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Perceptions and Attitudes Toward Eco-Toilet Systems in Rural Areas: A Case Study in the Philippines

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Abstract: Death due to diseases from poor sanitation is a serious global issue and it has become one of the priorities of the United Nations' Sustainable Development Goals (i.e., SDG6). This SDG6 aims to provide adequate improved sanitation facilities to over 2.3 billion people around the world who have no or limited access to sanitation, wherein more than two-thirds of these un-served people live in rural areas. One of the strategies for addressing this global issue is through emerging sustainable sanitation technologies such as the Eco-Toilet System (ETS), which uses small amounts of water or is even waterless and recovers nutrients from human waste thereby promoting water-energy conservation, improved sanitation and supplement nutrients essential to plant growth. Social acceptance, however, remains a key barrier in deploying the ETS. A social perception study on the use of the ETS was conducted in a rural community in Mulanay, Philippines. The researchers analyzed the proposed combined technology acceptance model and theory of planned behavior (C-TAM-TPB) using multiple linear regression and the Mann-Whitney U-test to evaluate the perceptions and attitudes of a rural community towards the use of the ETS. The results showed that more than 50% of the respondents are aware of the nutrient value of human excreta and believe that it is usable as fertilizer; however, less than 25% prefer to utilize it for food production. Results also indicate that the behavior of the users is driven by their attitude ($\beta = 0.420$, p-value < 0.010). Moreover, the Mann-Whitney U-test results revealed that people who are knowledgeable of the nutrient value of human excreta and are willing to collect them have more positive attitude towards the ETS.

Keywords: sustainable ecological sanitation; rural sanitation; eco-toilet system; social perception; social acceptance; technology acceptance model (TAM); theory of planned behavior (TPB)

1. Introduction

Poor sanitation is a global problem that results in one of the world's burden of diseases (i.e., diarrhea) which account for more than 846,000 deaths annually [1]. Although there is an increasing number of the global population who gained access to improved sanitation facilities in recent years, the challenge to provide access and better sanitation still remains for a greater share of 2.3 billion people, especially those located in the rural communities [2].

In the Philippines, the proportion of the rural population provided with sanitary toilets is consistently progressing [2,3]; however, the proper treatment of domestic wastewater remains a problem with most of the installed toilets connected to septic tanks. While treatment is known to be less efficient with septic systems, poor maintenance and improper operation add to the problem. Discharges of effluents to the environment, whether intended or not, have already created health risks from polluting components (e.g., pathogens such as *Salmonella*) carried by surface water flows, finding their way to the soil, surface water bodies and within aquifers [4]. These cases are evident from the rise of cases of waterborne infections and diseases after major flood events in the country. In most dwelling units connected to a community water system, water is often used as the medium to carry wastes from a toilet system to a connected septic tank [5]. While availability and access to freshwater and its affordability will likely favor water carriage systems, the water carriage approach remains difficult to communities, especially in rural areas, where availability of and access to water remains a big challenge. The demand of the growing Philippine rural population [6] on water for toilet flushing and anal cleansing will continue to compete with the available clean water supply for food and drinking in the future, thus there is already a need for a more sustainable water and sanitation management in the country [7].

One of the emerging paradigms that promotes sustainable water and sanitation management is called the source-separation sanitation system or coined as the Eco-Toilet System (ETS) [8]. The ETS does not necessarily require water to flush and transport the excreta to the septic tanks, and some configurations do not allow water and soap. Some types of eco-toilets are built with separate drop holes for the urine and feces to allow source-separation of excreta. Urine and feces are collected separately, stored and treated for pathogens including viruses to produce safe fertilizers [9]. Prior researches confirm that the ETS has the ability to close the loop of the material flow of the human excreta while preventing harmful discharges of effluents to the environment, conserving water consumption, and producing sanitized human excreta as fertilizers [8,9]. The technology acceptance of the ETS has appealed to many researchers because the development and implementation of the ETS still remain as a challenge [10] that would require attitudinal and behavioral changes [10,11], additional cost for the infrastructure [12], strong policy intervention, technical awareness, and sensitive environmental and hygiene initiatives [11,13,14]. Shifting from the conventional toilet culture to waterless sanitation practices may cause some constraints to new users in the Philippines since majority of the Filipinos are "washers" in terms of anal cleansing [5].

Perceptions and attitudes toward the ETS are recognized as important factors in addressing the different problems in sanitation. Shifting from a water-reliant system to a waterless and sustainable sanitation system involves numerous initiatives [10–14]. For example, previous researches [10,12] draw more attention on the technology evaluation and economic viability, but not much on the perception. Other than the evaluation of effectiveness of the new sanitation technologies, some studies explore more decision-making techniques in evaluating the end-user responses towards the sanitation technology in terms of willingness to adopt and reuse ecological sanitation products [15].

Although the principles of the ETS are not entirely novel, such sanitation system is perceived as a new environmental technology [16]. The ETS is not always socially accepted in some communities since "flush and discharge" type became the norm, like in the Philippines. Previous investigations have implemented diverse approaches to model and understand the social perceptions and attitudes towards acceptance of the ETS such as hypothesis testing [14], value-belief-norm theory [15], and theory of planned behavior (TPB) [17]. However, these approaches are only limited to the communities' perspectives based on their available resources, social influences, skills, and opportunities and not on how they perceive the use of the technology. One of the widely used acceptance models to address this gap is the Technology Acceptance Model (TAM). TAM was initially used as an acceptance model for new information technology systems, and has been recently recognized as one of the most powerful tools of explaining the users' behavioral intentions in using and accepting new technologies [18,19]. TAM was formulated to explain the users' perception in adopting new technology, i.e., it may be influenced by different factors such as perceived usefulness and perceived ease of use of the technology, attitude, and behavioral intention [19].

This study aims to explain not only the technology use through TAM but also how the community thinks towards the ETS based on their perceived behavioral control (or facilitation conditions) and subjective norms, in which TPB is capable of explaining [20]. An integrated TAM and TPB to evaluate potential users' perceptions and attitudes toward the ETS in rural areas is proposed. This methodology allows us to determine how technology adoption in particular to eco-toilet systems is affected by the perception on technology use, perceived behavioral control, and subjective norms. The integrated theory of TAM and TPB has already been explored to analyze projects that promote sustainable development such as green transportation [21] but not on sanitation.

This study also focuses on the behavioral intention as the measurement of social perception towards the use of the ETS in a rural community in the Philippines. The study area is situated in Mulanay, a rural municipality in Quezon Province, where the concept of the eco-toilet is recently introduced. Based on the 2014 statistics from the rapid community-based monitoring system (RCBMS) of Mulanay, about 46% of the total municipality population has no access to sanitary toilet facilities and 83% are at risk of unsafe water supply.

The rest of this paper is organized as follows. The next section gives a detailed description of the methodology. Section 3 discusses the results from a case study in Mulanay, Quezon. Finally, conclusions and recommendations for future work are given.

2. Methodology

2.1. Public Orientation to the ETS

The eco-toilet system was introduced to the community through a consultation meeting with the stakeholders and project presentation in the pilot sites (e.g., in Mulanay). This was conducted to present the concept of the ETS project that will be initiated in the rural area, as well as to enhance the awareness thereof. The eco-toilet that was introduced to the community was a urine-diverting type. This type of ETS has the ability to safely collect and process excreta (urine and feces) with compost additives into liquid and soil conditioners through aerobic decomposition. The main components of the ETS are: (1) superstructure, (2) urine diverting toilet (as illustrated in Figure 1), (3) collection chamber, (4) collection tank for urine, and (5) compost mixer. The superstructure is the main building structure of the ETS facility. This serves as the shelter and provides the privacy for the users. The superstructure also holds the collection chamber. The urine-diverting toilet is designed to separate urine and feces that occurs at the commode. The urine diverter is connected to a collection tank located in the collection chamber, while the feces drop hole is centered beneath the compost mixer. Foul odors are prevented by tightly closing the urine collection tank and by frequently mixing the feces with locally available dehydrating materials such as rice hull. Further details are explained elsewhere [22,23]. The urine and compost products were processed onsite until they were ready and safe for agricultural use.

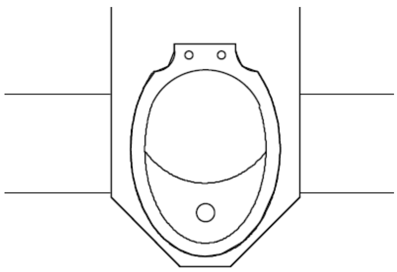

Figure 1. Urine-diverting toilet interface.

Finally, the public orientation was also executed to clarify the roles and responsibilities of the implementers and the adopters once the ETS units are already installed. Further, this activity was also facilitated to get the public's opinion about the ETS.

2.2. Technology Acceptance Model

Technology Acceptance Model (TAM) was originally introduced by Davis in 1989 to understand and provide explanation on the decision factors of the users on accepting new information technology systems [20]. This model assumes that the technology adoption is directly affected by the users' behavioral intention (BIU). BIU is a variable that predicts how the users intentionally engage in the adoption or actual use of a new technology (i.e., to adopt or not to adopt a new system). This decision factor is influenced by both perceived usefulness (PU) and attitude towards the use (ATU) of the new technology. PU refers to the belief of the users that using the new technology would improve the performance on a certain task. On the other hand, ATU pertains to the emotional judgment of the users on the idea of performing a certain behavior or task. The TAM also considers two major constructs that directly affect ATU. The first construct is the PU and the second is the perceived ease of use (PEU). The latter refers to the convenience and effortlessness of using the new technology. PEU also directly affects the PU of the new technology [24].

2.3. Theory of Planned Behavior

Theory of Planned Behavior (TPB) was initiated by Ajzen [20] to provide explanation on how behavioral intention (BIU) is influenced by the subjective norms (SN), perceived behavioral control (PBC), and ATU. SN is a measurement variable that describes how important individuals or groups favor or not favor the users' usage of the new technology. In other words, the users' decision towards usage of a technology or system depends on social influences. Another construct that is directly associated to the BIU is the PBC. The PBC refers to the resources (i.e., skills, experiences, money), and opportunities that enable the users to perform a behavior. The TPB assumes that sufficiency in the resources and opportunities would less hinder technology adoption and would increase the PBC of the users. ATU, in PBC, is similar to its definition in TAM [21].

2.4. The Proposed Combined Technology Acceptance Model and Theory of Planned Behavior (C-TAM-TPB) Model and Research Hypotheses

TAM and TPB differ in several ways. Firstly, the assumption of TAM is that the perception on usefulness and ease of use of a new technology primarily determines the decision of a user to intentionally adopt or use a technology or system; while TPB assumes that decision to use or adopt a technology or system requires relevant references such as outcomes based on experiences of another individual or group, subjective preferences of other groups, and control variables (i.e., skills, resources, opportunities). Secondly, unlike TPB, TAM assumes that decision to use or adopt a new technology or system is not directly affected by any social influences. Lastly, the predictors of behavior in TAM may be affected by external variables (i.e., political climate (PC), user demand (UD), and anxiety (ANX)), while TPB treats the variables independently [21,25,26].

C-TAM-TPB was initially developed by Taylor and Todd [27] to bridge the gap between the TAM and TPB. Although TAM has the ability to predict the BIU of the users of a new technology, it misses out two important factors in elucidating BIU which are the SN and PBC. Both TAM and TPB have the same objective on anticipating the users' BIU [21]. Combining the two models makes a more dynamic approach in explaining the BIU [25].

Based on the proposed C-TAM-TPB model, the constructs such as PU, ATU, SN, and PBC were hypothesized predictors of the users' BIU of the ETS. Chen et al. [25] used a similar framework of C-TAM-TPB. However, in this paper, the PU and PEU were hypothesized to be affected by external variables (See Figure 2). Hence, the model included PC, UD, and ANX as external variables resulting to the following thirteen hypotheses (**H**):

Hypothesis 1 (H1). *PU directly affects the BIU of the user of the ETS;*

Hypothesis 2 (H2). *ATU is directly associated to the BIU of the user of the ETS;*

Hypothesis 3 (H3). *PBC directly affects the BIU of the user of the ETS;*

Hypothesis 4 (H4). *SN is directly associated to the BIU of the user of the ETS.*

Hypothesis 5 (H5). *PEU directly affects ATU of the ETS;*

Hypothesis 6 (H6). *PU has a direct effect to ATU of the ETS;*

Hypothesis 7 (H7). *PEU directly affects the PU of the ETS;*

Hypothesis 8 (H8). *PC has a direct effect to the PU of the ETS;*

Hypothesis 9 (H9). *UD is directly associated to the PU of the ETS;*

Hypothesis 10 (H10). *ANX directly affects PU of the ETS;*

Hypothesis 11 (H11). *The PC has a direct effect to the PEU of the ETS;*

Hypothesis 12 (H12). *UD is directly associated to the PEU of the ETS;*

Hypothesis 13 (H13). *ANX directly affects PEU of the ETS*

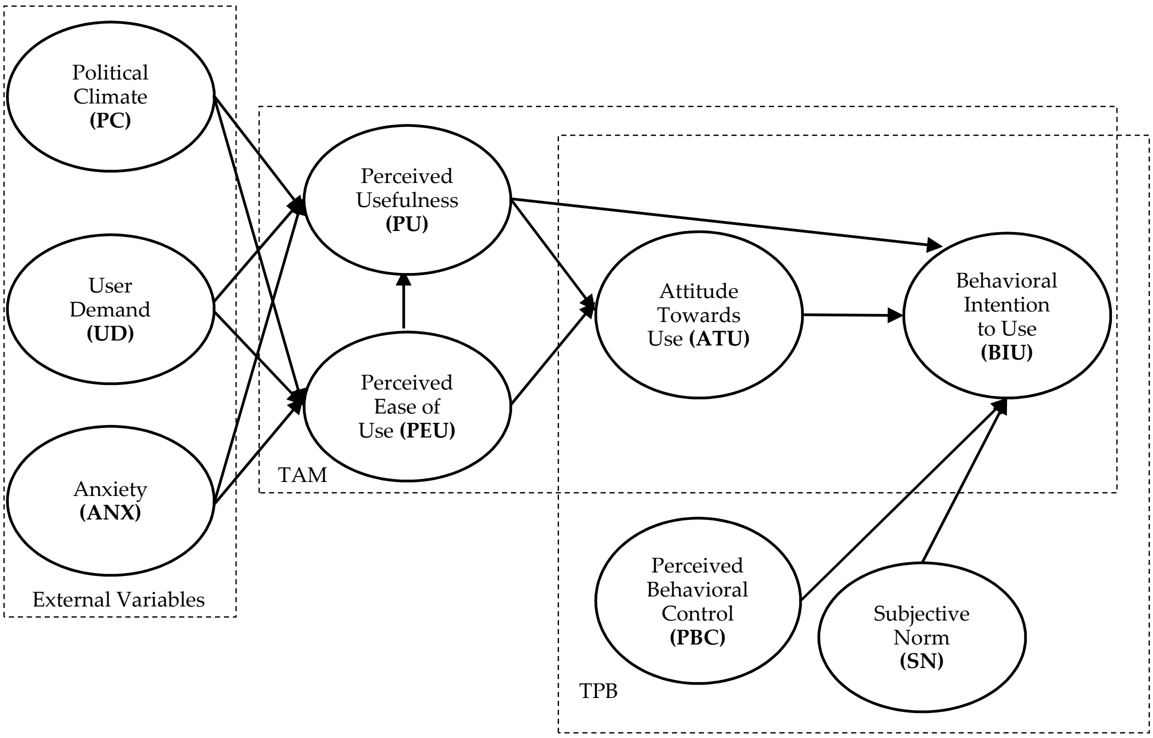

Figure 2. The proposed research framework.

The hypotheses were based on the path of the model as shown in Figure 2. The path of the research model indicates that PU and PEU were two precursors of the users' attitude. The effects of the external variables were mediated by PU and PEU; PEU may also have direct association with PU. Furthermore, PU, ATU of ETS, PBC, and SN may also have a direct effect to the behavioral intention to use of the ETS. These hypotheses were investigated by conducting a structured survey and data processing. The details of process are discussed further in the succeeding sections of this paper.

2.5. Survey Instrument

The survey questionnaire consisted of four sections: (1) consent form and declaration if the respondent is illiterate (with approval from the Research Ethics Office of De La Salle University, Manila); (2) demographic profile of the respondents: gender, age, educational attainment, civil status, years of residency, and number of household members; (3) items investigating community's perceptions and attitudes in using human excreta, with questions about the factors that would encourage and discourage users to install the ETS (see Table 1); and (4) adopted C-TAM-TPB questionnaire to evaluate the predictors of the behavioral intention of the rural community to use the ETS (see Table 2). Items listed in Table 2 were scored by the respondents on a five-point scale where 1 indicates strong disagreement, 2 for moderate disagreement, 3 for neutral/undecided, 4 for moderate agreement, and 5 for strong agreement. The questionnaire was also translated in Filipino language, the vernacular used in the community.

Table 1. Survey questions on perceptions and attitudes toward human excreta and factors that would encourage and discourage users to install the ETS.

Questions	Response
Are you aware that your feces and urine have nutrient value?	Yes No
Do you think urine can be used as a safe fertilizer?	Yes No
Do you think feces can be used as a safe fertilizer?	Yes No
Which type of plant do you prefer to use urine as fertilizer?	Edible Non-edible
Which type of plant do you prefer to use feces as fertilizer?	Edible Non-edible
Are you willing to collect your urine and feces?	Yes No
What factors would encourage you to install the ETS at your home?	Free Installation Conserve water Nutrient reuse Others
What factors would discourage you to install the ETS at your home?	Technology not tested Expensive Complicated Others

Table 2. C-TAM-TPB Questionnaire.

Constructs	Items	Statements
Political climate	PC1	The community leaders will support the implementation, operation, and maintenance of the ETS.
	PC2	The local government will support the implementation, operation, and maintenance of the ETS.
	PC3	Solution to water quality problems is a priority of our community leaders or local government.
User demand	UD1	Using the system is necessary in my lifestyle.
	UD2	The ETS will motivate us to improve the health in the community.
	UD3	I understand that the ETS has economic benefits
	UD4	The ETS will help solve the water-borne disease problems in my community.
	UD5	We need more toilet in the community.
Anxiety	ANX1	I hesitate to use the ETS for fear of making mistakes I cannot correct.
	ANX2	I am afraid I cannot operate and maintain the ETS well.
	ANX3	I am afraid that the ETS might be unsanitary.
	ANX4	I feel apprehensive and discomfort about using the ETS.
	ANX5	The ETS is somewhat intimidating to me.
Perceived ease of use	PEU1	My interaction with the ETS would be clear and understandable.
	PEU2	It is easy for me to learn and become skillful at using the ETS.
Perceived usefulness	PU1	I would find the ETS useful and efficient in improving the sanitation for my community.
	PU2	Using the ETS will enable me to improve the sanitation in my community faster.
	PU3	Using the ETS would motivate me to improve the sanitation in my community.
Attitude towards use of the ETS	ATU1	Using the ETS is a good idea.
	ATU2	The ETS makes my lifestyle more interesting.
	ATU3	I like to use the ETS.
Perceived behavioral control	PBC1	I have the resource necessary to use the ETS. (money, space, etc.)
	PBC2	I have the knowledge necessary to use the ETS.
	PBC3	A specific person (or group) is available for assistance if there will be difficulties in using the ETS.
Subjective norm	SN1	People who are important to me would think that using the ETS is good for me.
	SN2	People who influence my behavior would think that I should use the ETS.
	SN3	In general, my community has supported the use of the ETS
Behavioral intention to use the ETS	BIU1	I plan to use the system in the next 12 months.
	BIU2	I have no plan to use the system in the next 12 months.

2.6. Study Area and Data Collection

The study was conducted in Mulanay, a municipality in the third District of Quezon Province (also known as Bondoc Peninsula). The area is located on the coordinates of 13°31′20′′ longitude and 122°24′15′′ latitude. The municipality is about 279-kilometer south-east of Metro Manila and 142 km away from its provincial capital, Lucena City. Mulanay is divided into 28 barangays. Out of 53,123 people from all the barangays of Mulanay [28], 46% do not have access to basic sanitary facilities.

For this research, two community groups were identified: school and household community groups, representing the perception on public-shared and household-shared ETS, respectively. The respondents representing the household community (59 participants) included leaders or representatives from barangays of Mulanay, Local Government Unit (LGU) leaders, and household representatives from an ETS pilot site in a settlement village. On the other hand, the respondents representing the school community (137 participants) included students and faculty members from an ETS pilot site in an agricultural university. Two ETS units were deployed for each study community.

2.7. Data Analysis

The data collected from the respondents were analyzed using Statistical Package for the Social Sciences (SPSS) ver. 16 (SPSS Inc., Chicago, IL, USA). The steps for data analysis were as follows (see Figure 3):

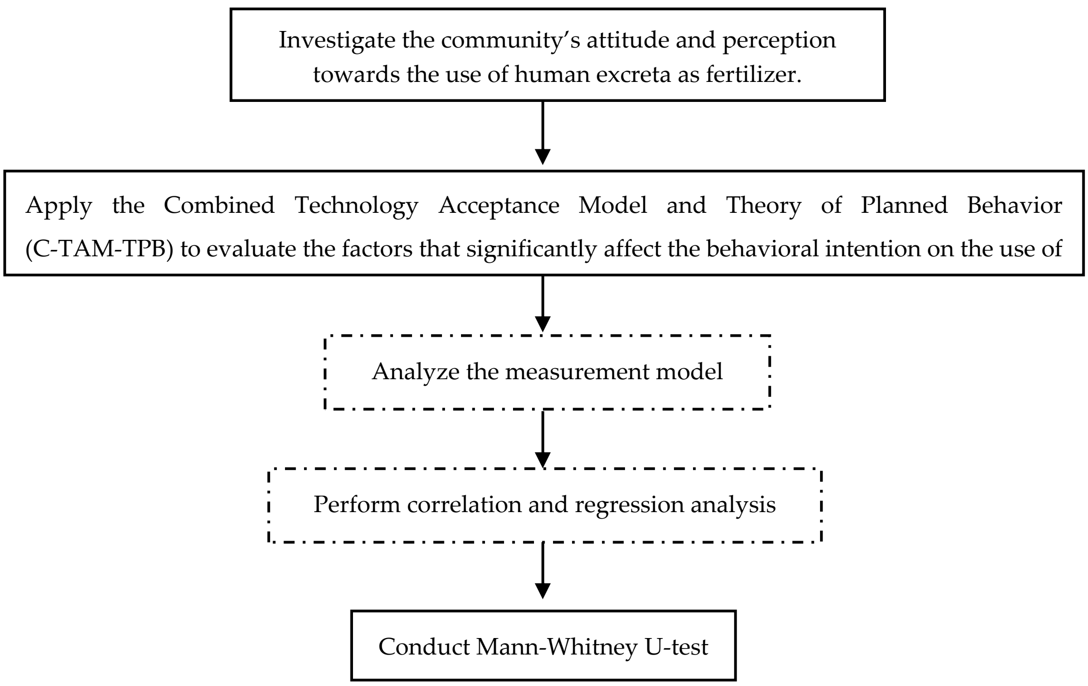

Figure 3. Flowchart of data analysis.

Step 1: Investigate the community's attitude and perception towards the use of human excreta.

The attitude and perception of the Mulanay community towards the use of human excreta were examined using six (6) nominal questions about their awareness of the nutrient value of human excreta, perception of human excreta as safe or unsafe as fertilizer, preference of use of human excreta, and willingness to collect the urine and feces. Descriptive statistics were generated then correlations between nominal data sets were evaluated by Chi-square test.

Step 2: Apply the Combined Technology Acceptance Model and Theory of Planned Behavior (C-TAM-TPB) to evaluate the factors that significantly affect the behavioral intention to the use of the ETS.

Step 2a: Analyze the measurement item

The internal validity and reliability of measurement items of the constructs were analyzed by applying factor loading and Cronbach's alpha reliability test [21]. Cronbach's alpha is mathematically presented in Equation (1), where N is the total number of items, $\bar{c}$ is the average inter-item covariance of the items, and $\bar{v}$ is the average variance. All factors with insignificant factor loading and low Cronbach's α < 0.50) were eliminated.

$$\alpha = \frac{N \cdot \bar{c}}{\bar{v} + (N-1) \cdot \bar{c}} \tag{1}$$

Step 2b: Perform correlation and multiple linear regression analysis

Correlation and multiple linear regression analyses were carried out to elucidate the relationships of the constructs with each other. The correlation analysis was first performed before the regression analysis. In the correlation analysis, the direction and strength of the association of each hypothesized construct to the dependent variable were quantified. Correlation coefficients, denoted by "r," ranged from +1.0 to −1.0. Values of r greater than 0 but less than +1.0 indicate positive linear association while values of r less than 0 but greater than −1.0 indicate negative linear association. On the other hand, r = 0 indicate no linear association with the dependent variable. In the multiple linear regression analysis, hypothesized predictors with significant correlation per dependent variable were investigated. Predictors with p-values higher than the threshold value of 0.05 were considered insignificant. Effects of significant predictors were assessed in terms of computed unstandardized (B) or standardized (β) coefficients. Coefficient of determination, R-squared was computed to quantify the explanatory power of the multiple linear model.

In this study, the C-TAM-TPB model has more than one dependent variable. Therefore, four multiple linear regression analyses were performed to model the following dependent variables: BIU, ATU, PU, and PEU; in terms of their corresponding hypothesized predictors as mathematically presented in Equations (2)–(5), where B_o is the intercept, B_{Hi} is the estimates of the unstandardized coefficients in connection to hypothesis Hi, and e is the random error:

$$BIU = B_{o,BIU} + B_{H1}PU + B_{H2}ATU + B_{H3}PBC + B_{H4}SN + e_{BUI} \tag{2}$$

$$ATU = B_{o,ATU} + B_{H5}PEU + B_{H6}PU + e_{ATU} \tag{3}$$

$$PU = B_{o,PU} + B_{H7}PEU + B_{H8}PC + B_{H9}UD + B_{H10}ANX + e_{PU} \tag{4}$$

$$PEU = B_{o,PEU} + B_{H11}PC + B_{H12}UD + B_{H13}ANX + e_{PEU} \tag{5}$$

Step 3: Mann-Whitney U-Test

The Mann-Whitney U-test was performed to compare rank data between two groups (e.g., the difference of responses to constructs between people who are aware and unaware of the nutrient value of the human excreta).

3. Results and Discussions

3.1. Socio-Demographic Profile of the Respondents

The demographic characteristics of the respondents comprise of gender, age, educational attainment, civil status, years of residency, and number of household members. The demographic profile of the respondents is presented in Figure 4.

Of the 196 respondents who participated in the self-administered survey, only 169 (86.22%) of the returned questionnaires were considered valid for analysis based on the completeness of the information provided. From the valid responses, 59 (38%) were from the household community group and 110 (62%) were from the school community group. There were 100 (59%) female respondents: 64 from the school community group and 36 from the household community group.

The survey respondents mostly belong to the age group of 19–40 years old, college undergraduates, and single because a large proportion of the respondents came from the school community group.

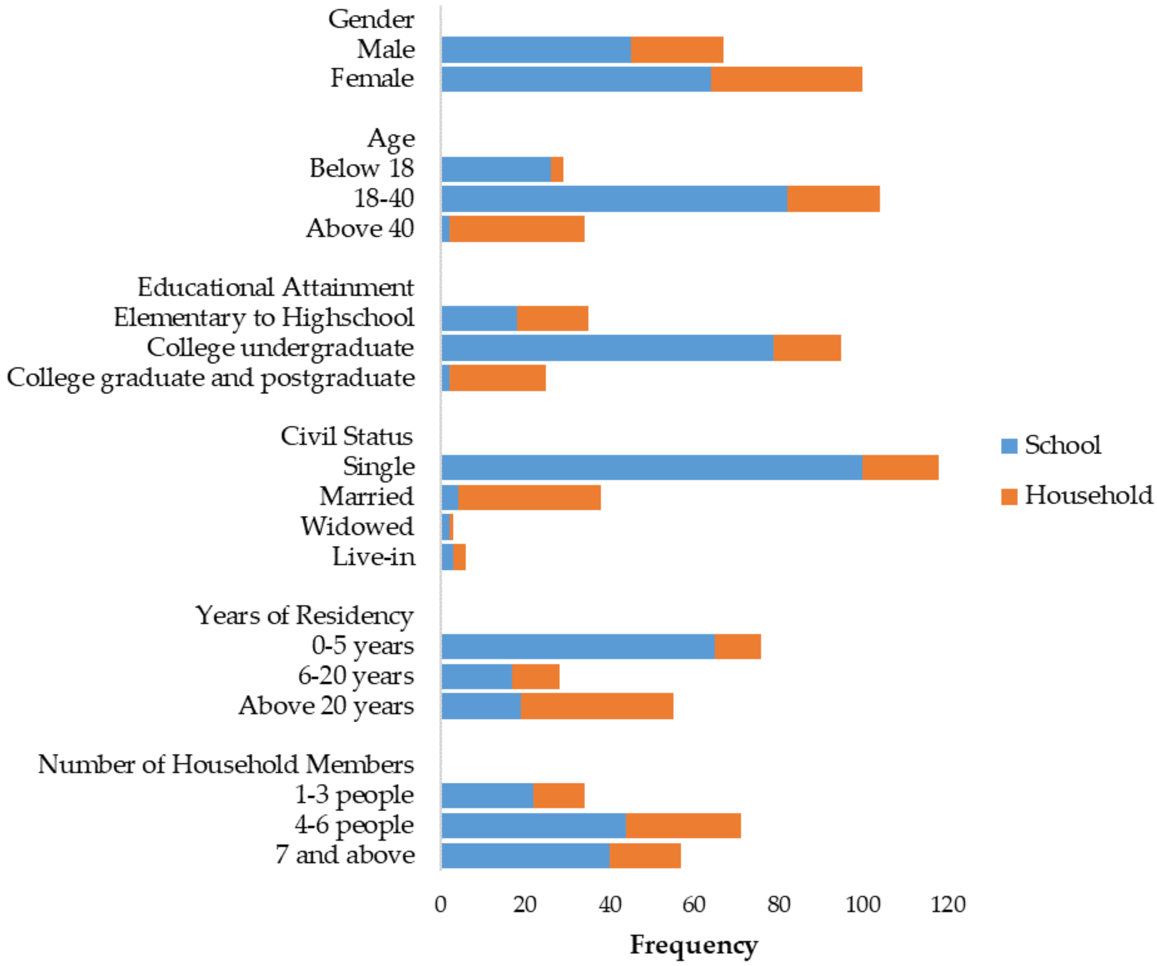

Figure 4. Socio-demographic characteristics of respondents, by community group.

3.2. *Community's Perception and Attitude Towards Using Human Excreta*

Responses to the nominal questions on respondents' awareness of the nutrient value of human excreta, perception of human excreta as safe or unsafe to be used as fertilizer, preference of use of human excreta, and willingness to collect the urine and feces were presented in Table 3. It is interesting to note that slightly more than half of the respondents are aware of the nutrient value of the human excreta (52.40%). Majority of the respondents think that human urine (55.70%) and feces (75.60%) can be converted into safe fertilizer; however, mostly do not agree that the human excreta should be used to fertilize the soil for edible crops (82.60% for urine; 77.70% for feces). Moreover, 57.70% of the respondents are not willing to collect urine and feces. Results of Chi-square test showed that the community's perception and attitude towards using human excreta was not influenced by their community group type.

Table 3. Survey responses to general ETS questions.

Questions	Response	% Frequency			*p*-Value (Chi-Square)
		School	Households	Overall	
Are you aware that your feces and urine have nutrient value?	Yes No	50.00 50.00	56.90 43.10	52.40 47.60	0.40
Do you think urine can be used as a safe fertilizer?	Yes No	50.90 49.10	64.90 35.10	55.70 44.30	0.08
Do you think feces can be used as a safe fertilizer?	Yes No	78.20 21.80	70.70 29.30	75.60 24.40	0.28
Which type of plant do you prefer to use urine as fertilizer?	Edible Non-edible	18.30 81.70	15.50 84.50	17.40 82.60	0.65
Which type of plant do you prefer to use feces as fertilizer?	Edible Non-edible	24.80 75.20	17.50 82.50	22.30 77.70	0.29
Are you willing to collect your urine and feces?	Yes No	40.90 59.10	44.80 55.20	42.30 57.70	0.62

Similar report was observed by Mariwah and Drangert [29] in Ghana. Based on their findings, the community believes that the human excreta contain nutrients that can potentially fertilize the soil for the crops. However, the community shows very low willingness to use any of the human excreta as fertilizers for the crops they eat, neither will they buy food that are grown with human excreta fertilizers. Results revealed that respondents' perception and attitude towards using human excreta is not influenced by their community group type.

Table 4 shows the main factors to be considered by all respondents for installing an ETS at their home/community. These are (1) opportunities for saving water (47%), (2) a shouldered cost of installation of an ETS (31%), and (3) the reuse of the nutrients from human excreta (22%). The results also show that no multiple responses were selected by the respondents. Water scarcity may be the probable reason why water conservation is the topmost priority of the Mulanay community. This is supported by the 2014 RCBMS data of Mulanay, wherein municipality is at risk of safe water supply and, thus, securing water supply is important. Hartley [30] reported a similar finding in United States. The public acceptance on Eco-Toilet is generally high when the water conservation is fronted as a primary benefit.

Table 4. Factors that would encourage users to install an ETS at their home/community.

Factors	Actual Count
Free installation	53
Conserve water	79
Nutrient reuse	37

The data also showed that, though willingness to pay was not particularly measured, the respondents from Mulanay would relatively prefer water conservation over free installation of the ETS. It should also be noted that roughly less than 5% of their income was being used for water expenditure. Willingness to pay for an ETS is moderate although only very few were aware of the ETS, according to the Lamichhane and Babcock [14]. The willingness to install an ETS in their home was agreed by 80% of the respondents provided that the installation would guarantee no cost to the adopters [14]. Furthermore, introducing the concept of recovering nutrients from human excreta for food production remains a challenge. Thus, low prioritization of nutrient reuse is unsurprisingly expected. In a study conducted in the University of Florida, Ishii and Boyer [17] discovered that nutrient reuse is ranked as the least important benefit of the ETS. Low prioritization on nutrient reuse can also be explained by the low willingness to use human excreta fertilizers for edible crops and low willingness on the collection of human excreta, as previously presented in Table 3.

On the other hand, the respondents selected at least one factor that would discourage them to install an ETS in their home/community. The responses were presented in Table 5. Apparently, most respondents included inexperience to the new technology (n = 135) as a factor that would discourage them to adopt the ETS in their community. Perceived complexity (n = 27) and potential high cost (n = 33) of the ETS were the other factors that would discourage the respondents to install the ETS in their homes. Note that the total number of responses is more than 169 due to the multiple responses. For instance, out of 27 respondents who indicated complexity, 16 of these selected the option 'complicated' only, while the remaining 11 selected both 'complicated' and 'expensive'.

Table 5. Factors that would discourage users to install an ETS at their home/community.

Factors	Actual Count
Technology not tested	110
Expensive	13
Technology not tested and expensive	9
Technology not tested, complicated, and expensive	9
Complicated	9
Technology not tested and complicated	7
Complicated and expensive	2

Lack of awareness is an anticipated barrier of the technology transfer of an untested technology such as the ETS [8]. In the Philippines, there are not much well-known success stories of implementation of the ETS in rural areas or even in the urban area. People might misunderstand and not consider to adopt the ETS because the technology is not yet tested in the community. Davies-Colley [10] suggests that the ETS should be promoted through awareness programs to overcome the lack of trust of the community to this newly introduced technology.

3.3. Factor Loading and Cronbach's Alpha Reliability Test

Before the correlation and regression analyses, factor loading analysis and Cronbach's α reliability test were performed to assess the validity and internal consistency of the measurement items of each construct in the model, as found in Table 2. The result of the tests is shown in Table 6. This study followed the threshold value of 0.5 for factor loading which is set by Hair et al. [31]. Thus, an item pertaining to user demand, i.e., UD5 with factor loading of 0.424, was eliminated prior to the correlation and regression analyses. According to Hatcher [32], removing such item prior to the path analysis would eliminate its effect to the overall result. The threshold value, however, may vary on some studies. For instance, Jen et al. [33] suggested that all measurement items on each construct should reflect a reliability scale not lower than 0.60 to ensure that all items subjected to the next part of the analysis are stable. On the other hand, the Chen and Chen [34] adopted 0.35 as suggested by Nunnally [35].

Moreover, based on the Cronbach's α reliability test, most of the constructs show strong reliability with $\alpha > 0.70$. Although the α values of Perceived Behavioral Control and Behavioral Intention to Use are below 0.70, the two constructs are still considered reliable for testing ($\alpha > 0.50$).

Table 6. Factor loading and Cronbach's alpha of the measurement items and constructs.

Constructs	Items	Factor loading	Cronbach alpha (α)
Political climate	PC1 PC2 PC3	0.873 0.923 0.831	0.846
User demand	UD1 UD2 UD3 UD4 UD5	0.785 0.819 0.846 0.771 0.424	0.765
Anxiety	ANX1 ANX2 ANX3 ANX4 ANX5	0.843 0.860 0.873 0.856 0.640	0.874
Perceived ease of use	PEU1 PEU2	0.946 0.946	0.883
Perceived usefulness	PU1 PU2 PU3	0.869 0.935 0.870	0.868
Attitude towards use of the ETS	ATU1 ATU2 ATU3	0.842 0.905 0.813	0.805
Perceived behavioral control	PBC1 PBC2 PBC3	0.756 0.797 0.676	0.593
Subjective norm	SN1 SN2 SN3	0.923 0.947 0.905	0.915
Behavioral intention to use the ETS	BIU1 BIU2	0.865 0.865	0.662

3.4. Correlation and Regression Analyses of the C-TAM-TPB Model

Correlation and regression analyses were conducted to elucidate the relationships of the constructs with each other. In this study, correlation and regression analyses were carried out in series based on the path illustrated in Figure 2. This is mainly because the C-TAM-TPB model involves not only one dependent variable. Aside from BIU, the model also treats Perceived Ease of Use, Perceived Usefulness, and Attitude Towards the Use as dependent variables. Thus, separate tests for each dependent variable are required to completely analyze the C-TAM-TPB.

3.4.1. Result of the Correlation Analysis

The correlation analysis was carried out to evaluate linear relationships between the paired constructs involved in each path. This method determined which of the hypothesized predictors were used in the multiple linear regression. The pairwise correlation coefficients of the construct pairs for this study were presented in Table 7. Evans [36] suggests the following guidelines for absolute value of r: (a) very weak if $0.00 < r \leq 0.019$, (b) weak if $0.20 < r \leq 0.39$, (c) moderate if $0.40 < r \leq 0.59$, (d) strong if $0.60 < r \leq 0.79$ and (e) very strong if $0.80 < r \leq 1.0$.

Table 7. Correlations of the constructs.

	ANX	PC	UD	PEU	PU	ATU	PBC	SN
PEU	0.026 ns	0.407 *	0.568 *					
PU	0.020 ns	0.381 *	0.651 *	0.711 *				
ATU				0.620 *	0.647 *			
BIU					0.293 *	0.429 *	0.143 ns	0.286 *

* Correlation is significant at the 0.05 level; ns Correlation is not significant (p-value > 0.05).

The results show that perception of the people of Mulanay to the usefulness and ease of use of the ETS is not influenced by their level of anxiety. This is indicated by perceived ease of use' and perceived usefulness' corresponding correlation coefficients of r = 0.026 and r = 0.020, respectively. Moreover, perceived behavioral control (r = 0.143) is not correlated with the behavioral intention to use. This means that the Mulanay community does not rely on their own available resources (i.e., money, space, knowledge, lifestyle) to potentially adopt the ETS. However, other studies reported that people are more hesitant towards the ETS when there is insufficient funding and provision of materials for construction of the ETS [13,37].

In summary, the following hypotheses stating anxiety influence ease of use and usefulness perception of respondents (H13 and H10) and perceived behavioral control directly affects the intention to use the ETS (H3) are not supported by the data. Thus, these path components were not used in the multiple linear regression step and the original linear models (Equations (2)–(5)) were modified accordingly.

3.4.2. Result of the Regression Analysis

The result of the regression analysis based on the modified model after correlation analysis is summarized in Table 8. A positive value of B or β indicates that the score of the dependent variable increases as the score of its paired independent variable increases. On the other hand, a negative value indicates inverse relationship between the two variables. Further, the B and β are only useful in explaining the effect of the independent variable to the dependent variable if statistically significant (p-value < 0.010). For the R-squared values greater than 0.67, 0.67 to 0.33, 0.33 to 0.19, and less than 0.19 are considered as a model that has substantial, moderate, weak and undesirable/unacceptable predictive power, respectively [38].

Table 8. Linear regression analysis.

Dependent Variable	Predictor	B	B Std. Error	β	p-value	Adj R^2 (p-Value)
BIU	Constant	1.685	0.348	-	-	0.169 (<0.010)
	PU	0.037	0.107	0.035	0.727	
	ATU	0.420	0.103	0.420	0.000	
	SN	0.022 (-)	0.109	0.021 (-)	0.839	
ATU	Constant	0.871	0.267	-	-	0.464 (<0.010)
	PEU	0.324	0.081	0.323	0.000	
	PU	0.444	0.086	0.417	0.000	
PU	Constant	0.735	0.248	-	-	0.590 (<0.010)
	PC	0.033 (-)	0.057	0.035 (-)	0.561	
	UD	0.422	0.074	0.383	0.000	
	PEU	0.478	0.058	0.506	0.000	
PEU	Constant	1.144	0.324	-	-	0.333 (<0.010)
	PC	0.135	0.076	0.133	0.080	
	UD	0.586	0.088	0.501	0.000	

Behavioral Intention to Use

The correlation analysis rejected the influence of PBC to BIU. For this multiple linear regression analysis, only perceived usefulness, attitude towards use, and subjective norms were investigated as predictors of BIU. These predictors were capable of predicting about 16.9% of the variance of BIU. Results showed that PU (β = 0.035, *p*-value = 0.727) and SN (β = −0.021, *p*-value = 0.839) failed to be statistically significant predictors of BIU. The community believes that their intention to use the ETS is not directly influenced by the usefulness of the technology (H1) or by their normative beliefs (H4). The behavior of the rural community is directly influenced by their attitude (β = 0.420, *p*-value < 0.010). This implies that the community would have higher intention on using the ETS when the community's attitude becomes more positive. Therefore, this model supports H2.

In the study of Van Gelder [39], the respondents believe that attitude of the people is a very important deciding factor in using ecological sanitation technologies. The community believed that keeping the right attitude in using the ETS would increase the human capacity and public awareness in solving the sanitation problem in the community.

Attitude Towards Use

As previously discussed, the ATU was concluded as a significant predictor of BIU. In this section, the predictors of ATU (PEU and PU) were investigated. The findings in this section support H5 and H6, which assume that PEU and PU directly affect ATU respectively. PEU (β = 0.323, *p*-value < 0.01) and PU (β = 0.417, *p*-value < 0.01) were able to explain the 46.4% of the variance (adjusted R^2 = 0.464) in the ATU of the ETS. These predictors also have positive and significant relationship with ATU. This means that, when the respondents from Mulanay recognize that the ETS is becoming more adaptable and useful, their attitude becomes more positive towards using the ETS. The result is consistent with other a previous study that utilized C-TAM-TPB. Chen et al. [34] explained that the users can improve their attitude towards the use of the new technology without exerting too much effort while fulfilling their service needs.

Perceived Usefulness

The ETS is believed to enhance sanitation [9]. The PU is to what extent the users believe that the ETS would improve the sanitation. In the previous multiple linear regression models, PU was found to be a not significant determinant of BIU, however it showed indirect effect to BIU through the mediation of ATU. PU, in this model, is hypothetically influenced by PEU, UD and PC. The regression analysis revealed that PEU (β = 0.506, *p*-value < 0.010) and UD (β = 0.383, *p*-value < 0.010) were significant predictors of PU. The result of this path analysis supports the H9 and H7, which suggest that UD and PEU have direct effect to the PU of the ETS. The people of Mulanay would consider the ETS to be more useful when they feel that they are more in need of sanitation solutions. In addition, the community would be more convinced that the ETS is a useful tool in improving sanitation in Mulanay if the system is more convenient to use and easy to understand. The significant relationship between PEU and PU is validated by the study of Chen et al. [25] in predicting the adoption of an electronic toll collection system.

Perceived Ease of Use

Perceived ease of use signifies that the system is considered effortless to use and learn [25] by the community. The predictors of PEU (political climate and user demand) were able to elucidate the 31.8% of the variation of PEU. It was found out that, in this multiple linear regression model, that only UD (β = 0.365, *p*-value < 0.010) can significantly predict the PEU of the ETS. Thus, H12 is accepted. The community perceives that it would be easier for them to understand and use the ETS if their demand on sanitation solutions becomes higher.

The ETS is not just a sanitation technology that needs to be introduced to communities, it is also a new philosophy of water conservation, food production, and environmental protection [5]. Raising the awareness on the need for sanitation may create a trend on the behavior of the communities towards the adoption of a sanitation solution [40]. Beliefs on the ease of use and usefulness of the ETS are higher as the demand on sanitation becomes higher. Therefore, activities like campaigns to raise awareness on sanitation may be beneficial to create bigger demand on sustainable sanitation solutions.

3.5. Acceptability and Willingness to Use the ETS, and Awareness on Its Benefits

The Mann-Whitney U-test was conducted to examine if there are significant differences in perceptions between (1) those who are aware and unaware of the nutrient value of excreta, (2) those who think or do not think that urine can be a safe fertilizer, (3) those who think or do not think that feces can be a safe fertilizer, and (4) those who are and not willing to collect their urine and feces.

The results of the Mann-Whitney U-test (in Table 9) show that those respondents who are aware of the benefits of the human excreta have more positive attitude and higher behavioral intention to use the ETS. The test also shows that they are more affected by their subjective norms.

Table 9. The difference of responses to the constructs between people who are aware and unaware of the nutrient value of the human excreta.

Construct	Are You Aware That Your Feces and Urine Have Nutrient Value?				*p*-value of Mann-Whitney Test
	Yes		No		
	Mean Rank	Median	Mean Rank	Median	
ANX	77.02	3.00	90.63	3.20	0.066
PC	89.67	4.00	75.74	4.00	0.056
UD	87.97	4.00	78.58	4.00	0.206
PEU	89.00	4.00	77.44	4.00	0.107
PU	87.62	4.33	78.96	4.00	0.232
ATU	92.95	4.00	72.16	3.67	0.005*
PBC	80.02	3.67	80.01	3.67	0.321
SN	92.79	4.00	73.27	4.00	0.007 *
BIU	92.13	3.50	73.06	3.00	0.008*

* Significant at 0.05 level.

In the result shown in Table 10, the differences of the responses were not statistically different between those who believe and do not believe urine can be used as a safe fertilizer. However, the responses on UD questions were significantly different between those who believe and do not believe feces can be used as a safe fertilizer (Table 11). Those who believe that feces can be used as safe fertilizer have higher demands of sanitation solution. Roma et al. [41] believed that raising the awareness on nutrient value of human urine and feces would promote the acceptance of the ETS.

Table 12 shows the comparison of responses in terms respondents willingness to utilize human feces and urine as fertilizer. All constructs, except anxiety, were scored higher by the respondents who are in favor of human excreta as fertilizer. The results highlighted that respondents from Mulanay have generally positive attitude toward the ETS however they are not willing to participate in excreta collection. Furthermore, anxiety to the ETS is not influenced by willingness.

Table 10. The difference of responses to the constructs between people who believe urine can be used as safe fertilizer.

Construct	Do You Think Urine Can Be Used as a Safe Fertilizer?				p-value of Mann-Whitney Test
	Yes		No		
	Mean Rank	Median	Mean Rank	Median	
ANX	83.54	3.20	84.58	3.00	0.889
PC	83.91	4.00	82.98	4.00	0.900
UD	86.51	4.00	80.84	4.00	0.449
PEU	88.08	4.00	78.87	4.00	0.202
PU	87.47	4.33	79.64	4.00	0.284
ATU	89.70	4.00	75.60	4.00	0.056
PBC	83.61	3.67	84.49	3.67	0.905
SN	88.81	4.00	77.95	4.00	0.134
BIU	86.15	3.50	80.13	3.50	0.407

Table 11. The difference of responses to the constructs between people who believed feces can be used as a safe fertilizer.

Construct	Do You Think Feces Can Be Used as a Safe Fertilizer?				p-value of Mann-Whitney Test
	Yes		No		
	Mean Rank	Median	Mean Rank	Median	
ANX	83.41	3.00	87.87	3.00	0.607
PC	86.12	4.00	77.49	4.00	0.311
UD	89.37	4.00	69.40	3.80	0.021*
PEU	87.66	4.00	74.72	4.00	0.123
PU	87.22	4.33	76.07	4.00	0.188
ATU	85.26	4.00	80.13	4.00	0.549
PBC	85.96	3.67	79.98	3.67	0.488
SN	88.46	4.00	72.24	4.00	0.054
BIU	84.40	3.50	82.76	3.50	0.844

* Significant at 0.05 level.

Table 12. The difference of responses to the constructs between the people who are willing to collect urine and feces.

Construct	Are you willing to collect your urine and feces?				p-value of Mann-Whitney Test
	Yes		No		
	Mean Rank	Median	Mean Rank	Median	
ANX	86.65	3.00	81.56	3.00	0.499
PC	75.17	4.00	95.94	4.00	0.005*
UD	68.59	4.00	106.24	3.80	0.000*
PEU	72.84	4.00	100.44	4.00	0.000*
PU	68.88	4.33	105.84	4.00	0.000*
ATU	67.22	4.00	106.68	3.67	0.000*
PBC	75.21	3.67	97.19	3.67	0.003*
SN	71.70	4.00	101.99	4.00	0.000*
BIU	77.32	3.50	93.04	3.00	0.032*

* Significant at 0.05 level.

The explanation to the results depicted in Tables 9–12 is related to the discussion in Section 3.2, which elucidated the community awareness on nutrient value and the unwillingness to use human excreta to fertilize the soil for edible crops.

Although the benefits of the ETS are mostly agreed by the people, shifting to ecological sanitation paradigm remains a long process. One of the major causes that slow the transition process is related to the management of the excreta. The taboo associated with the handling of human urine and feces most likely caused the unwillingness of the community to collect source separated excreta [42].

4. Conclusions

This work provides an elucidation on the factors that affect the perceptions and attitudes of the rural community towards the eco-toilet system (ETS) using Mulanay, Quezon as the study area in the Philippines. The combined Technology Acceptance Model—Theory of Planned Behavior (C-TAM-TPB) provides a useful tool in defining and explaining the significant predictors of community behavior towards adoption of new technology, particularly the eco-toilet. The findings reveal that attitude is the main driver of behavioral intention to use the ETS, which could be enhanced by promoting the ease of use and usefulness of the ETS. Creating demand on sanitation in rural areas also influences the perception of the users towards the use of technology. In addition, the ETS is most appealing to the people of Mulanay if the water conservation benefit will be guaranteed. Moreover, although the people believe that urine and feces can be converted to safe fertilizers, the collection of human excreta and nutrient reuse for food production are the least priorities in Mulanay.

Potential users of the ETS who are knowledgeable of the nutrient value of human excreta and are willing to collect them tend to have more positive attitudes toward the ETS. Such findings provide valuable insights to policy makers and researchers in achieving SDG 6 and promoting sustainable development of the ETS in villages or rural areas. This work thus serves as a baseline and impetus for future studies on sustainability of the ETS in the Philippines. Model validation and testing on other study areas in the Philippines will be investigated in future work.

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