

Community Empowerment of Banu Ayu Village, South Kikim District, Lahat Regency through Biogas Innovation and Utilization of Bio-Slurry in Supporting Energy Security and Environmentally Friendly Agriculture

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ABSTRAK

This community service activity aims to increase energy security and environmentally friendly agricultural management through biogas innovation and the use of bio-slurry in Banu Ayu Village, South Kikim District, Lahat Regency. The main problems of partners include the accumulation of livestock waste, dependence on LPG, and low utilization of agricultural waste. The implementation method is carried out through socialization, training, application of biogas technology, mentoring, and program evaluation. The activity was carried out in farmer groups and farmer-livestock groups with a participatory approach. The results of the activity show that there is an increase in public understanding of waste management, the use of alternative energy, and the use of bio-slurry as organic fertilizer. The program is able to reduce environmental pollution, reduce household energy costs, and support sustainable agricultural practices in villages.

INTRODUCTION

The development of village communities is one of the main focuses in Indonesia's national development agenda. Villages are not only seen as administrative areas, but also as centers of economic, social, and cultural activities of the community that have great potential to be developed independently and sustainably. In the context of rural development, strengthening community capacity is an important aspect to improve the welfare and quality of life of rural communities. The main problems that are still found in rural areas of Indonesia are low access to alternative energy and suboptimal environmental management. People's dependence on fossil energy such as LPG and firewood is still quite high, especially in underdeveloped areas and areas with limited energy infrastructure. This condition not only has an impact on high household costs, but also triggers environmental damage due to overexploitation of natural resources.

One of the sectors that has great potential to support village energy security is the livestock and agriculture sectors. Livestock activities produce organic waste in the form of large amounts of livestock manure every day. If not managed properly, the waste can cause environmental pollution, bad odors, and health risks to the surrounding community (Yusuf et al., 2021). In addition to livestock waste, agricultural waste such as straw, rice husks, and crop residues are also often not used optimally. Most people still burn agricultural waste after harvest, causing air pollution and lowering the quality of soil fertility. In fact, organic waste has economic potential that can be used as a source of energy and organic fertilizer (Sari & Wahyuni, 2020).

Appropriate technology-based organic waste management is one of the solutions that can be applied to overcome energy and environmental problems in rural areas. Appropriate technology is a technology that is designed according to the needs of the community, is easy to apply, and has relatively low operational costs (Mardikanto, 2017).

One of the appropriate technological innovations that is developing in organic waste management is biogas technology. Biogas is a gas produced through the anaerobic fermentation process of organic matter such as livestock manure, agricultural waste, and other organic waste. The gas produced contains methane which can be used as an alternative fuel for household needs and productive businesses of the community (Wahyuni, 2018). The use of biogas not only provides benefits from the energy aspect, but also supports environmental conservation efforts. This technology is able to reduce organic waste pollution and reduce greenhouse gas emissions from open waste decay. Therefore, biogas development is considered to be in line with the concept of sustainable development and a green economy (United Nations Development Programme, 2021).

In addition to producing alternative energy, the biogas production process also produces liquid and solid waste known as bio-slurry. Bio-slurry is a by-product of anaerobic fermentation that still contains essential nutrients for plants such as nitrogen, phosphorus, and potassium. Bio-slurry can be used as liquid organic fertilizer or solid fertilizer to increase soil fertility (Haryati et al., 2020).

The use of bio-slurry in the agricultural sector has various benefits, including improving soil structure, increasing crop productivity, and reducing farmers' dependence on chemical fertilizers. The use of organic fertilizers is also considered more environmentally friendly and supports sustainable agricultural practices (Sutanto, 2019).

Banu Ayu Village, South Kikim District, Lahat Regency is one of the villages that has great potential in the development of alternative energy based on organic waste. The majority of the village people work as farmers and breeders with a large number of cattle and goats. This condition causes the availability of organic waste in the village to be very abundant. Based on the results of field observations, most of the livestock manure waste in Banu Ayu Village is still disposed of around cages or open channels. This condition causes the environment to become dirty and cause an unpleasant odor, especially in the rainy season. In addition, agricultural waste such as straw and rice husks are still burned after harvest, thus worsening the quality of the village environment.

On the other hand, the people of Banu Ayu Village are still very dependent on subsidized LPG and firewood as a source of household energy. The limited distribution of LPG in rural areas causes LPG prices to be more expensive than in urban areas. This condition is an economic burden for the village community, most of whom have low incomes. These problems show that the people of Banu Ayu Village need innovative solutions that are able to answer energy problems as well as environmental management. One relevant approach is community empowerment through the use of biogas technology based on livestock and agricultural waste.

Community empowerment is a development process that aims to increase the capacity, ability, and independence of the community in managing their resources. Empowerment does not only focus on economic aspects, but also includes increasing knowledge, skills, and community participation in development (Kartasasmita, 1996). The community empowerment approach is considered effective in the development of appropriate technology because the community is actively involved from the planning, implementation, to program evaluation stages. Active community participation is an important factor in ensuring the sustainability of service programs at the village level (Adi, 2013).

In the context of public administration, community empowerment through technological innovation is also part of participatory development governance. The village government has a strategic role in facilitating collaboration between the community, universities, and the business world to create innovations based on local needs (Dwiyanto, 2015).

The biogas technology-based community service program is a form of implementation of the tridharma of higher education in supporting village development. Universities have a social responsibility to transfer science and technology to the community in an applicative and sustainable manner (Suharto, 2014).

Community service activities are also a means to increase the capacity of village communities in managing local resources productively. Through training

and mentoring, the community can understand how to manage organic waste into alternative energy and organic fertilizers with economic value.

The Ayik Mati Farmers Group and the Maju Bersama Farmers Group in Banu Ayu Village are the target groups in this service program. Both groups have great potential in biogas development due to the abundant availability of livestock waste and agricultural waste. However, based on the results of the focus group discussion (FGD), the community still has limited knowledge about biogas technology and organic waste management. In addition, the institution of farmer groups has also not run optimally, so assistance is needed in aspects of organizational management and group business development.

The application of biogas technology in this program is not only oriented towards the provision of alternative energy, but also directed at increasing agricultural productivity through the use of bio-slurry. This approach is expected to be able to create an integrated agricultural system based on a circular economy at the village level. The concept of the circular economy emphasizes the reuse of waste into resources that have economic added value. In the context of agriculture and livestock, organic waste can be processed into energy and fertilizer thereby reducing environmental pollution and increasing production efficiency (Ellen MacArthur Foundation, 2019).

This program also supports the achievement of the Sustainable Development Goals (SDGs), especially SDG 7 on clean and affordable energy, SDG 12 on responsible consumption and production, and SDG 13 on handling climate change (United Nations, 2021). In addition, the development of community-based biogas technology also supports national energy security through the use of renewable energy. The Government of Indonesia continues to encourage the development of new and renewable energy as part of the national energy transition strategy.

The development of alternative energy in villages also has a significant socio-economic impact. The use of biogas can help people reduce household expenditure on LPG purchases and open up business opportunities based on organic waste treatment.

In the environmental aspect, the use of biogas is able to reduce livestock waste pollution and reduce methane gas emissions that have the potential to cause global warming. Therefore, biogas technology is considered an environmentally friendly and sustainable solution.

The success of technology-based service programs is greatly influenced by community participation and local institutional support. Therefore, the involvement of the village government, community groups, and other stakeholders is an important aspect in the implementation of the program.

Continuous assistance is also needed so that the community is able to operate and maintain biogas installations independently. In addition, strengthening the institutional capacity of farmer groups is an important factor in maintaining the sustainability of the program after the service activities are completed.

This service program is expected to be able to become a model for empowering village communities based on appropriate technology that can be replicated in other rural areas. The use of organic waste into alternative energy and organic fertilizers is a strategic step in supporting independent and sustainable village development.

Thus, community service activities through biogas innovation and the use of bio-slurry in Banu Ayu Village, South Kikim District, Lahat Regency are real efforts to improve energy security, environmental management, and sustainable empowerment of village communities.

IMPLEMENTATION AND METHODS

Location and Time of Implementation

The service activity will be carried out in Banu Ayu Village, South Kikim District, Lahat Regency, South Sumatra Province in 2025. The target of the activity consisted of the Ayik Mati Farmer-Livestock Group and the Maju Bersama Farmers Group with a total of 38 participants.

Implementation Method

The method of implementing the program is carried out through a participatory approach by actively involving the community in all stages of activities. The stages of the activity include:

1. Program Socialization

The socialization activity was carried out to provide an understanding of the importance of livestock and agricultural waste management and the benefits of using biogas technology for the village community.

2. Biogas Technology Training

The training is carried out directly through field practice methods on:

- Creation of biogas plants
- Biogas operation
- Utilization of bio-slurry as organic fertilizer
- Biogas plant maintenance

3. Application of Technology

This stage includes the construction of biogas installations based on livestock waste and the use of bio-slurry on community agricultural land.

4. Mentoring and Evaluation

Mentoring is carried out periodically to ensure that the community is able to operate technology independently and evaluate the impact of the program on the community.

Program Implementation Framework

1. Identify community problems
2. Socialization and coordination of the program

3. Biogas technology training
4. Construction of biogas installations
5. Utilization of bio-slurry
6. Assistance and evaluation of program sustainability

RESULTS AND DISCUSSION

Early Condition of the Community

The results of initial observations show that around 65% of livestock waste in Banu Ayu Village has not been optimally utilized. Most people still use LPG with an average expenditure of IDR 150,000 per month. In addition, agricultural waste such as straw and rice husks are still burned, causing environmental pollution.

Implementation of Socialization and Training

The socialization activity received a positive response from the community. Participants showed high enthusiasm in understanding the benefits of biogas technology and organic waste management. The training was carried out in practice by introducing the process of fermentation of livestock waste into biogas.

Training materials include:

1. Livestock waste management
2. Biogas plant working system
3. Utilization of bio-slurry
4. Eco-friendly organic farming

Application of Biogas Installation

The implementation of biogas installations in Banu Ayu Village, South Kikim District, Lahat Regency is carried out as a form of implementation of appropriate technology based on community empowerment. This program is focused on the use of cattle waste and agricultural waste as an alternative energy source that is environmentally friendly and sustainable. The implementation of activities was carried out in a participatory manner by involving farmer groups, farmer-livestock groups, village governments, and community service teams.

The initial stage of implementing biogas installations begins with activities to identify the potential for organic waste available in the community. Based on the results of field observations, on average, each cow produces around 15–20 kilograms of manure per day. The number of livestock owned by the community is a great potential in the sustainable supply of biogas raw materials.

In addition to livestock waste, the community also produces agricultural waste in the form of straw and rice husks in large quantities every harvest season. Previously, the waste was burned or dumped around agricultural land. Through this program, agricultural waste began to be introduced as a mixed ingredient in the process of biogas fermentation and the manufacture of organic fertilizers. Before the construction of the installation is carried out, the implementation team first carries out socialization to the community regarding the benefits of biogas technology. The socialization aims to increase public understanding of the importance of organic waste management and opportunities for its use as an alternative household energy.

The socialization activity received a positive response from the community. Most of the participants showed interest in biogas technology because it is considered to be able to help reduce household expenditure on LPG purchases. In addition, the community is also beginning to understand that livestock waste which has been considered a source of pollution turns out to have economic value. After the socialization activity, the next stage is technical training on the construction and operation of biogas installations. The training is carried out in a hands-on manner at partner locations so that the public can understand the technology work process more easily and applicatively.

At the training stage, the public is introduced to the main components of biogas installations such as digesters, input lines, output lines, gas containers, and biogas stoves. The implementation team explained the function of each component and how to use it in the biogas production process.

The construction of biogas installations is carried out in mutual cooperation with the village community. Community involvement in the construction of the installation is an important form of active participation to foster a sense of belonging to the program being run.

The type of installation applied in this program is household- and group-scale biogas with a simple digester system. The technology was chosen because it is easy to implement, low operational costs, and in accordance with the socio-economic conditions of the village community.

The installation construction process begins with digging a hole for the placement of the digester. The digester serves as a place for the fermentation of organic waste under anaerobic conditions to produce methane gas. The size of the digester is adjusted to the amount of livestock waste available in the target group. After the construction of the digester is completed, the installation of input and output channels is carried out. The input channel is used to put a mixture of livestock waste and water into the digester, while the output channel is used to remove the fermentation residue in the form of bio-slurry. The community was then given training on biogas raw material mixing techniques. Livestock manure is mixed with water using a certain ratio so that the fermentation process runs optimally. The mixture is then put into the digester

regularly every day. The anaerobic fermentation process takes about 7-14 days to produce gas that can be used as fuel. During the process, the community is guided to monitor the condition of the installation so that gas production remains stable.

The results of the application show that the biogas installation is able to produce gas that can be used for household cooking needs. People are starting to use biogas stoves as an alternative to LPG and firewood. The use of biogas has a positive impact on people's household expenditures. Before the program was implemented, the average public expenditure for LPG purchases reached IDR 150,000 to IDR 200,000 per month. After using biogas, the expenditure begins to decrease significantly. In addition to saving household energy costs, the use of biogas also helps reduce people's dependence on firewood. This has a positive impact on environmental conservation because it can suppress logging activities around the village. From an environmental aspect, the implementation of biogas installations is able to reduce pollution due to livestock waste that previously accumulated around the cage. The community's environment has become cleaner and unpleasant odors have begun to decrease.

Livestock waste management through biogas technology also helps reduce the risk of public health disturbances. Before the program is running, livestock waste is often a source of the development of flies and disease-causing bacteria. Once the waste is treated regularly, the sanitary conditions of the environment become better.

In addition to producing methane gas, biogas plants also produce bio-slurry that is used by the community as organic fertilizer. Bio-slurry is a by-product of fermentation that still contains important nutrients for plants.

The service team provides training to the community on how to use bio-slurry on agricultural land. Bio-slurry is used as a liquid fertilizer and solid fertilizer for food crops such as rice and corn.

The results of the use of bio-slurry show an increase in soil fertility on community agricultural land. Plants look greener and growth is better than before the use of organic fertilizers.

The community has also begun to reduce the use of chemical fertilizers because some of the fertilizer needs have been replaced by bio-slurry. This condition helps farmers reduce agricultural production costs which were previously quite high due to the high price of chemical fertilizers.

The use of bio-slurry has a positive impact on environmentally friendly agricultural practices in Banu Ayu Village. The use of organic fertilizers helps maintain soil quality and reduce pollution due to agricultural chemical residues. In the implementation of the program, community participation is the main factor in the successful application of biogas technology. The community is not only a beneficiary, but also actively involved in the construction, operation, and maintenance of the installation.

The Ayik Mati Farmers Group plays an important role in the provision of raw materials for livestock waste and the operational management of biogas installations. Meanwhile, the Maju Bersama Farmers Group focuses on the use of bio-slurry to support agricultural productivity. The village government also provides support for the program through facilitation of coordination of activities and institutional strengthening of community groups. The support of the village government is an important factor in maintaining the sustainability of the service program.

In the institutional aspect, this program also encourages the formation of a more structured group management system. The community began to arrange the division of operational tasks, installation maintenance schedules, and the system for the use of biogas together.

Assistance is carried out periodically by the service team to ensure that the community is able to operate biogas installations independently. Assistance includes operational technical aspects, equipment maintenance, and group institutional development.

Program evaluation shows that the community has high enthusiasm in developing biogas technology in the village. Some communities have even begun to take the initiative to expand the use of biogas in other households.

However, the implementation of the program still faces several obstacles, such as limited installation development costs and lack of community experience in operating new technologies. Therefore, further assistance is still needed so that the sustainability of the program can be maintained. This program also shows that appropriate technology-based community empowerment can be an effective strategy in supporting sustainable village development. Through collaboration between the community, the village government, and universities, technological innovations can be applied in real terms to improve the quality of life of rural communities.



Program Impact on Society

The service program has a positive impact on the community, including:

- Increasing public knowledge about biogas technology.
- Reduced environmental pollution due to livestock waste.
- The decline in people's dependence on LPG.
- Increasing the use of organic fertilizers through bio-slurry.
- Strengthening the institutional capacity of farmer groups.

The application of bio-slurry on agricultural land also has an impact on increasing soil fertility and crop productivity. The community began to implement environmentally friendly farming patterns by reducing the use of chemical fertilizers.

Partner Participation

Community participation can be seen from the planning stage to program evaluation. Partners provide activity locations, livestock waste raw materials, and labor in the construction of biogas installations. The village government also supports the program through facilitation of coordination and institutional strengthening of community groups.

Program Evaluation and Sustainability

Program evaluation shows that the community has been able to operate biogas installations independently. To maintain the sustainability of the program, the formation of group administrators, the preparation of operational SOPs, and periodic assistance are carried out.

The sustainability of the program is also supported through cooperation with the village government and CSR parties in the development of appropriate environment-based technology.

CONCLUSIONS AND RECOMMENDATIONS

The community service program through biogas innovation and the use of bio-slurry in Banu Ayu Village, South Kikim District, Lahat Regency has succeeded in increasing community understanding and skills in managing organic waste into alternative energy and organic fertilizers. This program has a positive impact on reducing environmental pollution, saving household energy costs, and improving environmentally friendly agricultural practices.

In the future, it is necessary to develop programs in a sustainable manner through institutional capacity building of community groups, support from village governments, and collaboration with various parties so that biogas technology can be applied more widely to rural communities.

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