required (l/c/d)	Households (Frequency)	Percentage (%)
No Stress (1+)	50+	50	201	9.4
Partial Stress (0.5-0.99)	25-49	50	866	40.6
Severe Stress (0.1-0.49)	5-24	50	1,068	50.0
Total			2,135	100

*l/c/d is litres per capita per day.
Source: Joshua et al., 2017.

(Worm and Hattum, 2006). Similarly, the UK Environment Agency (2010) sees rainwater harvesting (RWH) as the collection of rainwater directly from the surface(s) it falls on. Planning for rainwater harvesting requires certain preconditions that need to be determined as criteria for area where the proposal will be applied. The data on

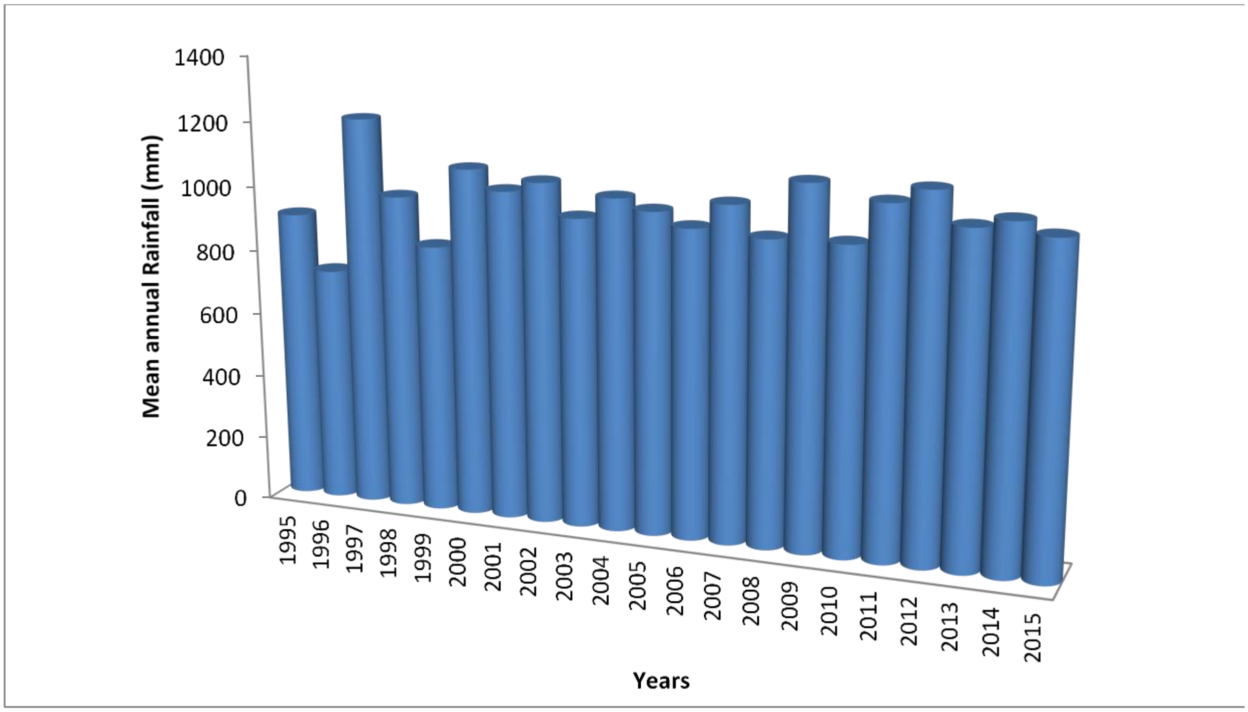

Figure 5. Mean Annual Rainfall for Hong Local Government Area (1995-2015).
Source: Adopted from Joshua (2018) and GeoNetcast, Netherlands and GIS Unit (Unimaid) (2016).

rainfall in the area must be handy to pave way for the sustainability of the planned project. Rainfall data is presented in Figure 5 depicting mean annual rainfall from 1995 to 2015.

Proposed project objectives

The objectives of the proposed improved RWH system are to:

1. harvest and store water for use in the dry season or scarcity period in the study area.
2. augment the shortfall in the quantity of water required by households for domestic uses through the stored water to boost socio-economic activities of households.
3. reduce the effects of domestic water stress on socio-economic indicators in the study area.
4. enhance socio-economic productivity of households through saving time which would have been lost through accessing water.
5. optimise the use of water without wastage within the environment through the most efficient process and sustainable development.

Site assessment for the RWH system

Assessing the site conditions together with the stake-holders is the first step towards a sound RWH system design. The five main site conditions assessed are:

1. Availability of suitable roof catchment.
2. Foundation characteristics of soil near the house.
3. Location of trees.
4. Estimated runoff to be captured per unit area of the roof.
5. Availability and location of construction/installation materials from catchment, conveyance and storage.

Households needs assessment as preconditions for RWH system planning in the study area

The most important of the preconditions for RWH system is the rainfall pattern of the area where the rainwater harvesting plan is intended. In Hong Local Government Area, the pattern of rainfall is sufficient for the RWH to be carried out. This is evident in the data collected on the local rainfall in the area for the period 1995 to 2015 (Figure 5) which indicates that rainfall (in mm) recorded within the period ranges between 729 mm (1996) and 1,211 mm (1997). Another thing is to calculate the consumption rate using the number of users, the roof catchment area (in m^2) and the run-off coefficient which depends on the roofing material and slope of the roof (usually between 0.5 to 0.9). The roofing types and their run-off coefficients are shown in Table 4.

Table 4. Roofing Materials and their Run-off Coefficient.

Roof Type	Run-off coefficient
Galvanized iron sheets	>0.9
Tiles (glazed)	0.6-0.9
Aluminium sheets	0.8-0.9
Flat cement roof	0.6-0.7
Organic (e.g. thatched)	0.2

Source: Worm and Hattum (2006), Environment Agency (2010) and Mechell et al. (2009).

1. Size of households in Hong local government area varies widely but 2006 census revealed that an average size of household in the area is made up of 5 persons.
2. Consumption or demand therefore is calculated as: Demand = Water Use × Household Members × 365 days. About 90.6% of the households live on less than 50 litres per capita per day and so augment this shortfall, an average of 20 litres per capita per day is proposed. So, 20 litres x 5 x 365 days = 36,500 litres (36.5 m^3) annual demand to augment the shortfall in the required water supply. Tanks or reservoirs sizes can be decided based on this estimate. Larger households can make their demand estimates before deciding on the size of tanks to install or reservoirs needed for the improved RWH.
3. An average roof catchment area in Hong LGA is 4 x 3 m^2 of corrugated roofing material popularly called "roofing zincs".
4. Supply or quantity of rainwater harvesting (RWH) system can be determined according to Worm and Hattum (2006) using the formula as follows:

$S = R \ x \ A \ x \ C_r$……………………………………...... (1)

Where: S = Mean annual rainwater supply (m^3), R = Mean annual rainfall (m), A = Catchment area (m^2) and C_r = Run-off coefficient.

In other words, 1 m^2 catchment area x 1 mm of rainfall = 1 litre of water. The rainfall data (Figure 5) of Hong LGA (1995 to 2015) indicates an average rainfall of 1,003mm for these years stated earlier as the supply average for the area (1.0 m), average catchment area of 4m x 3m (12 m^2) roof area and an assumed 0.9 run-off coefficient on the assumption that there is no leakage or loss of rainwater during capture. Therefore, the result of the estimate would be calculated as follows: 1.0 m x 12 m x 0.9 m = 10.8 m^3 (10, 800 litres/year) or 30 litres per day on the assumption that there is rainfall throughout the year. But Adebayo (1999) stated that rainfall on-set in Hong LGA is between 10th and 20th May and cessation between 26th September and 26th October which means there is a rainfall in the area for a period of 4 to 5 months approximately. So, the estimate for rainwater to be harvested should be calculated within the existing rainfall period of 4 to 5 months.

Planning and design criteria

The criteria for this proposal for RWH was in consistence and within the framework of the existing laws and policy of the federation on water use and management. The Water Resources Act (2012) provides that any person can take water within the environment for domestic uses or watering of animals freely. Therefore, the RWH system will operate under the provisions of this Act, other policies and standards set by government agencies in Nigeria. The materials required for capture, conveyance and storage of the rainwater must conform to the Standards Organisation of Nigeria (SON) requirement to guaranty safety for the end-users.

Other criteria necessary for the proposed RWH system was based on households' water requirement, water availability from rainfall, space design standards and existing data requirement on all other components contained in the criteria.

Planning and design concepts for the proposed RWH system

The concepts for the RWH system proposal for Hong LGA are based on the households and neighbourhood considerations and should be treated as alternatives by end users of the proposed system. It is worthy to note here that the proposal for the RWH system is the roof catchment system and not the ground catchment system because of the issues of water quality and hygiene.

Common roof catchment concept (shared between neighbours)

This concept of common-roof catchment is meant to serve a group of households in a neighbourhood comprising 2 to 4 households where the RWH system design will involve capturing rainwater from the roofs of the groups of houses', conveying the water through pipes and eventually stored into a central reservoir (cisterns) or tanks for the common use of the households that pulled their resources to install the system. This concept is hinged on the concept of "common pool resources (CPRs)".

Mono-household roof catchment concept

The mono-household roof catchment concept is proposed to serve one household whereby the rainwater from the roofs within the household is captured and stored in cisterns/tanks or reservoirs for the use of the household. This is a large scale and more organized system of rainwater harvesting which is already being practiced by the people as coping strategy but at a small scale with water stored in small containers like pots, iron drums and other water storage containers (Joshua, 2018).

The planning process for the proposed improved RWHS

The planning process for the improved RWH system proposed for households in Hong local Government Area will involve the question of legitimacy on the decisions and choices as contained in the planning theory. So, the question of public and client participation in the planning process for the proposed RWH system is key and paramount. The public for whom this proposal is intended will be involved in the decision-making process and will be educated on the process and relevance of the proposed RWH system to tackle domestic water stress in the area. The key stakeholders who are the residents, communities based organisations (CBOs), the government and the planner should work together for the success of the proposed plan (Joshua, 2018).

Public participation, education and cooperation

This is a process of involving the people of Hong Local Government Area in the decision-making process of designing a robust RWH system. There is need to educate the people on the importance of RWH on a large scale to ameliorate domestic water stress which affects their socio-economic activities such as occupation, education, income and health conditions. For this proposed plan to succeed there is the need for the people to cooperate with each other and with the planner from design of the system to the implementation stage.

Planning standards for RWH system design and installation

The design and installation materials standards shall be in conformity with the Standards Organisation of Nigeria (SON) products certification standards. The materials for the gutters, pipes, and tanks for RWH water storage proposed for the system are those approved and certified by SON for these purposes. The space standards for the installation of the RWH system are decided by the planner with regards to the dimensions of the materials to be used for the installation from collection, conveyance and storage of the harvested water. Similar materials are already in use in the small scale RWH system practiced in the area; so upgraded versions of these materials can be sourced locally in the area and its environs for sustainability.

Collection parameters standards

Collection of rainwater through RWH system requires the catchment surface which in this case is the roof. In most of the households in Hong local government area, the types of roofing materials are the galvanized sheets with Standards Organisation of Nigeria HS codes 3920, 3921, 6811.10, 7225, and 7606. The pipes, pumps, valves and other fittings required for households' use are regulated with SON HS code 8481 (SON, 2006). There is no specific roof size for the RWH system standard; the bigger the roof, the more rainwater is harvested and stored. Most of the roofing system in Hong Local Government Area is the four-sided or two-sided sloppy galvanized sheet roofing system.

Conveyance system standards

The conveyance system involves the plumbing work through piping, down spouts, and filtering of the harvested water. The materials to be used for this category of the RWH system shall conform to the SON standards HS code 8481 as stated earlier and fitting shall be within the framework of the plumbing code of Nigeria and based on the design provided or decided by the planner. Conveyance of the harvested rainwater shall be from the gutters fitted at the edge of the roofs into the downpipes and finally into the storage tanks. A funnel fitted with filter shall be fixed to the mouth of the tank to prevent particles and droppings from getting into the stored water. The Polyvinyl Chloride (PVC) pipes of different sizes are proposed and recommended for this RWH system. The curved gutters with a minimum width of 5 to 8 cm properly hung can provide adequate water and offers high performance (Still and Thomas, 2002). The length of the gutters should be equal to the length of the roof and should be slanted to enhance conveyance of the harvested water to storage tank(s).

Storage System Standards

Storage of the harvested rainwater shall be done in Rubber Tanks popularly known as "*GeePee* Tanks" and shall be placed on a platform 1 metre above so as to make it easy and flexible to dismantle them for washing from time to time especially at the beginning of the rainy season when another storage should begin after exhausting the previously stored water. The platform on which the storage tank will be placed will require 16 pieces of 9" blocks and 1 piece of 12 mm iron rod as well as 1 bag of cement for construction. The number of tanks required depends on household size and their calculated consumption rate as well as the quantity of rainwater that can be harvested during the rainy season. However, the size of the tanks also determines how much water can be stored for use during high water stress period largely during the dry seasons (Late January to Early May).There is need also to choose dark coloured storage tanks preferably black to avoid the growth of algae in the tanks and consequently contaminating the stored water. A light coloured tanks

Table 5. Cost of Materials per unit required for the proposed RWH system.

Materials	Cost per Unit (₦)	One Unit Estimate
Storage Tank (Small capacity) 2,000 Litres	65,000	*
Storage Tanks (Medium capacity) 5,000 Litres	110,000	*
Storage Tanks (Maximum capacity) 10,000 Litres	180,000	1 piece - ₦ 180, 000
1 Aluminum capping sheet for guttering	3,000	6 pieces - ₦ 18, 000
PVC T- joint	350	4 pieces- ₦ 1, 400
PVC union	500	4 pieces – ₦ 2, 000
Control Knob	2,500	1 piece – ₦ 2, 500
1 Piece of Tap x No. of Tanks required	500	1 piece – ₦ 500
Smaller PVC pipe (quarter)	2, 200	2 pieces – ₦ 2, 200
Medium PVC pipe	3,500	1 piece – ₦ 3, 500
PVC pipe joints	300	1 piece – ₦ 300
A Bag of Cement x No. of platforms required	2,700	1 bag – ₦ 2, 700
A piece of 12mm iron rod x No. of platforms	2,800	1 piece – ₦ 2, 800
One piece of 9 inch block x 16 per platform	200	16 pieces – ₦ 3, 200
A plank of wood x No. of platform	1,500	1 plank – ₦ 1, 500
Total		₦ 220, 600.00

Source: Joshua (2018).

Table 6. Adamawa State Government Budget for Water Supply (2017-2020).

Organisations	2017 Budget (₦)	2018 Budget (₦)	2019 Estimate (₦)	2020 Estimate (₦)
Min. of Water Resources	956,960,070	1,651,695,070	2,067,406,880	655,161,150
Water Board	768,000,000	1,986,555,150	1,199,416,847	1,199,416,847
Rural Water Supply and Environmental Sanitation Agency (RWESA)	383,967,000	228,000,000	499,167,000	499,167,000
Small Towns Water Supply Agency	256,000,000	287,000,000	391,000,000	486,000,000

Source: Adamawa State Government, 2018.

especially transparent tank favour the growth of algae and therefore causes contamination of the water. Black-coloured tanks are therefore recommended for the proposed RWH system (Joshua et al., 2017; Joshua, 2018).

Moreover, the tanks should be grouped together on the side of the building from which the RWH catchment is taking place. There should be room for upgrading of the system especially the storage capacity (more tanks) for the households to optimum level. A filter must be fixed at the mouth of the receiving tanks (below the gutters) so as to sieve out particles that may have entered the conveyance chain. The giant rounded water tank is proposed for the RWH system in Hong LGA because of its storage capacity, flexibility and relative cheapness compared to concrete reservoirs.

Funding and costing of materials required for the project

The project will be assisted by the government of Adamawa state (50%) and Hong Local Council (30%) while the people provides the remaining 20% of the total cost per household for the improved rainwater harvesting system planned and designed. The cost of units required for the project per household is presented in Table 5. The Adamawa state budgets a lot of money for water supply every year as exemplified by the information in Table 6.

Conclusion

Rainwater harvesting system is practiced all over the world in a crude form in developing countries and more organised and improved in developed countries. Majority of the households in Hong LGA are water-stressed at domestic level which goes to show the situation of water shortage in Nigeria in particularly in the study area (Hong LGA) and this needs a drastic planning strategy through improved rainwater harvesting system to reduce the effect of domestic water stress on the socio-economic wellbeing of the people in the area. It is believed that if this planned system is implemented properly in the area; it will ensure sustainable water supply and enhance socio-economic wellbeing of the people.

CONFLICT OF INTEREST

The authors declare that no conflict of interest exists.

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