Proliferations of Borehole Distribution Pattern in Suleja Local Government Area of Niger State, Nigeria

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Abstract

This study is aimed at analyzing the distribution pattern of boreholes in Suleja local government area of Niger state in Nigeria. The specific objectives of the study include: to identify the distribution of boreholes in Suleja LGA, identify the factors responsible for the distribution of boreholes, access the impact of such distribution pattern; profile recommendation based on findings. To achieve these objectives, a direct field survey was conducted and the geographical locations of the boreholes were acquired using the Garmin 78 hand held Global Positioning System (GPS). The data collected was used to prepare a dot-map showing the boreholes. An interview was also conducted to compliment and determine the perception of the borehole owners on sensitive issues as related to the aim of the research. The dot map was used to analyze the spatial distribution pattern of the boreholes using ArcGIS 10.0 version. The area was divided into four (4) quadrants which constituted the sample frame and the Nearest Neighbour Analysis was adopted. Household heads were purposively interviewed. The findings revealed that, unqualified engineers are sometimes involved in drilling boreholes, tiling and concretization of compound floor is a regular practice in the study area, and there is a very high demand of water in Suleja. In view of these, appropriate recommendations were made to reduce the proliferation of boreholes in the study area; provide pipe borne water for the populace, planting of trees should be encouraged, avoided concretization of ground surface to allow rainwater percolation to recharge groundwater.

Key words: *Aquifer, proliferation, hydrological Assessment, Groundwater, borehole, water shortage, water volume*

1.0 Introduction

Several studies have pointed out that the world's fresh water is not available all year round; usually it is not available always where it is needed. The basic physiological requirement for drinking water is about 2.1 per person in a day. Furthermore, a daily supply of 140 to 160 litres per capital per day is considered adequate to meet the needs for all domestic purposes [1].

Borehole water is the ground water available in an aquifer. Any contaminated surface water with pathogens that infiltrates into the soil and become ground water would be filtrated by the soil profile before the depth of an aquifer [9]. An Aquifer is saturated water bearing stratum that is capable of holding transmitting and yield sufficient water in underground well [6].

In developing countries like Africa where majority of the people live in rural areas, rivers, streams, wells and most recently boreholes serve as the main sources of water for drinking and domestic use. The underground water supplies are usually considered safe; provided they are properly located, constructed and operated according to the World Health organization Guidelines for drinking water [7].

In view of the progressive increase in population due to influx of persons to Federal Capital Territory (FCT), the demand for potable water in Suleija which serve as a satellite town that absorbs population explosion from FCT has increased [9]. Study by [5], explained that, the increasing rate of population growth, rising demands for food and cash crops, increasing urbanization and rising standard of living represent major factors for shortage of water supply.

Study by [3], explained the various dimensions of water accessibility in the southern part of Niger state. The study examined the determinants of household water accessibility in southern part of Niger state. [5], identified spatial distribution of water borehole facilities in parts of Rivers state [6], examined iron level in groundwater from boreholes and their spatial distribution across rural communities of in Benue state. The study was able to establish that the presence of iron in rural groundwater in study area may be traced to the local environment of the boreholes. These include the geology, dissolution of iron minerals from rocks and soil, precipitation/run off and infiltration activities, the use of galvanized materials in hand pump construction and agricultural land use activities.

According to the study carried out by [8], the groundwater quality use for domestic purpose was analysed in Suleja town Niger state, Nigeria. Five samples were collected for the analysis of chemical characteristics of the groundwater, these includes calcium, iron, sodium sulphate and manganese. The physical characteristics includes color, conductivity, turbidity total dissolved solid (TDS) and Ph. The findings of the study revealed that groundwater quality in the study area account for 95% of the physical characteristics mentioned and to meet the World Health

Organization (WHO) standard except for the turbidity. Among all these studies, none have been able to address the problem of proliferation and the distribution pattern of boreholes in Suleja area of Niger state. It is against this back drop that the research intends to fill in the gap created by determining the distribution pattern and end user's perception on its availability and affordability in Suleja.

Sequel to this aim, the following objectives are to be pursued: Identification of the distribution of boreholes in Suleja; Identification of the factors responsible for the distribution of boreholes; assessment of the impact or implication of such distribution pattern and; profiling recommendations based on findings.

2.0 Study Area

The Suleja emirate was established as the Abuja Emirate during the 19^{th} century, located just North of the site of the present-day Federal Capital city named Abuja. When the new city was established, the Emirate and its Capital were renamed the Suleja Emirate [2]. The Emirate covers about 1,150 sq miles (2980 sq km of wooded Savanna area). Suleja lies within latitude 9^0 17' 48 "N and 9^0 06' 07 "N and longitude 7^0 08' 27 "E and 7^0 14' 08" E (Federal Government of Nigeria 2016). The town is situated on the Iku River a minor tributary of the Niger at the foot of Abuchi Hill and lies at the intersection of several roads. Suleja local government is bounded by the Federal Capital Territory to the South, Gurara Local government area in Niger to the West and North and Tarfa Local government area of Niger State to the East. Currently Suleja covers a total land area of 12,980 square kilometers [5].

Niger State in which Suleja is situated is covered by two major rock formations – the sedimentary and basement complex rocks. The sedimentary rocks to the south are characterized of sandstones and alluvial deposits, particularly along the Niger valley and in most parts of Niger state. This sub area also contains the extensive flood plains of the River Niger and this has made the state to be one of the largest and most fertile agricultural lands in the country [4]. Figure 2.1 show the map of Niger State with Suleja.

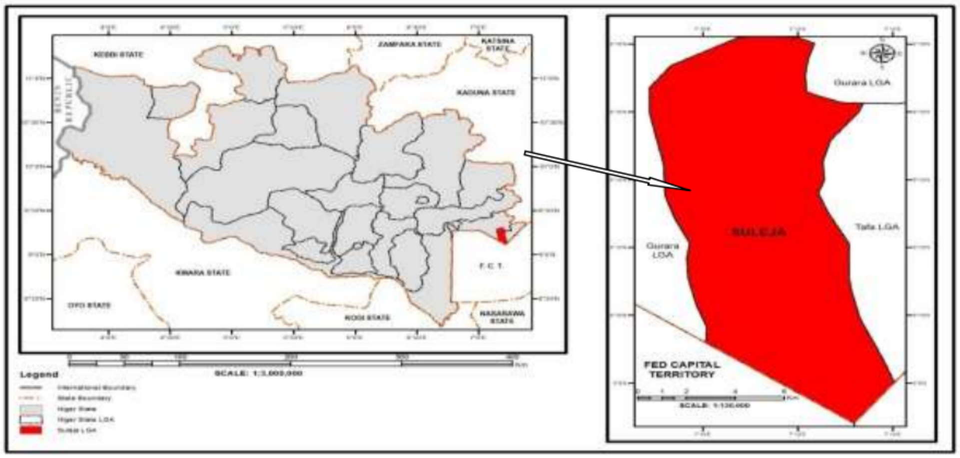

Figure 1: Map of Niger State with Suleja (**Source:** Office of the Surveyor-General of the Federation)

[4], recorded that the state experience two distinct seasons – the dry and wet seasons. The annual rainfall varies from about 1,600mm in the south to 1200mm in the north. The duration of the rainy seasons ranges from 150 – 210 days or more from the north to the south. Mean maximum temperature remain high throughout the year, hovering about 32^0f, particularly in March and June. However, the lowest minimum temperature occurs usually between December and January when most parts of the state come under the influence of the tropical continental air mass which blows from the north [4]. They also noted that dry season in Niger state commences from October.

Suleja is made up of the Gwaris, Hausas, Kuros, Gwandaras, Fulani, others like Yorubas and Igbos presently in tangible figure or number. This is due to exposure to trade from the Northern to the Southern part of the states. The total population according to National Population Commission (2006) census is 206,578. This can further be projected to 2015 as 308,138.

There are six rivers within the town and its immediate environs. The most important of these rivers is the Gurara with its source from Jos Plateau [4]. This river flows about 20 kilometers way from the West of Suleja and discharge into the river Niger near Koton-Karfe. The river Tafa which is a tributary of the Gurara flows at about 6 kilometers to the East of the town [4].The river Iku which also supply water to the town; now have a dam at Kofa 7 kilometres away from the town, the river flow east-west of the town [8]. Two tributaries of the river Iku flow through Kwamba and Dankuika ward and provide two of the town most important natural drainage channels other streams are Gefaure in the East and Rafin-Sanyi [8].

The study further stated that hydromorphic or water logged soils are largely found in the extensive flood plain of the Niger River [4], mentioned that, three major soils types can be found in the Niger state. These include the ferruginous tropical soils, hydromorphic soils and ferrosols. The most predominant soil type is the ferruginous tropical soils which are basically derived from the basement complex rocks, as well as from old sedimentary rocks [3], pin pointed that such ferruginous tropical soils are ideal for cultivation of guinea corn, maize, millet and groundnut. The soils are poorly drained and are generally grayish or sometimes whitish in colour due to the high content of silt [4].

In carrying out this study, a reconnaissance survey was conducted. This was to get acquainted with the study area. On this trip the existing map of Suleja was carried along to identify the boreholes locations and their total numbers. The data are purely quantitative (numerical) in nature. This includes the geo-spatial attribute of the surveyed site (longitude and latitude). The data was generated with the use of Gemin 78 Hand Held Global Positioning System (GPS). The generated data was used to plot the site of data collection, as well as subjected to statistical techniques. Furthermore, the responses generated through the questionnaire designed for in-depth interviews were used analyse the challenges and mitigation steps taken by respondents on factor responsible for the distribution of boreholes.

3.0 Methodology

Sample frame and sample size

The sample frame for this research constitutes the Suleja Local Government Area (LGA) of Niger state. The entire project area was divided into four quadrants namely North West, North East, South West and South East and the numbers of the boreholes in each quadrant were noted. The sample size includes all boreholes in the Study Area. A total of 307 boreholes were sampled in the course of this study. Table 1 shows summary of sample frame and sample size while Table 2 shows the summary of materials and methods of analysis used for the research.

Table 1**:** Summary of sample frame and sample size (**Source**: Field work, 2016)

S/N	Suleja LGA Regions	No of Boreholes
1	North West	70
2	North East	25
3	South West	73
4	South East	139
	Total	**307**

Table 2**:** Summary of materials and methods of analysis (**Source**: Field survey, 2016)

Computer	Used as work station
Arc GIS	Software used for the execution of the work. With ArcGIS the Dot map was produced with accurate positions of the boreholes
Handheld Gemini GPS	For point location of boreholes
Suleja map with Boreholes Distribution	Divided into four quadrants for Nearest Neighbor Analysis
Global mapper	This is a software used for importing data from the GPS to ArcGIS environment for further analysis
A4 printer	Used for printing out reports
AO Printer	Used for printing out project report

4.0 Data Analysis

Some statistical techniques considered to be more suitable were used in the analysis of the data. The dot map was first employed in analyzing the spatial distribution of boreholes in the local government. This was done with the aid of the ArcGIS computer software. Then, the Nearest Neighbor Analysis was adopted.

The map of the project area was divided into four quadrants namely North West, North East, South West and South East and the analysis was done on each of the quadrants. Through this division the clustered nature of some boreholes in some areas of the project and the random nature in some area were noticed. The data on temporal distribution, factors and impacts of drilling proliferation and distribution pattern of boreholes on the Suleja environment were represented on Dot map. They were analyzed, discussed and thereafter considering the socio-economic impact to the residence. Figure 2 shows the map of existing borehole points in Suleja.

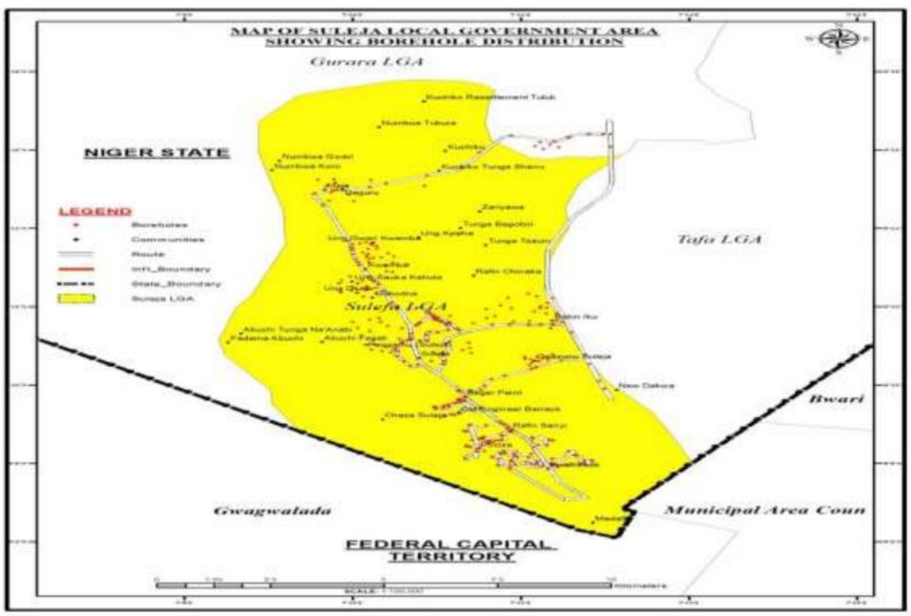

Figure 2: Map of Suleja showing borehole points

Statistical Technique

Nearest Neighbour Analysis was adopted and it involves a comparison between the observed spacing of a set of points and the spacing which would be expected in a random pattern. The observe spacing is the distance between any point and all other points. These can be determined in two ways:

By straight line measurement with a compass and ruler and express in metres or kilometers.

By determining the Euclidean distance in space obtained by pythagoras' theorem (which states that in a right angle triangle, the square of the hypotenuse is equal to the sum of the squares on the other two sides).

To determining the spatial randomness of borehole distribution, the locational data of mean distance (Do) of the phenomena in question was compared to the same expected mean distance (De) of a random distribution.

The nearest neighbor analysis was applied as:

$$R_n = \frac{D_o}{D_E} \qquad (1)$$

where,

$$D_o - \frac{E_x}{n} \qquad (2)$$

E_x= summation of distance between all points

n = number of points

$$D_e = 0.5\sqrt{\frac{a}{n}}$$

a = area of the region under stud

n = number of points in the study area

Null hypothesis

There is no specific pattern of Borehole distribution in Suleja Local Government.

Test for Ssignificance

The nearest neighbor index was also subjected to significant test; in other to justify the spatial randomness of the distribution of boreholes in the regions derived.

The test for significance can be derived from the standard error (SEd_E) and the test statistic.

$$SEd_E = \frac{0.26136}{\sqrt{\frac{n^2}{A}}} \qquad (3)$$

5.0 Results and Discussions

Determination of Borehole Distribution Pattern in Suleja Local Government of Niger State

The geo-spatial data (coordinates, distances and altitude) obtained from study frame were subjected to Statistical Analysis. The Nearest Neighbor Index Analysis was adopted to determine the clusteredness and randomness of boreholes in the study area.

Result of the nearest neighbor statistical test is examined in relation to the scale of random distribution proposed by David, (2000). Figure 3 shows the scale of random distribution of the borehole points in the study area and Table 3 depicts the results of borehole distribution.

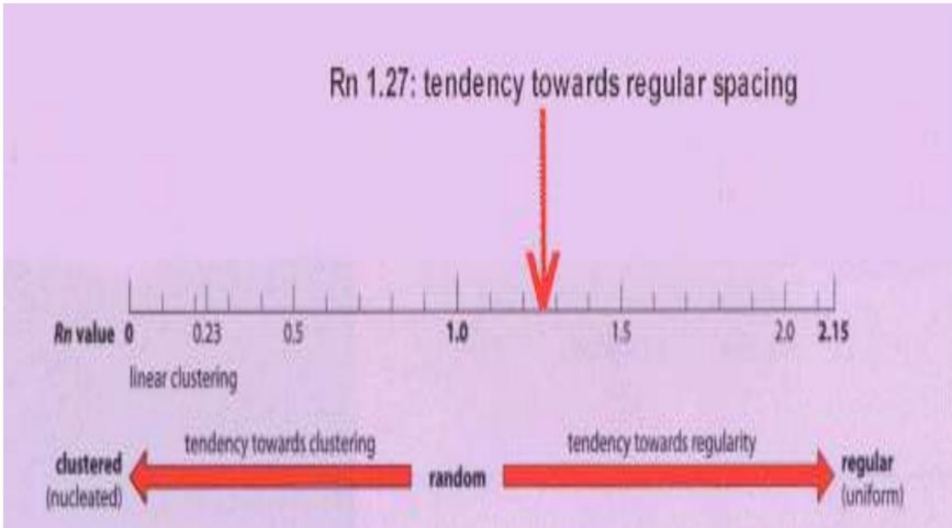

Figure 3: Scale of Random Distribution (**Source:** David Waugh, 2005)

Table 3: Results of borehole distribution (**Source:** Author's Computation, 2016)

ANALYSIS OF BOREHOLE DISTRIBUTION			
	Nearest Neighbor		
Quadrants	**Mean Distance**	**RN**	**Remark**
NW	0.20	0.4	Clustered
NE	0.31	0.37	Clustered
SW	0.12	0.2	Clustered
SE	0.14	0.76	Random

Borehole Distribution Pattern in the North-West Quadrant

Results from the analysis of boreholes distribution in the North West quadrant shows the calculated mean distance as $0.2m^2$ and the RN as 0.4m so therefore, the RN falls within the clustered value of the Nearest Neighbor (RN) index. From the Table 4.1 the result RN indicates a clustered pattern of distribution. This implies that the boreholes in this quadrant s are concentrated in one location.

The clustered pattern of the boreholes in this quadrant indicated by the statistical test implies that there is proliferation of boreholes as they are mainly concentrated in this area based on the fact that the area is highly populated, non availability of tap borne water and most of the boreholes are for commercial purposes.

Borehole Distribution in the North East Quadrant

Results from the analysis shows that the mean distance is $0.3m^2$ indicate that the Nearest Neighbor index (RN) of the distribution is $0.37m^2$ as calculated. This indicates a weak clustered pattern of the distribution of borehole in this quadrant (North East) as shown on the Table 4.1. The clustered pattern in this region is due to the fact that there are no presence of tap borne water, increasing drilling of most boreholes are used for commercial purposes and the area is highly populated.

Borehole Distribution in the South West Quadrant

Observation from the table shows that in the south-west quadrant the calculated mean distance of borehole distribution is $0.12m^2$ while the RN of the distribution of boreholes is $0.2m^2$ which indicates a very strong clustered pattern of the distribution of boreholes. This indicates that the area is highly populated, there is non-availability of tap borne water and most boreholes are used for commercial purposes.

Borehole Distribution in the South East Quadrant

Results from the analysis of the borehole distribution in the South-East quadrant shows that the mean distance of the borehole is $0.14m^2$ while the RN of the distribution pattern is 0.76m. The result of the RN indicates a random pattern. This indicates that the boreholes are scattered over the area because of the nature of the area which is high density area. The population is low and most of the boreholes are for personal uses.

Perception Study

This session presents the result of interview and Focus Group Discussion held with Borehole Owners in the study Area. Table 4 shows the total number of boreholes in Suleja LGA.

Table 4**:** Total number of boreholes in Suleja L.G.A **(Source**: Field Survey, 2016)

S/N	Location	Frequency	Percentage
1	North-East	25	8.1
2	North-West	70	22.8
3	South-West	73	23.8
4	South-East	139	45.3
	Total	**307**	**100**

A total of 307 boreholes were surveyed in Suleja L.G.A as indicated in Table 4.2. Most of the boreholes 45.3% were found in the South-Eastern part of Suleja L.G.A. This is followed by the South-West with a total of 23.8%, then the North-West, 22.8%. The North-East only had 8.1% of the boreholes. As a result of this water is not a problem to South-East, unlike the North-East. Table 5 shows the factors responsible for distribution pattern of boreholes in Suleja Local Government Area.

Table 5**:** Factors responsible for distribution pattern of boreholes in Suleja Local Government

Source: Field Survey, 2016

S/N	Location	Commercial Purpose		Tap water Inadequacy Or non-availability		Increasing Population		Convenience Sake		Irrigation/ Industrial Purpose	
		Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
1	N-E	2	8.0	9	36.0	6	24.0	1	4.0	7	28.0
2	N-W	8	11.4	19	27.1	21	30.0	9	12.9	13	18.6
3	S-W	15	20.5	21	28.8	15	20.5	19	26.0	3	4.2
4	S-E	39	28.1	33	23.7	22	15.8	41	29.5	70	2.9
	Total	64	20.8	82	26.7	64	20.8	70	22.8	27	8.8

Table 5 shows that most of the respondents (26.7%) were of the view that, tap water inadequacy/non-availability were responsible for the proliferation of borehole; this is a deliberate individual effort to providing water for the usual water needs. This is followed by factors like irrigation and industrial purposes 26.1%. Other factors were for convenience sake 22.8%, increasing population 20.8%, and for commercial purpose 20.8%.

While most of the respondents (36%) in the North-East of Suleja saw lack/inadequacy of tap water supply as a strong reason behind, the increasingly drilling of boreholes in the area; 30% in the North-West saw increasing population of the area the reason. In the South-East 29.5% of the respondents were of the view that it was water need for convenience that has led to proliferation of boreholes in the area. Those that were of the view that irrigation/industrial purposes were also a strong factor (28%) were from mainly the North-East. In the South-West, it was tap water inadequacy/lack (28.8%) that was responsible. Table 6 shows the negative environmental impacts awareness of boreholes drilling in the study area.

Table 6: The Negative Environmental impacts awareness of boreholes drilling

(Source: Field Survey, 2016)

Suleja L.G.A	**North-East**		**North-West**		**South-West**		**South-East**		**Total**	
Frequency	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Aware	3	12.0	9	12.9	11	15.1	7	5.0	30	9.8
Unaware	22	88.0	61	87.1	62	84.9	132	95.0	277	90.2
Total	25	100	70	100	73	100	139	100	307	100

Table 4.4 reveals that, most of the respondents 90.2% were unaware of the negative environmental impacts of borehole drilling in Suleja L.G.A. In the South-East only 5% of the respondents were aware; this is followed by North-East 12%, North-West 12.9%, and South-West 15.1 as presented in the table. Hence, Table 7 depicts the environmental problems associated with borehole drilling in Suleja LGA.

Table 7: Environmental Problems associated with borehole drilling in Suleja **(Source**: Field Survey, 2016)

S/N	Location	Fall in water table/drying up of wells		Cracks on building		Change in taste or colour of water		Pollution resulting to health problems		Increasing Cost of Water Pumping		Contribution to Climate Change		Waste Water Resulting to flooding	
		Fr	%	Fr	%	Fr	%	Fr	Fr	Fr	%	Fr	%	Fr	%
1	North-East	2	20.0	1	10.0	3	30.0	0	0	3	30.0	0	0	1	10.0
2	North-West	6	35.3	3	17.6	2	11.8	1	5.9	3	17.6	1	5.9	2	11.8
3	South-West	5	17.2	2	6.9	5	17.2	9	31.0	3	10.3	2	6.9	3	10.3
4	South-East	3	15.8	3	15.8	2	10.5	4	21.1	4	21.1	0	0	3	15.8
Total		16	21.3	8	10.7	12	16.0	14	18.7	13	17.3	3	4.0	9	12.9

Most of the responses as revealed by Table 7 are water table/drying up of wells (21.3%). In other words, the impacts of increasing drilling of boreholes in Suleja L.G.A are evidence in the dry-up of wells. This followed by increasing financial cost of water pumping (18.7%). Others are change in the colour/taste of water (17.3%), cracks on building walls (16%), and pollution leading to health problems (10.7%). The least impacts according the response are that of climate change (4%).

More of the responses can be identify in the North-West were 35.3% attested for change in water table/drying-up of wells. In the North-East 30% was the response recorded for increasing financial cost of water pumping and change in the colour/taste of water; while 31% of responses from the South-West were in favour of pollution leading to health problems. In North-East and South-East there was no response for climate change an impact of borehole drilling in Suleja, L.G.A. Table 8 shows the suggestion to managing environmental impacts of borehole drilling in the study area.

Table 8: Suggestion to managing Environmental impacts of borehole drilling **(Source:** Field survey, 2016)

Location	Provision of tap water		Regulation of drilling of boreholes		Creation of artificial rain and encourage rainwater harvesting		Avoidance of concretization to allow for water percolation		Taxation on borehole owners to response to improvement impacts		Encouraging tree planting to conserve groundwater	
	Fr	%	Fr	%	Fr	%	Fr	%	Fr	%	Fr	%
North-East	3	23.1	3	23.1	2	15.4	1	7.7	1	7.7	3	23.1
North-West	9	31.0	5	17.2	2	6.9	2	6.9	3	10.3	8	27.6
South-West	11	30.6	8	22.2	5	13.9	9	25.0	3	8.3	9	20.0
South-East	7	30.4	4	17.4	2	8.7	4	17.4	6	26.1	5	17.9
Total	30	33.3	20	22.2	11	12.2	16	17.8	13	14.4	25	21.7

The responses gathered as presented in Table 8 shows provision of tap water (33.3%) as a major solution to the environmental damaging effects of borehole drilling. This is followed by 22.2% response on regulation of borehole drilling through Environmental Impact Assessment (EIA), and then tree planting and greening which help in groundwater conservation (21.7%). Others are 17.8% avoidance of concretization of ground surfaces to allow for free percolation of rainwater which recharges the groundwater; 14.4% on taxation as a way of limiting the proliferation of boreholes; and 12.4% supported the creation of artificial rain and encouragement of rainwater harvesting.

Most of the respondents that support provision of tap as a solution to the environmental impacts of borehole drilling were drawn from North-West (31%), South-West (30.6%), and South-East (30.4%).Also, 27.6% of the responses supporting tree planting were from North-West, while 26.1% of respondents in South-East approve taxation to regulate the proliferation of borehole; and 25% of the responses from South-West were in support of avoiding concretization for free rainwater percolation into the soil. Respondents in the North-East (23.1%, each) seem to support regulation of drilling of boreholes, provision of tap water, and tree planting.

6.0 Summary of Findings

The study examined the distribution pattern of borehole in Suleja Local Government Area (L.G.A). The objectives were to identify distribution of borehole in terms of total number and analyzed the pattern using Nearest Neighbour (Rn) statistics; identify the factors and the impacts of the distribution pattern; and to proffer solution to the negative environmental impacts on the drilling of boreholes. A total of 307 clusters respondents were identified based on the points where the boreholes were plotted using the Global Positioning system (G.P. S).For analyzing and comparison the study was divided into four regions (North-East, North-West, South-West, and South-East) of the L.G.A.

The major findings were as follows:

About 45.3% of the boreholes were found in the South-Eastern part of Suleja L.G.A, and apart from this region where the distribution pattern is tending towards random (43.9%), the rest of the region indicated clustered distribution. This distribution pattern shows that South-Western part has more (36.2%) of the boreholes.

26.7% of the respondents were of the view that tap water inadequacy/non-availability were responsible for the proliferation of borehole, an individual effort to meeting water needs. While most of the respondents (36%) in the North-East saw lack/inadequate of tap water supply as a strong reason behind the increasingly drilling of boreholes in the area; 30% in the North-West saw increasing population of the area as the reason.

It was revealed that 90.2% of the respondents were unaware of the negative environmental impacts of borehole drilling in Suleja L.G.A. Out of the 9.8% of respondents that claimed they were aware most of them were of the view that change in water table/drying up of wells (21.3%) was evident, more of whom were drawn from the North-West (35.3%). Other impacts observed were increasing financial cost of water pumping (18.7%); change in the colour/taste of water (17.3%), cracks on building walls (16%), and pollution leading to health problems (10.7%). The least impacts according to the response were that of climate change (4%).

Finally, it was observed that provision of tap water (33.3%) as a major solution to the environmental damaging effects of borehole drilling was necessary in Suleja L.G.A; most of whom that was drawn from North-West (31%), South-West (30.6%), and South-East (30.4%). Other suggested solutions were regulation of borehole drilling through Environmental Impact Assessment (EIA); tree planting and greening which will help in groundwater conservation; avoidance of concretization of ground surfaces to allow for free percolation of rainwater which recharges the groundwater; taxation as a way of limiting the proliferation of boreholes; and support for the creation of artificial rain during dry season and encouragement of rainwater harvesting and storage during wet season.

7.0 Conclusion

Water is essential for our survival, no doubt. But the way people go about exploiting the resources can also be detrimental to human survival. The rate of bore hole drilling as a way of meeting water needs is alarming, and this; as observed in this study has some attendant negative environmental consequences. Some of which include: change in water table/drying up of wells; increasing financial cost of water pumping; change in the colour/taste of water, cracks on building walls, and pollution leading to health problems. All these calls for quick actions, in order to avert any impending future negative outcomes.

Recommendations

Since the consequences of indiscriminate drilling of boreholes are the one that man cannot trade for the life he is trying to save, this calls for action. It is therefore recommended that:

Government should provide tap water which will help in reducing the rate at which groundwater is exploited through borehole drilling.

Ministry of Water Resources should beam their satellites on the activities of borehole drilling and proliferation. Through regulating borehole drilling by Environmental Impact Assessment (EIA).

Tree planting and greening in line with human development should be encouraged as this will help in groundwater conservation.

Avoidance of concretization of ground surfaces to allow for free percolation of rainwater which recharges the groundwater.

Taxation as a way of limiting the proliferation of boreholes; and support for the creation of artificial rain during dry season and encouragement of rainwater harvesting and storage during wet season.

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