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by Badrus Zaman

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Assessing implementation of low-carbon technologies in Thekelan Hamlet, Indonesia using participatory rural appraisal method

A Rezagama¹, M A Budihardjo¹, B Zaman¹, E Yohana²

¹Department of Environmental Engineering, Diponegoro University, Semarang Indonesia 50275

²Department of Mechanical Engineering, Diponegoro University, Semarang Indonesia 50275

aryarezagama@lecturer.undip.ac.id

Abstract. Thekelan hamlet is located at the foot of Mount Merbabu makes the electricity that reaches this village experience a reasonably high loss percentage. By utilizing the sunlight, the community can make a power plant with solar cell technology. In addition, the majority of residents in Thekelan Hamlet still use wood-fired stoves for cooking. This condition is, of course, not environmentally friendly because the combustion releases high carbon into the atmosphere. Therefore, the prospect of renewable energy has not yet been fully exploited. This situation is due to the low level of knowledge, education, and capital owned by residents. The Participatory Rural Appraisal (PRA) approach were used to develop low-carbon society in Thekelan Hamlet. This approach comprises three stage including workshop, action, and reflection stage. Result shows that the community in Thekelan District were able to implement low-carbon society. However, the capital price of low-carbon technology such as solar cells and dew catcher is still high with respect to the output that they can generate. Therefore, the community is agree to contribute and join to the development of this program in the future since they realize that low-carbon society can induce economic development of the hamlet.

1. Introduction

Thekelan hamlet is an enclosed area or an area surrounded by the Mount Merbabu National Park area, which is located in Batur Village, Kopeng District, Semarang Regency. Mount Merbabu National Park is a conservation forest area of 5,725 hectares [1]. The number of residents living in Thekelan Hamlet is 280 families, with 720 residents employed in the livestock and agriculture sectors. They are active in the Mount Merbabu National Park area to take grass as a source of animal feed and firewood for cooking. The utilization is increasing in line with the community's increasing needs due to the low level of community income and the increase in population. The number of dairy cows in this village reaches 500 cows which the majority coming from Holstein Friesian breeds. Each house has an average of 3 cows, of which two of them are dairy cows [2,3].

Besides, Thekelan Hamlet has another energy potential that can be developed as a ecotourism spots through water energy and sunlight. There are also several small rivers as a source of water for irrigating the rice fields of the Thekelan Hamlet community and have the potential to be a location for the construction of micro-hydro turbines. Technically, the opportunity to build micro-hydro electricity



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around forest areas is tremendous and can be a solution to meet the needs of cheap electricity in remote areas [4]. Thekelan hamlet is also exposed to sufficient sunlight so that it is possible to use sunlight as a solar power plant. Thekelan hamlet has also attract many tourist since this area are considered as starting point for Mount Merbabu climbers. The development of tourism village in this area are intriguing and also becoming one of local government target [5]. Therefore, sustainable ecotourism can be another path that want to be achieve by the communities to increase the economic status of the society.

The target for developing mixed energy from renewable sources in Indonesia in 2025 is 23% [6]. Therefore, introducing renewable energy technology according to a local potential such as solar sources, biogas, and hydropower is needed to achieve the target. This system will be developed continuously into a grid system between houses in the villagers. The development of Thekelan Hamlet is interesting as a pilot village with a complete concept of using renewable energy to gain additional knowledge. In this study, we assess the technological implementation of dew nets and solar cells as part of low-carbon society development in Thekelan hamlets by using participatory rural appraisal (PRA) approach. The use of micro-hydro turbines is still on feasibility stage which cannot be explained in this action research. The potential of biomass utilization is already discussed and published elsewhere [2].

2. Methodology

In this study, a participatory rural appraisal (PRA) approach was used as part of action research (AR) which aims to improve the living condition of the community as the object. This approach is divided into 5 phases: identification, data collection, data interpretation, action plan development, and reflection. Most PRA is done by non-government organizations (NGOs) to solve problems and find solutions by working together with the community [2,7]. People will be interested in implementing technology through a continuous interdisciplinary learning process. The community will be invited to discuss through workshops and produce appropriate action plans to realize a low-carbon society in Thekelan Hamlet.

The lack of public knowledge about renewable energy utilization technology makes the mentoring process take a long time. So, this mentoring strategy is carried out simultaneously with economic development based on the potential of the surrounding nature. The PRA approach included in this study are considered as follows:

- a. The socialization and workshop stage aims to increase public awareness about the use of renewable energy and identify all problems in implementing low-carbon technology. Data interpretation which seeks to map the community strengths and weaknesses, is also included in this stage.
- b. The action stage aims to elaborate and educate the community with low-carbon technology and perform routine maintenance. This stage may be essential to increase public awareness of protecting the environment, such as managing waste, wastewater and reducing carbon by switching from wood-burning stoves.
- c. The reflection stage is a monitoring program to ensure the sustainability of the action plan

3. Result and discussion

3.1. Workshop stage

In this activity, the community was expected to aware of and understands the vitality of a local leader. The scope of discussion in this event includes several important points as follows:

- a. The proper management of community and stakeholder relations in the establishment of low carbon society
- b. The obstacles and challenges in the establishment and operation of the low carbon society
- c. The vital role of local leaders
- d. The potential and case studies of the development of Thekelan Hamlet, along with recommendations

Thekelan has potential as a place for the construction of solar cells. The air temperature in Thekelan Hamlet tends not to increase because of its location significantly at the foot of the mountain. In addition, it is located in a tropical climate zone, so that the solar radiation received is quite adequate in the utilization of solar energy through solar cells. Although fog often occurs in Thekelan Hamlet, the mist only lasts in the morning, and the area is relatively clean from air pollution to support maximum solar cell yields. Thekelan hamlet has a large area of land that can be used as a solar cell arrangement. The amount of solar cell energy produced is directly proportional to the square meter occupied by the solar cell [8].

A dew catcher is a tool used to harvest mist with high moisture content to produce water droplets. More water droplets will collect and can be used for agricultural irrigation needs [9]. Thekelan Hamlet has drought problems during the dry season where the available water sources are only sufficient for household needs such as drinking water. Meanwhile, vegetable commodities grown in Thekelan Hamlet require quite a lot of water. As a result, in the dry season, Thekelan Hamlet can only plant drought-resistant crops. This program is implemented as a solution to solving these problems. The prototype of this dew catcher is expected to be a new source of water that can support the running of agricultural activities in Thekelan Hamlet to increase agricultural yields to achieve a prosperous life.

3.2. Action stage

The prototype of this dew catcher is a miniature version of the conventional dew catcher carried out in several places even outside Indonesia. This tool uses several materials such as plastic nets as the primary material, bamboo, ropes, gutters, and water barrels. This prototype is in the form of a trap stretched between 2 bamboos by tying the net using a string. The nets that have been laid out are then given gutters as water reservoirs to then flow into water barrels (See Figure 1). Farmers can use the water collected in the barrels to water the crops in the fields.



Figure 1. The installation of dew catcher.

Thekelan hamlet is located at the foot of Mount Merbabu, so the interconnection of electricity from the city to this hamlet experiences a reasonably high loss percentage. Solar energy can be utilized as an alternative energy source for the Thekelan Hamlet power plant to overcome these problems. Solar cells use solar energy directly into electrical energy [4]. Solar cells are an environmentally friendly technology. In operation, according to Yuliananda et al., for solar cells to get the maximum value, the factors that need to be considered are ambient air temperature, solar radiation, blowing wind speed, the orientation of solar panels, and position of solar cells to the sun [10].

The inverter installation program aims to utilize new renewable energy to the maximum. With the installation of an inverter in the solar system, the electricity generated by solar panels can supply the power needs of various electronic devices and lights in the basecamp to meet the basecamp's energy needs as a whole and reduce the use of electricity. The existence of an inverter device can convert the solar panel output current, which is direct current (DC), into alternating current (AC) with a frequency

of 50 hertz, which is per Indonesian electricity frequency standards to achieve optimal utilization of new renewable energy (See Figure 2).



Figure 2. The installation of solar panel in Mount Merbabu climber's basecamp.

3.3. Reflection stage

The use of solar panels at the tourist base camp can be used to replace conventional electricity for one house, which reduces electricity use by 70-100 thousand rupiahs per month. This value is relatively smaller than the investment cost. Still, the existence of solar panels is an alternative where there are frequent power outages and the cost of replacing government subsidies. In addition, there is also a dew-catching technology that is expected to help farmers during the dry season. Seeing so much potential in Thekelan Hamlet to be brought to the Tourism Hamlet, it is necessary to have sustainable planning and assistance so that the quality of tourism management in Thekelan Hamlet is getting better. The village has the opportunity to develop further its existing low-carbon society potential. The capital price of solar cells and dew catcher are still high compare to the generated output of the technology. The community were agree to enhance the efficiency of the technology, so continuous improvement will be needed to boost the implementation of those technologies in the society.

4. Conclusion

The uniqueness of Thekelan Hamlet, which is difficult to find elsewhere in Indonesia, is thick with inter-religious harmony amid the heterogeneity of beliefs held by the people in the village. This situation makes Thekelan Hamlet one of the well-known tourist destinations in various parts of Indonesia. However, the use of firewood and electricity that is quite large can increase the potential for releasing large amounts of carbon into the atmosphere. Therefore, several alternatives such as installing solar panels and dew catchers are expected to reduce the possibility of releasing carbon emissions into the atmosphere. The action research shows that the two technologies still have weaknesses where the output produced is not as large as expected. Efforts to reduce the use of electrical energy from the state electrical company have not been achieved maximum results. However, as part of continuous improvement, the community is willing to follow the development of technology implementation to realize a low-carbon society can run well.

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