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Factors Affecting Biogas Technology Adoption by Cattle Farmers in Central Java

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ABSTRACT

Cow dung farm waste often creates problems when the waste is not properly managed. Beef cattle farmers as agribusiness entrepreneurs in the Polosiri Village, Semarang Regency had different behaviors in adopting technologies; one of the technologies is biogas. This study aimed to analyze the factors that influence the adoption behavior of biogas technology in the group of beef cattle farmer. A survey was conducted on 40 farmers in Polosiri Village, Bawen Sub-District in Semarang Regency, Central Java. Data were collected through interviews with structured questionnaires and analyzed by multiple regression models. The results showed the behavior of beef cattle farmers in the adoption of biogas technology in the medium category. Factors of income, farm experience, and motivation of farmers are important factors in technology adoption behavior. While the number of livestock and commercial gas usage have no significant effect. It can be concluded that behavior in adopting of biogas technology in farm household depends on the socio-economic condition. Appropriate policies should be formulated to take advantage of the adoption of biogas technologies to improve the sustainability of agricultural productivity.

Key Words: Adoption, Biogas, Cattle, Feces, Technology

INTRODUCTION

Cattle farms have a strategic position in the development of farms. The growth of beef cattle population in Indonesia increased from 14,726,875 in 2014 to 16,092,561 in 2016 (BPS 2017). East Java and Central Java are the two largest beef cattle centers in Indonesia with each contribution of 28.66% and 11.31%, respectively (Disnakeswan Jateng 2017). An increase in livestock population will be in line with increasing livestock wastes. Livestock waste such as cow dung has the potential to become an environmental problem if not processed. The processing of livestock waste in addition to having a positive impact on the environment also gives economic benefits (Roessali *et al.* 2014). Waste derived from cow dung can be utilized into biogas (Elizabeth & Rusdiana 2011). Biogas is environmentally friendly and one of the most efficient and effective options for renewable energy among other alternative sources (Miah *et al.* 2016). Eco-friendly farming requires the selection and application of technologies compatible with the environment, resulting in optimal farming productivity and safely-produced products (Abdullah *et al.* 2015).

Efforts to improve livestock productivity today is how to produce livestock products that are highly competitive so as to improve the welfare of farmers. One aspect to increase the production and income of the farmers is the technological aspect. Technology adoption is a bridge in an effort to increase the productivity of a business

(Roessali *et al.* 2013). A technology will be adopted by the user community if the technology provides higher benefits or a relative added value obtained when the technology is adopted (Musyafak & Ibrahim 2005). A technology must utilize existing resources around the community and should be perceived as a necessity (Baba 2008).

Waste processing technology into liquid fertilizer, solid and biogas is a technology that should be controlled by farmers (Haryanto 2009). The management of livestock waste is a concept in support of sustainable development. Handling and utilization of livestock waste is an innovation. Innovation itself requires the adoption of technology. Adoption involves making or not performing decisions (Setiawan *et al.* 2013). Mardikanto (1993) defines adoption as the behavior change process in the form of knowledge (cognitive), attitudes (affective) and skills (psychomotor) of a person after receiving the message delivered to the target market extension. When farmers are able to apply knowledge, improve attitudes and improve skills in farm business development, its effects on business development occur.

Biogas is one of the many renewable energy sources. Energy is an important factor in the development of the country because it has a direct impact on the quality of human life and industrial development (Domac *et al.* 2005). Biogas production encourages the sustainable agriculture with a renewable and environmentally friendly process system. The biogas production system has several advantages such as: (a) Reducing the effect of greenhouse gases; (b) Reducing unpleasant odor pollution; (c) As fertilizer; and (d) Power and heat production (Wahyuni 2009). Biogas technology is a economically viable fuel, especially to reduce environmental pollution in rural areas (Ginting 2007). An adopted technology will spread to other breeders or prospective adopters if the technology can have a positive impact that benefits the users. There are three aspects needed for the adopter candidate in relation to the adoption process of innovation: (a) the presence of other parties who have adopted it; (b) a systematic adoption process that can be followed by the adopter candidate; and (c) a favorable adoption result (Musyafak & Ibrahim 2005).

There are three levels of biogas production process namely hydrolysis, acidification, and methanogenesis. These three stages refer to the various reactions and interactions that occur between methanogens, non-methanogens, and materials fed into the biogas reactor as input. Cow manure is composed of 22.59% cellulose, 18.32% hemicellulose, 10.20% lignin, 34.72% of total organic carbon, and 1.26% of total nitrogen. In addition, cow dung also contains 0.37% phosphorus and 0.68% potassium. With high cellulose content, cow manure can produce large amounts of biogas (Sukmana & Muljatiningrum 2011). Cow dung can produce large amounts of biogas due to its high amount of solid waste (Gunawan 2013).

Previous researches related to the rate of technology adoption had been conducted by some experts (Nurlina & Maryati 2011; Mahardika *et al.* 2014; Suciani *et al.* 2015). Socioeconomic factors generally affect the rate of technology adoption. The objectives of the research are:

1. To analyze the technology adoption behavior by beef cattle farmers in Central Java.
2. To analyze the factors that affect the adoption of biogas technology in Central Java.

MATERIAL AND METHODS

The study was conducted in the central of beef cattle production in Bawen, Semarang Regency, from November to December 2015. Data were collected using questionnaires and interviews method with 40 beef cattle farmers as the respondents were the members of Bangun Rejo group. Questions in the research questionnaire were

submitted with accompanying answers prepared in the Likert Scale format. Twelve statements were developed to collect information on knowledge, attitude, skills and motivation of cattle farmers in adopting the biogas technology. Likert type scale is as follows: (1) strongly disagree; (2) disagree; (3) neither agree nor disagree; (4) agree; and (5) strongly agree.

Data were analyzed with multiple regression model to identify the factors that influence the farmers' behavior in adopting the biogas technology. The equation is as follows:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + e$$

Where:

Y :	Technology adoption behavior (scores)	X_3:	Income (IDR/month)
X_1:	Number of cows kept (head)	X_4:	LPG Gas Usage Fee (IDR/month)
X_2:	Farming experience	X_5:	Motivation

b_1, b_2, …b_5 are regression coefficient and e is error term

RESULTS AND DISCUSSION

The demographic condition of respondents presented in Table 1 shows that the percentage of the age of the respondents of beef cattle farmers in Bawen Sub-district, Semarang regency, Central Java province is more than 62% with the age of 36-45 years old and almost 27.5% with the age of 46-55 years. Forty percent of the respondents finished their high school level. Table 1 presents that there are more than 52% of beef cattle farmers with the farming experience of more than 23 years of, and 35% with less than 14 years of farming experience.

Table 1. Respondents' demographic condition (n = 40)

Description	Total	Percentage (%)
Age (year)		
<35	3.0	7.5
36-45	19.0	62.5
46-55	11.0	27.5
>55	7.0	17.5
Level of education		
Elementary	15.0	37.5
Junior high school	16.0	40.0
Senior high school	7.0	17.5
Graduate level	2.0	5.0
Experience (year)		
<14	14.0	35.0
15-22	5.0	12.5

23-30	17.0	42.5
>30	4.0	10.0
Income (IDR/month)		
<1,000,000	12	30.0
1,000,001-1,500,000	7	17.5
1,500,001-2,000,000	11	27.5
2,000,001-2,500,000	6	15.0
>2,500,001	4	10.0
Number of cattle kept (Animal Unit)		
<2.5	19	47.5
2.6-4	14	35.0
4.1-5	5	12.5
>5	2	5.0

Adoption behavior

Table 2 shows that the farmers' knowledge in the adoption of biogas technology is mostly at the medium criterion namely 62.5%. Knowledge aspect was very important in applying the biogas technology so that the resulting gas can be used optimally. Some farmers confessed that in determining the composition of cattle dung with forages and water, they just made an estimate so that the results were less maximum. According to Wellinger & Lindberg (2000), the resulting biogas composition depends on the type of the raw materials used.

Table 2. Biogas technology adoption behavior

Aspects	Score criteria (%)		
	High	Medium	Low
Knowledge	10.00	62.50	27.50
Attitude	0.00	92.50	7.50
Skills	7.50	50.00	42.50
Behavior	5.83	68.33	25.83

In terms of the criteria of farmers's attitude towards the biogas technology, the farmers had moderate scores (92.5%). In response to biogas technology, the breeders actually said that it is useful and easy to apply, but the cost incurred to build a digester according to them is quite expensive. It is in accordance with the opinion of Roessali *et al.* (2013) that the constraint felt by farmers in applying biogas technology was funding.

The aspect of the farmers' skills in the biogas adoption in Polosiri village was at the medium and low categories (50%) and (42,5%), respectively. This is because not all citizens participated in the manufacturing process of biogas. Some residents paid monthly fees for the operation and rarely took part in the process of the technical manufacture. So they lacked of the skills in the manufacturing process. The best-skilled breeders are usually the cattle farmers because they often take part in the training on the matter.

In general, the rate of adoption of beef cattle biogas in Polosiri Village was at a moderate level. This is because some farmers becoming the group administrators were very active in all activities related to biogas such as the installation of biogas, digester maintenance, and cattle maintenance. While other members only paid money dues and were not too active in biogas producing activities, but enjoyed the results of the biogas. This result is in accordance with that of Mahardika *et al.* (2014) at Gapoktan Simantri of Gianyar Regency in processing the cattle manure into organic fertilizer and biogas.

Based on interviews with respondents in the field it can be seen that with the existence of biogas technology, especially ranchers in the village of Polosiri, the respondents could save the purchase of commercial LPG. Villagers of Polosiri using the biogas in average could reduce their expenses to buy LPG as much as two 3 kg LPG tubes or biogas technology in average can save the cost for gas of 75% of the amount of gas in use. It is in accordance with research result made by Said (2007), that there is a potential of gas to be generated by a livestock and some benefits are obtained when biogas is used. One unit of a biogas reactor using a dung feed from 2-4 dairy cattles may be able to meet the needs of cooking of one rural household with 6 family members. The resulting biogas is equivalent to 1-2 liters of kerosene per day. Family farmers who previously used kerosene for cooking can save the use of kerosene 1-2 liters per day, if the price of kerosene in rural areas is IDR 4,500/l, it means that the farmers can reduce expenses of IDR 1.642.500-IDR 3.285.000 per year.

Determinant factors farmers adopt biogas technology

The multiple regression model showed that the relative independent variables explain the varieties of breeders in the adoption of the biogas technology. Multiple regression models were simultaneously significant at the 99% significance level. There were three independent variables that significantly influenced breeders in adopting biogas, namely income, livestock experience and motivation in the biogas technology adoption. Meanwhile, the number of cattle owned and the purchase of LPG tubes is insignificant for the adoption of the biogas technology. Regression equation of the model is presented in Table 3.

Table 3. Analysis of the estimate of biogas technology adoption

Farm characteristics	Determinant factors of adoption behavior	Sig.
Number of cattle owned (Animal Unit)	0.345362 (1.0199)	ns
Amount of LPG tube purchases (IDR)	0.000032 (0.00006)	ns
Income (IDR/month)	0.000028 (0.000001)	*
Farmer experience (years)	5.32245 (1.25195)	**
The motivation for adopt biogas technology	4.11198 (1.75013)	*
	Constant: 10.52918**(4.86392)	
	$R^2 = 0.61$	
	F Stat 10.47068**	

Standard error in brackets and **Significant at 1% (0.01) level, *Significant at 5% (0.05) level

The income variable has a positive influence on farmers in adopting the biogas technology. There was a tendency that higher the incomes obtaine by the farmers, the greater their tendency in adopting the biogas technology will be. The same opinion was expressed by Humayun (2013) that the most probable effect of income on household adoption of biogas energy is the financial ability to install a digester system, which is often cited as the single most important factor determining whether a household adopts biogas energy.

The variables of livestock raising experience significantly influence the adoption of biogas technology. The longer the farmers experience in using the technology, the better the breeders' ability in managing, developing, and accepting the adoption of biogas technology. Motivation shows a significant influence. Technology adoption is influenced by how farmers will be able to adopt technology in a sustainable way. When there are facilities and information in an effort to improve the ability to manage the use of the digester, it can be responded with high motivation by farmers.

CONCLUSION

This study finds that the adoption behavior of biogas technology in beef cattle ranchers at the research sites is at the moderate category. The decisive factors for beef cattle ranchers adopting biogas technology are monthly breeders' income, farmers' experience and motivation for the adoption of the biogas technology. While the number of cattle owned factors and the purchase of LPG gas did not have any significant effects. Therefore, the research findings show important policy implications to the variables which are found to have a significant influence on the sustainability of the adoption of the biogas technology.

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DISCUSSION

Question

How to determine technology adoption?