Asia Pasific Journal of Management and Education (APJME)
Vol.5 No.3, pp.58-71, November 2022
E-ISSN: 2655-2035 P-ISSN: 2685-8835
https://www.ejournal.aibpmjournals.com/index.php/APJME

Manure Waste Management to Produce and Utilize Biogas Efficiently and Effectively in a Smart Eco-Social Village in Bandung

Jenny N. M. Tan-Soetedjo[1], Susiana Prasetyo[2], Putri Ramadhany[3]
Universitas Katholik Parahyangan[1,2,3]
Jl. Ciumbuleuit No. 94, Bandung, 40141, Jawa Barat, Indonesia
Correspondence Email: pramadhany@unpar.ac.id
ORCHID: 0000-0002-3241-3382

ARTICLE INFORMATION

Publication information

Research article

HOW TO CITE
Tan-Soetedjo, J. N. M., Ranadhany, P., Martina, A., & Wanta, K. C. (2022). Manure Waste Management to Produce and Utilize Biogas Efficiently and Effectively in a Smart Eco-Social Village in Bandung. *Journal of Community Development in Asia*, *5*(3), 58-71.

DOI:
https://doi.org/10.32535/apjme.v5i3.1907

Received: 14 August 2022
Accepted: 14 October 2022
Published: 20 November 2022

ABSTRACT

The Cikapundung-River plays an important role for people-in-Bandung. Nevertheless, more-than 50%-of-the-upstream-population lives as agricultural and dairy-farmers that due-to their-activities, have jeopardized its-condition. Hence, the-Chemical-Engineering-Department and Student-Society(HMPSTK) of Parahyangan-Catholic-University(UNPAR) supported by Australia-government and The Lodge-Foundation, conducted a project that aimed to explore a-win-win-solution both for environment and community. The methods included the community-research, mobilization, education, and evaluation combined with laboratory-based-scientific-studies. A 5,000-Liter fiberglass-prototype-biodigester was installed in Cibodas, Maribaya, Lembang. The livestock-manures and organic-waste (3:1-ratio) was utilized and the biogas-generated was utilized for daily-cooking and 9-to-10-hours kerosene-lamps-lighting. Yet, local-communities were still resistant since no-significant contribution occured on incomes. Therefore, methods that are both ecological and economical friendly needs to-be-explored. Our team recommended further studies on the combination of biodigester and vermicomposting techniques.

Keywords: Biogas, Manures, Sustainability, Citarum, Cikapundung.

INTRODUCTION

Water is a crucial and basic necessity for living organisms. Water consumption includes domestic consumption (drinking, bathing, washing), industrial, and agricultural. Since the increase of economic growth in Indonesia, the demand for clean water supply increasing. Deforestation, drainage in wetlands, and conversion into farming reduce the water quality. The freshwater resources in Indonesia are classified as groundwater and surface water, in which rivers and lakes as the most common source of surface water.

Cikapundung is considered one of the major rivers in Java. For decades, the river has been used as a municipal water supplier, agricultural irrigation, hydropower, drainage, sewage for domestic and municipal waste industries, and tourist attraction. Its length from the upstream to estuary is 39 km, passing through three administrative areas namely Kabupaten Bandung Barat, Kabupaten Bandung, and Kota Bandung (Sofyan, 2004). At the present time, Cikapundung is used as an alternative source of freshwater due to the depletion of deep groundwater in Bandung (Sabar, 2006).

Despite the significant importance of Cikapundung as the freshwater source in Bandung, the water quality of Cikapundung is inferior due to heavy pollution (Andianti et al., 2020). Due to extensive farming in the basin, Asian Development Bank (ADB) claimed that Cikapundung river was also loaded with silt (ADB, 2016). The primary pollutant includes domestic waste, industrial waste, and agricultural waste including the organic waste contributed from the manure produced by the dairy farming from the upstream of Cikapundung river. In fact, around 30% of the upstream Cikapundung population lives as dairy farmers. Hence, it is undeniable that dairy farming activity is important from the economic point of view for the people on the upstream of Cikapundung river. Therefore, sustainable solutions should be explored that can be beneficial both economically and ecologically for the people as well as the environment.

LITERATURE REVIEW

The number of dairy cows of the upstream Cikapundung population is estimated at 19,712 in 2021 by KPSBU (*Koperasi Peternak Sapi Bandung Utara*) or about 30% of the total population living in the upstream of Cikapundung river (KPSBU, 2022). The solid wastes from dairy cows farming reach around 204 – 306 Tons per day, while liquid wastes reach 680–1,700 L per day (Bachrein, 2012). The solid and liquid waste from dairy farming or manures contains a wide variety of nutrients such as Nitrogen (N), Phosphorous (P), Potassium (K), micronutrients such as Copper (Cu), Manganese (Mn), and Zinc (Zn) (Andianti et al., 2020). With these excellent sources of nutrients, manures can be used as a natural fertilizer to improve soil quality. However, when these rich nutrients are disposed into the water, it will contaminate and reduce water quality. According to Lehnert et al. (2018), nitrogen and phosphorous are pollutants in rivers, lakes, and estuaries. They accelerate algae development, leading to many issues, including clogging, damaging aquatic ecosystems, and decreasing possibilities for recreation. Manures also contain pathogen bacteria, such as *Salmonella spp.*, *Campylobacter spp.*, *Escherichia coli*, *Listeria monocytogenes*, and *Protozoa* that can harm humans. Other threats if manures are not treated effectively are the greenhouse gas emissions (GHG), such as Methane (CH_4), Carbon dioxide (CO_2), Hydrogen Sulfide (H_2S), and Ammonia (NH_3) (Petersen et al., 2013).

Manure waste management becomes a crucial method to reduce the environmental pollution threat. According to Ayilara et al. (2020), composting and drying the manures can reduce the number of feasible pathogens. Anaerobic decomposition of manures can also be one of the solutions for reducing pathogenic bacteria, reducing smell, increasing the value of compost, and generating alternative energy called biogas (Zhao & Liu, 2019). Biogas is a potential renewable energy source that can quickly obtain from waste. It contains a heating value of 6 kWh/m^3, which equals a half liter of diesel oil. Biogas consists of Methane (CH_4), Carbon Dioxide (CO_2), Hydrogen Sulfide (H_2S), and Ammonia (NH_3) (International Energy Agency, 2020). Methane and hydrogen can be combusted with oxygen, thus enabling biogas usage as fuel that can be used for heating, cooking, and even converted as electricity.

Indonesia is the biggest economy in the ASEAN region. Currently, Indonesia encounters a significant challenge in supplying sufficient energy to satisfy increasing demands, maintain economic development, and improve the quality of the environment. Conventional energy is no longer a response to the long-term solution. Indonesia has been actively encouraging the use of renewable indigenous energy resources since 2009. Renewable Indigenous Energy (RE) is energy generated from renewable and sustainable resources, including geothermal, biofuels, hydropower, solar and wind energy, biogas, and oceans (Presidential Regulation No.5, 2006). The government intends to increase the share of RE to achieve sustainable development goals, where around 4% of energy allocations were given to biogas development.

Indonesia has a robust agricultural sector and, thus, a great potential to use residues from the agroindustry as feedstock. The Indonesian government has encouraged local communities to produce biogas from their wastes. Between 2011 and 2014, the Indonesia Ministry of Energy constructed around 206 biogas digesters through the BIRU (Biogas Rumah) program, cooperation between the Indonesian and The Netherlands governments (Direktorat Bioenergi, 2016). In 2019, Perum Jasa Tirta II constructed 35 biogas digesters upstream of Citarum to improve Citarum water quality and encourage biogas and compost production (Maulana, 2019). From 2007 to 2011, Indonesia has been focused on reducing pollution through the small-scale business sector using waste treatment from the tofu and livestock industries. Reductions in GHG emissions with biogas digesters in 13 livestock centers are close to 2,424.33 tons per year (Nurbaya et al., 2020). Indonesia’s livestock population reached 15.6 million in 2017, generating 88 million tons of manure waste. If these wastes are converted to biogas, it can achieve around 4.4 million m^3 (Sunarti et al., 2017). According to Hidayati et al. (2019), 1 m^3 of biogas equals 0.6 – 0.8 L of kerosene or Rp 7,200 – 9,600.

The biogas technology can be applied as part of the solution for farmers to promote a cleaner water ecosystem and improve the farmer’s economy. Unfortunately, not all communities of livestock industries have fully embraced biogas as the solution to waste management. This is due to a lack of information that leads to false misconceptions, such as complex applications and high investment. Therefore, this community service activity aims to study the obstacles faced by the local communities in manure management and to initiate a circular economy model in the local community for manure waste utilization, specifically in Cibodas Village. Expectantly, this will lead to the sustainable reduction of manure disposal in the river and later will improve the water quality in the Cikapundung River.

LITERATURE REVIEW

The number of dairy cows in the upstream Cikapundung population is estimated at 19,712 in 2021 by KPSBU (Koperasi Peternak Sapi Bandung Utara), or about 30% of the total population living upstream of Cikapundung river (KPSBU, 2022). The solid wastes from dairy cow farming reach around 204 – 306 Tons per day, while liquid wastes reach 680–1,700L per day (Bachrein, 2012). The solid and liquid waste from dairy farming or manures contains a wide variety of nutrients such as Nitrogen (N), Phosphorous (P), Potassium (K), micronutrients such as Copper (Cu), Manganese (Mn), and Zinc (Zn) (Andianti et al., 2020). With these excellent sources of nutrients, manures can be used as a natural fertilizer to improve soil quality. However, when these rich nutrients are disposed into the water, they will contaminate and reduce water quality. According to Lehnert et al. (2018), nitrogen and phosphorous are pollutants in rivers, lakes, and estuaries. They accelerate algae development, leading to many issues, including clogging, damaging aquatic ecosystems, and decreasing possibilities for recreation. Manures also contain pathogens such as Salmonella spp., Campylobacter spp., Escherichia coli, Listeria monocytogenes, and Protozoa that can harm humans. Other threats if manures are not treated effectively are the greenhouse gas emissions (GHG), such as Methane (CH_4), Carbon dioxide (CO_2), Hydrogen Sulfide (H_2S), and Ammonia (NH_3) (Petersen et al., 2013).

Santika and W (2020) state that Environmental pollution affects biotic and social environmental functions. Therefore, to prevent that from happening, manure waste management has become crucial to reducing the environmental pollution threat. According to Ayilara, Olanrewaju, Babalola, and Odeyemi (2020), composting and drying the manures can reduce the number of feasible pathogens. Anaerobic decomposition of manures can also be one of the solutions for reducing pathogenic bacteria, reducing smell, increasing the value of compost, and generating alternative energy called biogas (Zhao & Liu, 2019). Biogas is a potential renewable energy source that can quickly obtain from waste. It contains a heating value of 6 kWh/m^3, which equals half a liter of diesel oil. Biogas consists of Methane (CH_4), Carbon Dioxide (CO_2), Hydrogen Sulfide (H_2S), and Ammonia (NH_3) (International Energy Agency, 2020). Methane and hydrogen can be combusted with oxygen, thus enabling biogas usage as fuel that can be used for heating, cooking, and even converted as electricity.

Indonesia is the largest economy in the ASEAN region. Currently, Indonesia encounters a significant challenge in supplying sufficient energy to satisfy increasing demands, maintain economic development, and improve the quality of the environment. Conventional energy is no longer a response to the long-term solution. Therefore, Indonesia has been actively encouraging the use of renewable indigenous energy resources since 2009. Renewable Indigenous Energy (RE) is energy generated from renewable and sustainable resources, including geothermal, biofuels, hydropower, solar and wind energy, biogas, and oceans (Presidential Regulation, 2006). The government intends to increase the share of RE to achieve sustainable development goals, where around 4% of energy allocations were given to biogas development.

Indonesia has a robust agricultural sector that has a great potential to use residues from the agroindustry as feedstock. The Indonesian government has encouraged local communities to produce biogas from their wastes. Between 2011 and 2014, the Indonesia Ministry of Energy constructed around 206 biogas digesters through the BIRU (Biogas Rumah) program, cooperation between the Indonesian and The Netherlands governments (Direktorat Bioenergi, 2016). In 2019, Perum Jasa Tirta II constructed 35 biogas digesters upstream of Citarum to improve Citarum water quality and encourage biogas and compost production (Maulana, 2019). From 2007 to 2011, Indonesia has been focused on reducing pollution through the small-scale business sector using waste treatment from the tofu and livestock industries. Reductions in GHG (Greenhouse Gas) emissions with biogas digesters in 13 livestock centers are close to 2,424.33 tons per year (Nurbaya et al., 2020). Indonesia's livestock population reached 15.6 million in 2017, generating 88 million tons of manure waste. If these wastes are converted to biogas, they can achieve around 4.4 million m3 (Sunarti et al., 2017). According to Hidayati et al. (2019), 1 m3 of biogas equals 0.6 – 0.8 L of kerosene or Rp7200–9600.

The biogas technology can be applied as part of the solution for farmers to promote a cleaner water ecosystem and improve the farmer's economy. But unfortunately, not all communities of livestock industries have fully embraced biogas as the solution to waste management. This is due to a lack of information that leads to false misconceptions, such as complex applications and high investment. Therefore, this community service activity aims to study the obstacles faced by the local communities in manure management and to initiate a circular economy model in the local community for manure waste utilization, specifically in Cibodas Village. Expectantly, this will lead to the sustainable reduction of manure disposal in the river and later improve the water quality in the Cikapundung River.

RESEARCH METHOD

The methodology included the strategy used in implementing a certain intervention for the community (Luna, 1999) in combination with scientific research in laboratory. In this study, community development methods included community research (problem identification, location survey, sample collection), community mobilization and advocacy (advocacy with community leaders and participants), community education (biogas construction and socialization), and community evaluation (follow up the results). The method used in scientific research in laboratory includes the screening of several composition of livestock manure to organic waste to observe the highest volume of biogas produced using anaerobic flasks of $4M^3$ capacity.

The community service was explicitly conducted in Maribaya, Lembang, with the support from The Lodge Foundation and Australia Awards Program. There were two timelines to carry out the community service. The first timeline was executed between January to May 2019, while the second timeline was the follow-up after the biodigester installment.

The first timeline consists of:
1) Problem identification

2) Location survey and advocacy with community leaders and participants. This part also gathers information regarding the number of dairy farmers, farming and village condition, waste management, and location topography.
3) Sample collection of agricultural waste (cattle manure and organic waste) from Cibodas Village.
4) Research. It includes the construction of a laboratory-scale biogas digester and determining waste composition for biogas production.
5) Biogas digester construction in Cibodas Village.
6) Socialization to the local community in Cibodas Village.

And the second timeline consists of:

1) Follow up of the community service result

RESULTS

Problem Identification

Most local communities in Maribaya, Lembang, work as agriculture and dairy farmers. Unfortunately, their waste disposal is not managed well and disposed of in the Cikapundung River. This leads to water pollution and limits its use for daily needs and recreation. Manure waste management is one solution to reduce water pollution in Cikapundung.

Biogas production as manure waste management is not a new technology for dairy farmers in Maribaya, Lembang. Previously, the Indonesia Ministry of Energy has been actively encouraging the use of Renewable Indigenous Energy (RE) through the BIRU program and constructed a biodigester around the area. However, the program is short-lived due to several reasons.

The first problem encountered is due to the location selection erroneous. The constructed biogas digester was built higher than the dairy farms. It created difficulties for farmers, especially elderly people, to transport the cow manures to the biogas digester. The second problem is due to the material of the biogas digester. The most common material for constructing biogas digester is concrete, steel, paraffin, and plastics, depending on the location and surrounding forces. The previously built biogas digester used concrete as a material. It has advantages such as being inexpensive and practical. However, a biogas digester should be resilient to internal earth pressure forces and inner hydrostatic and gas pressure forces (Nkoi et al., 2018). Unfortunately, the Maribaya area is susceptible to earthquakes due to its location surrounded by active volcanoes. The inner hydrostatic also plays a role in biogas digester material's tensile stress. Thus, the constructed biogas digester was no longer in good condition in a short period.

The limited use of biogas was also an issue. Biogas is produced from the methanogenesis activities of anaerobic bacterial fermentation on cow manures and is proposed to replace the LPG (Liquefied Petroleum Gas) for cooking. However, the usage of biogas for cooking is very limited and some of the biogas is unused and released into the air which in fact caused air pollution. Using biogas for lighting the lantern and replacing kerosene is a promising solution for local communities. Even though the electricity is already available in the village, the current is still fluctuating. Hence, the locals still rely on kerosene lamps for lighting. However, they also encountered problems since the lantern needs to be modified further to support biogas.

Due to these challenges, the community service team decided to select inexpensive biodigester materials resistant to hydrostatic and gas pressures. The location selection must be lower than the farmer's house and cow pens for easy access for manure transportation. The biogas produced would be connected to replace kerosene in lighting lamps and LPG in cooking.

Location Survey and Advocacy to Local Community The location survey was conducted to observe the topography of the location, the transportation access, the resources (raw materials, electricity), and the community's condition. From the advocacy of The Lodge Foundation, two villages were observed. But conclusively, Cibodas Village is selected due to its location near the Cikapundung River, abundant agricultural and cow manure wastes as raw materials, and good cooperation and advocacy between the community service team and local communities. Cibodas village is located in Lembang Municipality with an area of 1,273.44 Ha and an altitude of 1,260 m above sea level. Most of its population work as agriculture and dairy farmers. Cibodas Village is divided into three hamlet areas (Dusun), where hamlet 1, hamlet 2, and hamlet 3 consist of six, five, and six citizen associations (RW).

With the assistance of The Lodge Foundation, the community service team met with the local community leaders of five citizen associations (RW) from three hamlet areas (look at Figure 1). From this meeting, it was confirmed that the locals previously have used biogas as LPG replacements. However, the biogas only lasted for two hours due to low capacity. The lack of information also plays a role in the deficit enthusiasm for biogas.

Figure 1. Location survey to Cibodas Village

Sample Collection and Biogas Production in Small Scale

Previous advocacy found that the low enthusiasm for using biogas is due to its low capacity that it will only last for two hours. Thus, research was conducted to formulate optimum biogas production and minimize leakage in the biogas digester.

Manure waste decomposition in airtight or anaerobic conditions will produce biogas. The preliminary investigation was conducted to establish the basic formulation of manure mixture and consideration for the biogas digester's design.

A comparative study on biogas production from cow manure and agricultural/organic wastes was carried out for 15 days. The varying variable was the ratio of agriculture and organic waste. Composting process was conducted in the plastic reactor equipped with a pressure device. From Figure 2, it can be seen that the mixture of manure and organic wastes can increase the amount of biogas produced. The ratio of cow manures to organic waste, 3:1, generates the largest biogas.

Enhancement of biogas production can be linked to several parameters, such as organic loading rates, mixing, and monitoring & control. According to Budiyono et al. (2014), low biogas production can be caused by the lag of microbial activities. The microorganisms need nutrients (i.e. carbon, nitrogen, phosphorous), while the organic waste (i.e. agricultural waste) provides good nutrients. The appropriate carbon to nitrogen (C/N) ratio and sufficient microorganisms might enhance biogas production. According to Yan et al. (2018), mixing the manures with organic waste will slow the degradation process, thus prolonging the biogas.

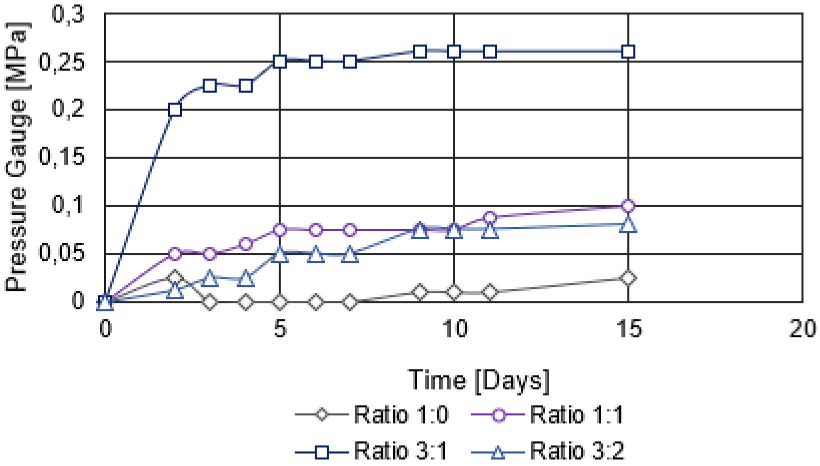


Figure 2. Biogas Production with the Varying Ratios

Biogas Digester Construction

The standard biogas digesters are fixed dome, floating drum, and polyethylene tube digesters. The measurement for distribution, installation, and maintenance relies on the type of biogas digester used, the distinct requirements for space, equipment used, and labor input.

The biogas digester was constructed in Cibodas Village RW 2, Kampung Areng, Lembang, with the help of Indonesia PRIMARY (Program Biogas Rumah). The reactor or digester selected for this project is fixed-dome due to its long lifespan (around 15 years) and easy to maintain. Fiberglass is used as material due to its fast installation (2-3 days), resiliencies to internal and external forces, and low operational cost. The biogas production scheme is available on Figure 3 and the process of construction was presented on Figure 4.

Figure 2. Biogas Production Scheme

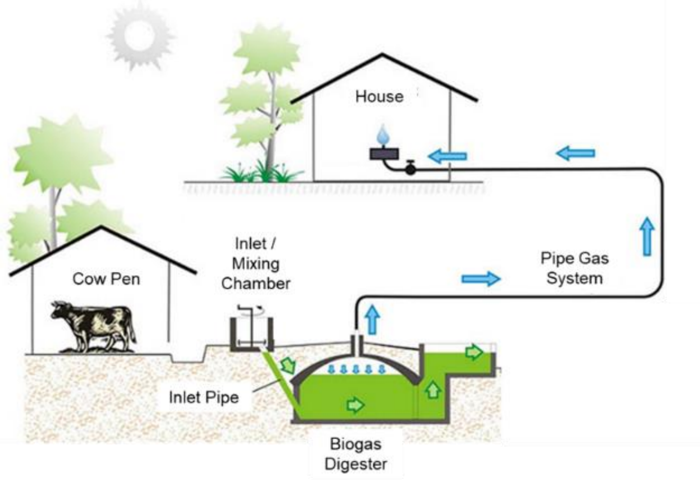


Figure 3. The construction process of a biodigester at a household in the Cibodas Village

Asia Pasific Journal of Management and Education (APJME)
Vol.5 No.3, pp.58-71, November 2022
E-ISSN: 2655-2035 P-ISSN: 2685-8835
https://www.ejournal.aibpmjournals.com/index.php/APJME

The biogas digester is constructed near the cow pens and farmer's house for easy access. One biogas digester has a capacity of 5,000 Liter manures with manure flow rates of 100 Liter per day. The biogas produced is around 1,000 Liter per day, which equals eight hours if used continuously. A biogas digester has several main parts: inlet tank (mixing), inlet pipe, digester, outlet chamber, and gas carrier system (as shown in Figure 3). The digester content is mixed to ensure even temperature distribution and alkalinity buffering, to improve the effective transfer of nutrients to microorganisms, to release trapped gas bubbles, and prevent particulate matter's sedimentation. However, a proper frequency and speed of mixing are necessary since the unproper mixing can reduce biogas production by disturbing microorganism aggregation and granulation.

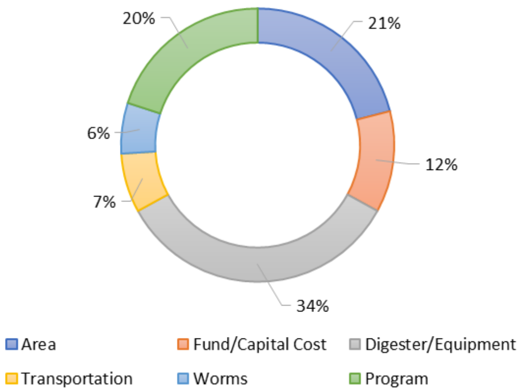
DISCUSSION

Community Socialization/Training

The community socialization/training was held in The Lodge Foundation on May 18, 2019. Around 100 villagers from two villages, Cibodas and Suntenjaya, were invited. The socialization aims to eliminate misconceptions about biogas and inform villagers regarding "Manure Management Training to Produce Biogas Effectively and Efficiently Toward Smart Eco-Social Village".

Figure 4. Training and socialization of manure management to produce biogas

Figure 5. Needs distribution of Cibodas and Suntenjaya communities



From this socialization, local communities showed positive yet low enthusiasm. This program has not moved community participation eminently despite biogas production potential from agricultural waste. It can be seen in Figure 6 that around 34% doubt the program due to a lack of the proper equipment and a biogas digester chamber. Approximately 21% of the sample population does not have enough space to build a biogas digester. Around 12% lack funds to build a biodigester. In comparison, 20% of the population is apprehensive about the program continuity because they feel the need to be evaluated periodically. Manure transportation or logistics also becomes a significant problem, and it shows about 7% of the population.

It was suggested that the program's success should be correlated to direct economic improvement. It might be one significant factor that influences community participation. Most community members think that they do not get direct income from biodigester installments. Therefore, they show low enthusiasm. Developing a solid and continuous system that emphasizes the waste utilization for biogas and other added-value products is necessary for the high involvement.

Our team suggested that further education and training about the processing of biodigester slurry can be the next step. The biodigester's slurry waste can be used as a breeding medium for earthworms (*Lumbricus rubellus)*, and a base for vermicompost. Vermicompost is a compost that is rich in nutrients (5-11 times higher than conventional compost) due to decomposition by earthworms. Thus, it has a higher value than traditional compost. Earthworms also can be sold as fish and bird food. As shown in Figure 6, about 6% of the sample population already showed interest in earthworm breeding to increase their incomes.

Applying the agricultural and livestock waste into biogas and compost would encourage sustainable and eco-friendly farming that reduces the waste disposal in the river. And at the same time, it would reduce the usage of chemical fertilizer, LPG, and improve the local economy.

Follow-Up of The Community Service

The community service does not stop after socialization. Instead, the team still follow-up about the continuity of biodigester utilization. The last follow-up was on October 29, 2021, and the biodigester still works properly. However, between May 2018 and October 2021, there were three lamp replacements and installments on September 9, 2019, February 2, 2020, and October 29, 2021. This might occur due to moisture getting carried away by methane gas and causing damage to petromax lamps. Therefore, installing the filter is necessary to avoid appliance failure for communal biogas utilization.

The community also informed that biogas utilization for lighting and cooking is not yet optimal. One day of biogas production can last for 2-3 days. Thus, further application of biogas must be considered. Food drying is one activity to optimize biogas utilization since many farmers also perform it during harvest.

CONCLUSIONS

The community service successfully constructed the biodigester to convert organic and livestock waste into biogas. Fiberglass is a more feasible material compared to concrete for the biodigester since only 2 until 3-days time for installation with no leaking has been detected for three years after biodigester installation. The best ratio of livestock manures to organic waste is 3:1 to produce the most significant biogas. The usage of biogas for lighting the lantern replacing kerosene is a promising solution for local communities besides cooking purposes. However, despite the success of biogas production, local communities still felt hesitant to build their own digester due to no income improvement after the investment. Therefore, it is essential to develop an eco-friendly system that can support the economy of local communities and at the same time reduce waste disposal in the river. Our team recommended a more comprehensive study to observe the most efficient way to manage the manure, which are including the processing of biodigester slurry waste into biogas and the output slurry of biodigester into vermicompost. Furthermore, biogas is suggested to be used for food drying to optimize biogas usage.

ACKNOWLEDGEMENT
The authors express gratitude to Australia Awards Indonesia through the Australia Grant Scheme, The Lodge Foundation, The Institute of Research and Community Service (LPPM) of Parahyangan Catholic University (UNPAR) who contribute in the financial support as well as Mr. Asep Suherman, S.I.P (head of Cibodas village), Ms. Rukmini (head of SDN 2 Cibodas) and Ms. Eti (owner of the cow farming) to have had the pleasure to cooperate during this study.

DECLARATION OF CONFLICTING INTERESTS
The authors have declared no potential conflicts of interest concerning the study, authorship, and/or publication of this article.

REFERENCES

ADB. (2016). Asian Development Bank report: *Indonesia Country Water Assessment*.

Andianti, R., Mardiah, S., & Purba, W. S. (2020). *Statistik Lingkungan Hidup Indonesia 2020*.

Ayilara, M., Olanrewaju, O., Babalola, O., & Odeyemi, O. (2020). Waste Management through Composting: Challenges and Potentials. *Sustainability*, *12*(11), 4456. doi:10.3390/su12114456

Bachrein, S. (2012). Pengembangan Daerah Aliran Sungai (DAS) Cikapundung: Diagnostik Wilayah. *Jurnal Bina Praja*, *04*(04), 227–236. doi:10.21787/JBP.04.2012.227-236

Budiyono, B., Widiasa, I. N., Johari, S., & Sunarso, S. (2014). Increasing Biogas Production Rate from Cattle Manure Using Rumen Fluid as Inoculums. *International Journal of Science and Engineering*, *6*(1). doi:10.12777/ijse.6.1.31-38

Direktorat Bioenergi. (2016). Buletin Bioenergi Volume 1. *Direktorat Bioenergi*, 1–16.

Hidayati, S., Utomo, T. P., Suroso, E., & Maktub, Z. A. (2019). Technical and technology aspect assessment of biogas agroindustry from cow manure: case study on cattle livestock industry in South Lampung District. *IOP Conference Series: Earth and Environmental Science*, *230*, 012072. doi:10.1088/1755-1315/230/1/012072

International Energy Agency. (2020). *Outlook for biogas and biomethane: prospects for organic growth*.

KPSBU. (2022). *Koperasi peternak sapi Bandung Utara*. https://kpsbu.co.id/

Lehnert, N., Dong, H. T., Harland, J. B., Hunt, A. P., & White, C. J. (2018). Reversing nitrogen fixation. *Nature Reviews Chemistry*, *2*(10), 278–289. doi:10.1038/s41570-018-0041-7

Luna, E.M. (1999a). Rethinking community development in the Philippines: Indigenizing and regaining grounds. In V.A. Miralao (Ed.), The Philippine social sciences in the life of the nation. Vol. 1: The history and development of social sciences in the Philippines (pp. 315–343). Quezon City: Philippine Social Science Council

Maulana, R. (2019). *Konservasi Citarum, PJT II Kembangkan Biogas dan Pupuk Organik*. Bisnis. https://ekonomi.bisnis.com/read/20190322/%0A45/903181/konservasi-citarum-pjt-ii-kembangkan-biogas-dan-pupuk-organik%0A

Nkoi, B., Lebele-Alawa, B. T., & Odobeatu, B. (2018). Design and Fabrication of a Modified Portable Biogas Digester for Renewable Cooking-Gas Production. *European Journal of Engineering and Technology Research*, *3*(3), 21–29. doi:10.24018/ejeng.2018.3.3.647

Nurbaya, S., Hendroyono, B., & Mahfudz. (2020). *The State of Indonesia’s Environment 2020*.

Petersen, S. O., Blanchard, M., Chadwick, D., Del Prado, A., Edouard, N., Mosquera, J., & Sommer, S. G. (2013). Manure management for greenhouse gas mitigation. *Animal*, *7*, 266–282. doi:10.1017/S1751731113000736

Presidential Regulation (2006). Presidential Decree No. 5 of 2006 on National Energy Policy

Sabar, A. (2006). Prospek Kontribusi DAS Cikapundung Memenuhi Laju Permintaan Sumber Air Baku Metropolitan Bandung. *Media Komunikasi Teknik Sipil*, *14*(2), 169–178. doi:10.14710/mkts.v14i2.3944

Sofyan, I. (2004). *Pengaruh Tata Guna Lahan Terhadap Kualitas dan Kuantitas Air Sungai Cikapundung*. Universitas Dipenogoro.

Sunarti, Supriadi, A., & Kencono, A. W. (2017). *Kajian Penyediaan dan Pemanfaatan Migas, Batubara, EBT, dan Listrik*.

Yan, J., Li, Y., Xiong, R., Ma, J., Xiao, B., Liu, J., Guo, X., & Liu, Y. (2018). Mixture ratio optimization of different organic solid waste co-composting in rural areas. *Chinese Journal of Environmental Engineering*, *12*(7), 2106–2113. doi:10.12030/j.cjee.201712100

Zhao, Q., & Liu, Y. (2019). Is anaerobic digestion a reliable barrier for deactivation of pathogens in biosludge? *Science of The Total Environment*, *668*, 893–902. doi:10.1016/j.scitotenv.2019.03.063