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PRELIMINARY SURVEY OF THE POTENTIAL SITES FOR HYDROPOWER PLANT DEVELOPMENT IN THE 5TH DISTRICT OF CAMARINES SUR: PHILIPPINES

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Abstract

Hydropower is a renewable energy resource that is available to various areas in any parts of the world. It is less expensive compared to other sources of energy and is environment-friendly since it does not release any greenhouse gases that may affect the environment. Rivers and falls are abundant water resources in the Philippines which are commonly found in many parts of the country. Rinconada is the common name of the 5th District of Camarines Sur province. This area is abundant of water resources such as falls and rivers, and potential sites for hydropower plant can be determined. Measurements of parameters and requirements served as bases in determining potential sites for the hydropower plant. Results found that Tubigan falls can produce a power capacity of 277.138kW, 73.561kW for the Itbog falls, 71.932kW for the Nalalata falls and 28.593kW for the Lologon river. These baseline data will be helpful for the Local Government Units and other institutions for future plans of installing hydropower plants in the areas.

I. Introduction

Energy is often known as the catalyst of socioeconomic development as per capita energy consumption. It is used as a barometer to know the development of the state in all important aspects [1]. Due to the demand for electricity, growing at an enormous pace of 93% in next 30 years, increasing from 20.2 trillion kilowatt-hours in 2010 to 39 trillion kilowatt-hours in 2040, the role of hydropower resources will be very important and this may be the major source of renewable energy in the future [2].

Renewable energy is energy collected from renewable resources which are

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constantly replenished and will never run out. This includes wind, solar, biomass, geothermal, hydrogen, ocean, hydropower and others. Hydropower or water power is power derived from energy of falling or running water, generally fast running water. Hydropower has been widely used as a source for generating electricity. It is clean energy technology. It helps slow down climate change since hydropower plants produces very small amounts of greenhouse gases [3]. It can be harnessed in many ways; tidal flows can be utilized to produce power by building a barrage across an estuary and releasing water in a controlled manner through a turbine; large dams hold water which can be used to provide large quantities of electricity; wave power is also harnessed in various ways [4]. Hydropower on a small scale, or micro-hydro, is one of the most cost-effective energy technologies to be considered for rural electrification in less developed countries [5]. Hydroelectricity is one of the most mature renewable forms of energy, providing about 20% of the world's electricity consumption [6].

Hydropower is an important renewable energy resource worldwide. As a renewable energy resource, it has many benefits including low operating and maintenance costs, no pollution nor greenhouse gas emissions, high efficiency (about 60-80%) and long-life equipment [7, 4, 8]. However, its development is accompanied by environmental and social drawbacks. Issues of degradation of the environment and climate change can negatively impact hydropower generation [9].

The Rinconada area is composed of six municipalities and one city. These are the municipalities of Nabua, Bato, Balatan, Buhi, Baao, Bula and the city of Iriga. Majority in these localities are rich in natural water resources such as lakes, rivers and falls. Possible sites for potential hydropower can be found in some of these localities.

This research is an exploratory study that determined the sites in the Rinconada area for potential development and installation of hydropower plant. Measurements of initial parameters such as flow rate of water and the head that is available was conducted. Data to these measurements served as basis in determining potential sites for the hydropower plant.

The study is deemed beneficial to the local governments in the Rinconada area. The local government units will be able to refer to the results of this study for possible water sources that have the potential of installing hydropower plant. With these, the LGU can seek funding or assistance for a possible installation of hydropower plant in the determined sites.

II. Methodology

This research is composed of the measurements of initial parameters of the water resources that served as inputs in determining the potential sites for mini-hydropower plants.

A. Research Setting

Itbog Falls is located in Barangay Sta. Cruz, on the southeastern side of Lake Buhi. Is an almost 60-feet, almost identical waterfalls cascading from atop Mount Asog. This not-so-known wonder of nature is tucked in the thriving vegetation of Buhi town. Together with Lake Buhi, Mount and Asog, Itbog serves as one of the town's major attractions [10]. **Nalalata Falls** is located in Barangay Lubgan, Bula, Camarines Sur. The falls hves an impressive gush of water providing a cool mist and spray to the area. The falls have an approximate height of 60 feet. Water streams down to a pool basin that is good for swimming [11]. **Tubigan Falls** is located in Waras river in sitio Tubigan in Brgy. Sta. Maria, Iriga City. It is 15 km from the city proper. **Lologon River** is located in Barangay Monte Calvario, Buhi, Camarines Sur. Lologon is a local dialect in Buhi which literally means "to be entered" in English [12]. Figures 1 show the four falls: a.) Itbog falls [13], b.) Nalalata falls [14], c.) Tubigan falls [15], and d.) Lologon river.

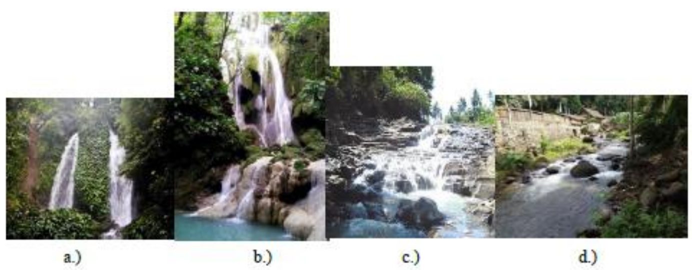

Figure 1. Falls.

B. Parameter Measurements

Water resources may be utilized for power generation if it possesses enough potential energy. Commonly, water flows from highlands to lower elevations. As this happens, the potential energy decreases through evaporation, drop in elevation, friction and turbulence. The remaining part can be used by turbines and generators to convert mechanical energy into electrical energy.

Field computation were done after gathering the data of the selected sites. Vertical distance was determined from $V_d = Ks \cos\theta \sin\theta$, where V_d is the vertical distance in meters, K is the stadia interval factor, s is the stadia interval and θ is the inclination angle.

To compute the head of the water, it was determined from, $H = R_m + V_d - I_H$, where H is the head in meters, R_m is the middle rod reading, V_d is the vertical distance and I_H is the height of the instrument.

In computing for the discharge, the Manning's equation was used. This equation best represent the law of flow in open channels, from $Q = A_T V_a$, where Q is the discharge in $m^{3/s}$, A_T is the cross-sectional area and V_a is the actual velocity.

The amount of water power developed from any stream, river or lake is a function of mainly, the flow rate of water and the head that is available. Hydroelectric power and energy that can be generated in a hydropower plant is determined from, $P = \gamma Q H_n \eta$ and $E = \gamma Q H_n \eta \Delta t$, where P is the power in kW, γ is the specific weight of water in kN/m3, Q is the discharge in $m^{3/s}$, H_n is the net head (gross head minus hydraulic losses) in meters, η is the overall efficiency (%), E is the hydroelectric energy in kWh and Δt is the time interval for power generation in hours [16, 17, 18].

III. Results and Discussions

Ocular inspection and surveys were conducted to determine the present actual condition of each sites from August to October, 2019.

A. Survey

Stadia surveys were conducted to measure the head of the system. Table

1 shows the corresponding rod readings in each site. The rod readings were used to calculate the head of the system.

Table 1. Field Data.

Location	Rod Reading			Height of Instrument (m)	Vertical Distance (m)
	Upper (m)	Middle (m)	Lower (m)		
Itbog Falls	2.3	2.2	2.1	2	4.021
Nalalata Falls	1.1	1	0.9	1.37	4.039
Tubigan Falls	0.87	0.8	0.73	1.40	3.58
Lologon River	1.35	1.3	1.25	1.475	1.899

B. Head of the Water

To measure the head (h), the vertical distance through which the water drops between the points where the water inlet pipe is located was measured. Below is the computation for the head of water. Table 2 shows the summary of the data obtained from the above computation. The highest computed head of water is at Itbog Falls which has 4.221 m followed by the Nalalata Falls, Tubigan Falls then the Lologon River.

Table 2. Condition of the Selected Sites in terms of Head of Water.

Location	Middle Reading (m)	Vertical Distance (m)	Height of Instrument (m)	Head (m)
Itbog Falls	2.2	4.021	2	4.221
Nalalata Falls	1	4.039	1.37	3.669
Tubigan Falls	0.8	3.580	1.4	2.980
Lologon River	1.3	1.899	1.475	1.724

C. Float Method Measurement

The float method is the simple method to measure the velocity and flow rate in a river by putting a floating object just beneath to reach a specified distance [19]. This method was done by getting the recorded time of a floating water bottle along the current of the falls up to the desired length of the area up to three trials. The results are shown on Table 3 where the site that has the highest average velocity is Tubigan Falls that has 2.403. Next is the Lologon River, Itbog Falls and lastly, the Nalalata Falls.

Table 3. Average Velocity at 5 m distance.

Location	Trial	Time (sec)	Velocity (m/sec)	Average Velocity (m/sec)
Itbog Falls	1	9.45	0.529	0.565
	2	9.27	0.539	
	3	7.98	0.627	
Nalalata Falls	1	17.77	0.281	0.263
	2	20.82	0.24	
	3	18.58	0.269	
Tubigan Falls	1	2.51	1.992	2.403
	2	1.71	2.924	
	3	2.18	2.294	
Lologon River	1	8.52	0.587	0.643
	2	8.33	0.6	
	3	6.75	0.741	

In table 4, the Tubigan Falls has the highest discharge rate among the four sites, followed by the Nalalata Falls, Itbog Falls then the Lologon River.

Table 4. Condition of the Selected Sites in terms of Discharge Rate.

Location	Average	Actual	Cross	Discharge

	Velocity (m/sec)	velocity (m/sec)	Sectional Area (m2)	(m3 /sec)
Itbog Falls	0.565	0.4803	4.3507	2.09
Nalalata Falls	0.263	0.2236	10.515	2.3512
Tubigan Falls	2.403	2.0426	5.46	11.153
Lologon River	0.643	0.5466	3.6384	1.989

Table 5 shows the result for the power capacity of each site. This was computed with an efficiency of 85%.

Table 5. Condition of the Selected Sites in terms of Power Capacity.

Location	Discharge (m3/sec)	Head (m)	Theoretical Power (kW)	Power Capacity (kW)
Itbog Falls	2.09	4.221	86.542	73.561
Nalalata Falls	2.3512	3.669	84.626	71.932
Tubigan Falls	11.153	2.98	326.045	277.138
Lologon River	1.989	1.724	33.639	28.593

The Tubigan Falls has the highest power capacity that has 277.138kW which can be classified as mini-hydro, followed by the Itbog falls (73.561kW; micro-hydro), Nalalata falls (71.932kW; micro-hydro) and Lologon River (28.593kW; micro-hydro).

IV. Conclusions and Recommendations

This study investigated the potential of hydropower in selected sites in the Rinconada area. The condition of the selected sites varies in terms the head of water, discharge rates and power capacity. Tubigan falls were revealed to generate the highest discharge rate as well as power capacity followed by Itbog falls and Nalalata falls. Lologon river exhibited to produce the lowest power capacity. Hydropower plant development in these areas are mini-hydro for Tubigan falls, and micro-hydro for the rest.

The utilization of the research findings paves the way for the development of plans and designs of a hydropower plant in the area. The results can serve as baseline data of the requirements for hydropower in the selected sites in Rinconada for the possible installation of a hydropower plant in the future. The condition of the sites can be validated further by conducting assessment study whose data will be gathered on different weather seasons to determine possible variation in the results. It is suggested that a long-term assessment be conducted to determine the effects of climate variation on hydropower development. Various assessment tools and methods can be applied to evaluate spatially variable head, slope and discharge which determines the power potential of water resources.

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