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APPLICATION OF WATER POVERTY INDEX IN ASSESSING VARIATION IN WATER SCARCITY AND STRESS IN KATSINA-ALA, NORTH-CENTRAL NIGERIA

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ABSTRACT

The study assessed water scarcity and stress in the twelve (12) council wards of Katsina-ala Local Government Area using indicators of water poverty; Resource, Access, Capacity, Use and Environment where chosen for the study based on data availability, applicability and relevance of such indicators in the study area. Questionnaires, interview, field observation and field measurement where employed for data collection. The study adopted the composite approach where the components of indicators were systematically integrated to provide the final scores of the water poverty index with 100 indicating the least water poverty and 0 indicating the highest level of waster poverty. Result of the final computation of water poverty index of the council wards indicates that, six (6) council ward; Tiir, Iwar, Utange, Mbayong, Mbatula and Mbagir council wards where classified under severe water poverty; Mbacher, Ikurav-Tiev I and II and Yooyo were classified under high water poverty; Mchihe was classified as having medium water poverty while Kastina-Ala Township was classified as having low water poverty. Based on result of the study, it was recommended that more research using many other relevant indicators should be carried out in the area and more water intervention programs should be carried out in the council wards to ameliorate the water scarcity situation in the study area.

Keywords: Water Poverty, Index, Water Scarcity, Water stress

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INTRODUCTION

Public water supply in Nigeria's urban and rural areas is generally inadequate and, in most cases, inaccessible, the supply is intermittent and unreliable, thus resulting into high dependency on unsafe supplementary sources such as streams, hand dug wells and ponds with compromised quality (Nnodu and Ilo, 2002; Ocheri, 2006; Ocheri and Vangeryina, 2020).Water is an indispensable resource and serves as the basis of life. Its importance to man and environmental functioning can never be over emphasized. According to Shiklamanov (2000), water is a driver for the sustainability of life's quality and for the economic and social wellbeing of people. Despite the importance of this resource to human development, increase in population coupled with industrialization is putting so much pressure on the resource and it is expected that there will be continuous increase in demand which invariably will lead to water scarcity and stress especially in developing countries like Nigeria.

Water scarcity refers to either physical or social water scarcity (Falkenmark*et al*., 2007). Physical water scarcity arises because of low availability of water resources, while social water scarcity is caused by unbalanced power relations, poverty and related inequalities (Falkenmark*et al*., 2007).watersscarcity can be further divided into demand-driven scarcity (water stress) and population-driven water scarcity (water shortage)(Falkenmark*etal*., 2007). Water stress on the other hand occurs when the demand for water exceeds the available volumeduringacertainperiod orwhen poor quality restricts its use. It is often measured with the use-to-availabilityratio(Rockström*etal*., 2009).Growing population together with climate change are predicted to considerably increase water stress within the following decades (Döll, 2002; Alcamo*et al.*, 2003) and it is estimated that by 2050 more than half the world's population will live in water-stressed areas (Schlosser*etal*.,2014,Schewe*etal*.,2014).Further,it has been proposed that the higher the water stress, the more vulnerable the population to changing water scarcity(vanBeek*etal*.,2011).According to Abrams (1999), water scarcity is one of the products of poverty. Sullivan*et al*. (2003) capture water poverty more succinctly as the unavailability of water to meet existing needs arising from lack of or inability to mobilize resource like human and financial. It therefore implies that the scarcity of water has a strong link with human, financial and institutional poverty.

The world over, attention is being given to the study of water stress in poor communities of developing nations. This has become pertinent partly due to decreasing trend in water availability and demand coupled with population explosion. Thishas led to concerted effort being made in recent times to develop an all-encompassing method that that can quantify water stress at community, sub-national and national levels (Sullivan *et al*., 2006 and Foguet, 2010). Falkenmark index, Water Resources Vulnerability Index, Water Availability Index and Water Poverty Index are some of the tools recently developed for this purpose (Falkenmark, 1989; Meigh*et al*., 1999; Sullivan, 2006 and Raskin*et al*., 2020).

Water Poverty Index (WPI) is a multidisciplinary indicator method developed by Sullivan (2006) to assess water stress and poverty through linking physical estimates of water availability with the socioeconomic drivers of poverty. The advantage of WPI is that all the interlinkedindicatorsare summed into a single numerical representation for easy understanding. The aim of Water Poverty Index (WPI) is to provide a mechanism by which water management decisions can be prioritized using a holistic standardized and transparent framework (Dlamini,2006). Using Multi Criteria Analysis, the five major components (Resource, Access, Capacity, Use and Environment) are combined as a weighted average. Each component is represented by various sub-components, with the resulting scores ranging from zero (extreme water poverty) to one hundred (zero water poverty). According to Dlamini (2004), the component Resources can include surface and groundwater, as well as some measure of variability and water quality. The Access component includes; access to water for domestic use, and access to irrigation. The Use component relates the use of water to the value of output it generates. The Capacity component focuses on individual and institutional capacity to manage water, and this is based on level of education, health status, and Gross Domestic Product (GDP) and the Environmental has to do with evaluation of environmental quality in relation to ecosystem goods and services.

This study investigates the applicability of water poverty indicators in assessing water scarcity and stress in the planning, monitoring and management of water resources-related development initiatives at community scale in Katsina-Ala Local Government. The applicability of these indicesat this scale, could present a sound basis for their development or adaptation as a tool for informing, monitoring and evaluating policies for water-related development and management in the study area.

MATERIALS AND METHODS

Study Area

Katsina-Ala Local Government is located in the North-Eastern part of Benue State and shares boundaries with Taraba State in the North-East, Ukum Local Government in the North, Logo in the North-West, Buruku in the West, Ushongo in the South and Kwande in the South-East. According to the 2006 national census the area has a population of 224,718 (NPC 2009). The local government geographically lies between latitude 7° 5′ 0″ and 7° 30′ 0″ north of the equator and longitudes 9° 15′ 0″ and 9° 55′ 0″ east of Greenwich Meridian Line. Politically the local government comprises of twelve (12) Council Wards (Fig. 1). The study area falls within the

Koppen's Aw (wet and dry) climatic region with temperatures mostly high throughout the year with average diurnal range of 23°C – 28°C with the peak of 38°C (Hundu and Bibi, 2018). The area lies between the transition zone of the rain forest and savannah vegetation, while the northern portion consists of typical grassland savannah vegetation, with undulating hills and shrubs, the south-east is of semi-deciduous forest vegetation. The area has an elevation of 95 to 753 meters above mean sea level and is drained by a lake, many streams and rivers; prominent among them are River Yooyo, Loko and the Katsina-Ala which is the largest. The dominant tribe in the area is the Tiv people who are mostly farmers.

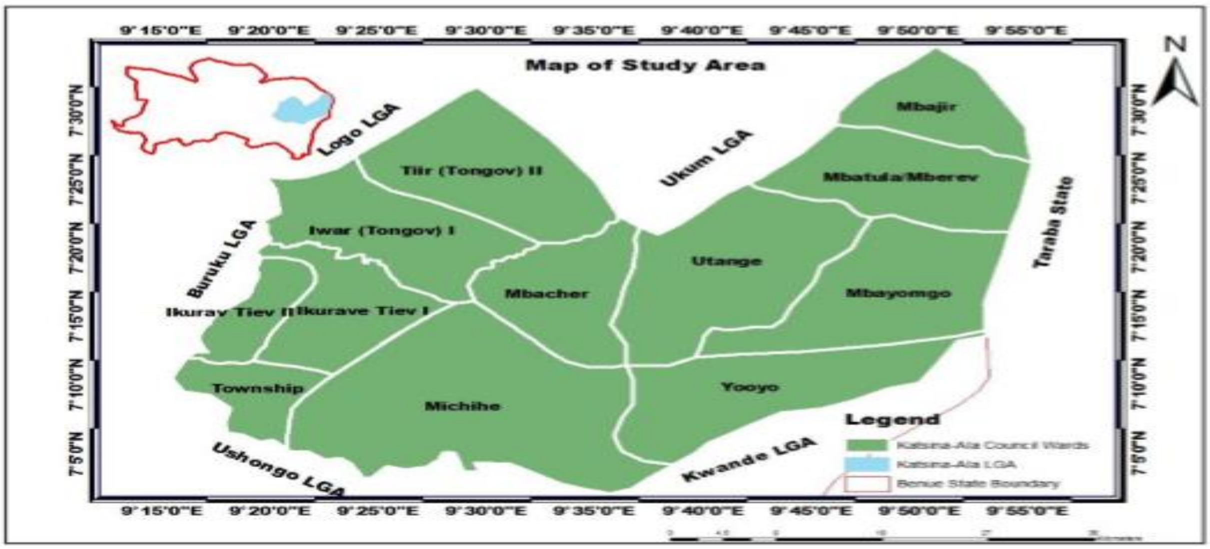

Figure 1: Map of the study area showing council wards

Composite Approach Methodology

Methodology of this study is based on a WPI framework developed by Sullivan (2002), Sullivan and Meigh (2003) and Sullivan *et al*., 2006). The methodology considers five components that integrate physical availability of water with socio-economic and environmental factors: Resource (R), Access (A), Use (U), Capacity (C) and Environment (E). The Resource component provides an assessment on availability of the water resource in the study area. Access indicates the access to adequate water and sanitation. The Use component shows the water consumption at the domestic level. The Capacity component depicts the socio-economic capacity of the population to manage water resource. The Environmental component denotes potential pollution sources that influences water quality and resources. These indicators for the components mentioned above were selected at the council wards based on availability of data and relevance to the communities. The WPI components and indicator with their functional relationship to water poverty is shown in Table 1.

Water poverty index calculation involves using composite index approach in which five (5) identified components are combined to calculate water poverty (Sullivan *et al*., 2006; Van der vyver, 2013; Xin *et al*., 2011; Maheswari, 2016). Mathematically, WPI is expressed as;

$$WPI = \frac{\sum_{i=1}^{N} w_i X_i}{\sum_{i=1}^{N} w_i} \quad \text{........ [1]}$$

Where *WPI* is water poverty index value for a particular community, *xi* refers to component of *i* of WPI structure for that location and *wi* is the weight applied to that component. Each component has indicators which are initially combined using same technigues. For each component (Resource, Capacity, Use and Environment), the equation can be re-wrtten as describe by Lawrence *et al*. (2000) as;

$$WPI = \frac{wrR+waA+wcC+wuU+weE}{wr+wa+wc+wu+we} \times 100 \quad \ldots\ldots\ldots [2]$$

Where WPI is Water Poverty Index and (*w*) is weight of each component. Before the application of this formula, the values are normalized. The final value of water poverty index should fall between 1 and 100 with 1 being the most water poor and 100 being the optimum condition.

Normalization of Sub-indicators

All indicator values are normalized to fall between 0 and 1 inorder to free them from various units and for harmonisation such that some indicators do not have undue dominance over others (Nardo*et al*., 2008). The value of 0 indicates the poorest level of water poverty while 1 indicates optimum condition. The normalization is done using the equation 3.

$$Index = \frac{Xi - X\min}{X\max - X\min} \ldots\ldots\ldots [3]$$

Where, Index is Resource, Access, Capacity, Use and Environment. *Xi* is real value of each parameter,*Xmax* is the highest indicator value across the council wards when compared and *Xmin* is the minimum indicator value. The negative indicator to water poverty is deducted by 1. The normalized values of the indicators are shown in Table 2.

Estimation of Weights for the Indicators

The Delphi method is used for the estimation of indicators. This method involves getting judgment from water related experts. The study adopted Guppy, 2014 weighting method for the study as shown in Table 3.

Table 3: Mean weight of indicators

Indicator	Weights
Resource (R)	2.78
Access (A)	1.83
Capacity (C)	1.58
Use (U)	2.00
Environment (E)	1.84

Source: Guppy 2014 adopted from Centre for Ecology and Hydrology

Sources of data collection

Data for the study was collected on the five components of water poverty; Resource, Access, Capacity, Use and Environment.Data on Resource component include; the number of people reporting water sufficiency (R1) and number of water supply sources in each of the council wards (R2). Data on both of these indicators were obtained at the Water, Sanitation and Hygiene (WASH) Desk office in Katsina-Ala LGA.

Under the Access component; data on percentage of people having access to safe water (A1) and those having access to sanitation (A2) were obtained from WASH office in Katsina-Ala LGA. Distance to water sources (A3) was obtained by observing and estimating distances in meters (m) from households to water supply points (river, streams, boreholes, and hand dug wells). The values obtained at various households of a council ward were averaged to get a single value for the council ward as the distance to water sources. This was done in all council wards.

Data on Capacity component include indicators such as poverty rate (C1) and percentage of educated people (C2) wasobtained from published literature.

Under the Use component, indicators on domestic water consumption rate (U1) and water treatment options (U2) were obtained from field survey.

Under environmental components data on number of pollution sources was obtained from field observation.

Table 1: Indicators and their functional relationship with water poverty

Components	Indicators (Sub-indicators)	Relationship with Water Poverty
Resource (R)	R1. Water quantity sufficiency (%)	The higher the % reporting water sufficiency, the lower the poverty (+).
	R2. Number of water sources.	The higher the number of water sources or points, the lesser the poverty (+).
Access (A)	A1. Access to safe water (%)	The higher the % of people having safe water, the lesser the poverty (+).
	A2. Access to sanitation (%).	The higher the percentages of people with access to sanitation, the lesser the poverty (+).
	A3. Distance to water source(s) (km).	The longer the distance covered to obtain water, the higher the poverty (-)
Capacity (C)	C1. Poverty rate (%)	The higher the percentage, the higher the level of water poverty (-)
	C2. % of educated people.	The higher the % of educated people, the less the level of poverty (+)
USE (U)	U1. Domestic water consumption rate (Litres per day per capital)	Higher consumption with availability is less poverty (+)
	U2. Use of local water treatment procedure (boil water)	The higher the percentage of those that treat water before consumption, the lower the poverty (+)
Environment (E)	E1. Number of water pollution source(s)	The higher the number of pollution sources, the higher the poverty level and vice-versa (-).

Source: Adopted and modified from Zahra *et al*. (2012) Maheswari and Sudha (2016)

RESULTS

Normalized Values of Indicators

Result of the normalized values for the indicators in each council ward of Katsina-Ala is presented in Table 2 while result of the multiplication of weight in the respective indicator is shown in Table 3. Result of the resource component indicates that, Katsina-Ala Township has an indicator value of 1 implying that in terms of water resource in the area, the township area has better available physical water sources while Mbatula has the least value of 0.02.

Weight of component indicators

Weight of each component indicator was assessed. Result presented in Table 3 indicates that on the Resource component, Township has a value of 1 indicating that it is lass poor while Mbatula has the highest level of poverty with a value of 0.02.

For the Access component Township has a value of 1 indicating less water poverty as compared to the other council wards with Tiir having the highest levl of water poverty with a value of 0.02. Under capacity, Township possessed the highest capacity and therefore less poverty with an indicator value of 1 while Mbayongo has the highest water poverty with a value of 0.22. Under the Use component, township has less water poverty with an indicator value of 1 while Utange has the highest level of water poverty with a value of 0.03. In terms of Environment, the Mbachihe has a value of 1 indicating the lesser poverty while Township has the highest water poverty level.

Classification of Water Poverty index in Katsina-Ala

Result of the Water Poverty Index calculated in Table 3 was compared to the scores of classifications in Table 4 to produce the different levels of water poverty in Katsina-Ala as shown in Table 5.

Table 2: Normalized values of indicators in the council wards

S/No	CouncilWard	R1	R2	A1	A2	A3	C1	C2	U1	U2	E1
1	Tiir	0.85	0.02	0.02	0.00	0.67	0.73	0.07	0.31	0.63	0.72
2	Iwar	0.33	0.27	0.07	0.16	0.72	0.27	0.27	0.25	0.25	0.70
3	Mbacher	0.42	0.22	0.04	0.51	0.54	0.88	0.13	0.38	0.45	0.86
4	Ikurav Tiev I	0.73	0.28	0.29	0.73	0.73	0.36	0.35	0.50	0.20	0.82
5	Ikurav Tiev II	0.90	0.04	0.63	0.55	0.14	0.40	0.44	0.63	0.42	0.80
6	Township	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
7	Michihe	0.30	0.38	0.18	0.78	0.78	0.96	0.00	0.38	0.48	1.00
8	Utange	0.39	0.31	0.12	0.33	0.58	0.69	0.28	0.00	0.06	0.94
9	Yooyo	0.30	0.00	0.10	0.42	0.43	0.57	0.26	0.38	0.00	0.98
10	Mbayongo	0.24	0.27	0.16	0.48	0.43	0.36	0.07	0.35	0.09	0.69
11	Mbatula	0.00	0.04	0.73	0.24	0.38	1.00	0.18	0.35	0.14	0.83
12	Mbagir	0.15	0.13	0.00	0.27	0.00	0.85	0.02	0.25	0.20	0.95

Table 3: Component indicators and weights assigned to components and the final Water Poverty Index

S/No	Council Ward	Resource(R) Weight- 2.75	Access (A) Weight- 1.83	Capacity(C) Weight- 1.58	Use (U) Weight- 2.00	Envi. (E) Weight- 1.84	WPI
1	Tiir	0.44	0.23	0.40	0.47	0.72	45.2
2	Iwar	0.30	0.32	0.27	0.25	0.70	36.8
3	Mbacher	0.32	0.36	0.51	0.42	0.86	49.4
4	Ikyurav Tiev I	0.51	0.58	0.36	0.35	0.82	52.4
5	Ikyurav Tiev II	0.47	0.44	0.42	0.53	0.82	53.6
6	Township	1.00	1.00	1.00	1.00	0.00	80.0
7	Michihe	0.34	0.58	0.48	0.43	1.00	56.6
8	Utange	0.35	0.34	0.49	0.03	0.94	34.0
9	Yooyo	0.15	0.32	0.42	0.32	0.98	43.8
10	Mbayongo	0.26	0.34	0.22	0.24	0.69	35.0
11	Mbatula	0.02	0.32	0.59	0.25	0.83	40.2
12	Mbagir	0.14	0.28	0.44	0.23	0.95	40.8

Key: WPI = Water Poverty Index

Table 4: Classification of Water Poverty Index

Water Poverty Class	Score
Severe	0 - 47.9
High	48.0 - 55.9
Medium	56.0 - 61.9
Medium Low	62.0 - 67.9
Low	68.0 – 100

Source: Adopted from Maheswari and Sudha (2016).

Table 5: Water Poverty Class of the Council Wards in Katsina-Ala

Water Poverty Class	Council Wards
Severe Poverty	Tiir, Iwar, Utange, Mbayongo, Mbatula, Mbajir
High Poverty	Mbacher, Ikurav Tiev I, Ikurav Tiev II and Yooyo
Medium Poverty	Michihe
Medium Low	
Low Poverty	Township

DISCUSSION

Resource

Resource component represents the sources of water available for use to the people of a community. In the township ward which is urban, the town has more water sources as compared to the other council wards which are mostly rural. The water sources in the area include the major river Katsina-ala which passes through the township area and is accessible. Other sources include water vendors selling in containers and hand dug wells which were seen in most of the households visited with close proximity unlike the rural council ward which depends mostly on streams most of which are ephemeral and yield water only during raining season and dry up during dry season.

Access

The Access component entails the availability and accessibility of water for consumption by the people. It has to do with the people having access to safe water and sanitation and a close proximity to water sources. The highest values for water accessibility in the study area is in the township wardas shown in Table 3 which invariably mean that the level of water poverty in terms of this component is minimal in township as compared to others which had low values. Most of the households visited in the township area in the town had handdugwells close to the household which mean that the people in the area will travel lesser distance to obtain water, moreover the water vendors in the township normally supply water directly to the people at a token in contrast to the rural council wards in which members of the community travel at long distances to fetch water which invariably may affects their socio-economic livelihoods. Also, the people in the township are better educated and therefore know better ways of treating water before consumption unlike the people in the rural areas which are mostly illiterates and do not even know the dangers of consuming untreated water. These have resulted in low values cross the council wards which are mostly rural.

Capacity

Capacity component shows the poverty rate in terms of financial capacity and literacy which are key components in water poverty assessment. The better the financial capacity and level of education, the lesser the water poverty level. Financial capacity and level of education helps one to have better ability to access water in terms of quality and quantity. A man which is financially capable will employ wealth to drill a borehole in a community while a less financially buoyant individual cannot. The people in the township ward had better capacity than the people in the rural communities. This was responsible for higher value as compared to the other rural council wards which have lower values indicating higher level of water poverty.

Use

Water use indicates the rate of water consumption and treatment options. The water consumption rate was higher in township probably due to high population and needs which are peculiar to urban dwellers which resulted in low values of WPI, although most of the household visited noted that they buy drinking water from vendors including the sachet water which in local parlance is called "pure water" the quality of such water remain in doubts. Most of the rural households interviewed in the area do not use any treatment option in treating water before consumption, many do not know the dangers of consuming this water as they fetch directly from the stream for their drinking and domestic purposes making them water poor in terms of water use.

Environment

The Environmental component indicates water pollution potential areas in the study area. Result of the study indicates that the township ward has the highest level of water pollution sources as indicated with an index of 0 showing that, it is the most water poor in terms of this component. This is probably attributed to many numbers of waste dump sites, indiscriminate construction of septic tanks very close to handdug well are dumping of refuse indiscriminately in the river which is the major source of water in the area. In the rural council wards of the study area, most of the streams are located far away from the households and there were no industrial activities generating waste in the communities thus making them less poor in terms of environmental quality as shown in Table 3.

Final Water Poverty Index

The sum of the values gotten from the major component; Resource, Access, Capacity, Use and Environment are summed in each council ward are averaged and multiplied by 100 using equation 2 to get the overall WPI of each council ward constituting the study area. The result is shown in Table 5. The WPI values in all the council wards was compared to the standard classification of WPI values of Table 4, to enable the classification of the level of water scarcity in the council wards. The council wards were classified in terms of severe poverty, high poverty, medium poverty, medium- low and low poverty. Six (6) council wards were classified as severely poor and they include; Tiir, Iwar. Utange, Mbayongo, Mbatula and Mbagir. Four(4) were classified under high poverty and they include; Mbacher, Ikurav TievI, Ikurav Tiev II and Yooyo. One(1) council wards; Michihe was classified under medium poverty; non was under medium low while the council ward with the lowest water poverty is the Katsina-Ala Township.

CONCLUSION

The study assessed water scarcity and stress in Katsina-Ala using composite index approach proposed by Sullivan *et al*. (2006) in which the indicators of water poverty; Resource, Access, Capacity, Use and Environment are systematically combined to calculate water poverty using relevant equations and procedure. Result obtained from this approach ranked the council wards in the study area in terms of the level of water poverty as severe, high, medium, medium low and low poverty. Result of the study revealed that, Tiir, Iwar, Utange, Mbayongo, Mbatula and Mbajir are under severe water poverty; Mbacher, Ikurav Tiev I and II and Yooyo are under high poverty; Michihe is under medium poverty while Katsina-ala Township is under low water poverty. The high value of the WPI of 80 (see Table 3) in the township which indicate low water poverty in the study area does not in any way imply that there is no problem of water scarcity and stress in the area but the comparison with the council wards in the rural areas has placed it at a vantage position over the others. The water poverty index approach used in the study has proven to be an effective tool for ranking of communities based on their level of poverty for easy intervention in terms of water provisioning by professionals and water managers.

RECOMMENDATIONS

Based on the result of the study, it is therefore recommended that a more detail and robust research should be carried out in the area with more indicators which are not included in this study. The aspect of water quality and other important variables should be included. It was observed that few communities visited had intervention in terms of boreholes in some communities by donor agencies and NGO's more needs to be done to alleviate the water scarcity situation in the study area.

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