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Household Awareness on the Consequences of Untreated Wastewater in Traditional Agro-Food Processing Villages in Nhue-Day River Basin, Vietnam

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ABSTRACT

The study sought to evaluate the household's awareness of the risks of untreated wastewater on health, agricultural production, environment, and recreational activities. A survey was conducted on 276 agro-food processing households residing on the Nhue-Day river basin in Vietnam. An Ordered Logit Model (OLM) determined that age, educational attainment of the household head, and household's monthly income were the main factors that affect the household's awareness of the effects and consequences of untreated wastewater. Results showed that these factors positively affected the household's awareness of the adverse effects of untreated wastewater health, environment, agricultural production, and recreational activities.

Keywords: *untreated wastewater, agro-food processing households, Ordered Logit Model, household awareness*

Introduction

Craft villages play an important role in Vietnam's economic development through job creation, especially in rural areas. Based on the 2014 report issued by the Ministry of Natural Resource and Environment (MONRE), Hanoi is considered as one of the cities with the most number of certified craft villages in Vietnam. Currently, Hanoi has a total of 1,350 craft villages and 277 traditional villages. Hanoi's craft villages employ 800,000 people with an average annual income of VND 30 to VND 35 million per worker (Nguyen Hanh 2017). Despite the significant contribution of craft and traditional villages to the economic development in Vietnam, the undeniable consequences to the environment of production activities in the agro-food traditional villages are worth considering.

Despite the significant contribution of craft and traditional villages to the economic development of Vietnam, reports, and studies showed that factories in the craft villages directly discharge their untreated wastewater to the environment. Specifically, in traditional agro-food processing villages in Hanoi, the amount of untreated wastewater released into the environment reached the maximum level of about 1,000 to 7,000 cubic meter per day in the Duong Lieu and Cat Que commune, and at least 1,000 cubic meters per day in Hoai Duc District (MONRE 2012). The wastewater from agro-food processing is rich in organic matter and characterized by high organic content

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expressed in BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), and TSS (Turbidity and Suspended Solids). Reports showed that the BOD, COD, and TSS wastewater content from the agro-processing is a hundred times higher than the allowable criterion. In 2013, a large volume of untreated wastewater from the Hanoi craft villages was recorded to be directly discharged to the environment (MONRE 2012). Based on the recorded indicators of COD and BOD or the total number of coliform bacteria, the content of the pollutants exceeded the threshold limit (Center for Environmental Monitoring [CEM] 2017).

The untreated wastewater produced from the agro-processing households in the villages have a foul odor and contain toxic substances which affect the environment and health of the residents within and near the area. Some households with deep-well as a water source are also affected by the discharged untreated wastewater. Studies also showed that the average longevity of residents who live in the villages is five to ten years lower than those who live outside the village (Thanh Tam 2015). Since water is mainly used in farms and aquaculture farms, agricultural production and activities are also affected.

According to Dang *et al.* (2010), the cause of environmental pollution boils down to the lack of awareness among households in the agro-processing villages on the effects and risks of untreated wastewater. The residents are more concerned about their business rather than addressing the effects of untreated wastewater on health, agriculture, environment, and recreation issues. A previous study by Dahal (2014) on the people's perception and behavior towards the reuse of wastewater was conducted in Nepal. In Vietnam, there is limited literature on people's awareness of the risks of untreated wastewater and its effects on the environment, agriculture, and recreational activities. Thus, it is fundamental to provide information and necessary solutions to improve the agro-processing household's awareness of the effects of untreated wastewater on the health, agriculture, environment, and recreation to achieve a quality of life and sustainable craft villages.

Methodology

There are more than 1,000 craft villages in Hanoi City. However, the study focused on three traditional agro-food processing villages namely: Duong Lieu, Tan Hoa, and Phu Do communes from the three districts of Hoai Duc, Quoc Oai, and Tu Liem of Hanoi in Nhue – Day River Basin. The criteria for selection were based on a) villages that directly discharge untreated wastewater to the Nhue-Day river basin; b) traditional agro-food processing craft villages in Hanoi; c) areas that contained the largest quantity of wastewater in the villages; and d) study sites that had one operating wastewater treatment facility since October 2016.

A household survey was conducted to collect primary data and utilized pre-tested survey questionnaires. An orientation on the background and purpose of the study was conducted to the survey respondents. A total of 276 respondents participated in the conduct of the survey. Secondary data and information were gathered from annual reports of their respective local governments, updated information from the internet portals and websites, published and unpublished materials, and statistical reports. Focus group discussions (FGD) were conducted among the head and vice head of the craft villages. There were three FGDs sessions conducted with six to eight participants per session.

All agro-food processing households in the Tan Hoa and Phu Do craft villages were surveyed since there are only a few households in these villages. Duong Lieu villages have only two hamlets. A total of 276 households were surveyed in the three communes. Data gathered from the respondents were sociodemographic characteristics (i.e., age, sex, and educational attainment), socioeconomic characteristics (i.e., household income, household size, sources of wastewater, type of wastewater, the volume of wastewater generated per month, and distance of household to the primary watershed outlet of effluents), individual's perception (i.e., wastewater problems and environmental improvement, risk reduction on health, agricultural

production, environment, and recreational activities), and preferred volume of treated wastewater.

A key informant interview with focal persons on natural resource and environment management was also conducted to elicit the condition of the wastewater system. Household's awareness of the risks of direct and indirect usage of untreated wastewater was determined from the focal persons in the respective study sites.

Methods of Analysis

As defined by Merikle (1984), awareness is the ability to make better and forced-choice decisions which concern either the identity or the presence of the primes. Conversely, it is assumed that observers were unaware of the primes when the decisions were at a chance level of performance.

According to several authors, limited awareness for health risks, lack of alternative water source, and the limited ability of cities to treat wastewater were the major reasons for reuse of untreated wastewater in irrigated agriculture in many developing countries (Jiménez and Asano 2008, Raschid-Sally and Jayakody 2008 as cited by Ndunda 2013). Household's awareness of risks from using untreated wastewater can be evaluated by using the Ordered Probit Model which is more suitable than a multinomial or nested Logit or Probit Model (Ndunda 2013). This is because unordered models do not account for the ordinal nature of risk awareness in wastewater reuse. In this study, the household awareness on the risk of untreated wastewater on the environment, production, and recreation was analyzed using the more suitable Ordered Probit Regression model. Since the Ordered Logit Model (OLM) and Ordered Probit Model yield similar outputs, the OLM is still used as the most suitable model to evaluate the household's awareness.

The awareness of the consequences of the untreated wastewater was treated as the dependent variable and was measured using a three-point scale (1= disagree; 2 = unsure; 3 = agree). In the Ordered Logit Model, the error term (ε_i) and the continuous latent variable Y* were assumed to be normally distributed as shown in equation (1) (Williams 2015):

$$Y_i^* = \sum_{k=1}^{K} \beta_k X_{ki} + \varepsilon_i \quad (1)$$

Where: Y* is a single latent measure of risks awareness of direct and indirect untreated wastewater users

X_k is a vector of factors that affect the households' awareness

β_k is a vector of parameters to be estimated

ε_i is the error term

$Y_i = \varkappa$ if $\alpha_{\kappa-1} < Y_i^* \leq \alpha_{\kappa}$

The probability that observation i will select alternative $\varkappa$ is:

$p_{i\kappa} = p(y_i = \varkappa)$

The continuous latent variable Y* has various threshold points.

Since the Y* cannot be measured, we only know when it crosses these thresholds and observes the categories of responses as shown in equation (2):

$$Y_i = \begin{cases} 1 \text{ if } Y^* < \varkappa_1 \text{ (disagree)} \\ 2 \text{ if } \varkappa^{1} < Y^* < \varkappa_2 \text{ (unsure)} \\ 3 \text{ if } Y^* > \varkappa_2 \text{ (agree)} \end{cases} \quad (2)$$

[1] $\varkappa$ is the Greek small letter Kappa

Parameters β or the coefficients denote the influence of the explanatory variables on the dependent variable. The positive sign of β implies higher awareness of risks associated with wastewater uses as the value of related variable increases.

The Ordered Logit Model estimates the non-stochastic part of equation 1 as follows:

$$Z_i = \sum_{k=1}^{K} \beta_k X_{ki} = E(Y_i^*) \quad (3a)$$

Note that, because of the random disturbance term, the unmeasured latent variable Y* can be either *higher* or *lower* than Z.

The K, βs and the M-1 $\varkappa$'s are parameters that need to be estimated.

$$Z_i = \sum_{k=1}^{K} \beta_k X_{ki} \quad (3b)$$

Because there is no intercept term, then the estimated M-1 cutoff terms (where M is the number of categories) were used to estimate the probability that Y will take on a particular value.

To address the multicollinearity problem in this model, information from the VIF was used to eliminate the explanatory variables that caused the high correlation. Independent variables show the strong evidence of multicollinearity impact if the value of VIF>10 (Akinwande *et al.* 2015, Yoo *et al.* 2014).

Similar to the case with Logit models, the parameters for an Ordered Logit Model is hard to interpret. Adjusted predictions and marginal effects were used to make the results more understandable and readily interpretable.

To analyze the households' awareness of the consequences of untreated wastewater (dependent variable), the Ordered Logit Model was used with the explanatory variables described in Table 1. The households' awareness about the consequences of untreated wastewater (y) is reflected in four fields, namely: (1) health risks; (2) productivity of agricultural production; (3) availability of recreation activities; and (4) environment. Three levels of household evaluation on the consequences of untreated wastewater on each of the four fields are disagree (y=1), unsure (y=2), and agree (y=3).

Table 1. Description of explanatory variables

Independent Variable	Mean	SE	Description
Decmak	0.70	0.03	Dummy, 1 if the respondent is household head, 0 otherwise
Gender	0.73	0.03	Dummy, 1 if the respondent is male, 0 otherwise
Age	46.19	0.48	Age of household head (years)
Educ	8.02	0.13	Education level of household head (years)
Exper	16.57	0.46	Experience of household head in agro-food processing (years)
Apinv	0.93	0.02	Dummy, 1 if the household involves in agro-food processing, 0 otherwise
Children	0.55	0.03	Dummy, 1 if the household has at least one child below 16, 0 otherwise
Sickness	3.00	0.14	No. of people in respondents' family got sick (people)
Loginc	1.38	0.02	Logarithm of household income

The empirical computations of households' perception of health risks, environment, recreation, and agricultural production were obtained using Ordered Logit Model in STATA® 14 which was based on the maximum likelihood estimation technique (MLE) (see Table 8). For this estimation method, the likelihood ratio (LR) chi-square tested the null hypothesis that all of the regression coefficients are simultaneously equal to zero. The results of all models of households' awareness about the health risks, agricultural production reduction, limited recreation activities, and environment degradation showed highly significant p-values (Prob > chi-square = 0.0000) which mean that null hypotheses are rejected or all independent variables

in these models are not simultaneously equal to zero. Also, all values of McFadden R^2 (pseudo R^2) presented the goodness of fit of the models.

Results and Discussion

Socioeconomic Characteristics of Respondents

Table 2 provides a summary of the socioeconomic characteristics of the respondents in the Nhue-Day River Basin. Of the 276 respondents, 70% are household heads who are also the decision-makers of their respective households. Most of the household heads are male (73%) with a mean age of 46.19 years. About 34% of respondents, with an age range of 40 to 45 years old, have children whose ages are above 16 years old. Most of the respondents were unable to finish their secondary school resulting in average schooling of 8.02 years. Based on the interview, as a succession plan of the agro-food processing households, they were trained at a young age. Hence, formal education is far from their priority.

Table 2. Socioeconomic characteristics of respondents in study areas

Variable	Variable Description	MEAN	SE
Decmak	1 if the household head, 0 otherwise	0.70	0.03
Sex	1 if male, 0 otherwise	0.73	0.03
Age	Age of household head	46.19	0.48
Children	No. of children/grandchildren under 16 years old	0.55	0.03
Educ	Education level (years)	8.02	0.13
Exper	Experience of working in agro-food processing activity (years)	16.57	0.46
Flourhh	Tapioca/edible canna flour processing households (1 if the household is a flour processing household; otherwise 0)	0.16	0.02
Verhh	Vermicelli processing households (1 if the household is a Vermicelli processing household; otherwise 0)	0.21	0.03
Frnhh	Fresh Rice Noodle processing households	0.42	0.03
Tofuhh	Tofu processing households (1 if the household is a tofu processing household; otherwise 0)	0.11	0.02
Roothh	Cassava/edible canna root processing households (1 if the household is a canna root processing household; otherwise 0)	0.10	0.02
Apinv	1 if working in agro-food processing, 0 otherwise	0.93	0.02
Sickness	Frequency of occurrence of sickness by family members	3.00	0.14
Agrofood	Monthly income from agro-food processing activity (Million Dong)	22.99	0.74
Loginc	Logarithm of the average monthly income of households	1.38	0.02

Based on the survey results, about 93% of respondents work in the agro-food processing industry where they produce fresh rice noodles (42%), vermicelli (21%), tapioca (16%), and edible canna flour and tofu (11%). Only 10% of the respondents produce cassava and edible canna root products. This supports the result of the survey that 95% of the households sourced their income from agro-food processing. The logarithm of the average monthly income of households in these areas was 1.384 which means that the households' average income was very high (about VND 24.21 million or USD 1,064)[2] compared to the average monthly income of other households of USD 400 to USD 700 (Tan Hoa, Duong Lieu, and Phu Do Statistics Departments 2017).

Moreover, results revealed that the agro-food processing industry contributed to the highest volume of waste and wastewater in the study areas. It was reported that within the last six months, an average of three residents gets sick (i.e., diarrhea, allergy, sore eyes, and stomachache) in each household.

[2]USD = 22,700 VND as of June 21, 2016, accessed http://vneconomy.vn/tai-chinh/gia-usd-tu-do-vuot-22700-dong-gia-vang-on-dinh-20161123111431488.htm.

Sources of Wastewater in Traditional Agro-food Processing Villages

Agro-food processing activities demand an immense volume of water and at the same time discharge a massive volume of water in the traditional agro-food processing villages. Table 3 provides information on the main sources and volume of wastewater of the households in selected traditional agro-food processing villages in the Nhue-Day River Basin. Results from the survey showed that 98.19% of the residents perceived that the main source of wastewater comes from the agro-food processing activities.

Table 3. Perception of traditional agro-food processing villages on the sources of wastewater in agro-food processing villages in Nhue-Day River Basin, 2017

Sources of Wastewater	No. of respondents*	%
Households/residential areas	261	94.57
Hospitals, hotels, garages, laundry, beauty salons, butcher shops, and other commercial complexes)	12	4.35
Agro-food processing	271	98.19
Husbandry	9	3.26

*Multiple responses

Table 4 shows that the quantity of wastewater discharge is 93.13 cubic meters per household per month which accounts for about 86.58% of the total volume of discharged wastewater in the three surveyed villages. It was revealed that the wastewater from the livestock also has high coliform content. The wastewater is untreated and discharged directly to the drainage system, ponds, and small lakes of the villages. Consequently, it causes sedimentation which obstructs the flow of water and pollutes the environment. Results also showed that the domestic wastewater (13.42%) was identified by the residents as the major source of water pollution and the majority of the respondents (94.57%) agreed.

Table 4. Sources of wastewater in the traditional agro-food processing villages, 2017

Villages	Domestic		Production		Total
	Volume (m^3/hh/month)	Percentage (%)	Volume (m^3/hh/month)	Percentage (%)	(m^3/hh/month)
Tan Hoa	21.29	18.11	96.28	81.89	114.39
Duong Lieu	11.32	9.07	113.52	90.93	124.84
Phu Do	13.66	15.62	73.78	84.38	87.44
Average	14.44	13.42	93.13	86.58	107.57

Note: Based on the sample analysis from the research conducted

Moreover, some studies conducted in the study sites revealed wastewater samples exceeded the BOD, COD, TSS level, and has a high content of coliform bacteria. In Duong Lieu commune, all indicators exceeded the standard levels of BOD, COD, and TSS level and have high coliform bacteria content. Households producing cassava (starch and filter) exceeds the BOD and COD indicators up to 113 times, its TSS indicators up to 4 times, and the coliform bacteria content up to 4 times than their standard levels (Pham 2010). In Tan Hoa commune, the BOD indicator was 22.7 higher than the standard level and the BOD indicator in the first wastewater sample (NT1) was 22.7 times higher than the standard level. Compared to the standard indicators, NT1 wastewater sample had a BOD indicator higher than 26 times, and the COD indicator higher than 50.8 times. All wastewater samples had the COD indicator higher than the standard level from 3.78 to 50.8 times (Do 2015). From the result of the analysis of wastewater samples in Phu Do commune in 2013, it is notable that the content of organic matter is quite high, in which the COD exceeds the standard level by 12.6 to 15 times. Furthermore, BOD exceeds the 2011 standards set by MONRE by 23 to more than 28 times (Tran 2013).

Perceived Consequences of Water Pollution to the Health in Selected Traditional Agro-food Processing Villages in Nhue-Day River Basin

Rivers are the major source of water in rural areas. Most respondents from Tan Hoa and Duong Lieu use deep well water for washing, bathing, and cooking. For years, established community water supply is still non-existent in the areas. In effect, polluted surface water from the rivers increases the risk of diseases among the residents near the river basin of the provinces.

In the study, it was revealed that in Duong Lieu village, skin disease, sore eyes, and headache were the common disease and illnesses of the residents (see Figure 1). The percentage of incidence of these diseases and illnesses is higher in Duong Lieu compared to other villages. As reported by the Duong Lieu Statistics Department (2016), among the common diseases, skin disease has the highest percentage (17.61%) and it is almost twice higher than other villages.

Meanwhile, in the Tan Hoa commune, the percentage of diarrhea has the highest level (15.73%) followed by headache (15.03%). The percentage of people who got diarrhea in Duong Lieu and Tan Hoa communes is much higher than in the Phu Do ward. This may be because, in the Phu Do ward, people use clean water supplied by the Hanoi Clean Water and Sanitation Company. As a result, the percentage of people who have diseases in Phu Do is lower than in the other two villages.

In contrast, in Duong Lieu and Tan Hoa communes, residents currently use water from private wells, collected rainwater, and common deep wells. However, due to the large volume of waste and wastewater discharge, underground water is also contaminated which causes some diseases to the residents. The farmers also use water from rivers and canals for their crops in farming. In effect, the fruits and vegetables were also contaminated by the polluted water.

Since wastewater emits a foul odor, previous researches revealed that it can cause headaches and dizziness to individuals.

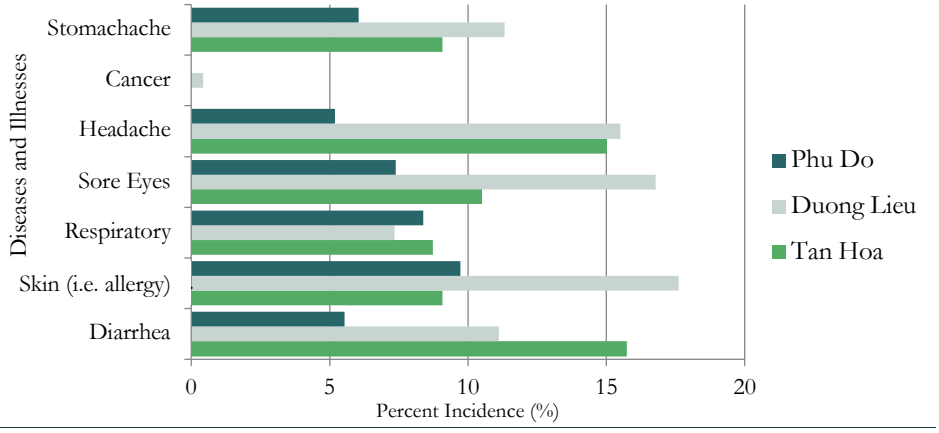

Figure 1. Percentage incidence of diseases in study sites, 2017

Recreation is also affected by untreated wastewater. For years, rivers, lakes, and ponds were used for agricultural production activities (i.e., irrigation), household activities, and recreational activities such as boating and fishing. However, the river became polluted due to the population increase which was accompanied by the disposal of waste and wastewater from households, agricultural activities, and industries. Since then, recreational activities were restricted in the Nhue and Day rivers.

Agricultural production is also affected by untreated wastewater. Farmers and fishermen, who reside along the riverbanks of the Nhue and Day rivers, depend on agriculture for their livelihood. Since the water in the rivers is contaminated, the agricultural yield decreases annually (Nguyen 2006). There is a lack of clean water for irrigation and as a result, farmers were unable to plant crops and vegetables. Consequently, the fishermen have limited harvests as well, thus, significantly affecting their livelihood.

As mentioned, the untreated wastewater emits a foul odor which also causes air pollution. Previous researches also revealed that the use of contaminated wastewater to crops also led to land pollution.

Households' Perception of Water Pollution in the Study Sites

Based on the survey, the residents identified urgent environmental issues to address such as water pollution, air pollution, and waste. Specifically, 80.07% of the respondents identified surface and underground water pollution as the top priority issue to be addressed. In terms of surface water, 60.87% of the respondents identified that surface water is polluted and 21% evaluated that the surface water is heavily polluted (see Table 5).

Table 5. Households' perception of environmental problems and the use and quality of surface water in Nhue-Day River Basin, 276 respondents, 2017

Items	Frequency	%
Most urgent environmental problems		
Surface and underground water	221	80.07
Air	21	7.61
Solid Waste	34	12.32
Surface water quality		
Clean	48	17.39
Polluted	168	60.87
Heavily-polluted	60	21.74
Main purpose of surface water		
Irrigation	59	21.38
Fishing	6	2.17
Useless	201	72.83
Others	10	3.62

Wastewater remains to be the main cause of water pollution in Duong Lieu commune even if there is an existing wastewater treatment plant (Cau Nga). Despite the results, 17.39% of the respondents still perceived that the surface water is clean. They also recognize that the wastewater from agro-food processing activity is not polluted, thus, safe for the environment. Due to the polluted water source, more than 70% of respondents consider that water from the rivers, lakes, ponds, and canals is unsafe to use for any purpose. For irrigation, 21.38% of households mentioned that they still use untreated water for farming purposes due to the lack of alternative water sources.

Nevertheless, some parts of the Nhue-Day River Basin, lakes, and ponds in the study sites, contain clean water. About 2.17% of the respondents confirmed that the surface water can still be used for their fishing. In contrast, about 3.62% of household heads responded that the rivers, ponds, lakes, and canals in their respective residential areas were converted as disposal sites for the waste and wastewater.

Households' Awareness of the Adverse Effects of Untreated Wastewater

Figure 2 summarizes the responses of the respondents on the effects of untreated wastewater. More than 67% of the respondents agreed that untreated wastewater has negative effects on health, recreation, and environment, while less than 20% disagreed.

For agricultural production, since there are few farmer respondents and family members, 24.64% responded they are unsure of the adverse effects of untreated wastewater.

However, about 59.06% agreed on the possible consequences of untreated wastewater to agricultural farms and aquaculture farms.

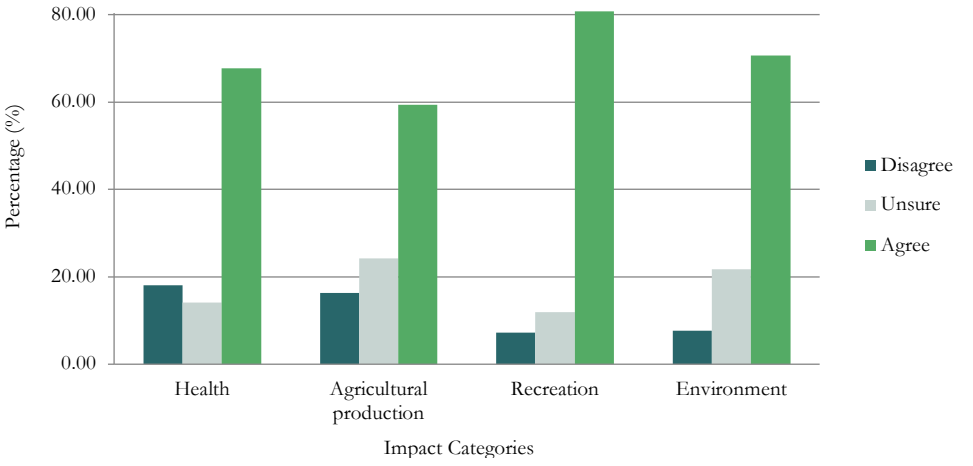

Figure 2. Respondents' awareness of the effects of untreated wastewater

Results also revealed that 88.41% of the respondents have the motivation to provide a better environment for their children (see Table 6). There are 65.22% of the respondents who are motivated to improve the wastewater treatment because they feel responsible for water pollution through the discharge of domestic and industrial wastewater to the river.

Table 6. Household's motivations for wastewater treatment in Nhue-Day River Basin, 276 respondents, 2017

Reasons*	%
Responsibility	65.22
Health risk reduction	47.83
Recreation activities	28.26
Agricultural yields and fish stock increase	19.20
Better environment for future generations	88.41

*Multiple responses

Moreover, 47.83% of the respondents identified improvement in health thru recreational activities (28.26%) as their motivation for wastewater treatment. Only 19.20% identified improvement in agricultural production, both for farming and fishing, as their motivation for wastewater treatment.

Factors Affecting the Household Awareness of the Adverse Effects of Untreated Wastewater

Based on the results, the households' awareness of the effects of untreated wastewater on health risks could be explained by the level of education and average monthly income of the household. Specifically, as the level of education and average monthly income increase, the higher the respondent's likelihood of agreement. The respondents who are on high health-risk awareness are more likely to agree with the consequences of untreated wastewater since they are aware of the health risks (see Table 7).

Table 7. Factors affecting households' perception of untreated wastewater influences

Explanatory Variables	Health		Agricultural Production		Recreation		Environment	
	Coefficient	Std. Err	Coefficient	Std. Err	Coefficient	Std. Err	Coefficient	Std. Err
Decmak	0.577	0.303	0.362	0.276	0.700*	0.336	0.275	0.306
Sex	-0.245	0.322	0.106	0.288	0.749*	0.338	0.305	0.306
Age	0.020	0.020	0.067**	0.019	0.064*	0.026	0.042*	0.021
Educ	0.536**	0.093	0.289**	0.074	-0.024	0.077	0.163*	0.071
Exper	-0.013	0.021	0.098**	0.020	0.010	0.024	-0.010	0.020
Apinv	0.064	0.533	-0.231	0.542	0.992	0.555	1.146*	0.490
Children	0.129	0.276	0.164	0.258	0.045	0.326	0.758*	0.282
Sickness	0.129	0.067	-0.035	0.056	0.175*	0.081	0.200**	0.072
Loginc	1.735**	0.525	0.771	0.420	-0.709	0.492	1.778**	0.526
LR chi-square	77.95		72.55		33.58		49.82	
Pro> chi-square	0.0000		0.0000		0.0001		0.0000	
Pseudo-R^2	0.1662		0.1381		0.0987		0.1167	

The households' perception of the effects of untreated wastewater on agricultural production was influenced by age, education, and duration of work experience in agro-food processing villages.

Household awareness of the impacts of environmental degradation is influenced by age, education, and type of household. Household awareness is important as there is always the presence of children in each household and to decrease the frequency of occurrence of sickness among family members.

Meanwhile, the main factors that affect the households' awareness of untreated wastewater and how it limits recreational activities were age, sex, the relationship of the respondent to the household head, and frequency of occurrence of sickness by family members.

The marginal effects were also calculated to represent the likelihood of an increase in respondents' awareness from "disagree = 1" to "agree = 3" that untreated wastewater has negative effects on health, agricultural production, recreation, and the environment. The marginal effects of households' perception of untreated wastewater influences are described in Table 8.

Health Risk Awareness (HRA)

The results of the study showed that at a 5% significance level, the respondent's level of education and average monthly income of households have a significant effect on the health risk awareness of households. Marginal effects showed that each additional year of education increases the chance of having high awareness about the health risks by 10.5% points. This is because education is one of the essential factors that affect an individual's views and beliefs. Oftentimes, an individual is likely to be identified by his or her educational attainment. Individuals with high educational attainment tend to be more aware of the negative effects of untreated wastewater. Marginal effects showed that a unit increase in income increased awareness of health risks by 34.1% points.

Agricultural Production Reduction Awareness (APRA)

Only a few households in the traditional handicraft villages are into agricultural production. Consequently, the household's perceptions of agricultural production are based primarily on their prior experiences. A unit increase in age, education, and level of experience increase the probability of answering agree by 1.6%, 6.8%, and 2.3% points, respectively. All

three variables have significant effects on the awareness that agricultural production is reduced by untreated wastewater (p-value <0.05).

Table 8. Marginal effects of households' perception of untreated wastewater influences

Variables	Dy/dx	Dy/dx	Dy/dx
Health Risk Awareness (HRA)	HRA = 1	HRA = 2	HRA = 3
Educ	-0.057**	-0.048**	0.105**
Loginc	-0.184**	-0.157**	0.341**
Agricultural Production Reduction Awareness (APRA)	APRA = 1	APRA = 2	APRA = 3
Age	-0.007**	-0.010**	0.016**
Educ	-0.029**	-0.039**	0.068**
Exper	-0.010**	-0.013**	0.023**
Limited Recreation Activities Awareness (LRAA)	LRAA = 1	LRAA= 2	LRAA= 3
Gender	-0.044	-0.068*	0.112*
Age	-0.003*	-0.005*	0.009**
Sickness	-0.009*	-0.015*	0.023*
Environmental Degradation Awareness (EDA)	EDA = 1	EDA = 2	EDA = 3
Age	-0.002	-0.006*	0.008*
Educ	-0.008*	-0.023*	0.031*
Apinv	-0.089	-0.171*	0.260*
Children	-0.037*	-0.109**	0.146**
Sickness	-0.010**	-0.029**	0.038**
Loginc	-0.088**	-0.255**	0.343**

Limited Recreation Activities Awareness (LRAA)

As mentioned, the majority of the household heads in traditional villages consist of males (73%). Also, older males reported having higher awareness than older females (11.2%) on the limits to recreational activities in the river brought about by wastewater discharge. The young persons (0.9%) were the least aware of the recreational activities restrictions in the river. The increase in the number of times that family members get sick also led to a high chance of agreeing by 2.3% points.

Environmental Degradation Awareness (EDA)

Results revealed that the older respondents who attained a higher level of education were more aware of environmental degradation. Also, an additional year in age increases awareness by 26% points. Similarly, an additional child below 16 years old increased EDA by 14.6% points and an added family member who gets sick by 3.8% points. This is related to the fact that respondents were aware that the quantity of the discharged untreated wastewater increases every day and causes water, air, and soil pollution.

A unit increase in the average monthly income of the respondent increased EDA by 34.3% points. An increase in income helps the respondents to allocate money to spend on their family health care. As the individual invests more in human health, awareness of the negative effects of untreated wastewater in the environment increases.

Summary and Conclusion

The traditional agro-food processing villages in Vietnam have helped boost the economic development of the country. However, the negative impacts of untreated wastewater from agro-food processing on health, agricultural production, environment, and recreation must also be given consideration. The research showed that the major form of pollution from agro-food processing households was the untreated wastewater discharges which amounted to 93 cubic meters per household per month. Consequently, it significantly

affected the health of the residents. Common diseases and illnesses identified were skin disease (17.61% in Duong Lieu commune), diarrhea (15.73% in Tan Hoa), and headache (15.03% in Tan Hoa).

The results of the empirical Ordered Logit Model showed that education and income variables positively affected the awareness of households on the effects of untreated wastewater on health. A unit increase in educational attainment and average monthly income, the higher the likelihood of agreement and high awareness on health-risks of untreated wastewater.

For agricultural production, a unit increase in age, education, and level of experience increase the probability of answering agree by 1.6%, 6.8%, and 2.3% points, respectively.

For recreational activities, it was revealed that young persons (0.9%) were the least aware of the restrictions on recreational activities in the river. The increase in the number of times that family members get sick, increases the chance to agree by 2.3% points on the restrictions on recreational activities due to water pollution.

Overall, the study revealed that the main factors that affect the household's awareness on the effects and consequences of untreated wastewater were age, educational attainment of the household head, and household monthly income.

References

Adewani, J.R., A.A. Ilemobade, and J.E. Vanzyl. 2008. "Model to Assess Public Perception Towards the Reuse of Treated Waste Water Effluent in South Africa." School of Civil and Environmental Engineering, University of the Witwatersrand, Johannesburg. South Africa.

Akinwande, M.O., H.G. Dikko, and A. Samson. 2015. "Variance Inflation Factor: As a Condition for the Inclusion of Suppressor Variable(s) in Regression Analysis." *Open Journal of Statistics* 5(7): 754-767.

Central for Environmental Monitoring [CEM]. 2017. "Xử lý môi trường làng nghề: Cần những giải pháp căn cơ. [Handle the Craft Village Environment: Need Basic Solutions]." CEM, accessed June 25, 2017, http://cem.gov.vn/VN/TINTRANGCHU_Content/tabid/330/cat/115/nfriend/3750162/language/vi-VN/Default.aspx.

Dahal, P.K. 2014. "People's Perception and Behaviour Towards Reuse of Wastewater in Dhulikhel, Nepal." *International Journal of Environment* 3(2): 137-142.

Dang et al. 2010. "Vietnam's Craft Villages and Water Pollution: A Review of Previous Research." Working paper for the Project Crafting Sustainability: Addressing water pollution from Vietnam's Craft Villages. Working Paper. Australian National University Canberra, accessed, December 12, 2016, https://crawford.anu.edu.au/rmap/pdf/_docs/water_pollution_craft/dang_et_al_2010.pdf.

David, J.M. 2010. "Public Perceptions on Water Reuse Options: The Case of Sulabiya Treatment Plant in Kuwait." Kuwait-Maastricht Business School, Kuwait University, Kuwait.

Do, T.H. 2015. "Ứng dụng mô hình DPSIR trong đánh giá hiện trạng môi trường nước mặt của làng nghềchếbiến tinh bột xã Tân Hòa, Quốc Oai, Hà Nội. [Application of DPSIR Model in Surface Water Quality Assessment of Tan Hoa Commune, Quoc Oai, Ha Noi]." Unpublished undergraduate thesis. The Hanoi University of Natural Resource and Environment.

Duong Lieu Statistics Department. 2017. "Report on Results of the Implementation of New Rural Community Standards." Vietnam.

Duong Lieu Statistics Department. 2016. "Annual Report on Environment." Vietnam.

Hanoi Portal. 2015. "Nghiên cứu thiết kế xây dựng hệ thống thông tin quản lý và quảng bá phục vụ phát triển bền vững các làng nghề trên địa bàn Thành phố Hà Nội. [Research on Designing to Build the Management Information System and Advertisement for the Sustainable Development of Craft Villages in Hanoi City]." Accessed November 8, 2016, http://vanban.hanoi.gov.vn/detaikhoahoc?p_p_id=VsubjectView_WAR_Vsubjectportlet_INSTANCE_1TyasZEx52tW&p_p_lifecycle=0&p_p_state=normal&p_p_mode=view&p_p_col_id=column-1&p_p_col_count=1&_VsubjectView_WAR_Vsubjectportlet_INSTANCE_1TyasZEx52tW_jspPage=%2Fhtml%2Fportlet%2FsubjectView%2Fdetail.jsp&_VsubjectView_WAR_Vsubjectportlet_INSTANCE_1TyasZEx52tW_subId=12002.

Jimènez, B. and T. Asano. 2008. "Water Reclamation and Reuse Around the World." In: Jiménez, B. and Asano, T. (eds), Water reuse: an international survey of current practice, issues and needs. London: IWA Publishing.

Merikle. P.M. 1984. "Toward a Definition of Awareness." *Bulletin of the Psychonomic Society* 22 (5): 449-450.

Ministry of Natural Resource and Environment (MONRE). 2012. "Report on Vietnam National State of Environment."

Ministry of Natural Resource and Environment (MONRE). 2014. "Report on Vietnam National State of Environment."

Ndunda, E.N. 2013. "Wastewater Reuse in Urban and Peri-urban Irrigation: An Economic Assessment of Improved Wastewater Treatment, Low-risk Adaptation and Risk Awareness in Nairobi, Kenya." Published Doctoral Dissertation in Environmental Economics. University of Pretoria, South Africa.

Nguyen Hanh. 2017. "Khuyến công Hà Nội năm 2017: Đầu tư cho công nghiệp nông thôn. [Hanoi Industry Encouragement in 2017: Investment for Industrial Sector in Rural Area]." Cuong Thuong, accessed June 23, 2017, http://baocongthuong.com.vn/khuyen-cong-ha-noi-nam-2017-dau-tu-cho-cong-nghiep-nong-thon.html.

Nguyen, T.A.T. 2006. "Đô thị hóa: lời cảnh báo về suy thoái môi trường. [Urbanization and Warnings About Environmental Degradation]." Accessed March 20, 2016, http://moc.gov.vn/tl/tin-tuc/49694/do-thi-hoa--loi-canh-bao-ve-suy-thoai-moi-truong.aspx.

Pham, H.N. 2010. "Đánh giá hiện trạng môi trường phục vụ phát triển bền vững làng nghề chế biến thực phẩm Dương Liễu, huyện Hoài Đức, thành phố Hà Nội. [Assessment of Environmental Status for Sustainable Development of Duong Lieu Agro-food Processing Village, Hoai Duc District, Hanoi City]." Unpublished master thesis. Vietnam National University, Hanoi.

Phu Do Statistics Department. 2017. "Annual Report on Results of the Implementation of the Socio-Economic Development Plan." Vietnam.

Raschid-Sally, L. and P. Jayakody. 2008. "Drivers and Characteristics of Wastewater Agriculture in Developing Countries: Results from a Global Assessment, Colombo, Sri Lanka." IWMI Research Report 127. Colombo, Sri Lanka: International Water Management Institute.

Tan Hoa Statistics Department. 2016. "Annual Report on Results of the Implementation of the Socio-Economic Development Plan, Security - Defense 2016, Mission Orientation 2017." Vietnam.

Thanh Tam. 2015. "Ô nhiễm môi trường làng nghề: Xu hướng gia tăng. [Environmental Pollution in Craft Villages: Increasing Trend]." Cong Thuong, accessed December 10, 2016, http://baocongthuong.com.vn/o-nhiem-moi-truong-tai-cac-lang-nghe-xu-huong-gia-tang.html.

Tran, T.H.G. 2013. "Đánh giá công nghệ xử lý nước thải làng nghề chế biến bún và đề xuất giải pháp nâng cao hiệu quả xử lý. [Evaluate the Technology of Waste Water Treatment in Vermicelli Processing Village and Propose Solutions to Improve Processing Efficiency]." Unpublished master thesis. Hanoi University of Natural Science.

Williams, R. 2015. "Ordered Logit Models." University of Notre Dame, December 15, 016, http://www3.nd.edu/~rwilliam/.

Yoo, W., R. Mayberry, S. Bae, K. Singh, Q.P. He, and J.W. Lillard. 2014. "A Study of Effects of Multicollinearity in the Multivariable Analysis." *International Journal of Applied Science and Technology* 4(5): 9-19.