SUSTAINABLE HYDROPOWER DEVELOPMENT IN NIGERIA (A CASE OF SMALL SCALE HYDROPOWER DEVELOPMENT)

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ABSTRACT
Access to reliable and adequate energy is crucial as an enabling condition for achieving sustainable development. Hence the use of sustainable hydropower development as a reliable tool for growth and sustainable development of any nation such as Nigeria was shown in this work. Hydropower accounts for the large majority of existing renewable power generation and there is significant potential to increase hydroelectricity supply in Nigeria. Hydropower has long been the dominant source of electricity production and will continue to play an important role in the transition toward a low-carbon use economy. As strategy for sustainable hydropower development and management in Nigeria, the study assessed the flow characteristics of Amanyi stream (a case study of hydropower potentials even at rural levels) for a mini hydropower development for Neke Uno, Isi-Uzo Local Government Area of Enugu state, Nigeria. The stream has a maximum flow discharge (Q_{max}) of 8.5 m^3/s, average discharge (Q_{av}) of 6.9 m^3/s, minimum dependable discharge (Q_{min}) of 4.21 m^3/s and a selected design discharge (Q_d) of 6.37 m^3/s. The topography survey and plant layout showed a head of 3.63m (low head) which is possible for mini hydropower generation. It was also determined that for the available head and selected design discharge, a power output of 154KW is achievable. This power can meet 83% of power required for Neke Uno Community near the hydropower plant. It is recommended that the hydropower development of Amaiyi stream be given serious consideration under private agreement with some financial assistance from various international agencies for development to make it feasible for the rural communities. This pilot hydropower supply source could be a model for rural areas that have similar streams and topography.

KEYWORDS: *Hydropower, Sustainable Development, Discharge, power output, hydropower* development, Stage (head), Small scale hydropower.

INTRODUCTION

According to The World Bank Group (2013), Hydropower accounts for about one-fifth of the world's electricity, and constitutes a vital energy resource. It is among the most effective renewable sources of energy currently deployed and deployable on a large scale. Sustainable large-scale hydropower is a necessary condition to provide the power to drive green growth for all. Properly exploited, hydropower could help deliver electricity to many of the 1.3 billion people who currently live without it. About 550 million of such people live in Sub-Saharan Africa. Sub-Saharan Africa—where less than a third of the population has access to electricity, has abundant hydropower resources, only seven percent of which have been tapped.

Hydropower Development in Nigeria

Hydropower Development in Nigeria commenced with the establishment of the Nigerian Electricity Supply Company Limited (NESCO), which was floated at the London Stock Exchange in 1923 by a group of businessmen to provide electricity to the mechanized Tin Mining Companies in the Plateau areas. In 1929, NESCO commenced operation with the installation of a 1000 KVA (800KW) hydro-electric plant at Kura falls In Jos Plateau State, with concession granted by the Federal Government to supply the Plateau Minefield with electric power, provide a bulk supply of electricity to Electric Corporation of Nigeria (ECN) and provide direct electricity supplies to the rural areas of Plateau not served by ECN (Arugbemi, 1984).

Nigeria has a total installed electricity generation capacity of over 6000MW and only about 39% is from hydropower and these are mainly large hydropower schemes (Makanju, 2003). Oyedepo, (2012) observed that hydropower from Power Holding Company Nigeria's (PHCN) most recent estimate, the country's outstanding total exploitable hydro potential, currently stands at 12,220 MW. Added to the 1930 MW (Kainji, Jebba and Shiroro) already developed the gross hydro potential for the country would be approximately 14,750 MW. Current hydropower generation is about 14% of the nation's hydropower potential and represents some 30% of total installed grid connected electricity generation capacity of the country (Manohar and Adeyanju, 2009). In spite of this, hydropower capacity in Nigeria still remains underexploited. It must be observed here that Small Hydropower (SHP) has gained rapid consideration in both the developed and developing economies of the world because of its inherent advantages like in-excessive topography problems, reduced environmental impact, minimal civil works and the possibility for power generation alongside with irrigation, flood prevention, navigation and fishery.

Need for Small Hydropower Development

Small Hydropower is defined internationally as any hydro installation rated as less than 10MW of installed capacity that makes use of a full renewable (at every stage of energy generation) indigenous and readily available natural source water (Essan, 2004). According to Makanju (2003) Nigeria signed in as the 52th member country of the Kyoto protocol agreement by which it became mandatory for Nigeria to adopt new policy in clean energy source for its energy development of power than from other environmental unfriendly sources, i.e. thermal, etc. Hence, there is the need for hydropower development in rural areas of Nigeria to effect the policy. The 1990 energy master plan for Nigeria indicates that 15,000MW of power was planned for the country by the year 2003. But due to gradual decline in Nigeria economy, this was reviewed downward to 9,000MW of which 1200MW must be developed from renewable energy sources.

Classification of Hydropower Scheme

Hydropower scheme can be classified based on:

(i) installed capacity and
(ii) gross available head

Classification of Hydropower Scheme by installed capacity

The classification of hydropower by installed capacity is shown in Table 1

Table 1

Scale of Hydropower	Capacity of hydropower
Big	> 10MW
Small	1.0 – 10 MW
Mini	100KW - 1 MW
Micro	< 100KW

(Source; http/www.unesco-ihe.org/edu/hydro power development, 2011)

Classification of Hydropower Scheme by gross available head

The classification of hydropower by installed capacity available head is shown in Table 2.

Table 2

Type of Hydropower	Gross Head Available
Ultra low-head	< 3 meters
Low – head	< 40 meters
Medium/High head	> 40 meters

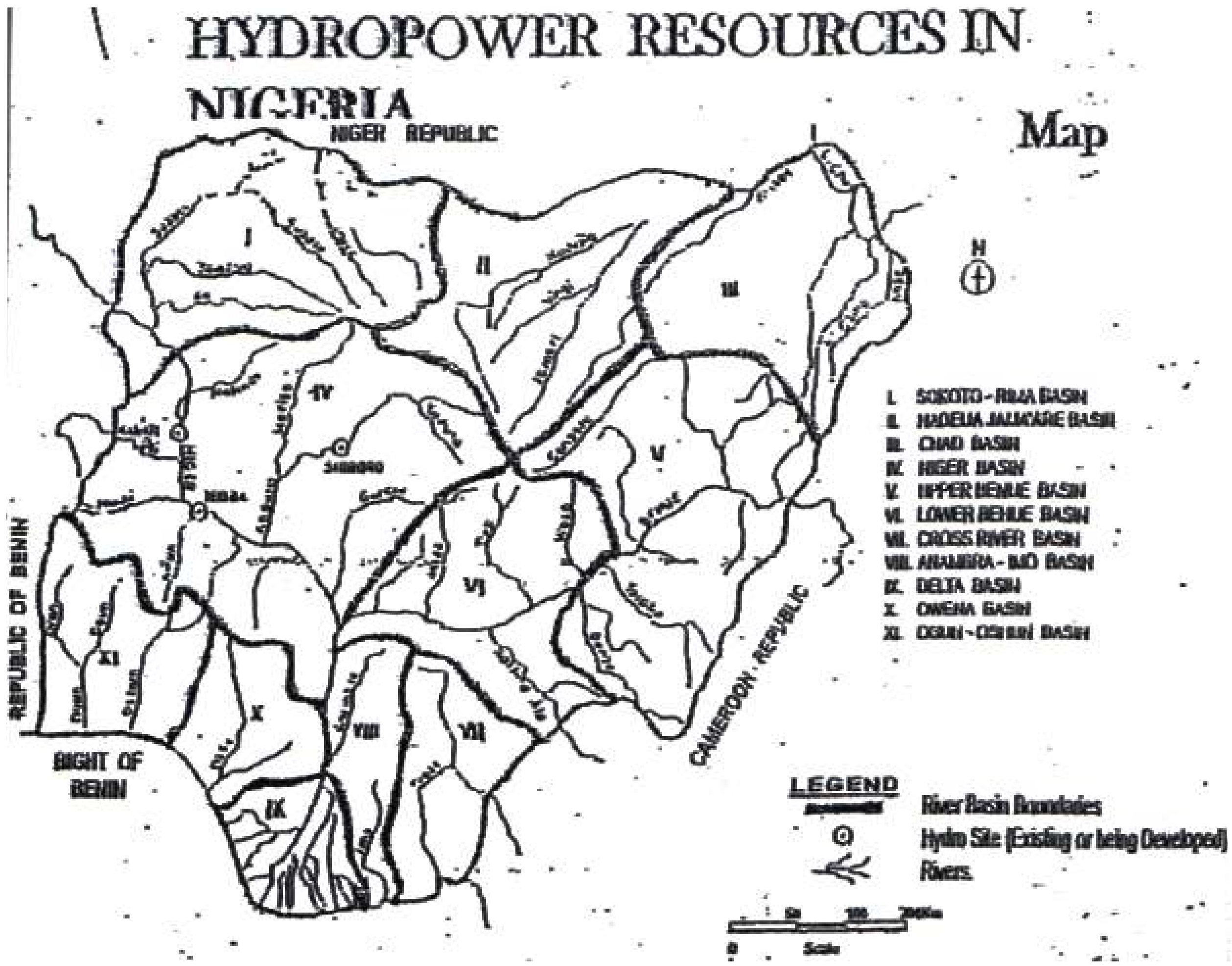
(Source; http/www.unesco-ihe.org/edu/hydro powerdevelopment, 2011)

About 70% of the populations of Nigerians reside in rural area where most of the rivers that can be harnessed for SHP development are located. These areas are known to be usually far away from the National electricity grid and the prohibitive cost of grid extension has further deterred the provision of electricity to the rural communities. The cheapest power is developed and utilized close to where it is needed. This makes Small Hydropower Development for rural electricity supply the best alternative source of electricity especially for communities that have favourable topography and water flow. In most of the rural areas and suburbs of the urban areas in the country, firewood is the primary source of energy for cooking. Gas, kerosene, and diesel are secondary sources of energy for cooking and lighting. These forms of energy are damaging to the environment in a number of ways including global warning. While wood is a commercial source of energy and is almost free, other sources of energy, like gas, diesel, kerosene, etc have to be transported over long distances to the rural and remote areas. Consequently, they are expensive and do not provide many viable options.

Amanyi stream is one which can be investigated for its hydropower potentials and possible exploitation. There are speculations about the hydropower potentials of Amanyi. However, no scientific or systematic attempts have been made to assess the full potential available. This study is the first time such an attempt is being made to fully assess the overall hydropower potential ofAmanyi stream. Therefore, this study will include hydropower development in Nigeria, the description of the types and classification of hydropower schemes, their components and existing small hydropower potentials in Nigeria.

Nigeria Hydropower Environment

According to Aliyu (2004) Nigeriahad a population of over 150 million people but presently Nigeria's population is over 180 million. Over 70% of these people reside in the rural area and only about 18% of these rural dwellers have access to electricity presently. Nigeria is naturally endowed with the abundance of water resources (rivers) crossing the length and breadth of the country as shown in Fig 1. The rivers are organized into five drainage systems, namely the Niger, Benue, Chad, Cross and Atlantic Systems. Apart from the Chad system of inland drainage, almost all the rest of Nigeria's river systems drain into the sea. The River Niger and its major tributary the Benue are very outstanding features of the Physical Geography of Nigeria. They have not only punctuated the land surface of the country in a remarkable way but also greatly influenced the lives of its people and form the major drainage route of all the rivers to the Atlantic Ocean. In the North, the central high lands of Jos Plateau form a major hydrographical centre from which radial pattern of drainage develops with streams draining to Zanfara, Sokoto and Chad basin. Other rivers drain into the Niger and Benue River. These form the Niger-Benue Systems.



(Source: Anambra Imo River Basin Authority, 2008)

Fig. 1Nigeria Hydropower Environment

In the Southeast, the major rivers in this area, the Imo River and the Cross River are oriented towards the sea while the Anambra River joins the Niger River near Onitsha. These form the Cross System. In the West, the major rivers of the area are the Ogun, Oshun, Shasha, Yewa and Oluwa which orients in the North South direction towards the Atlantic. These rivers in their naturally occurring state are the basis for the formation of the eleven river basins in Nigeria as shown in Fig.1.

Types of Small Hydropower scheme

There are basically three common types of Small Hydropower Schemes (Makanju, 2003)namely:

a. Diversion or Run-of-River Hydropower scheme
b. Canal Fall based Hydropower scheme
c. Dam Toe based Hydropower scheme

Diversion or run-of-river hydropower scheme

This type of scheme utilizes water diverted from a river or canal and flowing through the turbine to generate electricity. The basic components of this type of scheme are:

i. Diversion/intake structure
ii. Head race canal
iii. Desilting basin
iv. Conveyance channel
v. Fore bay
vi. Penstock
vii. Power house

The river is diverted into the headrace canal by the diversion/intake structure, causing water to flow through the components, the desilting basin, and canal, fore bay, and hydraulic turbine in the powerhouse where electricity is generated. This type of scheme is suitable generally in any terrain where there is appreciable water flow and he topography not favourable for dam construction.

Canal fall based hydropower scheme

This type of scheme is similar to Run-of-River type in having the same basic components and also utilizes water diverted from a river or canal which flow through the turbine to generate electricity. The basic components of this type of scheme are the same with that of diversion or run-off-river hydropower scheme. The river is diverted into the headrace canal by the diversion/intake structure, causing water to flow through to the components, the desilting basin, canal, fore bay, penstock and hydraulic turbine in the powerhouse where electricity is generated. This type of scheme is the ultra low head type and is applicable on irrigation canal where there is constant water flow and a drop in head range between 1.0m - 1.5m in the canal (Nanayakkara, 2004).

Dam toe based hydropower scheme

The major components of this type of scheme are:

- Dam
- Penstock
- Powerhouse

In this type, an impoundment facility is used to store water in a reservoir and to build up the water level to the desired head for power generation. The penstock connects the dam to the powerhouse, which is located at the toe of the dam at a lower elevation. Power is generated from water flowing through the penstock and the capacity depends on the gross head between the upstream water level in the reservoir and penstock intake to the turbine in the powerhouse. This type of scheme is applicable where the stream flow (Q) is not appreciable or adequate to generate the power required and the desired head (h) has to be achieved by constructing a dam in order to generate higher power. It is generally expensive due to high cost of civil works (dam, spillway, penstock, etc.) involved. However, when incorporated as in a multi-purpose dam its increased benefits accruing from the other uses of the water, e.g., water supply, irrigation, navigation, etc. makes it economically viable.

Existing Small Hydropower Schemes in Nigeria

There exist small hydropower schemes in Nigeria. According to the 2007 renewal energy master plan for Nigeria as discussed by Nwachukwu (2009), the types, capacity and location of existing small hydropower schemes in Nigeria are shown in Table 3.

Table 3 Existing Small Hydropower Schemes in Nigeria

S/N	Location	State	Installed capacity	Current status
1	Kwa falls	Platea	6.0 MW	Operational
2	Kwa falls	Platea	19.0 MW	Operational
3	Bakolori	Sokoto	3.0 MW	Dam construction completed. Electromechanical equipment, never installed
4	Tiga	Kano	6.0MW	Dam construction completed. Electromechanical equipment, never installed
5	Ikere Gorge	Oyo	6.0MW	Dam construction completed. Electromechanical equipment, never installed
6	Oyan Dam	Ogun	9.0MW	Dam construction completed. Electromechanical equipment, never installed
7	Waya	Bauchi	150KW	Completed 2006
8	Mgbowo	Enugu	30KW	Completed 2006
9	Challawa George Dam	Kano	7.0MW	Dam construction completed. Electromechanical equipment, never installed

Source; Nwachukwu, 2009

METHODOLOGY

Description of the Study Area (Case Study)

Neke Uno is an autonomous community in Isi-uzo Local Government area of Enugu state. It has four villages namely; Isi-enu, Umugwu, Obegabu and Umuegwu. It has a population of about 7500 persons (2006 population census). Neke Uno is located within the natural drainage area of Amanyi stream covering Neke and Mbu communities in Isi-uzo Local Government Area of Enugu State.

There are two major seasons in Nigeria, the rainy season from April to October and the dry season from November to March. The study area lies within the rain forest region where rainfall is experienced all through the rainy season. The average monthly rainfall has a minimum of 12.06mm occurring in December and a peak of 360mm occurring in September with an annual monthly average of 198mm. The stream has a maximum flow discharge (Qmax.) of 8.5 m3/s, average discharge (Qav) of 6.9 m3/s, minimum dependable discharge (Qmin) of 4.21 m3/s and a selected design discharge (Qd) of 6.37 m3/s. The topography survey and plant layout showed a head of 3.63m (low head) which is possible for mini hydropower generation.

Site selection

In order to ensure that a hydropower scheme is operational throughout its envisaged life span, water which is the primary non-consumptive fuel must be available in sufficient quantity throughout its life span and its utilization should not adversely affect downstream users. Water should therefore be available in sufficient quantity all the time. The river or stream from which water is tapped for small hydropower development must therefore be perennial. The suitable site for Small Hydropower Development must also show good head variation such that the combination of the head and flow produces the best hydropower potential and presents a lay-out that will influence minimum civil works cost.

The following criteria adopted by the Alternative Hydro Energy centre (AHEC) (2004) of the Indian Institute of Technology (IIT), Roorkee were considered in selection of the site for this study.

i. The catchment should have an area of at least about 250km. The objective is to ensure that there is a certain minimum discharge to generate small hydropower.
ii. The channel must be perennial in nature. The idea is to have round the year electricity generation.
iii. Main channel should be straight with no obstruction to flow; this is to enable a free flowing channel.
iv. Availability of head should be at least 3m as lower head and discharge may not yield significant power potential.
v. The location should be near centers of concentrated population (1.5 – 2.0 km) to reduce transmission losses and associated overall cost.

The study site was selected by applying the criteria adopted by the Alternate Hydro Energy Centre (AHEC) (2007) of the Indian Institute of Technology (IIT), Roorkee.

Data collection

The discharge data for this study were obtained from the hydrological year book of Anambra Imo River Basin Development Authority. The data consists of daily river discharge records for the existing gauge station at Uno-Neke old bridge. The daily flow discharges data are characterized by missing data within some months in the hydrological year and in some cases missing years. This is due to discontinuity in data collection in the late 1998 and early 1999. The available record for the period of 10 years (1988 - 1998) was collected for the study (see Table 4). Missing records in the discharge data were replaced by simple interpolation technique. The rainfall data was obtained from the Nigerian metrological station main office in Lagos. Twenty years record is available and was collected for this study.

Table 4 Mean Monthly Discharge Data (m3/s)

Year	Apri	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb	March
1988/89	3.85	3.65	3.54	3.77	4.09	5.35	7.48	6.56	5.79	4.64	4.07	2.61
1989/90	5.35	4.97	4.87	4.68	5.62	8.46	10.1	7.87	6.88	6.12	4.59	3.77
1990/91	2.49	2.23	3.22	3.85	4.33	5.45	6.14	6.14	5.70	5.55	4.66	4.49
1991/92	4.11	4.23	4.59	4.97	6.15	8.20	8.61	7.64	7.28	7.39	7.16	6.88
1992/93	6.67	6.97	6.93	7.01	6.97	6.97	7.99	8.42	8.68	7.69	7.11	7.33
1993/94	7.32	8.46	10.1	9.83	9.81	11.2	11.8	11.3	11.2	11.2	10.3	9.33
1994/95	6.06	6.35	6.81	7.33	7.87	7.55	8.10	8.53	8.84	7.82	7.47	7.82
1995/96	7.39	7.14	7.24	7.79	8.88	9.25	9.20	8.15	7.95	7.91	7.71	7.73
1996/97	7.84	8.77	8.19	8.01	8.08	8.67	9.23	9.21	9.13	9.08	8.69	8.96
1997/98	8.60	8.81	8.71	8.68	8.63	9.13	9.15	9.28	8.80	8.43	8.09	7.91

The analysis reveals that the contributions of the base flow to the total discharge for Amanyi stream is about 67% which is substantial while the contribution of the runoff is about 33%. Therefore, Amanyi stream is greatly sustained by the underground flow and runoff does not have significant effect on the river discharge. Amanyi stream is therefore suitable for small hydropower development.

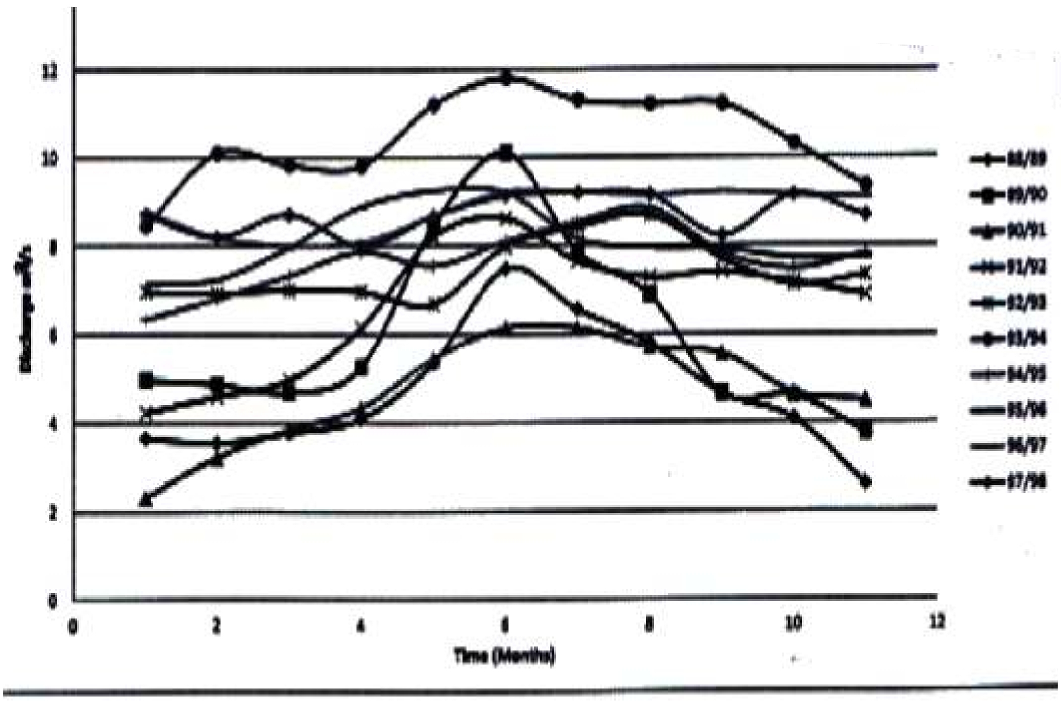


Fig.2. 10-year Hydrograph of Amanyi Stream

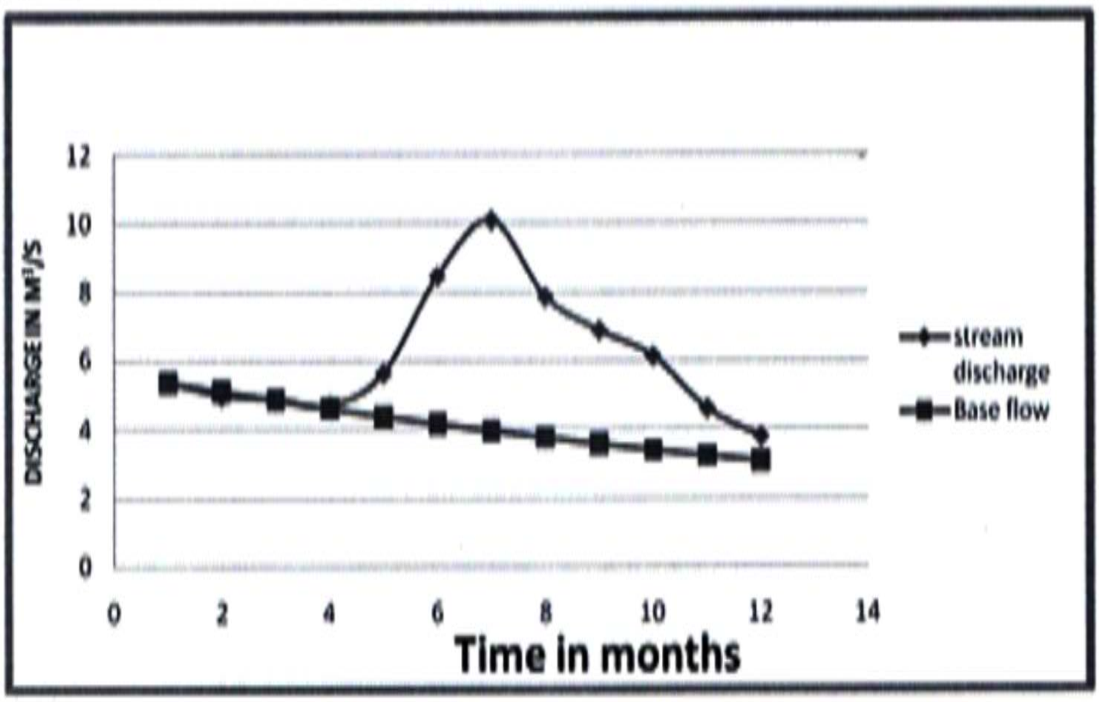


Fig. 3 1989/90 Stream Discharge Hydrograph of Amanyi

The readings in Table 5 are used to plot the flow duration curve (FDC) in Fig. 4.

Table 5 Flow duration Analysis of 10-daily average flow data for Amanyi stream

S/N	10 daily average monthly flow class interval (C.I.)	No. of occurrences in 10 years period (n)	No. of time equaled or exceeded (m)	% of time lower value of class interval equaled or exceeded (m/n) x 100	Monthly power p = 7 x Q x H (KW)
1	2 – 2.99	7	360	100	4
2	3 – 3.99	22	353	98.05	63
3	4 – 4.99	34	331	91.94	84
4	5 – 5.99	30	297	82.50	105
5	6 – 6.99	40	267	74.16	126
6	7 – 7.99	91	227	63.05	147
7	8 – 8.99	74	136	37.78	168
8	9 – 9.99	36	62	17.22	189
9	10 – 10.99	12	26	7.22	210
10	11 – 11.99	10	14	3.88	231
11	12 – 12.99	2	4	1.11	252
12	13 – 13.99	2	2	0.55	273

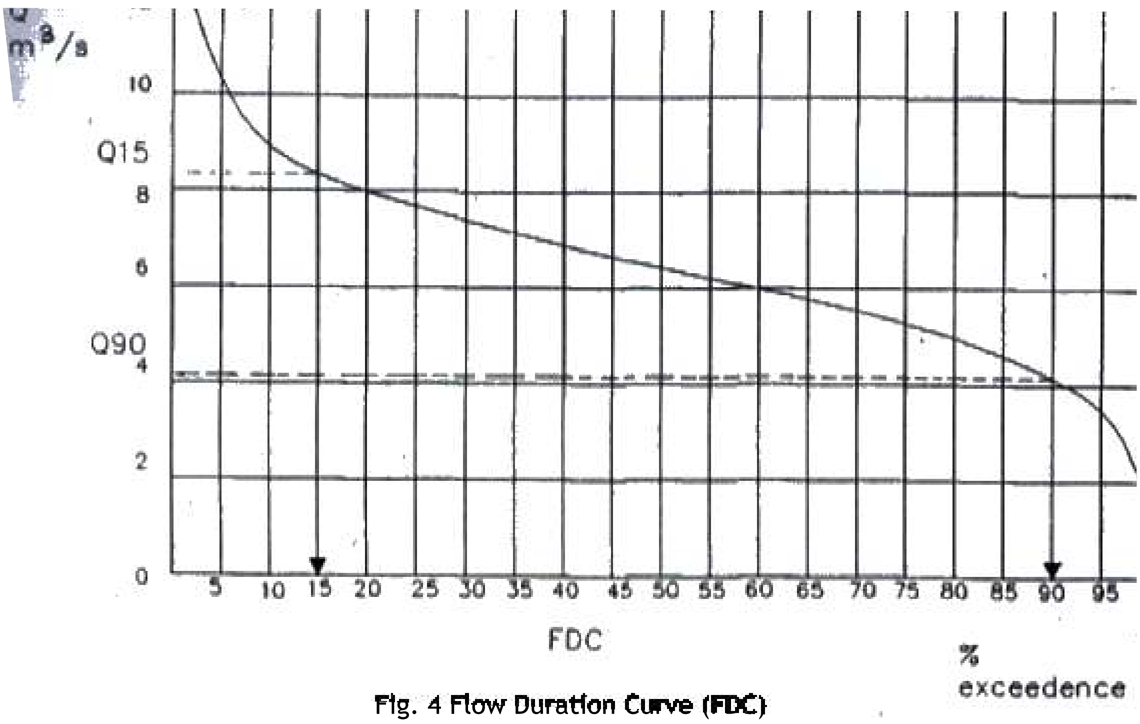


Fig. 4 Flow Duration Curve (FDC)

Maximum flow Q15 (flow exceedence 15% of the time (t)), was determined by reading off the flow corresponding to Q15 from the flow duration curve, Q15 = 8.5 m3/s. The minimum dependable flow Q90 is that flow that is available 90% of the time. From the flow duration curve (FDC), Q90 = 4.21 m3/s.

Design flow

The design flow is determined from the techno-economic assessment of the scheme. In this, various flow values greater than the dependable flow are used to compute the corresponding power potential P, the annual energy generated and the cost of turbine. The flow that gives the maximum energy generation with minimum turbine cost is the design flow for the site and the installed capacity is based on this flow (Nwachukwu, 2009). The availability of a flow is the percentage of time that flow is available for use in a year. The availability of flow therefore corresponds to their percentage exceedence. In computing the design flow, various values corresponding to different percentage exceedences Q15, Q20, Q30, Q50, Q60, Q70, Q80 and Q90 were read off the flow duration curve (Fig. 4) to obtain the flow values. The availability of each flow value was determined by selecting the percentage exceedence for that flow and recorded in appropriate column of Table 6. These flows were then substituted in the power potential equation to obtain various power potentials. These power potentials were then substituted in the energy equation to obtain the corresponding annual energy generated. These were also recorded as shown in Table 6. The flow that gives the maximum energy generation as well as an accepted turbine cost is the design flow Qd.

Table 6 Determination of Design Flow.

Discharge m^3/s	**Q_{15}**	**Q_{20}**	**Q_{30}**	**Q_{40}**	**Q_{50}**	**Q_{60}**	**Q_{70}**	**Q_{80}**	**Q_{90}**
	8.5	**8.6**	**8.0**	**7.92**	7.52	**7.12**	**6.37**	**5.30**	**4.21**
Gross head (m)	3.63	3.63	3.63	3.63	3.63	3.63	3.63	3.63	3.63
Power potential	206.53	201.60	198.46	177..41	168.45	159.49	142.69	118.72	94.30
Annual Energy (KWh)	267,660 . 29	348,364 .8 0	514,418.6 9	613,122 .0 5	727,695 . 36	826,785 . 79	862,977. 02	820,592. 64	733,307.9 0

Power potential

Any hydropower scheme, mini, micro, small or large requires water flow (Q) and a drop in height, H (referred to as a 'head') to produce useful power. The power input, or total power absorbed by the hydropower scheme, is the gross power, Pgross and the power usefully delivered is the net power. The power received by the consumer, Pnet is given by:

Pnet = (7.8) x Q x Hgross in KW 1

The above equation is known as the power equation and is used to estimate the power potential of any river. The power potential is therefore directly proportional to discharge Q and gross head H. the power potential P, is an indication of the average power production capacity of a river and is computed from the power equation.

P = 7 x Q x H 2

For this site, H = 3.63m fixed by the maximum head achievable at the culvert location.

Qav = 6.9 m3/s

P = 7 x 6.9 x 3.63

P = 175.33 KW

Actual Power generated

From Fig. 5, Design layout of Small Hydropower Scheme:

Maximum water elevation at the culvert = 49.45m

Downstream water surface elevation = 45.82

Gross head (Hg) = 49.45 - 45.82 = 3.63m

H = 3.63m. From the power equation) and substituting Hg =Hn

P = 7 x Q x Hn

P = 7 x 6.37 x 0.95 x 3.63

P = 154.0 KW

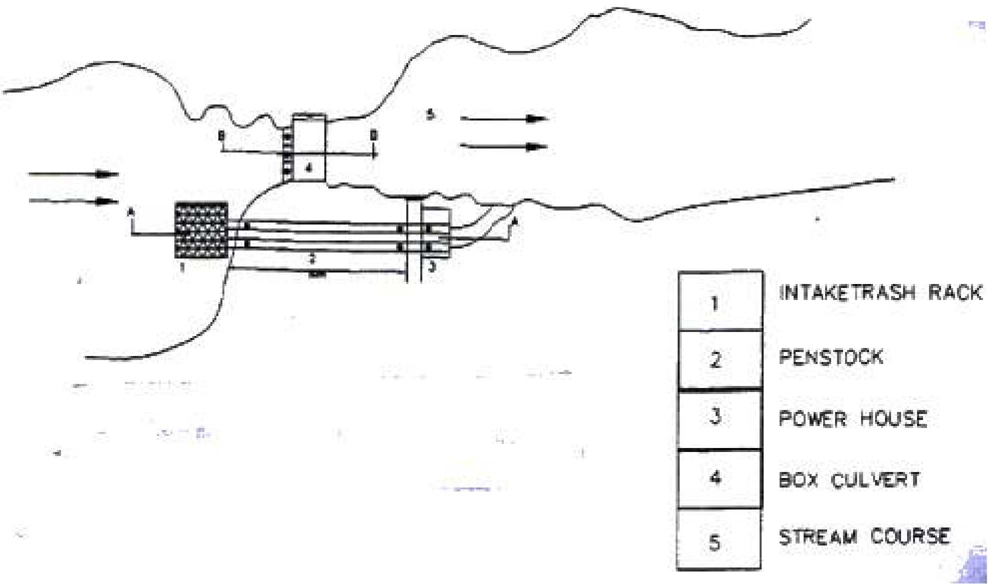


Fig. 5 Design layout of Small Hydropower Scheme

RESULTS AND DISCUSSION

The flow characteristics of Amanyi stream are presented in Table 7. The maximum flow for Amanyi stream is 8.5m3/s. It is used to compute the upper limit range of the installed capacity of the turbine that can be sustained by the stream. The stream discharge beyond this value is not used for power production and therefore is allowed to spill. The average flow for Amanyi stream is 6.9m3/s. This is the average of all the discharge data in the 10 year record. It is used to compute the power potential of the river. The minimum flow for Amanyi stream is 4.21m3/s. This flow is available for use 90% of the time and is used to compute the firm/dependable power that can be generated by the river. The design flow of 6.37m3/s is the turbine flow that will generate maximum annual energy. It is used to compute the installed capacity of the turbine required to generate maximum annual energy. The power and energy generation capacity of Amanyi stream are represented in Table 8. The maximum achievable head at this site is 3.63m and is fixed by the elevation of the top slab of the existing double cell culvert. The river has a power potential of 175.38KW which is the maximum power that can be generated from the river. The firm/dependable power of 106.41KW can be generated throughout the year and will satisfy over 50% of Neke Uno load demand.

Table 7 Stream flow Characteristics of Amanyi Stream

S/N	Description	Output
1	Maximum flow Qmax	8.5 m3/s
2	Average flow Qmax	6.9 m3/s
3	Minimum dependable flow Qmin	4.21 m3/s
4	Design flow Qd	6.37 m3/s

Table 8 Power and Energy Generation Capacity of Amanyi Stream

S/N	Description	Output
1	Firm/dependable power	102.41Kw
2	Power potential	175.38KW
3	Average Annual Energy Generation	!,536,328.8KW
4	Actual Power	154KW

MATCHING DEMAND WITH SUPPLY

Domestic Load Demand

The observed load centre within 1.5km radius of the proposed site is Neke Uno community. However, load survey for the entire community was not carried out but was done for only one village which is closest to the proposed project site. A load survey for Umuegwu village which is one of the four villages that make up Neke Uno community revealed that the power demand for the village (Umuegwu) is about 128KW (this is the only domestic load survey that was carried out). This constitutes about 83% of the actual power generated.

Industrial Load Demand

A survey for the proposed cottage industry for Neke Uno community as shown in Table 9 revealed a power requirement of 16KW.

Table 9 Industrial load demand for Neke-Uno

S/N	Type of Industry	Quantity	Power requirement KW
1	Garri processing	4	4.5
2	Grinding machine	1	2.5
3	Palm kernel	1	4
4	Maize thresher	1	3
5	Lighting		2

From the surveys and analysis, the power generated from Amanyi stream can adequately serve the proposed cottage industry as well as supply 100% of the power requirement for Umuegwu village (one of the villages in Neke-Uno). However, with scheme improvement (modification of the existing topography), more power can be generated which could possibly serve the remaining three villages.

Project Cost Estimate

The issue of cost will always be of interest to any project developer or proposer. The developer or proposer would want to know how much the proposed project is expected to cost in order to plan effectively for its development. A small hydropower scheme is one of such projects that require careful planning prior to implementation especially due to the huge financial resources required for its development. The cost elements associated with small hydropower development are classified into direct costs which include cost of civil works. Mechanical/ electrical, accessories, miscellaneous equipment and indirect cost which include engineering planning, design, legal cost and interest on loan during construction if applicable (Chukwujekwu, 2003).

Actual Project Cost

The total cost of the components required for the Small Hydropower is shown in Table 10.

Table 10 Total cost of proposed project

Description	% Construction to Total Cost	Amount	
		S	N
Civil features	15	65,384.61	9,807,691.50
Turbine and generator	39	170,000.00	25,500,000.00
Accessory electrical equipment	11	47,948.72	7,192,308.00
Miscellaneous power plant equipment	5	2,397.43	359,614.50
Interest during construction	10	43,589.74	6,538,461.00
Engineering and legal	20	87,179.49	13,076,923.50
Total cost		435,897.43	65,384,614.50

CONCLUSION AND RECOMMENDATIONS

Conclusion

This case study of Amanyi stream has shown that the stream has a power potential of 175KW which is less than 1MW, and therefore classified as a mini hydropower. It has a maximum discharge of 8.5 m3/s, average discharge of 6.9 m3/s, minimum discharge of 4.27m3/s and a design discharge of 6.37m3/s. These flows can be harnessed to generate power. The power demand for Umuegwu village (one of the villages in Neke Uno) is 128KW and the industrial demand is 16KW, which is about 83% and 10% respectively of the actual generation. The maximum achievable power without modifying the topography at a head of 3.63m is 154KW. The project cost estimate for developing the hydropower potential of Amanyi stream is N65, 384,614.50. The load centre according to International standard must be within 1.5km radius of the scheme in order to reduce to the barest minimum, transmission losses. Generally, higher powers are possible downstream due to envisaged higher catchment area and resulting higher river discharge. Amanyi stream is suitable for a low-head mini hydropower development. Sustainable hydropower development is a reliable tool for growth, as hydropower is an important source to economic growth.

Recommendations

The current power crises in Nigeria can be tackled by the development of small/mini and micro hydroelectric schemes especially where the resources are available for sustainable growth. Small hydropower schemes guarantee uninterrupted power supply because of the sustainable flow of the water resource on which the design is based. Amanyi stream is substantially sustained by ground water flow and the nearest load centre, Neke Uno community, is within 1.5km radius of the scheme. It is therefore recommended as follows:

i. The mini Hydropower potential of Amanyi stream at the selected study site should be further developed to sustain growth in the area.
ii. Extensive load survey should be carried out for other small communities in Nigeria, to determine the load requirements and provide allocation plan for such communities.
iii. Project cost estimate for the development of Small Hydropower use should be part of the strategies for economic growth in Nigeria and should include operation and maintenance cost tied to the life span of turbines and generators to be used.

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