Journal of Infrastructure, Policy and Development 2025, 9(2), 8396.
https://doi.org/10.24294/jipd8396

Article

Achieving sustainable development goals through ecological sanitation in the Philippines

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CITATION

Cruz GRC. (2025). Achieving sustainable development goals through ecological sanitation in the Philippines. Journal of Infrastructure, Policy and Development. 9(2): 8396. https://doi.org/10.24294/jipd8396

ARTICLE INFO

Received: 5 August 2024
Accepted: 26 August 2024
Available online: 6 February 2025

Abstract: This study aims to assess the current state of toilet use in the Philippines as well as present the perspectives of ecological sanitation as a viable alternative to the use of conventional toilet in addressing the issue of environmental sustainability to contribute to the achievement of Sustainable Development Goal 6: Water and Sanitation for all by 2030. Four identified ecological sanitation projects were pilot tested in certain localities in the Philippines such as the Tingloy Island in Batangas City, the City of San Fernando, La Union, in Cagayan De Oro, Misamis Oriental, and in Mulanay, Quezon Province. The findings of the feasibility study showed that people would be willing out to try a new technology like the ecosan toilet if the perceive benefit like solutions to lack of water supply and improve agricultural productions dispels community hesitations. Moreover, this study concludes that ecological sanitation aligns with environmental sustainability objectives. It manages to address the urgent need for effective sanitation solutions in the face of rapid development and consumption.

Keywords: ecological sanitation; sustainable development; wastewater management; urban development; closing the loop

1. Introduction

Humanity's unending desires and ambitions have driven it to seek the highest possible quality of life, often pushing beyond its natural limits. Luxury and comfort have become universal aspirations, with the improvement of lifestyle becoming the central goal for many. This focus has led to rapid and unprecedented development, accompanied by globalization, urbanization, and technological advancements. However, the relentless production and consumption of goods intended to enhance life have also generated significant waste, threatening the very ideals of progress. This waste poses serious environmental damage, highlighting a critical tension between the pursuit of development and the need for effective environmental protection. Thus, addressing this conflict requires sustainable and viable solutions.

Hence for nations situated near the Pacific ring of fire like the Philippines, threats of natural disasters and calamities like typhoons, flash floods, landslides, earthquakes, volcanic eruptions further aggravate the situation. Once such catastrophe struck, common scenario results to displacement of communities either temporary to evacuation centers or permanently to other government housing facilities.

One mitigation measure that can be explored is the principle of Ecological Sanitation[1] (EcoSan), an alternative holistic approach for ecological and economical sustainable sanitation. It is based on the principle of maximum possible re-use of nutrients from human excreta. It focuses on preventing pollution by sanitizing human excreta and reusing urine and feces as resources for agriculture reuse (Andersson et al., 2016; Esrey et al., 2001; Winblad et al., 2004).

This concept of sustainable sanitation has been adapted already in numerous places who experience issues on sanitation due to improper disposal of human waste brought by the lack of efficient water supply and access to sanitized toilets. Nevertheless, the absence of water supply and toilet facilities have been attributed to the rise of common social problems and illness which includes hunger, thirst, and unrest to name a few.

According to the data provided by the UNICEF and the World Health Organization (2015),

> "Around 1.1 billion people globally do not have access to improved water supply sources and 2.4 billion people do not have access to any type of improved sanitation [toilet] facility. While 70% of those lived in rural areas."

In the Philippines, survey results of the Social Weather Station in December 2019 revealed that 10% of households in the country do not have access to private toilets in which 6% of these have access to shared toilets with other households. However, 4% had no toilet access at all. Furthermore, the Department of Health reported that 50.3 million Filipinos or 10 million families have no access to safely managed sanitation services.

In addition, Kolesinskas (2016) provided that human excreta collected from toilets are usually simply piped into movies bodies of water that also serves as source of fresh water, with an annual estimate of 2000 million tons of untreated human waste. Such situation poses potential health risks associated with bacteria, parasites, and viral infection caused by diarrhea, malnutrition, and death. In addition, Werner et al. (2009), Kolesinskas (2016) estimated that 90% of the world's wastewater includes human excreta, industrial waste, and urban detritus are either discharged directly to freshwater sources or is unsatisfactorily purified. Relatively, the WHO (2003) estimates that 2 million people die every year due to diarrheal diseases. Such situation calls for a more sustainable way of life.

There has been a global paradigm shift in sanitation from primarily focusing on health issues to emphasizing the reduction of environmental impact, underscoring the need to care for and protect the environment. This shift is central to Sustainable Development discipline and has become a major concern for both Global North and Global South nations alike (Langergraber and Muellegger, 2005).

2. Materials and methods

Through descriptive analysis, this study aims to assess the current state of toilet use in the Philippines as well as present the perspectives of ecological sanitation as a viable alternative to the use of conventional toilet in addressing the issue of environmental sustainability to contribute to the achievement of Sustainable Development Goal 6: Water and Sanitation for all by 2030. Generally, this study answers the question, "How can ecological sanitation contribute to the achievement of SDG 6 that promotes water and sanitation for all?" Specifically, the study through a descriptive qualitative case analysis of four identified ecological sanitation projects demonstrates the potentials and the dilemma on the use of ecological sanitation. This study likewise aspires to contribute to the limited literature of the practice of ecological sanitation in the Philippines.

However, case selection was limited by data availability and the minimal number of local governments in the Philippines that adapted the practice of ecological sanitation, thus only the following cases were utilized in the study.

A. Municipality of Tingloy Island, Batangas
B. City of San Fernando in La Union
C. Cagayan de Oro, Misamis Oriental
D. Mulanay, Quezon Province

This study embarks on David's Theory of Acceptance Model in presenting how can ecosan toilets replicate and improve the utilities provided by the conventional toilet facility. The study works on the premise that the community and its people are hesitant to adopt the toilet designed after the ecosan model due to numerous psychological factors that includes: 1) resistance to change due to fear of the unknown; 2) perceived complex nature of ecosan; and 3) perceived hygiene issues and concerns.

The Theory of Acceptance Model prescribes, acceptance of new technology is greatly affected by two factors namely: 1) perceived usefulness or the degree to which a person believes that using a particular system would enhance one's performance; and 2) perceived ease-of-ease or the degree to which a person believes that using a particular system would be free from effort (Davis, 1989; Ignacio et al., 2018).

As such, this study demonstrates that ecosan toilet can be considered as a viable alternative to the conventional toilet, with benefits reaped leading to a cycle of sustainable development.

3. Case study results

At present, ecological sanitation projects were already pilot tested in certain localities in the Philippines such as the City of San Fernando, La Union; in Panglao Island in Bohol Province; in the Balit Infirmary Hospital at Agusan Del Sur; the Province of Oriental Negros; and in Cagayan De Oro. The Cagayan De Oro project uses the collected human waste from the ecological sanitation toilets for its demo-farm. In the metropolis, an ecological sanitation toilet has been installed in Quezon City in 2006 as a promotional and educational example that ecological sanitation is also feasible in the metropolis. **Table 1** summarizes the findings.

Table 1. Case study summary.

Project Area	Implementation Date	Actors Involved	Significant Impressions
Tingloy Island, Batangas	2002	Project WASTE Center for Advance Philippines Studies Philippine Center for Water and Sanitation—International Training Network Foundation	Community prefers the conventional toilet Mainly due to the foul odor generated by the feces after the use fails to cover it with ashes and the poor ventilation design of the toilet
San Fernando, La Union	2004	Project WASTE San Fernando Local Government Institute for the Development of Educational and Ecological Alternatives, Inc.	Limited awareness of other means of human waste disposal Limited knowledge that the commonly used pour-flush toilet design pollutes ground water The toilet design that uses a urine diverting bowl and a separate wash bowl was able to demonstrate the simplicity of the use of ecosan toilets Ecosan toilets have been widely used in public areas and public schools in the province

Cagayan de Oro, Misamis Oriental	2004	College of Agriculture of Xavier University	Food insecurity motivated the community to find alternative modes of sustainable farming Farmers are very supportive of ecological sanitation as it was able to increase their yield There are hesitations on the part of consumers to support agricultural products for consumption that utilized the principle of ecological sanitation
Mulanay, Quezon Province	2018	USAID Local Government Unit of Mulanay Polytechnic University of the Philippines (PUP) Mulanay Campus	The findings of the feasibility study showed that people would be willing out to try a new technology like the ecosan toilet if the perceive benefit like solutions to lack of water supply and improve agricultural productions dispels community hesitations.

A. Tingloy Island, Batangas

One of the earliest recorded manifestations of ecological sanitation in the Philippines transpired in 2002 at the Municipality of Tingloy Island, Batangas. It was a project under the global Urban Waste Management Expertise Program (UWEP) coordinated by the Dutch-based non-governmental organization WASTE and was facilitated by the Center for Advance Philippines Studies (CAPS)[2] as their counter-part representative for the project in the country in coordination with the Philippine Center for Water and Sanitation—International Training Network Foundation (PCWS-ITNF).

The first phase of the project was comprised of three dry-urine diversion toilets for three selected families. On the second phase, two of the toilets were then converted to pour-flush toilets in order to monitor community preference between the dry-urine toilet and the pour/flush-and-discharge toilets. Findings suggest that the community prefers the latter to the former which was attributed to the lack of educational and promotional campaign regarding the importance and benefits that the ecosanitation toilet could provide. Apparently, the identified problem was the strong foul odor generated by the failure of users to put ashes after defecating and the poor ventilation design of the structure Moreover, manifested poor participatory governance as the community felt alienated with the project, the community was not properly informed and consulted about the objectives and end-benefits of the project. More than that, the structure was constructed hastily without supervision such that the appropriate design was not consulted with the end-users as well as the area and overall landscape of where the ecological sanitation will be constructed (Fruh, 2003).

B. City of San Fernando in La Union

The case of San Fernando, La Union was facilitated largely by a Dutch-NGO, the WASTE: Advisers on Urban Environment and Development, in coordination with its local counterpart the Center for Advance Philippine Studies. In 2004, San Fernando, La Union led by its mayor, Mary Jane Ortega, embarked on a sanitation program comprised of the distribution of the traditional pour-flush toilets to poor households who cannot afford to have their own toilet facilities. Around that time, according to the City's Minimum Basic Needs Survey, the city had approximately 400 families without access to toilets.

Furthermore, the City is also experiencing water supply problems which are essential for the City's sanitation campaign; thus ecosanitation toilets which are not dependent on water for flushing became a feasible option.

Under the program specially drafted for the local government of San Fernando, La Union, there will be two pilot barangays[3], one urban and the other is a rural in order to cover broader perspective. Barangay San Agustin represents the former, while Barangay Nagyubuyuban represents the latter.

Prior to the formal launch of the project, an ISWM assessment of the City's sanitation was conducted. The assessment determined all the stakeholders involved, as well as the possible networks that can be sourced out. The assessment also documented the conditions of water supply, ground and surface water pollution, waste treatment facility, and the existing solid waste management system.

The findings of the assessment concludes that the state of ground water in the City no longer qualifies as potable, 56 of 59 water wells were positive for fecal contamination. The pollution was largely attributed to poor sanitation practices such as defective septic tanks drainage system.

To further strengthen the baseline of the programme, the Institute for the Development of Educational and Ecological Alternatives, Inc. (IDEAS) initiated a survey regarding the sanitation knowledge, behavior and practices of the residents.

Their findings concluded that although the residents are aware of the implications of sanitation and hygiene, their idea is limited to collect-and-throw or the disposal paradigm where in recycling has been discredited. The dominant perception of waste management is throwing away garbage correctly, thus reflects the human solid waste management amounts to flushing down the drain.

Furthermore, only few were aware that pour-flush toilets or de-buhos toilets can pollute ground water. 90 percent of the respondents were users of water or "washers" in maintaining their personal hygiene and sanitation. 51 percent of those utilize deep wells for their water source due to poor and limited water supply in the area.

This event triggered an alarm for the City to adopt necessary reforms that suggest a change of their way of life. Primarily, this has been the foremost concern of the facilitators of the programme, they knew that the citizens are already used to the conventional way of pour-flush toilet. It is for a fact that forcing the people to set aside their way of life will not be as easy as it seems. What the local government did was to make the most of the opportunity by using the households that were beneficiaries of the government's sanitation program as the catalyst for social transformation.

Initially, two ecosanitation toilets were constructed in two households in each of the two pilot barangays. The toilets were designed like the traditional ones that cater to both the male and female gender. Within three months time, the first feasible sign of the program begun to materialize, it was the dispel of the common conception that a toilet that doesn't make use of water for flushing and instead use ash for covering feces produces foul smell. It was also able to demonstrate the simplicity of the toilet and dismiss the idea of complexity due to the use of a urine diverting bowl and a separate wash bowl.

Furthermore, it brought out curiosity of the community regarding the wonders of the ecosanitation toilet. The pioneers of the programme were testament to that. In fact they were able to use their urine under the guidance of the facilitators, as organic fertilizers for their backyard plants and vegetables. This served as the tipping point for the programme that made it very appealing to other residents and communities.

The benefits that can be reaped from the ecosanitation toilets made the residents participative and appreciative of ecosanitation that paved the way for the promotion of sustainable development in the City. At present, there are already approximately 1,000 fully operational ecosanitation toilets distributed throughout the city. There are already ecosanitation toilets placed in public schools and other public areas in addition to the grants given to individual households.

C. Cagayan de Oro, Misamis Oriental

The city of Cagayan de Oro in Misamis Oriental in Mindanao is a rapidly growing urban community that faces the usual dilemma of food security. In 1997, the Periurban Vegetable Project (PUVeP), a community-based self-sustaining garden was initiated by the College of Agriculture of Xavier University, which was later on endorsed to the Research and Social Outreach Cluster in 2008.

The Cagayan De Oro project uses the collected human waste from the ecological sanitation toilets for its demo-farm. The success of the self-sustaining, community-based allotment gardens greatly received support from the community as it immediately developed into ten gardens in 2008 within five years. It is estimated that about 100 families were able to benefit from a stable food production and legal access to farmlands.

Aside from crops and other plantation, each garden is also comprised of compost heap where biodegradable wastes from the different nearby households are stored and converted to organic fertilizers. Nevertheless, a urine diversion dehydration (UDD) toilet was also installed in each garden in 2004, which in turn converts the collected urine as organic fertilizers. It was found that the application of urine as fertilizers increase the marketable yield of sweet corn by 14%. Such success triggered the interest of non-food crops commercial growers in the city which witnessed an increased flowering of different commercial ornamental plants.

Moreover, the benefits offered by UDD toilets were further expanded to nearby areas as 30 UDDs were subsequently established in other areas of the province of Misamis Oriental, Lanao del Norte and Zamboanga. Mostly were constructed in public school area were there is high people volume but lacks proper sanitation facility due to lack of access to water. Additionally, 15 UDDS were established in rural communities in Northern Bukidnon (Holmer et al., 2009).

However, post-project analysis showed 90% approval rate from farmers and gardeners while recording only 60% approval rate from consumers who are willing to buy crops and vegetables fertilized with urine and feces. An area that can be address by an intensive information campaign (Holmer et al., 20009).

D. Mulanay, Quezon Province

The municipality of Mulanay is part of the 3rd district of Quezon Province composed of 28 barangays with an estimated population size of 54,000, of which 46% do not have access to basic sanitary facilities and 83% are considered at risk because of lack of access to clean water (Ignacio et al., 2018).

As part of initial consultations and research in the process of initiating an ecological sanitation facility in the area, the community was surveyed regarding their knowledge about the use of urine and feces as forms of organic fertilizer. The level of interest and preference about ecological sanitation was also measured through the use of a self-administered questionnaire following the principles of Technology

Acceptance Model and Theory of Planned Behavior. On one hand, the Technology Acceptance Model assumes that technology adoption is directly influenced by the user's perceived usefulness and perceived ease of use of the newly introduced technology. On the other hand, the Theory of Planned Behavior explains that a user's acceptability of adapting new technology is affected by prevailing social influences or subjective norms which generates a perceived power to motivate the user (Davis, 1989; Ignacio, 2018).

With a retrieval rate of 86.22%, the results yield that 52.40 % are aware of the nutrient value of human excreta. Specifically, 55.70% believes that human urine can be converted into fertilizers while 75.60% believes that feces can be used as fertilizer as well. Nevertheless, overwhelming majority do not support the idea of using human excreta as fertilizer for the soil used for edible crops, 82.60% for urine while 77.70% percent for feces in particular. Moreover, 55.70% do not totally agree on the collection of urine and feces (Ignacio, 2018).

The findings of the study reveal that communities are willing to adopt a new technology or system if the perceive benefit is of much importance to them such as water conservation and if the new technology was proven to not make their previous comfortable way of life difficult such as the process involved in the collection of urine and feces. Aside to the four pilot-areas mentioned, attempts of ecological sanitation were manifested as well in Panglao Island in Bohol Province; in the Balit Infirmary Hospital at Agusan Del Sur; and in the Province of Oriental Negros. In the metropolis, an ecological sanitation toilet has been installed in Quezon City in 2006 as a promotional and educational example that ecological sanitation is also feasible in the metropolis.

4. Discussion

4.1. Ecological sanitation

Many people tend to frown when they hear the idea of ecological sanitation. Some sees it as a foreign concept, while others perceive it as a platonic idea of sustainability anchored on improved human waste disposal by recycling it at source and converting its nutrients to reap its potential economic value, hence closing the loop.

The concept of ecological sanitation pertains to an alternative approach to conventional wastewater treatment systems where in urine and feces are no longer treated as waste but as valuable resources towards an ecological and economical wastewater management. It is not a form of technology per se instead it is a philosophy or way of life that espouses for a sustainable sanitation system with an ecosystem and resource management perspective Furthermore, it is conceived as a holistic approach that will address the unsanitary conditions of both growing urban and thriving rural poor population. Its benefits include "reduction of health risks related to sanitation, and contaminated wastewater; prevention of pollution of surface and groundwater; prevention of soil fertility degradation; and optimization of water resources nutrients management (Werner et al., 2004)".

For Langergraber and Muellegger (2005), they view ecological sanitation not just as a poor people solution but also as a global panacea for different specific local

situation as it can reduce environmental damage of urban landscape and improve general living conditions. Fruh (2003) likewise suggested that ecological sanitation not only provides a sustainable process of returning the soil's nutrients, but it is also a more practical and cheaper method as it does away with sewer pipes, underground septic vaults, and sewage treatment plants.

Conversely, ecological sanitation adheres to the philosophy of closing the loop. Its central tenets lie on the idea that plant nutrients can be greatly found in the human excreta (Werner et al., 2009). Generally, ecological sanitation covers four forms of wastewater: 1) Yellow water, or urine; 2) Brown water, or feces; 3) Gray water, or wastewater obtained from showering, bathing, cleaning, or washing; and 4) Black water or wastewater from toilets with mixture of urine and feces.

On one hand, urine has nitrogen, phosphorus, potassium, and sulfur that are considered as ideal forms of uptake by plants; nitrogen provides urea, phosphorus for source of superphosphate, and potassium as an ion source (Esrey et al., 1998). The practice of using urine as a form of fertilizer has been tested already to improve yields in crop production as compared to the use of chemical fertilizer (Johansson et al., 2001; Kirchmann and Pettersson, 1995; Richert et al., 2012; Simons and Clemens, 2004). On the other hand, human feces consist of undigested organic matter such as fibers which makes it a valuable soil conditioner (Winblad et al., 2004).

Under the ecological sanitation process, human excreta are processed on-site to lessen the possibilities of bacteria expansion, and if necessary to be further processed off-site until they are completely free of disease organisms. Thus, the nutrients that were extracted from the excreta are to be recycled as organic fertilizers for agricultural farming (Winblad et al., 2004).

The recycling process for urine requires minimal activity and chemical reaction. Accordingly, urine is considered as the perfect nutrient solution for it contains high volume of nitrogen, phosphorus and potassium which are considered essential nutrients for plants. When urine is collected for fertilizer use, it is important for the urine to be stored in a proper container to prevent foul odors and loss of nitrogen to the air. Therefore, it is suggested for urine to be separated from feces at source to reduce foul odor, less exposure to pathogens, and facilitate lesser process and treatment in drying of feces for easy handling. In addition to that, separation minimizes the run-off of microorganisms and nutrients to soil, ground water, and surface waters for hygienic purposes and reduction of negative environmental impact (Käymäläseura Huussiry, 2017).

Moreover, the best way to preserve the nutrients of urine is to store it in a covered container with restricted ventilation. If the urine is to be applied on an open soil, dilution is no longer necessary but if to be used directly on plants it must be diluted first about one part of urine to 2–5 parts of water to prevent scorching (Esrey et al., 1998; Winblad et al., 2004). Nevertheless, Langergrabber and Muellegger (2005) suggested that for hygienic purposes incorporation of urine to the ground is highly recommended for crops in which edible parts are growing above the soil surface but for crops growing under the surface they recommended not to incorporate the urine to the ground but instead use it as pre-planting fertilizer. Likewise, they recommended for a one-month gap between fertilizing and harvesting or consuming in ensuring that pathogens[4] are already inactive.

For the case of the feces, Esrey et al. (2001) recommend a high pH, a long storage time and high temperatures are critical components in pathogen deactivation. Pathogens present in the feces need to be deactivated first which can be done in two ways, either by dehydration or decomposition. Under the dehydration process, pathogen destruction is resembled once feces were not able to gain contact to any forms of liquid such that the presence of low moisture, low amount of organic matter and nutrients, and high pH level lead to faster pathogen die-off rate (Esrey et al., 1998). For the decomposition process, it requires the feces to be stored first in a secured device for a period of six to 12 months at 18–32 degrees Centigrade or for a shorter period at a higher temperature until it is safe for recycling (Winblad et al., 2004). Furthermore, there are various environmental conditions can help increase the die-off rate of pathogens as shown in **Figure 1.**

Environmental factors	How
temperature	increase in temperatures
moisture	decrease in moisture
nutrients (organic matter)	decrease in nutrients
microorganisms (including other pathogens)	decrease in organisms
sunlight	increase in sunlight
pH	increase in pH

Figure 1. Environmental conditions that can increase die-off rate of Pathogens (Esrey et al., 2001).

Once pathogens are destroyed it is now called Biosolids[5] ready to serve as organic fertilizers that can be applied directly to the soil to enhance organic matter content, improve water holding capacity, and increase availability of nutrients (Esrey et al., 1998).

Nevertheless, the acceptance of the ecosan principle for some communities have been met with hesitations mainly due to socio-cultural barriers such as religion, ethics, and sanitation (Andersson, 2015; Nawab et al., 2006; Simha et al., 2017).

4.2. Conventional and ecological sanitation wastewater treatment systems

Apparently, there are three commonly utilized toilet system today as discussed by Tilley et al. (2014); 1) latrine, 2) septic and 3) sewer system. Firstly, the latrine system involves the collection of urine and feces in vault or pit beneath a toilet that time-to-time needs to remove and treated off-site or sent to a landfill. In some instances, this is also called drop-and-store type toilet or pit toilet, the most common form of toilet in rural areas that are based on containment and indefinite storage of human excreta (Winblad et al., 2004). However, such system does not involve flushing or water conveyance that raises the concern of possible leaking into surrounding soil and groundwater system Secondly, the septic system is the traditional flush-and-discharge type toilet where excreta are stored in a septic tank which is designed to prevent solids from leaching thus requires to be desludged (Fruh, 2003). Nevertheless, if improperly maintained may result to groundwater pollution. Such system is commonly present in developing countries like the Philippines. Lastly, the sewer system involves a flush

system as well that sends the excreta to a series of pipes or channels that are connected to a centralized treatment facility. Such system is commonly used in affluent countries that can accommodate a centralized treatment facility such as the one utilized in the United States (Kolesinskas, 2016). However, Kolesinskas (2016) argued that the three toilet systems "view excreta as a waste product produced by humans and disposed of in a linear fashion thus the nutrients held by the excreta are not collected and utilized in any productive function but are instead disposed of as they are diluted with clean water".

Moreover, the two predominant conventional wastewater systems present in the Philippines are the "flush-and-discharge" and "drop-and-store" system. Claudia Fruh (2003) highlighted the disadvantages of the two given conventional systems. Accordingly, a flush-and-discharge system which is commonly applied in urban areas advocates misuse and waste of drinking water for sewerage transport. Furthermore, it requires high monetary and energy investment for its operation and maintenance cost. Also, it exemplifies unsatisfactory treatment of uncontrolled discharge of more than 90% of wastewater which leads to water pollution and environment contamination, thus threatens water resources and public health.

Drop-and-store system on the other hand which is usually applied in rural areas offers no permanent solution to wastewater treatment system for once the pit latrine is full a new one needs to be built. This limits the system to areas with sufficient space and appropriate soil conditions since pit latrines cannot be constructed in rocky grounds. Furthermore, pit latrines possess high probability of soil and groundwater contamination especially if constructed in an area where systems of drinking water well lie. The system is also criticized for bad odors, outdoor installation of the toilet and flies breeding which makes it inconvenient and a non-attractive system. Furthermore, both systems said to provide loss of valuable nutrients and trace elements contained in human excreta with resultant loss of soil fertility and agricultural productivity (Fruh, 2003).

The ecological sanitation toilet is usually made of ceramic urine diverting toilet and a washbowl to cater to individuals who are not used to not washing and anal cleansing after usage of toilets. These urine-diverting (UD) toilets has two holes, a small one located in front for urinating and a rear hole which is used for defecating as shown in **Figure 2**. The idea is that once seated, the urine will directly flow to the front hole while the feces will fall to the rear hole for easy separation which matters greatly for easy processing and composting.

Figure 2. Urine diversion bowl toilets with separate wash bowl. Courtesy of the center for advance Philippine studies.

For defecation purposes, instead of pouring or flushing in of water, an absorbent such as ash, lime or similar additives needs to be placed to avoid foul smell and flies (Jönsson et al., 2004). For individuals who are used to washing and anal cleansing after defecating, they must transfer to the washbowl situated just at the side of the UD bowl so that fecal contact with liquids can be avoided.

Accordingly, the most efficient method of pathogen destruction is the dry method or dehydration where in the combination of low moisture, low amount of organic matter/nutrients and high pH hasten up the die-off rate of the pathogens. Moreover, wastewater contributes to pathogen survival for it is rich in organic matter and nutrients, moist and anaerobic capacities (Winblad et al., 2004).

Jerome and Ignacio (2006) provided a comparative benefit-cost and cost-effective analysis of the conventional wastewater systems (non-ecological sanitation) and ecological sanitation systems. He provided four typology of wastewater systems: two for each kind of system. On one hand, the conventional, he made use of flush-and-discharge and drop-and-store system; on the other hand, the ecosanitation, he made use of a toilet made from light materials (ecosan 1), and a toilet made from concrete materials (ecosan 2). Ecosan 1 costs approximately at P 22,000, while Ecosan 2 costs vary around P 44,000. Ecosan toilet made of light materials have a service life of up to 10 years, while the toilets made of concrete materials has a service life of more than 20 years.

Accordingly, the drop-and-store type is the cheapest to construct while the flush-and-discharge is the most expensive. The study showed that both ecosanitation toilets are far more competitive than the other two, cost-effectiveness analysis suggests that ecosanitation toilets are more effective in contributing to social equity and sustainability by registering high on all criteria except for the simplicity factor (Ignacio, 2006).

In addressing the simplicity factor for the ecological sanitation toilets which resembles resistance to change, Schurniga (2000) discussed the importance of public

awareness raising and community mobilization. Accordingly, the most effective method of carrying out awareness campaign and community mobilization are participatory approaches that are based on interaction of people, providing information, and making the community a significant part of the intervention project. The said approach stimulates people to think their own priorities against sanitation issues and help them decide on their own a selection of technologies based on what they need and can afford. The set-up will address resistance on the part of the community, creating a sense of belongingness and personal attachment to the project.

Regardless of the simplicity in the usage of the flush-and-discharge toilets, the risk that lies behind this simplicity are potential health hazards of unsanitary wastes ending up in wetlands or other bigger bodies of water which forms part of the production cycle of water as a commodity. Numerous pathogens are found in the human excreta which if not properly sanitized would lead to diseases. In a 2005 UN report, it showed that 25 Filipinos die every day from diarrhea caused by poor water sanitation, making it the second biggest killer of children. Accordingly, a child dies globally from water-related illness every 21 seconds mostly due to water contamination by fecal matter. UNICEF reports that it takes only two to three people openly defecating to contaminate 30 to 50 sitios (Tacio, 2015).

More than that, cost-benefit analyses would show that laying out of extensive network of sewerage in addition to the cost of the water used in flushing and discharging would incur high capital cost, not to mention the reservations against the use of freshwater resources for flushing. For the case of the urban areas, septic tanks have provided a great advent for sanitation which partly addressed the concerns regarding sewerage failure. However, these septic tanks require to be dredged periodically so as not to produce further health hazard. The problem is that, more often if not, dredging is done only once or twice a year. Furthermore, dredging only extracts portion of the wastes stored in the tank while many of it flows freely to the drainage system which again mixes up with bodies of water. Also, these unsanitary water gains contact with the surroundings thus implicating possible health hazards.

Nevertheless, Langergraber and Muellegger (2005) said that rationality alone might prove to be difficult in convincing the community to accept the use of ecological sanitation wholeheartedly, such that the change should make sure that emotions and values were given consideration. One problem commonly identified during transition phases is the reluctance of men to sit down in urinating to ensure that urine will go directly to the urine diversion box. Nevertheless, such issue can be addressed using a separate waterless urinal.

Recent studies and research also identified alternatives to ecological sanitation toilet that promotes the same principle. Dr. Rafael Guerrero III from the National Academy of Science and Technology advocated a ‘vermicompost toilet’ as an alternative citing its simplicity and cheaper cost as its advantage over the ecosan toilets. The vermicompost toilet follows a three-opening commode patterned after designs in India. It has a platform made of coconut lumber and bamboo slats with three openings: the front one for urine, the middle one for feces, and the one behind for washing. It utilizes vermicompost, comprised of worms (Earthworm or African Night crawler) that will facilitate the transformation of organic waste into vermicompost or vermicast fertilizers, instead of wood ash for covering the feces and installation costs can be as

low as Php 1000 using sack cloth for sidings and plastic containers for storage of compost and feces making it portable in moving from one place to another (Tacio, 2015). For the urban roamer, vermicompost starter kits are now readily available on the market[6].

Furthermore, Nicolo Del Castillo (2006) proposes the adoption of an ecological house in the Philippines called "Urban Bahay Kubo" as shown in **Figure 3**. Such house incorporates efficient use of space, climatic design, low-energy materials, renewable energy systems and an edible garden supported by an ecological sanitation toilet in an urban.

Figure 3. Ecological sanitation toilet in an urban setting. Courtesy of the center for advance Philippine studies.

The feasibility of vermicompost toilet and ecological house can be further studied. On one hand, adoption of ecological sanitation concepts in rural setting do not impose much economic, scientific, and technical challenges where space availability is not an issue, except for cultural and values concern. On the other hand, portability is an option in the urban setting where available space is inadequate. Likewise, the ecological sanitation concept can be applied in the construction and development of resettlement areas where livelihood problems and access to clean water and proper sanitation are the foremost issues. Furthermore, ecological sanitation toilets have replaced the 'flying toilets', or defecating in a plastic grocery bag in Uganda that can be replicated in the Philippine as well. If such ecological sanitation concepts can be instilled to the community, it will result to a greener and sustainable society.

5. Conclusion

Global climate change triggered the alarm for everyone to be wary and sensitive enough to its surroundings or else face its peril consequences, or even destruction. Everyone has joined the bandwagon in adopting sustainable development to mitigate the impacts of global climate change. For the Philippines, there is so much to be facilitated to adhere to the international campaign of sustainable development. One aspect that needs imperative action is waste management.

As established from the four case studies presented, this study was able to demonstrate the feasibility for ecosan toilet to be considered as a viable alternative to the conventional toilet. Despite of the conceptual failure of the ecosan project in the Tingloy Island in Batangas, the opposite was witnessed in successful attempt of the City of San Fernando in Pampanga and Cagayan de Oro in Misamis Oriental. However, the case of Mulanay in Quezon Province was able to establish the gap between the failed and successful attempts of ecological sanitation. It was found out that the people of Mulanay were hesitant to try the ecosan toilet because they do not agree on the collection of urine and feces for recycling as it is perceived as a human waste. Moreover, the findings of the case study presented that while majority agrees with the use of urine for fertilizer, an overwhelming majority have hesitations on the use of feces for fertilizers on edible crops.

With such results, these findings of this study suggest that the community has hesitations on the use ecosan toilets mainly due to the lack of concrete information on its safety, sanitation, and perceived utility value. But if the perceived value and benefit that can be reaped from the use of ecosan toilet can be demonstrated, there is great possibility for the community to successful adopt and switch to the use of ecosan toilet. Hence, this study recommends technical research on coming up with improved ecosan toilet designs to make it appealing and pleasing. Further studies can be commissioned to improve the design of the ecological sanitation toilets, to make it more palatable to both urban and rural communities. In the study of Dickin et al. (2018), one design concern that was identified is about menstrual hygiene management of female users. The users had concerns about the size design of the wash basin is too small which makes it difficult for the female users to use particularly during their menstruation periods.

There have been numerous documented cases of local governments and communities adopting the practice of ecological sanitation but has receive little support from the national government and other stakeholders. More so, the proposed Ecological Sanitation Bill in 2007 (H.B. No. 3279) that pushes further the advocacy of ecological sanitation as a method of sustainable urban development program in the country has been constantly ignored.

Although transition and conversion to complete ecological sanitation toilet is not yet recommended, as health issues might be present considering the ratio of feces storage and biosolid production, the use of ecological sanitation principle is perceived as an alternative to conventional toilet practice. This is the area which this study recommends further studies, focusing on the efficient collection of nutrients from feces and urine and converting it to effective soil and plant fertilizers. Moreover, research on intensive agricultural training in the adoption of human waste reuse can be conducted to promote safe and efficient reuse of the recycled waste material, particularly on the proper collection of the urine and feces and its storage to ensure the most efficient utilization.

Also, the feasibility of where ecosan toilets can be commercially used such as cruise ships, passenger ships, airplanes, etc. where access to clean water is limited can be conducted to make it commercially viable.

Nevertheless, in institutionalizing the practice of ecological sanitation, the Philippines can not only do its share in minimizing its wastewater and promote

recycling at source at the same time; moreover, it creates a revenue generation opportunity making it very practical and sustainable for the community thus contributing to the regeneration of both micro and macro economy. In a study conducted by the faculty members from the Ateneo de Manila University, Philippines, the agriculture industry is seen as the next bright spot second to the food manufacturing industry, but unlike the latter, the agriculture industry compels the greatest no. of employment across all sectors with a low infection risk. Furthermore, the study recommends the increase in the scale of household-based intensive farming system to facilitate a transition from subsistence farming to surplus agriculture farming (Aldaba et al., 2020).

In conclusion, this study demonstrated the ecological sanitation can bridge the gap between meeting sanitation needs and food security contribution thus fulfilling the promise of closing the loop.

Conflict of interest: The authors declare no conflict of interest.

Notes

[1] The concept of ecological sanitation gained popularity in the advent of the housing crisis of 2008 that compelled communities in major parts of America to downsize their lifestyle in order to make ends meet. The housing crisis that led to the Financial Crisis of 2008 prompted many to rethink their large mortgages, thus resulting to growth of the tiny house community which later on evolved to a global movement practiced in both developed and less developed nations such as Japan, Germany, Australia, New Zealand, Spain and even the United Kingdom. Though families have different reasons for embracing the tiny house philosophy from minimizing expenses to exploring freedom of space to reducing carbon footprint by minimizing unnecessary wastes, one key feature of tiny house living is having an ecological sanitation toilet for it requires less space and allows for greater mobility in cases of portable tiny house that can easily be driven away in times of relocation. The minimal, if not totally lack of access to a sewer or septic system is what usually discourages the use of the regular flush toilets in most tiny houses such that the usual common option is the use of a human waste composting toilet. Thus the success of the tiny house movement in developed counties paved the way for development of ecological sanitation movement mostly in developing nations where rural areas were mostly composed of little tiny houses.

[2] The Center for Advance Philippine Studies (CAPS), a non-stock, non-profit research and development foundation has been at the forefront of the Ecological Sanitation campaign in the Philippines.

[3] Barangays are the smallest political unit in the Philippines.

[4] Pathogens are organisms that can cause diseases. Some of them are parasites which live at the expense of their prey. Pathogens can be found in urine can cause typhoid, paratyphoid, and bilharzia while pathogens present in feces can cause various illness but not limited to diarrhea, malnutrition, iron deficiency, and vitamin A deficiency (Esrey et al., 1998).

[5] Biosolids are defined by the US Environmental Protection Agency as nutrient-rich organic materials resulting from the treatment of domestic sewerage in treatment facility (US EPA, 1994 in Kolesinskas, 2016).

[6] Urban Vermicomposting is at the forefront of introducing vermicomposting to the urban setting. They offer starter kits from basic to simple and powerful categories with price range from Php 895–Php 2495. Additional information can be obtained at https://www.urbanvermicomposting.com/.

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