

# Research on Influencing Factors of Farmers' Behavior of Using Environmental Protection Facilities

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**Abstract**—The use of environmental protection facilities by farmers is essentially the behavior of farmers targeting the production and consumption of public goods, which is affected by many factors. Based on field research data, this paper takes the use of biogas digesters as an example to explore the influencing factors of farmers' use of environmental protection facilities. It is found that economic factors and government intervention have significant impacts on farmers' use of environmental protection facilities. Among them, the construction cost and use income, government subsidies and government supervision have a positive effect on farmers' behavior, while the operation cost has a negative effect. In addition, gender is also an important factor affecting the use of biogas digesters. This paper proposes measures to strengthen the publicity and education of female farmers, increase government subsidies and improve the development of biogas industry chain, with a view to promoting the use and development of environmental protection facilities such as biogas digesters.

**Keywords**—environmental protection facilities; agricultural pollution; biogas digesters; influencing factors

## I. INTRODUCTION

The problem of non-point source pollution caused by livestock and poultry farming waste is becoming more and more serious. With the increase of environmental protection policies in recent years, the importance of the use of biogas digesters has become increasingly prominent. On March 11, 2018, ecological civilization was historically written into the Constitution, and China is doing its utmost to strengthen ecological environmental protection. Behind the pressure of environmental protection is the serious pollution problem brought by livestock and poultry farming. According to the official data of the Ministry of Agriculture, the total amount of livestock and poultry wastes produced in China reaches nearly 4 billion tons per year, and the chemical oxygen demand of livestock and poultry farming has reached 1,268 ten thousand tons, accounting for 96% of the total discharge of agricultural sources, is an important cause of agricultural non-point source pollution (Ministry of Agriculture and Rural Sciences of the People's Republic of China, 2018). As the main environmental protection facility for treating and fermenting livestock manure, the biogas digesters produce flammable gas through anaerobic fermentation of

aquaculture wastes, and the livestock and poultry wastes are handled with resourceful treatment, so that the problem of animal husbandry farming pollution can be solved in China (Ye Fang, 2016). The promotion and use of biogas digesters is an important means to reduce the current non-point source pollution of animal husbandry, and is also an inevitable requirement for sustainable development and ecological civilization construction in China.

By the end of 2015, the number of household biogas in the country reached 41.933 million, benefiting 200 million people; 110,975 types of biogas projects were built by central and local investment, and the total capacity of rural biogas projects reached 18,925,800 cubic meters, with an annual biogas output of 2.225 billion cubic meters, and the number of gas-storing households is about 2.0918 million (National Development and Reform Commission, 2017). In contrast to the country's vigorous promotion, the use of household biogas digesters is not ideal. According to a survey by the National Bureau of Statistics, the utilization rate of biogas digesters in some areas is only 35%-40%, and the utilization rate in urban areas and economically developed areas is only about 20% (Lu Xinzhong, 2015). Farmers' behavior is the result of constant reflection and adjustment based on their own motivations and goals as well as the information they receive (Zhong Zhangbao, 2007). On the one hand, farmers are weighing the costs, benefits and risks when making resource allocation and input of production factors, and then making choices, which belong to carefully rationalized "rational economic man" (Huang Weihong, 2017); on the other hand, the economic behavior of farmers is not completely in accordance with the logic of economic rationality, but also affected by social relations, policy conditions and market relations (Rao Xupeng). Therefore, the analysis of peasant behavior must be carried out in the context of its given, specific living conditions, institutional arrangements and social changes (Guo Yuhua, 2002). Is the economic benefit the only influential factor in the use of biogas digesters? If not, are there other factors that play a key role? The answers to the above questions are crucial to solving the dilemma of farmers' biogas digesters and promoting the development of environmental protection facilities in rural areas.

Theoretically, the behavior of farmers' biogas digesters is a rational choice under the combined effect of farmers' comprehensive economic, social and political factors. Individual and family characteristics, the benefits of biogas digesters and government regulation will have an impact on farmers' behavior. However, in the actual production and life, what factors are affected by the use of farmers' biogas digesters? How should the relevant policies of the household biogas industry continue? The research and thinking on the influencing factors of farmers' use of biogas digesters are of great significance for the development of household biogas digesters and even the development of environmental protection facilities. To this end, based on the perspective of farmers, this paper uses field research data to construct a quantitative analysis model, empirically analyzes the current behaviors and influencing factors of farmers using biogas digesters, and focuses on clarifying the economic factors and the impact of government intervention on farmers' biogas digesters, with a view to enriching the research on the use of rural biogas digesters and environmental protection facilities and providing a reference for the government to formulate relevant policies.

## II. THEORETICAL ANALYSIS FRAMEWORK

### A. Research Hypothesis

According to the "rational economic man", the government intervention theory and the public product theory, it is known that there are many factors affecting the behavior of farmers using biogas digesters. Generally speaking, when farmers conduct an economic behavior, the influencing factors include internal and external aspects. According to the existing literature, this paper selects three aspects of individual characteristics, family characteristics and economic benefits as internal factors, and chooses government intervention as external influence factors.

#### 1) Individual characteristics

*a) Gender:* Different genders often lead to differences in farmers' economic behavior. Generally speaking, men are more adventurous, women are relatively conservative, and therefore this paper thinks that effect of male on biogas digester is expected to be positive.

*b) Age:* Regarding the influence of age on the use of biogas by farmers, scholars have not proposed a unified conclusion. Generally speaking, the older the farmers are, the more conservative they become, and the enthusiasm for using biogas digesters may not be high. However, studies have been conducted (Cai Yaqing, 2012) that the effect of age on farmers' use of biogas digesters is not significant. Therefore, this paper assumes that the effect of age on the behavior of farmers using biogas digesters can be positive or negative.

*c) The level of education:* The level of education affects an individual's ability to receive, manage, and process information, affecting the quality and quantity of information obtained (Atanu S et al., 1994), but in terms of the use of biogas digesters, the level of personal education

doesn't affect farmers' biogas digesters use (Sun D et al., 2014). Therefore, this paper assumes that the influence of the degree of education on the behavior of farmers using biogas digesters can be positive or negative.

### 2) Family characteristics

*a) Household income:* There is also no consensus in the academic community about the impact of household income on the use of biogas digesters. Some scholars believe that most biogas users belong to middle- and high-income families in rural areas (Gosens J et al., 2013), but some scholars believe that low-income families have higher willingness and enthusiasm to build and use biogas digesters (Sun D et al., 2014). Therefore, this paper assumes that the impact of household income on farmers' use of biogas digesters can be positive or negative.

*b) The scale of livestock and poultry farming:* As an important facility for treating and solving aquaculture waste, there is no doubt that the breeding scale has a positive impact on the use of biogas digesters. The number of livestock significantly affected farmers' biogas utilization behavior, with a coefficient of 8.383 (Xu Yanan, 2016). Therefore, this paper assumes that the impact of livestock and poultry farming scale on farmers' use of biogas digesters is positive.

### 3) Cost and income

*a) Biogas digesters construction costs:* Construction cost of biogas digesters includes material fee, foundation fee, supporting pipe stove fee, etc. (Liu Hongmei et al., 2011). The higher the cost of biogas digester construction, the less reluctant farmers are to invest in this environmental protection facility, and the less active farmers are to use biogas digesters. Therefore, this paper assumes that the impact of construction costs on farmers' use of biogas digesters is negative.

*b) Biogas digesters operating costs:* The daily operating costs of household biogas digesters mainly refer to feeding costs, daily maintenance costs and electricity costs (Wang Da, 2013). The higher the operating cost of the biogas digesters, the lower the enthusiasm of the farmers to use the biogas digesters. Therefore, this paper assumes that the impact of operating costs on farmers' use of biogas digesters is negative.

*c) Income from use of biogas digesters:* The annual operating income of the biogas digesters is mainly derived from the benefits of the biogas, biogas slurry and biogas residue for self-use. According to the assumption that farmers are rational economic people, the larger the income from biogas digesters, the more active farmers are in using biogas digesters. Therefore, this paper assumes that the effect of using income on the behavior of farmers using biogas digesters is positive.

### 4) Government intervention

*a) Public subsidy ratio:* The ratio of public investment refers to the proportion of public investment in the construction cost of farmers' biogas digesters. This study

selected this indicator as a core variable of government subsidy policy. As a quasi-public product, the government's subsidies will reduce the spending of farmers' biogas digesters, an environmental protection facility, and increase the enthusiasm of farmers. Therefore, this paper assumes that the impact of the use of biogas digesters on the behavior of farmers using biogas digesters is positive.

b) *Whether the government is supervising or not:* Supervision is an important way for the government to intervene in the use of biogas digesters. When government regulation increases, the probability of farmers using biogas digesters will increase (Wang Huogen, 2017). Therefore, this paper assumes that government regulation has a positive impact on farmers' use of biogas digesters.

5) *Farmers' biogas digesters use behavior:* After consulting the relevant literature, this paper defines the biogas behavior of farmers as the willingness and extent of farmers' future use of biogas digesters. The research focus of this paper is to analyze the influencing factors of farmers'

behaviors, and to refer to domestic and foreign scholars' cooperative behaviors of small-scale water conservancy facilities in rural communities (Wang Geling et al., 2013), domestic waste disposal behavior (Ren Zhong, 2018), and pesticide use behavior (Zhao L et al., 2017), low-carbon production behavior (Tian Yun et al., 2015) and other related factors, and it is found that scholars have weakened the complexity and categories of farmers' behaviors, and define farmer households' behaviors directly according to the categories, degrees and intentions of intuitive behaviors. Therefore, this paper directly selects the surveyed farmers' "future development trend" as the explanatory variable and defines the behavior as "reducing use", "keep it as it is" and "expanding use".

### B. Variable Settings

According to the theoretical hypothesis, the definition of the variables in this paper and the expected action direction of the explanatory variables on the interpreted variables are shown in "Table I".

TABLE I. RELATED VARIABLES AND DEFINITIONS

Variable dimension	Variable meaning	Variable definition and assignment	Expected effect
<i>Explained variable</i>	Biogas digesters use behavior	In the future, you will: 1=reduce the use of biogas, 2=keep the same, 3=use more biogas	
<i>Individual characteristics of farmers</i>	Gender	0=female, 1=male	+
	Age	Actual age of the farmers interviewed	?
	Education level	1= primary school and below, 2= junior high school, 3= high school, 4= secondary school, 5= junior college, 6= undergraduate and above	?
<i>Farmer family characteristics</i>	Annual household income	1= less than 10,000, 2= 10,000 ~ 30,000, 3= 30,000 ~ 50,000, 4= 50,000 ~ 70,000, 5= 70,000 ~ 90,000, 6= more than 90,000	?
	Farming scale	Livestock and poultry breeding scale (head)	+
<i>Cost and income</i>	Construction cost 1	Actual cost of biogas digesters construction (yuan)	-
	Operating cost 2	Actual cost of biogas digesters operation (yuan)	-
	Use income 3	Economic benefits from the use of biogas digesters (yuan)	+
<i>Government intervention</i>	Government subsidy 4	Public subsidy ratio	+
	Government regulation	Will the government check the use of your biogas digesters at intervals? 0=no, 1=yes	+

a. Construction cost: the cost of biogas digesters construction and pipeline;

b. Operation cost: water fee, electricity fee and maintenance cost in the operation of biogas digesters;

c. Use income: the energy cost saved by direct use of biogas, the cost of biogas slurry and biogas residue used for production of chemical fertilizers and pesticides, the application of marsh fertilizer brings about the change of income of agricultural products, and the use of biogas digesters reduces the cost of incidence rate of livestock and poultry breeding in total;

d. Government subsidy: the public subsidy ratio is the ratio of the amount of government subsidized biogas digesters to the total construction cost of biogas digesters.

## III. RESEARCH METHODS

### A. Model Construction

The dependent variable  $Y_{k,i} (k = 1, 2, 3)$  indicates that the farmers will reduce the use of biogas, maintain the original sample, and use more biogas, and for the orderly categorical variables, this paper uses an ordered Logistic regression method to analyze the factors affecting farmers'

use of biogas digesters. The expression for the ordered Logistic model is:

$$\ln\left(\frac{P(Y \leq j)}{1 - P(Y \leq j)}\right) = \beta_0 + \sum_{i=1}^k \beta_i X_i$$

In the formula,  $Y$  represents the dependent variable in the model,  $X$  represents the independent variable in the model,

$j$  represents the classification of the dependent variable,  $k$  represents the number of independent variables,  $i$  represents the independent variable number,  $\beta_0$  represents the constant term and  $\beta_i$  represents the regression coefficient of the independent variable.

#### B. Data Source

The research data in this paper comes from the survey organized by the research group in January 2018. The survey takes the form of questionnaires and interviews. The selection of the research object is divided into three stages: Firstly, the time selection. Considering the maturity of the policy and the lag of the farmers' feelings, farmers who are involved in Qionglai government's 2015 rural non-point source pollution control and methane gas construction project are selected as the research objects. The project involved 22 towns of Qionglai; secondly, the selection of townships. Taking into account the availability of data, representativeness and feasibility of research, after communicating with the government, this survey ranked the number of household biogas digesters in 22 townships and towns, and selected the top 11 townships (Datong Township, Linqiong Town, Pingle Town, Guyi Town, Wolong Town, Sangyuan Town, Qianjin Town, Mouli Town, Huilong Town, Shuikou Town, Nanbaoshan Town and Chayuan Township) as surveyed areas, involving a total of 191 farmers; thirdly,

the selection of village-level farmers. In order to ensure the sample size, this study doesn't continue to sample the village-level farmers, all of which are listed as research objects. In the end, a total of 162 questionnaires are collected in this survey. After the later statistics and sorting out, 30 invalid questionnaires with missing key information are deleted, and 132 valid questionnaires are obtained. The effective rate of the questionnaire is 81.48%.

### IV. EMPIRICAL ANALYSIS OF FACTORS AFFECTING FARMERS' USE OF BIOGAS DIGESTERS

#### A. Ordered Logistic Model Estimation Results

In this paper, SPSS18.0 is used to perform the ordered logistic regression on the above related influencing factors. From the analysis results, the model parallel line test  $P=0.283>0.05$ , the hypothesis of the parallel line hypothesis is accepted, and the ordered logistic analysis can be used. The likelihood ratio test results show that the -2 log-likelihood value is 159.566 and the chi-square value is 23.752. After introducing 10 variables,  $P=0.008<0.01$ , indicating that the final model is better than the model with only the intercept term, and the model as a whole makes sense. The specific results of the influencing factors are shown in "Table II".

TABLE II. MODEL REGRESSION RESULTS

Variable category	Variable	Estimate	Standard error	Wald	df	Significance
<i>Individual characteristics of farmers</i>	Gender	2.270***	0.850	7.127	1.000	0.008
	Age	0.047	0.210	0.049	1.000	0.824
	Education level	0.084	0.199	0.180	1.000	0.671
<i>Farmer family characteristics</i>	Annual household income	0.022	0.220	0.010	1.000	0.919
	Farming scale	0.006	0.215	0.001	1.000	0.977
	Construction cost	0.999**	0.530	3.550	1.000	0.060
<i>Cost and income</i>	Operating cost	-0.744**	0.408	3.318	1.000	0.069
	Use income	0.541***	0.199	7.397	1.000	0.007
<i>Government intervention</i>	Government subsidy	0.565**	0.316	3.196	1.000	0.074
	Government regulation	0.711**	0.414	2.949	1.000	0.086

a. \*\*\*, \*\*, and \* respectively indicate that the confidence level is significant at 1%, 5%, and 10%

#### B. Analysis of Estimated Results

1) *Individual characteristics of farmers*: The regression results show that gender variables have a significant positive impact on farmers' use of biogas digesters. Compared with female farmers, male farmers are more inclined to maintain or expand the use of biogas digesters. The possible reason is that male farmers are more pioneering and adventurous than women, and they are more willing to show a proactive side in their behavior and expand their use of biogas digesters.

2) *Household characteristics of farmers*: The family characteristics of farmers have no significant impact on farmers' use of biogas digesters. As far as the regression results of the model are concerned, the two variables of the family have not passed the significance test, indicating that in this model, the annual income of the family and the scale of livestock and poultry farming have little influence on the behavior of farmers using biogas digesters. Judging by expectations, the scale of livestock and poultry farming is a very important factor, but the results are not significant. The

reason is related to the quasi-public property of biogas digesters. As a typical environmental protection facility with overflow of benefits, the use of biogas digesters not only brings economic benefits to farmers themselves, but also makes farmers control their own livestock and poultry breeding pollution to meet environmental requirements. This kind of behavior is not a choice of farmers to maximize economic utility based on their own economic rationality, but a passive response to the influence of various external factors such as politics and society. With the continuous increase in environmental protection policies in recent years, the larger the scale of livestock and poultry farming of farmers, the stronger the interference from the outside world. So the illusion that "the larger the scale of livestock and poultry farming, the more active the use of biogas digester" appears. When the external disturbance is separated from the scale of livestock and poultry breeding, the impact of the scale of individual livestock and poultry farming on the environmental protection facilities of the quasi-public goods using the biogas digesters is not obvious.

3) *Cost and income*: The cost and income of farmers using biogas digesters have a significant impact on farmers' use of biogas digesters, and all three variables have passed the significant test of more than 5%. Among them, the construction cost has a positive impact on the behavior of farmers using biogas digesters. Contrary to expectations, such a result may be due to the sunk cost of biogas digesters. For farmers who have already invested in biogas digesters, the higher the sunk cost of biogas digesters, the more farmers tend to adopt the active use of biogas digesters to fill the economic losses caused by sunk costs. The impact of operating costs on the use of biogas digesters in rural households is negative. The impact of biogas digesters on the use of biogas digesters is positive, which is in line with the expectation and will not be repeated here.

4) *Government intervention*: Government intervention has a significant impact on farmers' use of biogas digesters. First, the government subsidy is analyzed. This paper selects the public subsidy ratio as an indicator to indicate the government's subsidy for biogas digesters. The regression results show that the public subsidy ratio has a positive impact on farmers' use of biogas digesters, which is in line with expectations, but contrary to the research results of Sun D et al. (2014), Qiu Huanguang (2013) and other scholars, and the reason is that different scholars have different focuses on this issue. The above two scholars focus on the analysis of government subsidies on the behavior of farmers, focusing on the analysis of the efficiency of biogas digesters. The higher the public subsidy rate of farmers, the lower the opportunity cost for farmers to abandon the biogas digesters and the easier it is for farmers to choose other alternative facilities or methods, resulting in a negative impact of government subsidies on the efficiency of biogas digesters. The main research in this paper focuses on the research on the factors affecting farmers' continued use of biogas

digesters, and defines the use behavior of farmers' biogas digesters as the scale of farmers' future reduction/maintenance/expansion of biogas digesters. Obviously, government subsidies will reduce the use of farmers and the impact on farmers expanding the use of biogas digester is positive. Therefore, this study can be reasonably explained by government subsidies for farmers to use biogas digesters.

Government regulation has a positive impact on farmers' use of biogas digesters and has passed a 5% significant test. As an environmental protection facility with quasi-public product nature, biogas digesters can't always get rid of their weak competitive and weak exclusivity characteristics due to its benefits spillover. In the actual production and use of biogas digesters, it is necessary to rely on the government's mandatory force to ensure the actual use of the biogas digesters, and the empirical results also show that the more the government supervises, the stronger the enthusiasm of farmers to use biogas digesters will be, and the more farmers are willing to expand the use of biogas digesters.

## V. CONCLUSION

Based on the field research data, this paper takes the use of biogas digesters as an example to explore the influencing factors of farmers' use of environmental protection facilities. The main conclusions are as follows: First, the behavior of farmers using biogas digesters is not a single impact of economic factors, but the results of farmers' personal characteristics, economic benefits, and government interventions. Therefore, when analyzing the behaviors of different entities on environmental protection facilities, multiple factors should be included for analysis. Second, economic factors are important factors affecting the use of biogas digesters. Among them, the construction cost and use income of biogas digesters have positive impact on the use of biogas digesters, and the impact of operating costs is not negative. The sunk cost is the main reason for the positive impact of construction cost on biogas digesters. Third, government intervention has significantly affected the use cost of environmentally friendly facilities such as biogas digesters. The government subsidies directly reduce the use cost of farmers' quasi-public goods and increase the enthusiasm of farmers; government supervision adopts a compulsory role of supervision and restraint, which compensates for the disadvantages of weak competition and weak exclusivity of quasi-public goods in biogas digesters, thus increasing the enthusiasm of farmers. In addition, gender is also an important factor affecting farmers' use of biogas digesters. Men's natural adventures and courageous features make them more active in using biogas digesters.

According to the above conclusions, in order to better promote the use of environmental protection facilities such as biogas digesters, measures can be taken from the following aspects: first, it is necessary to develop targeted strategies for rural women, and actively improve their enthusiasm in using biogas digesters through specialized training and education; second, the government should increase subsidies for the use of biogas digesters. This study

believes that the impact of government subsidies on the use of biogas digesters is positive. The quasi-public product nature of biogas digesters requires government subsidies to promote its further development; third, it is also called for to strengthen the construction of biogas industry chain. Development still needs its own conditions. Economic factors are the main factors affecting the use of biogas digesters. Only by establishing a sound industrial chain integrating biogas production, use, sales and service, the spillover effect of environmental protection facilities such as biogas digesters can be transformed into higher economic benefits, and biogas digesters can truly be separated from external subsidies and become an important means for farmers to seek economic benefits.

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