Estimation of Sustainable Water Resources Potential of Ikpa Sub-Watershed Using GIS And NRCS (SCS) Approaches

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Received:06.04.2023 **Accepted**:16.05.2023 **Published**: 17.05.2023

Abstract:
The knowledge of water quantity that a watershed yields enables planning for its utilization and effective management for sustainability. Lack of adequate water infrastructures within Ikpa watershed and overstretched existing infrastructure problems have led to avoidable water related health hazards in Ikpa watershed. There is dearth of information on the quantification of water yield availability within the watershed. The study was therefore designed to estimate water resources potentials of the Ikpa watershed. Shape and drainage network of the watershed were determined using Geographic Information System (GIS). Data from Nigerian Meteorological Agency were used to estimate the watershed's water quantity using water balance model. Watershed physiographical characteristics were determined, while surface water quantities were estimated using National Resources Conservation Service - Soil Conservation Service (NRCS - SCS), GIS and Remote Sensing (RS) approaches. Pearson correlation analysis was used to forecast rainfall–runoff magnitudes. Best fitted probability distribution functions to the watershed were determined using three different plotting methods at four different return periods. Ikpa watershed is fern shaped with dendritic drainage network of stream order 4. Physiographical parameters of the watershed were as follows: area (360.56 km2), total length (158.23 km), average runoff coefficient (0.36), average slope (0.11) and average concentration time (0.06 min). Estimated surface water quantities with NRCS-SCS and GIS were 2.96 billion m3 and 4.89 billion m3, respectively and subsurface water quantity was 37.2 billion m3. Total annual potable water potential was obtained to be 24.12 billion m3 with 12.27% accounting for the surface water quantity. Human population within the watershed was 245,663. It was observed that 0.05% of the total water resources available was utilized annually, indicating underutilization of the available water. The overall available water resources within Ikpa watershed are fairly sustainable. The water resources potential was grossly underutilized and could be harnessed for beneficial use.

Keywords: Ikpa watershed, curve number, return periods, water balance, drainage network

1. Introduction

A systematic investigations into and study of hydrology by various researchers have established the facts and concluded that a watershed is "that portion of land entity, demarcated by a hydrologic system, within which all living things are separately connected by their common water course and where, as humans resolved to live together comfortably in such an entity, mere reasoning required that such an entity become part of a group of people inhabiting together with common ownership and ideology – a society" [1], [2], [3].

The rain that falls in Nigeria as a nation is connected through a network of drainages into various streams. These streams flow into rivers and rivers flow into the ocean. The two major rivers where all other rivers within Nigeria drainage network flow into are rivers Niger and Benue. These empty themselves into the Atlantic Ocean at the Niger delta region of the country while those within South Western watershed (Oshun – Ogun River Basin) find their ways into the ocean through the creeds and Lagoon in Lagos, [1].

Broadly, water is considered as being finite throughout the world generally; a very susceptible resource, [4]. Water usage policies and very recent legal underlying structure are formulated to accommodate new fundamental truth and effective designed plan for integrated water resources management [5]. Whenever the need for water policies and strategies are to be put into effect, it is inevitable to take into account river basins as relevant units for water and environmental resources development and utilization. To keep from eliminating undesirable challenges and serious disagreements and to meet social and legitimate demands for water, combined methods are absolutely necessary. A basin-wide planning scope, consideration to management of surface and subsurface water and to water quantity, water quality and environmental integrity as a closely related entity are fundamental elements of these combined methods. The relations between land use and water resources and to the integration of natural limitations, social and economic demands and legal, political and administrative processes should be further emphasized, [6].

Studies on a large scale on watershed have been conducted by various countries of the world in a bid to turn things around for the better but yet to achieve much significant level of success especially in developing countries of the world. In most of the existing world's watershed especially in developing countries (mostly in Africa), the total annual water yield of a river basin is hardly accounted for. This has made it practically impossible to know what the water yield from a chosen watershed is used for. In addition, the task of knowing the quantity of water required to meet the agricultural, domestic and industrial need of such watershed is not handily quantified. The knowledge of this would enable one to know when the watershed in question is having excess water above the normal demand level. This is what this study would want to determine the annual total yield of the watershed (surface and underground water), determine water portion annually used to meet its agricultural, domestic and industrial water needs, know the difference, [7].

Ikpa watershed occupies a large extent ranging from Abak through Uyo down to Itu linking with the Itu River along Uyo – Calabar highway. The study area, University of Uyo main campus (Nsukara Offot) Use and Ekpri Nsukara falls within Ikpa watershed, representing the study area. The main campus had only the Faculty of Engineering since 1995/1996 academic session and few surrounding households staggeringly located. But of recent, due to the relocation of Faculty of Science, the Post graduate school and the Vice Chancellor's office from the Town Campus in Ikpa road to the main campus (with other Faculties in line to be moved to the main campus), there have been proportional increase in households within the study area logically suggesting a corresponding need for increase in basic human needs like water, land for agricultural and industrial purposes, water resources infrastructures among others, [8]. However, despite the obvious increase in students and staff population and the population explosion witnessed within the adjoining communities from 1995 to date, there have been no corresponding increase in water resources infrastructure within the main campus and adjoining communities to meet daily needs of this population for agricultural, domestic and small scale industries purposes thereby over stretching the fragile existing infrastructure and exposing the study area to risk of shortage of potable water, outbreak diseases and general retardation of development among others.

This study was therefore designed to estimate the water resources potentials of Ikpa watershed by estimating the quantity of water needed to meet daily (monthly, yearly) requirements of the University Community and its environs for domestic and agricultural purposes, the quantity actually utilized presently within the study area while also evaluating the available water resources infrastructure, if any though. With this, one could determine whether the water resources potentials and available infrastructure could sustain the population depending on it for sustainable development, [8],[9].

2. Materials and Methods

2.*1 Study Area*

The University of Uyo, a sub catchment of the study area lies within Ikpa River Basin sub watershed which falls between longitude 70 5" 37.51E to 8o2"48.87'E east of the meridian, and latitude 5º 2"52.96N to 5º2"34.07N of the equator an average elevation of 52.705 m above sea level. Figure 1 shows the map of Akwa Ibom highlighting the watershed of the study area. The entire watershed area cuts across three Local Government Areas of Akwa Ibom which are Itu, Uyo and Uruan. It has an estimated basin area of 360.563 km2 and total length of stream of about 158.23 km, and a Basin Perimeter about 108.2 km., [10].

Ikpa watershed falls within the equatorial rain forest belt, which is a tropical zone that house vegetation of green foliage of trees shrubs and oil palm trees. Vast expanse of the watershed is built-up and still under developmental process. It has a tropical rainy climate with high incidence of rainfall coupled with high temperature. The average sunshine hours accumulate to 1450 hours per year with the annual mean temperature recorded, falling between 20oC and 29oC, [10]. The rainfall distribution pattern could be described as: seasonal, convectional and spatial. Uyo maximum and minimum humidity are recorded in July and January respectively while mean annual rainfall ranges from 1599 mm to 3855 mm. The cumoni cumulonimbus type of thick cloud is commonly experienced between the months of March to November. The study area has high evaporation with annual values ranging from 1500 mm to 1800 mm, [10]. Major occupations of occupants of the watershed are schooling, commercial, civil service and farming activities.

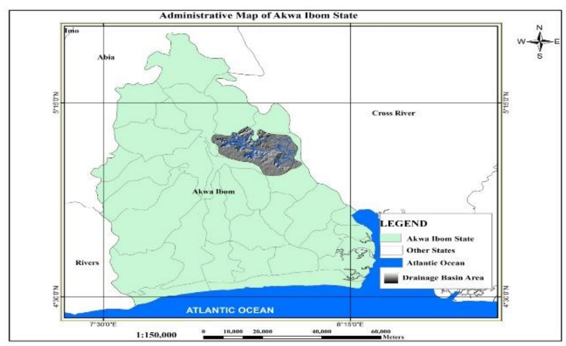

Figure 1: Akwa Ibom Showing the watershed Area

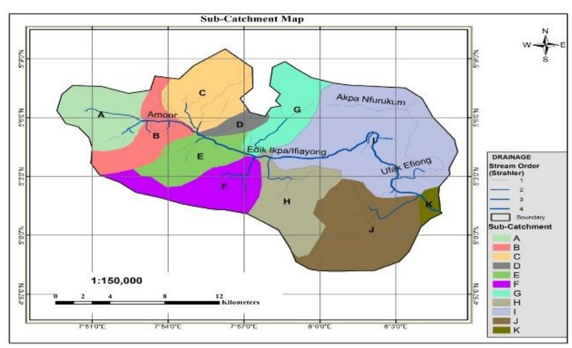

Figure 2: Sub Catchment delineation of the Studied watershe

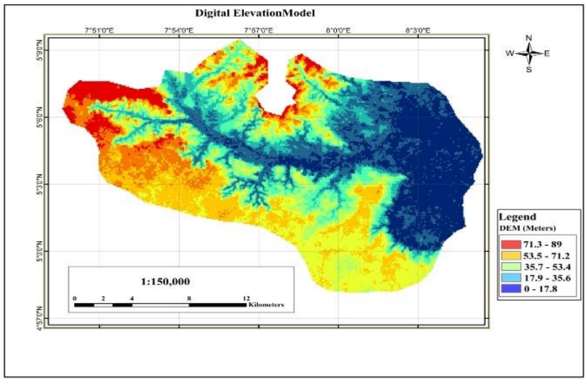

Figure 3: Digital Elevation Model (DEM) of watershed[11]

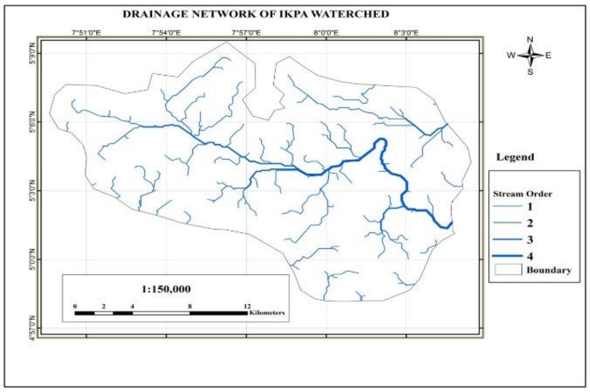

Figure 4: Drainage network of Ikpa catchment area [11]

2.2 Adopted Approaches and Data Used

The source of data used to obtained relevant results include field investigation and Laboratory analysis, extraction from administered questionnaire, relevant data extraction from United Nation Programme for Development (UNPD) retrieved online, Population data obtained from the National Population Commission (NPC) office, Akwa Ibom State; extracts from University of Uyo/ National Commission for Universities (NUC) data base, National Bureau of Statistics (NBS) obtained online, Ministry of Economic Development (MED) Uyo, Akwa Ibom State report (Retrieved online) and information from the GIS and RS technologies relevant to estimating the WSI values of the watershed. GIS and RS technologies were used to delineate the watershed, sub-watershed and obtain the watershed area, slope, drainage pattern, the morphometric parameters, land use, percentage of forest area, and estimation of the surface water quantity. Curve number (SCS) method was used to estimate the surface water quantity of the studied watershed using relevant meteorological data as obtained from (Nigerian Meteorological Agency) NIMET. This is according to [12], [13] and [14] as:

$$P_a = \frac{(P-0.2S)^2}{P+0.8S} \qquad 1$$

and

$$S = \frac{1000}{CN} - 10 \qquad 2$$

Where Pa is the direct runoff, CN is the curve number (for average/moderate condition) and S is the maximum retention of the watershed.

The groundwater quantity was estimated using the water balance approach, according to [15] as:

$$P = R + E + D + \Delta S_s + \Delta S_G \qquad 3$$

Where P= Precipitation; R= Runoff; E= Evapotranspiration; D= Annual average recharge or discharge; ΔS_S = Change in surface water storage; ΔS_G = Change in groundwater storage (both Saturated and unsaturated). According to their report, averaging over several years, $\Delta S_S \approx \Delta S_G \approx 0$. Equation 3 then becomes

$$P = R + E + D \qquad 4$$

Making R the subject of the formula, Equation 4 becomes [15]

$$R = P - D - E \qquad 5$$

Best probability distribution suited for the watershed studied using California, Hazen, and Weibull plotting positions was determined on information from relevant literature, [16], [17] and [18]. These distributions are described by different probability density functions (PDF), expressed according to [19] as:

Log-Normal Distribution

$$f(x) = \frac{1}{x\propto\sqrt{2\pi}} exp\left(\frac{(y-\mu_y)^2}{2\sigma_y^2}\right) \qquad 6$$

y = Log x, the equations for parameters in terms of the sample moments is

$\mu_y = \bar{y}$ and $\sigma_y = S_y$ within the range x > 0

Three Parameter gamma (Pearson Type III Distribution)

$$f(x) = \frac{\lambda^{\beta}(x-\varepsilon)^{\beta-1}e^{-\lambda(x-\varepsilon)}}{\Gamma(\beta)} \qquad 7$$

In terms of sample moments, the equation for parameters is

$\lambda = \frac{S_y}{\sqrt{\beta}}$, $\beta = \left(\frac{2}{C_s}\right)^2$ *and* $\varepsilon = \bar{x} - S_x\sqrt{\beta}$ within the range $x \geq \varepsilon$

Gumbel Distribution (Extreme Value Type I)

$$f(x) = \frac{1}{\alpha} exp\left[-\frac{x-\mu}{\alpha} - exp\left(-\frac{x-\mu}{\alpha}\right)\right] \qquad 8$$

In terms of sample moments, the equation for parameters is

$\alpha = \frac{\sqrt{6S_y}}{\pi}$ *and* $\mu = \bar{x} - 0.5772x$ within the range $-\infty < x > \infty$

The correlation between the predicted rainfalls – runoff for various years were carried out based on the linear regression model given by [14] as

$$R = aP + b \qquad 9$$

Where R is the runoff generated within the studied watershed, P is the rainfall while a and b are constant

And the values of the coefficients a and b are expressed as

$$a = \frac{N(\sum PR) - (\sum P)(\sum R)}{N(\sum P^2) - (\sum P)^2} \quad 9a$$

$$b = \frac{\sum R - a\sum P}{N} \quad 9b$$

Where N is the number of observations sets of R and P respectively. The coefficient of correlation, r can be calculated as

$$r = \frac{N(\sum PR) - (\sum P)(\sum R)}{\sqrt{[N(\sum P^2) - (\sum P)^2] \times [N(\sum R^2) - (\sum R)^2]}} \quad 9c$$

The value of r lies between 0 and +1 as R can have only positive correlation with P

The water resources infrastructure of the studied area together with their storage capacities were determined in order to predict if the water need of the population of the watershed is adequately met. The population data of the studied area was obtained from relevant agencies and authorities (UNPD, NPC, NBS, MED) to ease analysis after subjecting them to relevant population forecasting models, as uniform percentage increase and logistic methods, [20]; [21]:

$$ln\, P_t = \ln P_o + K_1 \Delta t \quad 10$$

This could also be expressed as

$$\ln P_t = \ln P_o + K_1(t - t_o) \quad 10a$$

$$K_1 = \frac{\ln P_t - P_o}{\Delta t} \quad 10b$$

3. Result and Discussion

3.1 Watershed Morphometric Parameters

The Sub catchment delineation map, digital elevation model (DEM) map and drainage network map of the studied Ikpa watershed, showing various streams and their order generated from the processed SRTM using ArcGIS 10.1 software are shown on Figures 2 - 4. The results obtained from the GIS and RS technology revealed that the entire watershed has a stream order of 4, total stream length of about 158.23 km, watershed perimeter of about 108.2 km. The bifurcation ratio (BR) was estimated to be 1.907, Drainage Density (Dd) of 0.595, Form factor (Ff) of 11.702, Shape Factor (Sf) of 1.344. The watershed has stream frequency of 0.416 and total stream count of 150 with an average basin slope (%) of 0.108, these values were obtained directly from the GIS and RS analysis, [22]. The result of the morphometric parameter shows that the number of streams in the watershed is high as reflected by the drainage density value irrespective of the extent of the watershed suggesting that there could be high rate of both surface and underground water quantity. This could boost agricultural activities if appropriate water resources infrastructure is put in place within the study area to harness the water resources potentials for utilization and developmental purposes. Infrastructure like reservoir to serve for agricultural, domestic and industrial purposes could be considered provided that the geological formation will not support excessive rate of seepage. Evaporation and evapotranspiration from the infrastructure so provided should be minimal.

3.2 Estimation of Surface Water: Curve Number (SCS) Approach

Surface runoff within the watershed was also estimated by using the curve number (SCS) method. This estimates the direct runoff (depth) or rainfall excess, storm wise for period of data collected from NIMET, between 1981 and 2013. Equations 1 and 2 representing direct runoff and CN (II) or AMC (II) estimation were adopted to obtain results. They were four categories of land use identified within the watershed whose hydrologic soil group lies between groups A to C with their corresponding curve numbers assigned, [13]. A weighted curve number derived from the identified hydrologic soil groups was obtained as 2 and used in the preceding process of estimating the volume of generated surface runoff. The month of July has the highest average rainfall and direct runoff values of 383.06 mm and 104.84 mm respectively recorded with estimated direct runoff volume of about 37,801,425 m3 representing about 21.60 % of the total direct runoff volume of 175,000,000 m3 generated within the studied period. However, December has the lowest average rainfall and direct runoff volume values of 12.42 mm and 18.11 mm resulting to the direct runoff volume of about 3.73 % of the total direct runoff. Similarly, year 2012 recorded the highest average rainfall for the 33years with a value of 385.56 mm and direct runoff of 106.35 mm resulting to a total runoff volume of about 225,000,000 m3 accounting for 7.60 % of the entire estimated runoff volume of about 2,960,000,000 m3. The year with the least estimated total runoff volume was 1981 accounting for just 2.17 % of the total estimated runoff volume. On the whole, cumulative total volume estimated for the watershed stood at 2.96 billion cubic meters of water.

3.3 Groundwater Estimation: Water Balance Approach

The result of the estimated recharge uses the runoff values for curve number (II) as obtained in the estimation for surface water quantity of the watershed. The values of the recharges (groundwater quantity) from 1981 to 2013 as obtained by evaluating equation 3.4 with the various variables defined earlier. The equations 3 - 4 revealed that the value for the first year, 1981, with recharge value of 175.53 over the entire watershed (assuming that no subsurface water was available in the system prior to the period of the study). This gave the subsurface water quantity 63287863 m3 resulting from a runoff depth of 17.82mm from a rainfall of 200.78mm. As the period (years) increases, the underground recharge value increased steadily as expected to a maximum of 6702.73mm equivalent to a recharge value of 6609.390 from a total runoff of 707.24 resulting to a total underground water potential of 37,400,000,000 m3 (37.4 billion cubic meter) of water. The total runoff volume (mm) is 707.24 yielding an equivalent recharge value of 103,673.8 mm of infiltrated water from the surface runoff resulting to an estimated total groundwater quantity of about 3.74 billion cubic meters of water for the entire watershed for the 33years.

3.4 Best Probability Distribution for the Watershed

Year 2012 was observed to have the highest mean rainfall of 385.56 mm, followed by 2013 (350.40 mm), 2011 (331.87 mm). The least mean rainfall (mm) values of 128.49, 139.44 and 146.91 mm in that order were recorded in the year 1983, 1997 and 1986. The values for each plotting positions, obtained from the computation, were recorded as observed rainfall for the three selected plotting positions. The analysis shows, therefore, that California and Hazen plotting positions are best fitted to the Log Normal probability distribution. While the Weibull plotting position showed a deviation when these values were compared [23], [24], [17], [8]. This suggests that for Log Normal distribution, the Hazen and California plotting positions perfectly best fitted the observed rainfall magnititude obtained.

The results from Pearson Type III (PT3) obtained show that observed values returned for each plotting positions used increased in magnitude to decreasing magnitude of the mean rainfall values obtained from NIMET. Comparing the obtained observed values for the three different plotting positions, plotted on a normal graph for the computed return periods, Weibull and Hazen assume a similar shape indicating that both best suit Pearson distribution for the computed watershed observed rainfall values. California plotting positions is not suited for the watershed rainfall data since it deviated significantly from the other two suggesting, [9].

From the extreme value type I distribution (EVT I), California plotting position recorded zero value for return period of 1 corresponding to the lowest mean rainfall data for the year 1983 when sorted in descending order of magnitude. Plotting the values obtained for the observed rainfall for the thirty-three (33) years rainfall data using the three plotting positions, Weibull and Hazen approximated the EVT I distribution with California plotting position showing a remarkable deviation from the other two suggesting that the two (Weibull and Hazen) distributions perfectly best fitted the EVT I distribution than the California plotting position.

From Table 1, it could be concluded that the order of fitting perfectly the three probability distributions of Log Normal, Pearson Type III (PT 3) and Extreme Value Type I – Gumbel (EVT I) into the three plotting positions used is in increasing order as: Hazen > Weibull > California. This is in agreement with the positions of other researchers like [18], [16], [17] and [25] who have worked on fitting the rainfall data of this region (South South, Nigeria). Using the three probability distributions to predicting the rainfall magnitude for the studied area for return periods of 1.25 years, 2 years, 5 years, 10 years, 20 years, 50 years and 100 years respectively, results obtained are as shown in Table 1. Log Normal distribution showed a remarkable increased in value for the predicted rainfall magnitude recording a value of 204.918 mm against corresponding low value of 175.065 mm and 135.985 mm for Pearson Type III and Extreme Value Type I (Gumbel) distributions respectively. Thereafter, the values of the three probabilities considered started increasing relatively to a corresponding increase in return periods in years as seen in Table 1. This contiuned till the return period of ten (10) years when the three probabilities distributions considered could be said to approximate the values of rainfall magnitude (mm) predicted.

The observed rainfall data obtained from NIMET was analyzed to test for the correlation between it and the estimated observed rainfall values obtained from the three probability distributions for the various plotting methods chosen, as shown in Table 2. All the three probability distributions showed a negative but strong correlation values of -0.61, -0.75 and -0.78 for Log Normal (LN), Three Parameter Gamma (PT III) and Gumbel (EVT I) under Weibull plotting methods with EVT I with the highest value. For Hazen plotting method, LN showed the strongest correlation, though negative with a value of -0.79 and PT III having the least value of -0.73. California plotting method showed that LN has the highest positive R2 value of 0.89, followed by EVT I and PT III having the least negative R2 value of -0.85. The absolute mean R2 values showed that the three used probability distributions correlated perfectly with values of 0.76, 0.78 and 0.78 for Log Normal, Three Parameter Gamma (Pearson Type III) and Gumbel (Extreme value Type I) respectively.

4. Conclusions

The water sources of the studied watershed were estimated to be about 24.12 billion cubic meters based on the meteorological data for thirty –three years used assuming that the entire studied watershed is taken as a closed system, that is, no abstraction of water from the watershed within the period which the data covered. Of the 24.12 billion cubic meter of water estimated Table 3, surface water quantity accounted for 2.96 billion cubic meter (12.27%) of water as obtained by the curve number (SCS) method since the value obtained from the rational method fell outside the values of various results obtained hence was considered an outlier. This is because of the obvious limitation of the rational method which states, according to [26], that the method is only useful when it is applied to a basin area equal or less than 0.65km2 (65ha). The method of water balance gave an estimated value of 37.4 billion cubic meters and the GIS estimation gave 4.89 billion cubic meters which, on average gave a value of 21.16 billion cubic meters (87.73%) of estimated sub surface water quantity obtainable in the studied watershed. Table 4 shows estimated population water need and availability in watershed. The estimated population water needs on this vast water resources, using 2015 population projection as baseline stood at 1,000,000l/h/d and 30,000,000l/h/d for the University of Uyo Community and the entire watershed Community respectively while only about 327,600l/h/d was estimated to be available presently within the University of Uyo (main campus) Community exclusive of the other part of the watershed considered in the entire estimation. This implies that the

Table 1. The Three Distributions with Results of Predicted Rainfall Magnitudes (mm)

S/N	**Return Period Tr (yrs)**	**Log-Normal (LN)**	**Three Parameter Gamma (PT3)**	**Gumbel (EVT1)**
1.	1.25	186.266	150.347	153.640
2.	2.00	197.432	150.726	194.714
3.	5.00	239.787	224.000	249.980
4.	10.00	265.454	295.930	286.570
5.	20.00	288.702	372.302	321.669
6.	50.00	317.303	478.239	367.100
7.	100.00	337.924	561.038	401.144

Correlation between observed and estimated rainfall for the distributions

Table 2. Calculated R^2 values of the observed rainfall for the three used distributions

Distributions/ Plotting Methods Used	**Weibull**	**Hazen**	**California**	**Absolute Mean R^2 Value**
Log Normal	-0.61	-0.79	0.89	0.76
Three Parameter Gamma	-0.75	-0.73	-0.85	0.78
Gumbel	-0.78	-0.77	0.86	0.80

Conclusion of Research findings

Table 3. Summary of Estimated Water Potential of the Studied Watershed

S/N	Activities	**Method of Water Potential Estimation (33 years)**		Average Value
		Rational Approach	SCS(CN) Approach	
1.	Cumulative Surface Water Estimated (m^3)	❖ 190.40 cubic meter	2.96 billion cubic meters	2.96 billion cubic meters
		Method of Water Potential Estimation (33years)		Average Value
		Water Balance Approach	GIS Approach	
2.	Cumulative Groundwater Estimated (m^3)	37.4 billion cubic meters	4.89 billion cubic meters	21.16billion cubic meter
3.	Total			24.12billion cubic meter

☐ This value was neglected since it stands out as an outlier

Table 4. Summary of Estimated Population Water Need and Availability in Watershed

S/N	Activities	**Location and Assumed Baseline Year (2015)** University of Uyo (l/h/d)	Entire watershed (l/h/d)	Total Estimation (Cubic Meter)
1.	Estimated Population Water Need	1,000,000	30,000,000	31,000,000litres 31,000 m^3
2.	Estimated Available Water	327,600	24.12 billion cubic meters	24.12 billion cubic meters

University of Uyo (main campus) could only boast of 327,600l/h/d (32.76%) out of the estimated 1,000,000l/h/d currently needed to meet its population water requirement while about 67.24% is still needed to sufficiently meet the water requirements of the school presently, Table 4. This is grossly inadequate hence the obvious shortage of water in the campus being experienced while nature has endowed the community with abundant storage of water resources based on this research finding that is yet to be harnessed to meet the minimum per capital water requirement of 120l/h/d as suggested by the World Health Organization [27] and [28] respectively. This has been shown and estimated while assessing the water resources infrastructure within the campus, the entire water supply presently utilized in the campus comes solely from borehole supply which in itself is not properly coordinated at the planning, sitting and drilling stages, not that such dependence on borehole water supply or the groundwater resources would not actually meet the needed estimated 1,000,000l/h/d (1,000m3/h/d) as shown by this research.

In addition, it was observed that the existing boreholes on which the school now relied on were probably dug during the time when each of the presently existing structures were being constructed, which the contractors solely dependent on then and later convert to use at the completion of each of these buildings (Faculties). The estimated population of 245,663 persons, using the 2015 population figure as bench mark, utilized 0.05% of the estimated water resources potential (that is 11.32 million m3 of the total 24.12billion m3) annually implying that 99.95% of the water resources potential is grossly underutilized.

Meanwhile other Faculties, such as that of Agriculture, Law, Basic Medical Sciences, Clinical Sciences, Arts, Environmental Studies, Education, Business Administration, Pharmacy and Social Sciences of the University of Uyo are yet to be relocated to the main campus which required that when such happens, that this findings should be review as the total water need will far exceed what is presently estimated now but happily, the abundant available estimated water resources potential will be enough to adequately carter for such increase.

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