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Hydro Power Potential in Mozambique "CHUA- MANICA"

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Abstract

Hydropower energy is one of most promising clean energy technologies, however this energy technologies has many challenges if compere other renewable energy for example Biomass, solar, wind energy, has high capital investment cost. In Mozambique, access to conversional energy in form of electricity has been limited to most of the rural population. The objective of this investigation research is to analyze the Chua Micro-Hydropower Plant exploration in Manica district in Mozambique and to examine the possibility of increasing energy production. The current total installed power generation capacity in Mozambique is about 939MW. Hydropower contributes 561 MW, making a contribution of 61%, oil contributes 27%, and natural gas 12% of the total electric grid generation in Mozambique

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Kaywords: Hydro power, Enerrgy, Mozambique

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1. INTRODUCTION

Hydropower energy is the most effective source of energy and electricity and has played a major role in the development of modern civilization and hydropower energy is kind of Renewable energy that comes from moving water and converts into electricity[1-3].
Hydropower technology has some benefits than fossil fuel; it is a renewable source of energy with no emissions of carbon dioxide in comparison to other forms of energy and fossil fuel. In addition, hydropower projects can be used for multipurpose use, such as irrigation, fishery, flood control and water supply and getting access to modern energy services is fundamental in fulfilling basic social needs and driving economic growth, as well as has an effect on productivity, health, education, safe water and communication services[1-5].
Mozambique has vast amounts of energy resources which include solar, wind, biogas, coal, natural gas, hydropower, biomass and geothermal power. Biomass related type of fuel is considered both cheap and more accessible to the poor majority in rural and urban areas, thus becoming the most exploited source of energy. Biomass energy resource, which are in the form of fuel-wood and charcoal derived from natural forest and plantations, accounts for over 90 percent of the total energy consumption in Mozambique**[5-8]**

1.1. CURRENTLY HYDROPOWER ENERGY OUTLOOK OF MOZAMBIQUE

Hydropower is most important commercial source of energy in Mozambique, with the potential estimated about 14,000 MW, and about 2,300 MW has so far been developed 2,075 MW at Cahora Bassa Dam over the Zambezi River and the remaining is from Small Hydro power plant and Outher sources like Biomass and Fossil fuel by Figure1.
The hydropower potential in Mozambique is attractive with hydropower potential estimated to 12000 MW of which only roughly 2200 MW has been develop to access the national grid, the government of Mozambique has placed rural electrification as a major component of its development programs to meet demand. Furthermore, Mozambique has liberalized its energy sector and allowed inflow of foreign direct investment into hydro projects. The government of Mozambique has adopted a number of broad policy objectives relating to the Development and governance of the energy sector. The government bears the responsibility of rural electrification in terms of creating an enabling environment for all stakeholders [9-10]. Development of Renewable energy in Mozambique dates back during the colonial period where hydropower plants were developed to supply power to large urban city like Maputo, beira and Nampula and even to some part of energy for selling to South Africa. The total energy mix installed in Mozambique according [11]was 408.9 PJ and it can see that Hydropower is 13%, biomass 78% , 7%Oil product and other resources 2%.

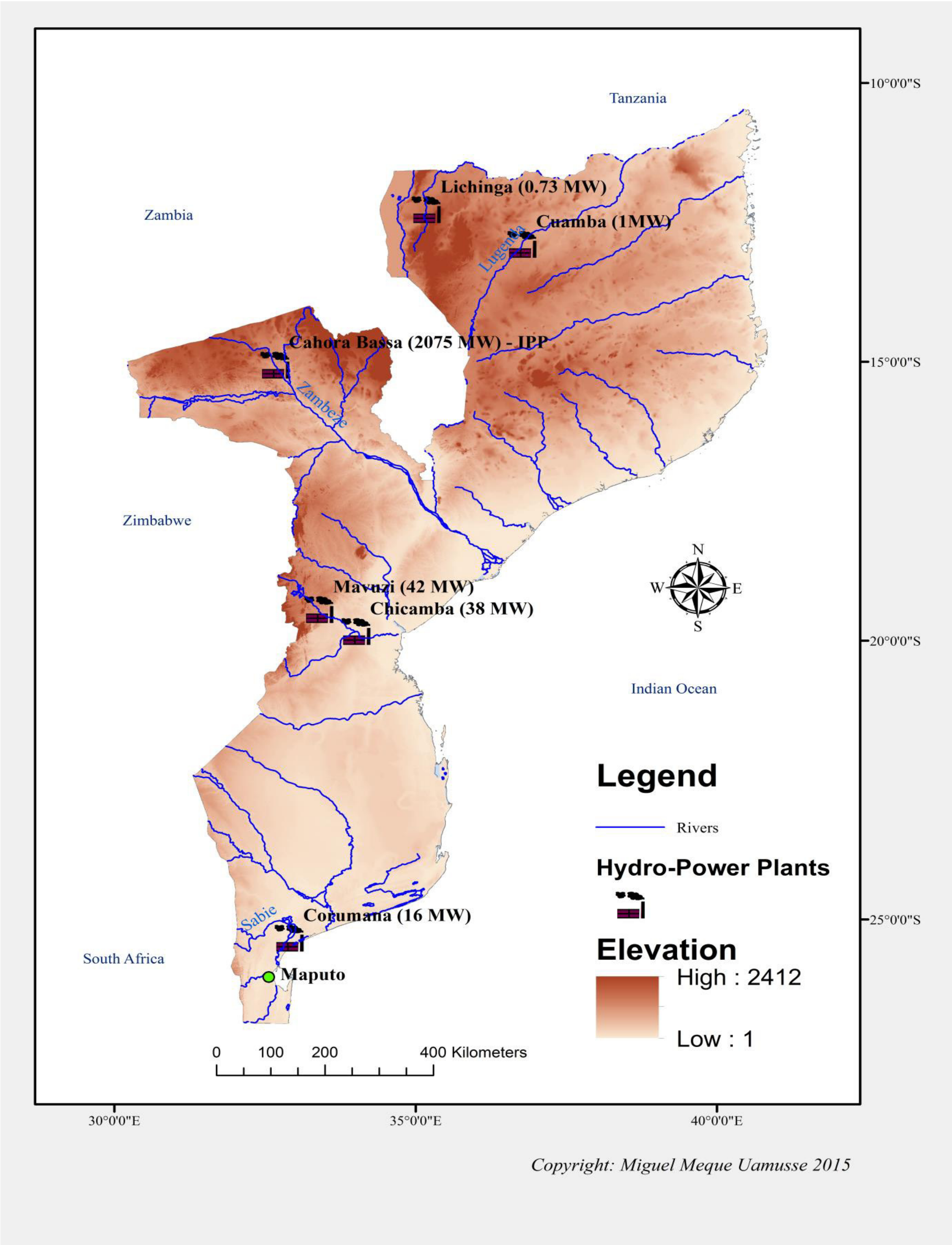

Figure1. Currently hydropower distribution in Mozambique

1.2. THE STUDY AREA

Mozambique occupies a territory located on the south-eastern coast of Africa, between the latitudes 10 and 27 south and longitudes 30 and 41 east. Chua is located located in Manica District at Manica province. Manica is a district of Mozambique in the Manica Province with a population of 215275 people and an area of 4.391Km². Manica District borders with the Republic of Zimbabwe in the west, the District of Gondola in the east, the District of Barué to the north through the Pungué River, and the District of Sussundenga in the south, which is bounded by the Revué and Zonué Rivers see Figure 2.

The climate in the district of Manica, according to Koppen climate classification is the moist temperate type.The rainy season starts in November and its end, in April and that the average annual is about 1220-1290 mm evapotranspiration.

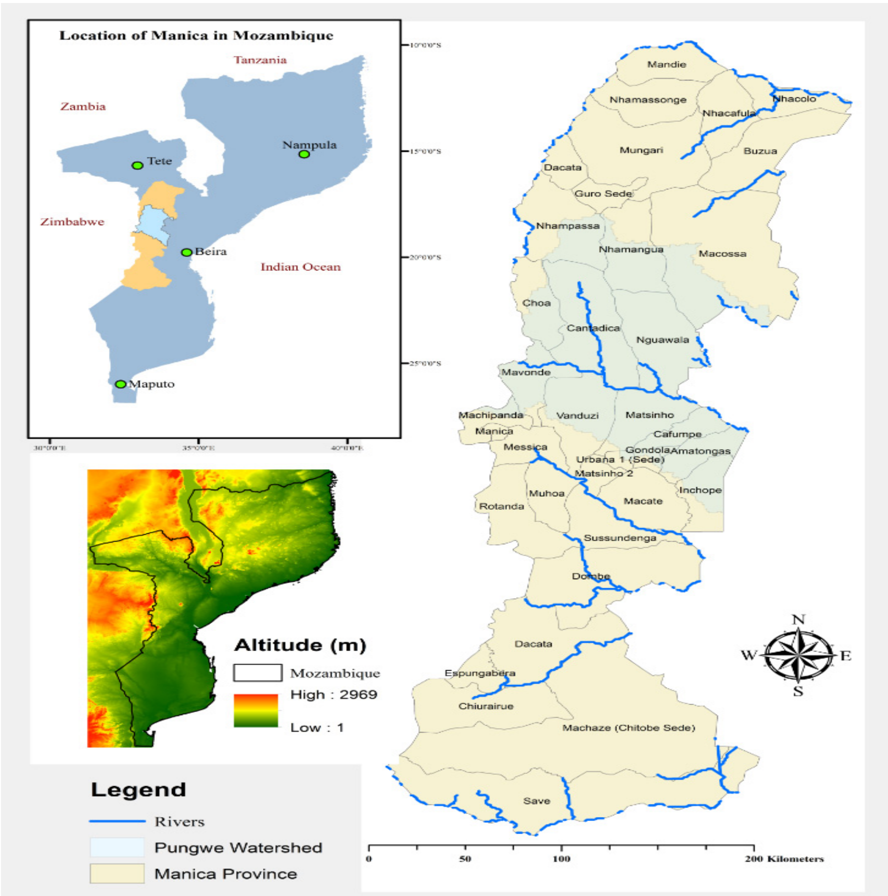

Figure 2. Mozambique map and area under study “Manica Disctrict

2. MATERIAL AND METHODS

For the purpose of this research and to achieve the above research objectives the following activities were carried out, literature search, materials and technology survey, and to do assessment of old hydropower potential at Chua in Manica district requires the following:

2.1. Literature Review

In order to have a better understanding and obtain useful information in the research area, various literatures in hydropower, small hydropower development and past research in this research area and the existing turbines for Small hydro power plant were reviewed. From past research, literatures and existing units; methods, strategies and techniques for developing hydro turbine were established.

2.2. Net Available Head

The net available head (H) equation (3) was estimated as the difference between available geometric head equation (4) and total head losses from headrace to tailrace equation (5), equation, resulting from simplification of energy equation (1) and continuity equation (2).

$$\Delta P = \frac{1}{2}\frac{\rho \cdot f \cdot L \cdot V^2}{D} \quad \textbf{(1)}$$

$$Q = A.V \Leftrightarrow V = \frac{4Q}{\pi D^2} \quad \textbf{(2)}$$

$$H = H_g - \sum h \quad \textbf{(3)}$$

Where Σh is sum of head losses (equation-3) and head losses-h_f (Equation 4) due to pipe friction and local constriction (Equation -5)- h_L

$$H_f = \frac{8 * f * L * Q^2}{\pi^2 * g * D^5}[m] \quad \textbf{(4)}$$

$$H_L = \frac{8Q^2 * \Sigma K}{\pi^2 * g * D^4}[m] \quad \textbf{(5)}$$

Where: f is Darcy friction factor, L is Length of the pipe (m), Q is flow rate (m^3/s), K is resistance coefficient based on type of local construction and **g** is gravitational accelerations $m.s^{-2}$.

2.3. Hydrological Correlation Analysis

To estimate the flow, analysis was made by utilizing the available historical flow data records from a nearby gauging station on the Chua River. A set of historical flow data recorded for 39 years dated from 1954 to 2004 were used Wavelet neural network model (WNN). The time series of the collected data sample for a period of 48 years was plotted. Equation 1 and 2 were computed to check if gauged points are correlated WNN method and forecasting Models search as Coefficient of correlation and root mean square error are used [12-13].

$$R^2 = 1 - \frac{\sum_1^n (Q_{measured} - Q_{predicted})^2}{\sum_1^1 (Q_{measured} - Q_{mean})^2} \quad \textbf{(6)}$$

$$\text{RMSE}=\sqrt{\frac{\sum_1^n\left(Q_{measered}-Q_{predicted}\right)^2}{n}} \quad \textbf{(7)}$$

Where: Q is flow in m^3/s

2.4. Power Generation

The power generated from hydraulic turbines is a function of the available net head, the flow rate, and the efficiency of the turbine[5]. It can be estimated by:

$$P=\frac{\eta.\rho.gH.Q}{1000}\left[\kappa W\right] \quad \textbf{(8)}$$

Where; P = Power estimate (kW) ,η = Efficiency of the turbine ,ρ = Density of the water (kg/m3)
g = gravitational constant (m/s^2).

2.5. Selection Of Turbines

Since, the net head of the mini hydropower system at Chua stream is 48 m and the design discharge is 0.15 m^3/s; therefore, from turbine chart, Figure 3 the appropriate turbine for this scheme is Pelton with efficiency of 80 - 90% whose rated power capacity is 52 kW.

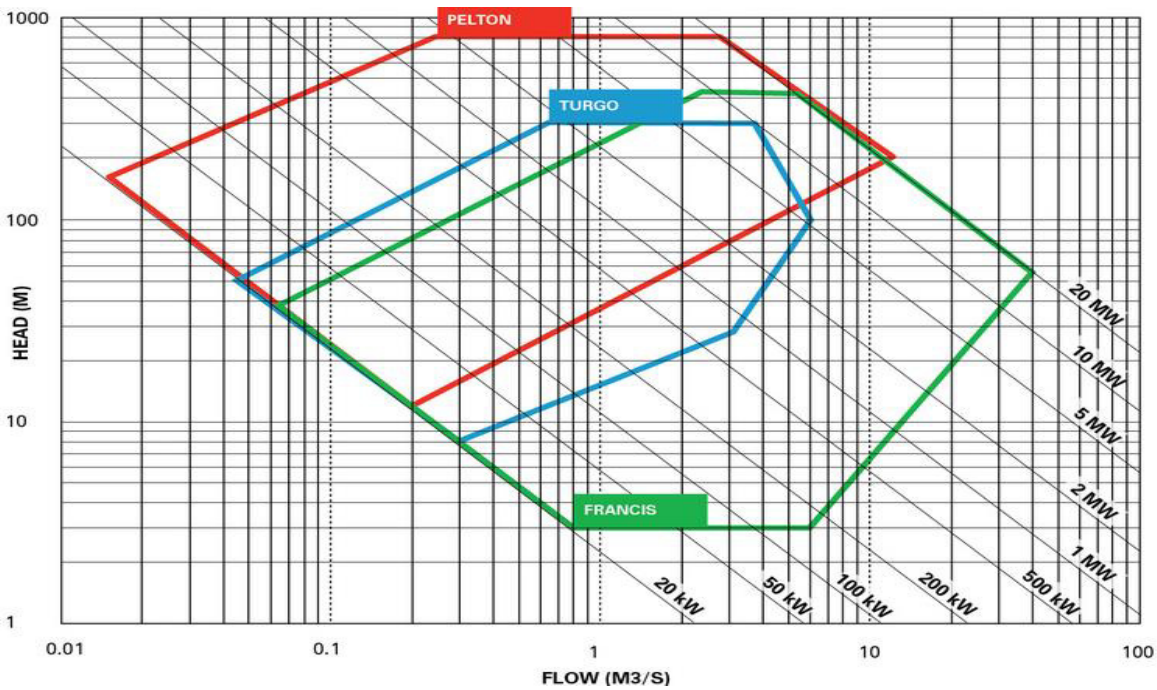

Figure 3: Turbine Selection, adapted in this Source: **http://www.gilkes.com/Turbine-Selection (01/09/2015**

3. RESULTS AND DISCUSSIONS

After a thorough investigation Table 1 show results of thios work are power potencial 52 kW while total energy demand are 1576 MWh and with this energy can electrify some houses including some buildings like Hospital, can develop small industries such as mills, water distribution, sterilize hospital supplies

Table1. The result of research

Parameter	Result	Unit
P	52	kW
H	90	m
E	1576	MWh

To estimate the flow, analysis was made by utilizing the available historical flow data records from a nearby gauging station on the Chua River. A set of historical flow data recorded for 39 years dated from 1956 to 2004 were used Wavelet neural network model. The time series of the collected data sample for a period of 48 years plotted. Moreover, to assess the performance of model we find training and validation coefficient of correlations is (R^2) is 0.9031 and 0.89 while the root mean square error is (RMSE) is 258 and 176.4 and NSE is 0.771 and 0.72

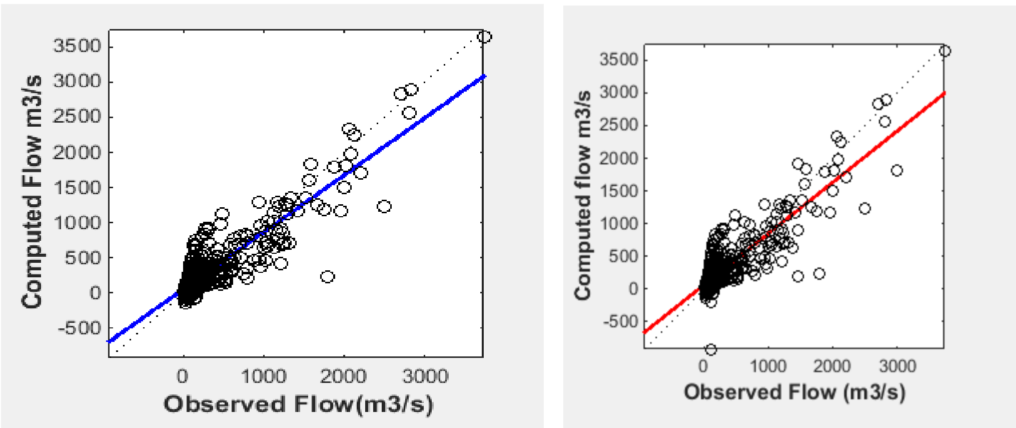

Figure 4. Scatter plot between observed an validation flow

4. CONCLUSIONS

The Chua village in Manica, the presence of electricity will be a major drive towards contributing to economic and social sustainability of the village. The power availability will change the livelihood of the villagers, resulting into creation of jobs such as small business enterprises. This will add some income to the village community.

This study were carried out with aim of capacity optimization study of chua mini-hydropower plant at Chua River in manica Mozambique where a hydropower was used used for milling corn other cereals. After this study, we can see is possible to increase power demand in Chua Hydropower plant to 52 kW and the power demand of the village can increase. Success refurbishing or upgrading of a small-scale hydropower schemes will create job opportunities during the good operation, as well as provide energy to households and promote some economic activities such as trade and irrigation**.**

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References

[1] Linus Hammar, Helene Ahlborg, Sverker Molander; Power sectors actors' views on productive use, private sector involvement, and renewable energy in rural electrification of Mozambique and Tanzania; 2011, Manuscript.

[2]Chiyembekezo S. Kaunda, Cuthbert Z. Kimambo, and Torbjorn K. Nielsen, "Hydropower in the Context of Sustainable Energy Supply: A Review of Technologies and Challenges," ISRN Renewable Energy, vol. 2012, Article ID 730631, 15 pages.

[3]L. Kosnik, "The potential for small scale hydropower development in the US," Energy Policy, vol. 38, no. 10, pp. 5512–5519, 2010.

[4].Project paper on a proposed restructuring of the energy reform and access project for the republic of Mozambique; Energy Team, Infrastructure Group, Africa Region, The World Bank; 2007

[5] Uamusse, M. , Persson, K. and Tsamba, A. (2014) Gasification of Cashew Nut Shell Using Gasifier Stovein Mozambique. *Journal of Power and Energy Engineering*, **2**, 11-18.

[6] H. Ahlborg, et al., A background on social context and renewable energy sources in Mozambique and Tanzania: an initial report from the STEEP-RES project, Chalmers University of Technology, in ESA Report 2008:21, 2008, Göteborg .

[7] Mishra, S., Singal, S. K., Khatod, D. K (2011), "Optimal installation of small hydropower plant-A review", *Renewable and Sustainable Energy Reviews* Vol. 15, pp. 3862–3869.

[8] Paish, O (2002), "Small hydro power: technology and current status", *Journal of Renewable and Sustainable Energy Reviews*, Elsevier Science Ltd, Vol. 6, pp. 537–556

[9] Nourani, V., Hosseini, A. , Adamowski, J., Kisi,O, (2014), Applications of hybrid wavelet–Artificial Intelligence models in hydrology: A review, Journal of Hydrology 514 , 358–377.

[10] Partal,T., Kisi, Ö. (2007), Wavelet and neuro-fuzzy conjunction model for precipitation forecasting. Jornal of Hydrology, 342,199-212.

[11] IEA, 2011b. World Energy Outlook: Access to Electricity. Available at:http://www.iea.org/weo/electricity.asp [Accessed March 7, 2012].

[12] IRENA, 2012.Mozambique RRA Preliminary Findings. Available at: http://www.irena.org/DocumentDownloads/Publications/RRA_Mozambique_English.pdf [Accessed March 8, 2012].