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Potential Development Of Micro-Hydro Power Plant In Bribin Underground River As Energy Efficiency On Gunung Sewu Karst, Gunung Kidul, Yogyakarta

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ABSTRACT

Electrical energy is one of the main needs in society. However the magnitude of demand for electricity needs, not balanced with the availability of electrical energy. As some regions in Indonesia have not received electricity. Base of The condition is the background of the emergence of small-scale electricity generating technologies such as micro-hydro that can be applied in areas that are difficult to access. One of the requirements of microhydro energy is the presence of adequate volume and flow debit. In karst areas such as Karst Gunung Sewu often appears underground river. One of the existing underground river systems in the study area is the Bribin-Baron underground river which is one of the main river systems in the Gunung Sewu kasrt region. The method used in this research is to collect secondary data from various literatures which then done field checking directly. Then performed analysis and evaluation of the data obtained. From this research it is found that Bribin river has some ideal location for developed micro-hydro power plant. There are locations that have been developed micro-hydro power plants and some places have potential to become new locations of micro-hydro power plants. Potential locations are usually located in karst caves through which River Bribin like Ngerong Cave. The development of micro-hydro power plants is expected to increase energy effectiveness in this area.

INTRODUCTION

Energy is a very important aspect in our life. Along with the increasing of living things, the energy needed is also increased. Therefore, a potential new energy resource that can be used sustainably is needed. One of the potential energy resource that has not been used well is water energy. Water that can be utilized by the community is not only water that is on the surface, but also underground water river can be used to fulfill their daily needs, for example in karst areas.

In Gunung Sewu Karst area, there are several underground rivers that provide clean water for everyday life and agriculture. The underground river flow on Gunung Sewu Karst area has sufficient discharge value to fulfill human needs of the surrounding community. One of the potential underground rivers in Gunung Sewu Karst area is Bribin River. This underground river has potential to be used as a Micro Hydro Hydroelectric Power Plant with sufficient high differences and a discharge value of 1,500 liters/ second (Water Resources Research and Development Center, 2010). The flowing direction of Bribin underground river is controlled by geological structures (cracks, fractures, faults, and sloping of layered rocks) and estimated start from Tambakromo, Ponjong District, Gunungkidul until it ends at Baron Beach (Kusumayudha, et al, 1998, 1999 at Kusumayudha, 2004).

In 2004, a water drilling and pumping project was started in Bribin River by a collaboration between BATAN, DIY Provincial Government, Indonesian Ministry of Research and Technology, German Government, German Karlsruhe University, German Herrenknecht Aktien Gesellschaft, and several other Indonesian institutions. The goal of this project is tend to build a micro hydro power plant in Bribin River. Therefore, it can be used optimally and sustainably for the community. Meanwhile, there are some obstacles in its realization that makes this project does not work anymore. This study was conducted to explain how the microhydro potential in Bribin River flow based on primary and secondary data which then resulted in an assessment of the potential and determination of potential locations for micro hydro construction on Bribin River.

Micro-Hydro Potential on Gunung Kidul

Micro-hydro Power Plant (PLTMH) is a power plant that uses hydraulic water energy, differences in altitude, as well as the amount of water discharge to produce electricity that has a small scale, unlike the Water Method Power Plant (PLTA). William & Porter (at Sentanu, 2013, at Ridwansyah, et al 2015), classified the types of hydroelectric power plants according to the generation capacity as follows; 1) large-scale hydropower> 100 MW, 2) medium-scale hydropower 10 - 100 MW 3) small scale hydropower 1 - 10 MW, 4) PLTM (Mini-hydro) 100 KW - 1 MW, 5) PLTMH (Micro-hydro) 5 - 100 KW and 6) Pico-hydro <5 KW.

According to the Ministry of Energy and Mineral Resources of the Republic of Indonesia (2017), basic principle of this power plant is to convert the potential energy of water into mechanical energy with the using of a turbine, then converted into electrical energy by a generator. Bribin underground river has micro-hydro potential with a water discharge value of 1,500 liters/second (Center for Research and Development of Water Resources, 2010). According to MacDonald et al (1984), in Nestmann (2003), the discharge will increase dramatically in rainy season.

In addition, Bribin River management is also build a dam by closing the entire underground cave hole. Therefoe, it raises the ground water level. With a high water level, the differences in height of water pressure (head) will also be higher. Discharge and high water pressure differences are needed to build a micro-hydro power plant (Center for Research and Development of Water Resources, 2010).

Study Area

The study are is located in Bribin River, Semanu District, Gunungkidul Regency, Special Region of Yogyakarta, Indonesia. This area consist of clastic and non-clastic limestone that makes it has many karst caves and underground rivers. Detailed location of this research located in Ngreneng Cave, Bribin I Cave, and Bribin II Cave which Bribin underground river flow below it. Distance location is about 60 km away from Univeristy of Pembangunan Nasional "Veteran" Yogyakarta and can be reached using two-wheeled or four-wheeled vehicles for 1 - 1.5 hours.

Fig. 1 Study Area, Source : Google Earth 2018

METHODOLOGY

The research methodology is collecting secondary data from previous research. Secondary data includes data on geological structure, rainfall, Bribin micro hydro power plant research that has been done previously, and the cave distribution data in Gunungkidul.

In addition to collecting secondary data, field observations were also carried out in the form of interviews and direct data collection on the Bribin River supported by secondary data that had previously been obtained. The location of observation and data collection was conducted at Bribin / Bribin I Cave, Sindon / Bribin II Cave, and Ngreneng Cave.

Then, the secondary data and field observation data are evaluated and analyzed to produce an assessment of the micro hydro power plant potential of Bribin River. From the assessment, the micro hydro potential locations in the Bribin River were determined.

GEOLOGY

Litostratigraphy

In regional stratigraphy, according to the lithostratigraphic naming of the Regional Geological Map Sheet of Surakarta-Giritontro scale 1: 100,000 by Surono, et al (1992) formation from old to young are Kebobutak Formation, Semilir Formation, Nglanggran Formation, Semilir Formation, Sambipitu Formation, Oyo Formation , then the Wonosari Formation.

The Southern Mountains Basin consists of rocks from volcanic activity and carbonate sediments. Carbonate material began to grow intensively in this basin after volcanic activity began to weaken in the Middle Miocene. The set of carbonate rocks forms karst topography, called Thousand Hills (Surono, 2009) or known as Sewu Mountains (Gunung Sewu), Gunung Kidul. The research area is included in the Wonosari Formation. Where the Wonosari Formation is deposited horizontally with the Oyo Formation that is located below it. The Wonosari Formation is composed of layered limestones at the bottom of the formation and reef limestones at the top of the formation. (Surono drr., 1992).

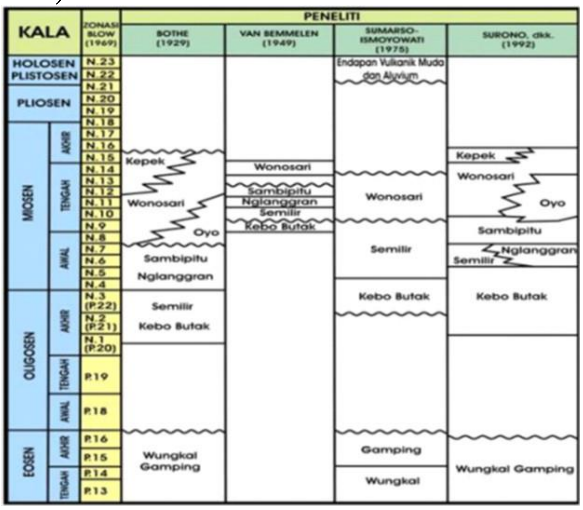

Fig. 2 Regional Stratigraphy on Southern Mountains Zone (Surono et al., 1992)

Geological Structure

Java Island is a pattern that has a fault and fold geological structure that affects its land conditions. Based on regional geological maps, the geological structure that developed in the Southern Mountains is dominated by structures northeast-southwest and northwest-southeast. The general direction of the northeast-southwest fault is parallel to the structure of the Meratus Pattern. According to Prasetyadi, et al (2011), the northeast-southwest fault group was formed due to the subduction of the Indian-Australian Plate under the Eurasian Plate at the end of the Cretaceous. This fault group was found in rocks older than Late Eocene - Middle Miocene. While the northwest-southeast group fault is generally an ascension.

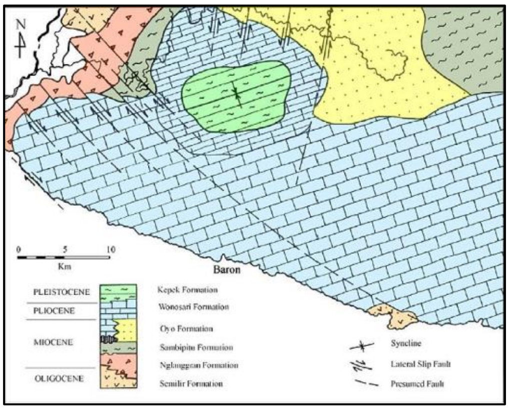

Fig. 3 Geological Map of Gunung Sewu Karst Area (Kusumayudha drr., 2015)

Geomorphology

According to Kusumayudha, et al (2015), morphology in the study area can be divided into morphology with positive and negative reliefs. Morphology of positive relief is a hill with a height of 10 - 90 m in the form of convex-cone, hills of cone, dome, comvex and ridge shapes. While the negative relief morphology is shaft, cave, doline, uvala, polje, and locva. Not only on the surface, interesting morphology also found on the subsurface, such as stalactite, stalagmite, pilar, sinter, and flowstones. The formation of the morphology is strongly influenced by its physical properties and geology structure.

RESULT AND DISCUSSION

Identification of Study Area

a. Map of Underground River Flow Bribin And Cave Distribution

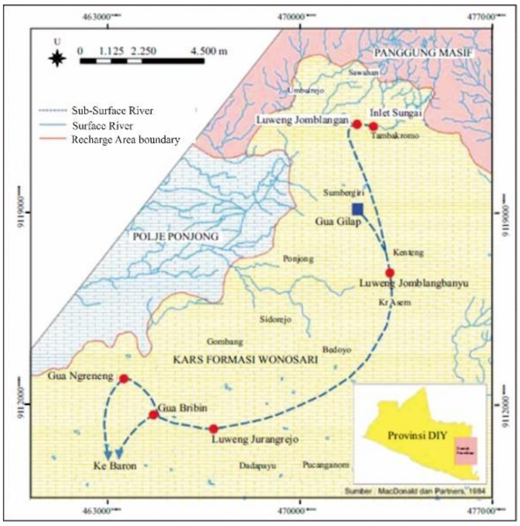

Fig. 4 Bribin River System (Adji, 2011)

Hydrogeologically in the Gunung Sewu karst area, there are several underground river basins with Baron River as its main river (which end at the Indian Ocean) located in south of the Wonosari Basin, with north-south flowing direction. The Baron River has several tributaries, from the largest are Bribin River (1 and 2), Suci River, Serpeng River, and Tegoan River.

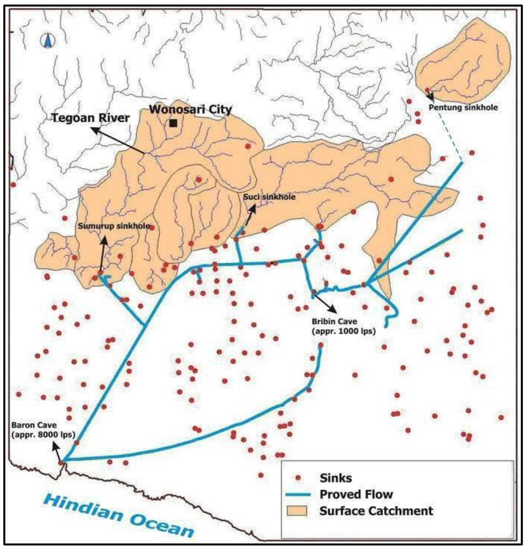

Fig. 5 Bribin River Catchment and Bribin-Baron System (MacDonalds and Partners, 1984 in Adji, 2011)

b. Discharge

The flow of Bribin River has been measured and analyzed by previous researchers several times. Subratayati (2008) said that the Bribin River had a discharge between 800 - 1500 liters/second. Bribin River discharge according to PDAM Gunungkidul Regency (2009) in Wardhana, et al (2013), reaching 800 liters/second - 1000 liters/second. Whereas according to the Pusat Penelitian dan Pengembangan Sumber Daya Air (Bahasa) (2010), the underground river discharge in dry season is still very sufficient for the needs of the community with a discharge value of up to 1,000 liters / second.

According to the Pusat Penelitian dan Pengembangan Sumber Daya Air (Bahasa) (2010), Bribin River has a very large water storage capacity of 400,000 m3. With dams integrated with micro hydro power plants, the Bribin River water level can reach 15 meters and can flow 70 liters/second of water to the surface constantly and continuously.

c. Gross Hydraulic Power Calculation of Bribin River

Asrori (2011) said that grass hydraulic power is the power from water energy based on gross head (Hg) and the hydraulic. There is equality that can calculate gross power based on its discharge and gross head:

$$P_h = \gamma . Q_d . H_{gross}$$

P_h : Gross Hydraulic Power (Watt)

γ : Water Density (N/m^3) = 9810 N/m^3

Q_d : Discharge (m^3/s)

H_{gross} : Gross Head (m)

$$P_h = \gamma \; . \, Q_d \, . \, H_{gross}$$
$$= 9810 \text{ N/m}^3 . \, 1{,}5 \text{ m}^3\text{/s} \, . \, 240 \text{ m}$$
$$= 3531600 \text{ Watt}$$
$$= 3{,}53 \text{ MW}$$

Bribin River discharge is 1500 liters/second or 1.5 m^3/s. With a gross head 240 m for the installation of turbine tools in Kanigoro area. From the calculation, gross hydraulic power value is 3,53 MW.

Assessment

Assessment of potential micro-hydro power plant in Bribin was conducted through two approaches : the qualitative and quantitative methods. The qualitative method focuses on some parameters, they are location, geology, morphology, hidrology, accessibility, and socio-cultural condition. Table 1 below is shown the qualitative assessment of potential micro-hydro power plant in Bribin.

Then for the quantitative method is numerical assessment (valuing) or scoring based on the parameters on qualitative methods. The objective of this method is to know and understand where the most have big potential to become a micro-hydro power plant. Six classes of values have been made for this purpose (Table 2): 0 = none; 1 = very poor; 2 = poor; 3 = fair; 4 = good; and 5 = very good (Rekinagara, 2018). And the score which was mentioned above is representating each potential-value based on perceptions of these criteria, where the score 0 means that the site have no potential at all for micro-hydro power plant and the score 5 means that the site has very good potential for micro-hydro power plant.

Evaluation

This evaluation was done by using SWOT Analysis (Table 3). SWOT analysis uses parameters such as strength, weakness, opportunities, threts. Which aims to find out the problems that exist in the area of Bribin and efforts that can be done to anticipate it.

Table 3 SWOT Analysis of potential micro-hydro power plant in Bribin River

No.	SWOT	Remark
1.	Strength	1. Road access is already available to reach the study area 2. Gunungkidul has lots of interesting tourist attractions such as caves and beaches 3. Ngreneng Cave is also potential to be a tourist attraction 4. Some sites in Gunungkidul have economic value 5. Bribin River has scientific value, especially for scientist and engineer 6. The discharge of Bribin River reaches 800 liters/second – 1,500 liters/second 7. Water from the Bribin River has been used as a source of clean water for the community both for life and agriculture 8. There have been many previous studies that prove that Bribin River is very potential for micro hydro power plants 9. Bribin I and Ngreneng Cave have spiritual value for community
2.	Weakness	1. The previous project of micro-hydro power plant was stopped and has not been continued 2. Difficult access to reach the location 3. Occurence of river over-flow is quite often
3.	Opportunities	1. Has potential to be developed become micro-hydro power plant

		2. Has been installed a pump device for micro-hydro power plant in Bribin II Cave 3. Has big potential to be developed into geotourism 4. Rejuvenation of existing facilities
4.	Threats	1. Vandalism 2. Sanitation 3. Installation damage because of bad maintenance 4. High humidity inside the cave

CONCLUSSIONS

The Bribin River which flows from Tambakromo, Ponjong Subdistrict, Gunungkidul until it ends at Baron Beach, passes through three caves that are the location of the observation, the caves are Ngreneng Cave, Bribin I Cave, and Bribin II Cave. With a discharge value of 1500 l / s, a height difference of 240 m, and a hydraulic power value of 3.53 MW. The great hydraulic power of the Bribin River is very potential to be used as a hydroelectric power plant, such as micro hydro power plant.

The most potential area according to the potential micro-hydro power plant quantitative assessment of its geology, morphology, accessibility, and socio-cultural conditions, is Bribin II Cave that reach a total score of 24. In addition, a dam has been built in this location subsurface that blocks the entire cave and channels it into the micro hydro pump.

RECOMMENDATION

From SWOT Analysis of potential micro-hydro power plant in Bribin River, we can get some recommendations of things that needed to be done. Evaluating the previous project is necessary to be a consideration for the next project.

Socialization to the community around Bribin River is necessary as well. Its aim is for their understanding about micro-hydro power plant potential of Bribin River in their residence. It is hoped that the community can also participate to build the micro hydro power plant, for their better future.

Maintenance of micro-hydro power plant is very important. The maintenances are cleansing of trash waste in the Bribin dam, installation of trash mines above the dam or downstream of the Bribin dam, maintenance of the valves and pumps, and also grouting / blockage of the cavity of the cave wall above the dam with materials that can blend with limestone (cement, kaolin and bentonite).

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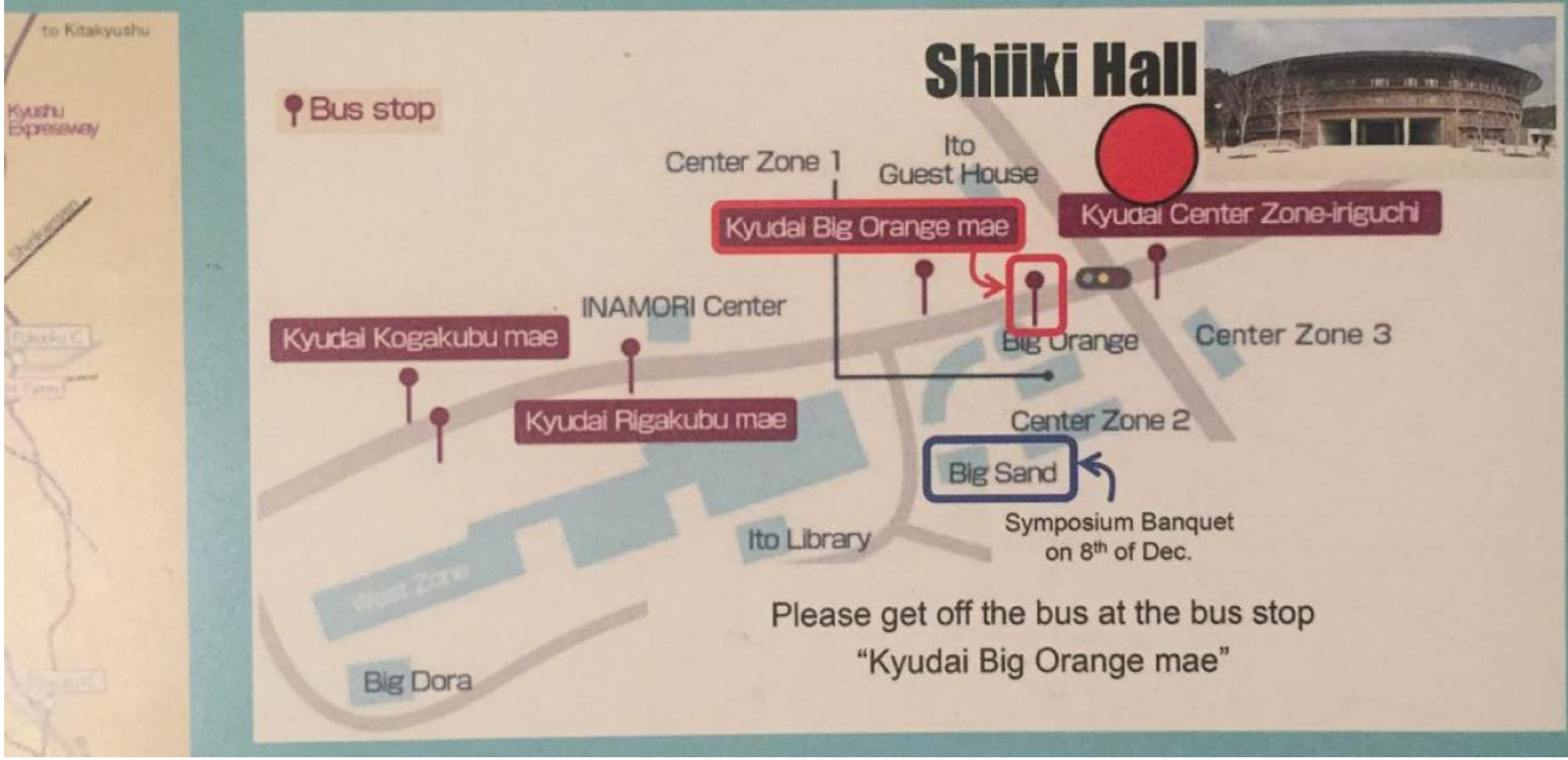
Table 1 Qualitative Assessment of Potential Micro-Hydro Power Plant (Geology, Morphology, Accessibility, and Socio-cultural Condition)

No	Location	Parameters				
		Geology	Morphology	Hidrology	Accessibility	Socio-cultural Condition
1	Bribin I Cave	The lithology contains of clastic limestone (at the bottom) and non-clastic limestone (at the top). There is a fault indication because there are many fractures and lapies structures.	Karst cave, underground river	It is included in the Wonosari-Baron sub-system, with elevation 0 - 350 m, characterized by a surface flow which then that will underground. It has discharge value 800 - 1000 liters / second (Pusat Penelitian dan Pengembangan Sumber Daya Air (bahasa), 2010).	The cave can be reached by foot. A clean water pump installation has been built which leads to a shelter on the hill to be distributed to the community of Gunung Kidul and its surroundings.	This location is used as a pumping place for clean water to supply water needs in Semanu District and its surroundings. Pumping installation has been installed by the Public Works Department in Gunung Kidul area. In addition, it is also used as a spiritual place by local residents.
2	Bribin II Cave				Microhydro pump installations have been built at a depth about 100 meters below the surface of the land that can be reached by humans with elevators. The installation that built at this location is a subsurface dam that blocks the entire cave and channels it into a microhydro pump.	
3	Ngreneng Cave	The lithology contains of reef limestone (at the top) and layered limestone (at the bottom). Many lapies structures and fractures are found in this cave.	Karst cave, spring, and underground river	It is included in the Wonosari-Baron sub-system, with elevation 0 - 350 m, characterized by a surface flow which then that will underground.	Ngreneng River has a quite easy access. It is located in beside of the main road. Ngreneng river can be reached by foot about 100 meters.	This location is used as a tourist attraction, a source of water for local people, and a spiritual place.

				It has discharge value 300 liters/second.		

2 Quantiative assessment of potential micro-hydro power plant

No.	Location	Parameters					Total
		Geology	Morphology	Hydrology	Accessibility	Social-cutural condition	
1.	Bribin I Cave	5	4	5	4	5	23
2.	Bribin II Cave	5	4	5	5	5	24
3.	Ngreneng Cave	5	5	2	3	4	19



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