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Original Article

Climate Variability Analysis in Anambra-Imo River Basin, Nigeria

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Abstract *- Climate variability in the Anambra- Imo river basin results from constructing infrastructural amenities, which increases temperature, rainfall volume and intensity. Managing uncertainties, projections, and scenarios in climate variability with the limited available resources would enhance food security and reduce deforestation and threats of flooding/erosion. Pollution of air, land and water will reduce human suffering and loss of lives and properties in the river basin. This paper examines the various parameters that result in climate variability in the river basin. The objective was to use the data generated for climate variation from the previous year's records to take necessary measures to mitigate climate variability's effects at the river basin. The methodology involves collecting data in the study area for variations in temperature, rainfall and other climatic conditions. The graphical trend analysis was used to predict climate variability for better planning at the river basin. The result shows temperature increases from 1986 to 2020, which heats the environment due to human-related activities. The trend of variability in rainfall from 1975 to 2020 shows that increased temperature increases the rainfall intensity, resulting in flooding, erosion induced gullies, pollution of river systems and other related challenges in the river basin. The optimal utilization of the river basin resources/assets will reduce the impact of human-related activities, leading to a green revolution at the river basin. This results in clean energy, reduced soil erosion impact, reduced flood disasters, failure of reservoir and dams, and improved hydroelectric power generation and water supply with security improvement.*

Keywords *- Capacity, Climate variability, River basin, Trend, Utilization.*

1. Introduction

The climate change in the world today is certainly a significant factor for the future management of water resources. Climate variability has a serious impact on a wide range of implementation strategies. The most relevant physical and chemical factors are changes in water temperature, river flow and recharge of groundwater, water availability, intensity and frequency of extreme events such as floods and droughts, rise in sea level and saltwater intrusion, pollution land changes and water quality. Freshwater ecosystems experience potential impacts, including loss of vulnerable species and protected areas, invasion, water supply, hydro-infrastructure and land use (Bates, Kundzewicz, Wu and Palutikof, 2008). Improved and integrated river basin planning and management is essential for adequate climate variability adaptation, which has a global potential contribution to multiple sustainability challenges. Policy development in most countries includes adaptation to climate change conditions with very few truly integrated approaches. River systems linking the downstream are complex. River systems face multiple stresses, such as changes in water and sediment flows, canalization, wetland reclamation, pollution (including legacy pollution), and water abstraction. The impact of these stressors may be greater in the short term when compared to the current effects of climate variability and sea level rise on some river systems. When combined with climate change conditions, these stresses often introduce different dynamics, resulting in a strong decline in the functioning of the natural ecosystem and quality of river systems, which complicates existing stresses. There is an interaction in river systems with the river, the catchment area and the outside world.

The potential climate variability impacts on freshwater may include;

- Reduced flows in hydro-electric power, which reduces power generation.
- Lower water tables in groundwater cause some wells to go dry.
- Warmer river temperatures stress habitats with cold water species such as trout.
- Lower river flow reduces water supply, water quality and recreation activities.
- Increased agricultural irrigation demand and a change in crop types due to a longer growing season.

- Possible increase in extreme weather, e.g. tornadoes, hail storms, heat waves, droughts, dust streams, floods, blizzards, etc.
- Increased forest fires result from warmer, drier summers and earlier springs.
- Glaciers melt, which causes a reduced supply of shrinking glaciers.
- Possible reductions in the snowpack can change the water supply.

The best-suited way to deal with the inherent uncertainty associated with climate variability may include climate change considerations at several steps, including characterization of water bodies, identification of pressures and impacts, design of monitoring schemes and economic analysis of measures with enhanced ecosystem resilience. Common Implementation Strategy (CIS, 2009) on Water Framework Directive (WFD) stipulates the main steps in the cycle of river basin management and essential components for planning for climate change to include the following:

- Risk assessment – the summary of significant pressures and impacts of human activities on the status of water bodies. This ensures that the likely scale of climate variability impacts on anthropogenic pressures and risk is understood.
- Monitoring and assessing water bodies to identify current Climate Change (CC) impacts through monitoring.
- Setting of environmental objectives for management
- Economic analysis of the use of water
- Programme of measures to achieve the environmental objectives to ensure that measures will not fail under future climatic conditions.

In order to achieve a sustainable climate change solution in River Basin Development Planning and Management, there should be a growing interest in institutional processes that bring together fragmented water users into an integrated planning, allocation and management framework essential for adaptation to climate change with global potential contribution to multiple sustainability challenges.

2. Aim and Objectives

The aim is to investigate the climate change variability trend in Nigeria's Anambra-Imo River basin. The objectives were to examine the climate change indicators of variation in temperature, rainfall, and other climatic conditions and their impact on the ecosystem in communities and regions of the affected area.

3. Literature Review

An improved and integrated river basin planning and management must incorporate checkmate of climate variability for adaptation to climate conditions. The climate variability adaptation would enhance the global potential contribution to multiple sustainability challenges. The increase in complexity of many river basins with increasing infrastructural activities and social amenities provisions are competing with population pressure and urbanization. The destruction of natural habitats, plantation/forestry, and recreation/tourism sites seriously damage the ecosystem in most river basin development areas. This has resulted in many crises related to flood disasters, water quality degradation, acute water sourcing and storage and degradation of ecological health.

The approaches to river basin planning must play significant roles in climate variability adaptation to the local communities' circumstances.Eme (2009) stated that flood disaster and their optimal alleviation strategies must incorporate proper monitoring and adaptation of climate variability in the region. Developing an engineering development scheme for optimal utilization of resources on multi-purpose/multi-objective projects will ameliorate the impact of climate variability in the river basin (Eme, 2015). Ezenwani (2017) opined that comprehensive investment in hydro-electric power generation, water supply, drainage/dredging, Navigation/water transport, flood control, recreation/tourism, erosion control, plantation/forestry and reservoir/gullies will result in multi-objective (benefits) of economic efficiency, regional economic redistribution, state economic redistribution, local economic redistribution, social well-being, youth empowerment, environmental quality improvement, gender equality and security improvement. These would mitigate the impact of climate variability in the river basin planning and management.

4. Methodology

The area of study where the Anambra-Imo River basin is situated is the southeastern region of Nigeria comprising Abia, Anambra, Ebonyi, Enugu and Imo States. The data was collected from the Climate Change Centre for Water Resources Development. The data analysis method used a trend graph to determine temperature changes, minimum and maximum temperature for thirty-four (34) years and rainfall data for forty (40) years.

5. Analysis and Discussion of Results

5.1. Climate Change Indicators of Variation in Temperature

The temperature data collected from the river basin from January 1986 to December 2020 were summarized to determine the average maximum and minimum temperature every month. The comparison was shown in Table 1 for 1986 and 2020 only from January to December. There has been an increase in maximum temperature from 1986 to 2020, as shown in Table 1. The increase in temperature indicates heating the environment due to human activities causing changes in climate conditions due to greenhouse gas emissions, construction activities, burning of fossil fuel, gas flaring, destruction of habitats, felling of trees, etc. The temperature trend graph was shown in Figure 1 for maximum and minimum based on temperature data collected from the river basin.

Table 1. Temperature variation from 1986 to 2020

1986	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Max	31.6316	31.5988	30.9789	30.0914	28.5808	26.49904	25.0142	24.9839	25.6419	26.5243	28.4179	30.9931
Min.	22.4235	23.5789	24.2172	23.954	23.1455	22.3284	21.752	21.7062	22.0782	22.3008	22.7518	22.7624
2020	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Max	36.9589	38.7722	39.028	36.5061	32.8721	30.0395	27.778	27.6327	28.6327	29.9293	33.0962	35.0805
Min.	20.6754	21.947	24.1504	24.5788	23.6883	22.6568	21.7384	21.7043	22.1495	22.5454	22.6023	20.9014
INCREASE IN TEMPERATURE												
Max	5.7273	7.1734	8.0491	6.4147	4.2913	3.5491	2.7638	2.6488	3.0408	3.405	4.9483	4.1074
Min.	1.7481	1.6319	-0.0668	0.6208	0.5428	0.3384	-0.0136	-0.0019	0.0713	0.2446	-0.1495	-1.841

Source: National Climate Change Centre for Water Resources, in Anambra – Imo River basin

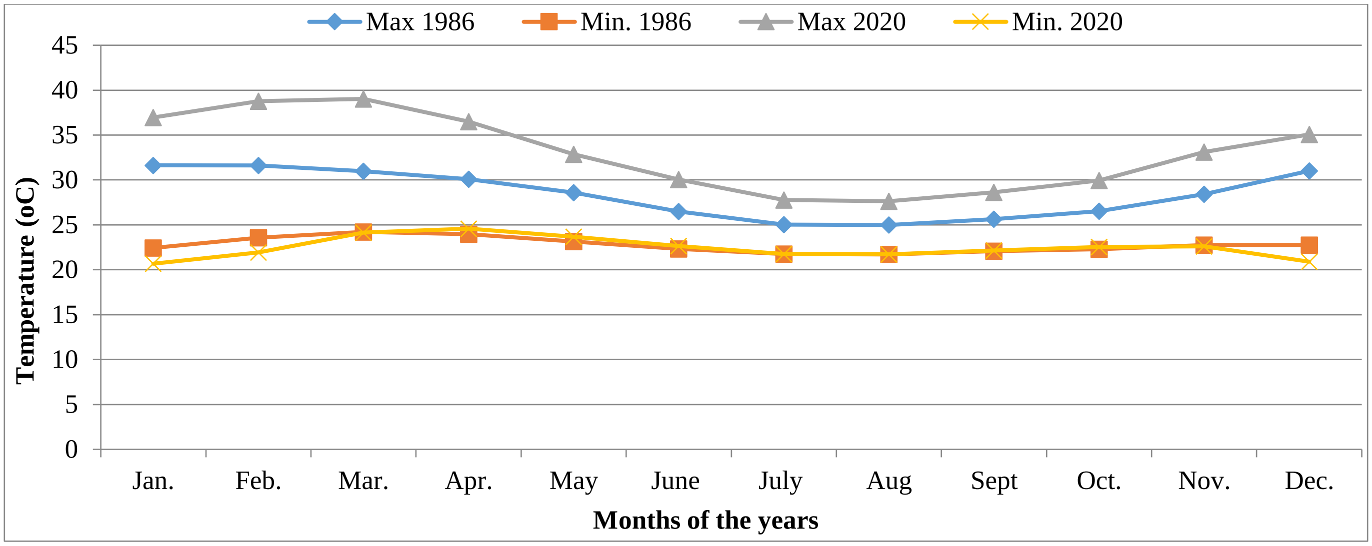

Fig. 1 The temperature trend graph for maximum and minimum in 1986 and 2020

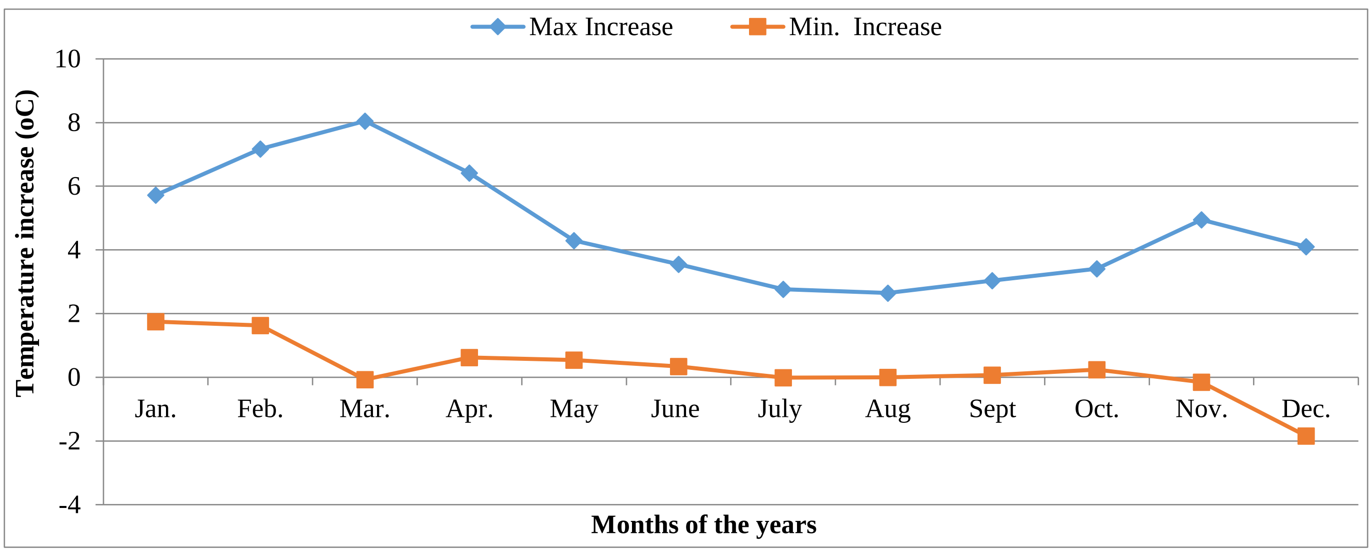

Fig. 2 The trend graph for maximum and minimum temperature values between 1986 and 2020

Discussion of Results in Table 1, Figures 1 and 2:

- The Figures in Table 1 and Figure 1 clearly show that there is climate variability or climate change due to human activities resulting in high temperatures, which would affect the ecosystem in the river basin.
- Compared with 1986 and 2020, the temperature increase value shows a very high record with a maximum temperature of 8.05ºC in March, followed by 7.17 ºC in February, 6.41ºC in April and 5.73 ºC in January in the river basin.

- The minimum temperature increases for the period also recorded the highest in January at 1.75 °C, followed by 1.63 °C in February.
- The variability in climate temperature is a serious danger to the environment because the rivers, the ecosystem, the aquatic environment and most related activities will be affected.

5.2. Climate Change Indicators of Variation in Rainfall

The rainfall data was collected from January 1975 to 2020 for two locations in the river basin for comparative analysis. However, there are fluctuations in the rainfall data; the amount of rainfall increases as the temperature increases. The total rainfall in the Anambra area increased to 3863.40mm in 2019. The rainfall increase in Anambra has been consistent with over 2000mm from 2015 to date. This can attest to continuous flooding experienced in some parts of the state. The trend of rainfall variations from 1975 to 2020 is shown in Table 2 and Figure 3.

5.2.1. Discussion of Results in Table 2, Figure 3, Table 3 and Figure 4.

- The high-temperature variability results in high rainfall from the two strategic areas of the river basin. Temperature is a serious danger to the environment because the rivers, the ecosystem, the aquatic environment and most related activities will be affected.
- These have resulted in incessant flooding. Erosion, blocking of rivers and stream channels, and various environmental threats to humans inhabiting the river basin area

Table 2. Trend of rainfall variability from 1975 to 2020 for Enugu State

Years	Total (mm)	Years	Total (mm)	Years	Total (mm)	Years	Total (mm)	Years	Total (mm)
1975	1407.4	1986	1617.9	1997	2277.4	2008	2056.2	2019	**3863.4**
1976	2067.7	1987	1503.7	1998	1375.3	2009	2157.6	2020	**2737**
1977	1729.9	1988	2008	1999	2101.2	2010	1485.9		
1978	1560.1	1989	1798	2000	2067	2011	1957.5		
1979	1814.1	1990	2009.6	2001	1516.6	2012	1986.1		
1980	1683.8	1991	2095	2002	1928.1	2013	1603.4		
1981	1838.6	1992	1804.9	2003	1671.1	2014	1677.7		
1982	1715.7	1993	1654.1	2004	1861.5	2015	2543.7		
1983	1327.7	1994	2081.7	2005	1914.7	2016	2034.9		
1984	1683.9	1995	2474.4	2006	1910.3	2017	3616.1		
1985	1799.6	1996	1526.7	2007	2026.8	2018	3636.1		

Source: Climate change center for water resources, Anambra-Imo River Basin

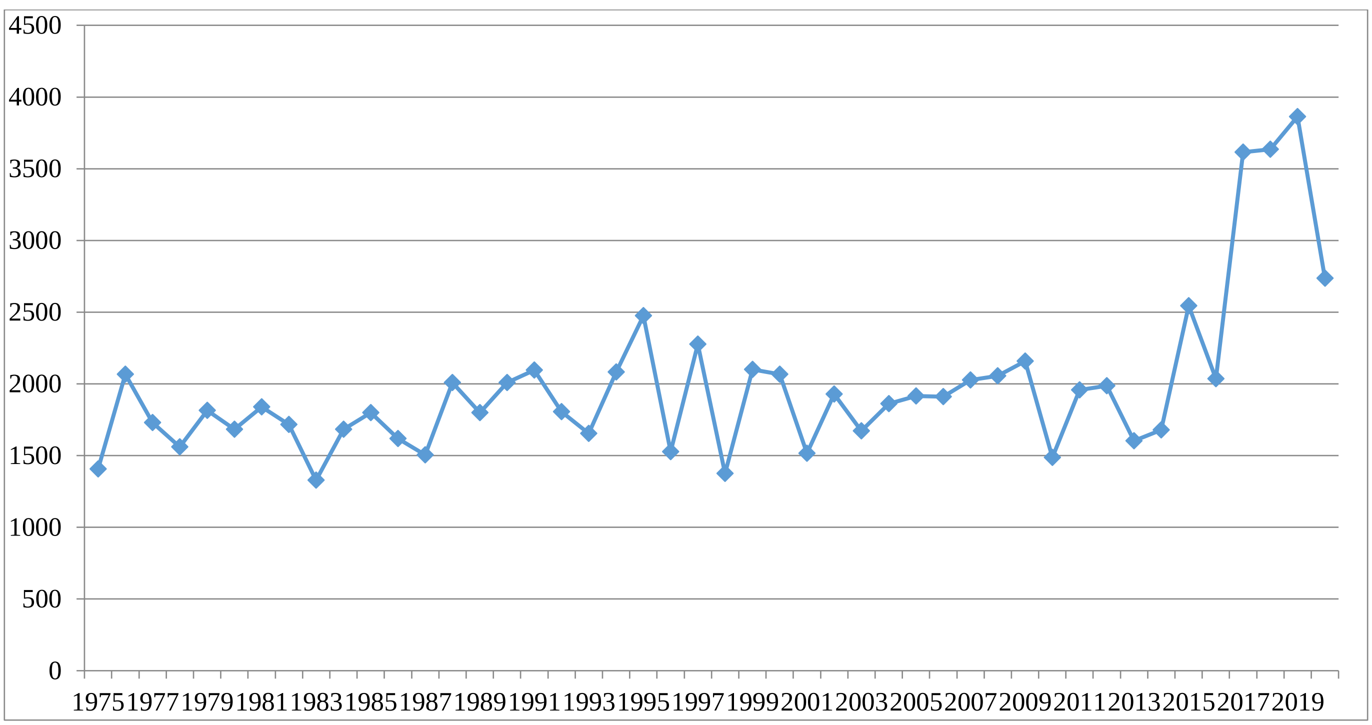

Fig. 3 Trend graph of rainfall variability from 1975 to 2020 for Anambra State

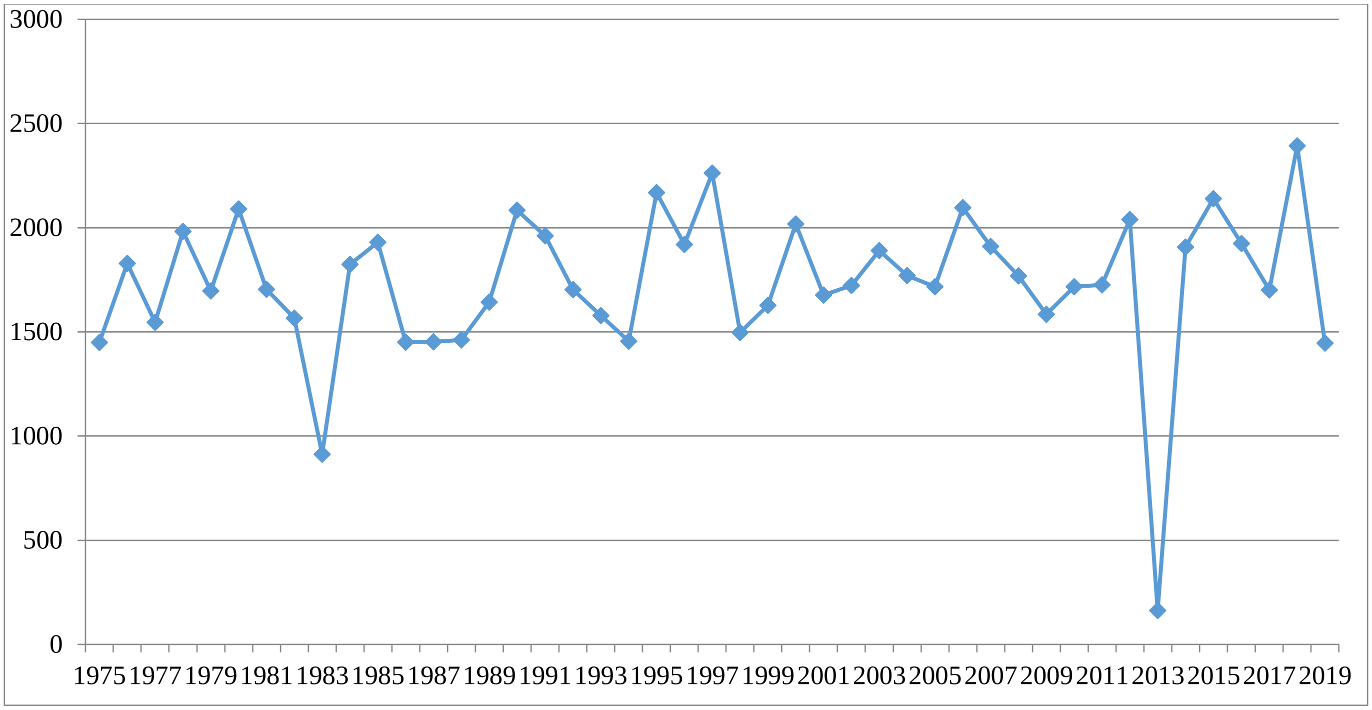

Fig. 4 Trend graph of rainfall variability from 1975 to 2020 for Enugu State

Table 3. Trend of rainfall variability from 1975 to 2020 for Enugu State

Year	Total (mm)	Year	Total (mm)	Year	Total (mm)	Year	Total (mm)	Year	Total (mm)
1975	1448.9	1985	1930.9	1995	2167.9	2005	1716.5	2015	2140.1
1976	1829.4	1986	1450.6	1996	1919.7	2006	2096.3	2016	1923.9
1977	1545.8	1987	1451.6	1997	2262.4	2007	1910.9	2017	1701.8
1978	1983.1	1988	1461	1998	1497	2008	1768.6	2018	2393.4
1979	1696.8	1989	1643.7	1999	1628.1	2009	1584.6	2019	1446.8
1980	2090.8	1990	2083.4	2000	2017.8	2010	1716.2		
1981	1704.2	1991	1961.2	2001	1677.2	2011	1725.3		
1982	1566.6	1992	1702.5	2002	1722.2	2012	2039.3		
1983	913.1	1993	1577.8	2003	1890.1	2013	162.6		
1984	1824.4	1994	1455.9	2004	1770.1	2014	1908.1		

Source: Geography and Meteorological Department Weather Observation Centre for Anambra-Imo River Basin

6. Conclusion and Recommendation

The optimal utilization in the Anambra-Imo basin entails the employment of all the purposes of Irrigation, Agriculture, and Hydro-electric power generation. Water supply, Navigation or water transport, Drainage/Dredging, Flood control, Recreation/Tourism. Erosion control, plantation/Forestry and Reservoir/Gullies for the optimum benefits based on the objectives of Economic Efficiency. Federal Economic Redistribution, Regional Economic Redistribution, State Economic redistribution, Local Economic Redistribution, Social Well-being, Youth Empowerment, Environmental quality improvement, Gender Equality and Security will help to mitigate the effect of climate change in the river basin. The climate variability status assessments in a river basin should incorporate human activities on the status of water bodies, impacts from anthropogenic pressures, and primary (direct) and secondary (indirect) impacts due to society's adaptation and mitigation activities to reduce risk for indirect or long-term drivers for the sustenance of basic infrastructural developments. Long term consistent series of monitoring data for natural variation in climate induced trends should be in place to establish or safeguard monitoring programmes to assist in benchmarking and tracking events as part of surveillance efforts. This is essential to detect and improve the prediction of impacts to improve the forecast of flood risks, water security, and drought to close the knowledge gap. There should be measures to encourage the use of green and clean energy while implementing the purpose/objectives in a multi-purpose/multi-objective Anambra-Imo river basin to reduce the impact of soil erosion, flood disasters, failure of reservoirs and dams, improve hydro-electric power generation, improve water supply, and check insecurity etc. that ravage the living environment.

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