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Adoption of agricultural innovations in the context of zero waste: The case of dairy cattle biogas waste

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Abstract
The success of a sustainable agriculture program is determined by the farmers, who are the main actors. Zero waste technology started to be used a few years ago, but there is still little awareness among farmers about how to use it. A large number of animal husbandry households have used biogas energy sources for cooking through the utilization of dairy cattle manure. The use of these technologies still causes problems, because there is a great deal of liquid and solid waste every day. The waste from biogas processing can be converted into liquid and solid fertilizers. This study aims to analyze the factors that influence the adoption of biogas waste technological innovations by farmer groups. The variables that are assumed to affect the adoption of the technology are age, level of education, the managerial skills of the farmer group, level of confidence in the success of the technology, the technological needs, interest in product sales, and the amount of guidance from extension officers. The research sample consists of the members of farmer groups who were chosen using a random sampling method from two farmer groups in different locations. The research results showed that the factors affecting the adoption of innovations in biogas waste technology are the level of education, the level of confidence in the success of the technology, interest in the product sales, and amount of guidance from extension officers.

Keywords: adoption innovation, biogas waste technology, farmer groups

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INTRODUCTION

Population growth has resulted in an increased consumption of food, including food for animals such as beef and dairy cattle. The dairy cow population in East Java in 2013 was 4,334,625. One district in East Java with dairy cows in the Malang district, with a population of 237,673 cows, or 5.48% of the whole dairy cattle population of East Java. Currently, the daily production of fresh milk in the Malang Regency is about 315 tons or nearly 50 percent of all the fresh milk produced in East Java (which amounts to 750 tons) (Dinas Peternakan Propinsi Jawa Timur 2013). These conditions provide economic benefits for the farmer households, including benefits from the implementation of biogas technology. Cattle manure is processed into biogas for cooking purposes in many farming households, so that since 2010 farmers have not needed to spend money to purchase kerosene or gas for cooking. However, it turns out that the biogas production process produces a new waste liquid. At present, the waste is stored in tanks at the backs of houses, but it often happen that the tank is not able to accommodate the growing amount of waste, and thus the home environment is contaminated.

A method of changing the biogas waste into solid and liquid fertilizers has been found by Effendy et al. that this fertilizer significantly improves the quality of farmer-managed growth of plants. When compared with the use of organic fertilizer by farmers over the years, fertilizers from biogas waste yield better growth in terms of the number of leaves, the leaf color, and the height of horticultural crops (Effendy et al. 2014).

The implementation of technology is successful if the technology is followed by other farmers. The facts show that the average farmer does not respond to the technology; this is shown by the tendency not to ask questions, and farmer group meetings have been attended by only a few members. With this background, we conducted research on the response of farmers to technological innovation in the treatment of waste from biogas, with the aim of discovering the reasons farmers are not interested in the innovation and finding a strategy to increase the adoption of the innovation.

MATERIALS AND METHODS

The survey was conducted in the Pujon sub-district of Malang, East Java, Indonesia. We took two farmer

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groups in two villages and 30 farmers from each farmer group, so the total sample was 60 farmers. The data were collected by interviews and questionnaires, and also from the Malang Statistics Bureau. We then analyzed the data using descriptive statistics and regression methods.

Descriptive Analysis

Descriptive statistics were used after the qualitative and quantitative data collected from the members of the farmer groups had been summarized, coded, and entered into spread sheets for the software program of Statistical Package for Social Sciences (SPSS) version 16. This gave quantitative descriptions of information, frequencies, and percentages that were used to present the results.

Regression Analysis

A multiple linear regression models was run to quantify the combined effect of the factors contributing to the adoption of biogas waste technological innovations, as independent variables, and to gauge the role of each variable in explaining the variances in the dependent variable. The factors used as predictors included age, level of education, level of managerial skill in the farmer group, level of confidence in the success of the technology, technological needs, interest in product sales, and amount of guidance from extension officers. The dependent variable was the adoption of biogas waste technology innovations. A rating scale of one to three was used to measure the adoption of biogas waste technology innovations and also for the independent variables (except for the age of the farmer, for which we used the actual age in years).

Model Specification

$Y = \alpha + \beta1X1 + \beta2X2 + \beta3X3 + \beta4X4 + \beta5X5 + \beta6X6 + \beta7X7 + \ldots \beta nXn + \varepsilon$

Where:

Y = adoption of biogas waste technology innovations

X1 = age of the farmer (in years)

X2 = level of education (score with three levels)

X3 = managerial skills of farmer group (score with three levels)

X4 = confidence in the success of the technology

X5 = technological needs

X6 = interest in product sales

X7 = amount of guidance from extension officers

α = constant

Ɛ = random error term.

β1 to βn = Standardized partial regression coefficients for the independent variables.

RESULTS

Characteristics of the Farmers

Table 1 depicts the respondents' ages, by categories. The table shows that six (10%) farmers were aged between 20 and 30 years, 26 (43.33%) were aged between 31 and 40 years, 20 (33.33%) were aged between 41 and 50 years, and eight (13.33%) were more than 50 years old.

Table 1. Age of respondents (n=60)

Age category in years	Number	Percent
20 – 30	6	6.10
31 – 40	26	26.44
41 – 50	20	20.33
> 50	8	8.13
Total	60	100

Table 2. Respondents' education level (n=60)

Education level	Number	Percent
Elementary school	40	67
Middle school	15	25
High School	5	8
Total	60	100

Table 3. Time period using biogas technology (n=60)

Time Period Using Biogas	Number	Percent
Less than 2 years	6	10
2 – 4 years	38	63
More than 4 years	16	27
Total	60	100

Table 1 shows that the farmers were predominantly aged between 31 and 40 years, but that there was a similar number in the age group of 41 to 50 years. This reflects that the average member of a farmer group is at a productive age.

The results in **Table 2** show that 40 (67%) of the farmers had only elementary education, 15 (25%) had a medium amount of education, and five (8%) had higher education. Therefore the majority of the farmers had only primary education. This means that the adoption of technological innovations to use biogas waste as a fertilizer will only occur slowly.

The results in **Table 3** show that the time for which the respondents had used biogas was as follows: six (10%) of the farmers had been using biogas for less than two years, 39 (65%) of the farmers had had three or four years' experience in using biogas, and 15 (23%) of the farmers had used it for more than four years.

The Factors Influencing the Adoption of the Biogas Waste Technological Innovation

Multiple regression analysis represents a logical extension of two-variable regression analysis. Instead of a single independent variable, two or more independent variables are used to estimate the values of a dependent variable (Gupta 1990). Collinearity or multicollinearity diagnostics are used in order to detect whether there is a correlation among the independent (X) variables. According to Lin et al. (2007), when there is a perfect linear relationship among the predictors, the estimates for a regression model cannot be uniquely computed. If there is collinearity, this implies that two variables are nearly perfect linear combinations of one another. When more than two variables are involved this is often called

Table 4. Predictors influencing the adoption of zero waste biogas technology innovations

Independent variables (X)	Std. Error (et)	Beta (β)	t	Sig
Constant	0.691		1.277	0.207
Age	0.011	0.045	0.373	0.711
Education	0.150	0.337	2.630	0.011*
Time Period Using Biogas	0.148	-0.022	-0.177	0.860
Managerial Skills	0.137	-0.171	-1.318	0.193
Lack of the Successing Technology	0.139	0.248	-2.058	0.045*
Lack of Technology Needed	0.126	0.086	0.702	0.486
Lack of Production Sale Ability	0.147	0.263	2.035	0.047*
Less of Guidance Extention Officer	0.120	0.243	1.975	0.054*

R Square (R^2) = 0.330
Adjusted R Square (R^2) = 0.224
F-statistics (for R^2) = 0.005*
* = significant at .05 level
Dependent Variable: Adoption level of waste biogas innovation technologies

multicollinearity, although the two terms are used interchangeably.

Table 4 shows the predictors influencing the adoption of zero biogas waste technological innovations. The regression is significant (p ≤ 0.05) and the nine independent variables account for 33% (Adjusted R2 = 0.330) of the variation in adoption. Also, the findings show that four out of the nine independent variables included in the analysis have significant (p ≤ 0.05) regression coefficients.

The education level of the farmer was the highest predictor of the adoption of biogas waste technological innovations (standardized regression coefficient of 0.337, significant at p ≤ 0.05). The positive regression coefficient implies that education level and adoption of biogas waste technological innovations are positively related. An increase in education level leads to an increased probability of the adoption of biogas waste technological innovations. A change of one in the education level scale translates into a change in the variance in the adoption of 0.337.

Lack of production sale ability had a standardized regression coefficient of 0.263, significant at p ≤ 0.05. The positive regression coefficient implies that the ability to sell the product and the adoption of biogas waste technological innovations are positively related. The amount of guidance from an extension officer had a standardized regression coefficient of -0.243, significant at p ≤ 0.05. The positive regression coefficient implies that the amount of guidance from an extension officer and the adoption of biogas waste technological innovations are positively related. Successful technology had a standardized regression coefficient of 0.248, significant at p ≤ 0.05. The positive regression coefficient implies that successful technology and the adoption of biogas waste technological innovations are positively related.

DISCUSSION

Iheke and Nwaru (2013) found from their research that the significant factors influencing the adoption of innovations and technologies were gender, age, years of formal education, household income, contact with extension and membership of a cooperative. This suggests that the biogas waste treatment technologies will be accepted by members of the farmer groups, although it will require time and determination.

Knight and Sharada (2000) found that household-level education is important to the timing of adoption but less crucial for the question of whether a household ultimately adopts an innovation; in other words, early innovators tend to be better educated and to be copied by those who adopt later, obscuring the relationship between education and adoption at the household level. By contrast, site-level education appears not to affect the timing of the introduction of an innovation to the site, but it does influence the extent of diffusion. Thus, there are two externality effects: better-educated farmers are early innovators, providing an example which may be copied by less well-educated farmers; and better-educated farmers are better able to copy those who innovate first, enhancing the diffusion of the new technology more widely within the site. The research result of Khanal and Gillespie (2013) is different. They reported that in the US dairy sector specialized, younger, and better-educated farmers are more likely to adopt advanced breeding technologies.

The research demonstrated that education, the managerial skills of the farmer group, the level of confidence in the success of the technology, the technological needs, the level of confidence in the marketing of products, the amount of guidance from extension officers, and the amount of leisure time of the farmers have an effect on the adoption of the innovation.

Biogas technology was introduced into the research area five years ago when it was provided by private institutions. This means that for more than five years the farmers who were using biogas have allowed the discharge of liquid biogas waste without any concerns. Most (63%) of the respondents have used biogas for between two and four years. If this is associated with the average level of education of the respondents, it can be concluded that farmers with low education tend to be less sensitive to the problems that exist in their vicinity.

An increase in the ability to sell the product increases the adoption of biogas waste technological innovations. An increase in the amount of guidance from an extension officer leads to a higher adoption level for biogas waste technological innovations. An increase in the success of the technology leads to greater adoption of biogas waste technological innovations. This is the relationship that would be expected because successful technology should influence other farmers and will improve the farmers’ welfare faster.

The results relating to the respondents’ education levels are in accordance with those of Swanson and Claar (1984) and show that the farmers’ educational background is a potential factor in determining the readiness to accept and use an innovation properly. El-Osta and Morehart (2002) found that age, size, and specialization in dairy production increased the likelihood of adopting a capital-intensive technology, whereas education and size of operation had a positive impact on the decision to adopt a management-intensive technology. In this context, the risk preferences of farmers are also important in influencing the technology adoption decision, especially if capital-intensive technology costs are irreversible (Sunding and Zilberman 2000). Hagmann et al. (1999) argued that extension services facilitate collective and individual learning about innovations for farmers and enhance a community's capacity to innovate.

CONCLUSION

On average, the dairy cattle farmers of the Pujon sub-district were aged between 31 and 50, had elementary school education and had been using biogas for between two and four years. They have adopted some innovations, like the application of an organic fertilizer, the utilization of dairy juvenile cows waste, and the use of biogas technology for the daily activity of the household. However, they have not been active in solving problems on their farms, including the growing problem of the waste from biogas.

The farmers' education level, level of production sale ability, amount of guidance from an extension officer, and the successfulness of the technology significantly influenced the adoption of technological innovations for biogas waste. The remaining factors which included the respondent's age, the time for which they had used biogas, the managerial skills of the farmer group, and the technology application knowledge, did not significantly influence the adoption of technological innovations for biogas waste. From this, we can set out a strategy for empowering farmer groups to solve their problems, especially regarding their farming businesses.

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