User Experience and Drivers for Adoption of Ecological Sanitation Toilets in Kisoro and Kabale, Uganda

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Preface

I first developed a fascination with sanitation and Ecological Sanitation during my internship at BRAC Uganda in the summer of 2009, and decided to pursue the Ecological Sanitation piece further for my Masters Thesis. I would like to extend the greatest thanks to Elisabeth von Muench and the German Technical Cooperation (GTZ), and Jo Smet and the International Water and Sanitation Resource Centre (IRC) for providing financial support for data collection in Uganda, and offering their valuable advice and expertise during this project. I could not have properly prepared for my field work without the help of Charles and Victoria Niwagaba, and am equally grateful to Mercy Ahimbisibwe for all the hard work accompanying me in the field. I would also like to thank Karsten Gjefle for providing me with project design input and background knowledge, and the local Ecosan program staff in Kabale, Kisoro, and Mbarara for sharing their expertise. Lastly, I would like to thank Professors Richard Cash, John Briscoe, and Gunther Fink for their guidance during the various phases of my thesis design and writing process.

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Abstract

The objective of this thesis is to develop a more detailed case study about past programs in Ecological Sanitation (Ecosan) in Uganda than is currently available in the literature. Poor sanitation is a problem still rampant in Uganda, contributing to high infectious disease prevalence and as a result, high infant mortality rates. Ecological Sanitation (Ecosan), treats excreta and eliminates pathogens on site through a decomposition process, and the decomposed product, rich in nutrients, can be incorporated back into the environment as fertilizer. Ecosan has been implemented in developing countries around the world as a way to provide improved sanitation while protecting environmental health and conserving water. The largest Ecosan projects in Uganda were started in Kisoro and Kabale districts over ten years ago, but thus far the technology still accounts for a negligible proportion of latrine usage in Uganda and has encountered limited spontaneous adoption.

To develop these case studies, qualitative research was conducted on household Ecosan usage and perceptions in Kabale and Kisoro, Uganda. Fifty-seven households, including current Ecosan users, former Ecosan users, and those who had never used Ecosan were interviewed. Results showed that for both locations, permanence of Ecosan, eliminating the need to save money and land for future latrines, was the strongest driving factor behind adopting this technology. However, in Kisoro, subsidies to initiate construction and local government assistance was also cited by several as a dominant reason for building, which may be correlated to the increased level of abandonment and partially built Ecosan structures.

Only three out of the 36 homes with Ecosan interviewed had low-cost models, all located in Kabale, despite the significantly cheaper costs. Excreta reuse was either being already being practiced or in future plans for 74% and 80% of Ecosan users in Kabale and Kisoro, respectively, higher than reported in previous literature. Recommendations for next steps include intensive research into actual measured impacts of Ecosan implementation on health outcomes, economic benefits, and environmental protection among different populations, focusing on promoting low-cost versions of Ecosan where there is demand, and increasing excreta reuse to maximize gains from investing in Ecosan.

I. INTRODUCTION

During June to August 2009, I designed and conducted an analysis on the current state of sanitation in Uganda for the NGO BRAC Uganda to inform the design of a new Water, Sanitation, and Hygiene program. The research consisted of a literature review into various aspects of sanitation in Uganda, conversations with leaders and key players in sanitation work, and field research at five BRAC branches across the countries to learn from communities about sanitation needs. During the project, I was introduced to the concept of Ecological Sanitation, and was intrigued by this system that appeared to be a possible solution to some of Uganda's sanitation challenges.

The aim of this paper is to introduce the concept of Ecological Sanitation (Ecosan), discuss its presence in Uganda, and to provide a case study of two larger-scale Ecosan projects in Uganda to offer insight into current gaps in knowledge. The first portion of the paper will cover background information on the link between sanitation and public health, sanitation in Uganda, and Ecosan and its history in the two locations of interest. The background information was gathered through a literature review, past field work in Uganda, and from expert interviews. The next section will provide an overview of the field work I conducted in Uganda and methods, followed by a presentation of field work results. Finally, I will offer further discussion of research results and recommendations and how it relates to the overall field of sanitation and public health in general.

II. BACKGROUND

Sanitation and Health

"Improved sanitation", as defined by the WHO, is having a facility that "ensures hygienic separation of human excreta from human contact."[1] It is estimated that 2.5 billion people in the world, 38% of the world's population, still do not have access to improved sanitation. The lowest sanitation coverage is in Sub-Saharan Africa, where only 31% of the population is estimated to have improved sanitation.[1] Proper sanitation not only facilitates improvements to human health, but also greatly impacts the environment, safety and security, and one's sense of dignity.

Insufficient management and storage of human excreta lead to increased risk of infection from bacteria, viruses, and parasites that are found in fecal matter. Diarrheal disease, which causes about 1.8 million deaths annually, mostly among children under five, is primarily spread through food and water contamination, often the result of poor sanitation and hygiene.[2] Lack of improved sanitation also contributes to parasitic infections such as schistosomiasis, affecting about 160 million people, and intestinal worms, which infect about one in ten people in developing countries.[2] Thus, improved sanitation and safe water supplies, which are closely linked, have the potential to prevent millions of deaths and cases of disease. In particular, they are integral to reducing child mortality and impaired childhood development.

Due to the difficulty of isolating causal effects of sanitation, which has many indirect effects and works in tandem with other factors such as water and hygiene, there have been limited comprehensive studies on the particular effects on health of sanitation alone. Esrey et. al. in 1991 conducted a review of existing studies examining the impact of improved water supply and sanitation facilities on a variety of widespread infectious diseases. Using data from five out of 18

studies on sanitation that were considered "rigorous", the authors estimated that the expected reduction in diarrheal disease morbidity from sanitation improvements alone was 36%.[3]

A more recent meta-analysis, published in 2005, found only two studies with usable data on sanitation, the pooled results from which suggested a 32% decreased risk of illness due to sanitation interventions.[4] Analysis of merged DHS data across 70 low- and middle-income countries also found a protective effect, albeit smaller, of improved sanitation against diarrhea, with an odds ratio of 0.87-0.92 for improved sanitation.[5] The available data clearly suggests that increasing access to improved sanitation has the potential to improve health outcomes significantly. Low income countries such as Uganda, where infectious disease such as diarrhea are prevalent and child mortality rates are still high, would be expected to benefit most from improved sanitation.

Uganda Background

The Republic of Uganda, located in East Africa, is a landlocked country bordering Kenya, Tanzania, Rwanda, the Democratic Republic of Congo, and Sudan. Its area is over 240,000 square kilometers and is currently divided into 80 districts. At the time of the last census in 2002, the population of Uganda totaled about 30 million – a fivefold increase since 1948. The total fertility rate is 6.7 births per woman, one of the highest in sub-Saharan Africa and the world.[6] Its population is very ethnically diverse, with Baganda being the largest ethnic group, comprising about 18 percent of the population.[7] More than 85% of the population lives in rural areas, and its economy is mainly agricultural, with most people depending on subsistence farming and an agriculture-based industry.[6] Uganda has the potential for rapid economic growth, with its significant natural resources, fertile soil, and regular rainfall, but continuous political instability and corruption has kept Uganda among the world's poorest countries.[7]

Uganda's current mortality and health status indicators demonstrate an urgent need for even the most basic of health interventions and infrastructure. Life expectancy is estimated at only 49 years old, largely impacted by the HIV/AIDS epidemic, which is the leading cause of overall deaths in the country.[8] Under-five mortality is reported as 138 per 1000 live births, but reaches as high as 192 among those in the lowest wealth quintiles.[8] Diarrheal diseases are the fourth most common cause of death in children under five, accounting for 17% of deaths (not including neonatal deaths due to diarrhea), in part due to poor sanitation and hygiene. The most recent DHS survey reports that on average, 26% of children under five in Uganda had diarrhea in the two-week period prior to the survey.[9]

Sanitation in Uganda

Literature Review

In the 1960s, Uganda had the highest sanitation coverage in Africa, with over 90% of households owning a private latrine.[6] While it is unclear whether this measurement of sanitation coverage is the same as those used today, it is apparent that after decades of conflict and dictatorship, the state of sanitation has declined considerably. Because there is no universal definition of "improved sanitation", different sources provide varying estimates on sanitation coverage in Uganda. A WHO/UNICEF joint report estimated that 33% of the population had improved sanitation facilities, which were defined as flush, pour-flush, VIP, composting toilets, or pit latrines with a slab.[1]

Overall latrine coverage (improved and not improved) at the household level in 2007 was around 59%, and 13% of the population is still believed to be practicing open defecation, considered to be one of the riskiest sanitation practices.[1,10] Many households that do not have a private latrine share a latrine with other households or use a neighbor's latrine. These coverage estimates fall around the average range for Sub-Saharan Africa, which is estimated to have a regional improved sanitation coverage of 31% and total sanitation coverage of about 60%.[1,11]

The most rigorous and detailed investigation into sanitation usage in Uganda encountered during the literature review was a local study published in 2003, consisting of interviews with almost 200 households across the country.[12] The author found that income and education were statistically significant predictors of the type of sanitation facility being used, and qualitative research also suggested that culture and traditional beliefs play a large role.[12] Of Uganda's many diverse cultural groups, some hold traditional beliefs about the use of toilet facilities and disposal of excreta that are strong determinants of sanitation choice. For example, the Nuwagaba writes that the Karimojong culture does not allow the use of toilet facilities in or near a household, socializing people instead to dispose of excreta in the bush.[12]

DHS Analysis

Because most of the country-specific data on sanitation is limited to overall latrine coverage or latrine ownership trends, I undertook analysis in STATA with the 2006 DHS data from Uganda to investigate the situation further. The sanitation-related questions asked in the DHS include the type of toilet (or lack thereof) used by the household, household water source, whether the toilet is shared with other households, method of disposing of children's stool, and prevalence of children's diarrhea in the past two weeks. The distribution of the type of toilet facility used by the household is shown in Table 1. Consistent with existing reports, various types of pit latrines (uncovered/covered, slab/no slab) are by far the most common, used by 80% of the surveyed population. Unfortunately, almost 16% reported using the bush, the equivalent to open defecation. The remaining 4 percent of respondents were using flush toilets, Ventilated Improved Pit latrines (VIP), or composting toilets, all considered "improved" facilities. Using the WHO/UNICEF definition of "improved sanitation", the DHS data results show that less than 20 percent of the population has access to improved sanitation.

Table 1. Type of Toilet Facility

Facility Type	Frequency	Percentage
Flush toilet	44	0.6
VIP latrine	208	2.84
Covered pit latrine, no slab	3,433	46.84
Covered pit latrine, with slab	1,150	15.69
Uncovered pit latrine, no slab	1,165	15.90
Uncovered pit latrine, with slab	128	1.75
Bush	1,165	15.90
Composting toilet	36	0.49

The results show that over 48% of those surveyed were sharing toilet facilities with others not in their household, often tenants under the same landlord. This is a condition that was the primary complaint of participants in my field work on sanitation in five districts of Uganda in July 2009.

The problem this creates is that no one household feels ownership over the toilet facilities, and thus nobody took responsibility for cleaning and maintaining them, creating an environment especially conducive to spreading disease. Some respondents also discussed community practices of child stool disposal, which ranged from use of potties indoors to laying out newspaper for children to defecate on, disposing of the stool in latrines or drains. The results of DHS findings on this aspect are presented in Table 2. Almost 33% of respondents report not disposing of stool in toilets or latrines, opting for drains, ditches, garbage, in the bush or ground, or just leaving it in the open. All of these methods are serious public health threats, as they do not effectively separate excreta from human contact or entering water sources.

Table 2. Disposal of Youngest Child's Stool

Disposal Method	Frequency	Percentage
Always use toilet/latrine	626	8.84
Put/rinsed in toilet/latrine	4,128	58.32
Put/rinsed into drain/ditch	516	7.29
Throw in garbage	514	7.26
Buried	493	6.97
Throw into bush	251	3.55
Left in open/not disposed of	550	7.77

I hypothesized that type of toilet facility, sharing toilets, and disposal methods of child stool could all be possible predictors of diarrhea prevalence. To analyze the relationship between sanitation facilities and health, I divided the variable for toilet type into three general groups: “high” – flush toilets, “low” – use of the bush/open defecation, and “middle” – which were all other toilet facilities. I also divided stool disposal methods into three groups: “high safety” – always using toilet/latrine, “average safety” – putting/rinsing stool into latrine, as there are some risks involved depending on the handling of the stool, and “unsafe” – all other methods of disposal. Water was also grouped into three levels: “high” – piped water sources, “middle” – protected public sources, and “low” – unprotected sources.

Table 3 shows the associations between children having diarrhea in the past two weeks and possible predictors of having diarrhea. Logistic regression was used, with diarrhea being the dependent variable and infrastructure and behavioral variables as the predictors. Coefficients shown are odds ratios, and the first column shows odds ratios for the simple, unadjusted model. For the unadjusted models, high quality water supply and safe disposal of child stool were found to be significant ($p<0.05$) predictors of decreased diarrhea, and sharing toilets was found to be a significant predictor of increased diarrhea. Even in the simple model, higher levels of sanitation were not significantly associated with less risk of diarrhea, although high quality sanitation is almost significant ($p=0.056$).

However, once the models were adjusted for possible confounders: mother’s education, wealth, child age, and de facto place of residence, only sharing toilets was found to be a significant predictor of diarrhea incidence in the past two weeks. The data suggest that children in households sharing toilets have a 32.5% greater chance of suffering from diarrhea. Regression analysis also found that significant predictors of having higher quality sanitation were wealth

(p<0.001) and years of education (p<0.001), consistent with conclusions from prior literature on predictors of sanitation choice.

Table 3. Sanitation Predictors and Diarrhea Risk

Predictor Variable	Diarrhea in past 2 weeks	
	Unadjusted model	Adjusted model
Middle sanitation	0.885	1.048
	(0.104)	(0.753)
High sanitation	0.425	1.153
	(0.056)	(0.837)
Middle water	1.112	1.132
	(0.210)	(0.390)
High water	0.753	1.323
	(0.019)*	(0.224)
Average safety stool disposal	0.941	1.358
	(0.310)	(0.183)
High safety stool disposal	0.555	1.353
	(<0.001)*	(0.164)
Sharing toilets	1.320*	1.325*
	(<0.001)	(0.001)

coefficients are odds ratios associated with the "less sanitary" aspects of each variable
**Significant at the 0.05 level*

Despite the fact that quality of sanitation was not found to be predictive of diarrhea risk when using Uganda-specific DHS data, the several studies cited earlier that are far more rigorous have found a significant relationship, and DHS data aggregated across many countries also show a strong relationship.[3-5] These disparate findings warrant a closer look at other data from Uganda to assess further the link between health and sanitation, but do not weaken the argument for improved sanitation in Uganda. Even if in Uganda's case sanitation alone does not predict diarrhea risk, sanitation in combination with other factors may significantly impact health. These interaction effects, not taken into account in this analysis, should be assessed in a more detailed epidemiological analysis. Additionally, prevalence of open defecation and rates of disposal of child stool into open spaces such as drains or the bush – known health risks, are arguments in and of themselves of the need for improved sanitation.

Ecological Sanitation

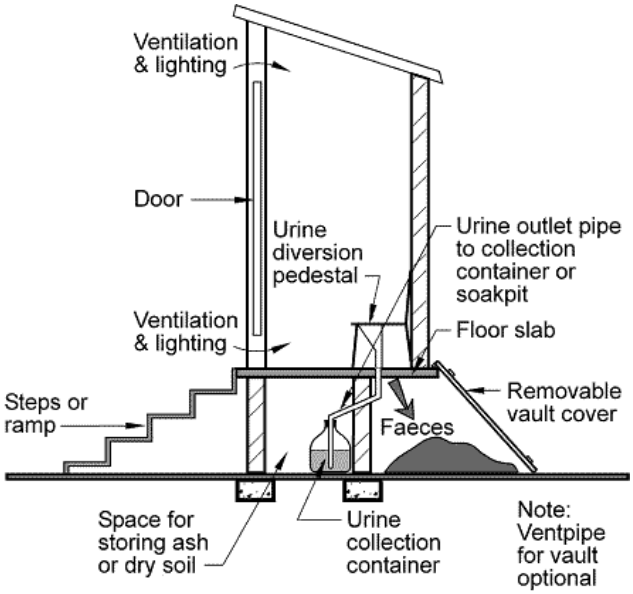
Promoting increased usage of traditional forms of sanitation is one approach to improving sanitation and hygiene, but alternative and innovative technologies have also become an option, especially in areas with geologic barriers to digging pit latrines. One such system, Ecological Sanitation (Ecosan) is based on the idea that human excreta is part of an ecological loop, and can be reconverted back into resources.[13] It is different from flush systems which require water and a sewage treatment system, and is also different from pit latrines because the pit is either above-ground or shallow and waste can be removed and reused. According to Stephen Esrey, with traditional sanitation technologies, "nearly all sewage in developing countries is discharged into

receiving bodies of water with no treatment. Pit latrines can also leach nutrients and pathogens into ground water and disperse into the environment during floods."[14] Pathogens that enter into water bodies have been shown to survive longer than on land, and pose a threat to the environment, organisms living in the water, and humans who consume, bathe in, or use the water for other purposes.[13]

Ecosan offers the potential to protect public health and prevent pollution of water sources by separating it from groundwater sources and treating pathogens on site. Excreta is mixed with ash in the toilet chamber and undergoes a decomposition process that treats pathogens, leaving a dry and odorless manure that can be applied in agriculture. Human urine and feces is rich in phosphorous, nitrogen, and potassium, which are valuable nutrients for soil and plants, and the Ecosan system incorporates these nutrients back into the environment.

One of the most common types of Ecosan toilets implemented in developing countries is the Urine Diversion Dehydration Toilet (UDDT), which is often referred to colloquially as the "Ecosan toilet" in Uganda. For the purposes of this paper, I will use "UDDT" when discussing only UDDT toilets, and "Ecosan", when discussing the use of potentially more than one kind of Ecosan toilet. The general structure of a UDDT is provided in Figure 1. UDDTs are usually built much closer to the house, often only a few feet away, because smell is much less of an issue. In this two-chambered structure, one chamber is used at a time, and urine is diverted into a separate storage, while feces are contained in the chamber to maintain dryness and facilitate the decomposition process. Ash is added after each use to promote further decomposition and drying, and when one chamber is full, it is closed and the second one is opened for use. When the first chamber has fully decomposed (around 3-6 months), it can be emptied and the dry manure can be used as fertilizer. High cost of building these structures and complexity of use have been cited as barriers to widespread usage of UDDTs.

Figure 1. UDDT diagram



Source: www.training.gpa.unep.org

Other Ecosan toilet designs include one commonly referred to as the composing toilet, which has a similar two-chamber structure as the UDDT, but feces and urine are combined in the same chamber. This requires the addition of further organic material such as soil or additional ash, and often takes longer to decompose. The Fossa Alterna also consists of two pits, but instead of being raised chambers, they are shallow pits dug in the ground, used in an alternating fashion such as the UDDT. The Arboloo is the most low-cost option, where one temporary shallow pit is used until full, at which point a new pit is dug and the manure can be left to compost or a tree can be planted directly in the manure. Additional images and photos describing the Ecosan system and structures is included in the "Additional Ecosan Information" section of the Appendix.

Ecosan in Uganda

The existing literature and research available on Ecosan use in Uganda is limited, with very few dedicated to detailed case studies of the experience over time of using UDDTs and other Ecosan technologies. Nuwagaba's 2003 study did have valuable information on Ecosan usage and excreta reuse from 81 households with Ecosan across the country, and found the main reason for choosing Ecosan were: durability/permanence, terrain issues, space limitations, and convenience.[12] The findings showed that the majority of users built the toilets primarily as a sanitation facility and not for agricultural purposes, and that very few were using the manure in agriculture.[12]

As discussed earlier, pit latrines have been and are currently the overwhelming dominant form of sanitation in Uganda. In areas with extensive land and little danger of pathogens leaching into groundwater or surface water sources, pit latrines are often affordable and appropriate if maintained and cleaned properly. However, Uganda's diverse geology means that some regions suffer from geologic difficulties in constructing traditional pit latrines. Kabale and Kisoro districts in the Southwest of Uganda, are two such regions.

Kisoro

Kisoro district is located on the most southwestern part of Uganda, bordering Rwanda. It is mountainous, and its geology is characterized by loose soil and stones in some places and hard rock in others. Loose soil leads to latrine sinking and collapsing, while digging pits in areas where the ground is hard rock is difficult and expensive. Kisoro town, the administrative headquarters of the district, and its surrounding areas are inhabited about around 20,000 residents. Chuho Spring, the only water source for Kisoro town, runs right below the town, and hydrogeological studies show that "diluted and infiltrated fecal matter from Kisoro town presents a high risk for contaminating the Town's own water source" due to the town's upstream position and its porous volcanic underground.[15]

In 1997, the first Ecosan project in Uganda began in Kisoro town, under the South Western Towns Water and Sanitation program (swTws), funded by the Austrian government. Kisoro was chosen for the immediate concerns with water supply contamination. Between 1999 and 2000, over 250 composting toilets and UDDTs were build in Kisoro town, most of them household toilets, but some were also constructed at schools and other public sites.[16] The toilets are quite expensive to construct if made out of cement and brick, which was the design chosen by the program, and reported costs range from $400 to almost $1000. In talking with program staff and

households, the price of cement, which often has to be transported from far away, accounts for the bulk of the high cost.

In the beginning of the program, the project paid almost the complete cost of constructing the base of the toilet, the roof, and four poles to hold up the roof. The household was then expected to pay the full cost of finishing the structure, which averaged around $200. Not surprisingly, a report from 2002 found that of the 247 household facilities that were initiated, only 109 had been completed and only 77 were operational.[16] In an effort to correct this problem, the second phase of the program constructed the entire facility for the household for than $50.

From 2001 to 2002, there were a few program documents and evaluations released from the swTws program in Kisoro, reporting on status of structures built and some discussions of challenges. An evaluation conducted in 2001 asked some UDDT and composting toilet users their motivation for adopting the new technology, and most common responses were in regards to the geological problems, the permanence of Ecosan, and possibility of using excreta in agriculture.[17] However, at the time no families were currently using the manure and only some expressed interest, and a later publication by the World Bank in 2005 still found no reports of excreta reuse in Kisoro.[18,17]

Kabale

Kabale district lies just east of Kisoro, with Kabale Municipality being the administrative center. It is a larger town than Kisoro Town, with a population of approximately 83,000, and its residents tend to be wealthier and more educated. Many areas in Kabale municipality are affected by very high water tables, which fill pit latrines soon after they are dug and often lead to latrine collapse, creating an unsafe environment.[19] Aside from safety issues, because the latrines are often rendered useless in six months or a year, households must continuously find new land to build additional latrines and pay high upfront costs each time. The Ecosan program in Kabale was also managed by the swTws program, and began in 1999. Under this program, there were no subsidies offered and only UDDTs were built, as the program learned from Kisoro that composting toilets were less likely to be used correctly and subsidies led people to build Ecosan in the absence of strong additional motivators. There is no official documentation of household UDDTs built, but reports estimate that around 150-160 were constructed in Kabale, only 27 of which were under the swTws program.[20,12,21]

The literature for Kabale, though sparse as well, is more current than those for Kisoro. However, because the swTws was less involved in the constructing of the UDDTs in Kabale, no available program documents were found. A local study conducted in 2009 had the primary aim of just determining the prevalence of UDDTs in Kabale, as the available information was so limited. The author found 163 UDDTs out of 806 households interviewed, but the research did not explore much further than prevalence.[20] The Nuwagaba research also included Kabale, but because it was a national study there was not much Kabale-specific information, aside from a brief mention that many in Kabale did not know that excreta could be used in agriculture and that negative attitudes towards this practice persisted.

One of the more recent and interesting studies on Ecosan conducted an economic and financial analysis of the costs and benefits of Ecosan compared to traditional technologies, and chose

Kabale as one of its case studies.[18] The analysis concluded that in Kabale, building UDDTs actually had a higher financial and economic net present value than flush toilets or VIP toilets, but that reuse of excreta was critical to benefitting from the UDDT economically or financially. The study also found that areas with regular rainfall and relatively fertile soil, such as Kabale and Kisoro, would benefit more greatly from using the manure.[18] Thus, this modeling exercise suggests that Kabale and Kisoro are areas with great potential to benefit from greater returns from Ecosan, but only if reuse of excreta is being practiced.

Other Projects

The program under swTws has also been initiated in several other districts, though not quite as large-scale as the Kisoro and Kabale programs. It is currently in the third phase, which runs from 2006 to 2011, and is present in 17 districts.[22] The overall goals for water and sanitation of the project as outlined by the Ministry of Water & Environment are as follows:

- To assist people living in South Western Uganda with access to clean, safe, and adequate water that is manageable, adaptable, and affordable.
- To introduce and promote Ecosan toilets, and improve general sanitation standards.
- To establish management structures that will ensure sustainability of constructed systems.
- To conserve the environment through use of appropriate technologies of water and sanitation interventions.
- To improve the economic status of people
- To ensure that the gender issues are addressed in the implementation and management of water and sanitation systems.[22]

In 2008, the Ministries of Health, Water and Environment, and Education and Sport developed a ten-year national strategy on Ecosan, to be carried out between 2008 and 2018. The overall strategy is to have Ecosan toilets constitute 15% of total sanitation coverage throughout the country.[10] The focus of the first five years will be to create a market for Ecosan and increase awareness across all stakeholders, so that the last five years can be devoted to large-scale implementation. Given that Kabale and Kisoro are the only larger-scale programs implemented thus far, these goals are quite a significant undertaking and require extensive analyses of programs both in Uganda and other countries.

DHS Analysis

The DHS survey records “composing toilet”, referring to Ecosan, as one of the responses for type of toilet facility owned by the household, offering potential further insight on Ecosan trends in Uganda. However, upon further analysis, it became clear that the context of the composting toilets captured in the DHS was completely different than the regions my research is focused on. The distribution of Ecosan across regions and wealth quintiles can be found in Table 4. Of the 41 composting toilets recorded in the survey, 66.7% were in the North, 61% were used by those in the poorest wealth quintile, and 100 percent were located in the country side. Most likely the majority of composting toilets were found in displacement camps where NGOs have introduced public UDDTs, very different from the relatively wealthy, peri-urban UDDT owners in the Southwest. There results indicate the truly low prevalence of household UDDTs, as the largest concentration in the Southwest was completely missed in a survey as comprehensive as the DHS.

Table 4. DHS data on composting toilets (n=41)

Region	Frequency	Percentage
Central 2	6	16.7
East Central	3	8.3
Eastern	3	8.3
North	24	66.7
Wealth Quintile	**Frequency**	**Percentage**
Poorest	22	61.1
Poor	7	19.4
Middle	2	5.6
Rich	5	13.9
Richest	0	0

III. FIELD STUDY

Research Questions

The implementation of medium- to large-scale Ecosan programs in Uganda exist only in Kabale and Kisoro so far. Based on the literature review and discussion during my first visit to Uganda with Ecosan experts, it appears that these regions have a significant amount of difficulty with traditional sanitation facilities that may pose a threat to the population health. Although the upfront costs and training requirements for initiating Ecosan in Uganda are very high, there is evidence that there is potential for financial and economic benefits to using UDDTs over other facilities, in addition to the improvements to health and safety. However, at this time, over ten years after the first Ecosan programs began, there seems to have been limited replication and spontaneous adoption of Ecosan.

Based on the literature I have acquired, there appears to be a lack of detailed case studies of these two largest programs, and much of the existing literature are from early stages of implementation. As the national government is carrying out the early stages of its ten-year national strategy on Ecosan, I believe there are still aspects of past program outcomes that are still not well understood that can inform future directions of this strategy. Thus, I developed a field study to investigate the overall experience of Ecosan use in the two towns, and in particular the following topics that I consider are gaps in current knowledge:

1. Affordable UDDTs

As mentioned above, the traditional UDDTs made out of brick and cement can cost upwards of $900. For most households the cost would represent a major barrier to even considering these facilities as an option. It has been reported that UDDTs made out of local materials such as mud and sticks can be constructed at a fraction of the cost, but there is little documentation on the use of such methods. Further research is needed to examine the prevalence of low cost UDDTs and potentially other low cost Ecosan toilet models, as the less wealthy are also those who tend to have higher rates of disease and could benefit most from improved sanitation systems.

2. Excreta reuse

There is evidence that households can realize an overall economic or financial benefit from UDDTs over time, if excreta reuse is taking place. Especially in areas dependent on subsistence

agriculture, this free and valuable manure can provide better and more food to families, or extra income in cases where crops are sold. The available literature all seems to indicate there is little or no reuse occurring, and that the idea is very unpopular. However, during my sanitation field research, I introduced the idea of Ecosan to households and focus groups, the large majority (83%) of whom did not express concerns about excreta reuse and 65% of whom stated there was a need for fertilizer. This could be due to respondent bias, especially given my outsider status, but this finding warrants further investigation to see just how widespread the reported aversion to excreta reuse is.

3. *Former users and non-users*
A few reports and documents have mentioned the fact that several UDDTs and composting toilets in Kisoro were never completed or owners discontinued use after it was completed. A key to understanding how to improve usage and adoption of Ecosan systems is to first understand the perceptions and experiences of those who have rejected or have not decided to adopt the technology. Most of the existing literature discusses current user experience, but there is little documentation of how UDDTs and other Ecosan toilets are perceived by other households in the community still using traditional forms of sanitation, or the experience of those who initially decided to build the structures but discontinued use.

The goal is to provide information on whether Ecosan is a viable option in Uganda, and if so, what implementers need to consider in making the product attractive and usable to communities so that long-term usage and continued adoption takes place.

Methods

Overview
I identified three groups of interest that I wanted to interview in Kabale and Kisoro: a) Current Ecosan users, b) Former Ecosan users or owners of partially built Ecosans, and c) Non Ecosan users living in areas where Ecosan is present. I also planned to speak with experts in the field who had participated in program implementation, both to gain additional technical knowledge but also as a validation tool to compare with my household interviews. Due to time constraints, I chose to focus on the household level as I thought it would reveal more about personal preferences and motivations behind using Ecosan, compared to public Ecosan toilets. I obtained IRB exemption from the HSPH Office of Human Research Administration to conduct the interviews and travelled to Kabale and Kisoro, Uganda, during January 2010 to collect the data. During the time in the field I had a university student with research experience assist me in translation and communication with respondents as needed.

Participant Selection and Data Collection
Before arriving in Uganda I was unsure about the level of documentation of Ecosan users, and therefore did not know exactly how participants would be identified. Because I was told that local program staff had the most knowledge about where to locate UDDT and other Ecosan toilet users, and communication with these individuals was not possible from the U.S., I had to wait to finalize a plan until I met with them. Upon arriving in Uganda, I discovered that there was virtually no record of where the houses were that had built Ecosan either in Kabale or Kisoro. One key informant provided a list of about 20 names she could recall from memory, a few of which she was able to tell us the village where we could find the households. Even in Kisoro,

where the town program had subsidized the majority of Ecosan facilities, there was poor documentation on locations where the households could be found.

Therefore, in the end we had to settle for walking through villages on foot and physically look at all the properties, to see where the Ecosan toilets were located. We also asked community members we came across whether they could direct us to households that had Ecosan. To identify Ecosan toilets, we looked for raised structures that had visible vaults in the back, and sometimes required us to enter on to someone's property before we were sure if it was an Ecosan toilet. Because the structures were often few and far between, it could sometimes take an hour or longer to find one qualified household. If we found an Ecosan toilet and someone was home, we would ask to speak to the head of household, and if unavailable, anyone over 18 who lived in the home. After introducing ourselves and the project, we asked if the individual was willing to complete the interview. Sample sizes can be found in Table 5.

Table 5. Field study sample sizes

	Kabale	**Kisoro**	**Total**
Ecosan Users	20	16	36
Former Users/Partially Built	1	4	5
Non-Users	10	6	16

As for former users or those who only partially built the structures, we mostly had to rely on community members and other respondents who knew of these people. In the case of Kisoro, sometimes we would also see partially built and abandoned UDDTs, but most of the time the house was also abandoned or the original owners no longer lived there. This group was much harder to find than expected, so in the end the sample size was very low as we were only able to locate a few people who fit the criteria. For the non-user group, we randomly selected households in the villages where there were UDDTs and asked them to participate in a research study about sanitation and Ecosan. All respondents were briefed about the voluntary nature of participation, the right to refuse questions or stop the interview at any time, and interviews were voice-recorded only when verbal permission by the respondent was given. Permission was also requested to take photos of the sanitation facilities.

I developed three semi-structured interviews for each of the three groups as a general guide for the interview process. Copies of the interview guides can be found at the end of the Appendix. All questions that were applicable to the respondent were asked and translated into the local language as needed by the research assistant. If the respondent was not the head of household, demographic information for the head of household was still requested to the extent of the respondent's knowledge. Interviews were always tape recorded if permission was granted, but if the respondent did not want to be recorded answers were written by hand. Photographs were catalogued by date, location, and household identification number for easy matching to specific respondents.

Data Analysis

After interviews were completed, I transcribed each interview into a Word document. Because the content was mostly short answer with brief elaborations at most instead of lengthy responses,

I chose to use Excel to organize and code my data since the interviews were short and the sample size was small, instead of a more complex program such as Nvivo or Atlas. Using Excel, with a separate worksheet for each of the three groups, each respondent counting as one observation, I recorded the responses to all relevant questions. Once all of the data was recorded in one document, I tabulated and created summary tables describing each parameter of interest. For the analysis portion I kept the data for the two districts separate because the Ecosan experience and programs are very different and not comparable.

IV. RESULTS

Household Characteristics

My hypothesis entering the research was that Ecosan users are more highly educated and wealthier than the general population, as these factors are significantly correlated with having higher quality sanitation. The results for educational attainment in Kabale Municipality and Kisoro town of the study sample as compared to the overall population are shown in Tables 8 and 9 in the Appendix. In Kabale, the proportion of the most and least educated was about the same as the general population, but those with secondary education were twice as great as those with only primary education, a reversal from general population trends. In Kisoro, surprisingly, education levels among Ecosan owners were visibly lower than that of the general population across all education levels. Thus my sample does not reveal that Ecosan users are necessarily better education, especially in Kisoro, and demonstrate that households of all education levels in both districts are using Ecosan.

While one question on income was asked, given the cultural tendency to treat income as a private matter, the validity of these responses is unclear. Furthermore, there is no available data on income distribution in the two locations to serve as comparison. The only comment I will make about income is that several households that reported fairly low income financed the complete cost of building an Ecosan toilet, some of which were low-cost models, indicating that lack of wealth may not be a barrier that cannot be overcome.

Pre-Ecosan Toilet Use

All households in both sites already had other forms of sanitation prior to constructing Ecosan toilets. In Kabale, 90% of households had a pit latrine and 10% had both a flush toilet and either a VIP or a pit latrine at the time of Ecosan construction. In Kisoro, 94% of households had a pit latrine and 6% had a flush toilet. However, several households acquired flush toilets after building the Ecosan toilet and were currently using both. Ecosan toilets were used primarily in the daytime and for non-residents such as visitors and workers, while the flush toilets were used mostly at night. At the time of the interviews, 40% of Ecosan owners in Kabale and 37.5% in Kisoro also had at least one other working toilet.

Almost all respondents said they disliked the pit latrine, and a full list of complaints are presented in Tables 10 and 11 of the Appendix. In Kabale the overwhelming complaint from 73.7% of respondents was that the latrines would fill with water in a short period of time due to the high water table. This problem led to the need to construct latrines every year or two, or in extreme cases, every six months. This placed a strain on finances and land availability, and also indicates safety issues because of easy collapse of latrines. One respondent states: *"I would need*

to dig two pit latrines in one year because one would fill up with water so fast, and it might also collapse." Kisoro does not have the same water table problems, but also cited building new pit latrines when the old ones filled and latrine sinking/collapsing as major problems. A few people in Kisoro actually stated that pit latrines were more expensive to build than UDDTs, because the ground many people live on is hard rock, and digging a pit underground can require steep labor costs.

A small portion of people had positive comments about the pit latrine (20%). Two people appreciated that they could dispose of more items in a pit latrine that are not allowed in the Ecosan, such as diapers, feminine pads, plastic bags, and broken glass. Other positive aspects included the deepness of the pits and that it is less complicated to build.

Initiation of Ecosan Use

The majority of respondents initially learned of Ecosan through swTws program in their town, and in Kabale 26% actually visited the office to see the demonstration structures. Several others also had the initial exposure from seeing neighbors building Ecosan, or hearing about it through acquaintances. The distribution of the year in which households built the Ecosan toilet are shown in Figures 12 and 13 in the Appendix. Kabale shows a more continuous stream of construction over the years, with several Ecosans built in the past two years. Kisoro on the other hand has the biggest spike in 2000, when the program was constructing Ecosans with heavy subsidies. All of the current users in Kabale had built UDDTs, while in Kisoro 13 were using UDDTs and three were still using the composting version built in the first phase of the program.

The reasons for constructing Ecosan toilets given by respondents are displayed in Tables 12 and 13. Respondents often gave more than one answer, but the most popular reason across both locations (60% in Kabale, 37.5% in Kisoro) was the fact that the household would not have to dig additional latrines as the Ecosan is permanent and can be easily emptied. Also of note are the three households in Kisoro whose primary reason for building Ecosan was because the town council program offered to help them, rather than self-motivation due to an attractive quality of Ecosan.

Low Cost Toilets

As one of the primary research questions was to investigate the presence of low-cost Ecosan toilets, respondents were asked about the out of pocket costs of building their toilets. These values varied dramatically, especially in Kisoro where many households were heavily subsidized. Figures 14, 15 and 16 in the Appendix show the distribution of out of pocket costs in Kabale and both the subsidized and unsubsidized household out of pocket costs in Kisoro. In Kabale, while over 50% of households spent over $400 on UDDTs, over 15% were able to keep costs under $200. In Kisoro, average costs of unsubsidized UDDTs also seemed to fall around $400, but most of the subsidized toilets managed to keep out of pocket costs under $200.

Figure 2. UDDT made from low cost materials

There are only three cases of UDDTs made from local materials such as mud, sand, and sticks, all located in Kabale. An example of this style is pictured in Figure 2. The least expensive one cost the owner only $15, because the male head of household built it completely on his town, eliminating the need for hired labor. This individual had seen a concrete UDDT at a home where he was working as a day laborer, and learned from the owners how to use it and studied the structure in detail so he could copy it. The second UDDT cost about $90 for materials and labor, and was owned by a single, middle-aged woman with only primary education and self-reported low income. The third UDDT was more expensive, around $250, as the foundation was made of cement and bricks, but the superstructure was constructed from mud and sticks. The owner also constructed a third chamber, adding to the cost.

Excluding these three cases, the average cost of building UDDTs in Kabale is almost $600, vastly greater than even the most expensive UDDT made of local materials, $250. Given that the reported average cost of building a pit latrine is about $100, and needs to be constructed about every two years because of the water table problem, this information would suggest that building a UDDT out of local materials is certainly a more cost effective option than pit latrines or cement UDDTs. In Kisoro, none of the households interviewed had a toilet constructed from local materials, and during our time in the town we only saw one such structure, the owner of which we were unable to locate.

Excreta Reuse

In this study sample, 95% of households in Kabale and 87.5% of households in Kisoro using Ecosan have a garden where they grow crops. Of those with gardens, the large majority in both locations are either using the urine and/or excreta in agriculture or are planning to once the

chamber has filled. The data are shown in Table 14 in the Appendix, and indicate that 52.3% of households in Kabale and 66.7% in Kisoro were already using excreta in agriculture, with 21% and 13.3% planning to in the future. These are very different findings compared to the literature available on this topic which reported virtually no excreta reuse among Ecosan users in Uganda in the early 2000s.

Most people who were using the excreta as fertilizer cited visible positive outcomes in crop output. In both districts, about 50% of respondents stated that yields had improved, and several also mentioned that the crops were larger and stronger. One respondent had this observation: *"Sometimes we give the manure to our family members and friends, and in these cases when we don't use them on our garden, we find the yields are low."* Another reports that urine is an effective pesticide: *"In the past if I planted 100 heads of cabbage, I would harvest only about 40 because the rest would be destroyed by insects. I just decided to use the urine on my own, and now I can harvest roughly all 100 out of 100 cabbages planted."*

Some respondents said that urine and excreta have performed about the same as other fertilizers they have used in the past, such as cow dung, but none cited any negative results. There were some respondents who shared that they only used the excreta on certain plants, such as banana trees or maize, because the manure would not touch the part of the plant that is eaten, but that they would not use them on things such as leafy vegetables that would have direct contact.

Ecosan owners who were not using excreta in agriculture gave a variety of reasons they chose not to use it, including lack of knowledge on how to use it, skepticism about whether it would be beneficial, and for one person whose garden was in a different village, transportation was a problem. When asked if they would be willing to eat crops fertilized with the manure, almost all said it would be fine. Only one person said they would not eat it because it was too "dirty", and one specified that it would only be ok if it was used on bananas. However, a 2005 conference paper by Windberg et al. also found a stated willingness among the population to eating crops fertilized with human manure, but expert interviews suggested otherwise.[23] Therefore, it is unclear whether the reported willingness matches actual practice.

One respondent discussed how her perception of handling the excreta changed once she had first-hand experience: *"I originally feared emptying it and was worried it would smell, but I have seen that it is decayed, and it doesn't smell."* From the data, it appears that while negative attitudes may persist in a small sample of the population, in general most Ecosan users are happily using their manure in agriculture and do not have strong stigma against the practice.

Non Users

Of the 16 non-Ecosan households surveyed, 75% were currently using a pit latrine, with the remaining 4 using flush or VIP toilets. Complaints about pit latrines were similar to those of Ecosan users, primarily the smell, temporary nature of structures, and possibility of collapse. Those who had flush toilets had few complaints, and liked that it was inside the home and had a seat, which is particularly important for the elderly who find it difficult to squat. Eleven out of 12 pit latrine users said they would prefer a different kind of latrine, while no owners of VIP or flush toilets expressed desire for something different. Out of these 11, eight wished to switch to a flush toilet or VIP, while three said they would like a UDDT.

Most people had heard about Ecosan (81%) but only 50% were able to describe specific aspects, such as feces and urine separation, use of ash, and chambers that can be emptied. Of those who were more familiar, the perceived benefits were similar to those cited by Ecosan users. The dominant aspect mentioned was that Ecosan latrines are permanent, eliminating the need to continue digging pit latrines over time. Several people also mentioned cleanliness, ability to get manure, and less smell as benefits as well, which matches up with user opinions. When asked about disadvantages, three people mentioned that the need to use ash would be inconvenient because they were not using wood stoves. Two people also mentioned the unpleasant nature of removing excreta and urine.

Respondents who were familiar with Ecosan were also asked if they had ever considered building an Ecosan toilet. Five out of 13 responded yes, while eight responded no, and the overwhelming reason for not having done so in both groups was because of high cost. The full range of responses is presented in Table 15 of the Appendix. One respondent expressed an aversion to handling the excreta, but cost seemed to be much more of a concern than stigma. Similarly, when asked if it would be ok to eat crops grown with manure from the toilet, only one person gave a firm "no". Others said it was ok if the food was washed, or it was ok because the manure was in the soil and not on the edible part itself.

Lastly, I asked respondents about what types of people in their communities they thought were more likely to use Ecosan, to add another angle to understanding their perception of Ecosan and those who use it. Fifty-five percent said those who were wealthier and 36% said those households who had less land were more likely to build Ecosan. One person also said that those who don't have flush toilets would have more incentives to build it.

Former Users

As mentioned above, the goal of finding a decently large sample of people who had built Ecosan but stopped using it was not possible. We were able to locate six households who had built or started building Ecosan toilets, two in Kabale and four in Kisoro, but for some reason or another were not currently using it. The situation and context behind discontinued use or non-completion of construction were very diverse across each case, and individual descriptions can be found in the "Former Users Description" section of the Appendix. In Kabale, one household had a UDDT that was built eight years ago to be a back-up for the flush toilet but has never been used. A second household actually tore down its UDDT after being dissatisfied with the decomposition process, which the owner said never produced completely dry manure.

In Kisoro, there was a common theme of households not understanding exactly what Ecosan was and what the structure would be like. Two respondents said that they did not know it would be raised above ground and have a shallow pit, and once they realized this, they did not want it anymore and stopped construction. We also interviewed a household where the residents were renting the house and the original owners had built a composting toilet. The renters, who were not informed about the toilet and the proper way to use it, assumed it was a pit latrine and have been using it as such since. Ironically, they told us that they would like to have a UDDT, and may have been more satisfied with their latrine had they known it was composting, as its benefits are similar.

V. DISCUSSION

Kabale

In general, implementation of UDDTs in Kabale seems to be limited, but those that have been built have been quite successful, with high rates of satisfaction, few problems cited, high prevalence of excreta reuse, and very low rates of discontinuing use. There are several potential reasons why UDDTs have been so well received by its users. First of all, virtually no subsidization occurred in Kabale in constructing the toilets, which meant that households had to have a high level of motivation to adopt and pay for this new system. Geological concerns and permanence of the structures seem to have been the primary driving factors for building UDDTs, as the high water table, coupled with the need to dig new latrines every few years inflicts burdens on the households. The presence of demonstration toilets in the town center also contributed to the success, providing a concrete example of how the whole system works to interested people, who then know exactly what to expect from the end-product.

The finding that most households are using excreta in agriculture or have plans to once the manure becomes available is also a positive finding, as most of the prior research stated otherwise. As mentioned earlier, a World Bank study found that most of the economic and financial gains that can be realized from UDDTs are through the use of manure to produce more food which can be consumed or sold.[21] UDDT users also seemed pleased with this aspect, as those actively using manure reported increased yields and improved crop quality. In a country where food security and malnutrition are concerns, having the means to grow more and better food to feed your family, or to produce a surplus that will bring in additional income is invaluable.

Kisoro

As the site of the first large scale Ecosan promotion program, a lot of lessons were learned in the first and second phases of the project in Kisoro. Much of Kabale's success probably stemmed from the observations of what worked and what failed in Kisoro, and designing a more appropriate program from the start. For example, a staff member at swTws reported that the composting toilets were much less successful than UDDTs, probably because they resembled pit latrines too much, so the program in Kabale only build UDDTs. The results in Kisoro were mixed. There were several Ecosan users that were similar to the ones found in Kabale – very knowledgeable about the system, using excreta in agriculture, and demonstrating a motivation for building Ecosan based on strong personal preferences. Many of these households were the ones that build Ecosan more recently and had paid for the cost in full.

However, there were also several cases, including those who had only partially built Ecosan, where resources were invested but benefits were not accrued. In several of these cases it seemed that household heads did not have a clear idea about what kind of structure was going to be built and whether it agreed with their preferences. This is evidenced by the two individuals who stopped the construction once they realized the latrine was going to be raised. One Ecosan user provided this commentary on the town council's role in these abandoned projects: *"Yes, I would have to blame them. When they were constructing them they would tell a few people about it, but they did not show an example. If you want to make a lesson, you should have an example to demonstrate the advantages."* I would also like to note again that although in Kisoro we only

managed to talk to four households that had abandoned use of Ecosan, we had seen far more of these partially built structures, upwards of 20.

From the Ecosan user group there were also cases where it seemed that personal motivation to use Ecosan was not the driving factor in building. In three cases, when respondents were asked why they decided to build Ecosan, the sole reasons given were "the town council offered to build it for us", and "the town council was offering it nearly for free." This differs from the other responses given that showed a desire for the specific qualities unique to Ecosan, such as manure production, and separation of urine and feces. Now that the program is no longer operating in Kisoro and there are no more subsidies, I would expect the path of Ecosan to take one that is similar to Kabale, where individual households develop an organic drive to build Ecosan based on the demonstrated benefits they see it provides others.

Costs

One challenge that still remains in making Ecosan use widespread in Uganda is cost. With or without subsidies, costs prevent the poorest people who probably have the worst sanitation from accessing improved sanitation. The DHS showed that for Uganda, sharing toilets is one of factors that significantly predicts child diarrhea risk. Yet, all of the households interviewed in Kabale already had a private household latrine prior to building Ecosan, and some even had more than one private latrine. This was the major criticism I had of the Ecosan program, that it is still something unattainable by those whose health are at the greatest risk due to poor sanitation conditions.

As the results show, most of those who have not had UDDTs in the home have the perception that only wealthy people can build them. We found that there were some people who would prefer a UDDT over their current sanitation system, but were under the impression that it is too expensive. While most of the UDDT owners were fairly well off, there were also several in our sample who seemed to be of average or lower income. Some people chose more affordable options such as structures made of local materials, but these were few and far between. This is likely because the traditional UDDT featured more prominently by swTws were those made of cement and brick. Many people are not familiar with the low-cost option, or may be under the assumption that it is of poor quality.

The perceived high cost of UDDTs may be exaggerated in some ways too because one may forget to factor in the permanence of the structure. As mentioned above, for the household that has to build a new pit latrine every six months to two years, over the span of 10 years the cost of building a UDDT is actually lower than the sum of all the pit latrines that need to be built. In addition, it has not used up any additional land or caused any other disruptions from having to shift latrines. If the goal is to increase UDDT adoption, perhaps this factor is something that should be advertised widely to put the large upfront costs in perspective.

An economic analysis by the World Bank in 2009 found that on the household level, of the higher cost sanitation options (UDDT, VIP, sewerage), the low cost UDDT is actually the most favorable option in terms of Net Present Value (NPV), followed by the high cost UDDT. Flush toilets with this model were found to be the least financially and economically beneficial. The model was created with the assumption that households are reusing excreta, and findings are

summarized in Table 5. This data suggests that for households that are able to consider these higher cost options, and who will reuse excreta with a UDDT, the UDDT would be the best choice in the long run in terms of financial and economic concerns.

Table 6. Financial and economic net present value (NPV) without subsidies[21]

		UDDT		VIP		Sewerage
		Low cost	High cost	Low cost	High cost	High cost
		US$	US$	US$	US$	US$
Financial NPV	Household	- 55	- 484	- 301	- 647	- 605
	Project	- 123	- 123	- 30	- 30	- 203
	Total	- 178	- 607	- 331	- 677	- 808
Economic NPV		+ 111	- 345	- 124	- 492	- 890

VI. RECOMMENDATIONS

After over ten years since the initial implementation of the Ecosan program in Kisoro, there have been many lessons learned, and adaptations have occurred in each additional phase of the program to account for these lessons. From my own review of the existing literature and conducting this field work, I have noted some additional points for consideration. Because my observations occurred during a short period of time in the field, and my exposure to the current program implementation is limited, these points should be taken more as food for thought rather than strict recommendations.

For any program striving for better sanitation conditions, a primary desired impact of implementing Ecosan should be improvements in health outcomes, such as child mortality or diarrhea prevalence. In addition, Ecosan aims to have environmental health impacts such as a decrease in contaminated water. While from the field study it is clear that the households feel an improvement in sanitation because they are no longer concerned about pit latrines collapsing and filling with water, no households could provide any definitive feedback on whether health had improved or disease had decreased. In the literature search I performed I was also unable to find any research investigating the actual health and environmental impacts Ecosan can have on the population level. Likely this is because a randomized controlled trial with Ecosan would consume vast resources and would be extremely difficult to design.

Nonetheless, I believe it is important to try to develop a way to measure the actual potential of Ecosan on influencing health outcomes. While Ecosan is indeed an intriguing concept, promoting sustainable and environmentally friendly sanitation methods, I question whether it can have a significant impact on health unless the majority of the population is using it. For example, in Kisoro, the impetus for building Ecosan was due to contamination of Chuho spring, the sole water source running through Kisoro town. However, ten years later, less than one percent of the town has adopted Ecosan. What real impact on health and water quality can this have? Understanding the degree to which Ecosan offers various benefits do different groups of people will enable program planners and implementers to better tailor programs to target those who can be most affected by the areas in which Ecosan is effective.

Without this kind of analysis, it is difficult to recommend Ecosan as a long-term solution for the majority of the population. The research has shown that wealthier households who build UDDTs without subsidy, who live in areas with geographic problems, and who reuse excreta have success with long-term use and there is evidence that UDDTs may be their best option economically. But what about poorer households who are not able to build a UDDT? Or what about areas where pit latrines do not pose a great risk on the water supply? Unless there is empirical data how the costs of Ecosan in each unique case measures up to the benefits it can provide in terms of health, dignity, and agriculture, I could not confidently state that Ecosan is the best or even a feasible option for all people in Uganda. In the government's efforts to expand Ecosan to 15% of the population by 2018, it should place particular emphasis on the groups for which Ecosan's benefits have been shown to outweigh the costs, and implement carefully thought out research and evaluation plans in all implementation to begin answering some of these questions.

If evidence suggests that Ecosan may be a beneficial option for poor communities, and there is demand for Ecosan among them, one of my recommendations would be to develop and test methods to bring Ecosan to these communities in a way that includes financial input from the users themselves. Depending on the wealth level of the users, subsidization or loans may be necessary initially for the high starting costs. Public Ecosan toilets built with pooled money from the area, with someone hired to manage and clean the facility is one potential idea, variations of which are being tested in some East African slums with traditional pit latrines.

A second suggestion for reducing costs is to more publicly promote the affordability and quality of low-cost Ecosan toilets built with local materials, and to train masons in working with these materials as well. As noted previously, there were few of these structures seen in the field, but those who were using them were generally not wealthy, and were pleased with the product. The interviews revealed the widespread belief that Ecosan toilets were prohibitively expensive, and could only be afforded by those who were wealthy. In a country where poverty levels are so high, I believe it is inappropriate to promote a model that costs hundreds of dollars as the norm. By demonstrating other options and promoting them more heavily, perhaps involving low-cost Ecosan owners as spokespeople or educators, this perception might be changed over time.

Another goal of the swTws programs in water and sanitation is to "improve the economic status of people".[22] The field study found higher than expected rates of excreta reuse, which is an indicator that perhaps many households are collecting economic gains through using free manure that increases crop yield and improves quality. The World Bank 2009 study concluded from its computer modeling that "The lower the capital costs, the higher are the benefits of reuse in Ecosan option, in terms of Net Present Value (NPV)."[21] This suggests that a combination of promoting lower cost toilets as well as proper excreta reuse practices is the key to gaining the most financial and economic benefits from using Ecosan. A longitudinal study following those who construct Ecosan toilets over time and tracking financial and economic well being compared to a control group could investigate if this hypothesis holds in reality in Uganda. Additionally, programs should maintain involvement with Ecosan owners after the structure is built – something that is not necessarily common practice now, to provide further education and advice for how to get the most out of their investment.

VII. LIMITATIONS

There were several limitations to my research and field study. First, the lack of documentation of households using Ecosan meant that the sample was more of a convenience sample rather than using a randomized method. To compensate for this, we were as thorough as possible, attempting to cover all households in each village. Second, the literature review was comprised of all of the sources I managed to acquire on the topic, but due to the unique nature and the developing country setting of my research, many sources were unpublished documents and "grey literature" obtained from individuals I encountered in the field. Therefore, there may be other reports and documents that I never came across that may address aspects of interest.

Third, due to the limited time in the field, the bulk of the time in Uganda was spent conducting household interviews to gather the most comprehensive data possible. Because the swTws headquarters have moved to the district of Mbarara, away from Kabale and Kisoro, I had limited engagement with program staff who previously or currently worked on implementing Ecosan in Kabale and Kisoro. Therefore, it was difficult to get a comprehensive picture of how the program differs presently from how it operated when the headquarters were in Kisoro.

Lastly, because of the short time and the small scale of this research, there were limited means by which I could verify the self-reported responses to my interview questions. Especially given my outsider status, I knew that respondents may have the urge to answer questions a certain way, or feel that I wanted to hear a certain answer. To mitigate these problems, I sought verification through observation on aspects that could be observed, such as the condition and existence of the Ecosan toilet, and practice of excreta reuse. Additionally tried to create an environment where participants felt comfortable answering truthfully, by conducting interviews with a research assistant from the region, and making clear my independence from any government or other institution.

VIII. CONCLUSIONS

Ecological Sanitation is an innovative system that is both resource-saving and resource-generating, offering the potential to improve the health, dignity, and livelihoods of communities in developing countries such as Uganda. The data gathered from this study has shown that several households have been motivated to adopt Ecosan, and that the large majority have been satisfied with the results. However, additional focus should be directed at promoting low-cost models, and creative strategies should be developed and tested for extending Ecosan to those who are poorer and have lower quality sanitation. Further research also needs to be conducted to determine if this is something desirable among other communities, what the financial, economic, and health impacts of Ecosan in reality. With Uganda's ten-year national strategy on Ecosan now underway, this kind of research will inform how finances should be most effectively used, what strategies should be employed in different settings, and where the benchmarks should be in terms of evaluation. I hope that this case study has provided valuable information on the successes and failures of past large-scale programs, and concrete suggestions on what to consider as the programs move forward.

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Appendix

Additional Ecosan Information

Figure 3. Ecosan Approach[14]

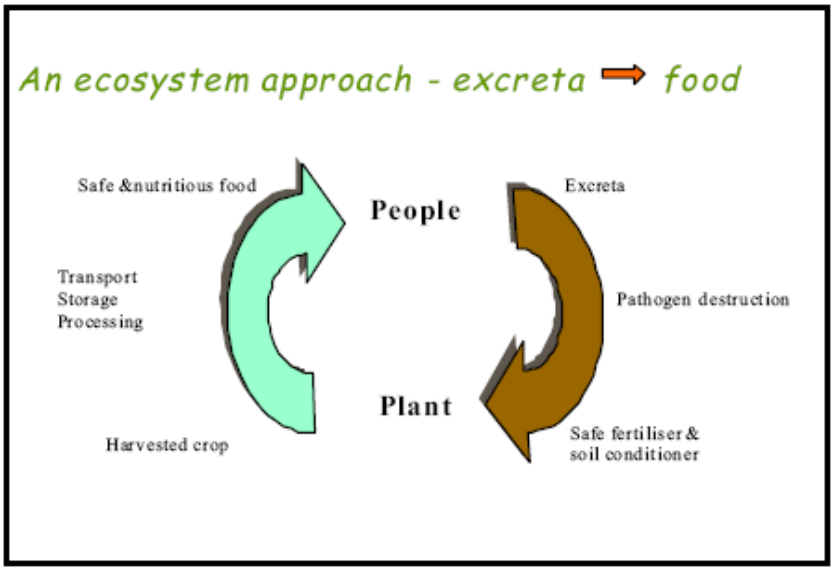


Figure 4. Outside view of UDDT

Figure 5. Urine-diverting pan of a UDDT

Figure 6. UDDT with a seat

Figure 7. View from back of UDDT - vault doors where excreta is emptied

Figure 8. Tube diverting urine from UDDT into jerry can, separate from feces

Table 7. Components found daily in human excreta per person[14]

Elements (g/ppd)	Urine	Faeces	Urine + faeces
Nitrogen	11.0	1.5	12.5
Phosphorous	1.0	0.5	1.5
Potassium	2.5	1.0	3.5
Organic carbon	6.6	21.4	30
Wet weight	1,200	70-140	1,200-1,400
Dry weight	60	35	95

Figure 9. Manure removed from UDDT and decomposing further

Figure 10. Garden fertilized with manure from UDDT

Figure 11. Partially built UDDT

For more photos from the field:
http://www.flickr.com/photos/gtzecosan/sets/72157623544743408/ (Kabale)

http://www.flickr.com/photos/gtzecosan/sets/72157623557121842/ (Kisoro)

Field Research Findings

Table 8. Educational Attainment, Kabale

Highest Completed	Ecosan Users (%)	Overall Population (%)
None	5	4.3
Some Primary	10	41
Completed Primary	10	
Some Secondary	20	18
Completed Secondary	20	
Post Secondary	35	36

Table 9. Educational Attainment, Kisoro

Highest Completed	Ecosan Users (%)	Overall Population (%)
None	25	5.5
Some Primary	12.5	42
Completed Primary	0	
Some Secondary	18.8	11
Completed Secondary	12.5	
Post Secondary	31.3	41

Table 10. Dislikes of Pit Latrine, Kabale

Dislikes about pit latrine	% respondents cited as problem
Fills with water (high water table)	73.7
Have to build another when full	31.6
Can sink/collapse	26.3
Bad smell	15.8
Children can fall in	5.2
Hard to keep clean	5.2
Flies/maggots breed	5.2

Table 11. Dislikes of Pit Latrine, Kisoro

Dislikes about pit latrine	% respondents cited as problem
Have to build another when full/uses more land	26.7
Can sink/collapse	26.7
Far from house	13.3
Urine & feces mix	6.7
Smell	6.7
Expensive	6.7
Difficult to build because of soil	6.7
Children can fall in	6.7
Filled fast	6.7

Figure 12. Year Ecosan Constructed, Kabale

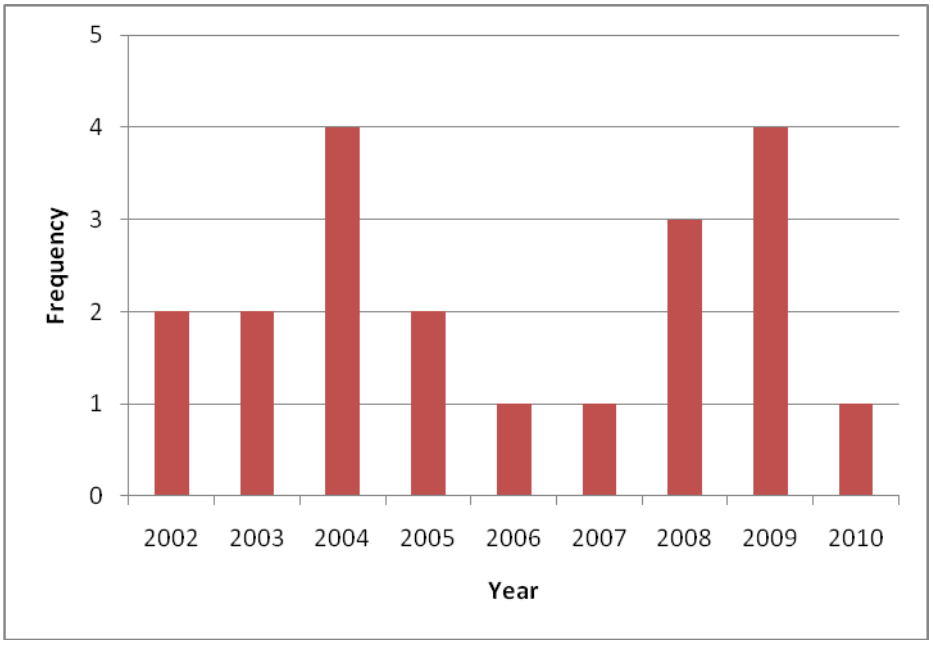


Figure 13. Year Ecosan Constructed, Kisoro

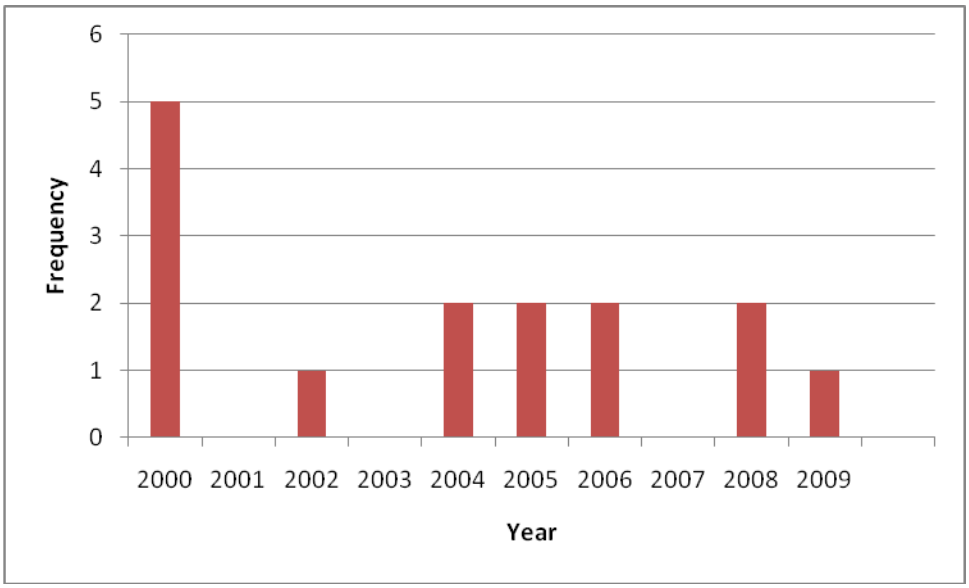


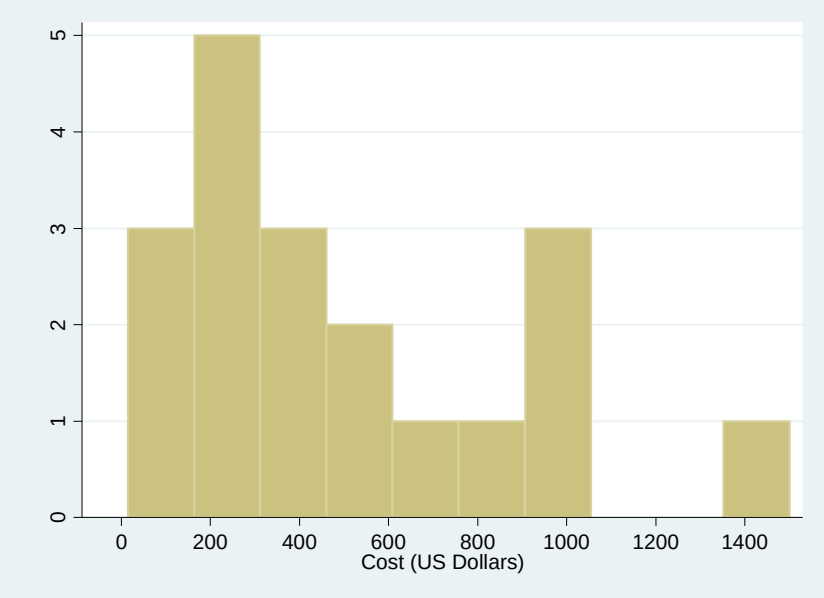
Table 12. Reasons for building Ecosan, Kabale

Reasons	Frequency	Percentage
Don't have to dig more/permanent/can empty	12	60
Less smell	5	25
Can't fill with water	5	25
Get manure	4	20
Cheaper	3	15
Renters/visitors/workers can use	3	15
Less flies	2	10
Cleaner	2	10
More durable	2	10
More reliable	1	5
Easy to clean/maintain	1	5
More convenient	1	5

Table 13. Reasons for building Ecosan, Kisoro

	Frequency	Percentage
Don't have to dig more/permanent/can empty	6	37.5
Get manure	4	25
Separate urine & feces	3	18.8
Town council offered to build	3	18.8
Hard to dig pit latrine	2	12.5
Healthier because urine & feces separated	2	12.5
Less smell	1	6.3
Cheaper	1	6.3
Wanted extra toilet	1	6.3

Figure 14. Out of pocket costs for unsubsidized households, Kabale



*Only one household in Kabale received a subsidy, and paid $75 out of pocket

Figure 15. Out of pocket costs for unsubsidized households, Kisoro

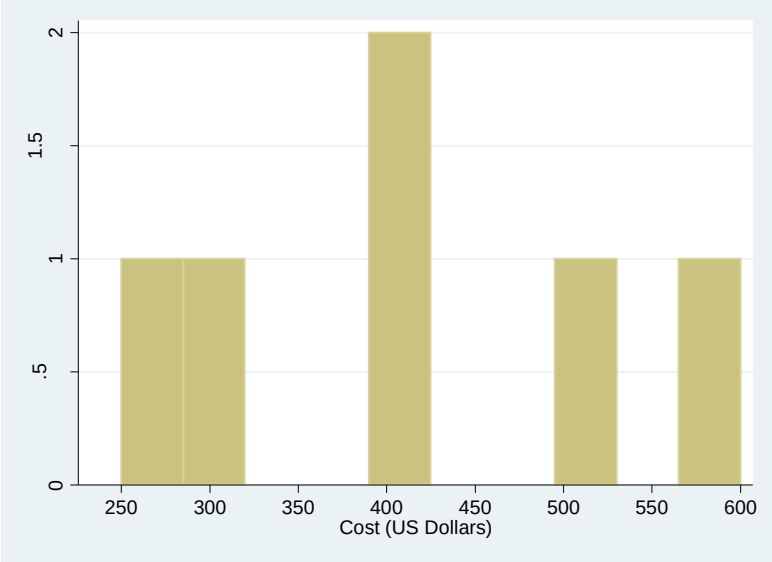


Figure 16. Out of pocket costs for subsidized households, Kisoro

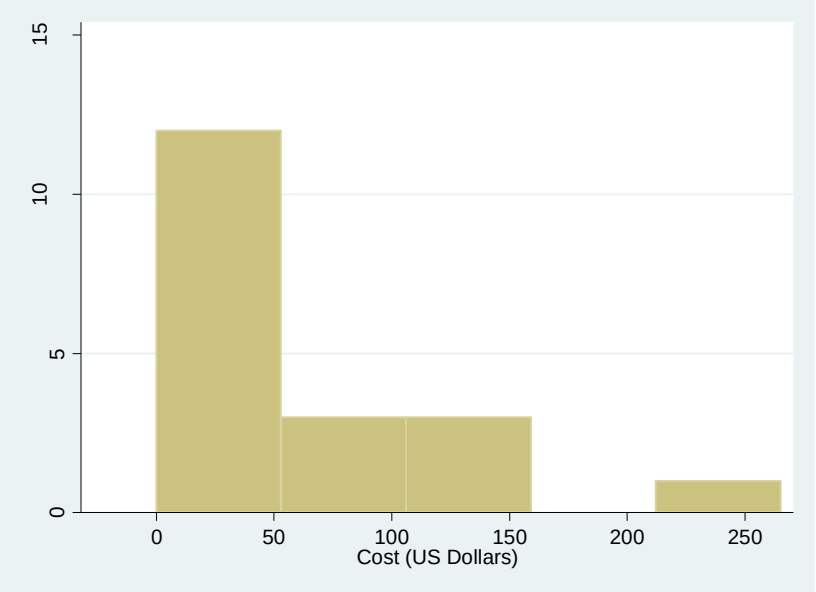


Table 14. Excreta reuse in agriculture

	Kabale (%)	Kisoro (%)
Yes	52.3	66.7
No	26.3	20
Haven't emptied but plan to	21	13.3

Table 15. Have non-users ever considered building Ecosan?

Response	Frequency
Yes	5
Too expensive	3
Planning to build	1
Don't like idea of handling feces	1
No	8
Too expensive	4
Have enough land	1
Not head of household	1
Inconvenient because need ash	1
Don't know enough about it	1

Former User Descriptions

Kabale

Case #1: This household appeared quite wealthy based on the size and construction of the house and the presence of cars in the driveway. The male head of household told us that they built their UDDT toilet in 2002 after hearing it advertised on the radio. They already had a flush toilet, but decided to build the UDDT as a back-up in case there were any problems with the flush toilet. When I asked him why he decided to choose the UDDT as a back-up instead of a pit latrine or VIP, he said that it seemed more "modern". However, since it was built 8 years ago, the family has never used the UDDT because the flush toilet has been functioning.

Case #2: This female head of household told us that their UDDT was built in 2002 after she heard about it from an acquaintance. They decided to build it because they liked the idea of being able to remove the waste after it had dried and continue using the toilet. However, she claimed that although they were using ash, the excreta was still not dry after 6 months of closing the chamber. The family used it for four years, but tore it down after they decided to switch back to the pit latrine. Based on the interviewee's responses, it appears that they were using the UDDT correctly, so it is unclear whether the excreta was really not decomposing as it should, and if so, why this was the case.

Kisoro

Case #1: This household was very interesting because when we saw the toilet from the outside it clearly looked like it had two chambers with vault doors for emptying, but when we asked the residents if it was, they said no. After more extensive probing, we realized that it was a composting toilet that had been built by the owner before these tenants moved in. Looking inside the structure, the slab had one hole similar to a pit latrine, instead of a urine diverting pan like UDDTs, so the new tenants assumed it was a pit latrine and said they had no idea it was Ecosan. Ironically, the tenants did not like this toilet and said they preferred a UDDT with urine and feces separated. This was a case where proper use of the toilet was not communicated between the house owners and the tenants.

Case #2: The man I interviewed was a big proponent of Ecosan toilets, and as a teacher had actually completed a project to have UDDT toilets built at a school. He had initiated the process to build a household UDDT in the late 1990s, at the beginning of the swTws program when they were heavily subsidizing the building of the general structural frame. The impetus for building it was because the family lived in the town center, with limited land, and it was getting increasingly crowded. Therefore they wanted to be able to have one permanent toilet, instead of having to find new land to dig pit latrines every time they filled. However, according to the respondent, he was never able to complete the structure beyond the base, four poles, and roof, because his neighbor built a concrete wall between their properties that was so close to the back of the toilet that the chambers could not be opened. For over 10 years this half-built structure has been standing in the back yard of this household.

Case #3: This female head of household told us that she had learned of Ecosan in 1999 through the town project, but did not decide to build on until 2004. Her main reason for building it did not seem to be from any personal preferences for Ecosan in particular, but primarily because the

town project offered to build one for her at the subsidized cost. She said that once the base was completed and she realized the toilet was going to be raised off of the ground and had a shallow pit, she decided she did not like it. I was not able to figure out in more detail why she disliked it so much, other than the fact that it was raised off of the ground and was not very deep. The structure was only built part-way, and eventually she had it torn down because there was no desire to complete it.

Case #4: This interview was actually never completed as the respondent wanted to stop after a few minutes because he felt uncomfortable. The information we learned was limited, but we did find out that he had only partially built a UDDT because after construction began he realized that the pit was very shallow. After realizing this, he refused to complete the structure. He did not offer additional information, however I felt it was important to note this additional case where someone clearly did not have the information needed in the first place to decide whether they actually wanted to build this structure, and had to abandon it part-way through.

Interview Questions

Ecosan Users

I. DEMOGRAPHIC INFORMATION

1. Sex
   - □ Male
   - □Female

2. Age
   - □ Under 20
   - □ 20-29
   - □ 30-39
   - □ 40-49
   - □ 50+

3. How much formal education you have completed?
   - □ None
   - □ Some primary
   - □ Completed primary
   - □ Some secondary
   - □ Completed secondary
   - □ Post secondary

4. What is your occupation?

5. What is your average household income per month? (Ugandan shillings)
   - □ Under 50,000
   - □ 50,000 – 100,000
   - □100,000 – 150,000
   - □150,000 – 200,000
   - □ 200,000 – 250,000
   - □ 250,000 – 300,000
   - □ Over 300,000

6. How many people live in this household?
   - □ 1-2
   - □ 3-5
   - □ 6-10
   - □ 10+

II. START OF ECOSAN USE

1. What kind of latrine were you using before Ecosan?

□ pit – no slab □ pit – wood slab □pit – concrete slab □ VIP □ other

2. How did you feel about that kind of latrine?
   Probes: likes, dislikes

3. When did you first learn about Ecosan?

4. Who taught you about Ecosan?

5. When did you decide to start using Ecosan in your own home?

6. How long have you been using Ecosan?

7. Does everyone in the household use Ecosan all the time? □Yes □No
   7.1 If not, who does not use it and when?

8. What made you decide to use Ecosan instead of what you were using before?

9. How was the Ecosan latrine paid for?
   □ self □ partially subsidized □ fully subsidized □ other

   11.1 Do you know how much it cost in total?
   11.2 If it was subsidized, how much was subsidized?

10. Who built the Ecosan latrine?
    12.1 Are these people members of this community or from somewhere else?
    12.2 Have local masons been taught to construct Ecosan?

11. What materials is the Ecosan latrine made of? Were these local materials or did they have to be brought from farther away?

III. MANAGEMENT OF ECOSAN

1. Who maintains the Ecosan latrine?

2. What do you do with the urine and solid waste when they are full?
   2.1 Where do you put the solid waste when you remove it?
   2.2 How long do you keep it there?

3. Do you have a garden, fruit trees, or other crops? □Yes □No (If no, skip next question)
   Probe: Are your crops just for your family's use or to sell?

4. Do you ever use fertilizer? □Yes □No
   4.1 If no, why not?
   4.2 If yes, where do you buy fertilizer from? What kind of fertilizer is it?

5. Have you heard of waste from Ecosan being treated and then used as fertilizer on crops?

□ *Yes → question 6*
□ *No → question 7*

6. Have you ever used waste from Ecosan as fertilizer? □Yes □No
   6.1 If yes, how do you feel about the results? Are you happy with compost as a fertilizer?
   6.2 If not, why not? Would you consider using it if you knew it was safe to use and you would not have to buy other fertilizer?
   6.3 Have you heard of others in the community who use this method?

7. [Interviewer: explain that if waste is treated correctly it is safe and beneficial to use on crops, and decreases the need to buy fertilizer] On a scale of 1-10 (1 being very unlikely and 10 being very likely) how likely you would be willing to eat crops fertilized with this kind of fertilizer?

IV. ATTITUDES TOWARD ECOSAN

1. What do you like about your Ecosan latrine?

2. What do you dislike about your Ecosan latrine?
   2.1 If there are any maintenance problems with the latrine, is there someone local who can fix it?

3. Besides having a new type of latrine, has Ecosan changed your household and your family members in other ways?
   Probe: Has it had any effect on health?

4. Do children feel differently or use Ecosan differently than the previous latrine?

5. If you could make changes to your Ecosan, what changes would you make?

V. ECOSAN AND OTHER HOUSEHOLDS

1. Since you built your Ecosan latrine, have there been other households in the village who have also built them? □Yes □No
   1.1 If so, why do you think more people have not decided to build them?
   1.2 If yes, why do you think they decided to build them?

2. Many households in the village did not begin using Ecosan. What do you think were their reasons?

3. Some households adopted Ecosan initially but have stopped using it since. Why do you think this is?

4. Do you think there are certain kinds of people who would like to use Ecosan more than others? If so, who?

Former Users/Partially Built

II. CURRENT LATRINE AND PAST ECOSAN USE

12. What kind of latrine are you currently using?
    □ pit – no slab □ pit – wood slab □pit – concrete slab □ VIP □ other

13. How did you feel about this kind of latrine?
    Probes: likes, dislikes

14. When did you stop using your Ecosan latrine?

15. When did you first learn about Ecosan?

16. Who taught you about Ecosan?

17. What kind of latrine were you using before Ecosan?
    □ pit – no slab □ pit – wood slab □pit – concrete slab □ VIP □ other

18. When did you decide to start using Ecosan in your own home?

19. For how long did you use Ecosan?

20. Did everyone in the household use Ecosan? □Yes □No
    9.1 If not, who did not use it and when?

21. What made you decide to use Ecosan instead of what you were using before?

22. How was the Ecosan latrine paid for?
    □ self □ partially subsidized □ fully subsidized □ other
    11.1 Do you know how much it cost in total?
    11.2 If it was subsidized, how much was subsidized?

23. Who built the Ecosan latrine?
    12.1 Are these people members of this community or from somewhere else?
    12.2 Have local masons been taught to construct Ecosan?

24. What materials was the Ecosan latrine made of? Were these local materials or did they have to be brought from farther away?

III. MANAGEMENT OF ECOSAN

8. Who maintained the Ecosan latrine when you were still using it?

9. What did you do with the urine and solid waste when they were full?
   2.1 Where did you put the solid waste when you removed it?
   2.2 How long did you keep it there?

10. Do you have a garden, fruit trees, or other crops? □Yes □No (If no, skip next question)
    Probe: Are your crops just for your family's use or to sell?

11. Do you ever use fertilizer? □Yes □No
    4.1 If no, why not?
    4.2 If yes, where do you buy fertilizer from? What kind of fertilizer is it?

12. Have you heard of waste from Ecosan being treated and then used as fertilizer on crops?
    □ *Yes → question 6*
    □ *No → question 7*

13. Have you ever used waste from Ecosan as fertilizer? □Yes □No
    6.1 If yes, how do you feel about the results? Are you happy with compost as a fertilizer?
    6.2 If not, why not? Would you consider using it if you knew it was safe to use and you would not have to buy other fertilizer?
    6.3 Have you heard of others in the community who use this method?

14. [Interviewer: explain that if waste is treated correctly it is safe and beneficial to use on crops, and decreases the need to buy fertilizer] On a scale of 1-10 (1 being very unlikely and 10 being very likely) how likely you would be willing to eat crops fertilized with this kind of fertilizer?

IV. ATTITUDES TOWARD ECOSAN

6. What did you like about your Ecosan latrine?

7. What did you dislike about your Ecosan latrine?
   2.1 If there were maintenance problems with the latrine, is there someone local who can fix it?

8. For what reasons did you stop using Ecosan? (Probe for all reasons)

9. In what ways would your Ecosan latrine have to have been different in order for you to not stop using it?

V. ECOSAN AND OTHER HOUSEHOLDS

5. Since you built your Ecosan latrine, have there been many other households in the village who have also built them?
   1.1 If yes, why do you think they decided to build them?
   1.2 If no, why do you think more people did not decide to use Ecosan?

6. Some other households have continued using their Ecosan latrines. Do you think they are having the same problems as you? Why do you think they continue to use it?

7. Many households in the village did not begin using Ecosan. What do you think were their reasons?

8. Do you think there are certain kinds of people who would like to use Ecosan more than others? If so, who?

Non-Users

II. CURRENT LATRINE

25. What kind of latrine are you currently using?
□ pit – no slab □ pit – wood slab □pit – concrete slab □ VIP □ other

26. For how long have you been using this current latrine?

27. Have you ever had a different kind of latrine in this household?

28. What do you like about this latrine?

29. What do you dislike about this latrine?

30. Would you prefer to use a different kind of latrine? □Yes □No
6.1 If yes, what kind and why?

31. If you were able to make changes to your current latrine, what would they be?

III. KNOWLEDGE OF ECOSAN

15. Have you heard of Ecosan latrines? □Yes □No
1.1 Can you describe what an Ecosan latrine is for me?

Only continue with remaining questions in section if answer is yes

16. Are there households in your village using Ecosan latrines? □Yes □No
Probes: Would you say there are a lot? A few?

17. When did you first hear about Ecosan and how did you hear about it?

18. Have you ever considered having an Ecosan latrine in your home? □Yes □No
1.1 If yes, why, and what has prevented you from having an Ecosan latrine?

19. In your opinion, what are the advantages of having Ecosan?

20. In your opinion, what are the disadvantages of having Ecosan?

21. Would you prefer to have an Ecosan latrine or your current latrine? Why?

IV. WASTE REUSE

1. Do you have a garden, fruit trees, or other crops? □Yes □No (If no, skip next question)
   Probe: Are your crops just for your family's use or to sell?

2. Do you ever use fertilizer? □Yes □No
   4.1 If no, why not?
   4.2 If yes, where do you buy fertilizer from? What kind of fertilizer is it?

3. Have you heard of waste from Ecosan being treated and then used as fertilizer on crops?
   □ *Yes → question 4*
   □ *No → question 5*

4. Have you ever used waste from Ecosan as fertilizer? □Yes □No
   4.1 If yes, how do you feel about the results? Are you happy with compost as a fertilizer?
   4.2 If not, why not? Would you consider using it if you knew it was safe to use and you would not have to buy other fertilizer?
   4.3 Have you heard of others in the community who use this method?

5. [Interviewer: explain that if waste is treated correctly it is safe and beneficial to use on crops, and decreases the need to buy fertilizer] On a scale of 1-10 (1 being very unlikely and 10 being very likely) how likely you would be willing to eat crops fertilized with this kind of fertilizer?

V. ECOSAN AND OTHER HOUSEHOLDS

9. Of the households in your village who built Ecosan toilets, why did you think they chose to build it?

10. Some other households started using Ecosan initially but have now stopped. Why do you think they decided to stop?

11. Do you think there are certain kinds of people who would like to use Ecosan more than others? If so, who?