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Determinants of Marketability for Organic Biomass Liquid Fertilizer from Human Waste in Da Nang City, Vietnam

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Abstract

Recently, 90 tons of human waste per day are collected from private residences, offices, and public facilities in Da Nang City. Meanwhile, farmers in this region have to allocate 10% - 20% of rice sales for purchasing chemical fertilizer. Therefore, it is essential to be adopted more inexpensive organic fertilizer. To deal with these problems, Japan International Cooperation Agency (JICA) has signed a contract with Da Nang city government about human waste treatment and production of organic biomass liquid fertilizer (OBLF) in 2015. The aims of this project are to promote the use of OBLF in farming and improve public awareness of environmental protection. 530 respondents were interviewed at Hoa Vang districts of Da Nang city, and data was analyzed by Contingent Valuation Method (CVM) under double bounded dichotomous choice approach. The results have revealed that 436 respondents (82%) agreed to use OBLF. The farmers' WTP depends on factors including household income, experience in using organic fertilizer, awareness of environment and training of organic fertilizer in the past. The estimated price for OBLF was 94,856 VND (4.0 USD)/ton. The cost that farmers paid for OBLF was lower than that of current available chemical fertilizers in Da Nang city. This proves that marketability seems to be existed for OBLF product in Da Nang city. From these findings, the government should have policies to support and subsidize the farmers to encourage them to use OBLF in a large scale of cultivation. Furthermore, establishment of a market to consume the organic products harvested from cultivated areas using OBLF is also recommended.

Keywords

Contingent Valuation Method (CVM), Double-Bound Dichotomous Choice, Organic Biomass Liquid Fertilizer (OBLF), Willingness to Pay (WTP), Marketability

1. Introduction

Nowadays, developing countries, especially large cities with rapid urbanization, are facing the problem of waste management, environmental protection and food safety [1] [2]. In Da Nang city, the third largest and most developed city in Vietnam, the city government also has encountered the major challenge of the same situation. Recently, 90 tons of human waste per day are collected from private residences, offices, and public facilities in Da Nang city. The current treatment method is pouring human waste into the disposal compartments of the landfill and handling the odor. However, irrigation canals located below the human-waste treatment plants cause serious environmental problems such as foul odor, mass generation of mosquitos and flies [3]. The problem of waste management, waste treatment and environmental pollution in term of air, soil and ecological system needs to be addressed.

In agricultural production, chemical fertilizers and pesticides have contributed significantly to increased crop yields. However, due to the prolonged and heavy usage of chemical fertilizers and pesticides, soil quality was degraded causing low yield and pour qualitative products. To minimize the adverse effects of conventional farming, organic agriculture production has been gaining familiarity as an organic and plant nutritional soil supplement [4]. The fact that consumers strongly concerned about the importance of health and safety food choice was well documented in the literature [5]-[10]. Statistical data from previous study indicated that 135 countries in the world already conducted organic farming model including Vietnam [11]. In Europe, government policies aim to stimulate the organic sector through subsidies for agriculture producers, consumer education, and support in the form of research, education and marketing [12]. At present, researchers together with farmers are concerning about natural farming sources such as human waste and animal waste to produce organic fertilizer for agricultural production. Application of human urine has been gaining popularities as a fertilizer in selected countries for agricultural practices [13]-[21].

However, Da Nang City has not taken advantages of this source from human waste because of limited technology. Meanwhile, the local farmers have to pay very high cost for fertilizer, especially chemical fertilizers. Every year, all Vietnamese farmers spend 110 thousand billion VND (5 billion USD) for purchasing fertilizer every year [22]. According to statistical data, about 1666 tons of chemical fertilizer and 4.3 tons of pesticides per year were applied in Da Nang city [23]. Additionally, rice-crop farmers have less income than urban residents, and moreover, they have to allocate 10% - 20% of rice sales for purchasing chemical fertilizer [3]. The environmental friendly agricultural production, combined with the consumer's desire for safe food containing no synthetic chemicals is needed for a sustainable agriculture.

In recent years, Da Nang city is shifting commercial agricultural production into organic production by applying organic fertilizers to produce safe and qua-

litative products [24]. In March, 2015, the municipal People's Committee of Da Nang, Japan International Co-operation Agency (JICA) and Chikujo Town's mayor had a discussion to give the best solution for Da Nang city in recycling human waste. Subsequently, the project on "Recycling organic waste into organic biomass liquid fertilizer for clean and environmentally friendly agricultural production in Da Nang, Vietnam" was contracted. The aims of this project are to promote the use of organic liquid fertilizer in farming and improve public awareness of environmental protection through supporting farmers to turn human waste into organic liquid fertilizer for farming at low prices, and migrating environmental contamination in irrigation channels caused by human waste treatment facilities [25]. This is the first project in Vietnam for OBLF production from human waste treated by auto thermal thermophilic aerobic treatment (ATAT) technology of Japan [26].

Since it is a completely new product, evaluation of this product's price on the market is very important, and the sustainability of an agribusiness product requires that the willingness to pay (WTP) for it by target consumers is ensured. Thus, the contingent valuation method (CVM) with double-bounded dichotomous choice technique was used in this study. The CVM is one of the standard approaches for valuing non-marketed resources, such as recreation, wildlife, and environmental quality [27]. Willingness to pay for a product is the amount of money which a consumer would be willing to pay for a higher level of environmental or commodity quality. According some previous studies [28] [29] [30] [2], socio-economic characteristic such as age, education, gender, household income and experience of using compost were used to determine the influence on farmer's willingness to pay (WTP) for compost made from organic and animal waste. However, awareness of environment and training factor seem to be not discussed yet in study of WTP for organic fertilizer product.

Therefore, in this study we want to use the combination of all above factors to estimate WTP and also to investigate factors affecting WTP toward OBLF from human waste in Da Nang city of Vietnam. In addition, we also determined whether marketability of OBLF exists or not in Da Nang city.

2. Methodology

2.1. Analytical Techniques

The double-bounded dichotomous choice (DBDC) method given by [27] is used to estimate the WTP for OBLF and factors that affect to the local farmer's purchasing decision. In this approach each interviewee has to give answers for two levels of bid, where the second bid is decided based on the reaction in the first bid. If the individual responds "yes" to the first bid, the second bid (to be denoted B_i^u) is some amount greater than the first bid ($B_i < B_i^u$); if the individual responds "no" to the first bid, the second bid (B_i^d) is some amount smaller than the first bid ($B_i^d < B_i$). There are four possible outcomes: a) both answers are "yes"; b) both answers are "no"; c) a "yes" followed by a "no"; and d) a "no"

followed by a "yes." The likelihoods of these outcomes are π^{yy}, π^{nn}, π^{yn}, and π^{ny}, respectively. Under the assumption of a utility maximizing respondent, the formulas for these likelihoods are as follows. In the first case, we have $B_i^u > B_i$ and

$$\begin{aligned}\pi^{yy}\left(B_i, B_i^u\right) &= \Pr\left\{B_i \le \max \text{ WTP and } B_i^u \le \max \text{ WTP}\right\} \\ &= \Pr\left\{B_i \le \max \text{ WTP} \middle| B_i^u \le \max \text{ WTP}\right\} \Pr\left\{B_i^u \le \max \text{ WTP}\right\} \\ &= \Pr\left\{B_i^u \le \max \text{ WTP}\right\} = 1 - \mathrm{G}\left(B_i^u, \theta\right)\end{aligned}$$

Since, with $B_i^u > B_i$, $\Pr\left\{B_i \le \max \text{ WTP} \middle| B_i^u \le \max \text{ WTP}\right\} \equiv 1$.
Similarly, with $B_i^d < B_i$, $\Pr\left\{B_i^d \le \max \text{ WTP} \middle| B_i \le \max \text{ WTP}\right\} \equiv 1$. Hence,

$$\pi^{nn}\left(B_i, B_i^d\right) = \Pr\left\{B_i > \max \text{ WTP and } B_i^d > \max \text{ WTP}\right\} = \mathrm{G}\left(B_i^d, \theta\right)$$

When a "yes" is followed by a "no", we have $B_i^u > B_i$ and

$$\pi^{yn}\left(B_i, B_i^u\right) = \Pr\left\{B_i \le \max \text{ WTP} \le B_i^u\right\} = \mathrm{G}\left(B_i^u, \theta\right) - \mathrm{G}\left(B_i, \theta\right)$$

and when a "no" is followed by a "yes", we have $B_i^d < B_i$ and

$$\pi^{ny}\left(B_i, B_i^d\right) = \Pr\left\{B_i > \max \text{ WTP and} \ge B_i^d\right\} = \mathrm{G}\left(B_i, \theta\right) - \mathrm{G}\left(B_i^d, \theta\right)$$

Given a sample of N respondents, where B_i, B_i^u and B_i^d are bids used for the i^{th} respondent, the log-likelihood function takes form

$$\begin{aligned}\ln L^D(\theta) = \sum_{i=1}^{N} \{ & d_i^{yy} \ln \pi^{yy}\left(B_i, B_i^u\right) + d_i^{nn} \ln \pi^{nn}\left(B_i, B_i^d\right) \\ & + d_i^{yn} \ln \pi^{yn}\left(B_i, B_i^u\right) + d_i^{ny} \pi^{ny}\left(B_i\ B_i^d\right)\}\end{aligned}$$

where $d_i^{yy}, d_i^{nn}, d_i^{yn}, d_i^{ny}$ are binary-valued indicator variables; the double-bounded dichotomous choice model is estimated using log-normal and log-logistic model.

$$\text{Mean}\left(\text{WTP}\right) = \int_L^U \left(1 + \mathrm{e}^{-(\beta_0 + \beta_1 \log T + \beta_2 X)}\right)^{-1} \mathrm{d}T$$

where $\left(1 + \mathrm{e}^{-(\beta_0 + \beta_1 \log T + \beta_2 X)}\right)^{-1}$ is the probability of saying "yes". T = bid, U and L are the upper and lower limits of the integration.

$$\text{Median}\left(\text{WTP}\right) = \exp\left(\frac{-\widehat{\beta}_0 - \widehat{\beta}_2 \overline{X}}{\widehat{\beta}_1}\right)$$

In which $\widehat{\beta}_0, \widehat{\beta}_1$ and $\widehat{\beta}_2$ are estimated parameters, $\overline{X}$ = mean of socioeconomics variables.In this study, zero protest bid was screened out and eliminated from empirical model. Finally, estimation of parameters was carried out using the LIMDEP software (NLOGIT version 5).

2.2. Study Area

Da Nang city is located on the Eastern Sea coast, midway between Ha Noi and Ho Chi Minh City and the largest city of Central Vietnam. The terrain of Da Nang includes main lands and islands. The mainland lies from 15˚55' to 16˚14' north latitude and from 107˚18' to 108˚20' east longitude. The population of this

city now is 1,028,800 people. Total area is 1285.4 km^2 including 6 wards (Hai Chau, Thanh Khe, Son Tra, Ngu Hanh Son, Lien Chieu, Cam Le) and 2 districts (Hoa Vang and Hoang Sa) [31]. Area for agricultural production is 721.30 km^2, and mostly distributes in Hoa Vang district [23]. Among 11 communes of Hoa Vang district, four communes (Hoa Nhon, Hoa Phong, Hoa Tien and Hoa Khuong) possess largest area of agricultural production. These areas basically produce and supply rice, vegetable and crops for Da Nang city. Hoa Khuong commune is located in the West of Hoa Vang district. The natural area of this commune is 5088.2 ha, in which 4023.8 ha is agricultural land (79.08%). Hoa Tien commune is placed in the Southeast of Hoa Vang district and 13 km far from the center of Da Nang city. The total area of this commune is 1394 ha including 807 ha agricultural area. Hoa Phong commune is located at the administrative center of Hoa Vang district with total area of 1859 ha, in which agricultural area occupies about 30%. The last commune in the study area is Hoa Nhon commune which is located in the North of Hoa Vang district. The total area of Hoa Nhon commune is 3259 ha including 2415.2 ha of agricultural land (74.1%) [32].

In recent years, Da Nang city, especially Hoa Vang district, is shifting commercial agricultural production into organic production by applying organic fertilizers to produce safe and qualitative products [24]. Thus, this study was conducted at these four villages of Hoa Vang district for data collection (**Figure 1**).

2.3. Sampling

A face-to-face interview with local farmer was under taken at four communes

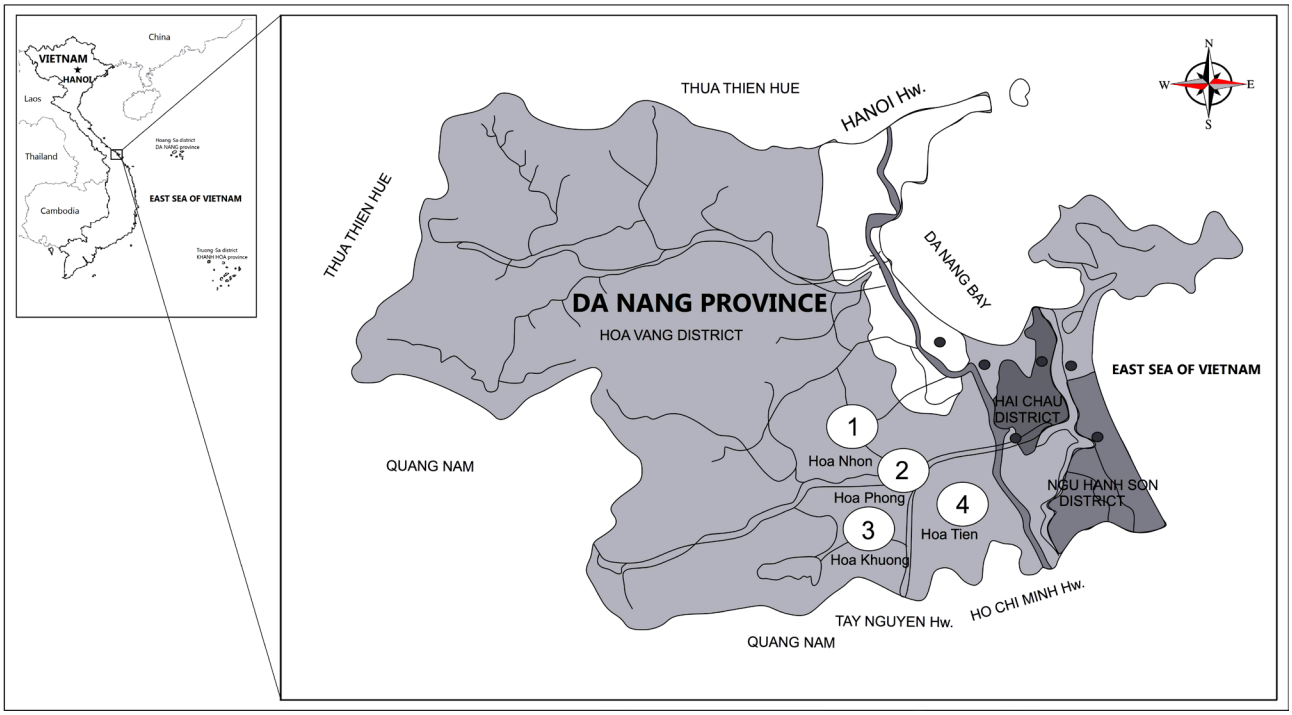

Figure 1. Map of study area in Da Nang city. 1: Hoa Nhon commune, 2: Hoa Phong commune, 3: Hoa Khuong commune, 4: Hoa Tien commune.

including Hoa Nhon, Hoa Phong, Hoa Tien and Hoa Khuong in September to October, 2016 and January, 2017. In total of 530 respondents, 436 respondents (82%) were willing to pay for OBLF whereas 94 respondents (18%) were not willing to pay. Clearly, the percentage of households willing to pay for OBLF is very high in Da Nang city. Similar results of high level of willingness to pay for organic fertilizer was found by researches in difference countries, where percentage of respondents willing to pay for organic fertilizers such as compost was above 70% [29] [33]. Questionnaires were designed by conducting a pre-test with 30 respondents randomly. The purposes of this test were to help the respondent understanding the content of questionnaire and to decide the format bid starting point to estimate the range of OBLF's price. Based on the result of pre-test, the questionnaire was revised again and the official one was designed for a main survey. The main survey was divided into two periods: September, 2016 and January, 2017. In total of 530 samples, only 436 (83%) were valid and could be used for further analyses. Firstly, the demographic information of respondents (name, age, gender, education level etc.), the information about their experience of organic fertilizer utilization and participating in organic fertilizer training were asked. Secondly, the information about agricultural production status of households, such as cultivated area, major crops, yield, annual income and benefit from agricultural production, cultivated expenses and chemical fertilizer utilization (type of fertilizer, fertilizer's cost and amount of fertilizer using for a hectare) was collected. Finally, a summary of current status of chemical fertilizer overuse, its harmfulness and impact on agricultural production was given. Furthermore, the information and advantages of OBLF were introduced to the respondents to help them more understand the questions regarding to WTP for OBLF. Nine pieces of paper were prepared, in which numbers from 1 to 9 were marked follow nine difference bidding version are 10,000 VND to 160,000 VND in Table 1. These nine numbers correspond to nine questions about bid levels. A

Table 1. Offer price of the double-bounded CVM.

Unit: 1000 VND[a]

First bid	Second higher bid	Second Lower bid
10	20	5
20	30	10
30	40	20
40	60	30
60	80	40
80	100	60
100	130	80
130	160	100
160	190	130

Note. [a]1USD = 22,365 VND in 2016, at the time of the study.

respondent will choose one of nine numbers randomly, and answer the corresponded question (See the section of CVM question for more detail in the **Appendix A**).

3. Results and Discussion

3.1. Situation of Chemical Fertilizer Usage in Hoa Vang District, Da Nang City

Recently most of farmers in Hoa Vang district are using chemical fertilizers for agricultural production as the main input. Table 2 indicates the cost of chemical fertilizer usage in agricultural production. It can be seen that farmers purchased more for compound (NPK) and nitrogen fertilizers for staple crops.

For vegetable production, they paid higher expense for compound (NPK) and phosphate fertilizers. In total, farmers spent 6,262,000 VND (280 USD)/ha and 16,366,000 VND (732 USD) for chemical fertilizer in staple crop and vegetables production, respectively.

3.2. Socio Demographic Characteristics of Respondents and Variables

Table 3 presents the socio-demographic characteristics of the respondents. Regarding to household income, the farmers averagely earned 52,493,000 VND per year. The mean actual age of the respondents was from 51 to 60 years old, and about 63% of respondents were female. The high percentage of female respondents may due to the fact that Vietnamese women dominated all parts of agricultural production while men work for other heavier jobs such as builders or workers to earn more income.

The educational background of the respondents showed that most respondents had under high school education (85%). Only 15% of respondents showed higher educational background. Regarding to household size, the average household members was 2.88 people. The result of farm size of respondents indicated that farmers owned average cultivated areas of 0.27 hectare. For respondents who had experience in organic fertilizer utilization, 87% of them agreed to purchase and use OBLF in the near future. For those who participated in organic fertilizer training by village's agricultural extension center, 49% of respondents were willing to purchase for this product. In addition, 83% of respondents who had consciousness in environmental protection agreed to buy OBLF.

Table 2. Cost of chemical fertilizer usage in agricultural production (1000 VND[a]).

Cultivation crops	Kind of chemical fertilizer (thousand VND/ha)					Total cost
	Nitrogen	Phosphate	Potassium	Compound (NPK)	Others	
Staple crops	1563	647	560	2783	708	6262
Vegetables	1561	2676	792	10,116	1221	16,366

Note: [a]1USD = 22,365 VND in 2016, at the time of the study. Source: Own estimates, data available from the authors

Table 3. Description of socio demographic characteristics.

Variables name	Description	Mean	Std. Dev
Household Income	Annual household income in year (million VND/year)	52.49	45.03
Gender	Gender (1 = Male; 0 = Female)	0.37	0.48
Age	Age of respondent (1 = below 40; 2 = 41 - 50; 3 = 51 - 60. 4 = 61 - 70; 5 = over 70)	3.05	1.06
Education	Level of education (1 = high school and higher; 0 = Under high school)	0.15	0.36
Household size	Household size of the respondent, *i.e.*, total no. of people living in respondent's household	2.88	1.10
Farm size	Total area used for crop cultivation (unit: ha)	0.27	0.23
Experience	Experience of using organic fertilizer (1 = Experience; 0 = No experience)	0.87	0.34
Awareness	Awareness of environment (1 if farmers have awareness of environment; 0 if otherwise)	0.83	0.38
Training	Participate in the training about fertilizer usage and cultivation methods (1 = Yes; 0 = No)	0.49	0.50

3.3. Willingness to Pay of Respondents

Table 4 shows the probability of answering "yes" response to first bid (FB) and second high bid (SHB) ranged from 96.55% for 10,000 VND to 5.13% for 160,000 VND. The proportion of "yes" responses to FB and "no" responses to SHB for 10,000 VND and 160,000 VND was 3.45% and 7.69%, respectively.

In the case two proportion of responses to FB and SLB. Respondents answered "no" at FB and "yes" at SLB ranged from 0% for 10,000 VND to 17.95% for 160,000 VND. Proportion of "no" responses to FB and "no" SLB ranged from 0% for 10,000VND to 69.23% for 160,000VND.

In addition, the respondents answered for WTP questions following the bids. In detail, percentage of respondents for "yes—yes" answer was 59.86%, for "yes—no" answer was 14.68% answer. Percentage of "no—yes" and "no—no" answers was 5.5% and 19.95%, respectively.

3.4. Estimate of WTP for OBLF

Table 5 indicates the estimated coefficients in the model which was estimated using maximum likelihood estimation with the NLOGIT 5 econometrics software. The log-logistic model is estimated using two models. In detail, all variables and only statistically significant variables were tested in model 1 and model 2, respectively. After testing, all of the significant variables in model 1 are still significant in model 2. In addition, all dependent variables have tested correlation and multicollinearity through Variance Inflation Factors (VIF). The result shows all correlations are less than 0.4 and all VIF values were less than 10. This implies that multicollinearity among combinations of independent variables was not a problem (Table B1 and Table B2 in **Appendix B**).

Table 4. Summary of respondents answer the WTP (1000 VND[a]).

First Bid (VND)	First bid (FB) and Second high bid (SHB)				First bid (FB) and Second low bid (SLB)				Observations
	yes—yes		yes—no		no—yes		no—no		
	Number	Percent%	Number	Percent%	Number	Percent%	Number	Percent%	
10	56	96.55	2	3.45	0	0.00	0	0.00	58
20	58	95.08	3	4.92	0	0.00	0	0.00	61
30	44	88.00	3	6.00	2	4.00	1	2.00	50
40	46	83.64	8	14.54	0	0.00	1	1.82	55
60	24	53.33	15	33.33	1	2.22	5	11.11	45
80	16	34.78	21	45.65	6	13.04	3	6.52	46
100	8	19.05	5	11.90	5	11.90	24	57.14	42
130	7	17.50	4	10.00	3	7.50	26	65.00	40
160	2	5.13	3	7.69	7	17.95	27	69.23	39
Total	**261**	**59.86[b]**	**64**	**14.68[b]**	**24**	**5.50[b]**	**87**	**19.95[b]**	**436**

Note: [a]1USD = 22,365 VND in 2016, at the time of the study. [b]percent (%) = (Number/Observations) × 100.

Table 5. Determinants of WTP functions.

Constant and Explanatory variables	Model 1 (all variables)			Model 2 (statistically significant only)		
	Estimated Coefficient		z-value	Estimated Coefficient		z-value
Constant	10.73	***	4.69	11.04	***	5.59
Household Income	0.28	**	2.15	0.23	**	2.11
Gender	0.38		1.39			
Age	0.20		0.14			
Education	0.05		0.14			
Household member	−0.08		-0.57			
Farm size	−0.60		-0.79			
Experience - UOF	1.31	***	2.91	1.18	***	2.75
Awareness	1.26	***	3.54	1.21	***	3.63
Training	0.59	**	2.26	0.61	**	2.37
Bid effect coefficient	−3.99	***	−13.72	−3.90	***	−14.20
Log Likelihood	−293.40			−295.37		
Mean	94,345[a]			94,856		
Median	87,447			87,749		

Note: [a] unit: VND. ***, **, *, significant at 1%, 5%, 10%. Source: Author's estimation.

However, the log likelihood ratio (LR) statistic is highly statistically significant. The sign of all coefficients of variables in the model is consistent with the intuition. The result of estimation shows that *Bid effect coefficient*, *household income, awareness of environment*, *experience of using organics fertilizer* and

training are the factors that determine the households' decision of whether to pay or not to pay for OBLF.

Bid effect coefficient variable (−3.99 in model 1 and −3.90 in model 2) has a negative significant difference at 1%; revealing that an increase in bid amount could reduce the "yes" response and the existence of the willingness to pay for OBLF (**Table 5**). This result is consistency with other studies by [34] [35] [36].

Household income variable was positive and significant at 5%. This indicates that as the income of the respondent increases, the WTP for OBLF is likely to be increased. This result is consistency with researches of [2] [37] [34] [36] [38].

The variable of *experience of using organics fertilizer* has estimated co-efficiency of 1.31 in model 1 and 1.18 in model 2, and high positive significant difference at 1%. This means respondents who have experience of using organic fertilizer in the past and know well about advantages of organic fertilizer are more likely to adopt and pay for improving farming techniques easier and faster than limited experience ones. This result is agreed with researches of [28] (0.1080 at 10%) and [29] (3.737 at 1%).

Awareness variable (1.26 in model 1 and 1.28 in model 2) was positive significant at 1%. This means the respondents who have consciousness in environmental protection are willing to pay for environmental friendly products and may enhance critical evaluation of the relevance of better products than commercial ones. In the researches of [28] [29] [30] [2], the variable of awareness about environment have not been discussed yet. In the study on estimating urban households' WTP for upland forest restoration in Vietnam, however, [39] indicated that environmental awareness strongly affected to households' decision on purchasing for environmental protection service to protect upland forest. Environmental awareness is one of the most important indicators for displaying national civilization. It reflects many aspects of environmental status, such as people's knowledge, personal consideration and behavior, public capacity, and the local citizens' attitude towards sustainable society in general. In our study, awareness of environment towards sustainable agriculture by using organic inputs.

Training variable also shows positive significant at the 5%. Nowadays in rural areas of Vietnam, agricultural extension activities are very popular and meaningful for farmers by giving a lecture about new organic products (organic fertilizer) or training of farming methods. Thus, in this study the respondents who have been already trained for organic fertilizer utilization and cultivation method are willing to pay for OBLF product. This result is consistency with a research of [40]. In their research on the "Adoption of organic farming in Thai Mahasarakham province", they found that the training variable was positive and significant at 5%. They explained that the farmers who had attended the training courses on organic vegetable farming (OVF) and organic fertilizer production had the tendency towards growing organic vegetables. Although the main purpose of the training programs is enhance the farmers' capability in OVF, the participants are also made aware of benefits for health and finance from raising

organic vegetables. Therefore, the training courses play the important and vital catalytic role in the adoption of new techniques and new organic products as well.

Finally, the mean WTP of OBLF from human waste was estimated to be 94,856 VND/Ton (4.0 USD/Ton). However, it is not the cost from producers based on production expenses. To determine the marketability exist of OBLF in Da Nang city, we hypothesized that above estimated price was the price of OBLF in the future market, and it has been used to compare to the cost of chemical fertilizer usage in Da Nang city.

3.5. Comparison between the Cost of Chemical Fertilizers and Organic Biomass Liquid Fertilizer Usage

According to a report of JICA project in Da Nang city, the amount of fertilizer applied to one hectare of staple crops was 56 tons and for vegetables was 115 tons based on nutrient composition and percentages of N, P and K compound in OBLF [41]. Using the results shown in **Table 2**, **Table 6** shows the cost comparison between the two types of fertilizers applying for staple crops and vegetables. It can be seen that if farmers use OBLF for production, the cost will be cheaper than that of chemical fertilizers. In detailed, for one hectare of staple crop production farmers have to pay 6,262,000 VND (280 USD) while the cost for OBLF was only 5,311,936 VND/crop/ha (237.21 USD). For vegetables production, 16,366,000 VND/ha/Crop (732 USD) was the cost for chemical fertilizer usage but only 10,908,440 VND/ha/Crop (487.75 USD) was purchased by farmers if they use OBLF as input. This proves that marketability seems to be existed for OBLF product in Da Nang city.

4. Conclusions

This study assessed the factor affecting to willingness of farmers to pay for OBLF. Using CMV double-bound method, the results have revealed that the most important factors strongly determining the WTP of the farmers were household income, experience of using organic fertilizer, awareness of environment and participation in organic product training. The estimated mean WTP for each ton OBLF from human waste was 94,856 VND (4.0 USD). By comparison with current available chemical fertilizer, the expense for purchasing OBLF in agricultural production such as staple crops or vegetables was much cheaper than that of chemical fertilizers. Thus, marketability seems to be existed for OBLF in Da

Table 6. Cost of chemical fertilizer and OBLF usage for staple crops and vegetables (1000 VND[a]).

Crops cultivation	Chemical fertilizer/crop/ha	Organic biomass liquid fertilizer/crop/ha
Staple crops	6,262,000 VND (280 USD)	5,311,936 VND (237.21 USD)
Vegetables	16,366,000 VND (732USD)	10,908,440 VND (487.75 USD)

Note: [a]1USD = 22,365 VND in 2016, at the time of the study.

Nang city. From these results, farmers in Da Nang city will be likely to more concern about environmental protection and change their thinking that sustainable agriculture only exists when agriculture practices shifted into organic farming using environment-friendly products such as OBLF from human waste. In addition, from the estimated price of OBLF we also recommend the fertilizer producers to refer this price when they sale this product in the market.

Because organic farming using organic fertilizer has benefits in improving soil tillage and productivity along with environment, the government should have policies to support and subsidize the farmers to encourage them to use OBLF in a large scale of cultivation. Furthermore, establishment of a market to consume the organic products harvested from cultivated areas using OBLF is also recommended.

In addition, environmental education should also be concerned, and lecture about recycling of human waste should be organized not only for farmers but also for young people such as students of elementary, secondary and high schools. This will help them to understand more about the importance of environment in sustainable agriculture production.

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Appendix

Appendix A. The Format of CVM Question

1. HH's Willingness to pay (WTP)

Pay for using this product, in comparison with your expected benefits. Nine pieces of paper were prepared, in which number from 1 to 9 was marked. These nine numbers correspond to nine questions about bid levels. A respondent will choose one of nine numbers randomly, and answer the corresponded question. When answering these questions below, please concern about your reaction if you actually had to pay for using this product.

Bid 1 (Number 1)

A_1. Are you willing to pay 10,000 VND for each ton OBLF?

☐ Yes (*go to* A_2) ☐ No (*go to* A_3)

A_2. Are you willing to pay 20,000 VND for each ton organic OBLF? (*No matter the answer,* 10,000 *VND is last price*)

☐ Yes ☐ No

A_3. Are you willing to pay 5000 VND for each ton OBLF?

☐ Yes ☐ No

Bid 2 (Number 2)

A_1. Are you willing to pay 20,000 VND for each ton OBLF?

☐ Yes (*go to* A_2) ☐ No (*go to* A_3)

A_2. Are you willing to pay 30,000 VND for each ton OBLF? (*No matter the answer,* 10,000 *VND is last price*)

☐ Yes ☐ No

A_3. Are you willing to pay 10,000 VND for each ton OBLF?

☐ Yes ☐ No

Bid 3 (Number 3)

A_1. Are you willing to pay 30,000 VND for each ton OBLF?

☐ Yes (*go to* A_2) ☐ No (*go to* A_3)

A_2. Are you willing to pay 40,000 VND for each ton OBLF? (*No matter the answer,* 10,000 *VND is last price*)

☐ Yes ☐ No

A_3. Are you willing to pay 2,000 VND for each ton OBLF?

☐ Yes ☐ No

Bid 4 (Number 4)

A_1. Are you willing to pay 40,000 VND for each ton OBLF?

☐ Yes (*go to* A_2) ☐ No (*go to* A_3)

A_2. Are you willing to pay 60,000 VND for each ton OBLF? (*No matter the answer,* 10,000 *VND is last price*)

☐ Yes ☐ No

A_3. Are you willing to pay 30,000 VND for each ton OBLF?

☐ Yes ☐ No

Bid 5 (Number 5)

A_1. Are you willing to pay 60,000 VND for each ton OBLF?

☐ Yes (*go to* A_2) ☐ No (*go to* A_3)

A_2. Are you willing to pay 80,000 VND for each ton OBLF? (*No matter the answer,* 10,000 *VND is last price*)

☐ Yes ☐ No

A_3. Are you willing to pay 40,000 VND for each ton OBLF?

☐ Yes ☐ No

Bid 6 (Number 6)

A_1. Are you willing to pay 80,000 VND for each ton OBLF?

☐ Yes (*go to* A_2) ☐ No (*go to* A_3)

A_2. Are you willing to pay 100,000 VND for each ton OBLF? (*No matter the answer,* 10,000 *VND is last price*)

☐ Yes ☐ No

A_3. Are you willing to pay 60,000 VND for each ton OBLF?

☐ Yes ☐ No

Bid 7 (Number 7)

A_1. Are you willing to pay 100,000 VND for each ton OBLF?

☐ Yes (*go to* A_2) ☐ No (*go to* A_3)

A_2. Are you willing to pay 130,000 VND for each ton OBLF? (*No matter the answer,* 10,000 *VND is last price*)

☐ Yes ☐ No

A_3. Are you willing to pay 80,000 VND for each ton OBLF?

☐ Yes ☐ No

Bid 8 (Number 8)

A_1. Are you willing to pay 130,000 VND for each ton OBLF?

☐ Yes (*go to* A_2) ☐ No (*go to* A_3)

A_2. Are you willing to pay 160,000 VND for each ton OBLF? (*No matter the answer,* 10,000 *VND is last price*)

☐ Yes ☐ No

A_3. Are you willing to pay 100,000 VND for each ton OBLF?

☐ Yes ☐ No

Bid 9 (Number 9)

A_1. Are you willing to pay 160,000 VND for each ton OBLF?

☐ Yes (*go to* A_2) ☐ No (*go to* A_3)

A_2. Are you willing to pay 190,000 VND for each ton OBLF? (*No matter the answer,* 10,000 *VND is last price*)

☐ Yes ☐ No

A_3. Are you willing to pay 130,000 VND for each ton OBLF?

☐ Yes ☐ No

Appendix B. Test for Multicollinearity

Table B1. Results of correlation matrix for listed variable.

Variables	*Household Income*	*Gender*	*Age*	*Education*	*Household member*	*Farm size*	*Experience*	*Environ-mental*	*Training*
Household Income	1.00								
Gender	0.086	1.00							
Age	−0.16	0.16	1.00						
Education	0.15	0.20	−0.19	1.00					
Household member	0.40	0.11	−0.03	0.09	1.00				
Farm Size	0.13	0.13	0.14	−0.04	0.13	1.00			
Experience	0.11	−0.01	0.05	−0.00	0.05	0.13	1.00		
Awareness	0.02	0.07	−0.06	0.05	−0.06	−0.01	0.14	1.00	
Training	−0.07	0.00	0.06	−0.01	−0.06	0.01	0.01	0.08	1.00

Table B2. Result of Variance Inflation Factors (VIF) test.

Variables	VIF
Household Income	1.26
Gender	1.12
Age	1.14
Education	1.11
Household member	1.21
Farm Size	1.08
Experience	1.05
Awareness	1.05
Training	1.02