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APPLICATION OF WATER POVERTY INDEX: A CASE STUDY OF UYO METROPOLIS IN AKWA IBOM STATE, NIGERIA.

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KEYWORDS: Water Demand, Water Poverty Index (WPI), Composite Index Approach (CIA), Time Analysis Approach (TAA), Descriptive Statistics.

ABSTRACT
Water poverty index (WPI) was used to evaluate the rate of water demand in some selected areas of Uyo metropolis in Akwa Ibom state, Nigeria. The composite index and the time series index approaches were used to measure the level of water stress in the four urban periphery communities selected. These communities are namely Ibiaku, Ekpri Nsukara, Nsukara Offot, Use Offot. Questionnaire and physical observations were the sources of data used. 30 respondents were sampled from each of the communities and simple descriptive statistics were used in analyzing the collected data. The showed that, using both the composite and time series approaches, Ibiaku was the least water stressed community while Ekpri Nsukara and Use Offot were the most stressed communities. The results further revealed that simple time analysis cannot link complex multidimensional aspects of water management together. The application of composite index approach to test the generated dataset provided flexible and strong decision making strategies in such a way as to construct a holistic water management tool to address the problems of poverty, and its relation to water access and use. It is recommended that improved water harvesting from both surface and underground sources should be harnessed to provide sufficient water for the water-stressed communities in Uyo Local Government Area in order to improve health and enhance economic productivity of the inhabitants of the communities.

I. INTRODUCTION
An adequate supply of safe and clean water is one of the most important factors for sustaining human life and for achieving sustainable development. This vital role of water in human life makes deprivation of water to be associated with poverty and is often seen as an offense to human rights and dignity (Molle & Mollinga, 2003). Lack of personal hygiene and contamination in water areas with inadequate supply of water have caused many people to suffer from water-borne disease such as typhoid fever, cholera, dysentery etc. These diseases are caused by the presence of pathogenic bacteria such as protozoans, worms, and viruses. Many other parasitic diseases of the tropics are related to the sources and storage of water. Water of bad quality promote the growth of intermediates hosts of parasites or encourage the breeding of vectors of diseases (Hill, 1988) and this is most prevalent among the economically and infrastructurally less privileged. In fact, the number of people who rely on the earth's limited freshwater reserves is increasing every day. In fact, a scarcity of clean, fresh water is one of the world's most pressing environmental problems (Arms, 2008). In relation to this, at the 2002 World Summit on Sustainable Development in Johannesburg, South Africa, great concern was expressed about the 1.1 billion people in the world who do not have access to safe drinking water and the 2.4 billion who live without proper sanitation (Cech, 2005). Thus, in the wake of a growing concern about both the unchecked rise of poverty and the local and global consequences of water scarcity, the relationships between water and poverty are the object of a sprawling literature. Indicators of performance are an important part of the process of evaluating achievement. They have become an important management tool giving direction to managerial policy and the allocation of resources. They have also become an important political tool, allowing both professionals and the lay public the possibility of making

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judgements about the effectiveness of government policy. Performance indicators have come under academic scrutiny with questions being raised as to the degree to which a set of numbers should be allowed to drive policy. Nonetheless these indicators do offer a relative measure of achievement which can serve to direct policy towards the improvement of performance.

According to Garriga & Fogue (2010), water supports livelihoods in different ways, and the link between poverty and access to water has long been recognized (Sullivan, 2002; Molle & Mollinga, 2003; Stephen et al., 2003). There is an increasing need to provide an insight into this relationship, since the provision of a reliable, sustained and safe water supply still remains elusive for vast numbers of people worldwide (Sullivan, 2007). This is evidence of both a knowledge and policy failure, lack of infrastructure, and poor capacities to deliver benefits to society over the long term (Harvey & Reed, 2004).

As presented in Yahaya, Akinro, Mogaji, & Ologunagba (2009), the Water Poverty Index (WPI) was identified as the possible indicator for monitoring progress at the local level as it puts access to water in a wider water-related context. The index has been designed to identify and evaluate poverty in relation to water resource availability that this aspect of development in the water sector is most pertinent to poverty alleviation (Sullivan *et al*., 2001). Also, the poor frequently put affordable access to safe water and sanitation at the top of their priorities (Steven, Caroline, & Jeremy, 2002).

According to Okoji (2001), the State is divided into the rural (over 80%) and urban (less than 20%) population. The rural population is involved in the production of food and industrial crops, ornamental and medicinal plant, as well as keeping animals. All these depend on constant water supplies from the natural sources. The urban dwellers, on the other hand, depend on groundwater for general domestic and other socio-economic activities. Groundwater is generally preferred because it is safer and highly protected especially for urban dwellers (NWRI, 1997).

According to Akpabio & Ekanem (2009) over 90% of the population of Akwa Ibom State lives without access to public water services. Current public water supply efforts of government are concentrated in the urban areas. Statistics show that the highest percent of urban population having access to public water services is 3.8% for Uyo, the state capital. The story in the rural areas is worse as current statistics (Udom, 2008) also show that over 90% of the state rural water projects suffer various degrees of difficulties e.g., abandonment, disuse, not functional, unsuccessful or uncompleted. The very few available ones are mostly and extremely irregular in services. Consequently, there is a very deep gap between water needs and supplies across the 3 hydrogeological zones, be it in terms of quality, public investments or other factors.

Akpabio & Ekanem (2009) in a review of water uncertainties in South Eastern Nigeria observed high incidence of inequity and access burdens on the general population of Akwa Ibom state (especially the vulnerable groups) as well as reckless incidence of exploitation of the aquifer for private market. These were all linked to weak government involvements in the management of the resource, a situation that has given rise to uncertainties relating to the survival and the ability of the resource system to sustain livelihoods beyond this generation. The observations in the study reflect the general absence of a strong government commitment in Nigeria to managing water resources with specific concerns on the survival of the ecosystem. While striving to meet the various international commitments on universalizing water access and services, the paper cautions that meeting human needs for water should not be at a degenerating cost to the ecosystem. In the recommendation, the paper advocates a centralized and coordinated water management practices with an ecosystem focus. Attaining this requires strong precautionary policies on water demand management backed up by effective regulatory measures to ensure optimum and balanced supply, efficient use as well as the protection of the natural system.

Health reports in the area have shown that the prevalence of disease like Typhoid are directly related to the consumption of water of poor quality. This can be attributed to the fact that the people cannot access potable water. Thus, this study seeks to examine how the economic state of the people affect the demand for quality water. Of the vulnerable class of persons affected by water problems, the poor are most affected. In a quest to assist global efforts to tackle the problem requires that relevant monitoring tools be made to assist in the policy making and review. Thus, Water Poverty index is one of the tools. The determination of water poverty index for some selected areas in Uyo metropolis will indicate to what level the area has tried to meet up with the Millennium Development goal on safe water provision.

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WATER POVERTY

As regarding water poverty, Sullivan (2002) first proposed the water poverty index (WPI) as an integrated approach to water poverty. According to Sullivan (2002), water poverty is defined as a lack of adequate and efficient water supplies that links physical estimates of water availability with socioeconomic variables. Moreover, the development of a Water Poverty Index is intended to help process of identifying those areas and communities where water is most needed, enabling a more equitable distribution of water to be achieved. This is one of the most important practical features of any potential water scarcity/poverty indicator. Advancing numerous novel ideas surrounding the identification of water poverty, Sullivan (2002) discusses the advantages and disadvantages of four possible approaches to calculating a WPI but refrains from recommending any one methodology.

The WPI is designed to operate at a number of scales and enable quick and reliable comparisons of water poverty across space and time. By utilizing a set of standard indicators community or regional performance can be assessed over time and compared to other localities enabling decision-makers to prioritize levels of need. Moreover, the indicators are intended to be flexible and can be modified to meet local needs. Finally, the index addresses the issue of representing qualitative data in an empirical manner (Fenwick, 2010). Figure 1 presents a schematic of the indicators of water poverty and their relationship in the water poverty index.

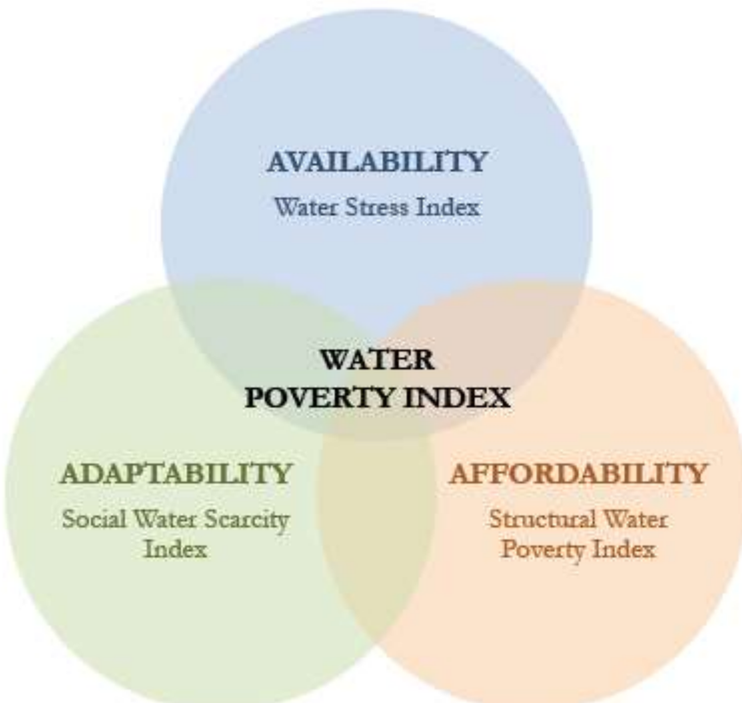

Figure 1: Schematic of modern indicators of water poverty. (Source: Fenwick, (2010)

STUDY AREA

Uyo metropolis is a merger of the Capital city of Akwa Ibom state and some parts of the adjourning local government areas including Itu, Uruan, Ibesikpo Asutan and Nsit Ibom.. Uyo has a population of about 304,000 and a land area of 95 square kilometers, Uyo has an average altitude of 6.5 (AKSG, 2008). The area falls within the equatorial rain forest belt that houses vegetation of green foliage of trees and shrubs. Being a state capital, the area is defined by large structures, institutions and a great inflow of people who migrate into it. The major water sources in the area are borehole and Pipe borne water supplied by the water corporation of the state.

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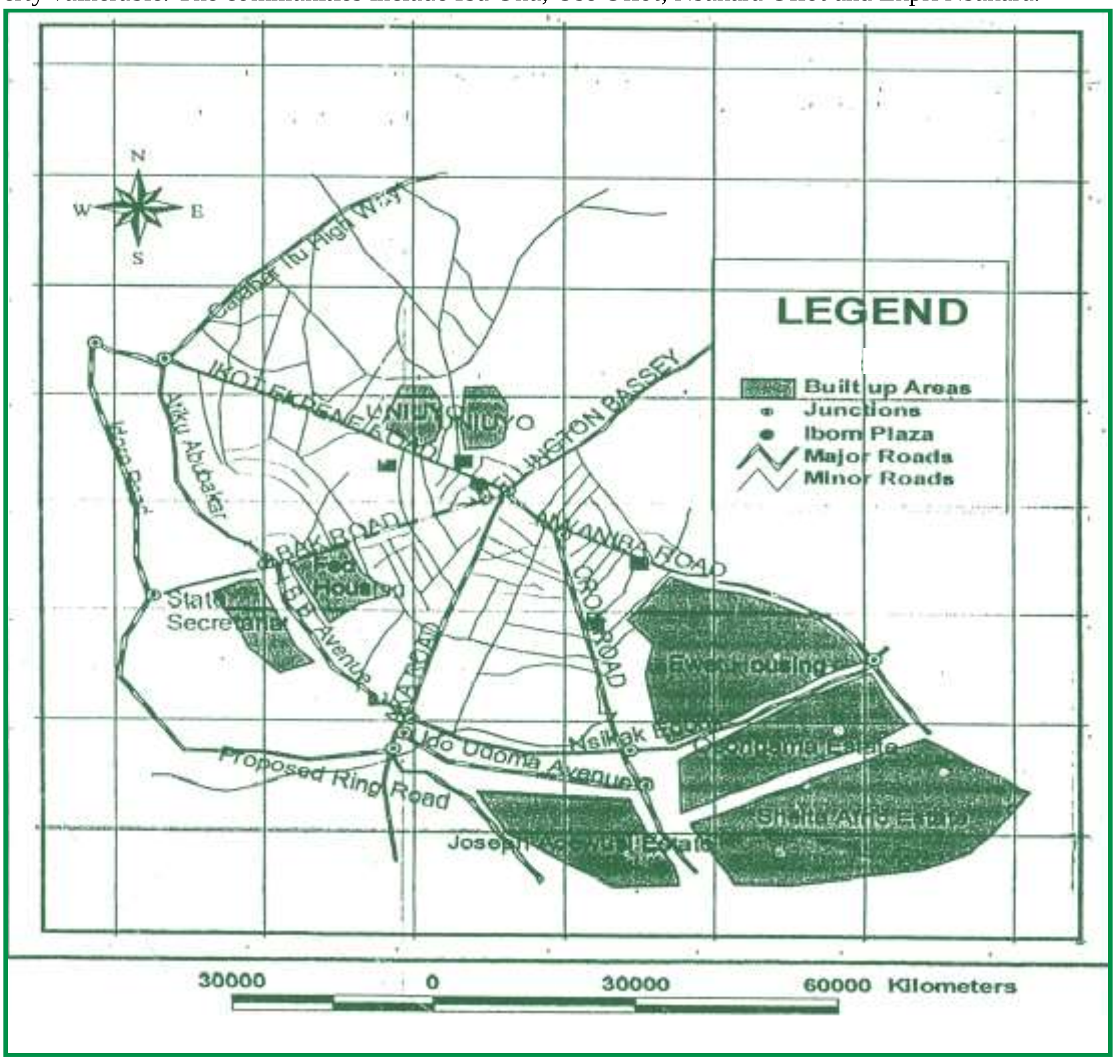
Uyo metropolis lies between latitude 5.05º North and longitude 80º East. Population of Uyo keeps on increasing on daily basis due to rural-urban migration. The area is paved and bounded by Nwaniba road in the North-West, Edet Akpan Avenue in the South-West and Oron road in the East. Uyo covers the most developed part of Akwa Ibom state. The climate of Uyo is a tropical rainy type which experiences abundant rainfall with very high temperature. Mean annual temperature recorded lies between 20ºC and 29ºC and average sunshine accumulates to 1450 hours per year. The rainfall in the area is seasonally, convectional and spatial in distribution. Uyo mean annual rainfall ranges from 1599mm to 3855.9mm. Maximum humidity is recorded in July while minimum humidity occurs in January. Thick cloud cumoni cumulonimbus type is commonly experienced in the months of March to November. Evaporation is high and annual values range from 1500mm to 1800mm (Akwa Ibom State Government, 2008). All households in Uyo metropolis constitute the total population for the study. Judgmental sampling technique was thus used to select four communities as case studies within Uyo metropolis. The criterion for this choice was the researcher's adjudged level of development (in terms of infrastructures) in these communities which portrays them as poverty vulnerable. The communities include Iba Oku, Use Offot, Nsukara Offot and Ekpri Nsukara.



Source: Department of Geography and Regional Planning, University of Uyo.
Figure 2: Map of Uyo urban showing study area.

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II. MATERIALS AND METHODS

2.1 INSTRUMENTS FOR DATA COLLECTION

Questionnaires were randomly given to 30 respondents from each of the four studied communities in Uyo metropolis. Each respondent represented a household. The total questionnaires issued were 120. Photographic camera was also used to take photographs at designated water source points.

The questionnaire is structured in two parts: Part 1 which relates to the demographic data of the respondents and Part 2 which contains questions relating to the water sources, demand and usage. The second part of the questionnaire is further divided into three sections as follows: (a) Water sources, quality, quantity and availability in Uyo metropolis (b) Factors which affect the water demand in Uyo metropolis. Three factors were identified here which include economic, social and political and (c) The indicators used in the computation of the water poverty index: resources, access, capacity, use and environmental integrity.

2.2 RESEARCH MODELS

This study adopted the water poverty index models of Sullivan et al (2003) and the modified index models presented by Yahaya et al (2009) for the calculation of the water poverty index for Uyo metropolis.

According to Sullivan et al (2003), the water poverty index The WPI is calculated using a composite index approach. The five key components are combined using the general expression:

$$WPI = \frac{\sum_{i=1}^{N} w_i X_i}{\sum_{i=1}^{N} w_i} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad .(1)$$

Where WPI is the Water Poverty Index value for a particular location, *Xi* refers to component *i* of the WPI structure for that location, and *wi* is the weight applied to that component. Each component is made up of a number of sub-components, and these are first combined using the same technique in order to obtain the components. For the components listed above, the equation can be re-written:

$$WPI = \frac{w_r R + w_a A + w_c C + w_u U + w_e E}{w_r + w_a + w_c + w_u + w_e} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

which is the weighted average of the five components Resources (*R*), Access (*A*), Capacity (*C*), **Use** (*U*), and Environment (*E*). Each of the components is first standardised so that it falls in the range 0 to 100; thus the resulting WPI value is also between 0 and 100.

According to Yahaya (2009), WPI is evaluated using simple time analysis. The index was determined by evaluated using volume of water collected and the time of collection and is evaluated as follows:

$$WPI = \frac{T}{V} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . (3)$$

Where V is the total volume of water collected in minutes, and T is the time for the collection of water in litres. WPI is measured in mins L^{-1}

1.3 METHOD OF DATA ANALYSIS

Descriptive statistical tools like mean, standard deviation and simple percentages were used to analyse the results obtained in the study. Charts were also be used for clarification of results to enhance discussions.

III. RESULTS AND DISCUSSIONS

3.1 Demography of Respondents

Some of the demographic data of the respondents analyzed were Sex and educational qualification. Tables 1 and 2 present the distribution of their sex and educational qualification of the respondents. The percentage distribution for each classification of the analyzed variables was expressed relative to the total number of the retrieved questionnaires being 120.

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Table 1: Distribution of Respondent by Sex

Sex	Frequency	Percentage (%)
Male	77	64.2
Female	43	35.8
Total	**120**	**100**

Table 2: Distribution of Respondent by Educational Classification

Educational Qualification	Frequency	Percentage
Degree	70	58.3
Secondary Education	36	30
Primary Education	14	11.7
Total	**120**	**100**

3.1.1 Water sources and availability in Uyo

Borehole, rain, well, stream and pipe borne water were the five major sources of water were identified at Ibi aku, Use Offot, Nsukara Offot and Ekpri Nsukara in Uyo Local Government Area. Table 3 presents distribution of major water sources among respondents in the four selected communities in Uyo Local Government Area.

Table 3: Water Sources used in Uyo

S/N	Community	Water Sources				
		Borehole	**Rain**	**Well**	**Stream**	**Pipe Borne Water**
1	Ibiaku	26	0	1	1	2
2	Use Offot	21	0	2	0	7
3	Nsukara Offot	18	2	0	9	1
4	Ekpri Nsukara	25	0	0	1	4

From Table 3, Ibiaku villagers depend more on borehole water. Well, stream and pipe borne were the least sources of water. Rain was not harvested in the area due to the season being dry. Use Offot village had a good number of pipe borne water compared to other villages. Nsukara Offot villages depended on stream water besides borehole for water supply. Ekpri Nsukara villages depend more on borehole and pipe born water. The major source of water being a man-made source was attributed majorly to insufficiency of natural supply. This was because the season of the assessment was the dry season with very little amount of rain water. Stream sources were also reduced in volume. The percentage distribution of the water sources in the villages are presented in Figure 2.

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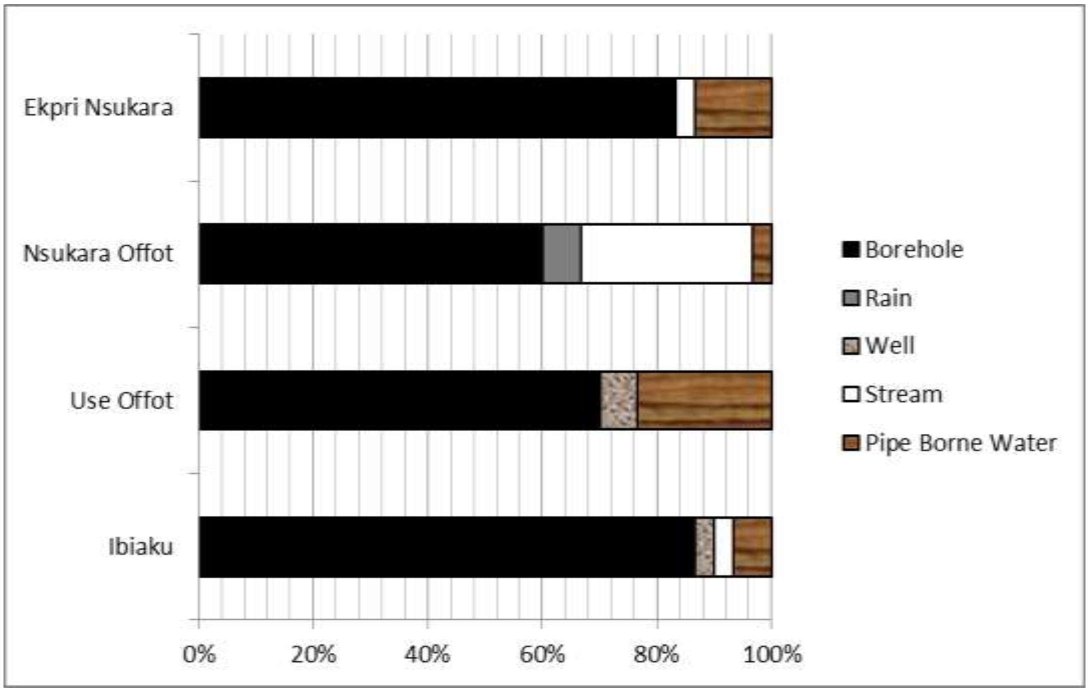

Figure 2:Percentage distribution of water sources in Uyo

Finding also revealed that only the pipe borne and borehole water sources were good in quality. The treatment of stream water to a safe level for drinking drinking either by desalination or any other processes was not frequently practiced due to cost of facilities.

3.1.2 Water poverty index

The water poverty indexes for the four communities in Uyo Local Government Area of Akwa Ibom state were computed using the composite index approach and simple time analysis method.

3.1.3 Composite Index Approach

Composite index approach is based on the combination of relevant variable components collected and summed, to an index, based on the range of values on each variable in that location (Steven et al., 2002). Several indicators have been used to describe water availability or access and composite approach focused on water stress and water productivity (Claudia, 2006). The composite index approach computation of WPI is in line with Yahaya (2009). Table 4 shows the computed WPI values for the communities using the composite index analysis.

Table 4: WPI (composite) values for communities in Uyo Local Government Area

S/N	Community	W_aA	W_sS	T	100-T	W_t(100-T)	WPI
1	Ibiaku	40	23.33	11.59	88.41	22.10	28.48
2	Use Offot	30	23.33	13.10	86.90	21.73	25.02
3	Nsukara Offot	40	15	16.38	83.62	20.90	25.30
4	Ekpri Nsukara	20	24.17	9.30	90.70	22.68	22.28

Where W_aA = Water availability index (%) (weight: 0.5); W_sS = Water Access Index (%) (weight: 0.25); $W_t(100-T)$ = Index to time spent (weight: 0.25)

$WPI = 1/3[W_aA + W_sS + W_t(100-T)]$

From table 4, the results of water poverty index (WPI) obtained using composite index approach showed that Ibiaku community has the highest value of WPI (28.48) while Ekpri Nsukara community has the least value of 22.28. This

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simple analysis shows that Ekpri Nsukara community is the most water-stressed community in Uyo Local Government Area while water stress was considered to be least at Ibiaku community. This is clearly seen in the bar chart (Figure 3). During the consultation process, it was discovered that the dwellers at Ekpri Nsukara villaage still derive their drinking water from a variety of sources such as; direct withdrawal from streams and other surface water sources. The community had the least number of borehole facilities. Ibiaku community on the other hand had more boreholes which is at close fetching distances from the residents of the respondents. The people of Ibiaku community rarely visit the stream to harvest water for domestic use. Figure 4 shows radar comparing the three indexes vis: water availability, time stress and access indexes.

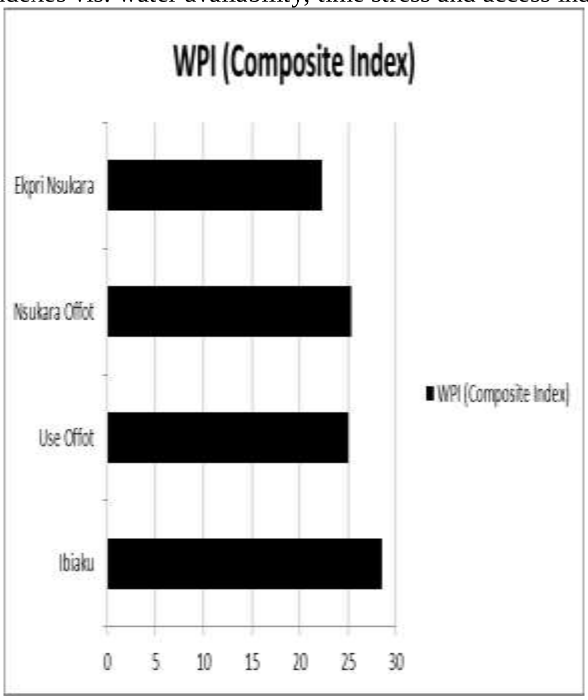

Figure 3: WPI (composite) values for communities in Uyo Local Government Area

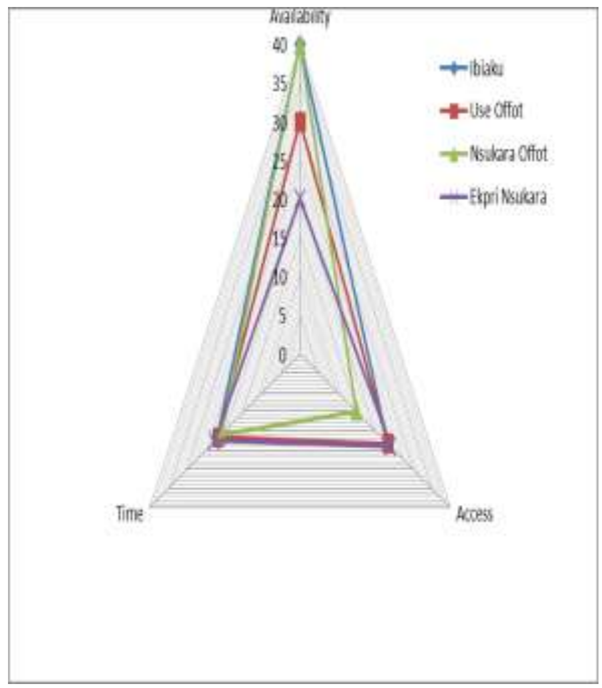

Figure 4:Radar comparing water availability, time stress and access indexes

From Figure 4, there is a visible variation in the values of water availability index for Use Offot, Ibiaku and Ekpri Nsukara communities. However, Ibiaku and Nsukara Offot communities had close-to equal values of water availability index. The high values of water availability index for Nsukara Offot and Ibiaku communities show that these two communities have multiple water sources for the people. However, Ekpri Nsukara with the least water availability index has very few water sources.

Also, Figure 4 also shows that all four communities had almost the same value time stress index. This shows that residents in all four communities still spend almost the same time at water collection centres. Ibiaku, Use Offot and Ekpri Nsukara communities had almost same value of water access indexes quite higher than that of Nsukara Offot communities. This shows that a higher population of people in Nsukara Offot have poor access to good water sources. This was evident by the fewness of boreholes and pipe borne water sources in the community. In other three communities, a good proportion of their population have access to good water sources like boreholes and pipe born water.

The relationship between water poverty index and the average water fetching time (see Figure 5) for the communities show that the relationship is fairly strong (R^2 = 0.68). Thus, WPI can be forecasted even when the water fetching time is known but the result will not be dependable due to a fairly strong relationship. A similar plot of water poverty index values against average volume of water (Figure 6) obtained from each community shows a very weak relationship that the relationship (R^2 = 0.28). Thus, WPI cannot be forecasted with available water

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volume. This results is thus in line with Yahaya et al (2009) who computed WPI using the composite index approach. However, the range of values of WPI using the composite in this study is greater than that obtained by Yahaya et al (2009) in a similar season. This shows that communities in Uyo which falls within the South-Southern is less water-stressed than communities in the Ondo state (Western Nigeria) probably because of the high precipitation obtained in South-southern Nigeria. This assures more of the recharge of Natural water reservoirs to provide for sufficient water for rural communities.

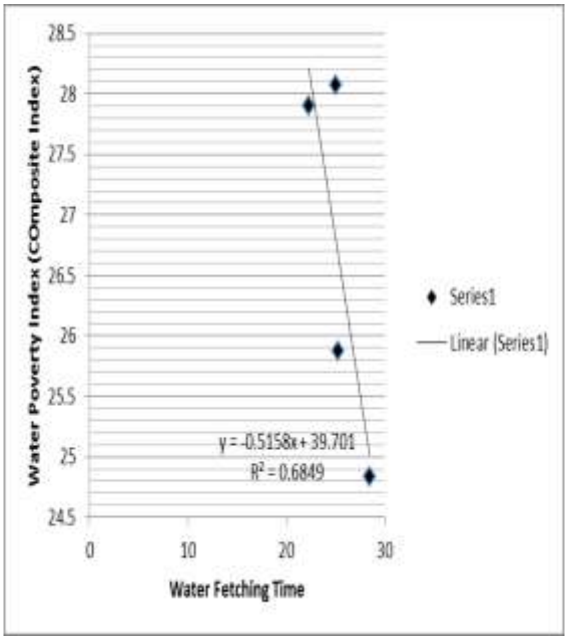

Figure 5: Relationship between WPI (composite) and water fetching time

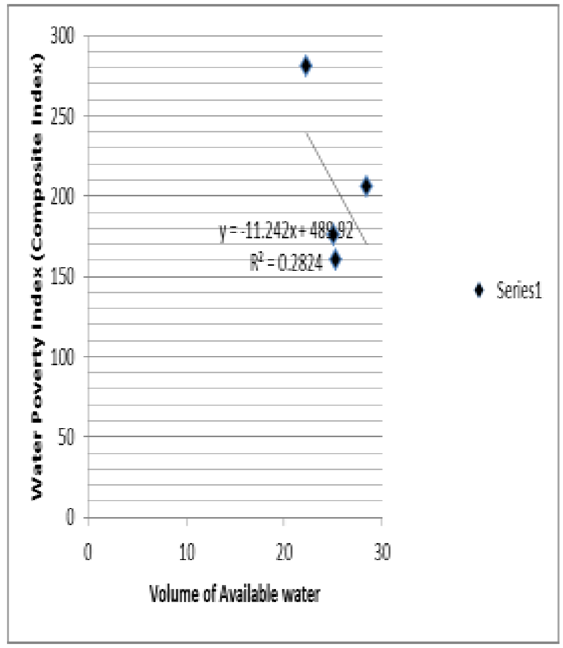

Figure 6: Relationship between WPI (composite) and volume of available water

3.1.4 Time Analysis Approach

Time approach is based on the consideration of time of fetching water and and the volume of water fetched (Yahaya et al., 2009). This approach is simple and presents the water poverty index in terms of minutes per litre of water fetched. Table 5 show the computed WPI values for the communities using the time analysis approach.

Table 5: WPI (Time Analysis) values for communities in Uyo Local Government Area

S/N	Community	T (minutes)	V (Litres)	WPI ($minsL^{-1}$)
1	Ibiaku	24.83	206.33	0.13
2	Use Offot	28.07	176	0.21
3	Nsukara Offot	25.87	160	0.17
4	Ekpri Nsukara	27.90	281	0.16

Where T = Average time for fetching water; V = Average volume of water fetched
WPI = T/V

From table 5, the results of water poverty index (WPI) obtained using composite index approach showed that Use Offot community has the highest value of WPI ($0.21minsL^{-1}$) while Ibiaku community has the least value of $0.13minsL^{-1}$. This simple analysis shows that Use Offot community is the most water-stressed community in Uyo Local Government Area while water stress was considered to be least at Ibiaku community. This is clearly seen in the bar chart (Figure 7). During the consultation process, it was discovered that the dwellers at Use Offot village fetch less volume of water with a greater time probably because some of the residents still derive their drinking

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water from streams which are far away from the residential area. Ibiaku residents on the other hand fetch water from sources (boreholes and pipe borne water) that are at close proximity to their residential area and thus can have more volume of water at a less time.

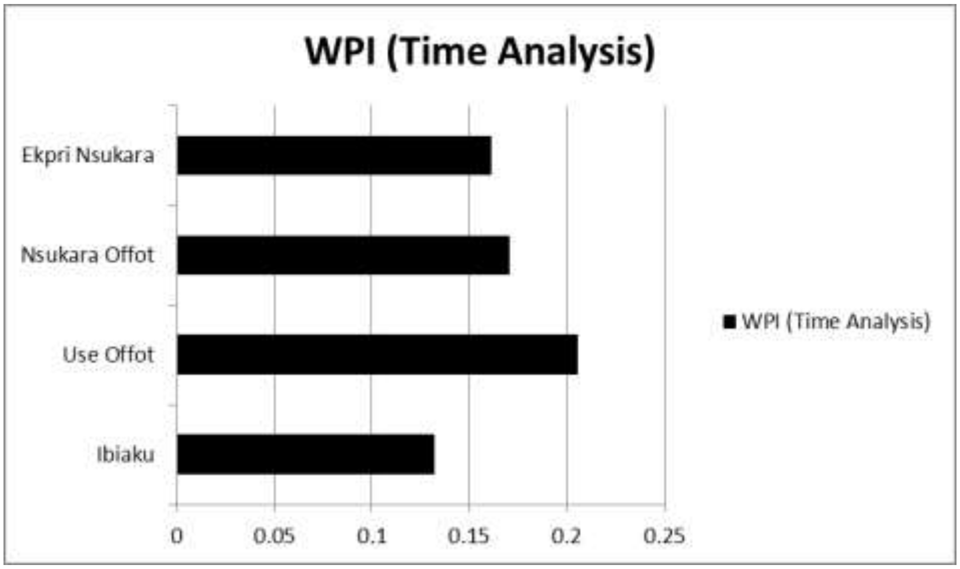

Figure 7: ***WPI (Time analysis) values for communities in Uyo Local Government Area***

The relationship between water poverty index and the average water fetching time (see Figure 8) for the communities show that the relationship is not strong (R^2 = 0.56). Thus, WPI cannot be forecasted even when the water fetching time is known. A similar plot of water poverty index values against average volume of water (Figure 9) obtained from each community shows a very weak relationship that the relationship (R^2 = 0.136). Thus, WPI cannot be forecasted with available water volume. This results is thus in line with Yahaya et al (2009) who computed WPI using the time analysis approach. However, the range of values of WPI using the time analysis approach in this study is less than that obtained by Yahaya et al (2009) in a similar season. This shows that communities in Uyo which falls within the South-Southern is less water-stressed than communities in the Ondo state (Western Nigeria) probably because of the high precipitation obtained in South-southern Nigeria. This assures more of the recharge of Natural water reservoirs to provide for sufficient water for rural communities.

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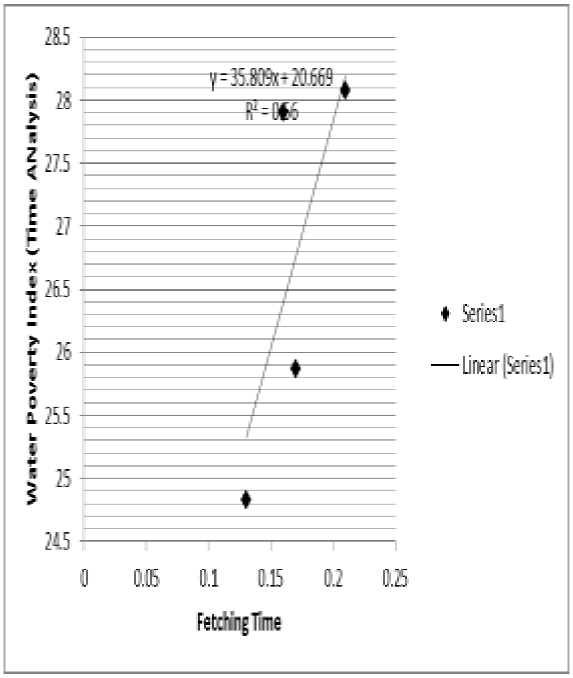

Figure 8: Relationship between WPI (Time Analysis) and water fetching time

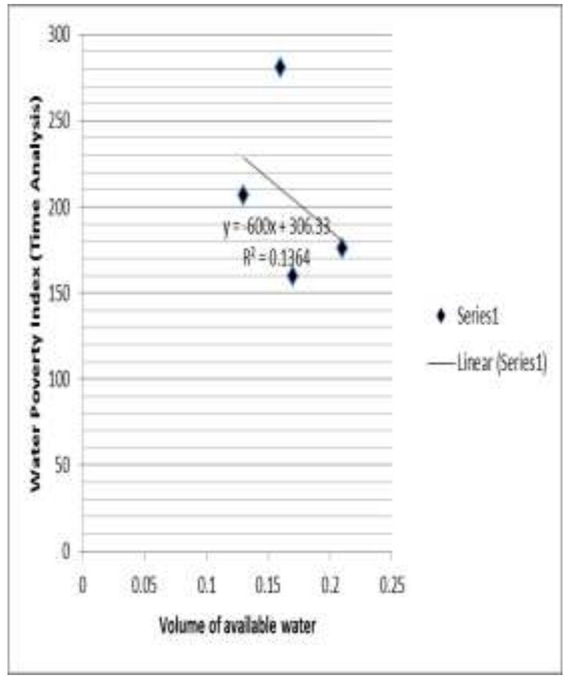

Figure 9: Relationship between WPI (Time Analysis) and water volume available

IV CONCLUSION

From the results of the study, the values of the water poverty index using composite index approach indicates that Ibiaku community is least water-stressed while Ekpri Nsukara is most water-stressed followed by Use Offot community. On the other hand, the computed water poverty index using time analysis approach indicates that Ibiaku community is least water-stressed while Use Offot is most-water stressed followed by Nsukara Offot. The WPI ranks of the four communities from the computations of the two different approaches are presented in Table 6. The ranks increase from the least water-stressed to the most water-stressed.

Table 6: WPI ranks for communities in Uyo Local Government Area

S/N	Community	Water Poverty Index Ranks	
		Composite Index Approach	Time Analysis Approach ($minsL^{-1}$)
1	Ibiaku	1	1
2	Use Offot	3	4
3	Nsukara Offot	2	3
4	Ekpri Nsukara	4	2

From Table 6, both approaches show that Ibiaku is the least water-stressed community. Use Offot ranked third and fourth in composite index and time analysis approaches computations tends to be the most water-stressed community in Uyo Local Government Area.

However, simple time analysis cannot link complex multidimensional aspects of water management together as a result of this, composite approach is always preferred. The application of composite index approach to test the generated dataset provided flexible and strong decision making strategies in such a way as to construct a holistic water management tool to address the problems of poverty, and its relation to water access and use. Thus, the results

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presented here using various approaches to test our standardized data sets are expected to enhance our understanding of the significant effects of water poverty to economy.

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