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Techno-Economic Viability of Small Hydro Power Plants for Mini-Grid Electrification in Southwest Nigeria

Christian O. O. Okwori[1,*], Olawale S. Ismail[1], and Moses O. Petinrin[1,2]

[1]Department of Mechanical Engineering, Faculty of Technology, University of Ibadan

[2]School of Mechanical Engineering, Fiji National University, Suva, Fiji

Abstract

The commercial viability of small, mini, and micro hydroelectric power generation collectively termed Small Hydro Power (SHP) potential in Southwest Nigeria was investigated by collecting proven historical and real-time data of extant SHP-convertible water bodies as well as general hydrology and population settlement pattern in the region based on reservoir hydroelectric power technology in distributed mini-grid application using a 100kW pilot model. Small hydropower with scores high on the Techno-Economic Renewable Energy Viability Index (TEREVI) scale with a value of 0.795 compared to the minimum viability threshold of 0.70 which is a reflection of good hydro potential given widespread water resources and high year – round precipitations with mean runoff flowrate being 180.65m3/s ranging from 23.12m3/s in January to 430.67m3/s in June representing corresponding rainfalls of 0.59mm and 10.99mm respectively. The cost of small hydro energy generation is relatively low compared to other sources, given values of \$0.022069123/kWh from HOMER simulation, \$0.02316/kWh from Matlab simulation, \$0.027878615/kWh from LCOE, and \$0.0296/kWh from Techno-Economic Levelized Cost of Energy (TELCOE), with a mean COE of \$0.025676935/kWh. Southwest West Nigeria's surface runoff hydro power potential is 448.16kW/m2, the overall finding reveals that reservoir SHP harnessed in distributed generation power mini–grids is a very technically and commercially viable sustainable clean energy opportunity for Southwest Nigeria with proven potentials between 70MW to 350MW and probable potential up to 3900MW, which could be much higher with flood and stormwater optimization.

Keywords: Hydroelectric power, reservoir hydro, Small Hydroelectric Power (SHP), TEREVI, TELCOE, HOMER, LCOE, stormwater hydropower.

1.0. Introduction

Clean, affordable, and sustainable energy solution has for the last 50years been among the top of the agenda of the United Nations, World Bank, International Finance Corporations (IFC), International Donor/Development Agencies (IDA), leading finance institutions and all countries of the world yet about 1billion people in the globe of which more than 50% are living in sub Saharan Africa have being groping in darkness with little proof of the situation improving in the foreseeable future unless something drastic is done and urgently so(IEA, 2023).

Nigeria has over the last 40years have had most of her development programs and targets perpetually extended or ultimately cancelled due to failure to meet them owing mostly to inability to tackle the ever-worsening power supply problem that has become endemic leading to high cost of local production, preference for importation, capital flights, and massive de-industrialization among other things (NDP 2021 -2025).

Despite being the largest economy in Africa, Nigeria's economy has been greatly slowed and stunted by inadequate and epileptic power problems causing serious productivity deficit both at industrial and individual levels hence the national grid has been grossly inefficient, with power generation and wheeling capacities of 4,000MW and 8,000MW respectively which is a far cry for the nation's over 200million population and about \$1Trillion economy that ought to be not less than 100,000MW output as a reasonable figure for consideration being a Global Top 20 Economy aspirant(Sowande, 2022; Aduloju, 2023; Okwori, 2011).

Due to the gross inefficiency of the national grid of over 30%, it is obvious to most observers and energy experts that the unwieldy national grid system or any central configuration is not an ideal solution but the widespread deployment of mini-grids powered by locally available renewable energy resources such as the numerous small hydropower potentials scattered in various parts of the country including the Southwest (Ikeme and Ebohon 2005).

Though over 80% of Nigeria's power stations are natural gas – fired in the form of Open Cycle Gas Turbine (OCGT), Combined Cycle Gas Turbine (CCGT) or Steam Turbine, hydroelectric power is responsible for about 80% of Nigeria's base load generation given that the former mostly serve for peak shaving operationally (ITA, 2023).

Southwest Nigeria has been one of the biggest casualties of inadequate power generation and distribution in the country being the most industrialized geopolitical zone and having suffered the highest loss of manufacturing organization and influx of migrants from other parts of the country following worse lack of jobs and weakening economic state of the nation and neighbouring countries at large.

SHP stands out as one of the best promising alternative power generation contributors if the long list of potentials in various states in the region especially in Ogun and Osun aside storm and floodwater systems are properly optimized and harnessed in the short, medium, and long term instead of focusing on only major hydro and fossil sources via the national grid which has been a cardinal bane in failed developmental strategies over the years.

A network of SHP – fired mini – grids will help tackle heads on the problems of rural electrification which slows agricultural development, causes food wastages, increases rural – urban migration, worsen social inequality, increases insecurity, and widens the massive infrastructure gap being suffered the people having just around 30% grid connection compared to urban areas' 80% grid connection (Trading Economics, 2023).

The integrated development of SHP will, aside from boosting power production, enhance fadama (all–season) crop farming, improve inland fishing practice, engender navigation, and increase economic activities in the areas involved, thus helping to address multiple aims of the Sustainable Development Goals, aside from other positives.

Hydropower is one of the most reliable energy technologies known to man and has been applied in various works and farming operations for centuries aside from electric power generation with a high capacity factor as well as efficiency of up to 90% and lifespan of over 40years coupled with its relative simplicity and safety among other things that makes it a technology of choice in the committee of experts wherever available to be harnessed (DoI, 2005).

1.1. Objectives

1.1.1. Obtain the relevant hydroelectric power data for Southwest Nigeria

1.1.2. Design a hypothetical pilot small hydroelectric power mini-grid system for application in Southwest Nigeria

1.1.3. Simulate and test the grid systems using energy models such as TELCOE, generic COE, MATLAB, as well as HOMER

1.1.4. Determine the viability of small hydroelectric power using TEREVI

3.0. Literature Review

Bankole et al. (2022) studied the techno-economic viability of small hydroelectric power generation systems in a hybrid configuration of solar photovoltaic, Battery Energy Storage Systems (BESS), and diesel-fuelled generators at Itapaji and Owena in Ekiti State and Ondo State, respectively, based on 25-year data using HOMER. The results showed that small hydro–solar–BESS yields the best configuration the lowest energy cost from all the simulation results. However, this study is based on just the Owena River dam and does nit take into account other potential hydropower sources. In addition to that, local constraints were practically left out in their analysis. Very importantly, their cost of energy being over \$0.2/kWh are quite above the deregulated electricity price, though it still represents a fair insight suggesting good promises.

Otu (2023 reported that four states in Southwest Nigeria have a combined 3900MW small hydroelectric power potential based on initial studies, with Ondo, Ogun. Lagos and Ekiti have 2000MW, 900MW, 500MW, and 500MW, respectively. To this end, following the removal of electricity from the exclusive legislative list by the Federal Government, some of the State Governments have taken initial steps based on further studies for possible exploration and exploitation. However, no practical measures or tangible results have been reported in that regard.

Mohammed and Olowoniyi (2024) carried out a multicriteria assessment of small hydropower and other renewable energy sources in Nigeria. The study shows that while it is convenient for the Federal Government to be fully in charge of developing large hydropower potentials across the country, small hydropower plants are best sustainably developed and managed by collaborative efforts by state and local governments in partnership with communities and private sector-driven initiatives. Though the study is not techno-economic and focuses more on social and governance issues on renewable electrification in Nigeria, it supports the research drives of this studywhich is based on a bottom-up electrification strategy to clean energy development in Nigeria and Sub-Saharan Africa at large.

Nkolo (2025) carried out a present and future analysis of Nigeria's renewable energy generation. The result showed large hydro as the biggest contributor, with small hydro showing a leading prospect. However, the study was not techno-economic and did not use a extant or conventional energy model to base decisions but rather used purely empirical assertions that do non – the – less reflect the realities on the ground and do corroborate results from earlier researchers generically.

4.0. Principles and Methodology

Hydro Electric Power (HEP) is electrical energy generated by the conversion of the potential energy of water concerning its height (reservoir hydro) or gradient (run – of – River hydro) impinging on hydro turbine blades and causing it to rotate and generate electricity via an alternator coupled to the turbine shaft.

HEP generation technology is of 2 types: Run–of–River hydropower system is based on using the speed of fast-moving rivers and streams to turn a hydro turbine installed on its flow path, such as a waterwheel, but are typically of MHP and PHP output capacities. The natural speed of the water, which is enabled by the topographic gradient between the source and the turbine, is often enhanced by narrowing the river channel.

By natural speed, most streams will not generate much power unless tunneled. Given that the higher the gradient and the narrower the channel, the faster the water flow rate concentration directed at the turbine blade tip and the higher the power generated, most run–of–river sites are optimized by carrying out minor or major civil works to enhance power generation.

Reservoir hydropower system is based on the damming and gating of the river upstream then releasing by opening a gate(ring or butterfly gate) just like valve at desired flowrate and channeling the water down through a pipe called penstock to the hydro turbine suction to turn its blade by which electricity is generated in the process through a suitably sized alternator coupled to the turbine blade shaft/gearbox from which the water exit to the river downstream to continue its natural course via a discharge pipe.

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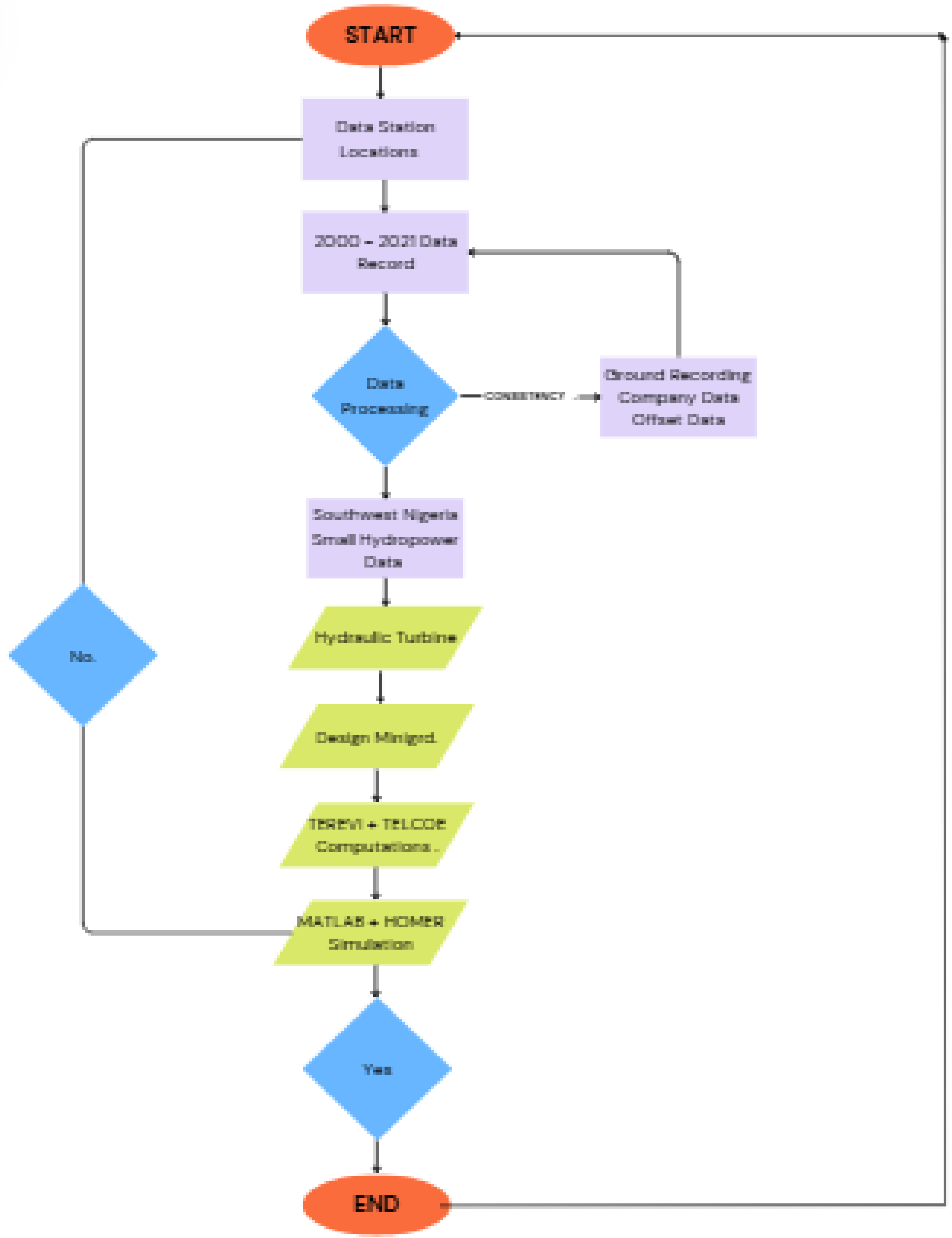

Figure 4.1: Process Flow Diagram of the Techno-Economic Viability Assessment of Small Hydropower System in Southwest Nigeria

The purpose of creating an artificial dam upstream is to serve as a capacitor in storing more water and ensuring consistent flow irrespective of precipitation rates, as well as enabling dispatch in order to regulate flow rate and power generation based on plan, desire, or emergency. The purpose of creating an artificial dam upstream is to serve as a capacitor in storing more water and ensuring consistent flow irrespective of precipitation rates, as well as enabling dispatch in order to regulate flow rate and power generation based on plan, desire, or emergency.

Figures 4.2 and 4.3 show the small hybrid power system in a hybrid mini-grid configuration in standalone or concatenated modes, interoperable with the main grid. This system is based on a bottom–up strategy for addressing rural electrification by prioritizing autonomous renewable enerby resources based rural electrification as opposed to national grid extension.

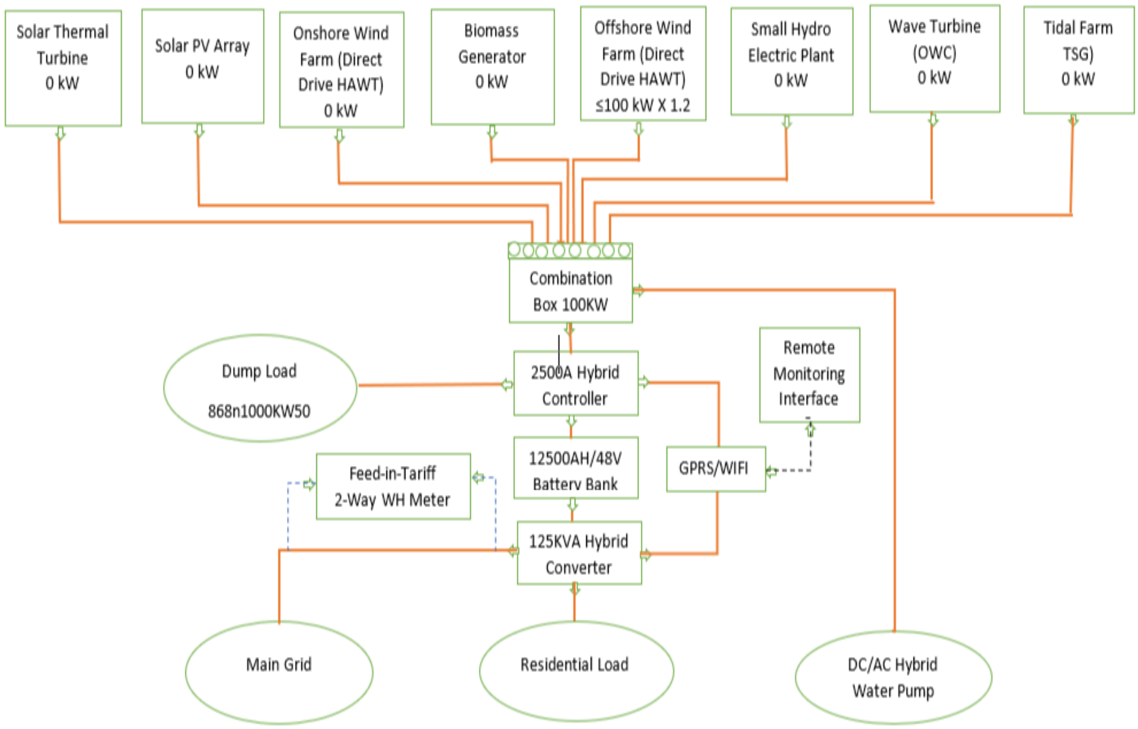

Figure 4.3: Small hydro-powered renewable energy hybrid mini-grid

Figure 4.4: schematic of bottom-up renewable energy mini-grid including small hydropower

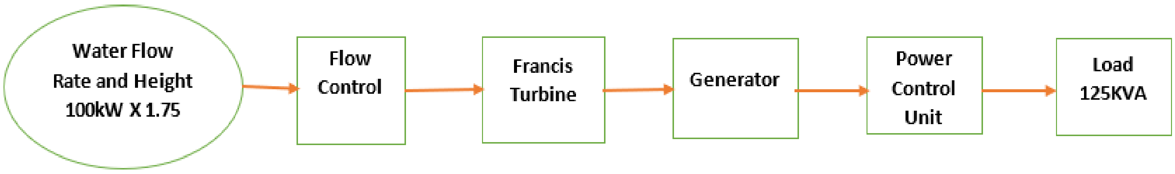

Figure 4.5: Small hydroelectric powertrain configuration

Since most waters for hydro power do originate from different countries, states, or communities, a collaborative upstream water management or memorandum of understanding that is sustainable between the power plant committee, the upstream community, and impacted communities is crucial.

Figure 4.1 shows the project workflow for this research, while the powertrain configuration is based on the process link in Figure 4.5. The hydraulic unit is based on the Francis turbine design configuration, while the hydroelectric technology is open of reservoir hydro, pump-storage hydro, or storm-water hydro, or run-of-river hydro.

The hydrometeorological data of Southwest Nigeria were obtained from the NASA Langley Research Center (LaRC) Satellite record using a 21-year mean. These values were compared with those from other sources in order to ensure integrity and consistency before processing and evaluation with various energy models and metrics.

A 100kW hypothetical small hydropower system was designed in a hybrid configuration as shown in Figure 4.2. The system was simulated on HOMER and MATLAB Simulink and thereafter evaluated using a generic Cost of Energy (COE) and Techno-Economic Levelized Cost of Energy (TELCO) model based on Okwori et al (2025). Following consistency across the indices and metrics, the system was finally tested using the Technoeconomic Renewable Energy Viability Index (TEREVI) based on Okwori et al (2025).

4.1. Technical Theory

The power of hydro water flow P_H is calculated by the following equation (Sambo, 2005) given H_N as the net hydraulic head, $\dot{Q}$ as the flow rate(m3/s), $\boldsymbol{\rho}$ as density of the river water, G as the acceleration due to gravity, and Ɛ as overall plant efficiency:

$$P_H = \mathcal{E}\dot{Q}\boldsymbol{\rho H_N G} \qquad \textbf{4.2}$$

Typically, Ɛ≤ 80% for small hydro power systems aside upstream flowline losses (Sritram and Suntivarakorn, 2021; Kala, 2005; Yildiz et al, 2024)

The net heat is the difference between the gross head HG and the sum of the maximum tail water level H_{Tail} and the conduit head loss H_{con} given that C_H (usually 0.003 to 0.008) is the conduit head coefficient thus (EIA 2012; BHA, 2005; National Resource Canada, 2004; Yildiz and Rouge, 2024):

$$H_N = H_G - [H_T + H_C] \qquad 4.2$$

$$H_N = H_G - [H_T + \mathcal{E}H_G] \qquad 4.3$$

$$P_H = \mathcal{E}\dot{Q}\rho G[H_G - (H_T + \mathcal{E}H_G)] \qquad 4.4$$

Since hydroelectric power can also be produced from runoff and storm waters as well as flood waters daming apart from naturally suited water bodies, there is need to factor in environmental variables such as precipitation rates and edaphic factors among other things in order to comprehensively assess and predict overall hydropower potential in a given geopgraphical area such as the southwest Nigeria (Jiheng et al, 2020; Chikoti et al, 2017)

Precipitation rate and hydropower generation potential have very high correlation of between 50% and 95%, which accentuates the degree of sensitivity of precipitation variable for renewable energy generation and environmental sustainability. This is so given the fact that global temperature rise is expected to reach 1.5°C by the end of the 21st century same way as precipitation rates are increasing globally, and harnessing renewable energy resources can help slow, stagnate or even reverse climate change and its attendant consequences on the ecology (Jiheng et al, 2020; Chikoti et al, 2017)

Due to climate change and carbon accumulation, surface runoffs and underground water accumulation in Southwest Nigeria is expected to continue to increase in (Ayejoto et al, 2023) with time and from north to south which also reflects a progressive drop in elevation respectively as current precipitation rates in southwest Nigeria ranges across cities between 1.5mm and 3.8mm (Layi – Adigun, 2020; Ayejoto et al 2023)

Surface Runoff water flow rate is estimated based on the Rational Methods according to the following equation by Bhagat (2025):

$$\dot{Q} = \frac{RAC}{360} \qquad 4.5$$

Where $\dot{Q}$ = the rainfall runoff flowrate (m^3/s)

R = Precipitation Rate or intensity of rainfall (mm/hr)

A= the land Area (hectares (Ha)), which for this study is the total land area of southwest Nigeria, which amounts to 796650Ha.

C = Coefficient of runoff.

The C is taken for this study from the Rational Method Rainfall Water Soil Chart as the mean value of median arable land slope infiltrability, quoted as 0.60, and median forest land slope infiltability quoted as 0.35, which yields 0.425.

The soil penetration coefficient is obtained from the Rational Method Land Slope Infiltrability Chart

$$P = \frac{1000gH\dot{Q}}{796650} \qquad 4.6$$

$$P = 0.00126\dot{Q}gH \qquad 4.7$$

Where P = the potential power (kW/m2)

g = Acceleration due to gravity = $10ms^{-2}$

H = Mean topographical elevation of the runoff area (mAMSL).

Based on records from Topography.com (2024), the mean elevation for southwest Nigeria is 197mAMSL from Ekiti down south to Lagos.

5.0. Results and Technical Information

The hydrometeorological data at Southwest Nigeria are presented in Tables 5.1, 5.2, 5.3, 5.4, and 5,5. This information forms the basis for the hydrological characteristics as well as hydrp electric power generation potential for a given geographical location. Small Hydro Power (SHP) is the generation of hydroelectricity on a small scale, mostly by use of streams and waterfalls with a small hydraulic flow rate, which amounts to power generation between 1MW and 99MW. Other categories are micro hydro power (MCP) with capacity between 1KW and 999KW, and Pico Hydro Power (PHP) with capacity between 1W to 999W, while Large Hydro Power (LHP) has capacities from 100MW and above.

Just like the Atlantic and other rivers in the South-west, over 60% of Nigeria's land mass and the vast majority of her population are located around the River Niger and River Benue as well as their tributaries (Zama et al, 2006) which makes SHP development cost effective and sustainability enhancing in terms of lower electricity transmission cost and integrated value chain activities such as fishing, irrigation and navigation among other things due to proximity to the market. The fact that not every river is feasible for hydro power and that not every human habitation is blessed with water bodies, globally, hydroelectricity constitutes just 2% of all energy use with total value of 2800TWh in 2004 and projected to reach 5,000TWh by year 2030 at 1.8% cumulative annual growth rate (Bada, 2011)

Due to the insecurity, remote and sometimes inaccessible location of most natural SHP potential sites, there is Limited data on viable small hydro power potentials in Nigeria (Sambo, 2005) of which about 248 of the small hydro potential are dispersed in remote areas with generation potentials ranging from 0.1MW to 0.5MW (Kela et al, 2012). Nigeria's current proven small hydro power potential stands at about 3,500MW which as at 2005, about 277 small hydro power potential sites sparsely located across the country worth over 724MW of electricity have been identified but which only just about 30MW have been developed for power generation (Kela et al, 2012) due to the fact that SHP is not a top priority to the Federal Government who are focused on harnessing the remaining 80% of the country's 11,500MW LHP potentials.

A small river is a water body with less than 500Km km (Abdullahi, 2005). Knowing that SHP is based on small rivers, it is good to take note of some major dams and rivers in the South – West of Nigeria with small hydro opportunities aside their numerous tributaries include such as: Oyan River in Oyo State, Ogun River in Ogun, State and Osun River in Osun State which all flow directly downstream to the Atlantic Ocean (Zama et al, 2006). Generally, the more northerly Southwest rivers are tributaries to the River Niger, while the southerly rivers drain to the Atlantic Ocean via Lagos, Ondo, Ogun, and the Niger Delta through lagoons, creeks, and other channels

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By natural speed, most streams will not generate much power unless tunnelled. Given that the higher the gradient and the narrower the channel, the faster the water flow rate concentration directed at the turbine blade tip and the higher the power generated, most run–of–river sites are optimized by carrying out minor or major civil works to enhance power generation. Reservoir hydropower system is based on the damming and gating of the river upstream then releasing by opening a gate(ring or butterfly gate) just like valve at desired flowrate and channelling the water down through a pipe called penstock to the hydro turbine suction to turn its blade by which electricity is generated in the process through a suitably sized alternator coupled to the turbine blade shaft/gearbox from which the water exit to the river downstream to continue its natural course via a discharge pipe.

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Major Rivers in South – West Nigeria include:

I. Ouémé River (Weme River) : Between Atakora Mountains in Northwest Benin Republic and South – West Nigeria

II. Okpara River: Between Borgou in Benin Republic and Southwest Nigeria

III. Osse River: Akpata Hills. Ekiti State

IV. Ogun River: between Shaki in Oyo State and Lagos Lagoon.

V. Oyan River: Abeokuta North Local Government in Ogun State

VI. Ofiki River: Between Shaki and Ogun

VII. Ona River (Awna River): Between Oyo and Lagos Lagoon

VIII. Ogunpa River: Oyo State

IX. Osun River: between Osun and Lagos Lagoon

X. Erinle River: Between Ofa in Kwara, Ogbomoso in Oyo and Osun River in Osun State

XI. Otin River: Osun State

XII. Oba River: Between Oyo and Osun State

XIII. Omi Osun: Oyo State

XIV. Owena River: between Oyo and Ondo

XV. Okpeki River: between Oyo and Ogun State.

State	Discovered Natural Potential Small Hydropower Site	Estimated Power (MW)
Lagos	0	0
Ekiti	6	1.25
Ondo	1	1.30
Oyo	3	1.06
Osun	8	2.62
Ogun	13	15.61

Table 5.1: Recorded and confirmed natural hydroelectric potential power in Southwest Nigeria (source: UNIDO-RC-SHP in Africa, Abuja, 2005)

MONTH	PRECIPITATION (MM/DAY)	MEAN RAIN DAYS	MEAN RELATIVE HUMIDITY (%)	MEAN WATER TEMP (°C)	MEAN MONTHLY TEMP (°C)	MEAN MONTHLY PRECIPITATION (mm)
JAN	0.59	2	81	27	27.7	18.29
FEB	1.56	4	79	27	28.9	43.68
MAR	2.38	6	76	28	29.2	73.78
APR	4.18	8.5	82	28	28.8	131.4
MAY	7.61	10	84	28	28	235.91
JUN	10.99	17.6	87	27	26.6	327.3
JUL	6.34	12.5	87	25	25.9	258.54
AUG	2.39	7.67	85	24	25.7	74.09
SEP	6.94	14	86	27	26	208.2
OCT	7.59	12.33	87	26	26.7	235.29
NOV	4.31	6.5	84	27	27.8	129.3
DEC	0.48	0.5	82	27	28	14.88
MEAN	4.61	8.47	83.33	26.75	27.44	145.89
ANNUAL	55.36	101.6	1000	321	329.3	1750.66

Table 5.2: Hydrometeorological data of southwest Nigeria

MONTH	ABSOLUTE HUMITY (g/m3)	HUMIDEX	MEAN DAY TIME TEMP (°C)	MEAN NIGHT TIME TEMP (°C)	MEAN TEMP (°C)	SUNSHINE HRS/DAY
JAN	23.5	47	34.1	23.2	28.65	5.3
FEB	24.7	47	34.5	25.1	29.8	6.1

MAR	24.2	45	33.9	25.3	29.6	4.9
APR	25.5	45	33.9	24.9	29.4	5.7
MAY	24.8	44	32.3	24.7	28.5	5.4
JUN	23.5	40	30.1	23.7	26.9	3.7
JUL	22.4	38	29	23.5	26.25	2.8
AUG	21.6	38	29	23.2	26.1	2.6
SEP	22.3	39	29.7	23.5	26.6	3.5
OCT	23.6	42	30.9	23.5	27.2	4.5
NOV	24.5	44	32.6	24.1	28.35	5.7
DEC	24.2	46	33.4	23.4	28.4	5.3
MEAN	23.73333	42.91667	31.95	24.00833	27.97917	4.625
ANNUAL	284.8	515	383.4	288.1	335.75	55.5

Table 5.3: Hydrometeorological Data of Southwest Nigeria

Southwest State	Topographical Elevation (mASL)
Osun	266.33
lagos	5
Ogun	66.45
Oyo	271
Ondo	154
Ekiti	423
MEAN	197.63

Table 5.4: Mean Elevations of Southwest Nigeria

Month	Precipitation Rate (mm/day)	Mean Rainy Days	Rainfall (mm/hr)	Runoff (m^3/s)	Potential Runoff Power (kW/m^2)
JAN	0.59	2	0.024583	23.12037	57.35616
FEB	1.56	4	0.065	61.13182	151.6536
MAR	2.38	6	0.099167	93.26522	231.3689
APR	4.18	8.5	0.174167	163.8019	406.3538
MAY	7.61	10	0.317083	298.2136	739.7973
JUN	10.99	17.6	0.457917	430.6659	1068.38
JUL	6.34	12.5	0.264167	248.446	616.3357
AUG	2.39	7.67	0.099583	93.65709	232.3411

SEP	6.94	14	0.289167	271.9582	674.664
OCT	7.59	12.33	0.31625	297.4298	737.853
NOV	4.31	6.5	0.179583	168.8963	418.9916
DEC	0.48	0.5	0.02	18.80979	46.66264
MEAN	4.61	8.47	0.192083	180.6524	448.1558
ANNUAL	55.36	101.6	2.306667	2169.396	5381.758

Table 5.5: Surface water and runoff power potential for Southwest Nigeria

Though not all water bodies are naturally suited for SHP, majority of the rivers in the Southwest can be optimized for power generation beyond the current proven 19.594MW based on limited survey of 3 states in the region; Ogun, Oyo, Osun and Ondo (UNIDO-RC-SHP, 2005).

In addition, given the high rainfall and generous drainage density in the region. Lots of the hydraulic channels can be reworked for reservoir and run – of – river hydro even as a means of managing perennial flood problems in rough estimated between 70MW and 350MW of SHP and MCP electricity can be generated through active government, corporate and community participation.

This is supported by the fact that Nigeria's precipitation rate is between 50mm in the Northern extremes with rainy season lasting up to 3months and 3400mm in the Atlantic borders having up to 8months rainfall per annum (Ohunakin, 2010). Thus, the Southwest of Nigeria is endowed with both natural and artificial SHP electricity generation potentials.

6.0. Discussion of Results

From the data obtained, Southwest Nigeria has an annualized precipitation rate of 1750mm per square meters and an average daily value of 4.6mm/day ranging from 0.48mm/day mean in December and 10.99mm/day mean in June which makes the area a medium to heavy rainfall zone with propensity for surface water given elevated water tables and topographies slanting down to the Atlantic fringes, the creeks, swamps, and the lagoons, resulting in high surface water volume and potentials for flooding enhanced by conglomeration of catchments generation build ups (Breini et al, 2021). These result in regular flooding and heavy storms as well as perennial catastrophic storms, causing devastating consequences.

These huge amounts of surface water that have become a serious environmental risk also present an opportunity for harnessing hydro energy for small power generation and other uses via damming or reservoir hydro electricity generation. This is in addition to overhead storm water, hydro power, cisterns, and pump storage hydro power systems, among other things. Hydrometeorological predictivity of surface water geodesy, storm water volumes, and catchment fluxes is key in managing catastrophic flooding and adequately harnessing (Breugem et al, 2020).

Small hydropower with scores high on the TEREVI scale with a value of 0.795 compared to the minimum viability threshold of 0.70 which is a reflection of good hydro potential given widespread water resources and high year – round precipitations with mean runoff flowrate being 180.65m3/s ranging from 23.12m3/s in January to 430.67m3/s in June representing corresponding rainfalls of 0.59mm and 10.99mm respectively. The cost of small hydro energy generation is relatively low compared to other sources, given values of \$0.022069123/kWh from HOMER simulation, \$0.02316/kWh from Matlab simulation, \$0.027878615/kWh from LCOE, and \$0.0296/kWh from TELCOE, with a mean COE of \$0.025676935/kWh.

Southwest West Nigeria's surface runoff hydro power potential is 448.16kW/m2, which indicates a great opportunity for structured stormwater and floodwater management and optimization systems, enabling power generation and other ancillary uses. The proven natural potential in Southwest currently stands at about 19.594MW with the optimization of existing dams, a probable potential of about 350MW or more, with unproven potentials of over 560MW upon structured management and optimization of storm water and flood water systems for power generation.

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Hydropower is a pivotal base load technology with a high capacity factor to strengthen the resilience of the mini-grid networks across demand regimes. Figures 6.1, 6.2, 6.3, 6.4, and 6.5 show the runoff and natural hydro power potentials, precipitation rates, and flow rates as well as hydrometeorological patterns in Southwest Nigeria.

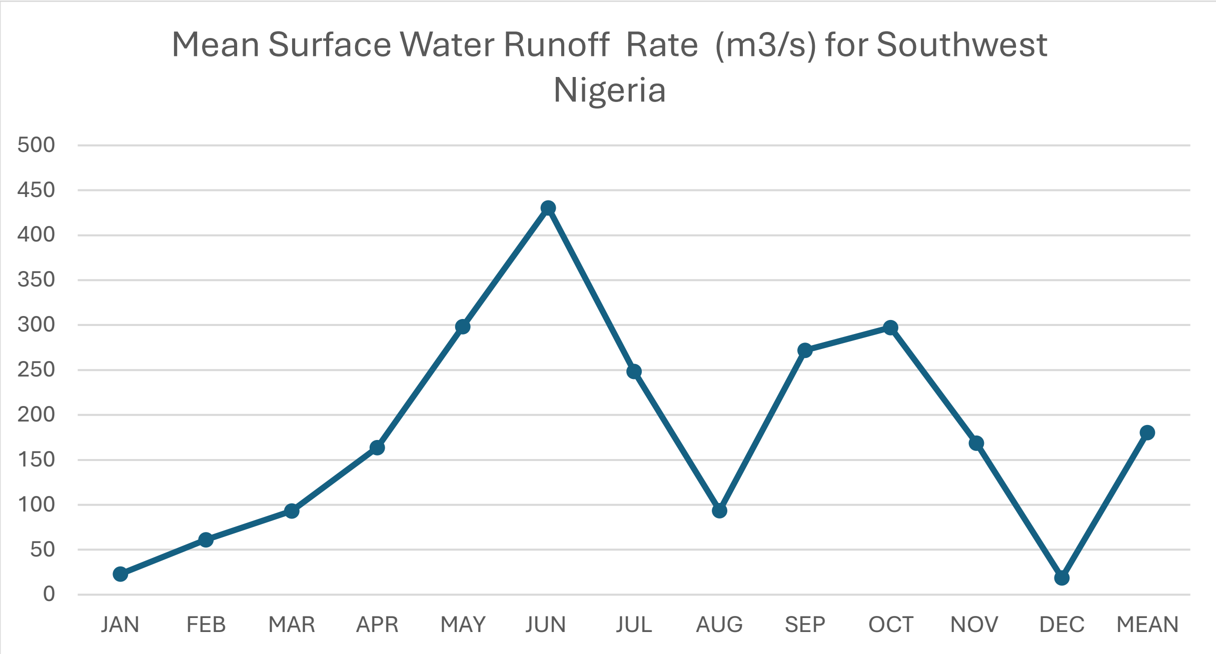
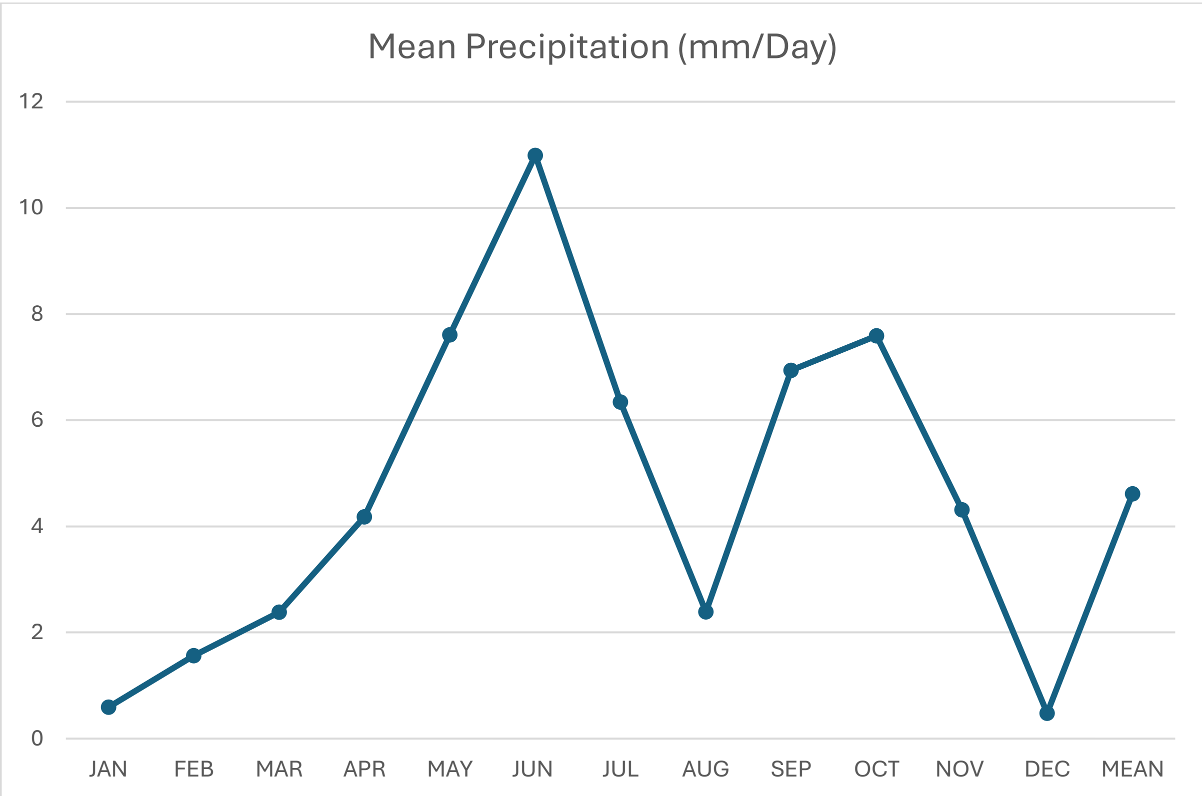


Fig. 6.1: Mean surface runoff flowrate in Southwest Nigeria



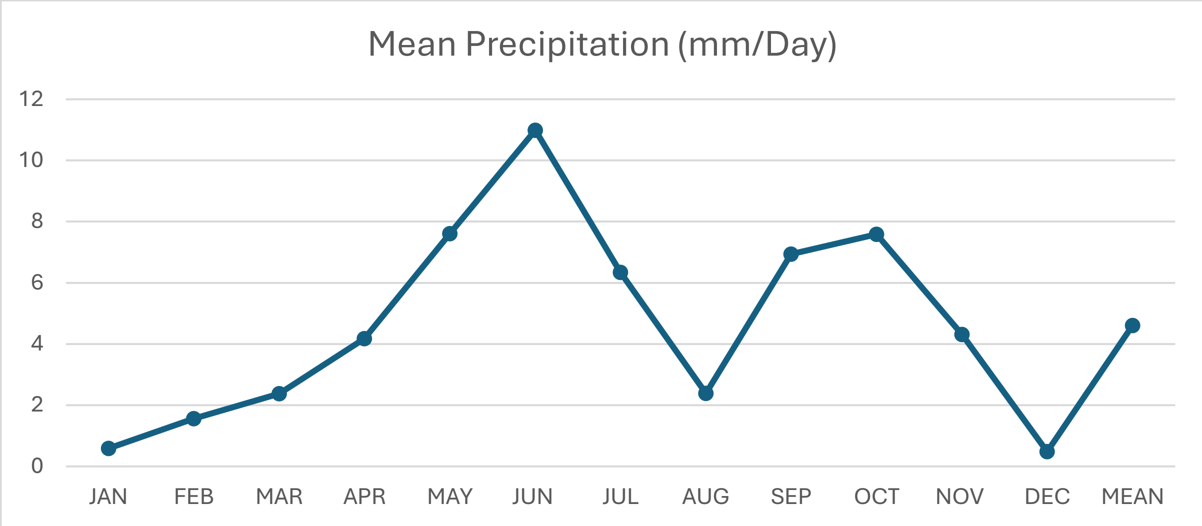


Fig. 6.2: mean precipitation rate in Southwest Nigeria

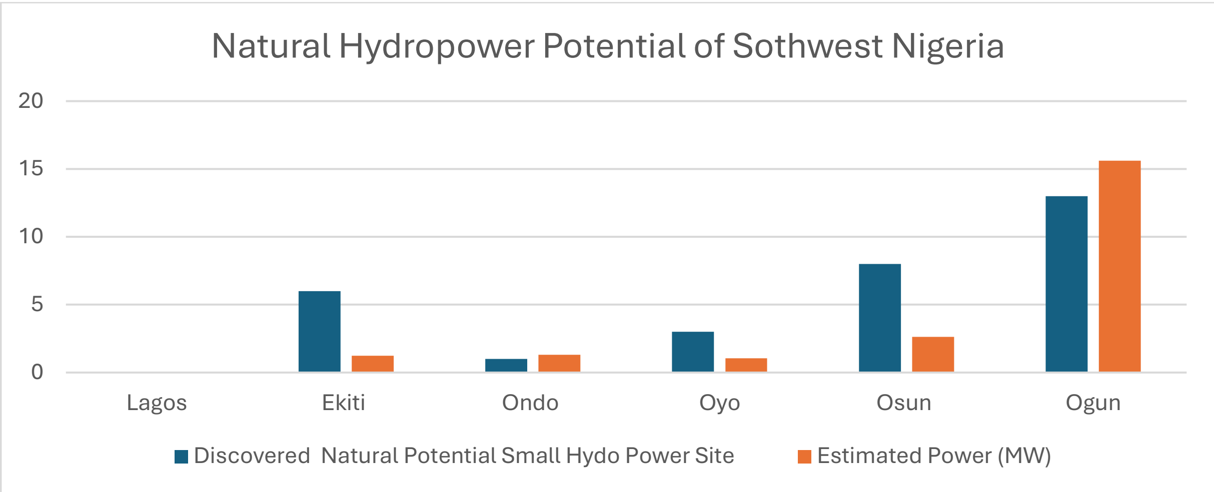


Fig. 6.3: Natural hydro power potential in Southwest Nigeria

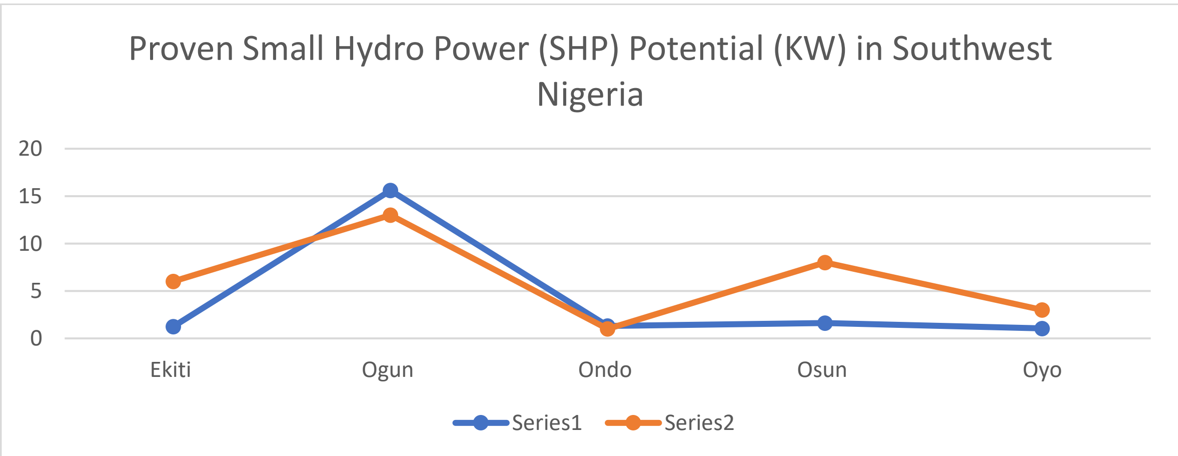


Fig. 6.5: Proven small hydropower potential in Southwest Nigeria

7.0. Conclusion and Recommendation

The exploration and exploitation of various potential small hydropower generation sites as a renewable energy resource present in Southwest Nigeria is key to tackling energy poverty and associated problems, given the high TEREVI score and general positive results of analysis in this study, which shows high competitiveness and the ability of projects to pay for themselves within 10years, even at the current least regulatory prices.

The need for adequate data cannot be overemphasized to ensure a comprehensive knowledge of all available SHP potentials and draw out a short, medium, and long-term development plan for the full implementation of SHP targets since upstream water management collaborations need to sometimes be made in concert with some other states or even nations as most rivers have their sources external to the region. The development of SHP should be an urgent imperative and most advisedly developed by state or local government authorities to minimize bureaucracy and ensure shorter turnaround times in actioning various phases of project implementation and requisite authority approvals.

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