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FEASIBILITY STUDY AND CHARACTERIZATION OF UGBOHA RIVER FOR HYDROELECTRIC POWER PLANT

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ABSTRACT
This paper presents a feasibility study and characterization of Ugboha (Edoha) river situated at Esan South East Local Government Area of Edo State, Nigeria, for hydroelectric power plant. The study was done on the need to mitigate the inadequate and epileptic electricity supply being experienced by the National Institute of Construction Technology and Management (NICTM), Uromi, Edo State, Nigeria, a Federal Polytechnic situated between Amendokhian community and Ugboha community in Edo State, Nigeria. The use of backup diesel generating plants has increased the overall operating cost of the polytechnic due to the need to purchase fuel and the associated maintenance cost of the plants. The method adopted in this research was the determination of the discharge (flow) rate via the floating technique, while the surface and the mean velocities of the river, the kW derivability, irrigation potential to the communities' farmers and flood control in the Local Government Area of the state were evaluated. The Ugboha (Edoha) river has a flow rate of 1.75 m^3/s with estimated head of 4.3 m and hydroelectric power generating potential of about 55.31 kW. The feasibility work and characterization of the Ugboha (Edoha) river was significant at it will aid the commencement of detailed project report (DPR) that will highlight detailed study of hydrology and geology, environmental impact assessment, flood control in the area and weir structure for hydropower plant on the Ugboha (Edoha) River.

1. INTRODUCTION
Energy is distributed across the surface of the earth; according to the law of conservation of energy, it can neither be created nor destroyed; but can be transformed from one form to another. At every particular time, there is enough energy for human consumption, but the challenges of converting it from its existing form to a useful form like electricity has not be fully addressed; if power for all is going to be a reality. A power plant that utilizes the potential energy of water at a high level for the generation of electrical energy is known as hydroelectric power and is a clean and environmentally friendly renewable energy source. Its multi-

functional capacity in the area of electricity generation, farm irrigation, flood control, etc. cannot be overemphasized.

Electricity has been one of the major catalysts that drive any viable economy as it is an inevitable input required for the technological and socioeconomic development of a nation (Oliver, 2002). Nigeria being a developing country needs steady economic drive and this can be achieved by stable electricity supply to the citizens of the country. The Nigeria grid utilizes hydro and thermal electricity generation methods. The hydroelectricity generation method is dated back to 19th century, first in Northumberland, England in 1878 and today, quite a good number of hydropower plants have been developed across the globe with these plants providing 2,998 billion kilowatts hours of clean and renewable energy in 2006, approximately 20 % of the worldwide (Painted Sky RC & D Council Incorporation, 2001).

The Nigeria power supply dated back to 1896 when electricity was first produced in Lagos, fifteen years after its introduction in England (Niger Power Review, 1985). From that time till now, Nigeria generation capacity fluctuates around 2500 MW and 5000 MW to support the country's socioeconomic growth and development (Kela et al., 2001). This range of megawatts generation, over decades has affected the socioeconomic growth and development of the country. The total installed capacity of power generation in this country has fallen below the country's electricity demand because of overwhelming population growth (Odje, Uhunmwangho and Okedu, 2018). To achieve sustainability, reliability and a decentralized electricity supply in Nigeria which has chunk of its populace living in remote and isolated rural communities with no access to electricity and over the years, renewable energy sources have been appraised as one of the guaranteed technology that must be aggressively harnessed since some of these rural areas located far from National Grid have enormous unexploited hydro energy sources e.g flowing rivers, streams, water fall, biomass, solar and wind energy amongst others capable of bridging the energy gap in the country (Odje, Uhunmwangho and Okedu 2018; Olayinka, 2011).

Nigeria as a country is yet to substantially harness the huge potential power available with small or micro hydro schemes despite its huge electricity supply available in the country is characterized with epilepsy in nature. The electric energy supply deficit in the country has caused serious and high load shedding and rationing in the country which has impacted socioeconomic growth and development negatively. This is one of the major reasons for the recent economic quagmire in Nigeria as a country facing now, where companies can no longer sustain production cost and paying due to high cost of production of fuel purchase in powering generating plants in the various companies to sustain production. According to Okoye, Kassen and Gokcekus (2023). Nigeria faces challenges in meeting the electricity demand of its rapidly growing population despite being blessed with power production sources abundantly. The existing large gap between energy demand and supply in the Nigeria electricity grid has been obvious and worrisome to stakeholders in the power industry and today a bridge is needed. No wonder, according to Ravneet and Jayati (2013). Stated that renewable energy is a sustainable, clean source of energy and its development is thriving due to failure of existing generation to meet load demands and its growth, inefficiency of existing grid system, shortfall in fossil energy and adverse environmental impacts.

To maintain stable power supply in Nigeria today, renewable energy sources are key factors. Hence, electricity generation from the flow of rivers is a clean and environmentally friendly renewable energy source (Ozigis et al., 2019). Hydropower plant is currently the least expensive source of electric power and is much cleaner than power generated from fossil fuel

(Ozigis et al., 2019). In a small flowing river or stream, small hydropower is considered as the best appropriate method of generating renewable energy (Hatata et al., 2019). Hydropower plant systems are classified as large-scale hydro plants: over 100 MW capacity, Medium scale hydro plants: 10 -100 MW, small hydro plants less than 10 MW, mini-hydro plants: 1000 – 100 kW, Micro-hydro plants: 5 – 100 kW and Pico-hydro plants: less than 5 kW (Paish, 2002a; Paish, 2002b). Small hydropower schemes have been on the front burner for cleaner energy sources that can fast-track rural electrification considering the huge unharnessed rivers and streams in the rural settlement (Penche, 1998). This huge unharnessed rivers and streams in Nigeria can play a huge support to the National Grid, if properly harnessed.

The roles of electric energy and its application in socioeconomic development become obvious as they continually increase with the growing population of the country. Hydroelectricity in Nigeria is the most used type of energy for power generation in that Nigeria's geographical area favours it usage (Fakehinde et al., 2019). Nigeria is enormously blessed with renewable energy resources, as presented in Table 1. Therefore, this paper aims at determining the river's flow rate, availability of hydropower potential, feasibility of harnessing and characterization of the Ugboha (Edoha) river for small and micro – hydroelectric power generation.

Table 1. Energy Potential in Nigeria (Sambo, 2009).

Resource type	Hydropower			Biofuel			
	Large Hydropower	Small Hydropower	Solar Radiation	Fuel Wood	Animal Waste	Crop Residue	Wind
Reserves	11,550 MW	3,450 MW	3.5 – 7.0 kWh/m^2-day	13,071,464 Hectares	61 million tonnes/yr	8.3 million tonnes/yr	2 – 4 m/s (annual average)

1.1 Brief Description of Ugboha Community

Ugboha is a town in Esan south East Local Government of Edo State, Nigeria (Okosun et al., 2000). Ugboha lies on the geographical coordinate of latitude 6^0 45' N, 6^0 28' E. The correct name is Owoha. Although the population was given as 3,003 (Three thousand and three) in the 1993 census, the more accurate figure was likely to be nearer to 5000 (five thousand) than anything else, for Eguare, Emuado, Idumu-Ihaza, Uzogbon, Inemen and Amalu without Idegun and Otokhimin have a population of 4,480 (Four thousand, four hundred and eighty) people (Okojie, 2022). Ugboha is organized into several key districts. The main districts are Eguare and Emuado, which play significant roles in the town's traditional and administrative structure.

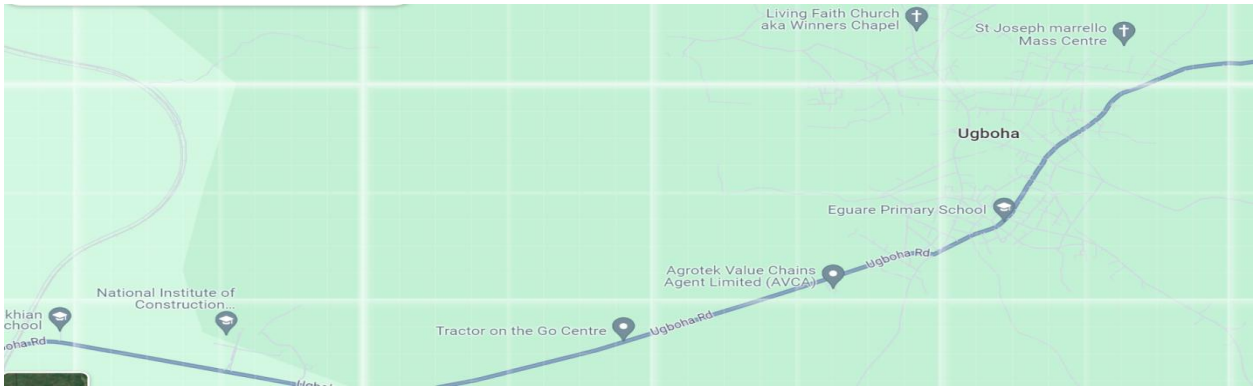

Figure 1. A Map showing NICTM situated between Amendokhian Community and Ugboha Community

Figure 2: A Map showing the location of Ugboha Community

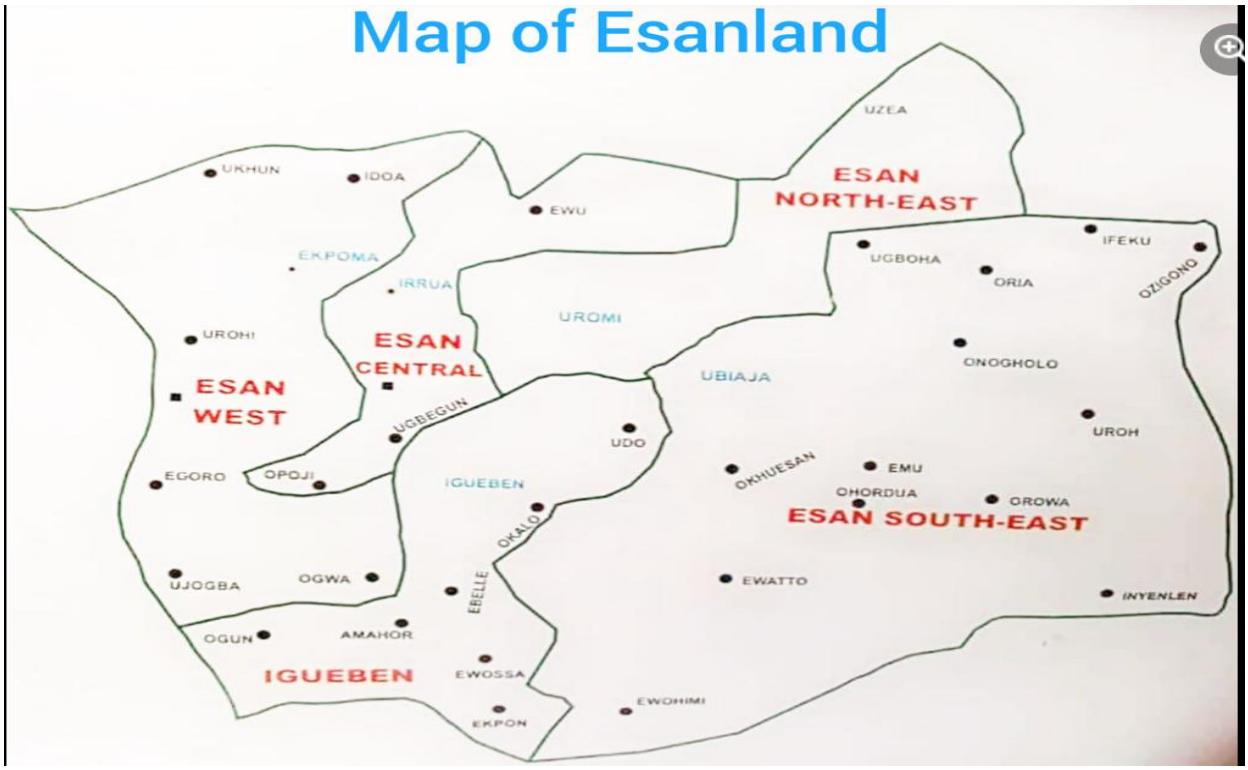

Figure 3. A Map showing the Entire Esan Land in Edo State, Nigeria

2. MATERIAL AND METHODS

This section of the research paper presents the materials used in the research and the method adopted as shown 2.1 and 2.2 respectively.

2.1 Materials

The tools and equipment used are GPRS, measuring tape, stop watch, 100 m twine rope, 100 m chain meter, 20 numbers of wooden float, pen, notebook, camera, two chain men, qualified surveyor, civil engineer and electrical engineers.

2.1.1 Brief Description of Ugboha (Edoha) River

The Ugboha River cuts through Ugboha to Ubiaja and through Oria River in Esan South East Local Government Area of Edo State, Nigeria. The Ugboha town lies on the geographical coordinate of latitude 6º28’ E. Ugboha River is also called Edoha River, it flows into Ubiaja

river to Oria river and then to Uzea river and then, to River Niger. Figure 2 and 3 shows the Google map location of Ugboha and Esan South East Local Government Area in Edo State, Nigeria respectively.

2.2 Method

The float technique was adopted as a method to determine the flow rate of the river at estimated time and other parametric equations were adopted to calculate the available potential power and the river head.

2.2.1 Determination of the River Flow Rate

The Ugboha River, also known as Edoha River, the flow rate measurement was achieved by employing the "Float Technique using a weighted piece of light wood." This technique is to determine the duration it will take an object to float at specified distance in the river (Bartram and Balance, 1996). The float technique was to measure the surface velocity and the cross-sectional area at a selected spot of the river (Odje, Uhunmwangho and Okedu, 2018). The following were done at the river site:

i. The start and end points of the reach were noted and market-out

ii. A piece of wooden measuring 0.5 m by 0.3 m by 0.02 m was dropped into the river to float from the start point to the end point already marked-out

iii. Records of time was taken by a stop watch as the object crosses the start point marked and stop when it crosses the end point marked.

iv. The float processes were repeated for ten (10) times using two (2) wooden floats at the same time at different points to see the current at different points of the river and the different times recorded were documented and the average time determined.

v. The river's width at the end point and calibration of the width into subdivision as well will be done to determine the corresponding river's depth of each sub-division.

The Ugboha (Edoha) River's discharge rate was determined by the surface velocity which is a ratio of the distance traveled by the wooden float to the time it takes the wooden float to travel such distance (Odje, Uhunmwangho and Okedu, 2018):

$$V_{surface} = \frac{d}{t_{av}} \text{ m/s} \qquad (1)$$

where d = distance, t_{av} = average time.

$$V_{mean} = C * V_{surface} \text{ (m/s)} \qquad (2)$$

where C is a factor that takes care of the nature of the river bed, C = 0.6 for rough bed and C = 0.9 for smooth bed.

The river discharge rate:

$$Q = V_{mean} * A \text{ m}^3/\text{s} \qquad (3)$$

The potential output power is given as:

$$P_o = g * H * Q * \eta \quad \text{kW} \qquad (4)$$

where P_o is the potential output power in kW and Ƞ is the overall efficiency of the hydropower. H is the available head in meters, Q is the design discharge rate in m^3/s and g is the acceleration due to gravity given as 9.8 m/s^2

3. RESULTS PRESENTATION AND ANALYSIS

The river discharge (flow) rate measured using floating technique earlier mentioned in this research is presented with the cross-sectional area of the river Edoha (Ugboha River).

Table 2. Ugboha River Flow Measurement Data taken from May - July, 2024 with Travel Distance of 20 M

Number of Trials	Travel Time T(secs)
1st	32.10
2nd	32.00
3rd	35.05
4th	34.16
5th	34.58
6th	34.40
7th	35.01
8th	35.00
9th	35.40
10th	35.02

The cross-sectional area of the Ugboha River is presented as follows:

Table 3. Ugboha River Cross-Sectional at 5.0 M Intervals

S/N	Average River Width (m)	Average River Depth (m)	Area of the River (m^2)
0	0.00	0.00	0.00
1	8.20	1.26	47.68
2	7.17	1.28	37.10
3	8.56	1.27	42.08
4	9.96	1.35	47.26
5	11.41	1.48	54.43
6	13.90	1.60	66.46
7	15.38	1.63	75.68
8	22.09	1.79	115.59
9	19.50	1.85	101.92
10	18.10	1.96	95.57
11	22.70	2.09	118.72

The records in Table 3 show the sharpness of the Ugboha (Edoha) River bed as shown in Figure 3. The various areas associated with the various depths and widths of the river are shown in Table 3. The various areas were obtained through the bathymetric survey which covers the determination of the depths of the Ugboha (Edoha) River. Also, the hydrographic survey covers both bathymetric survey and the topographic survey which is the collection of the existing points and features along the coaster lines. The Ugboha River's surface and mean velocities are obtained by applying equation 1 and 2 to the documented records using tolerance of 0.6 and t_{av} = 34.27 s.

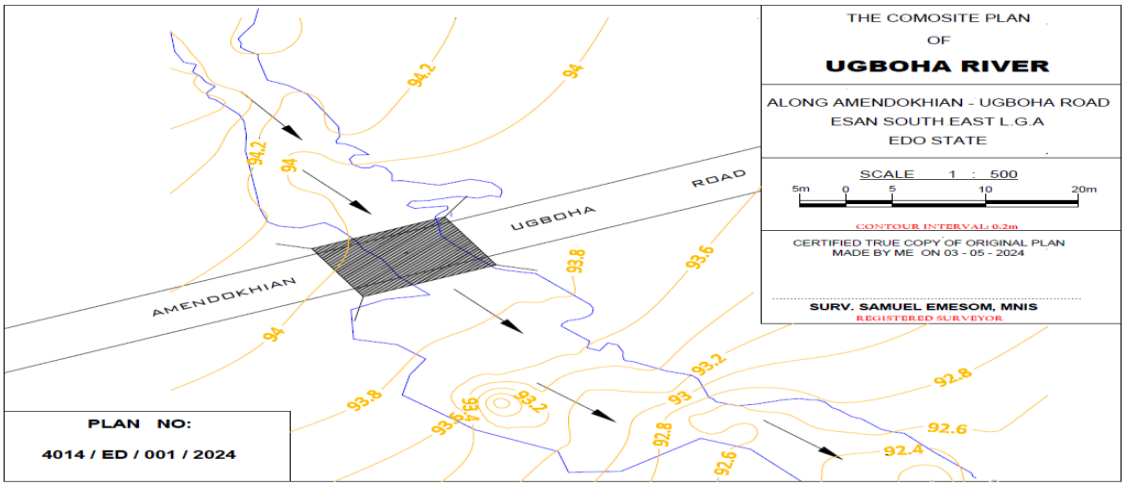

Figure 3. Ugboha (Edoha) River Bed Sharp at Ugboha Community, Esan South L.G.A, Edo State, Nigeria.

The Ugboha River discharge rate was gotten using equation 3 as Q = 1.75 m^3/s and the potential power generation estimated from the Ugboha (Edoha) river using equation 4 at efficiency of 75 % with net head of 4.3 m of the river, the would be output: P_{output} = 55.31 kW. The viability of the Ugboha River is obvious from the power output of about 55.31 kW and also, the Ugboha community; the majority are farmers who need irrigation in their farms, which the micro-hydroelectric plant will also serve. The Ugboha and Amendokhian communities have been having prolonged power fluctuation and failure which affects the tertiary institutions such as the National Institute of Construction Technology and Management (NICTM), Uromi which is situated between these communities. The feasibility analysis and the characterization of the Ugboha River are significant to the NICTM, Uromi and the immediate communities (Ugboha and Amendokhian). Additionally, the river can also serve as erosion collector from the NICTM, Uromi and the immediate communities if proper land scalping and erosion control is implemented. The various sections of the Ugboha (Edoha) River are presented in plate 1 to 6.

Plate 1. Shallow Section showing the Bed Sharp and Current of the Ugboha (Edoha) River

Plate 2. Side View of Ugboha (Edoha) River

Plate 3. Section of the Ugboha (Edoha) River

Plate 4. Water level of the Ugboha (Edoha) River

Plate 5. Sectional Depth of the Ugboha (Edoha) River

Plate 6. A Curve Section of the Ugboha (Edoha) River

4. CONCLUSION

The research presents the feasibility study and characterization of the Ugboha (Edoha) River for micro-hydropower plants. The research has demonstrated that the Ugboha (Edoha) river can generate about 55.31 kW of electric power at a flow rate of 1.75 m^3/s and head of 4.3 m. For a more detailed and accurate flow rate measurement, standard current meter should be used instead of the wooden float technique adopted in this research. Also, a lengthier hydrological data over a wide period of time should be considered to further improve the accuracy of the flow rate measurement of the Ugboha (Edoha) river as well as the potential of the river for hydroelectric power generation to ascertain it accurate viability and potential for irrigation and flood control in the area.

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Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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