Application of the watershed sustainability index to drainage basins in Akwa Ibom,South-South Nigeria

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Abstract: Watershed Sustainability Index (WSI) is an indicator which assesses the sustainability in the basin. It contains many components, suchas the parameter and sub-indicators. These components represent the influence on the sustainable development of the river basin. TheWSI of the senatorial districts of Akwa Ibom State with three randomly selected communities within each senatorial district were investigated. Watershed population was estimated using data obtained from the National Population Commission (NPC). Average WSI for Uyo senatorial district watershed reveals that the final averages are 0.63, 0.57, and 0.57 for Obio Offot, Nung Udoe, and Ifiayong, respectively. The overall WSI score was 0.59 denoting an average sustainability. For Ikot Ekpene senatorial district watershed, it was observed that the final averages are 0.58, 0.55, and 0.55 for Ikot Ubo, Ikot Osurua, and Ikot Etefia, respectively, with overall WSI score of 0.56 indicating an average sustainability. For Eket senatorial district, it was revealed that the final averages are 0.59, 0.59, and 0.57 for Ikot Ibiok and Idua Eket, and Esit Udua, respectively, and it has an overall WSI score of 0.58 denoting an average sustainability. The study revealed that the most critical indicators were related to the hydrological component, namely, State sub-indicator (associated with low water availability per capita),Responsesub-indicator (related to high loss rates in the district), and the water quality-Response sub-indicatorwhich is accentuated by the lack of sewage collection and treatment in the herein studied watersheds. The study infers that the watersheds require priority attention in the hydrological dimension, especially as it concerns sewage collection and treatment along with water supply. It would be important to note that the resolution of these two critical points may, in-turn, solve other issues associated with the people's health as well as the improvement in the quality of life in the watersheds.

Keywords: sustainability, watershed, hydrology, environment, life, policy

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1 Introduction

The Watershed Sustainability Index (WSI) is an integrated basin indicator used to estimate basin sustainability.It is based on basin hydrology, environment, life, and policy (HELP) state condition which include gathering, describing, and assessing relevant socio-economic data (HELP, 2009). It is a quantitative, dynamic, and aggregated indicator, which uses a pressure–state–response function,

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developed by Chaves and Alipaz (2006). WSI is suitable for application in a catchment area up to 2,500km^{2}and has been applied globally in UNESCO-(intergovernmental hydrological programme)IHP HELP River Basins since 2004. The HELP index, developed by UNESCO and further consolidated into one single variable called the Watershed Sustainability Index (WSI), is a watershed specific index that takes into account cause-effect relationships and considers policy responses implemented in a given period as part for evaluating a basin's sustainability (Chaves and Alipaz, 2006).

The WSI integrates the hydrology (H), environment (E), life (L) and policy (P) aspects of a watershed under three parameters: pressure, state and response. Pressure addresses the human activities exerted on the watershed, state assesses the quality of the watershed in the base year of study, as well as the quality and quantity of natural resources, while response examines the society's level of desire to address ecological problems in the watershed. The pressure-state-response structure incorporates cause-effect relationships and thus provides a more comprehensive understanding of the watershed than an index that only examines the State.

Each indicator in Equation 1 is obtained from appropriate tables, that consider factors such as pressure (i.e. human activities that cause or can provoke impacts to the environment), state (i.e. situation of different environment at a given moment), and response (relating to the societal efforts to address environmental problems and reclaim impaired systems). The advantage of using a pressure-state-response approach lies in the fact that it takes into account cause-effect relationships, allowing different stakeholders, managers, and decision makers to recognize and understand the inter-connections between the parameters. A study of water sustainability index by Ewemojeet al.(2016) on Ikpa river basin, Uyo reveals that the watershed is fairly sustainable across all the indicators. Since Uyo metropolis had witness increased in the entire population as rural to urban migration is increasing and, therefore, it becomes necessary to forecast the state of the watershed sustainability in the area.

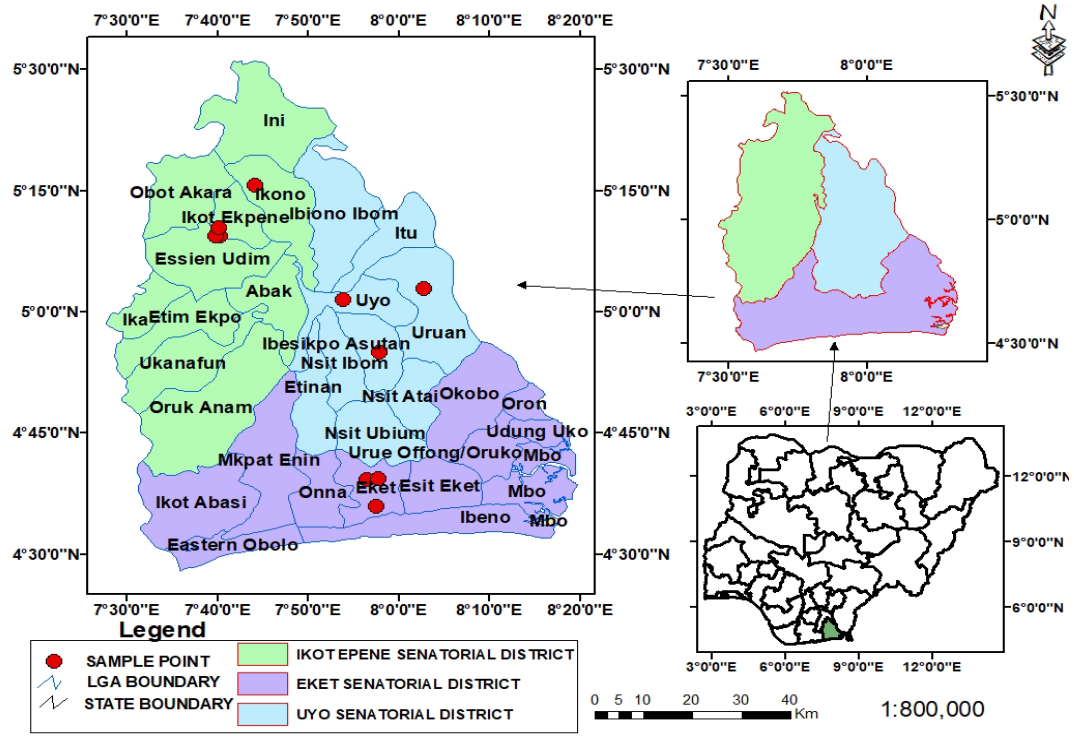
2 Materials and methods

2.1Description of study area

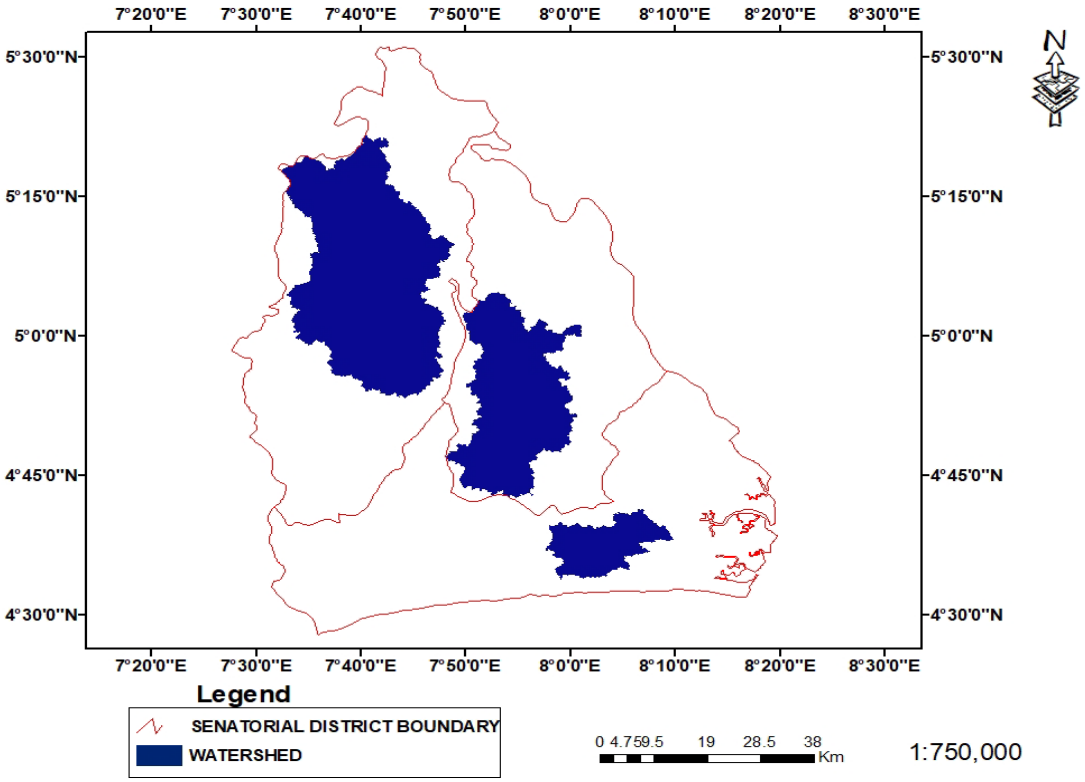
Akwa Ibom (longitudes 7°25′Eand 8°25′E; latitudes 4°32′N and 5°33′N) is a state located in the coastal southern part of Nigeria.It is within the equatorial rainforest belt, which is a tropical zone forest that houses vegetation of green foliage of trees shrubs and oil trees (AKSG, 2008). Figure 1(a) shows the map of Nigeria with Akwa Ibom State included in it. Figure 1(b) shows the map of Akwa Ibom State highlighting the studied watershed. Akwa Ibom state is located in theSouth geopolitical zone, and is bordered on the east byCross River State, on the west by Rivers State and Abia State, and on the south by theAtlantic Ocean (Gulf of Guinea) and the southernmost tip of Cross River State, with an area of 7081km^2(AKSG, 2008). The climate of Akwa Ibom state is a tropical rain type having abundant rainfall with high intensity. Mean annual temperature recorded lies between 2℃ and 31℃ and average sunshine accumulates to 1450 hours per year. The rainfall in the area is seasonal, convectional, and spatial in distribution. The mean annual rainfall ranges from 1599mm to 3855.9mm. Maximum humidity is recorded in July while minimum humidity occurs in January. Evaporation is high and annual values ranges from 1500mm to 1800mm (AKSG, 2008). Its tropical climate is marked by two distinct seasons: the dry season (November – March) and the wet season April – October). The wet season is usually interrupted by a short dry period in August (AKSG, 2021).The projected population of 2016 conducted by the state government put the population of the state at 5,451,277 (AKSG, 2021). However, as the population increases, scattered housings have also been built in other parts of the state.

The main economic activities of the people are fishing (for riverine and coastal dwellers), farming (mostly for upland dwellers), trading, artisanship, and white-collar services. A robust public sector employs

significant proportion of the state labour force (AKSG, 2021). All houses in Akwa Ibom state constitute the total population for the study; random sampling technique was used in the selection of the communities in each of three senatorial districts as case studies within the state. They are Uyo senatorial district (Obio Offot, Ifiayong, Nung Udoe.), Eket senatorial district (Esit Udua, Ikot Ibiok, Idua eket), and Ikot Ekepene senatorial district (Ikot uboh, Ikotosura, Ikot Etefia).



(a) Sample points and Location



(b) Map of Nigeria showing the watershed in Akwa Ibom State (Source: ASTAL, 2021)

Figure 1 Map showing the study locations of the various watersheds I Akwa Ibom State Nigeria.

2.2 Sources of data

Preliminary investigation was made to obtain related literatures which confirmed the actual existence of the problem intended to be solved. The data used for this research work were sourced from both primary and secondary sources. The secondary sources were journals, documented papers, textbooks, internet, and maps, whereas field observations and measurements as well as questionnaires served as primary sources of data.

2.2.1 Instrument for data collection

Questionnaires were randomly given to 20 respondents for each of the three villages in each of the three senatorial districts. Each respondent represents a household. The total of 180 questionnaires was used.

2.3 Research models

Watershed Sustainability Index (WSI), proposed by Chaves and Alipaz (2007) for Akwa Ibom. The index incorporates four dimensions (hydrology, environment, life, and policy), with each having the pressure, state, and response parameters. The components are combined using the expression:

$$WSI = \frac{H+E+L+P}{4} \quad (1)$$

Where，

WSI (0-1) is the average of four indicators;

H is the hydrologic indicator (0-1);

E is the environment indicator (0-1);

L is the life (human) indicator (0-1);

P is the policy indicator (0-1).

Each parameter is given a score of 0.00, 0.25, 0.50, 0.75, or 1.00.

3 Results and discussion

3.1UNESCO – IHP HELP INDEX (WSI)

The WSI was applied to the randomly selected communities in three senatorial districts of Akwa Ibom State. The results are presented below:

3.1.1 Hydrology indicator and hydrology water quality (H)

The hydrology indicated encompasses all aspects of water management and it was evaluated based on two sub-indicators namely, water quality and water quantity.The water availability calculated within the watershed encompasses the data for the pressureand state parameters. A summary of the average water availability per person per year for the three senatorial districts with three randomly selected communities in each for both long term (1991-2018) and short term (2018-2021), considering the population 1991 census as the base population as estimated from NPC Uyo,is presented in Table 1 which gives the average water availability in the communities as extracted from the questionnaires suggested by Falkenmark and Widstrand (1992) far aboveno stress conditions. Table 2gives estimated population and average water availability of the selected communities while, Table 3shows estimated values for hydrology quantity for the entire watershed in three senatorial districts.

Table 1Average water availability per capita (m^3) for the studied communities

Communities	Water source		
	Surface water	Ground water	Rain water
Obiot Offot	>1700	>1700	>1700
Nung Udoe	>1700	>1700	>1700
Ifiayong Esuk	>1700	>1700	>1700
Ikot Ubo	>1700	>1700	>1700
Ikot Osura	>1700	>1700	>1700
Ikot Etefia	>1700	>1700	>1700
Ikot Ibiok	>1700	>1700	>1700
Idua Eket	>1700	>1700	>1700
Esit Urua	>1700	>1700	>1700

The data in Table 1 shows that the water availability per capita for the studied community is greater than that of the internationally agreed water poverty index of per capita water resources (Falkenmark and Widstrand, 1992).

Table 2 Estimated population and average water availability of studied communities

Community	Long term (1991 – 2018) community water availability (m^3/person/year)		Short term (1991 – 2018) community water availability (m^3/person/year)	
	Population	Water availability	Population	Water availability
Obiot Offot	5564	667680	5024	400541
Nung Udoe	13969	1676280	12614	1612262
Ifiayong Esuk	3982	477840	3596	290336
Ikot Ubo	1731	207720	1563	133315
Ikot Osura	7365	883800	6651	540002
Ikot Etefia	4098	491760	3771	319546
Ikot Ibiok	8777	1053240	7926	694296
Idua Eket	4030	483600	3639	279231
Esit Urua	8067	968040	7285	579469

The variations in the watershed's per capita water availability period were assigned scores in accordance with Chaves and Alipaz (2006). Each selected community received a score of 0.00 in the state parameter of this indicator is the long-term community water availability. Table shows that the long-term water availability is far above 1,700m^3/year/person, as opined by Falkenmark and Widstrand (1992) scale, hence the score of 1.00 was assigned to these communities. In case if water use efficiency in all the watershed scores the communities 1.00 there was an overall score of 0.67 in each of the communities resulting in an average WSI hydrology value of 0.67 for the entire 3 watersheds.

3.1.2 Hydrology water quality (H) indicator

Demise and John (2014) five-day biochemical oxygen demand (BODs) data was used for based BODs determination as well as their2021 report on the determination of BODs. The variation of BODs of 2021 relative to that of 2014 was used to estimate pressure parameter for all the considered communities. The field value of the year 2021 was used to determine the state parameters for the response parameter, field investigation data, and appropriate scores were assigned as compared to what Chaves and Alipaz (2006) and Catanoet al.(2009) investigated. The analysis revealed relatively good quality conditions across the watersheds, with average hydrology quality scores of 0.89 in Uyo Senatorial district and 0.75 in both Ikot Ekpene and Eket Senatorial districts. These values fall within the acceptable sustainability range, suggesting that the water bodies within the study area have not yet experienced severe pollution. The higher score observed in Uyo Senatorial District may be attributed to relatively better water resource management practices and greater public awareness of environmental sanitation in urbanized areas. The score scale for determining how sustainable a watershed lies between 0.00-1.00. Any value below 0.50 means poor sustainability while values from 0.5-1.00 indicate a strong sustainability. Table 5, shows that Eket has the highest percentage variation in estimation of life (pressure parameter) indicator (L) of studied watershed life pressure parameter.

3.2 Life (Livelihood) indicator (L)

The life indicator computed for the studied watershed is shown in Tables 6 to 8 using the data obtained from the United Nations Development Programme (UNDP) 2021 and raw data from NPC. The 2021 population based on the 1991 census figure was used as the baseline population for this estimation. To estimate the life pressure parameter, the present variation of the HDI income, population weighted by community data and UNDP (2021) were used in the estimation. The three watersheds scored 1.00 implied that human activities are higher in them. The state parameter is the HDI parameter of the

communities for 2021 year, weighted by population. For this parameter, all the communities received a score of 0.00, implying that the HDI in terms of income of the dwellers is very poor. The response parameter which is the present variation in the overall HDI, Ikot Ibiok in Eket senatorial watershed received highest score of 0.75. Other communities recorded a score of 0.50. The final average WSI Eket senatorial watershed scored higher value of 0.53while others received score of 0.50. These imply that the watersheds indicate a fairly to very strong sustainability according to Chaves and Alipaz (2006, 2007).

3.3 Policy indicator (P)

The study indicators for consideredwatershed are presented in Table 9 to Table 11, based on data extracted from UNDP 2021 and raw data from 1991 censusof NPC. The result of final WSI obtained for policy indicator parameter is presented in Table 12.

Table 3 Estimated values for hydrology quantity (H) indicator of studied communities

Community	Pressure		State		Response		WSI	
	Value	Score	Value	Score	Value	Score	average	Score
Obio Offot	-40.01%	0.00	667680	1.00	Excellent	1.00		0.67
Nung Udoe	-38.50%	0.00	1676280	1.00	Excellent	1.00		0.67
Ifiayong Usuk	-39.24%	0.00	477840	1.00	Excellent	1.00		0.67
Total Score		0.00		1.00	Excellent	1.00		0.67
Average Score		0.00		1.00	100			0.67
Ikot Ubo	-35.02%	0.00	207720	1.00	Excellent	1.00		0.67
Ikot Osura	-38.90%	0.00	883800	1.00	Excellent	1.00		0.67
Ikot Etefia	-35.08%	0.00	491760	1.00	Excellent	1.00		0.67
Total Score		0.00		1.00	Excellent	1.00		0.67
Average Total		0.00		1.00		1.00		0.67
Ikot Ibiok	-34.08%	0.00	1053240	1.00	Excellent	1.00		0.67
Idua Eket	-42.26%	0.00	483600	1.00	Excellent	1.00		0.67
Esit Urua	-40.14%	0.00	968040	1.00	Excellent	1.00		0.67
Total Score		0.00		1.00	Excellent	1.00		0.67
Average Score		0.00		1.00		1.00		0.67

Table 4 Calculated values for hydrology quality (H) indicator of studied communities

Community	Pressure		State		Response		WSI	
	Value	Score	Value	Score	Value	Score	average	Score
Obio Offot	-15.69	0.75	8.5	0.25	Medium	0.50		**1.17**
Nung Udoe	-3.65	1.00	4.8	0.50	Good	0.75		**0.75**
Ifiayong Esuk	-3.96	1.00	4.8	0.50	Good	0.75		**0.75**
Total Score		2.75		1.25		2.00		**2.67**
Average Score		0.92		0.42		0.67		**0.89**
Ikot Ubo	-3.25	1.00	4.3	0.50	Good	0.75		**0.75**
Ikot Osura	-3.00	1.00	3.8	0.50	Good	0.75		**0.75**
Ikot Etefia	-3.94	1.00	4.4	0.50	Good	0.75		**0.75**
Total Score		3.00		1.50		2.25		**2.25**
Average score		1.00		0.50		0.75		**0.75**
Ikot Ibiok	-3.27	1.00	4.2	0.50	Good	0.75		**0.75**
Idua Eket	-3.45	1.00	4.8	0.50	Good	0.75		**0.75**
Esit Urua	-3.65	1.00	4.9	0.50	Good	0.75		**0.75**
Total Score		3.00		1.50		2.25		**2.25**
Average Score		1.00		0.50		0.75		**0.75**

Table 5 Estimation of life (pressure parameter) indicator (L) of studied watershed life pressure parameter

Community	Population		HDI Income		Population Weighted HDI		% Variation	WSI Value
	2018	2021	2018	2021	2018	2021		
Obio Offot	5564	5024	0.439	0.498	0.1039	0.1178	11.79	1.00
Nung Udoe	13969	12614	0.439	0.498	0.2608	0.2958	12.63	1.00
Ifiayong	3982	3596	0.439	0.498	0.0743	0.0434	7.10	1.00
Total	23515	21234						
Ikot Ubo	1731	1563	0.439	0.498	0.0564	0.0653	13.63	1.00
Ikot Osura	7635	6651	0.439	0.498	0.2489	0.02780	10.47	1.00
Ikot Etefia	4098	3701	0.439	0.498	0.1336	0.1547	13.64	1.00
Total	13464	11915						
Ikot Ibiok	8777	7926	0.439	0.498	0.1846	0.0961	0.2094	11.84	1.00
Idua Eket	4030	3639	0.439	0.498	0.1697		50.57	1.00
Esit Urua	8067	7285	0.439	0.498	0.0475	0.1925	11.84	1.00
Total	20874	18850						

HDI= Human Development Index

Table 6 Estimation of life (state parameter) indicator (L) of studied watershed life state parameters

Community	Population	HDI	Population Weighted HDI	WSI Value
	2021	2021		
Obio Offot	5024	0.539	0.128	0.00
Nung Udoe	12614	0.539	0.320	0.00
Ifiayong	3596	0.539	0.0913	0.00
Total	**21234**			
Ikot Ubo	1563	0.539	0.0854	0.00
Ikot Osurua	6651	0.539	0.3698	0.00
Ikot Etefia	3701	0.539	0.0823	0.00
Total	**11915**			
Ikot Ibiok	7926	0.539	0.267	0.00
Idua Eket	3639	0.539	0.104	0.00
Esit Urua	7285	0.539	0.208	0.00
Total	**18850**			

Table 7 Estimation of life (response parameter) indicator (L) of studied watershed

Community	Population		HDI		Population Weighted HDI		% Variation	WSI Value
	2018	2021	2018	2021	2018	2021		
Obio Offot	5564	5024	0.534	0.539	0.126	0.128	1.56	0.50
Nung Udoe	13969	12614	0.534	0.539	0.317	0.320	1.00	0.50
Ifiayong	3982	3596	0.534	0.539	0.0904	0.0913	1.00	0.50
Total	23515	21234						
Ikot Ubo	1731	1563	0.534	0.539	0.0687	0.07071	2.8	0.50
Ikot Osura	7635	6651	0.534	0.539	0.3028	0.3089	1.97	0.50
Ikot Etefia	4098	3701	0.534	0.539	0.1625	0.167	2.69	0.50
Total	13464	11115						
Ikot Ibiok	8777	7926	0.534	0.539	0.225	0.267	15.73	0.75
Idua Eket	4030	3639	0.534	0.539	0.103	0.104	1	0.05
Esit Urua	8067	7285	0.534	0.539	0.207	0.208	0.5	0.50
Total	20874	18850						

The 2021projected population, obtained from the base population census of 1991 and HDI – Education, was used in the analysis. Ikot Ekpene watershed receives a medium score of 0.50 while remaining watershedshad a score of 0.75. The results of policy state are based on legal and institutional framework related surveys but insufficient data was gathered from the administered questionnaires and organization for this report hence the value as "poor" was assigned therefore making every studied community to score 0.25, also for the response parameter a value of 0.50 was assigned. Table 9 shows the final average WSI scores of 0.50 for Uyo watershed, 0.42 for Ikot Ekpene watershed and 0.50 for Eket watershed respectively as shown in the Table 12. Uyo and Eket watershed value of 0.50 was slightly sustainable, while, Ikot Ekpene watershed with average WSI value of 0.42which indicates a poor sustainability.

Table 8 Estimated values of life indicator (L) of studied watershed calculated values for life indicators (L)

Community	PressureValue	Scores(HDI-Income)	StateValue	Score(HDI-2021)	ResponseValue	Score(HDI-2021)	WSI average Score
Obio Offot	11.79%	1.00	0.128	0.00	0.50		0.50
Nung Udoe	12.63%	1.00	0.320	0.00	1.00	0.50	0.50
Ifiayong	7.10%	1.00	0.0913	0.00	1.00	0.50	0.50
Total Score	3.00		0.00		1.50		1.50
Averge Score	1.00		0.00		0.50		0.50
Ikot Ubo	13.63%	1.00	0.0854	0.00	2.8	0.50	0.50
Ikot Osura	10.47%	1.00	0.3698	0.00	1.97	0.50	0.50
Ikot Etefia	13.64%	1.00	0.0823	0.00	2.69	0.50	0.50
Total Score	3.00		0.00		1.50		1.50
Average Total	1.00		0.00		0.50		0.50
Ikot Ibiok	11.84%	1.00	0.267	0.00	15.73	0.75	0.58
Idua Eket	50.57%	1.00	0.104	0.00	1	0.50	0.50
Esit Urua	11.84%	1.00	0.208	0.00	0.5	0.50	0.50
Total Score	3.00		0.00		1.75		1.58
Average Score	1.00		0.00		0.58		0.53

Table 9 Estimation of policy (response parameter) indicator (P) of studied watersheds

Community	**Policy response parameter evocation in basins/WRM expenditure**	**WSI Average. score**
Obio Offot	N/A	0.50
Nung Udoe	N/A	0.50
Ifiayong	N/A	0.50
Ikot Ubo	N/A	0.50
Ikot Osura	N/A	0.50
Ikot Etefia	N/A	0.50
Ikot Ibiok	N/A	0.50
Idua Eket	N/A	0.50
Esit Urua	N/A	0.50

Table 10 Estimation of policy (pressure parameter) indicator (p) of different watershed policy pressure parameter

Community	**Population**		**HDI education**		**Population weighted HDI**		**% Variation**	**WSI Value**
	2018	2021	2018	2021	2018	2021		
Obio Offot	5564	5023	0.42486	0.42486	0.1006	0.1006	0	0.75
Nung Udoe	13969	12614	0.42486	0.42486	0.2522	0.2522	0	0.75
Ifiayong	3982	3596	0.42486	0.42486	0.0720	0.0720	0	0.75
Total	23515	21234						
Ikot Ubo	1731	1563	0.42486	0.42486	0.0546	0.0321	-2.25	0.50
Ikot Osura	7635	6651	0.42486	0.42486	0.2410	0.2372	-1.60	0.50
Ikot Etefia	4098	3701	0.42486	0.42486	0.1294	0.1320	1.97	0.50
Total	13464	11915						
Ikot Ibiok	8777	7926	0.42486	0.42486	0.1787	0.1787	0	0.75
Idua Eket	4030	3639	0.42486	0.42486	0.0473	0.0821	0	0.75
Esit Urua	8067	7285	0.42486	0.42486	0.1643	0.1643	0	0.75
Total	20874	18850						

Table 11 Estimation of policy (state parameter) indicator (p) of different watershed policy pressure parameter

Community	Legal and institutional framework-survey	WSI average score
Obio Offot	Poor	0.25
Nung Udoe	Poor	0.25
Ifiayong	Poor	0.25
Ikot Ubo	Poor	0.25
Ikot Osura	Poor	0.25
Ikot Etefia	Poor	0.25
Ikot Ibiok	Poor	0.25
Idua Eket	Poor	0.25
Esit Urua	Poor	0.25

Table 12 Calculated values of policy indicator (P) of different watersheds

Community	Pressure		State		Response		WSI average
	Value	Score	Value	Score	Value	Score	Score
Obio Offot	0	0.75	Poor	0.25	N/A	0.50	0.50
Nung Udoe	0	0.75	Poor	0.25	N/A	0.50	0.50
Ifiayong	0	0.75	Poor	0.25	N/A	0.50	0.50
Total score		2.25		0.75		1.50	1.50
Average. score		0.75		0.25		0.50	0.50
Ikot Ubo	-2.25	0.50	Poor	0.25	N/A	0.50	0.42
Ikot Osura	-1.60	0.50	Poor	0.25	N/A	0.50	0.42
Ikot Etefia	1.97	0.50	Poor	0.25	N/A	0.50	0.42
Total score		1.50		0.75		1.50	0.84
Average score		0.50		0.25		0.50	0.42
Ikot Ibiok	0	0.75	Poor	0.25	N/A	0.50	0.50
Idua Eket	42	0.75	Poor	0.25	N/A	0.50	0.50
Esit Urua	0	0.75	Poor	0.25	N/A	0.50	0.50
Total score		2.25		0.75		1.50	1.50
Avg. score		0.75		0.25		0.50	0.50

Table 13 Estimation of environmental indicator (E) of studied watershed

Community	Pressure			State			Response		
	VP1	VP2	Average	Nv	Lm	Average	RF	UL	Average
Obio Offot	20.29	9.71	5.29	16.79	38.64	27.72	16.48	11.45	2.52
Nung Udoe	21.81	9.70	6.06	17.00	38.64	27.82	20.32	14.08	3.12
Ifiayong	22.85	9.69	6.53	18.21	38.64	28.43	32.86	21.88	5.49
Ikot Ubo	29.02	9.71	9.66	38.14	45.38	41.76	10.16	2.88	3.89
Ikot Osura	30.50	12.89	8.81	28.78	45.38	37.08	20.98	12.62	8.36
Ikot Etefia	31.10	9.69	10.71	38.20	45.38	41.79	32.82	21.64	5.59
Ikot Ibiok	41.49	9.70	19.90	33.24	48.62	40.93	23.49	12.63	5.43
Idua Eket	48.50	9.70	19.40	32.87	48.62	40.75	25.96	13.85	6.06
Esit Urua	48.85	9.69	19.58	33.65	48.62	41.14	28.87	15.75	6.56

VP=percentage variation of basin population, Nv=Non availability, Lm=percentage of watershed area covered by natural vegetation,

RF =restored forest, UL = urban land

Table 14 Values of environmental indicator (E) of studied watershed

Community	Pressure		State		Response		WSI / Avg.
	Value	Score	Value	Score	Value	Score	Score
Obio Offot	5.29	0.50	27.72	0.75	2.52	0.50	0.58
Nung Udoe	6.06	0.50	27.82	0.75	3.12	0.50	0.58
Ifiayong	6.53	0.50	28.43	0.75	5.49	0.50	0.58
Total score		1.50		2.25		1.50	1.75
Avg. score		0.50		0.75		0.50	0.58
Ikot Ubo	9.66	0.50	41.76	1.00	3.89	0.50	0.67
Ikot Osura	8.81	0.50	37.08	0.75	8.36	0.50	0.58
Ikot Etefia	10.71	0.25	41.79	1.00	5.59	0.50	0.58
Total score		1.25		2.75		1.50	1.83
Avg. score		0.42		0.92		0.50	0.61
Ikot Ibiok	19.90	0.25	40.93	1.00	5.43	0.50	0.58
Idua Eket	19.40	0.25	40.75	1.00	6.06	0.50	0.58
Esit Urua	19.58	0.25	41.14	1.00	6.56	0.50	0.58
Total score		0.75		3.00		1.50	1.75
Avg. score		0.25		1.00		0.50	0.58

3.4 Environmental Indicator (E)

The environmental indicator was computed for the studied watershed as shown in Table 13 and Table 14.For the pressure parameter, each communityreceived a score of 0.50 for having a lower value for the environmental performance index EPI. Evaluating the percentage of area of natural vegetation which is the state indicator obtained a score of 0.75. The response parameter yielded the score of 0.50 all thins the communities, evaluating the evolution in basin conservation.The communities obtaining an average WSI of 0.61 for the environmental indicator EI implies that the environmental indicator component of the studied community watershed is sustainable since a value below 0.50 will infer a poor sustainability of the watershed. The score scale for determining how sustainable a watershed is lies between 0.00-1.00. Any value below 0.50 means poor sustainability while its value in between 0.50 and 1.00 indicates a fairly to very strong sustainability (Chaves and Alipaz, 2006, 2007).

Table 15 Calculated overall WSI of studied watershed (Uyo Senatorial district)

Community	Indicator	Pressure score	State score	Response score	Indicator score	Mean score	Final score
Obio Offot	Hydrology quantity	0.00	1.00	1.00	0.67	0.92	
	Hydrology quality	0.75	0.25	0.50	1.17		0.63
	Environment	1.00	0.75	0.50	0.50	0.58	
	Life	1.00	0.00	0.50	0.50	0.50	
	Policy	0.75	0.25	0.50	0.50	0.50	
	Parameter score	0.60	0.45	0.60			
Nung Udoe	Hydrology quantity	0.00	1.00	1.00	0.67	0.71	
	Hydrology quality	1.00	0.50	0.75	0.75		
	Environment	0.50	0.75	0.50	0.58	0.58	0.57
	Life	1.00	0.00	0.50	0.50	0.50	
	Policy	0.75	0.25	0.50	0.50	0.50	
	Parameter score	0.65	0.50	0.65			
Ifiayong	Hydrology quantity	0.00	1.00	1.00	0.67	0.71	
	Hydrology quality	1.00	0.50	0.75	0.75		
	Environment	0.50	0.75	0.50	0.58	0.58	0.57
	Life	1.00	0.00	0.50	0.50	0.50	
	Policy	0.75	0.25	0.50	0.50	0.50	
	Parameter score	0.65	0.50	0.65			
Grand total parameter score		1.90	1.45	1.90			1.77
Grand average parameter score		0.63	0.48	0.63			0.59

Table 16 Calculated overall watershed sustainability index (WSI) of watershed (IkotEkpene Senatorial district)

Community	Indicator	Pressure score	State score	Response score	Indicator score	Mean score	Final score
Ikot Ubo	Hydrology quantity	0.00	1.00	1.00	0.67		
	Hydrology quality	1.00	0.50	0.75	0.75	0.71	0.63
	Environment	0.50	1.00	0.50	0.67	0.67	0.58
	Life	1.00	0.00	0.50	0.50	0.50	
	Policy	0.50	0.25	0.50	0.42	0.42	
	Parameter score	0.60	0.55	0.65			
Ikot Osurua	H/Quantity	0.00	1.00	1.00	0.67	0.71	
	H/Quality	1.00	0.50	0.75	0.75		
	Environment	0.50	0.75	0.50	0.58	0.58	0.55
	Life	1.00	0.00	0.50	0.50	0.50	
	Policy	0.50	0.25	0.50	0.42	0.42	
	Parameter score	0.60	0.50	0.65			
Ikot Etefia	H/Quantity	0.00	1.00	1.00	0.67	0.71	
	H/Quality	1.00	0.50	0.75	0.75		
	Environment	0.25	1.00	0.50	0.58	0.58	0.55
	Life	1.00	0.00	0.50	0.50	0.50	
	Policy	0.50	0.25	0.50	0.42	0.42	
	Parameter score	0.55	0.55	0.65			
Grand total parameter score		1.75	1.60	1.95			1.68
Grand average parameter score		0.58	0.53	0.65			0.56

Table 17 Calculated overall watershed sustainability index (WSI) of studied watershed (Eket Senatorial district)

Community	Indicator	Pressure score	State score	Response score	Indicator score	Mean score	Final score
Obio Offot	Hydrology quantity	0.00	1.00	1.00	0.67	0.71	
	Hydrology quality	1.00	0.50	0.75	0.75		
	Environment	0.25	1.00	0.50	0.58	0.58	0.59
	Life	1.00	0.00	0.75	0.58	0.58	
	Policy	0.75	0.25	0.50	0.50	0.50	
	Parameter score	0.60	0.55	0.70			
Idua Eket	Hydrology quantity	0.00	1.00	1.00	0.67	0.71	
	Hydrology quality	1.00	0.50	0.75	0.75		
	Environment	0.25	1.00	0.50	0.58	0.58	
	Life	1.00	0.00	0.50	0.50	0.50	0.59
	Policy	1.00	0.25	0.50	0.58	0.58	
	Parameter score	0.65	0.55	0.65			
Esit Udua	Hydrology quantity	0.00	1.00	1.00	0.67	0.71	
	Hydrology quality	1.00	0.50	0.75	0.75		
	Environment	0.25	1.00	0.50	0.58	0.58	0.57
	Life	1.00	0.00	0.50	0.50	0.50	
	Policy	0.75	0.25	0.50	0.50	0.50	
	Parameter score	0.60	0.55	0.65			
Grand total parameter score		1.85	1.65	2.00			1.75
Grand average parameter score		0.62	0.55	0.67			0.58

3.5 Overall watershed sustainability Index (WSI)

The outcome of the overall WSI values from the three senatorial districts as shown in Tables 15 and 17 indicated that the watersheds currently exhibit moderate sustainability conditions. Although, water availability and environmental conditions remain relatively favorable, it increases human pressure and weak institutional frameworks. Final average values obtained for Obio Offot, Nung Udoe and Ifiayong were 0.63, 0.57 and 0.57 respectively. Figure 2, shows Obio Offot recorded the highest score when compared to Nung Udoe and Ifiayong. The overall

WSI score was 0.59 denoting an average sustainability. The results in figure 3, shows that Ikot Ubo recorded a higher score than Ikot Osura and Ikot Etefia (0.58, 0.55 and 0.55) hence, the overall WSI score was 0.56 representing an average sustainability.

It was observed in Figure 4, that Eket senatorial district watershed has the final averages of 0.59, 0.59, and 0.57 for Ikot Ibiok, Idua Eket, and Esit Udua, respectively. While, Ikot Ibiok and Idua Eket has the highest values for the studied watershed in Figure 4. The overall WSI was 0.58 denoting an average sustainability. Comparing the three senatorial districts score from Figure 5, it shows that the Obio Offot has the height score among all the studied communities, whereas, Uyo senatorial district has the highest among the studied senatorial district.

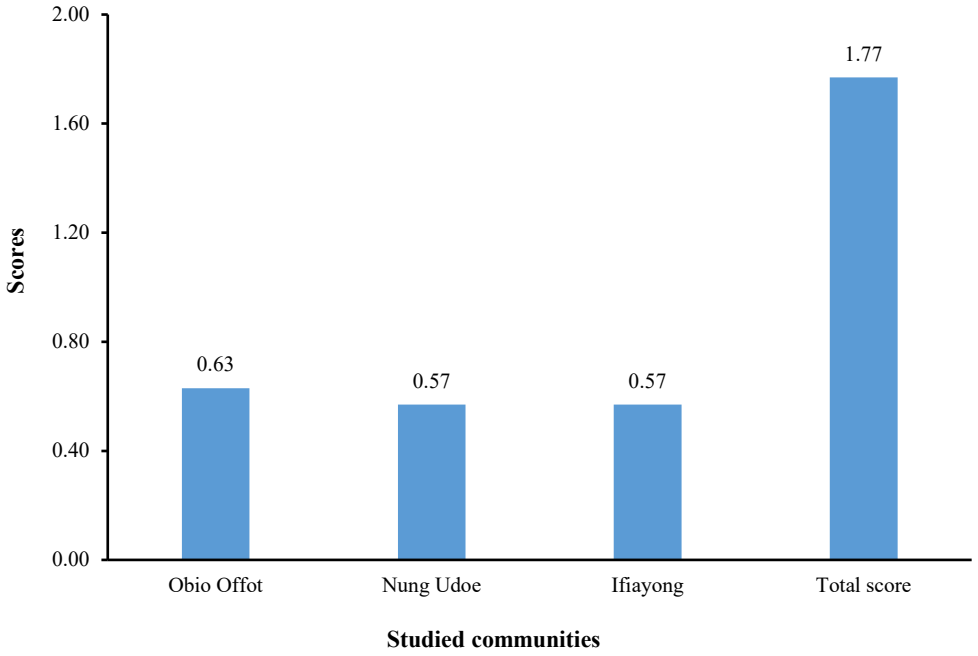


Figure 2 Chart showing final score of Uyo senatorial district

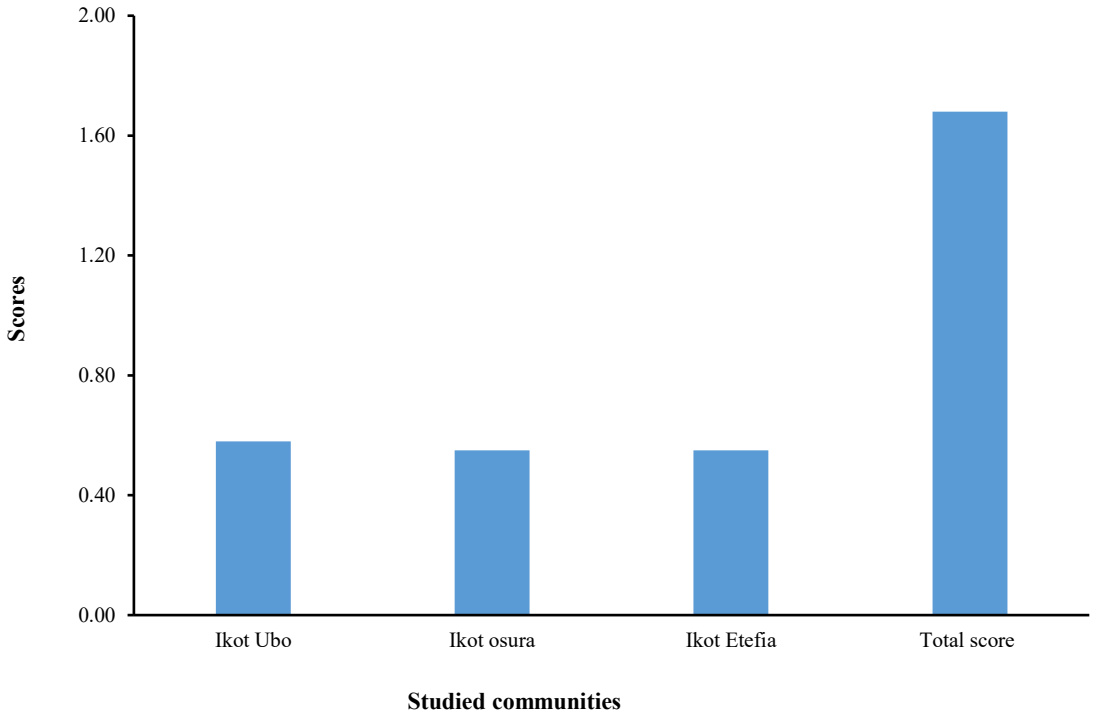


Figure 3 Chart showing final score of IkotEkpene senatorial district

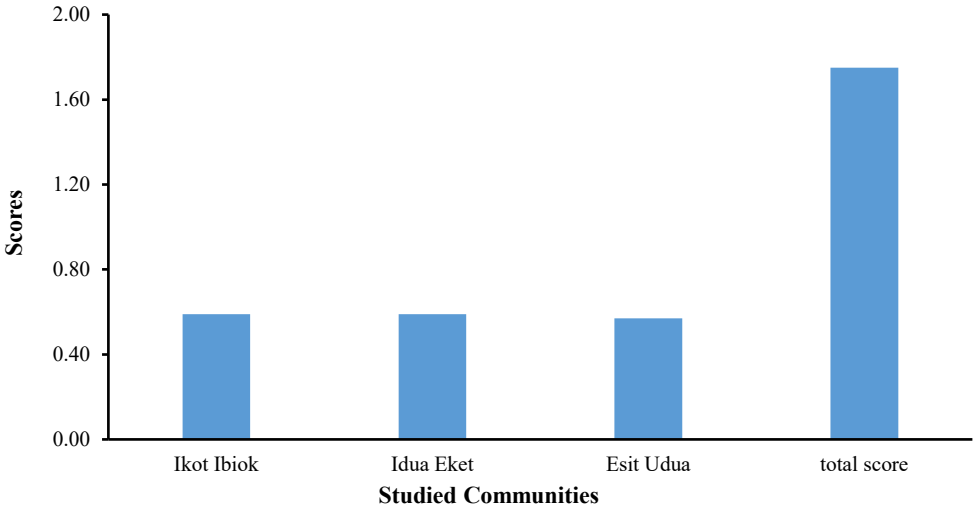


Figure 4 Chart showing final score of Eket senatorial district

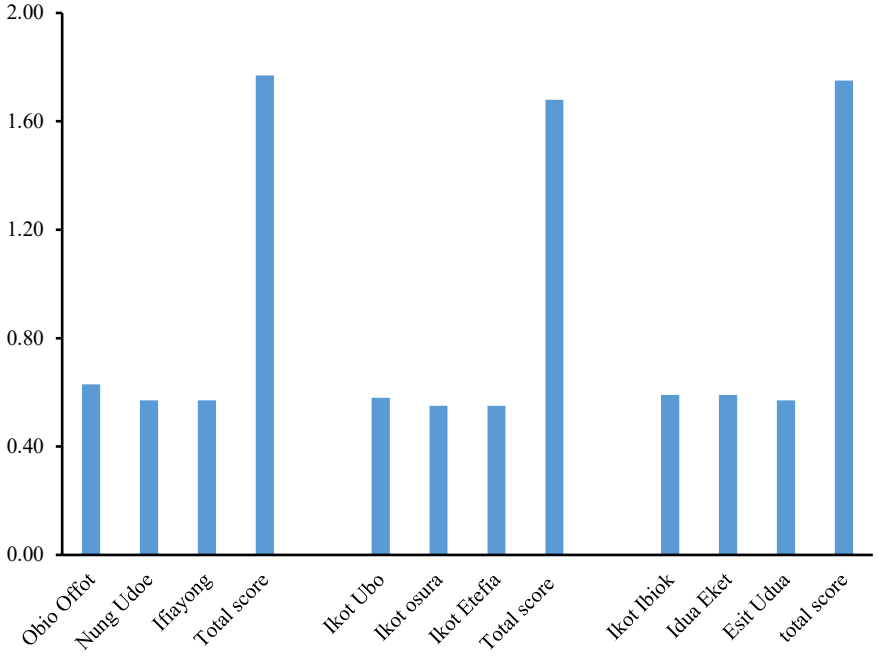


Figure 5 Chart comparing final score of studied senatorial districts with respective communities

4 Conclusion

The WSI final score based on this research showedthat the watershed in Uyo senatorial district average score was 0.59 from a maximum score of 1.00 representing 59%. Achieving this score, the pressure, state, and response parameters contributed an estimated score of 0.63, 0.48, 0.63, respectively indicating that the quantity and quality of the natural resources is likely to be stretched. This is characterized by the high average pressure state of 0.63 with the desired level of the response in the watershed of 0.63 (63%) to address the ecological problems in the watershed.

For watershed in Ikot Ekpene senatorial district, its final average WSI score of 0.56 from a maximum score of 1.00.Evaluating this score for the watershed, the pressure, state, and response parameters contributed grand average estimated score of 0.58, 0.53, 0.65 respectively, indicating that the quantity and quality of natural resources in the ecosystem is likelyto be stretched. This was showed by the high value of the pressure parameter of 0.53 though the level of desire response to tackle these ecological problems in the watershed was slightly high (65%). For watershed in Eket Senatorial district, its final WSI score indicates an average of 0.58 from a

maximum of 1.00. Achieving this score, the pressure, state and response parameters contributed an estimated average value score of 0.62, 0.55, and 0.67, out of a maximum of 1.00, indicating that the quantity and quality of the watershed is likely to be stretched. Characterized by the high value of the pressure parameter of 0.62 and a level of response to the ecological issues of 0.67%, this indicates that undue pressure is exerted on the ecosystem.

The final average score for Uyo, Ikot Ekpene, and Eket watershed stood at 0.59, 0.56, and 0.58, respectively. Uyo and Eket senatorial district exerts high pressure on the ecosystem with the value of 0.63 and 0.62 against 0.58. This was because the population densityand human activities on the environment are higher in Uyo and Eket Watershed.

A close review of the value obtained in the three studied watersheds revealed that watersheds are sustainable and that there is abundant water resource in the watershed since all the watershed obtained the maximum value of 1.00 (100%) in their state and response parameter. The grand average parameter scores of 0.59, 0.56 and 0.58 obtained for the three watersheds indicate that these watersheds are slightly in good condition in terms of sustainability.

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