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Community Perception of Biogas Production from Cacao Waste

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ABSTRACT

Indonesia can use bioenergy to meet its renewable energy consumption target. Community perception must be known when designing communication strategies or policies regarding biogas as a renewable energy source. This study aims to 1) evaluate the knowledge, attitude, behavior, and overall perception of the Gambiran Hamlet, Gunungkidul, Yogyakarta, Indonesia residents on biogas from cacao waste, and 2) investigate the factors affecting the perception of the Gambiran Hamlet residents on biogas. Socio-economic data were collected by doing surveys and observation. One sample t-test was conducted to determine the perception of the Gambiran Hamlet community towards biogas made from cacao waste. Moreover, logistic regression was used to determine the factors affecting the perception of biogas. Most of the residents can define biogas properly. Moreover, the residents' attitude and behavior were positive regarding relative advantage, compatibility, complexity, and observability components. Gambiran Hamlet residents' perception of biogas from cacao waste is positive. Furthermore, the higher the educational attainment and being male, the greater the chance of a positive perception of biogas. However, household size, age, and income are statistically insignificant. Furthermore, socialization, training, and mentoring are needed for biogas installation. This research successfully provides fresh insights into residents' perception of biogas from cacao waste and uncovers key factors, like gender and education, influencing their perception, offering valuable guidance for targeted policy and communication strategies.

INTRODUCTION

Renewable energy is an advantage for our planet as it significantly reduces global warming emissions, and positively impacts public health and the environment by enhancing their quality. Additionally, it provides an abundant and never-ending energy source, creates job opportunities, brings economic benefits, helps

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regulate energy prices, and contributes to a more dependable and sturdy energy infrastructure (Spellman, 2016).

Indonesia's key theme is integrating local resource capacity with advanced technological options to provide modern and reliable energy services while supporting sustainable growth (Silveira et al., 2018). Bioenergy potential could use paddy, cassava, coconut, sugar, maize, and palm oil residues. The types of bioenergy include bioethanol, biodiesel, biogas, and biosyngas. In Patuk Sub-district, Gunungkidul Regency, some farmers plant cacao plantations on their lands. In Gambiran Hamlet, Bunder Village, Sari Mulyo Farmers' group processes the cacao bean into various chocolates: cocoa mass, cocoa butter, cocoa nib, and cocoa powder. The cacao pod husk (CPH) produced from the plantation has not been optimized yet. This condition allows utilizing the available CPH as biogas. Tabatabaei and Ghanavati (2018) stated that the small-scale biogas plant product is used for cooking, lighting, and heating purposes at household levels. There is a growing body of literature that recognizes perception regarding biogas technology. Pullaila et al. (2018) use a face-to-face interview survey on 235 farmers to gather perceptions of rice transplanters' and combine harvesters' utilization. Multiple regression models were used to recognize the factors determining the perceptions. It is found that farm size, extension, and farming experience are statistically significant in determining the negative perceptions. This means that the extension service played a role in lessening farmers' negative perceptions of transplanters and combine harvesters and then facilitates agricultural mechanization to cope with rapid improvement in agricultural labor wages.

Another study by Kiwelu et al. (2021) found that as many as 320 smallholder farmers' perceptions of the varieties of coffee and determinant factors influencing their adoption in two districts in Tanzania were observed using a household survey questionnaire. The perception was assessed using a five-point Likert scale questionnaire, and a logistic regression model was applied to determine the adoption factor. It turned out that many smallholder coffee farmers perceived improved coffee varieties positively. Overall, the model used (which consisted of independent variables: age, sex, education level, household size, residentship in a cooperative, training on GAPs, access to extension services, coffee land size, yield, price, and income) is statistically significant to predict the dependent variable.

Furthermore, Nimoh et al., (2022) stated that education, years, monthly income, and perception to sell cassava leaves as leafy vegetable significantly affected consumers' willingness to pay for cassava. Cholidi et al., (2020) stated that farmer's perception significantly influenced farmers' behavioral responses to the cane grower management consolidation plan.

Meanwhile, Islam and Hossein (2014) studied the knowledge, perceptions, and attitudes toward biogas plants in Bangladesh. The study found that Bangladesh has a promising future for biogas technology as it has vast raw materials: cow dung and poultry litter. Moreover, the farmers have positive attitudes toward biogas technology.

Although some research has been carried out on perception towards biogas, no studies have been found in incorporating knowledge, attitude, and behavior concept towards biogas from Cacao Pod Husk (CPH) as well as biogas comparison to LPG (Liquid Petroleum Gas). So, this study offers some important insights into Gunungkidul, Yogyakarta Province residents' perception regarding biogas technology which needs to be known to design communication strategies or policies regarding biogas. Factors affecting the perception, therefore, were also researched.

METHODS

Data Collection

Fieldwork was conducted on September 2021 at Gambiran Hamlet, Bunder Village, Patuk Sub-district, Gunungkidul Regency, Yogyakarta Special Region, Indonesia. This location was chosen because there are cacao farmers in Sari Mulyo farmers' group, which has a cacao processing unit and cacao waste problem to be processed as biogas. Socio-economic data is collected through surveys and observation, which gathered information on the knowledge, attitude, and behavior of farmers' group residents on biogas; and respondents' identity. Participants in this study are the residents of the Sari Mulyo farmers' group. There are 51 respondents chosen by 1) their status as cocoa farmers (which means all cocoa farmers in the Gambiran Hamlet) and 2) randomly selected 21 farmers from the total 28 respondents who do not plant cacao. So, at first, the data frame was collected by asking for the list of Sari Mulyo farmers' and non-farmers group members, and from the available data, cacao farmers and non-cacao farmers were chosen. The non-cacao farmers' samples were necessary to have as they represent non-cacao farmers views on biogas plants which are better geographically and culturally appropriate, meet energy needs, and provide co-benefits (Taylor et al., 2019). The villages usually have communal culture, so it is better to know the perspective of non-cacao farmers.

Measuring Perception

The unit of analysis for the economic indicator (i.e., income) is household, and the perception is individual respondents. Meanwhile, to reach the second objective, logistic regression was conducted. Perception is a psychological process that results from the thinking process. The measurement of the level of perception uses a five-point Likert score. Knowledge, attitude, and behavior concept advantage is understanding in detail which parts of the those three which are not adequate so as to provide information where to

give attention to. The maximum score for the perception of biogas would be 300, as the 3 categories (knowledge, attitude, behavior) would contain 5 more categories inside (relative advantage, compatibility, complexity, trialability, observability) with 4 questions each, and the maximum score for each question is 5. Meanwhile, the lowest score for a question is 1. Positive perception scores ranged from 181 to 300, and negative perception ranged from 60 to 180 as the lowest score for the perception starts from 60.

Measuring Independent Variables

Age is the year of the study minus the year of birth of the respondent. The unit of age in this study is years. Educational attainment is the level of education earned by farmers using units of years. The male dummy is categorized into male and female (1 = male; 0 = female). Total household income is household net annual income measured in rupiah(s). Household size is a group of people who inhabit part or all of the physical/census building and usually live together and manage food from one kitchen, i.e., the management of daily needs is managed together into one.

Validity and Reliability Test

Moreover, a research instrument is a tool for collecting data. The research instrument must be valid and reliable for the data obtained to have high accuracy and consistency. An instrument can be said to be valid if the instrument is measuring what it should measure.

The instrument's validity is determined by correcting the scores obtained on each question or statement with the total score. The correlation formula for finding the correlation value is the Pearson Product Moment correlation.

$$r = \frac{N(\sum XY) \pm (\sum X \sum Y)}{\sqrt{[N\sum X^2 - (\sum X)^2][N\sum Y^2 - (\sum Y)^2]}}$$

Where r is correlation coefficient, X is item score, Y is total score of items, N is number of samples (respondents). The r-value is then compared with the table r-value with degrees of freedom (n-2). It means significant if the calculated r-value is greater than the r-value at a certain α. Therefore, statements are valid to be used for research instruments.

Reliability contains objectivity because the measurement results are not influenced by who the measurer is. Reliability can be calculated using the formula:

$$a = \left(\frac{k}{k-1}\right)\left(1 - \left(\frac{\sum ab^2}{\sum at^2}\right)\right)$$

Where α is cronbach's alpha coefficient or reliability instrument, k is number of questions or statements. $\sum \alpha b^2$ is number of variants per item, and $\sum \alpha t^2$ is total variant.

Determining Perception

Hypothesis I testing was conducted to determine the perception of Gambiran Hamlet community towards biogas made from CPH as raw material. This hypothesis testing was done by using the t-test. T-test was used instead of z-test because the population variance is unknown. H_1 :

$\mu > 180$, and the H_1 stated that Gambiran village members' perception regarding CPH biogas is positive. Furthermore, the classification of positive and negative perception was used as it provides simplicity in interpreting the data collected.

$$t = \frac{m}{s/\sqrt{n}}$$

Where m is mean differences and s is standard deviation. Meanwhile, n is sample size.

Understanding Factors Affecting Perception

Turning now to hypothesis II testing which was conducted to understand the factors affecting Gambiran community residents' perceptions of biogas with CPH as input. This testing was done with binary logistic regression.

The logistic regression method was also used by Rondhi et al., (2021), Mienur et al., (2021), Asfew et al., (2023), Cobo-angel & Gohar (2022), Bamikole & Adebowale (2023), Abugri (2020) and Damodar & Nibal, (2020). Criteria to test the hypothesis are as follows.

Binary logistic regression accepts a binary response of 1 or 2, but the internal mechanism of the algorithm converts these values to 0 and 1. The equation of logit function is:

$$\text{Log}\left(\frac{P(Y=1)}{1-P(Y=1)}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7$$

Where $\text{Log}\left(\frac{P(Y=1)}{1-P(Y=1)}\right)$ is the odds of Gambiran Hamlet residents perceptions (1 = positive, 0 = negative), β_0 is intercepts, β_1 to β_7 is regression coefficients of the independent variables except for β_3 which is regression coefficient of independent dummy variable. X_1 is respondent's age (year), X_2 is educational attainment (year), X_3 is male dummy, X_4 is income (rupiahs), and X_5 is household size.

Binary logit regression analysis in this study uses the Stata 16 application. Determination of model accuracy and hypothesis testing in binary logit regression is known through the following tests:

a. Hosmer-Lemeshow Test

The Hosmer-Lemeshow test is used to determine the suitability of the model used. The Hosmer-Lemeshow test has a null hypothesis. The model adequately predicts/represents group residentship, and the null hypothesis value is rejected if the associated significance level is less than 5%.

The tested H_1: $b_1, b_2, \ldots, b_i \neq 0$, means that the model used does not represent data appropriately. While, the criteria for the z-test results are: if probability HL $<\alpha$ (0.05), then H_0 is rejected, meaning that the model used is not suitable to represent the data.

b. McFadden R^2

McFadden R^2 is an alternative to R^2 which was conducted to determine the goodness of fit.

c. Overall Test

The overall test was conducted to determine the effect of the independent variable simultaneously influence the dependent variable.

d. Partial Test: Wald Test

In logistic regression, the

partial test uses the Wald test. The score (z), which follows the chi-square distribution is calculated as follows:

$$z = \left(\frac{b_i}{Seb}\right)^2$$

H_1: $b_i \neq 0$; there is an effect of the independent variable i on the dependent variable. If probability $z \geq \alpha$, (0.1), then H_0 fails to be rejected, meaning that independent variables partially not influence the dependent variable.

e. Odds Ratio

Odds ratio 1, means 1:1 odds indicates that the variable has no effect. The further from 1.0 in either direction, the greater the effect.

f. Classification Table

Binary logistic regression defaults to a classification probability cutting point of 50%. In a perfect model, the overall percent correct is 100%.

RESULTS AND DISCUSSION

Knowledge of Biogas

The early signal of acceptance towards biogas can be seen from the society's knowledge, attitude, and behavior towards biogas. It is important to know the community's perception before installing a new technology as it was the base of the biogas activities (continuous maintenance and use).

The value of the validity of each item of the perception statement toward biogas in Gambiran Hamlet is as follows. From the 60 statements, 3 items are invalid, as a correlation coefficient of more than 0.21 is deemed valid. Thus, only 57 question items can be used as perceptions towards biogas in Gambiran Hamlet. Furthermore, three categories of perception toward biogas statements have reliability, as Cronbach Alpha of more than 0.7 is deemed reliable.

As seen in Table 1 most of the respondents in Gambiran Hamlet, 78% of the respondents, can define biogas. This large percentage results from the past biogas installation in a farmer house in Gambiran Hamlet in 2005. Unfortunately, the biogas plant was short in manure as the input, so it did not last. Meanwhile, the percentage varied for each input (livestock manure, crop waste, food waste, and human dung). Most respondents understand that biogas is made from livestock manure, but only 24%, 14%, and 12% can tell whether the biogas is made of crop waste, food waste, or human dung. Furthermore, the most famous biogas output is gas, which accounts for 73% of respondents who guessed it right. Meanwhile, only 14% and 20% of respondents can think of electricity and fertilizer as biogas output.

Furthermore, the knowledge part of perception questions shows that complexity, which highlights the degree to which an innovation is perceived as relatively difficult to understand and use, has an average score below 3 (Figure 1.). This means that respondents cannot decide whether biogas can be easy to use or understand, as there was no biogas on the site at the moment of data collection.

Meanwhile, all other categories: observability, relative advantage,

compatibility, and trialability; have average scores above 3. This means that the respondents understand whether biogas is better than LPG, whether it is consistent with past experiences and needs of potential adopters, whether it can be tried, and whether the results are visible.

Attitude and Behavior Towards Biogas

Attitude can determine whether the respondents want to apply the biogas to their neighborhood. This is the next level after the knowledge step, which can help identify which farmer(s) is a *champion* in terms of the very accepting ones of biogas innovation. Identifying these respondent(s) is crucial to smoothen biogas socialization and application at the field level.

As stated by Rogers (2010), in developing a favorable or unfavorable attitude toward an innovation, the new idea is mentally applied by an individual to his or her current or anticipated future before deciding whether or not to try it. Therefore, the ability to think hypothetically and to project into the future is needed.

The overall attitude of the respondents is positive, as can be seen in Figure 1., except for the trialability section. Trialability highlights the degree to which an innovation can be experimented with or tried out. This means the farmers mostly do not want to use biogas if biogas is not available for use, has a possibility to suffer loss, and expensive. Hence, it is important for the future biogas provider to make it cheap and has a kind of guarantee not to cause losses due to its operations.

Trialability section in attitude and behavior also scored lesser than the knowledge counterpart. It happens because the knowledge section only assesses whether the respondents know the trialability of biogas, which is whether there is no chance to try biogas and whether there is a possibility of loss in using biogas, whether it is expensive to build biogas, and whether the limited existence of biogas makes it difficult to use. Meanwhile, the attitude and behavior section assessed the desire to apply the innovation and support which will be given if those statements are true. This means that the respondents

Table 1. Respondents' ability to determine the nature of biogas

Knowledge type	Percentage (%)
Definition	78
Input	
i. Livestock manure	78
ii. Crop waste	24
iii. Food waste	14
iv. Human dung	12
Output	
i. Gas	73
ii. Electricity	14
iii. Fertilizer	20

Source: Primary Data Analysis, 2021

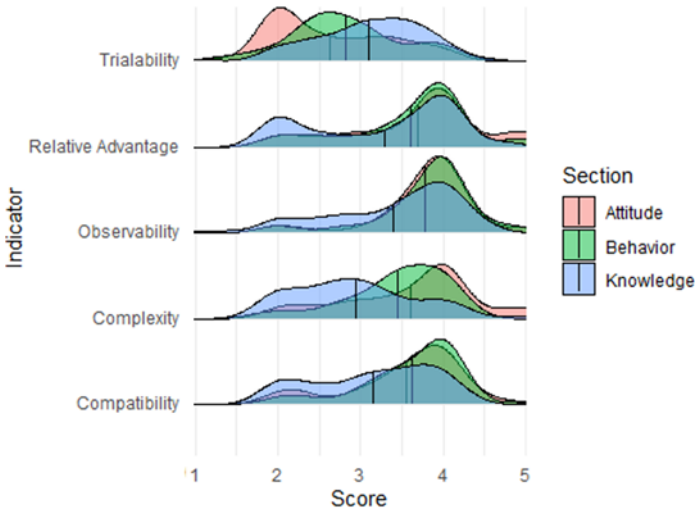

Figure 1. Perception Score Chart
Source: Primary Data Analysis, 2021

understand the trialability of biogas condition; therefore, the attitude and behavior scored lower than the knowledge.

Rogers (2010) also stated that forming a favorable or unfavorable attitude toward an innovation does not always lead to an adoption or rejection decision. In this case, behavior towards biogas also follows the attitude (Figure 1). Where relative advantage, compatibility, complexity, and observability are positive.

Overall Perception Towards Biogas

Those who have a positive perception of biogas are the majority (78% of the respondents). This is inline with the research by Islam & & Hossein (2014) in which the farmers have positive attitudes toward biogas technology. Meanwhile, those who had a negative perception towards CPH biogas are only 11 respondents or 22% of the total respondents asked (Table 2). These respondents tend to have negative perceptions in all of the 5 sections: relative advantage, compatibility, complexity, trialability, and observability; except for the trialability section in attitude and behavior. This means those 11 respondents will support and want to use biogas, which can save expenses, benefit the environment, and add knowledge. The T-test result for hypothesis II is that Gambiran village residents' perception regarding CPH

Table 2. Perception Towards Biogas

Perception	Number of Respondents	Percentage (%)
In favor	40	78
Disfavor	11	22
Total	51	100

Source: Primary Data Analysis, 2021

Table 3. Factors Affecting Perception Towards Biogas

Perception	Coef.	Odds ratio	Std.Error	z	P>|z|
Male dummy	2.001*	7.401	8.500	1.74	0.081
Age	-0.655	0.936	0.057	-1.06	0.287
Income	-4.85	1	2.550	-0.19	0.849
Education	0.399*	1.490	0.323	1.84	0.065
Household size	0.570	1.768	0.613	1.64	0.100
Constant	-0.844	0.430	1.815	-0.20	0.842

Source: Primary Data Analysis, 2024

Table 4. Classification Table

Classification	Percentage
Sensitivity	89.74%
Specificity	50.00%
Positive predictive value	87.50%
Negative predictive value	55.56%
Correctly classified	81.63%

Source: Primary Data Analysis, 2021

biogas is positive, as the p-value in the Pr(T > t) row (under Ha: mean > 180) is less than 0.05, and H_0 is rejected. Perception towards biogas is 1, if the farmer has a positive perception and 0 if the farmer has a negative perception. It is hypothesized that the factors affecting perception towards biogas are male dummy, age, income, educational attainment, and the number of household residents.

The Prob > chi^2 is 0.9240, which puts it at more than 0.5. This means that it is insignificant, and therefore, there is not enough evidence to say the model is a poor fit.

Pseudo R^2 0.3324 is a good R^2, as 0.2 to 0.4 for R^2 represents an excellent fit. This also means that 33.24% dependent variable variation (perception) can be explained by the variables in the model, which are male dummy, age, income, education level, and the number of household residents. The larger the number of pseudo R^2, the better the model predicts the outcome.

The overall correct classification rate is estimated to be 81.63%, with 50% of the negative perception group correctly classified (specificity) and 89.74% of the positive perception group correctly classified. Meanwhile, the probability of respondents with a positive perception truly having a positive perception is 87.5%, and the probability of respondents with a negative perception truly having a negative perception is 55.56%. The LR probability 0.0027, which is lower than 0.05, means that H0 is rejected, and the independent variables simultaneously influence the dependent variable. Based on the

p-value (0.1626), null hypothesis cannot be rejected, again indicating that the coefficients for household

residents, male dummy, income, and education are simultaneously equal to zero, meaning that including these variables create a statistically insignificant improvement in the fit of the model.

The effect of an independent variable on the perception towards biogas can be known by significance value of z. If the significance value of z is lower than alpha (1%, 5%, and 10%), then the independent variable affects dependent variable. Variables affecting the perception of biogas are education and household size. Meanwhile, male dummy and income variables do not affect the perception of biogas.

Significance value of z which is 0.84, not significant at alpha 5%. This means that constant does not affect the farmers' perception towards CPH biogas. The coefficient -0.844 means that the respondents tend to perceive biogas negatively if the other variables are considered constant. In the study Patria et al., (2022) Patria et al., (2022) logistic regression with likert scale also was used to determine perception of farmer's card policy implementation. The constant was also negative. The method was also used by Rondhi et al., (2021), Mienur et al., (2021), Asfew et al., (2023), and Damodar & Nibal, (2020) to understand farmer's decision and perception.

Table 3 shows that male dummy has 0.081 as the significance value of z. It is smaller than alpha (10%). Therefore, H_0 which said that there is no difference between the perceptions towards CPH biogas between male and female respondents is rejected which means the perception towards biogas between male and female is different. The positive coefficient shows that the chance of male respondents has positive perceptions is higher than female respondents. Moreover, odds ratio 7.401 indicates that being male tends to improve the perceptions of biogas by 7.401 times. It is in line with Kiwelu et al., (2021) research which applied a five-point Likert scale questionnaire and a logistic regression model. The males' adoption of innovation tends to be positive due to their capacity to own resources, including land and/or socio-cultural values and norms.

Table 3 shows that age has 0.29 as the significance value of z. It is larger than alpha (1%, 5%, and 10%). Therefore, H_0, which said there is no difference between the perceptions towards biogas between ages, failed to be rejected. This means that the perception towards biogas between ages is not different. The negative coefficient shows that older respondents have a higher chance of negative perceptions than younger respondents. This result aligns with Sarker et al., (2020), who stated that older people are less willing to adopt biogas technology.

The significance value of z for income variable is 0.85, which is larger than alpha (1%, 5%, and 10%). Therefore, H_0, which said that income does not affect the perception towards CPH biogas, failed to be rejected. This means that income has no effect to the perception towards biogas. Moreover, a negative coefficient is a sign

that income negatively affects the perception of biogas, which means that the higher the respondents' income is, the lower the perception of biogas. Surprisingly, income was hypothesized to have a positive effect as higher income means a bigger capacity to adopt innovation. It will be much easier for higher-income respondents to buy LPG gas than to operate biogas. Higher-income also consumes more time, which means less time to take care of biogas plant. Therefore, the perception is negative. Meanwhile, the insignificant effect of income on the perceptions towards biogas can be attributed to the lots of help from the government for the farmers.

Education variable shows how many years the respondents went to school. Based on the significant value of z, 0.065, which is lower than alpha 10%, the education variable affects the perception of CPH biogas. The coefficient of 0.399 and odds ratio of 1.490 shows that the increase of 1 year of education improves the perceptions towards biogas by 1.490 times. This finding aligns with Putra et al., (2019), which indicates that education is vital in fastening biogas technology adoption among farmers. Sarker et al., (2020) also stated that higher education status builds confidence and awareness of adopting biogas technology with a highly significant logistic regression coefficient 0.687. Meanwhile, this result cannot be separated from the fact that the farmers in Gambiran also obtain informal education (which is not recorded in this variable).

Household size variable shows how many residents the household is. Based on the significant value of z, 0.10, the same as alpha 10%, the household residents variable does not affect the perception towards CPH biogas, as p-value $\geq$ 0.1 indicates insufficient evidence to say otherwise (Ganesh & Cave, 2018). However, a coefficient 0.57 and odds ratio 1.768 shows that the increase of 1 household member tends to improve the perceptions towards biogas by 1.768 times. This result can be attributed to the more needs of a household in a large household, which then the household is more open to the innovation that may improve their lives. The larger the household is, the more information can be gathered, enhancing the perception. This result is in line with the research of Walekhwa et al., (2009), which said that household size significantly influenced the household's decision to adopt biogas technology, and the larger household had a higher probability of adopting biogas energy than the smaller one.

Gender and educational attainment are significantly affecting the perception of biogas innovation. Therefore, in choosing which farmer(s) is a *champion,* these two factors are crucial to be taken in, especially to smoothen biogas socialization and application at the field level. For example, in choosing who might be the biogas ambassador in the community.

CONCLUSION AND SUGGESTION

The knowledge possessed by Gambiran Hamlet farmers about

biogas is already good. However, they still cannot decide whether biogas can be easy to use or understand as there was no available biogas on the site at the moment of data collection.

Meanwhile, the attitude of Gambiran Hamlet residents is mostly positive, except if biogas is not readily available, could result in financial loss, and is too expensive. Overall, Gambiran Hamlet residents' perception regarding CPH biogas is positive. Moreover, the higher the educational attainment and being male, the greater the chance of a positive perception of biogas. However, household size, age, and income are statistically insignificant.

Furthermore, socialization, training, and mentoring are needed for biogas installation so that the farmers will understand the difficulty level of biogas use as well as be assured that biogas will not result in financial loss and will not be expensive to install. For this case, it is recommended to cooperate with either government, NGO, or any other entities that can provide a biogas plant. Moreover, suppose the selection of the farmers who can be given free biogas plant or socialization, training, and mentoring is required. In that case, it is worth considering the male farmer and high educational attainment of the farmer, as those variables are proven to affect perception towards biogas.

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