DISTRIBUTION OF BOREHOLES IN RESIDENTIAL LAYOUTS AND IMPLICATIONS FOR PLANNING OF AWKA, NIGERIA

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Abstract
Lack of adequate public water supply to the inhabitants of Awka urban area since the urban water supply scheme at Imo Awka broke down over 30 years ago has been a source worry to successive governments since 1991, when the State was created. The government in an attempt to solve the problem started constructing boreholes at some areas in the town as a crash programme to reduce the water supply problem. The aim of this paper is, therefore, to investigate the distribution pattern of boreholes in some new settlements within the urban area to see whether their locations are accessible to the inhabitants. Data for the work were gathered from field observation and questionnaire to households from April to October, 2016. For the data analysis, quadrant and nearest neighbor techniques were used and quadrant results shows that our p-value of 0.620 for Ifite and 0.0082 for Okpuno, all are more than 0.05 indicating that the distributions are random. The implication of this is that some residents have better access to borehole locations than others revealing that little or no planning was done before they were located. The situation led to the concentration of houses close to areas with boreholes with attendant social and environmental problems. It is recommended that water boreholes should be sited in a regular manner as much as possible and where this is not possible water collection points should be divested from the borehole locations to avoid the concentration observed. Urban planners should factor this into their planning scheme.

Keywords: *Residential layouts, Public Utilities, Planning and Demographic Data.*

INTRODUCTION
For over 30 years now, Awka urban area has not enjoyed water supply through a regional water supply scheme. The old Imo-Awka scheme which was serving the urban area became dysfunctional because of poor management which led to soil erosion and massive silting of the river channel in the destroying of once functional scheme that assured an uninterrupted water supply to the urban area. Since the supply of water from this source seized, the State government began to source water for supply to the town from boreholes. Apart from having high maintenance cost, this source do not guarantee even distribution because of the problem and nature of its geology, largely made up of unproductive Mamu formation. As a result, most government boreholes function for only a short time resulting in the inability of supply to meet up to 20% of demand. Ezechukwu (2016) described the supply of water to an urban area through borehole source as the biggest water planning problem for any city as the source is not usually designed to serve for a long period of time but to fill a gap. Agreeing with this assertion, many researchers in the field had repeatedly called on the

State government to seek ways of exploring the nearby Agulu Lake or Mamu river for a regional water supply scheme (Ezenwaji, 2013, Ibekwe, 2015 and Anyaduba 2015).

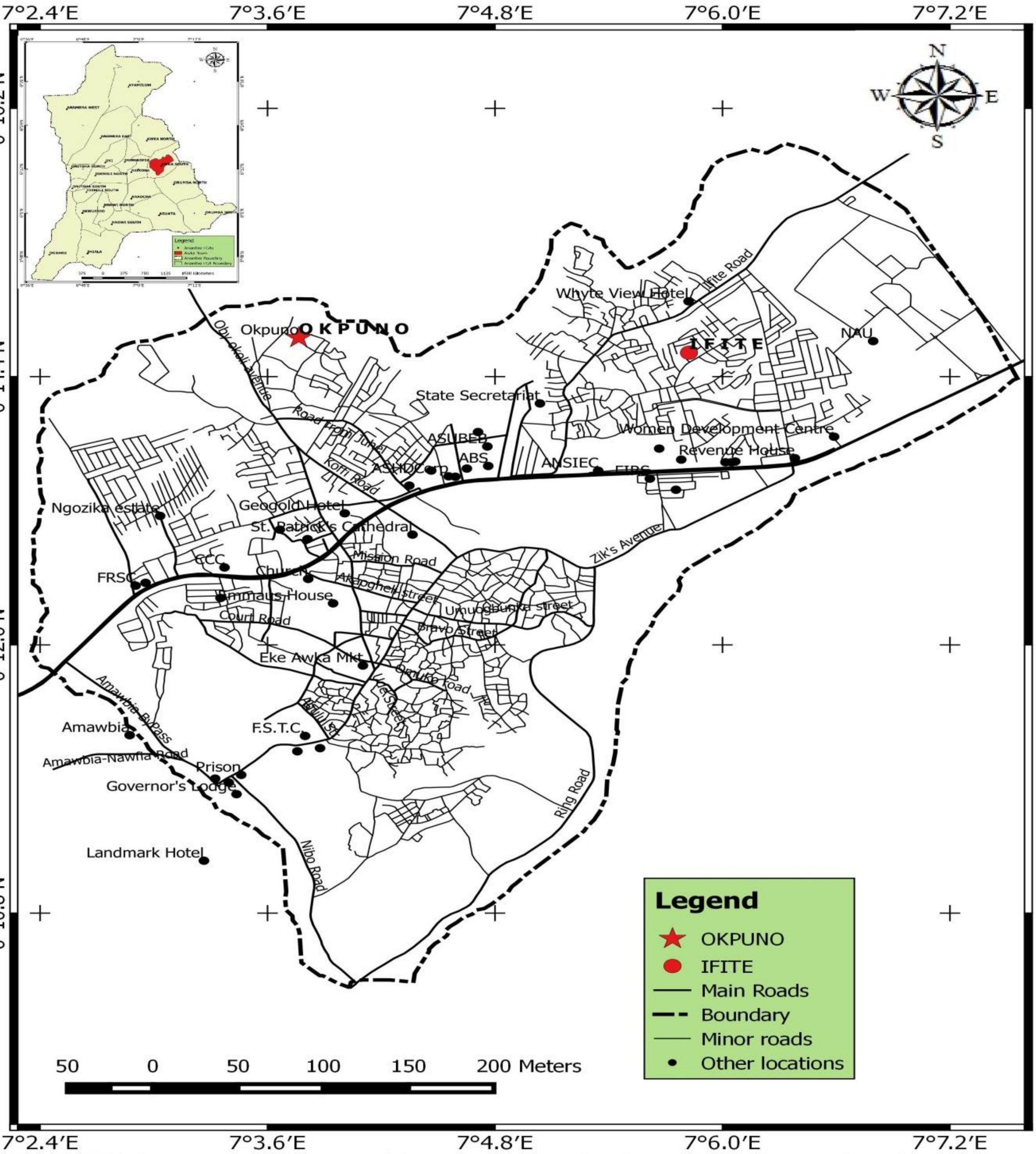
Regional water supply schemes are known to be sustainable sources of water supply, provided that routine operation and maintenance are carried as required and this means that the procurement of necessary spare parts is a must. Procurement itself is the process of buying of goods, works or services, which in this instance comprise water works infrastructure and services in water resource planning. Waterworks are nevertheless complex to implement given the physical and social fabric of urban settlement (Cotton Sohail and Tayler, 1998). The recourse to borehole source by the Anambra State Ministry of Public Utility and Water Resources for the supply of water to a rapidly growing town like Awka is to say the least unfortunate because not all parts of the town will benefit from the borehole supply. For example in 1986, the geographical extent of the town was only 9.55km^2 but now it is about 21.45km^2 signifying an aerial expansion of 45% by 2015 (Nzoiwu, Ezenwaji and Igu, 2017). This spatial spread makes a good demand on urban amenities including water supply because the spread is usually positively correlated with the provision of amenities.

Boreholes cannot therefore serve all areas in the town unless they are reticulated. Added to this is their indiscriminate siting as a result of two factors which are political considerations and geological limitations. These as a results led to the poor access of water source to some inhabitants and high access to others. The aim of this paper is to investigate the distribution pattern of these boreholes in some new settlements within the urban area with a view to determining the level of their accessibility to consumers and its implication for urban planning of the capital city of Awka.

Materials and Methods

Area of Study

Awka, the capital of Anambra State is a pre-colonial town whose main function of the original inhabitants was blacksmithing. However later the town was made a local government headquarters from where it was elevated to a zonal headquarter of the then Awka Province and finally to a State capital on 27th August, 1991. It is located within latitudes $6^0 11^1$N and $6^0 17^1$N and longitudes $7^0 02^1$E and $7^0 08^1$E (Fig1) and has a land area of 21.45km^2.



SOURCE: GIS & Cartography Lab, Department of Geography and Meteorology, Nnamdi Azikiwe University, Awka, Anambra State.

Fig 1: Map of Awka Town showing Ifite and Okpuno districts

In terms of topography, the town lies on top of Awka-Orlu upland with the height ranging from 91m in the western parts to about 160.2m in the eastern zone although there are local topographic variations within the town. The climate is the tropical wet and dry type according to the Koppen's climatic classification system with a clear cycle of seasons. The mean daily maximum temperature is usually 27^0C all over the year, although it could reach 36^0C in March and the mean annual rainfall is about 1805mm. In recent times the onset and cessation period of rainfall has been varying probably because of the on-going climatic variability in the area. The geology of the area is predominately of sedimentary origin having mainly the Mamu formation which is characterized by poor water productive aquifer.The study was carried out in Ifite and Okpuno districts of the town, both of themnew settlements.

Data Collection

Data for the work were collected through fieldwork withthe use of GPS to properly locate the site of the boreholes, as well as their elevation. The depths of the boreholes were ascertained from the record obtained from the office of the Director of Water Resources in the State Ministry of Public Utilities, Water Resources and Community Development. Altogether 35 government boreholes in Ifite and 9 of such boreholes in Okpuno were studied out of a total of 54 and 17 boreholes in the two districts respectively. The choice of the boreholes to be studied was governed by their accessibility to our research officers.

Data Analysis

Two statistical analysis namely nearest neighbor and quardrat analyses which together belong to the pattern of points in space were utilized. Nearest neighbour analysis involves a comparison between observed spacing of sets of points and the spacing which would be expected under a random pattern. The observed spacing is the distance between any point and all other points. This is usually done 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 square of the other two sides and written by the formula.

$$AC^2 = AB^2 + BC^2 \quad (1)$$

$$\text{Therefore } AC = \sqrt{AB^2 + BC^2} \quad (2)$$

Similarly dij which is the distance between two points x,yi and x;y; will be

$$\sqrt{dij = (xi - xj)^2 + (yi - yj)^2} \quad (3)$$

Again quadrat analysis was used to determine the randomness of point patterns in space and specifically employed to test that a set of points in space is randomly distributed or has no pattern. If the hypothesis is rejected, then there is a pattern in the set of points and this pattern may be determined by inspection to be either regularly distributed or clustered. If on the other hand the hypothesis is accepted then the pattern is random (Anyadike, 2010, Harvey, 1976). The expected distribution is obtained by generating a poisson probability distribution which gives the probability of obtaining 0, 1, 2, etc points per quadraton the assumption that the process generating the points is independent and random. The Poisson distribution is given as:

$$P(x) = \frac{e^{-\lambda}\chi x}{x!} \quad (4)$$

where, x = number of points per quadrat

λ = Probability of obtaining a point per quadrat

e = the base of the natural logarithms = 2.7183

For ease of computation, the Poisson distribution equation 4 may be rewritten as:

$$P_x = \frac{1 \quad \lambda^x}{e^{\lambda} x!} = \left(\frac{1}{2.7183} \times \frac{\lambda^x}{x_!}\right) \quad (5)$$

The data obtained from field work carried out in Ifite and Okpuno is presented in Tables 1 and 2.

Table 1: Field Data from Ifite Awka and Okpuno in Awka Urban Area

S/N	Depth of Water (m)	Latitude	Longitude	Elevation (m)	Static Water Level
1)	9.14	6°.14'41"N	7°.6'02"E	108	99
2)	9.30	6°.14'43"N	7°.6'06"E	110	101
3)	1.49	6°.14'44"N	7°.6'08"E	97	96
4)	8.53	6°.14'46"N	7°.6'08"E	110	101
5)	7.62	6°.14'48"N	7°.6'08"E	118	110
6)	0.14	6°.14'49"N	7°.6'10"E	50	50
7)	0.70	6°.14'50"N	7°.6'10"E	57	56
8)	0.80	6°.14'51"N	7°.6'10"E	51	50
9)	0.54	6°.14'53"N	7°.6'08"E	50	49
10)	0.27	6°.14'54"N	7°.6'10"E	49	49
11)	0.37	6°.14'55"N	7°.6'14"E	46	46
12)	2.13	6°.14'56"N	7°.6'15"E	49	47
13)	1.52	6°.14'58"N	7°.6'20"E	50	48
14)	0.82	6°.14'59"N	7°.6'20"E	52	51
15)	1.37	6°.14'60"N	7°.6'21"E	48	47
16)	0.76	6°.15'01"N	7°.6'25"E	47	46
17)	0.91	6°.15'02"N	7°.6'25"E	46	45
18)	1.01	6°.15'03"N	7°.6'25"E	45	44
19)	2.53	6°.15'05"N	7°.6'25"E	44	41
20)	2.68	6°.15'07"N	7°.6'27"E	43	40
21)	5.18	6°.15'08"N	7°.6'27"E	40	35
22)	2.35	6°.15'10"N	7°.6'27"E	39	47
23)	2.13	6°.15'13"N	7°.6'27"E	40	38
24)	1.98	6°.15'13"N	7°.6'30"E	50	48
25)	2.13	6°.15'13"N	7°.6'31"E	57	55
26)	1.93	6°.15'13"N	7°.6'33"E	55	53

Table 2: Field Data from Okpuno in Awka Urban Area

1)	29.26	6°.14'46"N	7°.3'06"E	95	25
2)	29.28	6°.14'46"N	7°.3'07"E	77	78

3)	29.44	6°.14'48"N	7°.3'10"E	83.4	84
4)	45.72	6°.14'46"N	7°.3'08"E	103.94	42.67
5)	56.39	6°.14'49"N	7°.3'10"E	110.95	53.34
6)	50.29	6°.14'50"N	7°.3'10"E	104.24	47
7)	50.29	6°.14'54"N	7°.3'15"E	99	47.42
8)	43.89	6°.14'56"N	7°.3'15"E	100.89	40.84
9)	60.96	6°.14'49"N	7°.3'15"E	136.89	57.91

The wells were grouped based on their co-ordinates (longitudes and latitudes). After this, Nearest Neighbour Analysis was utilized for this purpose and performed by the model at 5% level of significance leading to the formation of 4 groups/classes.

Result and Discussion

Furthermore, the result of the analysis shows first the grouping of wells in Ifite (Table 3) and followed by those of Okpuno (Table 7).

Table 3: Initial Groupings of Well Locations in Ifite Awka

S/N	Longitude	Latitude	Groups/Classes
1.	6°.14'41"N	7°.6'02"E	1
2.	6°.14'43"N	7°.6'06"E	1
3.	6°.14'44"N	7°.6'08"E	1
4.	6°.14'46"N	7°.6'08"E	1
5.	6°.14'48"N	7°.6'08"E	1
6.	6°.14'49"N	7°.6'10"E	2
7.	6°.14'50"N	7°.6'10"E	2
8.	6°.14'51"N	7°.6'10"E	2
9.	6°.14'53"N	7°.6'08"E	1
10.	6°.14'54"N	7°.6'10"E	2
11.	6°.14'55"N	7°.6'14"E	2
12.	6°.14'56"N	7°.6'15"E	3
13.	6°.14'58"N	7°.6'20"E	3
14.	6°.14'59"N	7°.6'20"E	3
15.	6°.14'60"N	7°.6'21"E	4
16.	6°.15'01"N	7°.6'25"E	4
17.	6°.15'02"N	7°.6'25"E	4
18.	6°.15'03"N	7°.6'25"E	3
19.	6°.15'05"N	7°.6'25"E	3
20.	6°.15'07"N	7°.6'27"E	3
21.	6°.15'08"N	7°.6'27"E	3
22.	6°.15'10"N	7°.6'27"E	4
23.	6°.15'13"N	7°.6'27"E	3
24.	6°.15'13"N	7°.6'30"E	3
25.	6°.15'13"N	7°.6'31"E	3
26.	6°.15'13"N	7°.6'33"E	3

For ease of understanding of the output, the summary of frequency distribution of the wells that reflect the grouping is presented in Table 4.

Table 4: Summary of Frequency Distribution of Wells in Ifite Awka

No of Points	1	2	3	4	
Frequency of Observation	6	5	11	4	Total = 26

To determine the expected, we use Chi-square goodness of fit (Poisson distribution) and arrived at the result which is presented in Table 5.

Table 5: Poisson Distribution of the Wells

Group	**Observed**	**Poisson Probability**	**Expected**	**Contribution to Chi-square**
1	6	0.2873	7.4697	0.2892
2	5	0.2565	6.6694	0.4179
3	11	0.2138	5.5578	0.3289
>4	4	0.2424	6.3030	0.8415

The output of Table 5 is presented in Table 6

Table 6: Chi-square and p-value of the distribution

N	**Df**	**Chi-Square**	**P-value**
26	2	6.8774	0.620

From the result of the analysis, the p-value was calculated to be 0.620 which is more than 0.050 and this can be interpreted to mean that there is enough evidence to accept the null hypothesis and conclude that there is no significant difference between the distribution and random distribution. This, therefore, means that the distribution is random, so we can say there is no pattern in the distribution of wells in Ifite.

Then for Okpuno district the location of the wells are seen in Table 7.

Table 7: Field Data on the Distribution of Wells in Okpuno and their Grouping

S/N	**Longitude**	**Latitude**	**Group**
1.	6°.14'46"N	7°.3'06"E	1
2.	6°.14'46"N	7°.3'07"E	1
3.	6°.14'48"N	7°.3'10"E	2
4.	6°.14'46"N	7°.3'08"E	1
5.	6°.14'49"N	7°.3'10"E	3
6.	6°.14'50"N	7°.3'10"E	3
7.	6°.14'54"N	7°.3'15"E	4
8.	6°.14'56"N	7°.3'15"E	4
9.	6°.14'49"N	7°.3'15"E	3

From the above grouping in Table 7, the frequency table is then constructed (Table8)

Table 8: The Observed Frequency of the Location of Wells in Okpuno

Observe	1	2	3	4	Total
Frequency	3	1	3	2	9

After this we performed the goodness-of-fit for Poisson distribution (Table 9).

Table 9: Goodness-of-fit Table

Group	Observed	Poisson Probability	Expected	Contribution to Chi-square
<1	3	0.2989	2.6900	0.03572
2 – 3	4	0.4705	4.2344	0.0129
>4	2	0.2306	2.0756	0.0028

The output of Table 9 results in Table 10.

Table 10: Chi-square and P-value of the Distribution

N	Df	Chi-square	P-value
9	1	0.0514	0.821

From the result of the analysis, the p-value is 0.821 which is by far greater than the p-value of 0.05. There is, therefore, enough evidence to accept the null hypothesis and conclude there is no significant difference between the distribution of wells at Okpuno and random distribution, meaning that the distribution exhibited no pattern.

Discussion

The result obtained from the analysis of the distribution of boreholes in the two district show that they are random with Okpuno revealing more randomness because of the higher p-value of 0.821 obtained from the analysis of the distribution in the district more than 0.620 found in Ifite. During the fieldwork it was observed that the distribution of these boreholes was random but the analysis has come out to establish the situation through scientific technique. The reasons for the established distribution according to some respondents were as a result of

i. Accessible area factor
ii. Geological disposition
iii. Political consideration.

The random location of these boreholes has generated the problem of poor access of the boreholes from some consumers who because of long distance to the borehole locations have decided to rely on any accessible source of water no matter the quality. The poor access has forced the affected consumers to spend unbearable amount of money to purchase water from private suppliers. Again the issue of affliction and spread of water borne disease were also observed from consumers that are located away from the borehole points, and all these call for proper urban planning that will take into account the distribution of boreholes.

Implication for Urban Planning

Lack of water supply, as well as, irregular location of few available sources has added to many inadequate urban amenities and services in Awka urban area making it one of the amenities that contribute to dysfunctional urban development process. This calls for immediate urban planning to properly locate the boreholes so that people will benefit maximally from theirprovision. In Awka, the Urban Planning Board now renamed the Physical PlanningBoard has been unable to develop a sound physical planning for the town since 1991 when it was made a State capital. The urban sprawl has resulted in the conversion of hitherto rural environment into urban areas and this is the situation with Okpuno and Ifite once rural communities but now wholly inside Awka urban. The urban area has indeed increased in territorial space from mere 9.55sqkm in 1986 to 21.45sqkm in 2015 meaning that it has increased in size to about 46% of its 1986 size. In the same period primary vegetation has declined from occupying a total of 33.69sqkm in 1986 to only 4.075sqkm in 2015 (Nzoiwu, Ezenwaji and Igu, 2017). The above is a clear indication that the Awka urban area is spreading and therefore needs to be better planned to properly situate houses, roads, recreational facilities,meducational institutions, commercial and industrial establishments all of which require water and some in prodigious quantity for their proper functioning. This perhaps explains the reason for the construction of boreholes in newly developed Ifite and Okpuno districts of the urban area. The planning for the construction of these boreholes should be as regular as possible to address the water needs of consumers, but this is not the case in the two districts where the construction of the boreholes were random, not only by the individuals but also government.

In areas where regular sitting will not be possible as a result of geological and environmental factors, reticulation of the available ones should be carried out to get to those that are located far away from the boreholes. The Anambra State Physical Planning Board and Awka Capital Territory Development Authority should take up this responsibility of providing water supply at desired access levels to consumers through conscious and articulate physical planning.It is only through this, that the severe water supply shortages which the construction of boreholes as crash programme was intended to serve would readily address.

Conclusion

This paper has analysed the distribution of boreholes as a water supply source in Awka and its implication for urban planning. We saw through the analysis that the distribution of government boreholes in the town was random in the two districts – Ifite and Okpuno were the study took place. The urban planning authorities namely: the Awka Capital Territory Development Authority (ACTDA) and the Anambra State Physical Planning Board were enjoined to take up the responsibility of ensuring good planning of the borehole locations to guarantee access to majority of consumers. The water scarcity problem will persist if enough sources are provided without ensuring their even distribution. When it is not possible to site these boreholes evenly, the paper suggests that proper reticulation be done to ensure that the water supply points are as near as possible to consumers. A good urban planning is required to address the existing skewed distribution of the boreholes in the town.

Recommendations

In order to have a proper urban planning for the even location of borehole, to ensure access to consumers, the following recommendations are made:

1. The siting of government boreholes should not be politically motivated as this will in most cases result in the uneven siting of such boreholes.

2. Urban planning should take the proper siting of the boreholes into serious consideration especially in the physical design of new layouts.
3. Where it is not possible to site the boreholes as near to consumers as possible, reticulation should be used to spread the water points to consumers.
4. The ACTDA and the Physical Planning Board should not work at cross purposes as it is the ease in some new areas where there is always a claim of authority by the two agencies which has resulted in the poor execution of physical plans.

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