An Assessment of Effects of Domestic Water Stress on Income and Occupation in Hong Local Government Area of Adamawa State, Nigeria

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Abstract

This paper examined domestic water stress (DWS) which is a ratio between water available per capita and water requirement per capita at household level. The shortfall between water availability and requirement defines domestic water stress. This incidence is studied in Hong Local Government Area (LGA) with a view to examining its effects on income and occupation of the residents of the LGA. The study utilized the compendium of localities in LGAs in Adamawa State obtained from the National Population Commission (NPC) which chronicled the autonomous communities in the 7 districts of Hong LGA. Out of the 126 communities reported, 32 (25.4%) were systematically selected and a total of 2,135 households randomly sampled for the study. Domestic water stress index (DWSI) was obtained using the 50 litres minimum standards of the UN to establish the pattern and level of DWS in the area. Results indicated that 50% of the sampled households are severely water-stressed, 40.6% are partially water-stressed while only 9.4% of the households are not water-stressed. Results also indicated a significant correlation between DWS and occupation and income at r = 0.650 and 0.590 respectively. Similarly, DWS affects income and occupation at R^2 = 0.730 and 0.643 respectively. This means that changes in DWS account for 73% and 64.3% unit changes on income and occupation respectively. To tackle the problems of DWS and its consequent effects on income and occupation in the area, a physical planning proposal of Rainwater harvesting system (RWHS) was advanced with planning standard recommendations for conveyance and storage facilities since there is adequate rainfall for this type of system in the LGA.

Keywords: Domestic Water Stress, Income, Occupation, Households, Planning

INTRODUCTION

The phenomenon of domestic water stress is the ratio between per capita water availability and per capita water requirement within the context of the United Nations (UN) minimum standards. The concept of water stress has been defined differently by scholars and organisations in water sector. For example, Tatlock (2006) defined water stress as social, economic and environmental problems due to unmet water needs. Water stress occurs when the demand for water exceeds the available amount during a certain period or when poor quality restricts its use (European Environment Agency, 2017). Similarly, World Business Council for Sustainable Development (WBCSD, 2006) defined water stress as a situation where there is not enough water for all uses whether agricultural, domestic and industrial. Water stress" also refers to the inability due to shortage or lack thereof, to meet human and ecological demand for water (Schulte, 2014).Water stress is also a condition where an imbalance occurs between water demand/need and water availability required for meeting the need (Ali, 2008). But specifically water stress as it relates to domestic front has been reflected in the definition provided by Ahluwalia (2008) where he said Domestic water stress could be estimated as ratio of domestic water supply of potable quality to domestic water demand.

It is widely acknowledged globally that fresh water is a scarce resource but very vital in every aspect of human endeavour. Many researchers such as Tatlock, 2006; Joshua *et al.* 2018 have also confirmed that water supply of portable quality is grossly inadequate in most countries of Africa and Asia. Nigeria is not an exception in the problem of domestic water supply shortage leading to stress. Hong Local Government Area (LGA) of Adamawa State is largely affected by domestic water stress where majority of the households are living below the minimum quantity of 50 litres per capita per day. This paper therefore addressed the effects of this phenomenon on income and occupation of the residents of the LGA with a view to recommending a physical planning solution to the lingering problem of domestic water stress in the area.
The aim of this paper is to examine the incidence of domestic water stress and its effects on income and occupation of the residents of Hong LGA with a view to recommending a physical planning solution to the problem in the area. The objectives are:

a. To assess domestic water stress at household level in the study area
b. To examine the pattern of domestic water stress in the area
c. To establish a relationship between domestic water stress and the socioeconomic indicators (income and occupation) in the LGA
d. To examine the effects of domestic water stress on income and occupation of the people
e. To proposed a physical planning solution to domestic water stress in the LGA.

Hypothesis

H_0- There is no significant relationships between domestic water stress and the socioeconomic indicators (income and occupation) in Hong LGA, Adamawa State, Nigeria.

H_1- To reject H_0.

Conceptual Framework

The study is based on the concept of water stress index and concept of social and economic indicators within social change. The water stress index (WSI) was conceptualised by a Swedish water expert known as Malin Falkenmark to assess or measure the amount of water in a country as a function of population using a minimum per capita water requirement of 100 litres for all uses (Gleick, *et al*., 2003). In the International Social Science Journal of UNESCO, Social Indicators are socially important indices which describe the conditions of the society. United States Department of Health, Education and Welfare in 1969 describes a social indicator as a statistic of direct normative interest which facilitates concise, comprehensive and balanced judgements about the condition of major aspects of the society. Similarly, Economic indicators are indices of economic activity which demonstrate a historical pattern of timing and co-variation with business cycles (Rao, 1975). It is being said that the human society is dynamic and not static. This dynamic nature of human society is referred to as 'Social Change.'

Study Area

Hong LGA is located between latitudes 10° 00′ 00″ N and 10° 35′ 00″ N and longitudes 12° 35′ 00″ E and 13° 20′ 00″ E. It has a total land area 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. It has its headquarters 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. Fig. 1 and 2 provides the geographical detail of the study area.

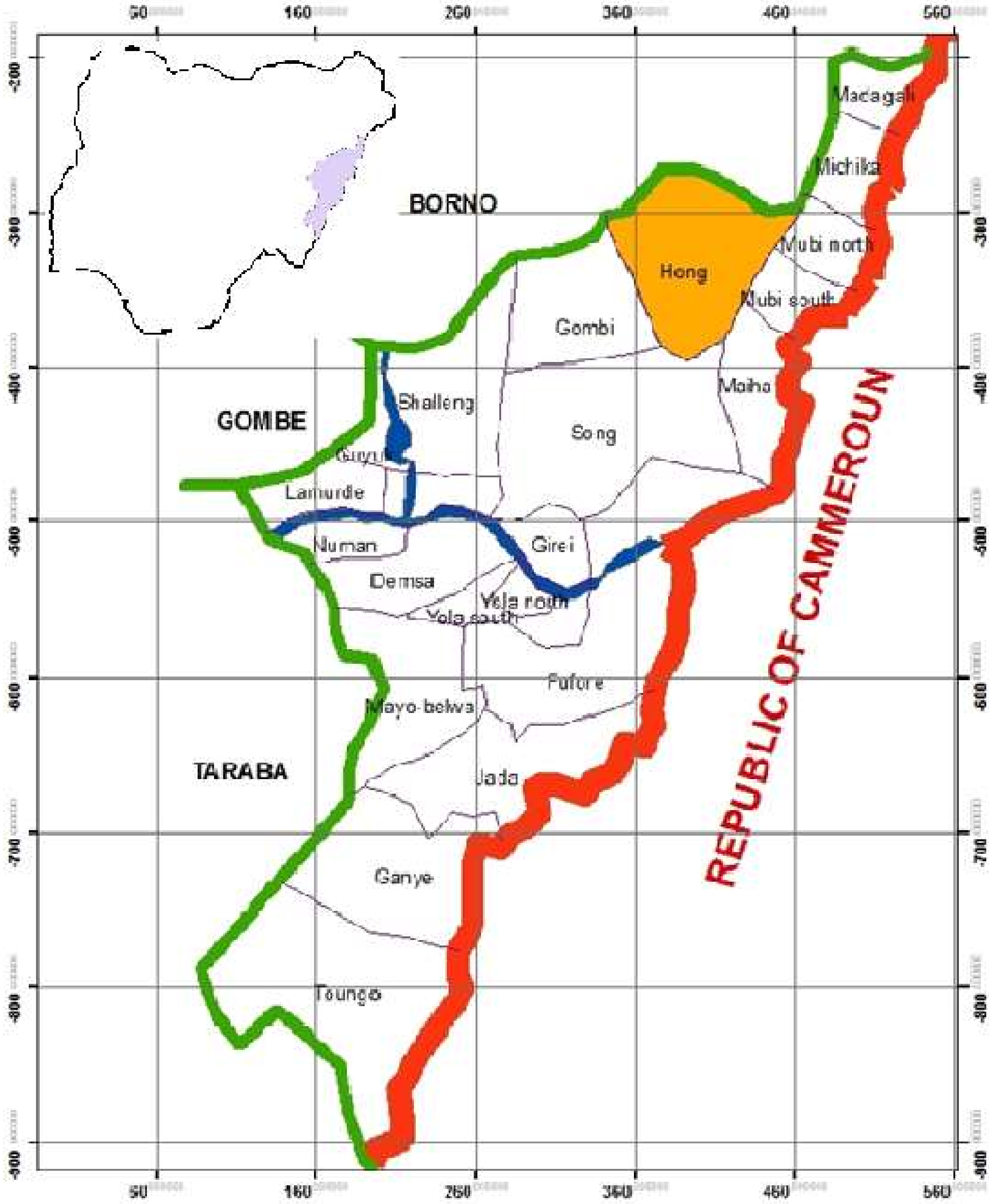

Figure 1: Adamawa State showing Hong LGA (Study Area). Inset is map of Nigeria with Adamawa State in purple.

MATERIALS AND METHOD

The materials utilized for this study are (a) A compendium of autonomous communities in Adamawa State prepared by the National Population Commission (NPC) from which all the communities in the 7 districts of Hong LGA were obtained. (b) Primary data obtained through field survey from sampled households in the 32 (25.4%) of the 126 communities in the 7 districts of the LGA. (c) Archive water stress related data from relevant organisations in Adamawa State (d) Published secondary data from books, journals, maps and documents. A total of 2, 135 households were used as sample for the study across the seven (7) district of the LGA. The households were selected at random while the communities were systematically selected from the existing NPC list of localities. The details are presented in Table 1. The incidence of domestic water stress was examined in the LGA to establish its pattern and level.

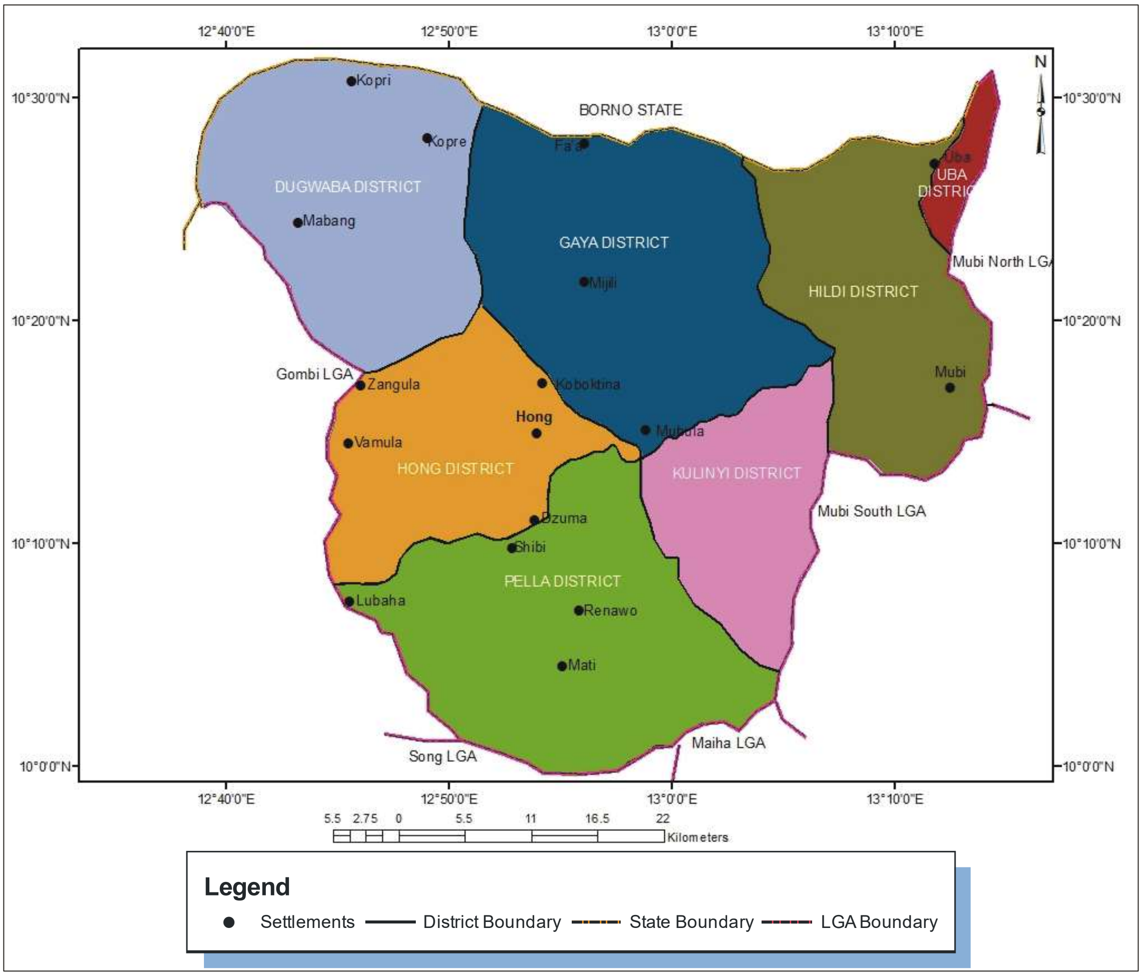

Fig. 2: The Districts of Hong LGA

The ratio of the DWS was obtained through the constructed formula as follows (Ahluwalia, 2008):

$$\text{DWSI} = \frac{QWA_c}{QWR_c} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

$$= \frac{\sum QWA_h}{\sum QWR_h} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where QWA_c is quantity of water available per capita $_c$,

QWR_c is quantity of water required per capita $_c$.

$\sum QWA_h$ is the summation of quantity of water available per household $_h$ and,

$\sum QWR_h$ is the summation of quantity of water required per household $_h$. Equation 2 is extension of equation 1 in the formula stated.

Ratios 0.1-0.49 signify *severe* water-stress; 0.5-0.99 is *partial* water-stressed, 1+indicates *no stress*.

The statistical tools used for the analysis of the results are simple correlation and linear regression. Regression analysis was carried out to assess the effects of DWS on income and occupation while simple correlation using the p-value approach was used establish a relationship (test hypothesis) on a one-tailed test between DWS and the variables income and occupation. The dependents variables (Y) are:

Y_1= Income and
Y_2= Occupation
while the independent variable (X) is DWS (domestic water stress). The dependent variables (study variables) Y_1 (income) and Y_2 (occupation) are regressed against the independent variable (explanatory variable) X (DWS). The regression is as follows:
$Y = b_0 + b_1x_1$
Where:

Y (dependent variables; income and occupation)
b variables are the constants or slope of the line
x is the independent variable (DWS). Therefore: Income = $b_0 + b_1$(DWS), so for each 1 unit change in DWS, income will change by b units. Similarly, Occupation = $b_0 + b_1$ (DWS) and so for each 1 unit change in DWS, occupation will change by b units.

Table 1: Sample Frame and Size for the Study

*Districts	*Projected Population (2014)	**Estimated Households	*Number of Communities	Number of Sampled Communities	Percentage of Sampled selected	Sampled Households at 5%
Dugwaba	14, 475	2,890	15	4	26	144
Gaya	31, 439	6, 279	24	6	26	313
Hildi	37, 328	7, 456	24	6	26	373
Hong	47, 603	9, 514	14	4	29	476
Kulinyi	40, 592	8, 108	27	7	26	405
Pella	22, 149	4, 423	16	4	25	221
Uba	20, 310	4, 059	6	2	33	203
Total	**213, 896**	**42, 729**	**126**	**33**	**-**	**2, 135**

*Source: NPC (2016)
**Households estimated as 5 persons per household (2006 Census)

RESULTS AND DISCUSSION

Domestic water stress (DWS) is a serious problem that has bedeviled the people of Hong LGA for a long time and has manifested through the effects it is having on the social and economic statuses of the people. The research investigated how much water is available to households per day which also translates to per capita water availability per day measured against the minimum water requirement set by United Nations. The United Nations sets a minimum or average water requirement globally of 50 liters per capita per day for all domestic uses. Domestic water stress index (DWSI) has been calculated using the 50 litres UN standards minimum (Brown and Matlock, 2011; Pacific Institute, 2010, 2017) where a ratio of quantity of water available against quantity of water requirement is obtained to show the level of stress per household in Hong local government area of Adamawa State, Nigeria. The patterns of DWS in Hong LGA are categorized into *severe stress* (0.1-0.49), *partial stress* with a value range of 0.5-0.99 and *no stress* category (1+). Table 2 presents the pattern and level of DWS in Hong LGA which explains clearly the issues raised that forms the basis for the study. The quantity of available per capita per day and the quantity required per capita per day defines the level of

DWS and this varies across households in the area. Table 2 also indicates that people with severe water stress are those who have access to only 5-24 litres per capita per day, while those experiencing partial water stress are those with daily per capita water supply of 25-49 litres. However, there are people who have access to the 50 litres minimum per capita water supply per day and this group of people is termed as no stress category.

Table 2: 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*

DWS in Hong LGA is largely severe as 50.0% of the respondents are within this category of people who access less than half the required minimum quantity of water per capita per day. There is however those experiencing partial water stress which constitute 40.6% of the households while only 9.4% of the households are without domestic water stress.

Results from the research have shown that there is significant relationship between domestic water stress and socioeconomic indicators of income and occupation generally. The null hypothesis (H_0) which states that there is no significant relationship between domestic water stress and these indicators (income and occupation) have been proven as follows:

H_o: There is no significant relationship between domestic water stress and income and occupation

Table 3: Relationship between Domestic water stress and Income and Occupation

Elements	Correlation Coefficient	p –value	Decision
DWS			Reject
Income	0.590	0.006	p<0.05
Occupation	0.781	0.000	P<0.05

***Note:** decision taken at p<0.05, and at 8 df. * variable (relationship) significant*

Results from Table 3 indicate that there is a significant relationship between domestic water stress and the two variables income and occupation. Therefore, since r = 0.590 and 0.781 at p<0.006 and p<0.000 respectively, it implies that there is significant but moderate correlation between domestic water stress and income and strong correlation between it and occupation. The p-values are both <0.05 which negate the null hypothesis, thereby rejecting it and accepting the alternate which can now be stated that there is a significant relationship between domestic water stress and income as well as occupation since it is clear that the calculated $x^2 < \alpha < 0.05$.

Having established that there is a significant relationship between DWS and these two (2) socioeconomic variables (income and occupation), it is also pertinent to examine the effects of DWS on them. The correlation and regression analysis Table 4 indicates profound effects of domestic water stress on both income and occupation. There is a significant correlation between DWS and occupation and income at r = 0.650 and 0.590 respectively. The effects of DWS on income and occupation are indicated by R^2 which is coefficient of determination.

Therefore, results show that DWS affects income and occupation at $R^2 = 0.730$ and 0.643 respectively. This means that changes in DWS (X) accounts for 73% and 64.3% of the changes income and occupation respectively.

Table 4: Multiple correlation and regression between DWS and Variables; income and occupation, decision taken at $p<0.05$

Elements	Statistics	Occupation	Income
DWS	*Correlation Coefficient*	0.650	0.590
	R^2	0.643	0.730
	p-value	0.003	0.001

The decisions on significance of correlation are taken at $p < 0.05$ and it is clear from Table 4 that there is a significant correlation between DWS and the 2 variables at p-values 0.003 (occupation) and 0.001 (income) respectively. The Regression analysis (X, Y_1), (X, Y_2) was carried out on the assumption that there is no multicollinearity since there is only one independent variable which is DWS and therefore not autocorrelated. More so, the F-tests (9.105, 11.349) and the t-test (2.507, 1.225) for occupation and income respectively did not show any significance and usefulness. The implication of this analysis is that the incidence of domestic water stress (DWS) in Hong LGA affects both income and occupation. Water stress tends prevent people from engaging in meaningful ventures that can give more income and some of their meager income is channeled into buying water to augment the shortfall in quantity required. Businesses tend to suffer when there is water stress (Schulte, 2014; Koolwal and Walle, 2010). Similarly, poor access to water and time spent on accessing the little water for domestic uses affects productivity at work (occupation). The income of the people of Hong LGA is greatly affected by DWS as the result has shown and has been supported by the views of Mwinzi (2014) who disclosed that in Kenyas' Kibauni area, higher water costs for individuals has reduced household disposable income and that water scarcity has affected the productivity and income of women. Similarly, Living Water International in a document by Darilek (2016) indicated that the poorest people in the world pay one of the world's highest prices for water thereby affecting their income.

Planning Proposal

Rainwater harvesting system (RWHS) through the roof catchment system is proposed to mitigate domestic water stress in Hong LGA. This is the capture, conveyance and storage of rainwater through proper planning and calculation of households' water requirement. However, the water captured from this system is not to be used for drinking but for other domestic uses that require little or no purification. Furthermore, the positive implication of RWHS in the home will reduce flooding and pressure on drainages and sewers around the house as the water is diverted into a storage system. This will not impact negatively on groundwater recharge, plants and evapotranspiration imbalance since it is a small harvesting system of rainwater.

The steps involved in household's RWHS planning are as follows:

I. Size of households in Hong LGA varies widely but 2006 census revealed that an average size of household in the area is made up of 5 persons. The estimate of the water requirement for a household in this proposal is based on this average of 5 persons per household.

II. Annual 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 to 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 RWH.
III. An average roof catchment area in Hong local government area is 4x3 m^2 of corrugated roofing material popularly called "roofing zincs".

Similarly, quantity of Rainwater harvesting (RWH) system can be determined according to Worm and Hattum (2006) using the formula as follows:

Supply (S) = Rainfall (R) x Area (A) x Run-off coefficient (C_r):

$S = R \times A \times C_r$…………… (1)

$MRS = \sum MAR \times \sum RCA \times \sum RRC_r$……… (2)

Where:

MRS = Mean annual rainwater supply (m^3)
MAR= Mean annual rainfall (m)
RCA = Catchment area (m^2)
RRC_r = Run-off coefficient

The size of water storage tanks for each household depends on the number of users and therefore the calculation and choice should be tailored to meet the water needs of the household. The various formulas serve different purposes and therefore should be applied for the purpose it is meant for in plan preparation for RWHS. Every plan requires an acceptable process in order to succeed; the people should be involved in the process through a participatory approach. The RWHS planning will need adequate public education, participation and cooperation.

The planning standards for the system are as follows:

i. The conveyance system are curved gutters with a minimum width of 5-8cm properly hung to the edge of the roof can provide adequate water and offers high performance. 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).
ii. The storage system is the round plastic water tank popularly called 'GeePee' tanks with different dimensions and storage capacity as presented in Table 5. The tanks should be dark-coloured or protected from sunlight to prevent algae growth and compromise the quality of the water.

Table 5: Dimensions of Water Storage Tanks for the proposed RWH System

Volume (Litres)	Diametre (mm)	Height (mm)
1,000	1,100	1,300
1,500	1,150	1,700
2,000	1,200	1,900
2,500	1,450	1,700
5,000	1,800	2,000
5,500	1,840	2,300
10,000	2,200	3,000

iii. The concept of *reduce* and *reuse* of water is recommended in the management of the stored water in all households for efficiency and judicious utilization.
iv. A household with an average of 5 persons require a minimum tank storage capacity of 10, 000 litres, 10 persons household will need at least 20, 000 litres (2 tanks) to augment their water supply shortfall for the period of severe water stress which is usually during the dry season.

Funding the proposed RWHS can be done through soft loans from the local microfinance bank especially for less buoyant households. This proposed system will ameliorate the incidences of DWS in the area if adequately implemented.

SUMMARY

DWS is widely experienced in Hong LGA as confirmed by this research that over 90% of the households are water-stressed and this situation has affected the income and occupation of the people of the area. A planning strategy proposed to ease the effects of this phenomenon on the people in the area is the rainwater harvesting system (RWHS) since rainfall regime can support this system. Therefore, the RWHS is proposed considering the fact the area is blessed with high rainfall and the move towards harnessing environmental resource like water in the face of the global challenges.

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