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ASSESSMENT OF GROUND WATER ABSTRACTION IN KWADON, YAMALTU DEBA LOCAL GOVERNMENT AREA, GOMBE STATE

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ABSTRACT

Groundwater is the major freshwater store acting in the hydrological cycle. It provides water for human consumption, agriculture, industry and many groundwater-dependent ecosystems, especially during dry season and drought periods. This study "Assessment of Ground Water Abstraction in Kwadon, Yamaltu Deba Local Government Area" aimed at examine the quantity of water abstracted for various uses in the study area and its implications for future development. Field Measurement, Questionnaire and GPS device was used to collect information about water sources and uses in the study area and data collected were analyzed using T-test and descriptive statistics. The result shows that there is a significant difference in the depth of boreholes and wells between periods with minimum and maximum depth of 26m and 53.5 for boreholes and 12m and 21m for wells respectively. The study also revealed that Table water industries, Block industries, Fishpond, Water Vendors and Irrigation agriculture are the dominant activities that are using underground water with annual abstraction rate of 1785000m^3, 1905600m^3, 1818150m^3, 3168000m^3 and 1827100m^3 respectively. A general decline in rainfall and geological nature of Gombe town has led to the over exploitation of groundwater in the study area. Sustainable groundwater management in the future requires groundwater to be used in a manner that can be maintained for an indefinite time without having unacceptable environmental, economic or social consequences.

Contribution/Originality: This research work title assessment of groundwater abstraction in kwadon Gombe state will contribute to existing literature especially in the fields of water resource management and hydrology. Empirical methods were used in collecting relevant data and this study is among few and non-carried out in the state. The study is original and the primary findings was that groundwater in the study area is under threat due to over utilization. Therefore this study document the rate of groundwater abstraction and need for sustainable utilization.

1. INTRODUCTION

Groundwater is the major freshwater store acting in the hydrological cycle. It provides water for human consumption, agriculture, industry and many groundwater-dependent ecosystems, especially during droughts (Bassey, 2003; Wada *et al.*, 2010; Treidel *et al.*, 2012). In recent decades the increasing use of groundwater for human consumption, industries and irrigation has resulted in groundwater lowering in large parts of the world. (Longe *et al.*, 2010). It is well recognized that regional depletion of groundwater resources is a global –scale problem (Konikow and Kendy, 2005; Adah and Abok, 2013). Most groundwater resources are non-renewable on meaningful time scales for both human society and ecosystems. The predicted climate change will exacerbate these concerns in many parts of the world by reducing precipitation and increasing evapo transpiration, both of which will reduce recharge and possibly increase groundwater withdrawal rates (Shaminder *et al.*, 2006; Adekunle *et al.*, 2007; USAID, 2010). Sustainable groundwater management in the future requires groundwater to be used in a manner that can be maintained for an indefinite time without having unacceptable environmental, economic or social consequences (Amengo-Etego and Grusky, 2005). Groundwater sustainability is a value driven of intra and inter-generational equity that balances the environment, society and the economy (Aeschbach-Hertig and Gleeson, 2012). This requires groundwater management to be approached in a holistic way, where all water uses are seen in the context of socio-economic development and protection of ecosystem and ecosystem services (Ademiluyi and Odugbesan, 2009). Even with the discovery of vast amount of groundwater, there is a concern about groundwater depletion and contamination' There is therefore a strong need to understand, protect and manage the groundwater resources of an area wisely (Eduvie, 2006). Nearly all rural dwellers depend mainly on groundwater for their domestic supplies, which is an extensive reliance on diminishing resources. On average water is being removed from the ground several rates higher than it is being replenished (Agboola, 2003; Omole and Isiorho, 2011).

Kwadon basin in Yamaltu Deba extends about 7km away from the state capital and stores much underground water on which Gombe metropolis depend on despite the commission of Dadin Kowa regional project in 2006. Underground water abstraction is the main source of water supply for domestic and irrigation purposes. There are many boreholes that are operated in Kwadon. A general decline in rainfall for the area has led to the over exploitation of underground water and the available groundwater is on the decline. Water levels in boreholes have fallen and borehole yields have drastically declined over the years.

No research has been conducted to determine the volume of water abstracted for various activities and its implication on future underground water depletion or availability. It was against this background that this research was carried out.

The aim of this research was to analyze the rate of water abstracted from Kwadon basin and its implication on future water needs.

The objectives include the followings:

i. To map out the distribution of water sources in the study area.
ii. To take inventory of all types of activities using underground water in the area.
iii. To quantify the volume of water abstracted by various users in the study area.
iv. To find out the problems associated with abstraction of undergroundwater in Kwadon.

2. STUDY AREA AND METHODOLOGY

2.1. The Study Area and Location

Kwadon district is an area within Yamaltu Deba Local Government Area of Gombe state. It lies between 10°00^1, 10°30^1 and on 11°11^{1}E to 11°45E respectively. The study area is located about 7km away from the State Capital, along Gombe-Biu road Figure 1. The area under study is part of extreme tropical continental type of climate. One of the basic characteristics of this climatic zone is its relative short rainy season and the comparatively long dry season. The beginning and the end of the rainy season changes from year to year. It usually begins in late April to early may and ends in late September or early October. The area has a rainfall distribution ranging from 970.7mm – 1.142mm annually, with a mean of 850mm and a mean maximum and mean minimum temperature of 32.8°C and 18.3°C respectively.

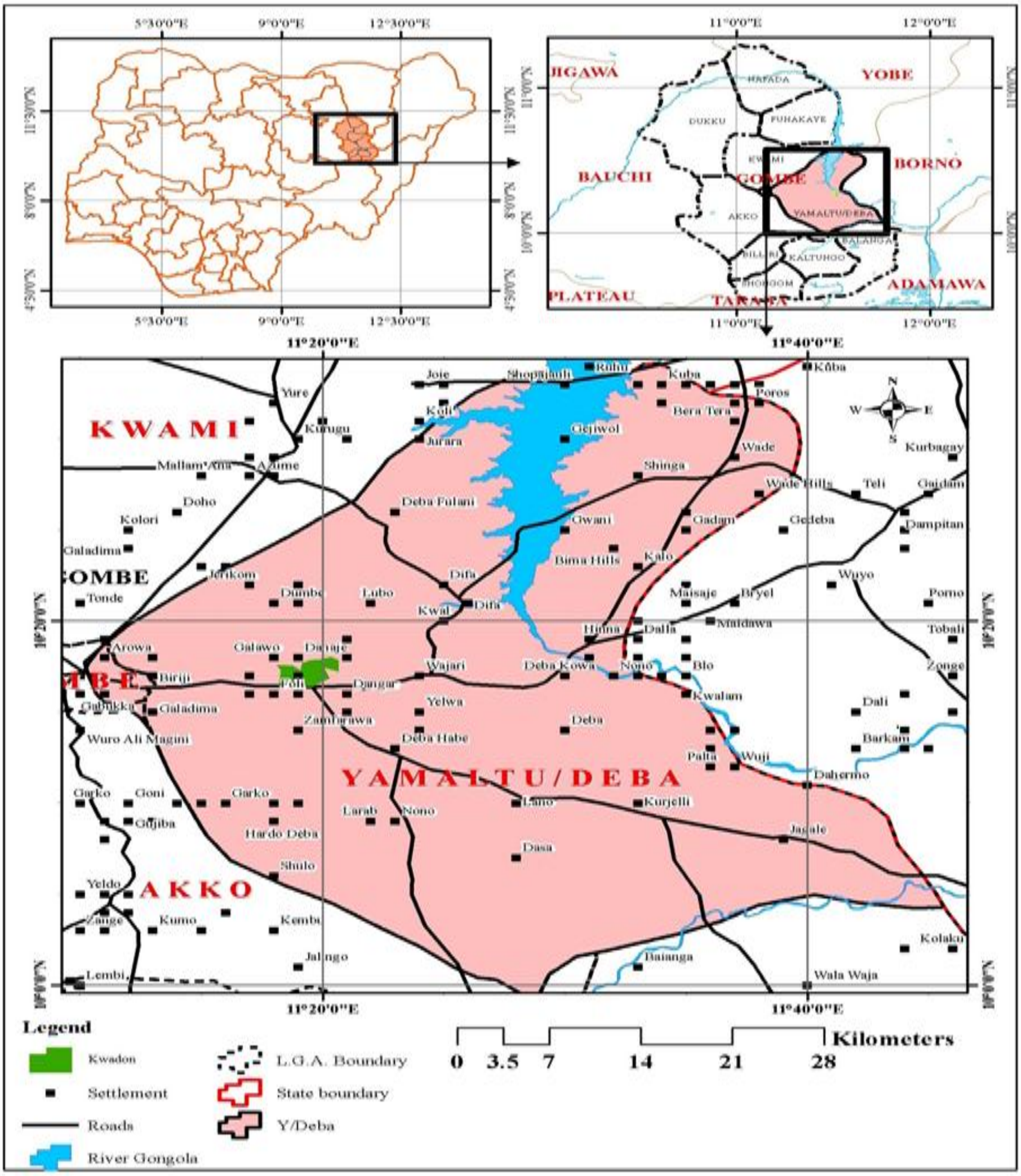

Figure-1. Kwadon the study area in Yamaltu- Deba LGA, Gombe state.
Source: National Centre for Remote Sensing (2017).

The Yamaltu Deba L.G.A occupies a land mass of 1,981km with a postal code of 781 003. The major tribe's area are Tera and few minor tribes such as Fulani with some few diver's tribes: Kanuri, Hausa, Jara and Waja. Yamaltu Deba has the population of 255,726 (National Population Commission, 2007).

The relief of Yamaltu Deba L.G.A comprises part of the upper Benue trough of northern Nigeria. The plain has generally undulating characteristics especially towards the northern part of Kwadon where the height of the area is estimated to be 274m above sea level. The area is drained by Wango Stream through Kwadom, Zambuk down to Dadin-Kowa which is a tributary to River Gongola. The soils are shallow to deep loamy, sandy, clay, vertisols and cracking clay that have weathered and very fertile and support intensive agriculture. The soil of the study area is developed on sand stone parent material (Gombe Sandstone). The vegetation of the area is Sudan Savannah; most of forest cover in the area has been reduced to semi desert shrubs. The inhabitants of Kwadon are predominantly farmers who depend on this activity for their livelihood inherited from their fore fathers. The geology of the study area is that of Gombe sandstone (Mbaya, 2012). The soil of the study area is typically that of ferruginous type. The soil is dark grey in colour with pit value ranging from 4 to 6 depending on the location.

2.2. Hydrogeology and Hydrology

The Upper Aquifer System: The Upper aquifer system consists of at least three zones. These zones referred to as A, B and C system is found at depths of 10- 40 m, 40-70 m and 78-99 m respectively. The system is heterogeneous in nature consisting of arenaceous deposits intercalated with clay layers. The Upper aquifer is in hydraulic continuity with the water table therefore, direct recharge by infiltration through the soils, clay cracks, fractures and fissures, constitute a major component (Yusuf, 2015).

The Middle aquifer system: This is the most widespread and best exploited confined aquifer, with surface area in excess of 50,000 km2. Its depths range from about 200 to 350 m. Lithological it is the most varied aquifer, consisting mainly of sand and gravels with silt and clay intercalations. It is isotropic in nature. Recharge to this aquifer is reported to occur by horizontal inflow around the ridge of the rocky areas, and also by vertical percolation from a ridge. Yields of boreholes tapping this aquifer range between 5 and 10 l/sec.

The Lower aquifer system: The lower aquifer system is found at depths of 420-650 m, with varying yields according to location ranging from about 15 l/sec to as high as 30 l/sec. Initially it was taught that the aquifer was mainly confined to the area but geophysical investigation later indicates its presence beyond Gombe. The geometry, lithology and hydrogeology of this aquifer are fairly well known due to the greater number of boreholes drilled in and around the area (Bumba *et al.*, 1985). Not much is known about the recharge to this aquifer but it is believed to be at a far distance at the fringe of the basin (Yusuf, 2015).

2.3. Materials and Methods

Primary source data were derived from the field, they include; measurements of the depth of wells, boreholes and years dug and drilled respectively, questionnaire responses to determine the volume of water used and abstracted by block industries, irrigation agriculture, fish ponds, water vendors and table water industries, Also, ground coordinates of water sources i.e boreholes and well were collected using Global Positioning System (GPS) device. Sample responses /information to be obtained in the field. Secondary sources of data included information collected from sources such as books, academic journals, and record information from ministry of water resources and others.

A purposive sampling technique was employed during the collection of data using questionnaire. The purposive sampling is a non-probability sample that was selected based on characteristics of a population and the objective of the study. For the purpose of this sampling techniques 10 questionnaires was administered each to, Water vendors, irrigation farmers, block industries, fish pond, water vendors and table water industries to determine and quantify the average volume of water abstracted daily in the basin (study area). This will make a total of 50 questionaires. For this study all accessible wells and boreholes within the study were mapped using to analyse the results and draw conclusions.

Data collected were subjected to descriptive and inferential statistics. Simple descriptive inform of tables and graphs were employed to present findings from respondents. Also, percentages and standard deviation values (i.e mean, median, variance and range) from field records were presented. GIS software (ArcGIS 10.5) to generate the maps and other relevant information using Spatial analysis toolbar.

3. RESULT AND DISCUSSION

3.1. Distribution of Water Sources in the Study Area

Figure 2 and 3 shows the number and spatial distribution of water sources in the study area. The study revealed two major sources were identified and these are wells and boreholes. From Table 3 boreholes constitute 60% of the water sources while wells constitute 40%. The main implication of this finding is that boreholes abstract high volume of water from the underground surface than wells. This is because boreholes provides most of domestic water demands to Gombe metropolis such areas as Tumfure, Federal College of Education, Gombe State University, Federal Low cost. The wells on the other hand are used for the fish ponds and irrigation. This finding revealed that there is significantly high abstraction of underground water leading to lowering of the water table level and thus negative future implication of water availability.

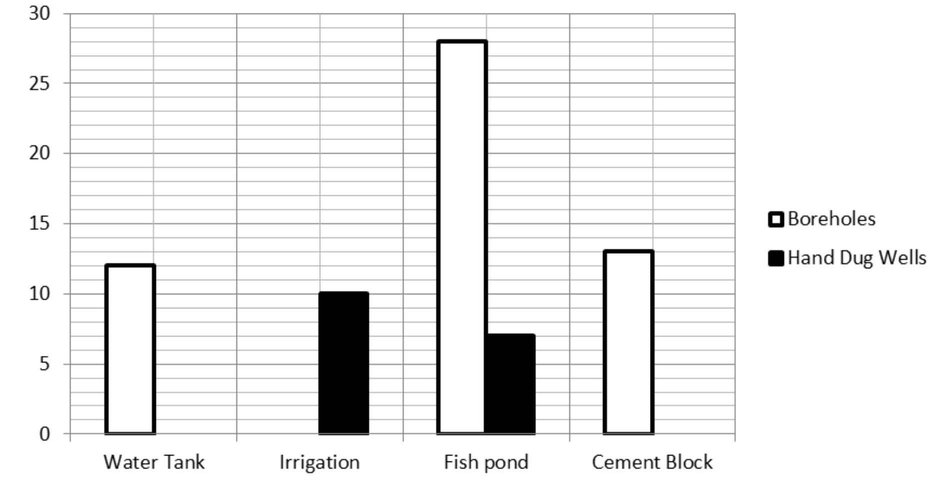

Figure-2. Number of water abstraction means per activities.

Source: Fieldwork, 2018.

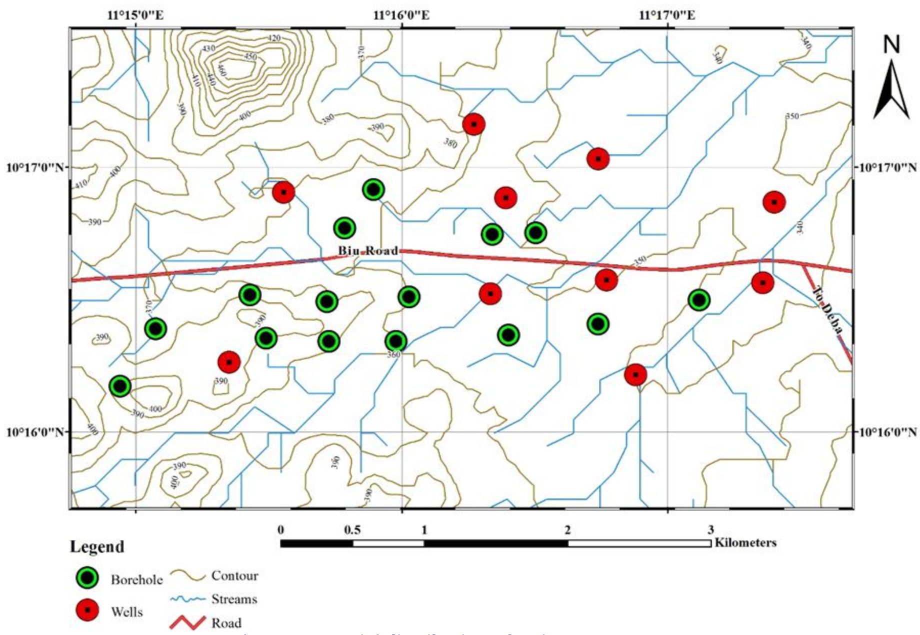

Figure-3. Spatial distribution of major water sources.

3.2. Depth of Water Sources

Figure 4 shows the depth of 15 boreholes and 10 wells sampled. The depth of the boreholes and wells from 1995 – 2017 ranges from 26m to 53.5m and 12m to 21m respectively. This study revealed that the depths of boreholes and wells have increased to 3.6 metres and1.4 metres over the 15 years. This was further supported by the t-value Table 1 that revealed there is a statistically significant increase in the depth of wells and boreholes in the study area. This could be attributed due to expansion of Gombe metropolis and water demands due to inadequate connection and supply of water from the regional water scheme. The future implications for this findings is that; as underground water abstraction continues to increase without a sustainable practice to limit and maintain the level of the water table, the study area underground water resource may deplete or dry up leading to severe water scarcity.

Table-1. T-test result for boreholes and wells depths.

	Test value = 35.5					
	t	Df	Sig. (2-tailed)	Mean difference	95% Confidence interval of the difference	
					Lower	Upper
Boreholes	1.91	14	0.077	4.36	-0.5348	9.2548
Wells	-21.424	9	0	-19.7	-21.78	-17.62

Source: SPSS analysis, 2018.

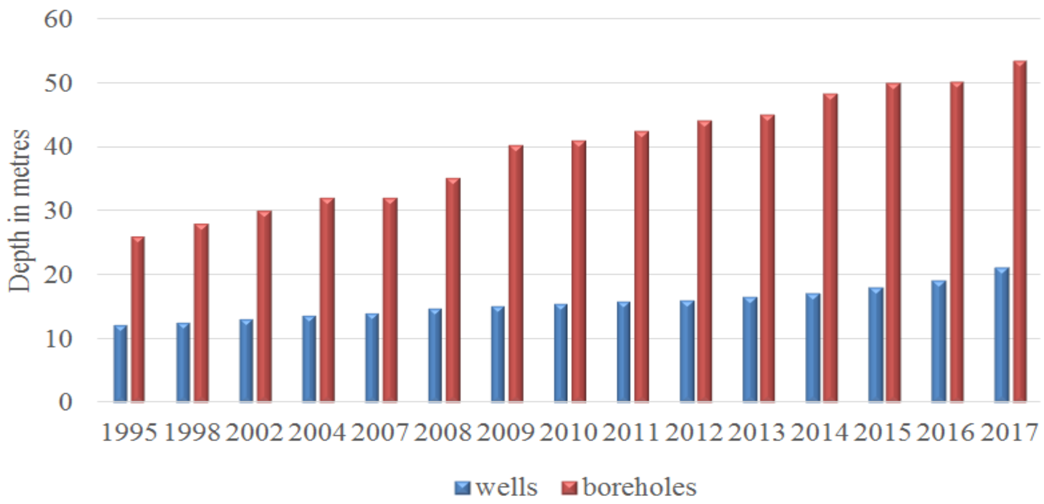

Figure-4. Depth of wells and boreholes 1995 – 2017.

Source: Fieldwork, 2018.

3.3. Underground Water Utilization in the Study Area

Table 2 and Figure 5 shows various activities of underground water utilization in the study area. The result revealed that water vendors are the main primary users (47.78%). Others are fish ponds (8.87), block industries (21.88); irrigation agriculture (10.87%) and table water industries (10.90%). The water vendors in form water tankers are the main supplier of water from boreholes to urban Gombe and some settlement such as Gadam, Bojude and to some extent Dukku town. Well water is mainly used by fish pond and irrigation and mostly during dry seasons while table water and block industries abstracted water through boreholes almost throughout the year. These activities constitute threats to underground water sustainability and future water demands in the study.

Table-2. Uses of underground water.

Activity	Water sources	Number	%
Table water industries	Boreholes	3	10.90
Fishponds	Wells	10	8.87
Block industries	Boreholes	10	21.88
Irrigation sites	Wells	10	10.87
Water vendors	Boreholes	20	47.78
Total		53	100.00

Source: Fieldwork, 2018.

3.4. Volume of Water Abstraction per Utilizations in the Study Area

Figure 5 and Table 3 shows water abstraction by table water industries, fish farming, block industries, water vendors and irrigation farmers. The annual volume of abstraction of water by table water industry was 1785000m^3 with monthly average of 595000m^3; fishpond farming is one of the dominant activities that uses underground water with annual abstraction of 1905600m^3 and monthly average of 190560m^3. Block industries used 1818150m^3 annually with monthly average of 303025m^3. Water vendors the highest volume with 3168000m^3 annually for urban consumption and construction purposes and irrigation accounts about 1827100m^3 annually with monthly average of 365420m^3. This gave an annual abstraction of underground water withdrawal of 6,046,150m^3 and mean monthly of 1,209,230m^3. The abstraction of underground water reaches highest pick during the dry season for all activities especially during the months of December to April.

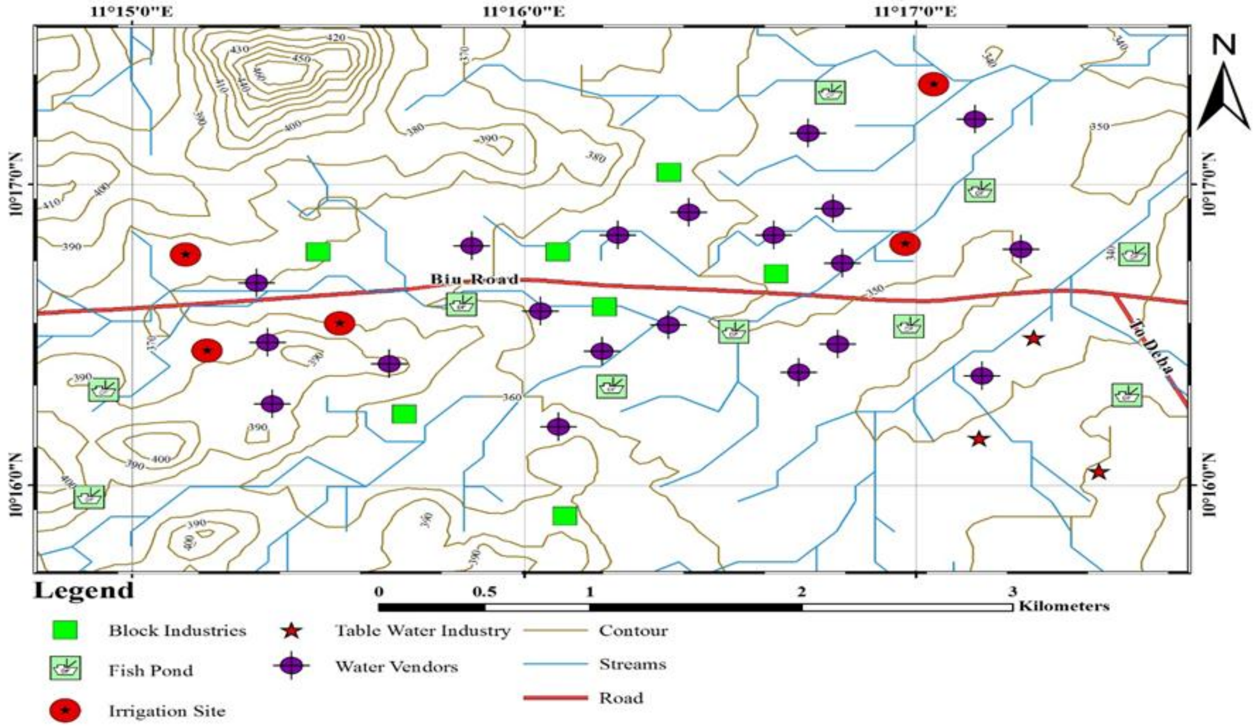

Figure-5. Spatial distribution of underground water utilization types.

Source: Fieldwork, 2018.

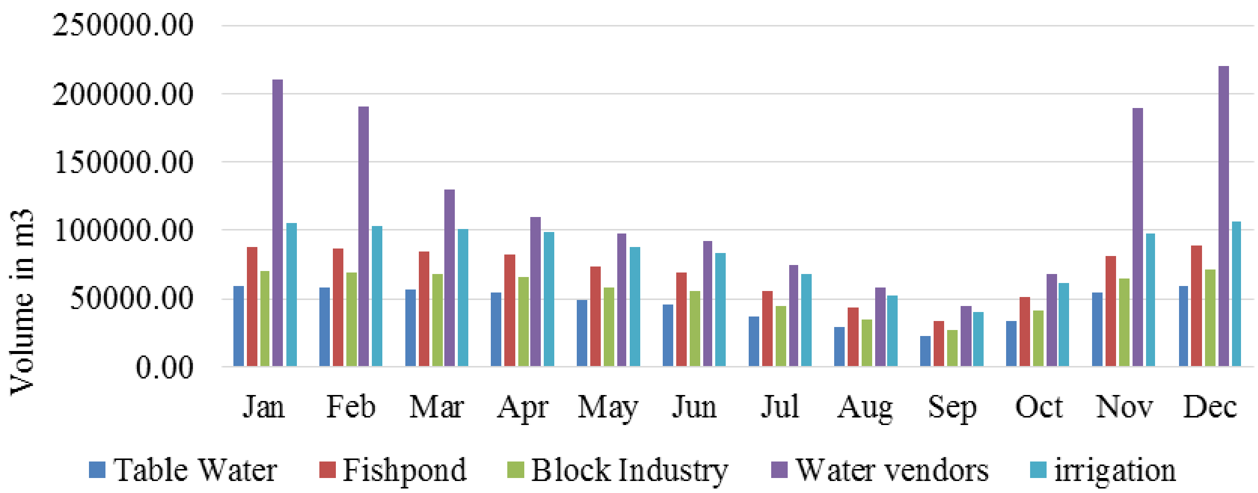

Figure-6. Mean monthly volume of water abstracted in the study area (2010 – 2017).

Source: Fieldwork, 2018.

Table-3. Water abstraction by various sector in the study area.

Name	Source of water	Volume in Dry (m^3)	Volume in Rainy (m^3)	Volume in a Year (m^3)
Table water Industry				
Diyam table water industry	4 boreholes	300000	225000	525000
Pummis table water industry	1 borehole	360000	270000	630000
Charlim Table Water industry	1 borehole	360000	270000	630000
Total		1020000	765000	1785000
Average		340000	255000	595000
Fishpond				
1st	Borehole	60000	36000	96000
2nd	Borehole	180000	108000	288000
3rd	Borehole	30000	18000	48000
4th	Borehole	30000	18000	48000
5th	Borehole	60000	36000	96000
6th	Borehole	45000	27000	72000
7th	Borehole	105000	63000	168000
8th	Borehole	282000	169200	451200
9th	Borehole	120000	72000	192000
10th	Borehole	279000	167400	446400
Total		1191000	714600	1905600
Average		119100	71460	190560
Block industry				
Kwadon Block industry	Borehole/wells	300000	165000	465000
MARABA block industry	Borehole/wells	300000	165000	465000
Rahawa Block industry	Borehole/wells	240000	132000	372000
Maigana block industry	Borehole/wells	210000	115500	325500
Ten ten general	Borehole/wells	78000	42900	120900
Al Sadiqu Shehu and sons	Borehole/wells	45000	24750	69750
Total		1173000	645150	1818150
Average		195500	107525	303025
Water vendors				
	Borehole/well	1920000	1248000	3168000
Total		1920000	1248000	3168000
Average		1920000	1248000	3168000
Irrigation				
1st	Borehole	408000	500	408500
2nd	Borehole	312000	500	312500
3rd	Borehole	480000	700	480700
4th	Borehole	300000	200	300200
5th	Borehole	324000	1200	325200
Total		1824000	500	1827100
Average		364800	620	365420
Grand total		6168000	2751850	8919850
Grand average		246720	110074	356794

Source: Fieldwork, 2018.

Table 3 and Figure 6 shows the level of underground water abstraction by various users in the study area. Table water industries monthly abstract about 50,000m^3 with maximum in the month of December and minimum abstraction in the month of September. As observed the level of abstraction is more during the dry season than in rainy seasons as shown in Figure 7.

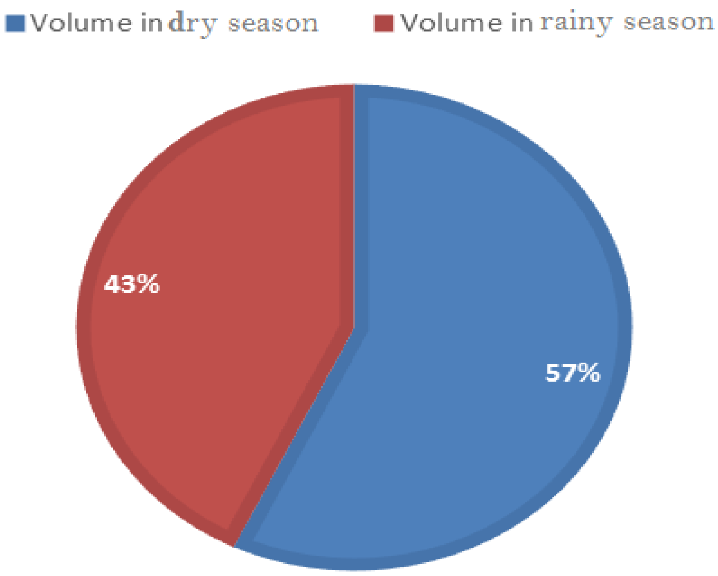

Figure-7. Mean volume of water abstraction between dry and rainy season by table water industries
Source: Fieldwork, 2018.

Figure 8 further revealed fish ponds uses more water during the dry seasons especially the month of December to April. Water abstraction for fishpond was estimated to about 1905600m³ with mean monthly average of 190560m³. This is one of the biggest activities that are using underground water in the study area.

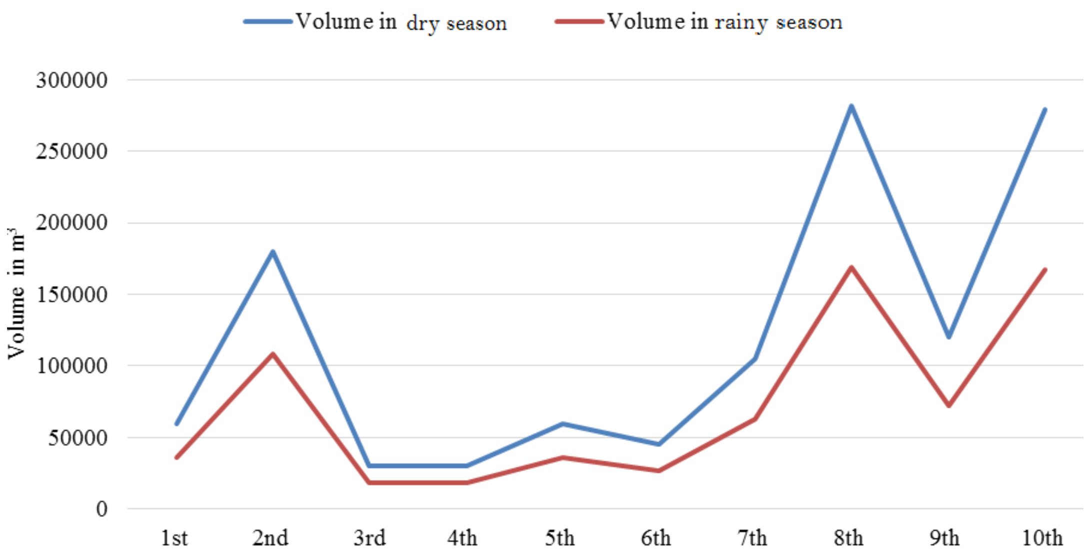

Figure-8. Mean volume of water abstraction between dry and rainy season for fishponds.
Source: Fieldwork, 2018.

Block industries on monthly average uses about 303025m³ with annual abstraction volume of 1818150m³. Dry season has the largest volume of abstraction from this source than in rainy season because rain helps in watering the bricks after production even though production is less during the rainy season and highest in dry season as shown in Figure 9.

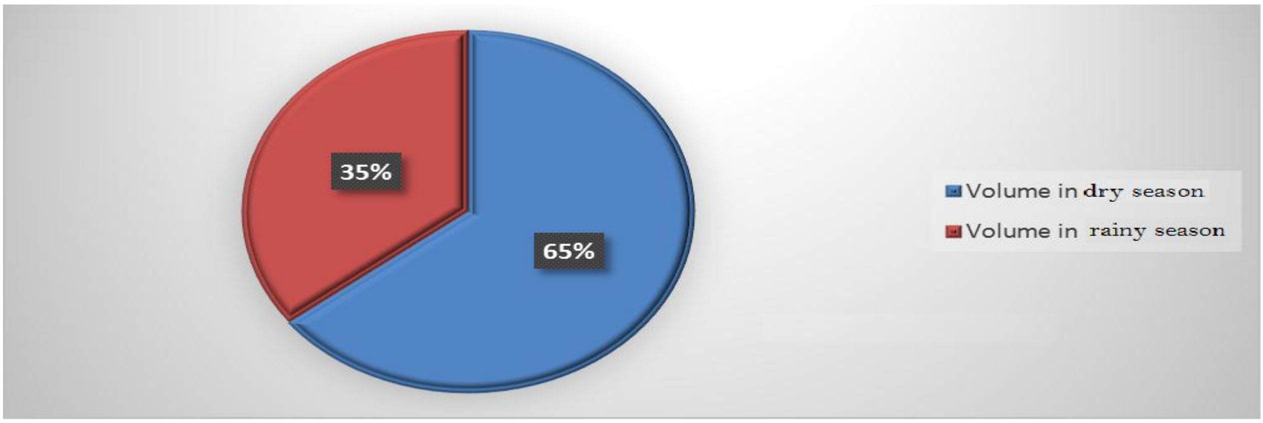

Figure-9. Mean volume of water abstraction between dry and rainy season for block industries.
Source: Fieldwork, 2018.

Water tank vendors on the other hand Figure 10 usually source their water from boreholes. The category of vendors includes; Water vendors and individual users who normally deliver at distant locations usually to Gombe main town. The average volume abstracted in dry season were 1920000m^3 and 1248000m^3 in rainy season while the annual abstraction volume was estimated at 316800m^3.

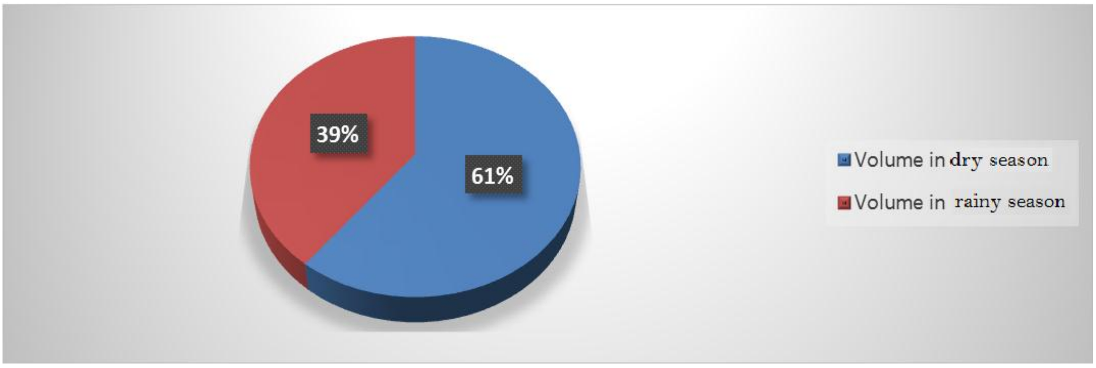

Figure-10. Mean volume of water abstraction in the study area between seasons for dry and rainy season by water vendors.
Source: Fieldwork, 2018.

Irrigation farming is one of the dominant activities that are using underground water in the study area. As the activity name implies, it involves the application of water to crops especially during dry season Figure 11 as this is not be practiced during rainy season . Crops cultivated through this method includes; rice, maize, sweet melon and vegetables of different types. Average volumes of 365420m3 are used monthly by an average size irrigation plot of 2 hectares. While the annual abstraction volumes are estimated at 1827100m^3 annually.

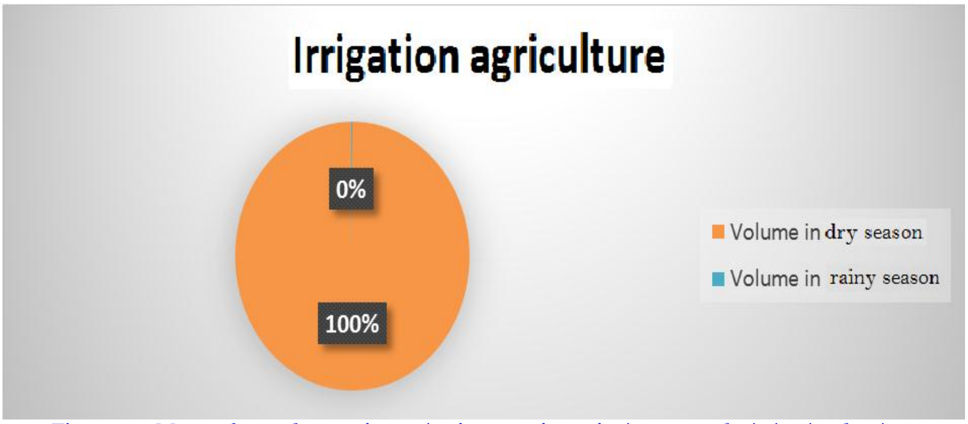

Figure-11. Mean volume of water abstraction between dry and rainy season for irrigation farming.
Source: Fieldwork, 2018.

4. CONCLUSION

Based on the analysis of the of groundwater abstraction in Kwadon, it can be deduced that there has been an over exploitation of the groundwater which has resulted in the decline of water table as reflected in increase in depth of wells and boreholes in the study area. This have serious implications on future water demands if current trends and climate change continues. The study therefore proffers sustainable water management in the area through:

1. A proper management of groundwater in the study area is required with capacity to estimate how much water is available for sustainable development. This management system should be implemented by the State Government in collaboration with the Ministry of Water resources.
2. Historically, one of the earliest approaches to analyzing groundwater yields was built on the concept of safe yield. Safe yield is defined as the rate of groundwater abstraction from basin for consumptive use over an indefinite period of time that can be maintained without producing negative effects. The goal of the safe yield is to achieve a long term balance between groundwater use and ground water replacement and to arrest the declines in the water table.
3. The recharge zones should be protected from construction of permanent structures like roads and housing. The amount of abstraction should be less than the recharge amount to the system to avoid water level decline.
4. Reliable databases and regular monitoring progammes are essential to assess changes in both quality and quantity of the groundwater resource. Constant enlightenment on issues related to water and environment can make costing and planning easier. Management strategy aimed at reducing wastage must be adopted and taking cognizance of fundamentals of water demand and water supply in the area.

The Dadin Kowa water project scheme should be extended to areas without underground water potential in Gombe metropolis and other LGAs so as to reduce the current pressure of water abstraction in the study area.

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