

## Economic Value of Liquid Organic Fertilizer Project in the Vietnamese Mekong Delta

**KHAI, Huynh Viet**  
School of Economics, Can Tho University

**XUAN, Huynh Thi Dan**  
School of Economics, Can Tho University

**YABE, Mitsuyasu**  
Laboratory of Agricultural and Farm Management, Department of Agricultural and Resource  
Economics, Faculty of Agriculture, Kyushu University

<https://doi.org/10.5109/4772418>

---

出版情報：九州大学大学院農学研究院紀要. 67 (1), pp.121-127, 2022. Faculty of Agriculture,  
Kyushu University

バージョン：

権利関係：

## Economic Value of Liquid Organic Fertilizer Project in the Vietnamese Mekong Delta

Huynh Viet KHAI<sup>1</sup>, Huynh Thi Dan XUAN<sup>1</sup>, Tran Thi Thu DUYEN<sup>1</sup> and Mitsuyasu YABE\*

Laboratory of Environmental Economics, Department of Agricultural and Resource Economics,  
Faculty of Agriculture, Kyushu University, Fukuoka 812–8581, Japan  
(Received November 12, 2021 and accepted November 5, 2021)

The study determined the economic value of the proposed liquid organic fertilizer (LOF) project in the Vietnamese Mekong Delta through the estimation of farmers' willingness to pay using the approach of the double-bounded dichotomous choice contingent valuation model (DBDC CVM). The results showed that the majority of farmers supported and agreed to buy LOF with a willingness to pay or a price of around 169,000 VND (\$7.44) per ton. Farmers who used to apply organic fertilizers before or consider the use of biomass fertilizer as safe are more likely to pay for the proposed LOF.

**Key words:** double-bounded dichotomous choice contingent valuation model (DBDC CVM), Mekong River Delta, organic fertilizer, willingness to pay (WTP).

### INTRODUCTION

Rapid population growth increases pressure on the natural environment and social environment. The capacity of the natural environment is limited, when the population increases rapidly and untreated waste is discharged into the environment, it exceeds the self-cleaning capacity of the natural environment. In recent years, the Vietnamese population has been constantly increasing from 86,947 million in 2010 to 93.7 million in 2017. Along with the increase in population, the quantity of solid waste has increased rapidly to cause difficulties for collection and treatment. Sludge from septic tanks, a form of solid waste, is expected to increase in volume along with population growth and people's living needs. Sludge generation from sanitation (septic tanks) in Vietnamese urban areas is 0.04–0.07 m<sup>3</sup>/person/year (QCVN 07:2016/BXD). However, at present, there are no complete statistics on sludge generation nationwide. At the same time, the management of septic tank sludge in Vietnam currently does not have an effective sludge management mechanism (Oanh and Hong, 2019). The composition of sludge from the septic tank contains mainly organic substances with a high content of nitrogen, phosphorus which is a good condition to use as fertilizer for agriculture (Heinonen-Tanski and van Wijk-Sijbesma, 2004; Winker *et al.*, 2009).

On the other hand, chemical fertilizers in agricultural production in Vietnam is widely used due to its cost advantages and fast efficiency for crops. On average, plants only absorb about 40–50% of chemical fertilizers (about 30–45% of nitrogen, 40–45% of phosphate, and 50–60% of potassium) the rest is discharged into the environment. The amount of fertilizer imported in 2017 was 8,708 tons, equivalent to about \$2,549 million, doubled compared to that of 2016 when only 4,197 tons were imported with a turnover of about \$1,125 million

(Ministry of Natural Resources and Environment of Vietnam, 2018).

Therefore, recycling sludge from the septic tank into organic fertilizer to supply agricultural production is properly considered to both help deal with the increasing amount of waste and limit environmental pollution caused by chemical fertilizers. Moreover, the domestic production of organic fertilizers, will also limit the import of chemical fertilizers is the reason why this study evaluates the economic value of the liquid organic fertilizer project to recycle sludge from septic tanks to have a basis for proposing policies to increase the use of organic fertilizers by farmers in agricultural activities. The results of the study contribute to the improvement of waste management and environmentally friendly agricultural production.

### LITERATURE REVIEW

The approaches of revealed and stated preferences are popularly used to evaluate the economic value of non-market goods (Pearce and Moran, 1994). The technique of revealed preference evaluates the economic value of market goods, which are considered equivalent to the environmental goods to be valued, to infer the economic value of environmental goods (Bockstael and Kling, 1988). The revealed preference approach is suitable for estimating the economic value of an environmental good when a comparable market good exists. However, finding equivalent market goods is a very complex task (Carson, 1998; Barkmann *et al.*, 2008). Therefore, in case it is difficult or impossible to find equivalent market goods, the research prioritizes using the stated preference methods.

The stated preference methods directly value the non-market commodity, assuming that individuals can reveal their true preference for environmental goods through their behavior in the hypothetical market (Hanley *et al.*, 1998). The outstanding advantage of the stated preference technique is to be used to value any

<sup>1</sup> School of Economics, Can Tho University, Vietnam

\* Corresponding author (E-mail: yabe@agr.kyushu-u.ac.jp)

non-market goods with relatively uncomplicated data requirements (Diafas, 2016). Besides, the stated preference method is considered suitable when used to estimate the values of the total economic value, especially indirect use value and non-use value, of environmental goods (Freeman III *et al.*, 2014; Diafas, 2016). The contingent valuation method (CVM) is the first stated preference method applied in valuing non-market resources and goods. The origins of this approach can be traced back to the work of Ciriacy-Wantrup (1947), which used public opinion surveys to collect values for public goods. However, Davis's (1963) study, which estimated the value of outdoor recreation in the Maine forest (New England, USA), is considered the first experimental study using the CVM. Subsequently, the CVM became a popular method in valuing entertainment and other fields such as air pollution control, landscaping, wetlands, and other public goods (Smith, 2006).

Although some studies have applied the CVM to estimate the willingness to pay (WTP) for organic fertilizer in some countries (Etim and Benson, 2016; Okuma and Isiorhovoja, 2017; Muhammad *et al.*, 2020; Rachmah, Darwanto and Mulyo, 2020), only three studies on farmers' demand for organic fertilizers from human waste (Danso *et al.*, 2006; Hong *et al.*, 2017; Kuwornu *et al.*, 2017) (reviewed by Gwara *et al.*, 2020). This study also aims to contribute to the literature and provide more information on farmers' demand or willingness to pay for liquid organic fertilizer produced from human waste.

The CVM approach is used to estimate values associated with public and non-market goods using five types of elicitation techniques, namely the bidding game, the open-ended, the payment card and single-bounded dichotomous choice, and double-bounded dichotomous choice approaches (Bateman *et al.*, 2002). The double-bounded dichotomous choice question requires respondents to answer two bid questions (the initial bid and the follow-up bid). The outstanding advantage of this question is to help researchers to get more information related to the respondents' preferences for non-market goods (Bateman *et al.*, 1999) to measure WTP effectively (Hanemann *et al.*, 1991). Moreover, the double-bounded dichotomous choice question could overcome choosing an initial price too low or too high (Hanemann and Kanninen, 2002). Therefore, this study conducts an economic valuation of the liquid organic fertilizer project by asking the WTP of the household in the form of a double-bounded dichotomous choice question.

## DATA COLLECTION

Primary data was randomly collected by directly interviewing 620 farmers in four provinces (225 farmers in Vinh Long, 120 farmers in Hau Giang, 110 farmers in Ben Tre, and 30 farmers in An Giang) and one city (135 farmers in Can Tho) of the Vietnamese Mekong Delta. The farmers selected for the interview are those who grow typical crops in each region. The content of the questionnaire is designed to estimate the economic value of the liquid organic fertilizer (LOF) project by the

DBDC CVM questionnaire. The structure of the questionnaire included the information of the farmers' knowledge, chemical fertilizer uses, and their willingness to pay for LOF from septic tank sludge. Before asking the CVM question, the questionnaire provided information on the harmful effects of chemical fertilizer overuse, the composition of LOF from the sewage sludge of the septic tank, and the advantages and disadvantages of the LOF.

The production technology of LOF is described as human waste collected from residential areas, offices, and public facilities (e.g. schools, supermarkets) which is processed by the technology of the self-heating treatment system developed by Japanese technology. During the treatment process, bacteria harmful to soil, plants and affecting human health have been eliminated. LOF from human waste has high contents of N, P, K, Ca, and other minerals which are indispensable components in the growth and development of plants. Human waste is recycled into liquid biomass for use in agricultural production.

The initial bid level used in the study was the price of the LOF product. Then the farmers were asked if they are willing to buy the above-mentioned LOF at an initial bid price, if yes, they continue to be asked for a higher price, if no, asked for a lower price. Based on the results of previous research by Hong *et al.* (2017) in Da Nang, the given bid prices was 100,000VND, 120,000VND, 140,000 VND, 160,000 VND, and 180,000 VND per ton of LOF. The prices were also found to be quite suitable with the ability of farmers' payment after doing the pilot survey.

## METHODOLOGY

According to Markantonis *et al.* (2012), there are some limitations such as starting-point bias, non-response bias, and yea-saying bias in the approach of contingent valuation method (CVM). However, the approach of double-bounded dichotomous choice contingent valuation method (DBDC CVM) could partly reduce these above biases and the variation of the estimated parameters (Hanemann *et al.*, 1991). This study applied the approach of DBDC CVM with the STATA command "doubleb" to estimate WTP for the proposed LOF with the linear assumption between WTP and its related factors (Lopez-Feldman, 2012; Batte *et al.*, 2007; Sriwaranun *et al.*, 2015):

$$WTP_i(z_i, u_i) = z_i\beta + u_i \quad \text{with } u_i \sim N(0, \sigma^2) \quad (1)$$

where  $z_i$  is a vector of independent variables,  $\beta$  is a vector of parameters,  $u_i$  is an error term. In the DBDC CVM model, farmers were asked to answer two closed WTP questions with the first bid labeled  $t^1$  and the second bid labeled  $t^2$ . Then, each farmer's WTP falls into one of the following four groups:

$$\text{Yes - Yes answers: } t^2 > t^1 \text{ and } t^2 \leq WTP < \infty$$

$$\text{Yes - No answers: } t^1 \leq WTP < t^2$$

No – Yes answers:  $t^2 < t^1$  and  $t^2 \leq WTP < t^1$

No – No answers:  $0 \leq WTP < t^2$

The answers to the first and second closed questions could be defined as the dichotomous variables  $y_i^1$  and  $y_i^2$ , respectively. If the farmer answers “yes”, the variables take the value of 1, and 0 for the answer of “no”. According to Lopez–Feldman (2012), with the normal distribution assumption of the WTP and the error term  $u_i$ , the probability of farmers’ answers is described as the following expressions:

$$\begin{aligned}
 y_i^1 = 1 \text{ and } y_i^2 = 1: \Pr (y_i^1 = 1, y_i^2 = 1 | z_i) &= \Pr (Y, Y) \\
 &= \Phi \left( z_i^1 \frac{\beta}{\sigma} - \frac{t^2}{\sigma} \right), \\
 y_i^1 = 1 \text{ and } y_i^2 = 0: \Pr (y_i^1 = 1, y_i^2 = 0 | z_i) &= \Pr (Y, N) \\
 &= \Phi \left( z_i^1 \frac{\beta}{\sigma} - \frac{t^1}{\sigma} \right) - \Phi \left( z_i^1 \frac{\beta}{\sigma} - \frac{t^2}{\sigma} \right), \\
 y_i^1 = 0 \text{ and } y_i^2 = 1: \Pr (y_i^1 = 0, y_i^2 = 1 | z_i) &= \Pr (N, Y) \\
 &= \Phi \left( z_i^1 \frac{\beta}{\sigma} - \frac{t^2}{\sigma} \right) - \Phi \left( z_i^1 \frac{\beta}{\sigma} - \frac{t^1}{\sigma} \right), \\
 y_i^1 = 0 \text{ and } y_i^2 = 0: \Pr (y_i^1 = 0, y_i^2 = 0 | z_i) &= \Pr (N, N) \\
 &= 1 - \Phi \left( z_i^1 \frac{\beta}{\sigma} - \frac{t^2}{\sigma} \right). \tag{2}
 \end{aligned}$$

The parameters of  $\beta$  and  $\sigma$  are identified using the technique of the maximum likelihood estimation (MLE) with the log-likelihood (LL) function as followings:

$$\begin{aligned}
 \sum_{i=1}^n & \left[ d_i^{Y,Y} \ln \left( \Phi \left( z_i^1 \frac{\beta}{\sigma} - \frac{t^2}{\sigma} \right) \right) \right. \\
 & + d_i^{Y,N} \ln \left( \Phi \left( z_i^1 \frac{\beta}{\sigma} - \frac{t^1}{\sigma} \right) \right. \\
 & \quad \left. - \Phi \left( z_i^1 \frac{\beta}{\sigma} - \frac{t^2}{\sigma} \right) \right) \\
 & + d_i^{N,Y} \ln \left( \Phi \left( z_i^1 \frac{\beta}{\sigma} - \frac{t^2}{\sigma} \right) \right. \\
 & \quad \left. - \Phi \left( z_i^1 \frac{\beta}{\sigma} - \frac{t^1}{\sigma} \right) \right)
 \end{aligned}$$

$$+ d_i^{N,N} \ln \left( 1 - \Phi \left( z_i^1 \frac{\beta}{\sigma} - \frac{t^2}{\sigma} \right) \right) \tag{3}$$

where  $i = 1, \dots, n$  in  $d_i^{Y,N}$ ,  $d_i^{Y,Y}$ ,  $d_i^{N,Y}$ , and  $d_i^{N,N}$  are variables that value equal 1 or 0 depending on the relevant case for each farmer.

### RESULTS AND DISCUSSION

Table 1 presents the demographic and socio-economic characteristics of farmers. With an average age of about 40 years, farmers have about 17 years of experience in agricultural production, of which the highest experience is 57 years and the lowest is 1 year, indicating that most farmers have a lot of experience in production as well as experience in choosing which fertilizers to use for their crops. Although the percentage of male farmers interviewed in the study was quite high, about 87%, the data was still acceptable and did not affect the accuracy of the data analysis. In most rural areas, men are usually the heads of households and are directly involved in agriculture, planting, fertilizing, and often also the ones who make decisions about which fertilizers to use, so they have a good understanding of the fertilizers being applied to their plants.

The results also show that other demographic and socio-economic characteristics of farmers such as the average education level of about 8 years, family size of 4 members, agriculture land of 0.46 ha, and average annual net farm income of about 56.2 million VND/1,000 m<sup>2</sup>, are quite consistent with the characteristics of households in rural areas in the Mekong Delta. About 35% of farmers in the sample said that they had attended training courses on agricultural production. On average, they use about 690 kg of chemical fertilizers per year and there is a significant difference between the farmers who attended the training courses (about 611 kg/year) and those who did not participate in the training (about 735 kg/year).

Table 2 presents the use of organic fertilizer by farmers. The results show that 298 farmers, accounting for nearly half of 48%, have used organic fertilizers in the past, of which 23% of farmers used manure from chickens, ducks, goats, bats, etc. About 18% of farmers used to use green fertilizers and some other organic fer-

**Table 1.** Demographic and socio-economic characteristics of farmers in the sample

Items	Mean	Standard Deviation	Min	Max
Age (years)	39.71	11.943	21	98
Experience (years)	16.53	12.646	1	57
Male farmer	0.87	0.337	0	1
Education (years)	6.99	3.088	0	16
Family members (persons)	4.25	1.409	1	10
Agricultural land (1000 m <sup>2</sup> )	4.63	8.63	0.50	200
Training attendance	0.35	0.48	0	1
Chemical fertilizer use (kg/year)	690.87	789.79	50	6500
Net farm income (million VND/1.000 m <sup>2</sup> /year)	56.19	34.88	3	250

**Table 2.** The use of organic fertilizers by farmers

Items	Frequency (N)	Ratio (%)
<b>Use organic fertilizers</b>	<b>298</b>	<b>48.06</b>
Manure (chicken, duck, goat, bat, etc.)	143	23.06
Mineral organic fertilizers	45	7.26
Green manure or other organic fertilizers	110	17.74
<b>Do not use organic fertilizers</b>	<b>322</b>	<b>51.94</b>

**Table 3.** Farmers' awareness about liquid organic fertilizer use

	Safety	Environment
Safety	Absolute safety (1,9%)	Safety (31,9%)
Environment	The same (60,3%)	Good (5,8%)
Profit	Absolutely good (0%)	
Safety	Absolute safety (2,4%)	Safety (16,8%)
Profit	The same (48,9%)	High (31%)
Environment	Absolutely high (1%)	
Safety	Absolutely good (1,8%)	Good (8,5%)
Environment	The same (50%)	High (38,1%)
Profit	Absolutely high (1,3%)	

**Table 4.** Farmer's willingness to pay and unwillingness to pay at  $Bid_1$  and  $Bid_2$  for LOF

$Bid_1$ (VND)	No.	$Bid_1 < Bid_2$				$Bid_1 > Bid_2$			
		Yes – Yes		Yes – No		No – Yes		No – No	
		No.	%	No.	%	No.	%	No.	%
100.000	124	73	58,87	11	8,87	0	0	40	32,26
120.000	124	67	54,03	9	7,26	1	0,81	47	37,9
140.000	124	68	54,84	10	8,06	0	0	46	37,1
160.000	124	57	45,97	13	10,48	0	0	54	43,55
180.000	124	55	44,36	10	8,06	2	1,61	57	45,97
Total	620	320	51,61	53	8,55	3	0,48	244	39,36

tilizers. Moreover, the study also asked farmers about their perception of liquid organic fertilizer use, explained by three criteria of concern among farmers: Safety, Environment, and Profit (See Table 3). When comparing criteria such as Safety–Environment, Safety–Profit, and Environment–Profit, most farmers choose these criteria as equally important, about 60% for Safety–Environment, nearly 49% for Safety–Profit, and 50% for Environment–Profit, respectively. A part of farmers (about 32%) towards Safety criteria when comparing Safety and Environment criteria. About 31% of farmers consider Profit when comparing Safety criterion with Profit and 38% when comparing Environment criteria with Profit. Thus, of the three criteria, Profit is the most concern by farmers. However, they also tend to pay more and more attention to Safety criterion in the production process. This is also a potential signal for the development and promotion of organic fertilizer use in agricultural production.

Although the Profit factor is more concerned by

farmers in the agricultural production process, it is not the only factor. Safety and Environment factors are still concerned, which shows that it is not impossible to receive environmentally friendly inputs, namely organic fertilizers. The percentages of farmers agreeing and disagreeing with the Bid levels of organic fertilizers are presented in Table 4.

Table 5 summarizes farmers' willingness to pay for LOF. The percentage of farmers who answered "Yes" to both  $Bid_1$  and  $Bid_2$  prices ranged from 59% for 100,000 VND to 44% for 180,000 VND, on average farmers answered "Yes–Yes" with the two Bid prices of 52%. Only 0.48% of farmers answered "No" to  $Bid_1$  and "Yes" to  $Bid_2$ . The percentage of farmers who answered "No" at the  $Bid_1$  and "No" at the  $Bid_2$  ranged from 32% for 100,000 VND to 46% for 180,000 VND, while farmers saying "No"–"No" for the two Bid prices were about 39%.

Table 5 summarizes farmers' reasons for their unwillingness to pay for LOF at both  $Bid_1$  and  $Bid_2$  prices. About 57% of farmers did not agree to pay for LOF with

**Table 5.** Reasons for farmers unwilling to pay for LOF

Reasons	Frequency (N)	Ratio (%)
I think that the price of LOF is too high	3	1.23
I don't care about the environment in the production process	20	8.20
I feel that LOF is not effective	66	27.05
I am worried that LOF affects farmer's health	8	3.28
I do not need to use LOF	139	56.97
I don't have much information about LOF	139	56.97
I don't know how to use LOF for my crops	96	39.34
I don't like using organic fertilizers	14	5.74
The application of LOF causes difficulties and inconveniences, especially in transportation.	25	10.25
Other reasons	16	6.56

the reason of “I do not need to use LOF” and “I don't have much information about LOF”. Next is the reason “I don't know how to use LOF for my crops” with nearly 39% of farmers choosing. It is also worth noting that only 1.23% of farmers said “I think that the price of LOF is too high”. These reasons show that increasing publicity about LOF is essential to increase farmers' payment for this product.

Table 6 shows the results of the DBDC CVM model of the respondent's willingness to pay for LOF. Model 1 is only estimated with the  $Bid_1$  and  $Bid_2$  variables, while Model 2 is analyzed including the variables of farmers' demographic characteristics (*Age*, *Male*, *Education*, and *Family members*) and other important factors affecting the WTP (*Agricultural land*, *Net farm income*, *Training*, *Organic fertilizer use*, and *Safety*). *Age* is the age of the respondent, expected to have a positive effect on farmers' willingness to pay. *Male* is a dummy variable that takes the value 1 if male and 0 otherwise. Men are often the main laborers of the family and often work hard to study, research, and cap-

ture information about pesticides and fertilizers for their crops. Therefore, men tend to be willing to pay for organic fertilizer. *Education* is the number of farmers' schooling years. The higher the level of education, the more knowledgeable farmers about organic products or better understanding of the advantages of organic fertilizers. Therefore, this variable is expected to have a positive effect on willingness to pay (Ranjith and Clem, 2004). *Family members* is the number of members in the household. This variable is expected to have a positive effect on farmers' willingness to pay (Kuwornu *et al.*, 2017).

*Agricultural land* is the total farming area of the household in 1000 m<sup>2</sup>. The more agricultural land a farmer has, the more concerned it is with soil nutrients and the quality of agricultural products. Therefore, households with more arable land tend to prefer to use organic fertilizers. *Net farm income* is total net income from farming activities in million VND/1.000 m<sup>2</sup>/year. Farmers with higher net farm income from farming activities tend to choose to use organic fertilizers more (Hong

**Table 6.** The results of the DBDC CVM model for calculating farmers' willingness to pay for LOF

Variables	Model 1		Model 2	
	Coefficient	Standard Error	Coefficient	Standard Error
<i>Age</i>			0.305	0.740
<i>Male</i>			6.425	25.457
<i>Education</i>			3.861	2.877
<i>Family members</i>			4.232	6.226
<i>Agricultural land</i>			0.000	0.001
<i>Net farm income</i>			-0.084	0.361
<i>Training</i>			-6.715	18.592
<i>Organic fertilizer use</i>			108.844***	21.836
<i>Safety</i>			58.080***	19.998
Beta constant	169.185***	9.346	14.563	59.893
Sigma constant	180.830***	21.746	171.451***	20.510
Log likelihood		-607.010		-579.821
Mean WTP (VND)		169.185		168.617
(95% CI) (VND)		(150.867–187.504)		(150.866–186.367)

Notes: 95% CI: 95% confidence interval; \*\*\*, \*\*, \* are levels of statistical significance at the 1%, 5%, and 10%, respectively.

*et al.*, 2017), *Training* is a dummy variable that takes the value 1 if the farmer has attended training courses on fertilizer use and 0 otherwise. Farmers who participate in more training courses related to organic production have a better awareness of safe production and the use of organic fertilizers, so they tend to use organic fertilizers (Hong *et al.*, 2017). *Organic fertilizer use* is a dummy variable that takes the value 1 if the farmer has used organic fertilizers and 0 otherwise. Farmers who know and have experience in using organic fertilizers tend to continue to use other types of organic fertilizers for crops (Danso *et al.*, 2006; Hong *et al.*, 2017). And safety awareness is a dummy variable that takes the value 1 if the farmers have an understanding of health and safety and 0 otherwise. This variable is expected to be in the same direction as the farmer's willingness to pay for LOF. Before estimating the model, this study has tested the existence of multicollinearity and the results show that there is no multicollinearity between the independent variables because all VIF values are less than 3 and the correlation of independent variables is not higher than 0.7 (Khai and Yabe, 2014; Khai, 2015).

Model 2 shows that farmers who have used organic fertilizers before are more likely to pay for LOF (this variable has a positive sign at the 1% level of statistical significance). This result is consistent with previous researches (Danso *et al.*, 2006; Hong *et al.*, 2017). The research result also indicates that farmers who consider the use of biomass fertilizers as safe are more likely to pay for LOF (this variable has a positive sign at the 1% level of statistical significance). This result shows that safety is an important characteristic of biomass fertilizer. The average WTP of farmers for LOF is about 169,000 VND/ton, which is higher than the WTP of farmers in Da Nang for LOF by Hong *et al.*, 2017 (94,800 VND/ton). If this estimated WTP is assumed to be the price of LOF with the scenario that farmers use 10 tons/1000 m<sup>2</sup> for their crop, the cost of LOF (1.69 million VND/1000 m<sup>2</sup>) is higher than the current fertilizer cost (1.35 million VND/1000 m<sup>2</sup>) about 0.34 million VND/100 m<sup>2</sup>. However, this cost increase is really meaningful because farmers will receive benefits for themselves and their living environment.

## CONCLUSION

The study identified the demand of the proposed LOF through the estimation of Mekong Delta farmers' WTP to find out the marketability of LOF in the Mekong Delta. The results showed that a number of farmers began to pay more attention to Safety and Environment criteria in agricultural production. Nearly 50% of Mekong Delta farmers used to make "do-it-yourself" organic fertilizers. However, this is a favorable first step to introduce LOF into agricultural production. The study estimated the Mekong Delta farmer's WTP of about 169,000 VND/ton for LOF with the percentage of farmers answering "Yes – Yes" accounting for 51.61%, revealing that the LOF production program is feasible. Farmers with organic knowledge and experience in using

organic fertilizers also pay higher for the proposed LOF. Farmers who prioritize safety over other factors (environment, profit) are also more likely to pay for LOF. The lack of basic information on LOF and the environmental, social, and health benefits of using LOF for farmers is a major obstacle in their use decision. Therefore, providing information on the benefits of liquid organic fertilizer for farmers to have more understanding and access to organic inputs is very important to increase the use of environmentally friendly inputs or LOF. When farmers have great confidence in LOF, the demand and market for LOF in the future will become more and more positive and feasible. Policymakers should promote LOF in Vietnam because this provides an organic fertilizer source for agriculture, reduces pressure on the waste management system, and decreases environmental pollution.

## AUTHOR CONTRIBUTIONS

Huynh Viet KHAI and Huynh Thi Dan XUAN designed the study questionnaire, collected and analyzed the data, and drafted the manuscript; Tran Thi Thu DUYEN drafted the manuscript; Mitsuyasu YABE supervised the research and made critical revisions to the manuscript under the Can Tho University Improvement Project VN14–P6, supported by a Japanese ODA loan. All authors read and approved the final manuscript.

## ACKNOWLEDGEMENT

This study is funded in part by the Can Tho University Improvement Project VN14–P6, supported by a Japanese ODA loan. Our warmest thanks go to the staff and students in the staff and students in the Department of Environmental and Resource Economics, School of Economics, Can Tho University for assisting in data collection.

## REFERENCES

- Bandara, R. and C. Tisdell 2004 The Net Benefit of Saving the Asian Elephant: A Policy and Contingent Valuation Study. *Ecological Economics*, **48**(1): 93–107.
- Barkmann, J., Klaus Glenk, A. Keil, C. Leemhuis, N. Dietrich, G. Gerold and R. Marggraf 2008 Confronting unfamiliarity with ecosystem functions: the case for an ecosystem service approach to environmental valuation with stated preference methods. *Ecological Economics*, **65**(1): 48–62
- Bateman, I. J., R. T. Carson, B. Day, M. Hanemann, N. Hanley, T. Hett, M. Jones–Lee, G. Loomes, S. Mourato, D.W. Pearce and R. Sugden 2002 *Economic Valuation with Stated Preference Techniques: A Manual*. Edward Elgar, Cheltenham/Northampton
- Batte, M. T., N. H. Hooker, T. C. Haab and J. Beaverson 2007 Putting their Money Where their Mouths are: Consumer Willingness to Pay for Multi–Ingredient, Processed Organic Food Products. *Food policy*, **32**(2) : 145–159
- Bockstael, N. E. and C. L. Kling 1988 Valuing Environmental Quality: Weak Complementarity with Sets of Goods. *American Journal of Agricultural Economics*, **70**(3): 654–662
- Carson, R. T. 1998 Valuation of Tropical Rainforests: Philosophical and Practical Issues in the Use of Contingent Valuation. *Ecological Economics*, **24**(1): 15–29

- Ciriacy-Wantrup, S. V. 1947 Capital Returns from Soil-conservation Practices. *Journal of Farm Economics*, **29**(4): 1181–1196
- Danso, G., P. Drechsel, S. Fialor and M. Giordano 2006 Estimating the Demand for Municipal Waste Compost via Farmers' Willingness-to-pay in Ghana. *Waste Management*, **26**: 1400–1409
- Davis, R. K. 1963 Recreation Planning as an Economic Problem. *Natural Resources Journal*, **3**(2): 239–249
- Diafas, I. 2016 *Estimating the Economic Value of Forest Ecosystem Services using Stated Preference Methods: The Case of Kakamega Forest, Kenya*. PhD thesis, Georg-August-University Göttingen, Germany
- Etim, N. A. and D. N. Benson 2016 Willingness to Pay for Organic Fertilizer by Resource Poor Vegetable Farmers in the Humid Tropic. *Journal of Agriculture and Ecology Research International*, **6**: 1–11
- Freeman III, A. M., J. A. Herriges and C. L. Kling 2014 *The Measurement of Environmental and Resource Values: Theory and Methods*. Routledge, New York
- Gwara, S., E. Wale, A. Odindo and C. Buckley 2020 Why do We Know So Much and Yet So Little? A Scoping Review of Willingness to Pay for Human Excreta Derived Material in Agriculture. *Sustainability*, **12**(6490): 1–25
- Hanemann, M. W. and B. Kanninen 2002 The Statistical Analysis of Discrete-Response CV Data. In "Valuing Environmental Preferences: Theory and Practice of the Contingent Valuation Method in the US, EU, and Developing Countries", ed. by Bateman, I. J., K. G. Willis and K. J. Arrow, Oxford University Press, USA
- Hanemann, M., J. Loomis and B. Kanninen 1991 Statistical Efficiency of Double-bounded Dichotomous Choice Contingent Valuation. *American Journal of Agricultural Economics*, **73**(4): 1255–1263
- Hanley, N., D. MacMillan, R. E. Wright, C. Bullock, I. Simpson, D. Parsisson and B. Crabtree 1998a Contingent Valuation versus Choice Experiments: Estimating the Benefits of Environmentally Sensitive Areas in Scotland. *Journal of Agricultural Economics*, **49**(1): 1–15
- Hanley, N., R. E. Wright and V. Adamowicz 1998b Using Choice Experiments to Value the Environment. *Environmental and Resource Economics*, **11**(3): 413–428
- Heinonen-Tanski, H. and C. van Wijk-Sijbesma 2004 Human excreta for plant production. *Bioresource Technology*, **96**(4): 403–411
- Hong, B., Y. Takahashi and M. Yabe 2017 Determinants of Marketability for Organic Biomass Liquid Fertilizer from Human Waste in Da Nang City, Vietnam. *Journal of Environmental Protection*, **8**(11): 1354–1371
- Khai, H. V. 2015 Assessing Urban Residents' Willingness to Pay for Preserving the Biodiversity of Swamp Forest. In "Handbook of Research on Climate Change Impact on Health and Environmental Sustainability", ed. by S. Dinda, IGI Global publisher, pp. 283–305.
- Khai, H. V. and M. Yabe 2014 The Demand of Urban Residents for Biodiversity Conservation in U Minh Thuong National Park, Vietnam. *Agricultural and Food Economics*, **2**(1): 1–10
- Kuwornu, J. K. M., A. B. Narh JNR, I. S. Egyir, E. E. Onumah and S. Gebrezgabher 2017 Willingness to Pay for Excreta Pellet Fertilizer: Empirical Evidence from Ghana. *Acta Agriculturae Slovenica*, **109**(2): 315–323
- Lopez-Feldman, A. 2012 Introduction to contingent valuation using Stata. *MPRA Paper 41018*, University Library of Munich, Germany.
- Markantonis, V., V. Meyer and R. Schwarze 2012 Valuating the Intangible Effects of Natural Hazards: Review and Analysis of the Costing Methods. *Natural Hazards and Earth System Sciences*, **12**(5): 1633–1640.
- Ministry of Natural Resources and Environment of Vietnam 2018 Report on the current state of the national environment in 2017. Hanoi: Publishing House of Natural Resources – Environment and Maps of Vietnam
- Muhammad, M. S. Bacha and S. A. A. Shah 2020 Urban Farmers Willingness to Pay for Organic Fertilizer in District Mardan, Khyber Pakhtunkhwa, Pakistan. *Sarhad Journal of Agriculture*, **36**(2): 419–426
- Oanh, T. H. and L. S. Hong 2019 Alarm on Septic Tank Sludge Pollution (in Vietnamese). Retrieved October 29, 2021, from <https://nhandan.vn/dieu-tra-quua-thu-ban-doc-bao-dong-tinh-trang-o-nhiem-bun-thai-be-tu-hoi-376777/>
- Okuma, L. O. and R. A. Isiorhovoja 2017 Farmers' Perception and Willingness to Pay for Organic Fertilizer in Delta State, Nigeria. *Journal of Agriculture and Food Environment*, **4**(1): 9–20
- Pearce, D. W. and D. Moran 1994 *The Economic Value of Biodiversity*. Routledge, London
- Rachmah, M. A., D. H. Darwanto and J. H. Mulyo 2020 Farmers' Willingness to Pay for Bio-slurry Fertilizer. *Agro Ekonomi*, **31**(2): 1–12
- Smith, V. K. 2006 Fifty Years of Contingent Valuation, In "Handbook on Contingent Valuation", chapter 2, ed by A. Alberini. and J. Kahn, Edward Elgar Publishing.
- Sriwaranun, Y., C. Gan, M. Lee and D. A. Cohen 2015 Consumers' Willingness To Pay For Organic Products in Thailand. *International Journal of Social Economics*, **42**(5): 480–510
- Winker, M., B. Vinneras, A. Muskolus, U. Arnold and J. Clemens 2009 Fertilizer Products from New Sanitation Systems: Their Potential Values and Risks. *Bioresource Technology*, **100**: 4090–4096



