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Adoption and Sustained Use of the Arborloo in Rural Ethiopia: A Cross-Sectional Study

By

Dionna Fry
Master of Public Health

Global Environmental Health

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Matthew Freeman, PhD, MPH
Committee Chair

____
Paige Tolbert, PhD
Committee Member

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Dionna Fry
B.A.
The George Washington University
2010

Thesis Committee Chair: Matthew Freeman, PhD, MPH

An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
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Abstract

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In rural Ethiopia, 81% of the population utilized unimproved or no sanitation in 2011 (JMP 2013). 16.2% of the total burden of disease and 14.9% of all deaths in Ethiopia were attributable to water, sanitation, and hygiene in 2004. In 1999, Peter Morgan developed the arborloo, a low-cost, composting toilet, for use in rural areas with poor sanitation coverage. The arborloo allows users to plant fruit trees on their nutrient rich composted excreta.

CRS began promoting the arborloo in 2004 and has provided 80,000 arborloos to Ethiopian households. We assessed the adoption of the arborloo and sustained arborloo use in CRS intervention communities. We collected 690 household surveys and conducted 24 key informant interviews and 33 in depth interviews.

The arborloo had high rates of adoption in study areas. CRS reached 462 (67.0%) of surveyed households. We found strong evidence that arborloo usage was sustained. Of the 462 households who ever had the arborloo, 352 (76.2%) had sustained arborloo use at the time of the survey. Sustainability was most strongly associated with use of the arborloo pit for planting, male head of household having some education, receipt of a cement slab, and socio-economic status.

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Contents

1. LITERATURE REVIEW

1.1. Introduction

This is the first study to rigorously assess the arborloo, a low-cost ecological sanitation approach implemented throughout sub-Saharan Africa. The arborloo is a design that allows for movement of the latrine slab and planting of a tree in the used pit, increasing food availability. The goal of this study was to assess the sustained use and drivers of sustainability of arborloos, within Catholic Relief Services program areas in rural Oromia Region, Ethiopia. We also examined the equity of access to initial program benefits and barriers to sustainability. This literature review was conducted to provide a deeper understanding of the sanitation gap that exists in Ethiopia, the health effects of poor sanitation coverage, ecological sanitation interventions, and the arborloo.

1.2. Sanitation Gap

According to the Joint Monitoring Program for Water Supply and Sanitation (JMP), an estimated 2.5 billion people (about 36% of the world's population) did not have access improved sanitation facilities in 2011, and it is likely that 2.4 billion people will still lack access to improved sanitation by 2015 (JMP 2013). Slightly over 1 billion people (15% of the world's population) continue to practice open defecation (JMP 2013). While improved sanitation coverage is increasing, it is unlikely that the Millennium Development Goal for sanitation coverage (75% of world population with improved sanitation) will be achieved by 2015 (JMP 2013). The majority (71%) of people without any sanitation live in rural areas (JMP 2013).

1.3. Sanitation Gap in Ethiopia

The percent of the Ethiopian population who practice improved sanitation went from 2% in 1990 to 21% in 2011; the percent who use shared sanitation increased from 4% to 12%, and the percent who used unimproved sanitation also increased from 1% to 22% (JMP 2013). In the same time period, the percent of the population who practice open defection decreased from 93% to 45% (JMP 2013). In rural areas in 2011, 19% of people used improved sanitation, 6% used shared sanitation, 22% used unimproved sanitation, and 53% practiced open defecation (JMP 2013).

Interestingly, DHS found that improved sanitation coverage was much lower in 2011. According to the 2011 DHS, 6.6% of households employ improved latrine, 2.8% use a shared latrine, 45.5% used an unimproved pit latrine, and 44.8% of households practiced open defecation in fields or bush (DHS 2012). These differences in reported improved sanitation coverage are likely due to the fact that JMP and DHS's working definitions of improved sanitation differ. The JMP defines improved sanitation as *those toilets that ensure the hygienic separation of human excreta from human contact* (Rosemarin 2008). This definition may overestimate the improved sanitation coverage because the JMP's definition does not include a clause about containment of raw feces specifically, just separation from human contact (Rosemarin 2008). DHS classifies latrines without a concrete slab as unimproved, while JMP might classify these latrines as improved (Rosemarin 2008). Composting toilets, considered an improved sanitation option by both organizations, are used by approximately 3.5% of households in Ethiopia (DHS 2012, Rosemarin 2008)

Regardless of these discrepancies in total coverage, the fact remains that *at least* 81% of Ethiopians utilized unimproved or no sanitation in 2011 (JMP 2013). It is clear that there is a lack of adequate sanitation coverage in rural Ethiopia.

1.4. Health Effects of Poor Sanitation Coverage

This lack of sanitation contributes to the burden of disease in Ethiopia. The pathogens and parasites in human excreta are responsible for a variety of diseases (Pruss et al. 2002). The World Health Organization estimates that 154 deaths per 100,000 people and 4,967 DALYs per 100,000 people were attributable to diarrheal disease in Ethiopia in 2004 (WHO 2014). 16.2% (5,928,500/36,594,800) of the total burden of disease (in DALYs) and 14.9% of all deaths (160,800/1,080,200) in Ethiopia in 2004 were attributable to water, sanitation, and hygiene (WASH) (WHO 2014). All cases of diarrheal disease were included in these estimations; a fraction of intestinal infection, malnutrition, trachoma, schistosomiasis, and lymphatic filariasis cases were also included (WHO 2014). There is evidence that interventions which aim to improve excreta disposal methods via introduction of latrines or increased adoption of latrine usage are effective in the prevention of diarrheal and other WASH related diseases (Clasen et al. 2010, Fewtrell et al. 2005).

1.5. Ecological Sanitation

1.5.1. Conventional sanitation options

Traditional sanitation options include drop and store pit latrines and flush and discharge sewer systems (Esrey et al. 2001). These sanitation options can have a number of pitfalls. Drop and store latrines generally include deep pits, which cannot be easily utilized in areas with rocky or sandy soils because the soil type can make them difficult to excavate or prone to collapse (Winblad et al. 2004). The deeper pits can also lead to ground water contamination in areas with a high water table since the deeper pit can allow excreta to leach into the water table if they are proximate (Hailu 2010, Winblad et al. 2004). Deeper drop and store latrines can be costly to build, since a professional is generally hired to dig the deeper pit (Esrey et al. 2001). Finally, drop and store latrines can also become wet breeding grounds for flies and odors since nothing is added to dry the excreta (Hailu 2010, Morgan 2005).

The other traditional sanitation option, flush and discharge systems, can be costly to build and maintain; they require large water inputs as well (Langergraber et al. 2004, Winblad 2000). They can pollute the environment when the sewage is not fully treated before being discharged into waterways, which occurs in many areas of the world including the United States (Winblad 2000). Both of these sanitation methodologies are linear sanitation systems, which simply remove excreta from the environment; these systems do not recognize and utilize human excreta as a resource (Langergraber & Muellegger 2004, Winblad et al. 2004).

1.5.2. What is eco-san?

Ecological sanitation (eco-san) is a more holistic and interdisciplinary approach to sanitation. It can be used as an alternative to the conventional sanitation options of pit latrines and sewer systems (Esrey et al. 2001, GTZ 2002). Eco-san provides sanitation and utilizes sanitized human excreta in agriculture in such a way as to maximize benefits to people from composted waste and minimize risks to human health and the environment that human waste often presents if not contained (Morgan 2001).

Eco-san promoters aim to use sanitation to help solve a number of different societal problems (Esrey et al. 2001). Use of eco-san can address the immediate issues caused by lack of sanitation access including WASH related morbidity and mortality. Eco-san interventions should prevent disease and promote health (Esrey et al. 2001, Hannan et al. 2002, Winblad 2000). Promoters also aim to change the paradigm of how we think about and handle human excreta in order to address the issues of environmental degradation and flagging soil fertility (Esrey et al. 2001). Eco-san interventions aim to recover and reuse the nutrients and organic matter found in human excreta (Esrey et al. 2001, Hannan & Andersson 2002, Winblad 2000). Usage of eco-san can also mitigate some of the larger societal and international issues caused by inadequate or unsustainable sanitation including environmental pollution and water scarcity (Esrey et al. 2001, Morgan 1998a). Accordingly, comprehensive eco-san interventions should consider how to best protect the environment and conserve of water (Esrey et al. 2001, Hannan & Andersson 2002, Winblad 2000).

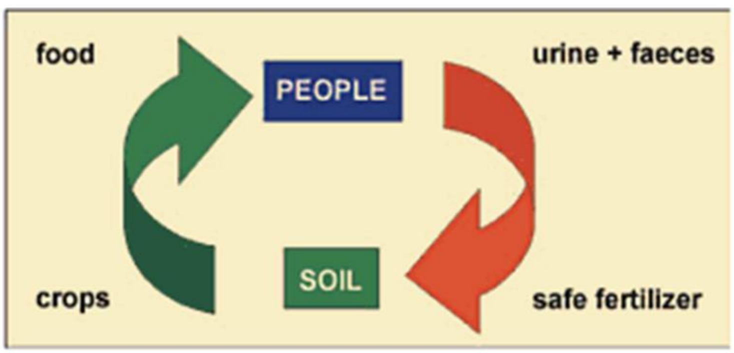
Eco-san approaches should also meet the criteria of affordability, acceptability, and simplicity (Winblad et al. 2004). Langergraber et al. state,

> "The EcoSan approach is resource minded and represents a holistic concept towards ecologically and economically sound sanitation. The underlying aim is to close (local) nutrient and water cycles with as less expenditure on material and energy as possible to contribute to a sustainable development "(Langergraber & Muellegger 2004).

Eco-san promoters seek more cost effective sanitation options that are both feasible and appropriate to the setting (GTZ 2002). For example, modular, decentralized eco-san systems are available for rural areas and low cost systems are available for low resource settings (GTZ 2002). The eco-san system can also contribute to lowering household costs because the compost can be used for agriculture, which could offset other agricultural input costs (Langergraber & Muellegger 2004).

Eco-san works to accomplish these six goals by turning the linear system of food production, consumption, and finally disposal of excreta (and associated nutrients) into a sustainable closed loop cycle (Figure 1). This closed loop ecosystem approach recognizes the value of human excreta as a resource that can be recycled and utilized instead of being discarding through a piped water system or in a pit that goes unused (Esrey 2000).

Figure 1: Closed loop eco-san cycle (Schönning et al. 2004)



1.5.3.Eco-san and health

Use of eco-san can prevent disease and promote health. Ecological sanitation sanitizes excreta on site through decomposition or desiccation treated to remove pathogens and parasites before it is released into the environment (Winblad et al. 2004). If done correctly, this reduces the introduction of pathogens into the water cycle and decreases the resultant prevalence of fecal-oral disease burden (Esrey et al. 2001, GTZ 2002, Were 2007). Additionally, eco-san toilets are generally dryer than traditional latrines, which means they are less likely to be breeding grounds for flies that can spread disease (Morgan 2005).

However, use of eco-san requires households to have a deeper understanding of hygiene and the process of composting in order to safely and correctly utilize the intervention in a manner that allows the household to reap the compost benefits without causing damage to household members or the environment. Eco-san interventions require practice of hygiene behaviors such as added ash after defecation and while handling compost in addition to traditional hygienic practices such as hand washing (Hailu 2010). A good eco-san program recognizes and minimizes the dangers to health that the pathogens and parasites in human waste present in order to safely use the resources, including soil nutrients and organic matter, that can be gained through utilization of Eco-san (Dagerskog et al. 2014).

1.5.4. Eco-san and waste recycling

Eco-san promotes the onsite recycling of human waste in order to use the nutrients in human excreta for agricultural purposes (GTZ 2002). Morgan states of eco-san, "It creates a valuable resource that can be productively recycled back into the environment. Over time, through proper management and storage, excreta is transformed from a harmful product into a productive asset" (Morgan 2005). More specifically, eco-san promoters aim to reuse the nutrients and organic matter that were taken from the soil in the form of agricultural crops by hygienically recycling human excreta in order to use it to fertilize agricultural crops thus completing the closed loop system (Figure 1) (Langergraber & Muellegger 2004, Winblad 2000, Winblad et al. 2004). This closed loop cycle helps to improve agricultural sustainability by stemming the loss of nutrients and organic matter from soil and returning the nutrients that were lost in agricultural production of food back to the soil (GTZ 2002). Returning nutrients and organic matter to soil in the form of compost can increase soil fertility and agricultural productivity (Esrey et al. 2001, Winblad 2000). If eco-san is utilized to its full potential it can increase food yields or allow for production of novel crops, which can potentially increase nutrient variety or caloric availability; in these ways, eco-san has the potential to help improve nutrition status and even address food security issues in some cases (Esrey et al. 2001, GTZ 2002).

1.5.5.Eco-san and the environment

Eco-san can minimize adverse environmental impacts caused by both lack of sanitation and other conventional sanitation systems (Esrey et al. 2001). Eco-san promoters aim to prevent pollution of the environment through sanitization and recycling of excreta on site (Langergraber & Muellegger 2004, Winblad et al. 2004). With conventional sanitation options, excreta is simply discarded; this can cause to pollution of the environment, which must then be controlled (Winblad et al. 2004). Treatment of waste on site can decrease the possibility of environmental pollution from waste such as dumping untreated sewage or excreta on a smaller scale into waterways (Esrey 2000, Esrey et al. 2001, GTZ 2002). Using eco-san can get excreta out of the water ways, which is a major benefit to water quality (Esrey et al. 2001, Morgan 2005). Eco-san toilets also conserve water as compared to sewer systems, which require large inputs of water for use (Esrey et al. 2001, GTZ 2002, Morgan 2005, Zhou et al. 2008). However, this is less relevant in the low income rural setting this evaluation examined. The other available sanitation options, pit latrines, also require no water for use.

1.5.6.Types of eco-san

There are two basic types of ecosan toilets. The urine diversion toilet separates the urine and feces during use; the urine is used as fertilizer, and the feces are desiccated (dried) until they turn into humus, which is then used for agricultural purposes as well (Esrey et al.

2001). Non-urine diverting toilets compost urine and feces together by utilizing a moist decomposition system to make compost, which is used for agricultural purposes once (Esrey et al. 2001). The arborloo is a type of eco-san, which utilizes decomposition of excreta to make compost. The arborloo will be discussed further below.

1.5.7.Eco-san improves soil quality and yields

Human excreta, which contains much of the nutrients taken from the soil in the form of harvested plants, is not often considered as an option to address this environmental issue (Dagerskog et al. 2014). However, eco-san can be helpful in addressing these soil fertility and degradation issues. Most of the nitrogen, phosphorus, and potassium (NPK) in excreta, nutrients which are so important to soil, pass through the body during digestion and are excreted (Dagerskog et al. 2014) Use of composted excreta can both renew and maintain topsoil and restore nutrients to the soil which can increase crop growth (Esrey et al. 2001).

Ecological sanitation puts nutrients and organic matter back into the soil, which can improve soil quality. Most of the nutrients in excreta come from urine but feces are also valuable as a soil additive to improve soil consistency and add organic matter and carbon to depleted topsoil (Figure 2).

Figure 2: Nutrients and organic matter found in human excreta (Esrey 2000)

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

The compost generated from the arborloo looks like normal soil, but it has many benefits to the soil it is added to. The foremost benefit of compost is that it returns the nutrients to soil that were lost in sustained agricultural usage. One experiment found that crops fertilized with combined excreta generally contained 8 times more NPK nutrients than other topsoil in Zimbabwe (Figure 3).

Figure 3: Nutrient level comparison between unenhanced topsoil and ecological sanitation (Fossa Alterna) compost in Zimbabwe (Winblad et al. 2004)

Source of soil	N (mg/kg)	P (mg/kg)	K (mg/kg)
Natural dryland topsoil	38	44	192
Fossa Alterna soil	275	292	1763

Increased nutrients in soil improve plant yields. Winblad notes that crops that are fertilized with compost produce 4-10 times the yield as compared to crops planted in poor quality, unfertilized soil (Figure 4). Ecological sanitation improves crop yields by significantly reducing soil and therefore crops' nitrogen stress (p-value $< 2.2 \times 10^{-16}$). When nitrogen stress was decreased via usage of eco-san maize yields increased by 12% in Andersson's South Africa study (Andersson et al. 2013).

Figure 4: Crop yield comparison between crops grown in unenhanced topsoil and crops grown in an even mixture of topsoil and compost from a fossa alterna, another ecological sanitation option in Harare, Zimbabwe (Winblad et al. 2004)

Plant – *Top soil type* – Growth period	Weight at cropping (top soil only) *grams*	Weight at cropping (50:50 top soil:FA* soil) *grams*
Spinach – *Epworth* – 30 days	72	546
Covo – *Epworth* – 30 days	20	161
Covo 2 – *Epworth* – 30 days	81	357
Lettuce – *Epworth* – 30 days	122	912
Onion – *Ruwa* – 4 months	141	391
Green pepper – *Ruwa* – 4 months	19	89
Tomato – *Ruwa* – 3 months	73	735

*FA denotes soil taken from Fossa Alterna pits.

While returning nutrients to the soil is compost's most obvious benefit, compost also improves soil structure, improves soil and plant's pest resistance, and increases a soil's ability to moderate temperatures (Esrey et al. 2001). Furthermore, microorganisms in compost can neutralize toxins and heavy metals and continue to break up organic matter in the soil it is added to in order to release additional available nutrients for plants over time (Esrey et al. 2001).

Finally, compost also improves a soil's water holding capacity and prevents soils from drying out (Esrey et al. 2001, Winblad et al. 2004). By decreasing soil and crops' nitrogen stress, eco-san can improve a crop's water productivity or ability to fully exploit the moisture that is available in the soil. This is particularly relevant in areas where droughts occur. Therefore, eco-san has the potential to be beneficial in many water-stressed areas as a way to improve yields without increasing water inputs (Andersson et al. 2013). In more extreme scenarios, humus enriched crops can survive drought when other plants perish, which can help families through periods of food scarcity due to droughts (Winblad et al. 2004).

1.5.8.Eco-san fills a fertilization gap

Declining soil fertility and soil degradation are issues in much of Sub-Saharan Africa, where 38% of total agricultural land has been degraded since WWII (Henao et al. 1999). Henao and Baanante (2006) stated that in the period from 2000-2004, 85% of farmland had losses of 30 kg nutrients / hectare / year or more (Dagerskog et al. 2014). Nutrients are lost from natural and man-made causes including erosion, leaching, volatilization, and farming, which pulls nutrients from the soil into plants for human or animal consumption (Dagerskog et al. 2014). Eight million tons of nitrogen, phosphorous, and potassium (NPK) macronutrients are lost every year in Africa (Henao & C. 1999).

Steps have been taken to address nutrient and soil loss through conservation and addition of animal manure and fertilizers in some cases. While chemical fertilizer can increase crop growth, it does not replace or renew the topsoil itself (Winblad et al. 2004). Additionally, synthetic fertilizers are not a sustainable option for improving crop yields, since they are made from non-renewable resources, pollute waterways, and contribute to climate change (Esrey et al. 2001, Langergraber & Muellegger 2004, Winblad et al. 2004) Additionally, rock phosphate is a non-renewable source of phosphate additions to chemical fertilizers whose reserves are dwindling quickly; rock phosphate reserves will be depleted within 100 years or sooner if fertilizer use and population increases continue at the same pace (Cordell et al. 2009 in (Lines-Kelly 2010). Compost can revitalize soil and reduce overall need for synthetic fertilizers though this fertilization method should likely be used in concert with others in Sub Saharan Africa (Andersson et al. 2013).

Where synthetic fertilizer is used in large quantities to improve soil fertility, use of compost instead can offset the costs of purchased chemical fertilizers if enough compost is available (Smet 2007, Zhou et al. 2008). Utilizing eco-san compost instead of purchased fertilizers can provide cost savings to farmers (Winblad et al. 2004). One study examined the cost savings of using composted excreta instead of purchased fertilizer and found that farmers saved $90 USD per 1000 square meters per year by using the composted excreta (Winblad et al. 2004).

However, in Sub-Saharan Africa smallholder farmers' usage of synthetic fertilizer to improve soil fertility and crop yields is currently quite low due to financial restrains (Andersson et al. 2013). Additionally, a study on yield improvements with eco-san technologies in South Africa found that, while use of eco-san compost improves yields, the output of eco-san cannot supply the nutrient demands alone. The study found that eco-san can supply enough phosphorus and nitrogen to fully meet the nutrient demands of about half a hectare of agricultural land per person- year (Andersson et al. 2013). Where there is not enough compost to fulfill demand for soil fertility additives, composted excreta can be used in concert with fertilizers and animal manure to achieve higher crop yields (Dagerskog et al. 2014). This applies to in smallholder famers in sub-Saharan Africa. Both the use of fertilizer and composted excreta should be used to in concert to fill the fertilization gap.

1.5.9.Eco-san has the potential to impact food security via increased yields

Eco-san can improve soil quality and therefore improve yields, which can, in turn, impact food security (Esrey 2000, Esrey et al. 2001). The amount of compost one individual produces per year is about 5kg of nutrients. Since the extra nutrients harvested per kilogram of compost applied is around 10 times higher than normal soil yield in Sub-Saharan Africa, recycling human excreta could potentially increase the output of cereal crops by 50kg / year. This would cover the nutrient requirements for one individual for 71 days (assuming 3500 kcal/kg cereals and 2500kcal daily energy intake). This figure is not insignificant; it could have a positive impact on an individual's food security (Dagerskog et al. 2014).

A limitation of eco-san, in terms of its ability to address food security, is that a relatively small amount of compost will be produced each year (Winblad et al. 2004). However, as more humus is produced via eco-san toilets over time, larger percentages of a family's crops can be enriched, which can help improve a family's food security (Winblad et al. 2004).

1.6. Risks and Challenges Associated with Eco-san

1.6.1. Achieving complete decomposition in eco-san composting

Almost all pathogens in excreta are located in the feces (Pruss et al. 2002). Using a risk management approach, the WHO created guidelines for the safe use of excreta in agriculture. Their risk assessment found that composting fulfills the criteria for acceptable risk reduction (WHO 2006). Composting decreases the number of pathogens in excreta through decomposition during which the organic substances present are mineralized and turn into composted material (Winblad et al. 2004).

There are a number of factors that influence a pits' decomposition rate and pathogen destruction. Increasing pH levels are critical to pathogen destruction; higher pH levels can be achieved with the addition of ash, urine, and soil (Schönning & Stenström 2004, Torondel 2010, WHO 2006, Winblad et al. 2004). Higher temperatures can also improve decomposition; addition of leaves and other organic matter can help to increase temperatures (Winblad et al. 2004). Storage time of the composting material is quite important to achieving safe levels of decomposition (Winblad et al. 2004). For eco-san systems that rely on mixed excreta decomposition, moisture levels between 50 – 60% are ideal for optimal decomposition; the addition of ash and organic matter such as soil, ash, and leaves after usage can aid in drying the mixture to these levels (Winblad et al. 2004). The ratio of carbon (feces and additives such as soil and leaves) to nitrogen (urine) in the pit is also important to decomposition of the pit contents (Winblad et al. 2004). Aeration of the composting material by allowing oxygen into the pit contributes to decomposition as well (Winblad et al. 2004). Maintaining competition amongst the micro-organisms in the pit, which helps balance pathogen destruction with pit decomposition, is also important to the composting process (Winblad et al. 2004). Other factors that can contribute to composting include pit size and the surrounding soil characteristics (Torondel 2010).

The most practical way to improve excreta composting and pathogen/parasite die off in low resource settings is increasing the pH of decomposing matter, since this can be achieved with the addition of ash, which is generally readily available (Esrey et al. 2001, Were 2007). It is more difficult to control and monitor the other factors that impact excreta composting rates, such as temperature and moisture levels, in order to maintain optimal levels for pathogen/parasite dye off in low resource settings, though the above strategies can be helpful (Esrey et al. 2001, Were 2007).

1.6.2.Pathogen and parasite die -off estimates

Pathogens and parasites will die off with effective excreta composting, but different pathogens and parasites do so at various rates. The most influential factors in achieving complete pathogen destruction are high pH and length of storage time before use. The rate of die-off has been shown to vary from study to study as well, which is not unexpected since there are so many inputs such as pH, moisture levels, temperature, and etc. that impact excreta composting rates. However Peasey states, "With the regular addition of the appropriate absorbent, for example ash or lime, the recommended storage time prior to re-use of the faeces pile however varies from 3-12 months depending on the study" (Peasey 2000).

A WHO report found that ascaris eggs will die off in feces after 4 months (WHO 2006). A Vietnam study found bacterial pathogen die-off to be 37 days with a pH level of 9.5-10, the same study reported die-off of ascaris eggs to be 65 days (Were 2007). In another study, which took place in Kenya and Zimbabwe, 6 months were needed for complete pathogen and ascaris egg destruction even with high pH levels (Were 2007). Endale found that complete removal of fecal coliforms and ascaris eggs were achieved after 40 days of ash treated feces storage (Endale et al. 2012). In another study, complete inactivation of parasite eggs was achieved after 30 days in a high pH environment (Endale et al. 2012).

If excreta is excavated and applied to soil, Mara and Cairncross (1989) suggest that levels of <1 nematode egg per kilogram and <1000 fecal coliforms per kilogram be the safety cut off; these are the same guidelines that are applied to wastewater (Peasey 2000). The amount of treatment required is also dependent on the health of the users and the pathogenic load of the excreta itself (Winblad et al. 2004). Since one-third of people in developing countries are infected with intestinal worms, it is more critical to achieve effective pathogen die-off (Chan 1997).

A South African study looked at the dangers to human health if eco-san materials applied to soil without being completely free of pathogens. In this study eco-san sludge that contained pathogens was applied directly to soil while plants were growing. The sludge was applied at various rates from 0 to 35 tons per hectare (Jimenez et al. 2006). While other present pathogens died off, helminth eggs remained, though their viability was only 20-25%. It was found that helminth ova concentration was greater in leaves than in soil, which lead the scientists to believe that the eggs attached preferentially to the plants over soil (Jimenez et al. 2006). Jimenez calculated the health risks that would result from crop consumption. No risks of salmonella were found for consumption of carrots. For consumption of spinach, salmonella risks were inconclusive. Morbidity risk from helminthes was elevated by 9% by consumption of vegetables (Jimenez et al. 2007). While composted excreta is not the same as sludge, this study indicated that if arborloo excreta is used before 1 year of composting, it would be safest to plant crops on the arborloo that have no contact with soil (fruit trees) or that are cooked to eliminate risk to those consuming the vegetables (Jimenez et al. 2006).

1.6.3.Acceptability of using human waste

There is some historical and contemporary precedent for use of human excreta in an agricultural context both internationally and in Ethiopia specifically. Faecophilic cultures exist in China and Vietnam, where use of human excreta in agriculture is a long standing practice (Lines-Kelly 2010). In Ethiopia the FAITH (Food Always in the Home) program, a household level vegetable growing program, utilized composted human excreta (Duncker et al. 2007). Outside of Ethiopia, the arborloo design builds on a tradition of planting trees on old latrine pits in countries such as Kenya, Malawi, India, and Rwanda (Morgan 2001). This practice has spread, via the arborloo, to other countries including Mozambique, Zambia, and

Zimbabwe (Morgan 2001). Morgan argues that the simple fact that this method is being practiced by individuals means that it is acceptable to the users (Morgan 2001).

While there is some precedent for use of composted excreta in an agricultural context, the emotion of being disgusted by feces is fairly common worldwide, and some religions and cultural groups have more defined taboos against touching feces. People or cultural groups who are disgusted by feces are faecophobic (Lines-Kelly 2010). Taking a cultures' beliefs about feces into account and working within that cultural context is very important in an ecological sanitation intervention (Lines-Kelly 2010).

It is important to differentiate between the practice of planting on the pits and the actual consumption of the trees' products (Duncker et al. 2007). A number of studies have examined participants' feelings on consumption of agricultural products grown on human excreta. The majority of people interviewed in one South Africa survey (78%) said they would eat the food grown with composted human excreta, however none of the participants had actually used the composted excreta on their gardens at the time of the survey (Duncker et al. 2007). Similarly, a Ghana study found that there was a negative attitude towards handling excreta and this influenced their willingness to use excreta on crops or eat crops that were fertilized with composted excreta even though people acknowledged that excreta could be used as a fertilizer (Mariwah et al. 2011). In a study on ecological sanitation as part of a Rosa (Resource-Oriented Sanitation concepts for peri-urban areas in Africa) Project in Arba Minch, Ethiopia, 92.5% of respondents reported they felt that reuse of human excreta was acceptable (Hailu 2010).

1.7. The Arborloo

The arborloo is an eco-san approach, which is designed to utilize composted material for tree planting; Peter Moran developed the design in Zimbabwe in 1998 (Morgan 1998a). It is an inexpensive sanitation option ($5USD) that can be built in half of a day (Morgan 1998a, Simpson-Hebert 2007). It is one of the most affordable and easy to construct latrine options; therefore, arborloos are appropriate for low resource settings, such as rural Ethiopia. (Esrey et al. 2001, Winblad et al. 2004). The arborloo can be an entry point to sanitation since it is an inexpensive, easy to construct sanitation option that does not require a lot of behavior change for adoption (Morgan 1998a, Simpson-Hebert 2007). Morgan states,

> "An Arborloo is the simplest of all eco-san latrines designed because it requires the least amount of behaviour change. Many families tend to build this type of latrine first, when they are convinced of eco-sanitation. This creates a demand of fruit seedlings among households. For most the *Arborloo* is the entry point for ecological sanitation" (Morgan 2005).

Elimination of these barriers to acquiring household sanitation has the potential to increase the rate of rural sanitation adoption in Ethiopia, which could in turn decrease the burden of WASH related disease (Simpson-Hebert 2007).

The arborloo's components include a household-dug pit, a ring beam to protect the pit, a concrete slab, and a superstructure (Morgan 2004b). The slab can be made on sight by artisans or purchased by households from CRS or other suppliers. Since the arborloo design necessitates the latrine's movement, the latrine slab must be small and light and the superstructure must also be portable or easily replaceable; furthermore, a small slab dictates a narrow latrine pit (Morgan 1998a). The ring beam, which is currently not used in

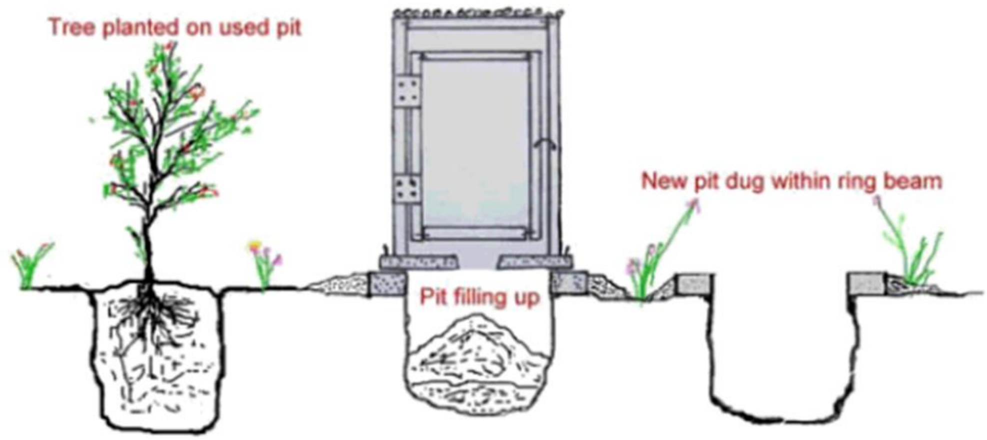
CRS Ethiopia programming, is made of bricks or stones and home-made mortar or cement. The stones or bricks are mortared together in a circle, and the pit is dug inside of the ring beam once they are dry (Figure 5). Soil is then mounded against the ring beam to provide further protection from flooding. The ring beam effectively raises the pit and slab above ground level, and it is very beneficial in areas that are flood prone or that experience heavy rains (Morgan 1998a). It also provides support for the slab and can keep the arborloo from collapsing in areas with weak soils(Morgan 2004b, 2007a).

Figure 5: Making an arborloo ring beam (Morgan 2007a)

The concrete ring beam is being molded between two brick circles, and reinforced with wire.

Before the arborloo is first used, a layer of leaves, ash, and/or soil is placed in the pit, and the same components are added after each use to accelerate composting and reduce odor and flies (Morgan 1998a, 2007a) . Once the pit is two thirds full, which generally occurs every 6 months to a year since the pit is smaller, a thick layer of soil is applied and a fruit tree is planted on the nutrient rich pit, which has been shown to aid in tree growth (Morgan 2004b, 2007a). The household digs another arborloo pit once the first one is filled, and the concrete slab and superstructure are moved to the new pit (Morgan 2004a). This process is repeated as pits are filled (Figure 6).

Figure 6: The life cycle of an arborloo (Morgan 2007b)



1.7.1.Design can be used in difficult to reach areas

The Arborloo utilizes decomposition to remove harmful pathogens from excreta before usage. (Morgan 2005). Since arborloos have shallower pits (maximum 1.5 m depth) and the excreta is composted relatively quickly (usually 3-4 months) they have a lower risk of groundwater contamination, (Esrey et al. 2001, Winblad et al. 2004). The arborloo is also a good option in areas where soils are rocky or sandy or where the water table is high, these conditions make conventional deeper pit latrine designs difficult to dig and maintain safely (Morgan 2005, Simpson-Hebert 2007). The arborloo can also be utilized in water scarce areas both as an option that does not require water and in order to improve crop resiliency to drought (Esrey et al. 2001). To decrease the water burden the planting of seedlings on the arborloo pit might place on water scarce areas, gray water can be used to water the arborloo seedlings as well. Simple precautionary steps can be taken to mitigate risks associated with gray water use; these include: application to soil instead of sprinkling on plants, use on crops including trees where stems and roots are not eaten directly, and not using grey gray water on vegetable crops directly before harvesting (Winblad et al. 2004).

The arborloo meets the criteria for ecological sanitation because it provides a low cost sanitation option that can decrease open defecation and the associated environmental pollution and allows waste to be recycled for reuse in agriculture (Morgan 1998a). However, this ecological sanitation intervention is better suited to rural environments, since space is required for movement of the arborloo to new pits. However, there is potential for its success in peri-urban environments if there is adequate space (Esrey et al. 2001). Other ecological sanitation options are better for urban environments, these include the skyloo and the fossa alterna (Esrey et al. 2001).

1.7.2. Increased soil fertility and crop yield with the arborloo

In addition to providing a sanitation solution, the arborloo is designed to promote tree planting. This is environmentally beneficial on the global and local scale, especially in areas where deforestation is an issue as is the case in some of the surveyed areas (Morgan 1998b). Fruit trees that have been proven to thrive on the arborloo pits (given enough moisture) include avocado, mulberry, guava, mango, paw paw, banana, citrus, eucalyptus, and ornamental trees (Ogunyoku 2008). Vegetables such as tomatoes and pumpkins as well as non-fruit trees have also been proven to grow well on the arborloo pits (Morgan 2007a). Trees do the best when they are planted prior to the rainy season (Ogunyoku 2008). Trees and vegetables that are planted on the arborloo do better because the arborloo compost provides more nutrients than normal unenhanced topsoil (Figure 7).

Figure 7: Nutrient comparison between unenhanced topsoil and arborloo pit soil in Zimbabwe (Ogunyoku 2008)

Soil source	pH	N*	P*	K*	Ca*	Mg*
Local topsoils (mean of 9 samples)	5.5	38	44	0.49	8.05	3.58
Arborloo (one yr. after tree planting. N=2)	5.95	111	309.5	0.95	11.07	5.1

Nitrogen (N) and Phosphorus (P*) are expressed as ppm and Potassium (K*), Calcium (Ca*) and Magnesium (Mg*) as ME/100g (Source: Morgan, 2003)

1.7.3.Using the arborloo's increased crop yields to motivate sanitation

Improved crop production can be a motivating force for sanitation adoption. Sugden states, "There are naturally still doubters, but it has been found that once they have seen how well a Papaw sapling grows in an Arborloo latrine pit, they are soon converted and become advocates for eco-sanitation themselves"(Sugden 2006). Presenting the potential for agricultural benefits of a composting latrine in sanitation education has been successful in interventions in Burkina Faso, Niger, and Ivory Coast (Dagerskog et al. 2014, Dankelman et al. 2009, Sugden 2006). However, work is needed to educate people on the agricultural benefits of the arborloo. Province states, "The Arborloo was well received by Masiyarwa residents, the main perception being as a social solution to their sanitation problems, and to a lesser extent as a composting toilet." (Province 2009).

1.7.4.Income generation

Arborloos offer a potential added economic value in the form of rich compost and healthy, higher yield crops (Morgan 2009). The arborloo's agroforestry benefits can help households by providing fruit, a marketable good that can be sold or eaten (IFAD 2008, Mara 2008). Fruit tree planting was found to be extremely lucrative in a pilot program in Cameroon. The pilot was focused on tree domestication alone instead of ecological sanitation; however, the income generated, improvements in nutrient rich food availability, and improved status of women who participated within the household could have similar implications for arborloo programs (IFAD 2008).

1.7.5.Women's empowerment

The arborloo can help to empower women. Province states,

> "The Arborloo was perceived as a 'technology for women' in Masiyarwa since widows managed to dig the meter-deep pit, and have been operating their Arborloos without men's assistance, as was the case with VIPs. Women were boasting that a technology that considers women's plight and targets women is definitely bound to succeed" (Province 2009).

The arborloo can help women to take charge of sanitation for their household since this latrine can be constructed more easily than other designs (Morgan 2007a). Furthermore, home gardens are often the responsibility of women, and if crop yields increase it can provide additional income which could improve gender equity (Esrey 2000). Women in a South Indian study expressed appreciation for the arborloo's ability to be used for planting (Dankelman & Advice 2009).

On a somewhat separate note, women reported liking the arborloo design because it can be build close to their homes (Dankelman & Advice 2009). The arborloo can provide more privacy to women as compared to utilization of open defecation.

1.7.6.Cost effective sanitation option

Arborloos are cost effective (Figure 8). They have lower investment costs initially than pit latrines or VIP latrines since the slab is smaller and cheaper and no hired labor required (Morgan 2005, Smet 2007). They also have lower operations and maintenance costs than other latrine options. While other latrine options may require emptying or have associated replacement or even medical costs if the deeper pit collapses, the only maintenance costs associated with the arborloo are replacement of the slab or superstructure materials (Evans et al. 2009, Smet 2007, Zhou et al. 2008). Pit collapse is less costly and dangerous with the arborloo since the pit is shallow, and households can dig the arborloo pit themselves (Morgan 2005, Smet 2007).

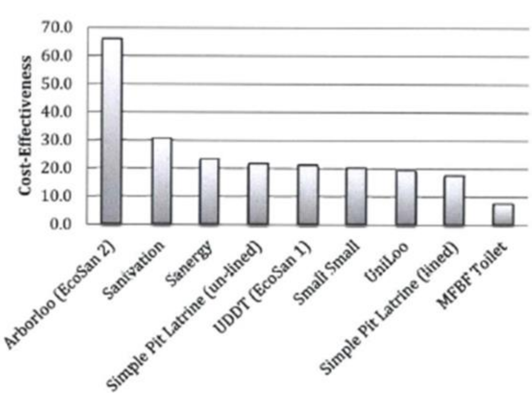
Figure 8: Cost Effectiveness of Latrine Technologies (10=High Level of difficulty, 0=Low level of difficulty) (Questad 2012)

$$Cost - Effectiveness = \frac{(Maximum\ Difficulty\ Points - Technology\ Difficulty\ Points)}{PV\ (costs)(GHS)} * 1000$$

$$Maximum\ Difficulty\ Points = 12$$

The Ratio was multiplied by 1000 to create a more manageable value

	Pit Required?	Construction Difficulty Level	Waste Disposal Difficulty Level	Cultural Conflict with Waste Handling	Frequency of Pit Emptying	Difficulty Points	PV (Costs) (r=0.03) (GHS)	PV (Costs) (r=0.03) (USD)	Cost-Effectiveness
Arborloo (EcoSan 2)	YES	3	1	NO	10	19	318	175	66.1
Sanivation	NO	0	0	NO	0	0	1304	717	30.7
Sanergy	NO	0	0	NO	0	0	1700	934	23.5
Simple Pit Latrine (un-lined)	YES	6	6	YES	2	24	731	401	21.9
UDDT (EcoSan 1)	NO	4	3	YES	2	14	1220	670	21.3
Small Small	YES	1	3	YES	2	16	1179	648	20.4
Uniloo	NO	0	0	NO	0	0	2047	1125	19.5
Simple Pit Latrine (lined)	YES	7	6	YES	2	25	843	463	17.8
MFBF Toilet	YES	6	3	YES	5	24	2069	1137	7.7
YES = 5 points, NO = 0 points									



The arborloo is a good sanitation option because it is cost effective. It is cheap to construct and maintain, and the barrier to use are low. The pit is easy to construct, the waste is easily disposed of and does not need to be handled. It is more time consuming to maintain, since the structure and pit must be moved often, but this cost is outweighed by the many benefits of this design. It also has the added benefit of providing compost for use in planting which is not considered in this cost benefit analysis.

1.7.7. Reported challenges of arborloo implementation and sustainability from other study areas

There are a number of possible challenges and potential health risks that households could face during arborloo implementation or usage. A challenge that faces arborloo implementers is ensuring that households correctly manage their arborloo to safely compost the excreta and prevent fly breeding. The arborloo promotes composting through the additions of ash (increases pH), urine (increases nitrogen content), and carbon rich materials such as feces, leaves, and soil (increases the pit's temperature) (Jönsson et al. 2004). While composting is generally effective with the arborloo design, there can be health risks if it is not managed or maintained correctly; this primarily includes adding ash and other carbon rich materials to the arborloo pit after each use.

An arborloo pilot project in Brazil found that participants were not adding ash or sawdust as taught during training, which caused flies and bad odors around the arborloos (Galbiati et al. 2007). This challenge also occurred in Malawi (Lungu et al. 2008). There are a number of possible reasons for this breakdown in arborloo maintenance. For example, the ROSA project in Arba Minch found that households might not want to move their pit more than once every two years. The implementers felt that this sentiment could cause improper application of low amounts of soil and ash to prevent the toilet from filling up as quickly ("Arba" 2009). Province notes,

> "Low technical sensitisation was apparent from observation at most of the households. This was evidence that the soil, ash, and leaves mixture was not being applied after each toilet visit. New technologies should be easy to understand and operate. The moment it poses challenges and complications for the intended beneficiaries, then the tendency is for them to develop a negative perception and, thus, shun it" (Province 2009).

In Brazil, the training was repeated to combat this issue, and better adoption of hygiene and usage techniques were seen after the second training (Galbiati et al. 2007).

Other management issues that may or may not be tied to improper addition of soil and ash are movement of the arborloo pit when needed. In Malawi, households found the frequent movement of the arborloo pit and the safe handling of excreta when applicable to be a challenge (Lungu et al. 2008). In the ROSA project, implementers were concerned that a lack of seedling availability and seedling death could cause underutilization of the composted excreta ("Arba" 2009). These issues have the potential to limit the sustainability of arborloo programs.

In the Malawi study, implementers were concerned about the sustainability of the program after donor support ended (Lungu et al. 2008). This has the potential to have large implications for the present CRS arborloo program since the government has a zero-subsidy policy.

2. STUDY BACKGROUND

2.1. CRS Arborloo Intervention Background

CRS Ethiopia completed an evaluation of their sanitation programs in 2004 and found that sanitation coverage remained low in intervention areas (Seremet 2008). Possible reasons for this low coverage were high cost ($60 USD) per conventional pit latrine or ($150USD) ventilated improved pit latrine and difficulty in utilizing these deeper latrine designs in the rocky or sandy soils found in much of Ethiopia (Seremet 2008). Ecological sanitation was recommended as an appropriate sanitation option for rural Ethiopia at the EU Water Initiative Multi-Stakeholder Forum, which was held on October 2006 in Addis Ababa " (Seremet 2008). A memorandum of understanding was signed noting this recommendation at the end of this Forum by the Ministries of Water Resources and Health and Education (Seremet 2008). CRS Ethiopia began promoting the Arborloo in 2004 in partnership with the Global Water Initiative, and CRS has assisted in the construction of over 80,000 arborloos throughout Ethiopia since that time (CRS 2010a, Tolessa 2013).

From 2005 to 2012, the program coupled latrine promotion with Participatory Hygiene and Sanitation Transformation (PHAST), a step-by-step approach in the prevention of diarrheal disease that empowers communities to take collective action to improve their water, sanitation and hygiene (WASH) practices (Simpson-Hebert 2011). The PHAST training was open to all community members. For best results with eco-san adoption, a participatory method that includes women has been recommended (Langergraber & Muellegger 2004). Arborloo demonstration sites were initially constructed near water points to generate interest (Tolessa 2013). CRS implemented the arborloo program through their local partner organizations.

Slabs were distributed free of charge after training completion; however, slabs were not always available to every household who attended the training. Slabs were distributed on a first come first serve basis for those households that had dug arborloo pits, this was done in part to stimulate competition among participants (Tolessa 2013). Seedlings were distributed for free or at a very small cost once yearly, though this varied regionally. The seedlings most often distributed include mango, papaya, avocado, banana and coffee. Seedlings were also available in certain areas through the local government ministry of agriculture or at the local market. Some farmers chose to access seedlings for their arborloos via these channels. Arborloo implementation also focused on working with established community governance structures, health extension workers, and development agents (Tolessa 2013).

In 2012, the Ethiopian government changed its WASH policy to mandate a zero subsidy model. . As a result, households seeking to construct an arborloo must pay the full cost of the slab and seedlings. The cost of a slab produced by CRS partners is 80 Birr (USD 4.30). These changes altered how the program operated, and sanitation marketing was prioritized to increase access to slabs and seedlings for purchase through local marketplaces. These changes could be beneficial to local masons and other private sector groups since subsidies can undermine the market for the sanitation goods such as slabs that these groups produce and sell (Dagerskog et al. 2014).

At this time CRS also changed its sanitation approach to Community Lead Total Sanitation and Hygiene (CLTSH), an intervention strategy based on stimulating a collective sense of shame and disgust around mass open defecation and its negative impact (Kar 2005).

Ethiopia CLTS programming includes a hygiene component. “The CLTSH approach combines the basic principles of Community-Led Total Sanitation with intensive interpersonal communications (such as community Conversation and Family Dialogue) to foster improvements in hygiene practice through problem solving and collective action” (*CLTSH* 2011).

A rapid assessment of CRS’ arborloo programs in east Africa was completed by Paul Herbert in 2010. Among other findings, this assessment found that access to seedlings influences whether or not arborloos are adopted (Herbert, 2010). Focus groups with arborloo users were also held in 2011. Among other findings, participants reported liking the arborloo because of ease of construction, the benefit of being able to use the compost as fertilizer, the slabs durability and portability. They reported breakdown in sanitation via households not digging pits immediately after the old pit was filled. This was attributed to people not being able to purchase seedlings to plant on the old pit immediately (Tolessa 2013). The program also found that utilizing existing community governance structures and the relationships between the Health Extension Workers and CRS animators who living in the villages were effective strategies (Tolessa 2013). A full survey of the program has not been completed previously.

2.2. Current Study Justification and Background

The current research project is nested within a broader collaboration between Emory University (PI: Matthew Freeman, Assistant Professor of Environmental Health) and the partners of the Millennium Water Program in Ethiopia (MWA-E), of which CRS is a member. Emory and MWP-E have been collaborating in Ethiopia since 2009 on monitoring and evaluation of WASH programs.

The Ethiopian government has dictated a zero-subsidy policy for sanitation programs, but 81% of rural residents lacked access to improved sanitation and 14.9% of all deaths in 2004 were attributable to water, sanitation, and hygiene-related diseases. There is a need to understand programmatic implications of these low-cost, zero-subsidy models to ensure equity of access and sustained benefit of these development programs.

While there is a growing body of evidence on sanitation interventions, there is a lack of peer-reviewed literature on the adoption and sustainability of these low-cost ecological sanitation interventions. By identifiying factors that may contribute to the adoption and sustained use of arborloos, we provide evidence for implementation of arborloo interventions in rural areas including Catholic Relief Services' ongoing sanitation programming. By identifiying behavioral, attitudinal and resource-related factors that contribute to the sustained use of arborloos, we provide programmatic evidence for arborloo interventions in rural areas. This is the first study to rigorously assess the arborloo.

This research provided evidence for the effectiveness of the current arborloo intervention in Ethiopia, which is being used to improve programming. Improved programming has the potential to increase rural sanitation coverage, which could decrease the burden of WASH-related disease in Ethiopia.

Evaluation of the adoption and sustained use of the arborloo serves as a way to compare this sanitation option against others. Program implementers can use this knowledge to inform their choice of sanitation option and implementation strategy. Utilizing an appropriate sanitation strategy for the circumstances also impacts sanitation coverage and, in turn, the burden of WASH-related disease.

2.3. Expanded Research Aims and Problem Statement

The primary goal of this study was to **assess the sustained use of arborloos** within Catholic Relief Services' program areas in rural Oromia Region, Ethiopia. Our study examined how households who sustained arborloo use differ from those households who stopped using the arborloo and barriers to arborloo sustainability. By identifiying the drivers of arborloo sustainability, we provide evidence for implementation of arborloo interventions in rural areas.

The secondary goal of this study was to examine the **equity of access to initial program benefits**. By identifiying factors that may contribute to the arborloo adoption in CRS' program areas, we provide evidence for implementation of arborloo interventions in rural areas.

3. MANUSCRIPT

3.1.Abstract

In rural Ethiopia, 81% of the population utilized unimproved or no sanitation in 2011 (JMP 2013). 16.2% of the total burden of disease and 14.9% of all deaths in Ethiopia were attributable to water, sanitation, and hygiene in 2004. In 1999, Peter Morgan developed the arborloo, a low-cost, composting toilet, for use in rural areas with poor sanitation coverage. The arborloo allows users to plant trees on their nutrient rich composted excreta.

CRS began promoting the arborloo in 2004 and has provided 80,000 arborloos to Ethiopian households. We assessed the adoption of the arborloo and sustained arborloo use in CRS intervention communities. We collected 690 household surveys and conducted 24 key informant interviews and 33 in depth interviews.

The arborloo had high rates of adoption in study areas. CRS reached 462 (67.0%) of surveyed households. We found strong evidence that arborloo usage was sustained. Of the 462 households who ever had the arborloo, 352 (76.2%) had sustained arborloo use at the time of the survey. Sustainability was most strongly associated with use of the arborloo pit for planting, male head of household having some education, receipt of a cement slab, and socio-economic status.

3.2.Key Words

Adoption, Arborloo, CRS, Ecological Sanitation, Ethiopia, Sustainability

3.3. Introduction

3.3.1. Sanitation gap

An estimated 2.5 billion people (about 36% of the world's population) did not have access improved sanitation facilities in 2011, and it is likely that 2.4 billion people will still lack access to improved sanitation by 2015 (JMP 2013). Slightly over 1 billion people (15% of the world's population) continue to practice open defecation (JMP 2013). While improved sanitation coverage is increasing, it is unlikely that the Millennium Development Goal for sanitation coverage (75% of world population with improved sanitation) will be achieved by 2015 (JMP 2013). The majority (71%) of people without any sanitation live in rural areas (JMP 2013).

3.3.2. Sanitation gap in Ethiopia

According to the Joint Monitoring Program for Water Supply and Sanitation (JMP), the percent of the Ethiopian population who practice improved sanitation is just 21% while the percent of the population who practice open defection is 45% (JMP 2013)[1]. In rural areas, 19% of people use improved sanitation, 28% used unimproved or shared sanitation, and 53% practice open defecation (JMP 2013). It is clear that there is a lack of adequate sanitation coverage in rural Ethiopia, and lack of sanitation contributes to the burden of disease in Ethiopia. Ecological sanitation, considered an improved sanitation option by the Ministry of Health in Ethiopia, is used by approximately 3.5% of households in Ethiopia (DHS 2012, Rosemarin 2008).

[1] The JMP defines improved sanitation as those toilets that ensure the hygienic separation of human excreta from human contact (Rosemarin 2008).

3.3.3.Health effects of poor sanitation

The pathogens and parasites in human excreta are responsible for diseases when excreta is not properly contained (Pruss et al. 2002). The World Health Organization estimates that 16.2% of the total burden of disease (in DALYs) and 14.9% of all deaths in Ethiopia in 2004 were attributed to poor water, sanitation, and hygiene (WASH) (WHO 2014). Interventions which aim to improve excreta disposal through increased adoption of latrine usage or introduction of latrines are effective in the prevention of diarrheal and other WASH related diseases (Clasen et al. 2010, Fewtrell et al. 2005).

3.3.4.Ecological sanitation

Ecological sanitation (eco-san) is an alternative to conventional sanitation options such as pit latrines (Esrey et al. 2001, GTZ 2002). Conventional sanitation employs a linear sanitation principal, which simply removes excreta from the environment (Langergraber & Muellegger 2004, Winblad et al. 2004). Eco-san is a closed loop approach that recognizes the value of human excreta as a resource that can be recycled (Esrey 2000). Eco-san users can reuse the nutrients and organic matter that were taken from the soil in the form of agricultural crops by hygienically breaking down human excreta for later use as fertilizer on agricultural crops (Langergraber & Muellegger 2004, Winblad 2000, Winblad et al. 2004). Use of eco-san can address the immediate issue of lack of sanitation access in low resource settings by providing cost effective sanitation options that are feasible, affordable, and appropriate (GTZ 2002, Langergraber & Muellegger 2004, Winblad et al. 2004). It can also address the national and international environmental pollution and water scarcity issues caused by inadequate or unsustainable sanitation.

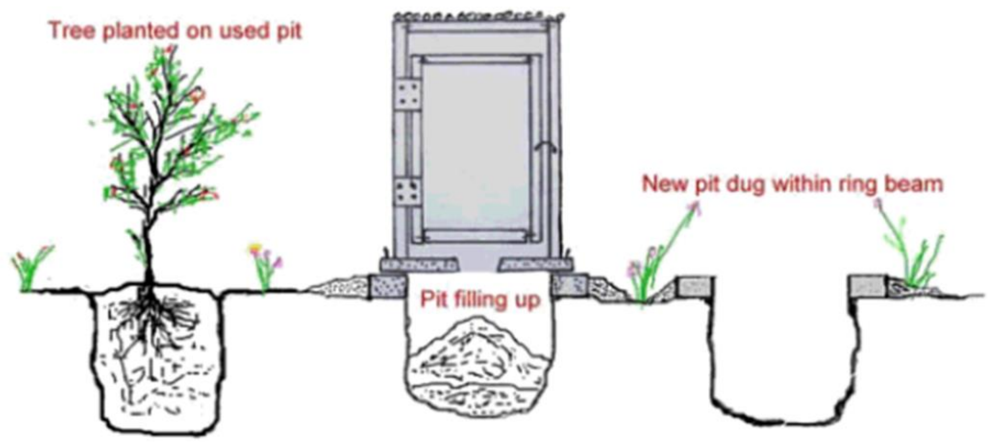
Use of eco-san can also address the issues of environmental degradation and flagging soil fertility since human excreta contains much of the nutrients taken from the soil in the form of harvested plants (Dagerskog et al. 2014, Esrey et al. 2001, Morgan 1998a). When added to soil, eco-san compost can improve soil quality and therefore crop yields; improvements in crop yields can positively impact food security or nutritional status by increasing nutrient variety or caloric availability (Esrey 2000, Esrey et al. 2001, GTZ 2002). This aspect of eco-san is particularly relevant in much of Sub-Saharan Africa, since soil degradation and declining soil fertility is occurring in many countries (Dagerskog et al. 2014, Henao & C. 1999). A limitation, in terms of eco-san's ability to address food security in Sub-Saharan Africa, is that a relatively small amount of compost will be produced each year via small scale eco-san (Winblad et al. 2004). However, as more humus is produced via eco-san toilets over time, larger percentages of a family's crops can be enriched, which can help improve food security (Winblad et al. 2004). Eco-san options generally fall into two categories, these are urine-diversion latrines, which separate urine for use and utilize desiccation (drying) to treat feces, and composting latrines such as the arborloo, fossa alterna, and modified blair latrine, which utilize decomposition to treat combined urine and feces excreta (Winblad et al. 2004).

3.3.5.The arborloo

The arborloo is an eco-san approach which is designed to utilize composted material for tree planting; Peter Moran developed the design in Zimbabwe in 1998 (Morgan 1998a). It can be an entry point to sanitation since it is an inexpensive sanitation option ($5USD) that can be built in half of a day (Morgan 1998a, Simpson-Hebert 2007). By eliminating the barriers of cost and time, the arborloo has the potential to increase the rate of rural sanitation adoption in Ethiopia which could in turn decrease the burden of WASH related disease (Simpson-Hebert 2007).

The arborloo's components include a household-dug pit (which should measure about 0.8m wide and 0.5m- 1m deep), a ring beam to protect the pit, a concrete slab (which should overlay the ground by at least 0.1m on all sides), and a superstructure (Morgan 1998a, 2004b). The ring beam is currently not used in CRS Ethiopia arborloos. Since the arborloo design necessitates the latrine's movement, the latrine slab must be small and light and the superstructure must also be portable or easily replaceable; furthermore, a small slab dictates a narrow latrine pit (Morgan 1998a). Before the arborloo is first used, a layer of leaves, ash, and/or soil is placed in the pit, and the same components are added after each use to accelerate composting and reduce odor and flies (Morgan 1998a, 2007a) . Once the pit is two thirds full, which generally occurs every six months to a year since the pit is smaller, the pit is backfilled with a thick layer of soil and a fruit tree is planted on the nutrient rich pit, which has been shown to aid in tree growth (Morgan 2004b, 2007a). The household digs another arborloo pit once the first one is filled, and the concrete slab and superstructure are moved to the new pit (Figure 8). This process is repeated as pits are filled (CRS 2010b).

Figure 8: The life cycle of an arborloo (Morgan 2007b)



The arborloo meets the criteria for ecological sanitation because it is a sanitation option that can decrease open defecation and the associated environmental pollution and allows waste to be recycled for reuse in agriculture (Morgan 1998a). Since arborloos have shallower pits (maximum 1.5 m depth) and the excreta is composted relatively quickly (usually 3-4 months) they have a lower risk of groundwater contamination as compared to deeper, unlined latrine designs (Esrey et al. 2001, Winblad et al. 2004). The arborloo is a good option in areas where soils are rocky or sandy, as is the case in much of Ethiopia, or where the water table is high; these conditions make conventional latrine designs difficult to dig and maintain safely (Morgan 2005, Seremet 2008, Simpson-Hebert 2007). The arborloo can also be utilized in water scarce areas both as an option that does not require water and in order to improve crop resiliency to drought (Esrey et al. 2001).

3.3.6.CRS Ethiopia intervention background

CRS Ethiopia completed an evaluation of their sanitation programs in 2004 and found that sanitation coverage remained low in intervention areas (Seremet 2008). Possible reasons for this low coverage were high cost ($60 USD) per conventional pit latrine and difficulty in utilizing these deeper latrine designs in the rocky or sandy soils found in much of Ethiopia (Seremet 2008). CRS Ethiopia began promoting the Arborloo in 2004 in partnership with the Global Water Initiative, and CRS has assisted in the construction of over 80,000 arborloos throughout Ethiopia since that time (CRS 2010a, Tolessa 2013).

From 2005 to 2012, the program coupled latrine promotion with Participatory Hygiene and Sanitation Transformation (PHAST) (Simpson-Hebert 2011). The PHAST training was open to all community members. Slabs were distributed free of charge if a household dug a pit after training completion, however they were not always available to every household who attended the training (Tolessa 2013). Households sometimes competed to build the best superstructure and pit in order to receive a slab (Tolessa 2013). Seedlings were distributed to households with a filled pit for free or at a very small cost once yearly, though this varied regionally. The seedlings most often distributed include mango, papaya, avocado, banana and coffee. Seedlings were also available in certain areas through the local ministry of agriculture or at the local market. CRS focused on working with established community governance structures, health extension workers, and development agents as part of their implementation strategy (Tolessa 2013).

In 2012, the Ethiopian government changed its WASH policy to mandate a zero subsidy model. As a result, a household seeking to construct an arborloo must pay the full cost of the slab and seedlings. The cost of a slab produced by CRS partners is 80 Birr (USD 4.30). These changes altered how the program operated, and sanitation marketing was prioritized to increase access to slabs and seedlings for purchase through local marketplaces. These changes could be beneficial to local masons and other private sector groups since subsidies can undermine the market for the sanitation goods such as slabs that these groups produce and sell (Dagerskog et al. 2014). At this time CRS also changed its sanitation approach to Community Lead Total Sanitation and Hygiene (CLTSH), in line with Government of Ethiopia policy. CLTSH is an intervention strategy based on stimulating a collective sense of shame and disgust around mass open defecation and its negative impact which includes a hygiene component (*CLTSH* 2011, Kar 2005).

3.3.7.Research aims

In this study we assessed the sustained use of arborloos within CRS program areas in rural Oromia Region, Ethiopia. By identifiying factors that may contribute to the sustained use of arborloos, we provide evidence for implementation of arborloo interventions in rural areas. Our study examined how households which sustained arborloo use differ from those households which stopped using the arborloo. We also examined arborloo adoption in program areas including factors associated with households beginning arborloo use and the types of households reached.

3.4.Methodology

3.4.1.Ethics and study design

The study was deemed by Emory University to be exempt from ethical review as it was a program evaluation without human subjects. This study was conducted as part of a multi-country collaboration between Emory University and the partners of the Millennium Water Program in Ethiopia (MWP-E), of which CRS is a member. Emory and MWP-E have been collaborating in Ethiopia since 2009 on monitoring and evaluation of WASH programs. Fieldwork was conducted from June through July 2013.

3.4.2.Sampling

We used a two-stage stratified sampling approach to assess arborloo coverage in CRS intervention areas. The three partner organizations were each considered as strata. We estimated that there was a 75% chance of households ever having an arborloo; with a design effect of 2, we estimated a sample size of 577 households. Using 80% power and a significance level of 0.05 with an additional 10% for non-response, our sampling target was 625 household surveys completed in 20 communities.

The community was our primary sampling unit. We included in the sampling frame all communities in Oromia region where CRS intervened by providing at least 30 arborloo slabs. Communities were selected using random sampling from each of the three strata. The number of arborloo slabs provided in each of the three CRS partner's catchment area was used to decide the proportional sample size for each of the three strata. Meki Catholic Secretariat (MCS) had provided 9,115 arborloo slabs, Wongi Catholic Church (WCC) had provided 1,490, and Hararghe Catholic Secretariat HCS had provided 6,425 since 2004. Nine communities were sampled in the MCS strata, four were sampled for the WCC strata, and seven were sampled from the HCS strata.

Households, our secondary sampling unit, were selected through random sampling from a census list of all households in the community. These lists were obtained from the government, the CRS partner organization, or from community leaders. This random sampling design ensured that a representative sample of the community was captured and that households close to the community center were not over sampled. All households in the community were eligible for inclusion in the study, including households who have or had an arborloo (provided by CRS and those who sought one out on their own), households with a traditional latrine, and those households without any latrine. The enumerators only skipped over a selected household (replacing it with a different one from the census list) if a adult member of that household was not available or if the household refused to complete the survey.

3.4.3.Research tools

3.4.3.1. Household surveys

Data were collected on paper surveys by trained enumerators. The survey included questions on respondent and household characteristics, past and present latrine usage, and types of latrines used. If applicable, questions on the household's experience with the arborloo and their arborloo pit usage were asked. The survey also included questions on how households heard about the arborloo and if CRS assisted the household with their latrine in any way. Questions and observations to establish a household wealth index were included on the survey. The latrine and handwashing station were also observed as part of the survey if applicable.

3.4.3.2. In-depth Interviews and Key Informant Interviews

The interviews were conducted in Oromiffa or Amharic according to the participants' preference, and the responses were translated during the interiew via CRS staff or partner staff. Rigorous notes were taken and pertinent quotes were recorded in English at the time of the interviews.

Thirty three in-depth interviews with households were conducted to examine household level experiece with the arborloo and to elucidate the reasons behind the associations seen in the survey data. Interviews were conducted with households who currently had an arborloo, with households who had stopped using their arborloo, and with households who never had an arborloo. Questions asked in the household interviews included reasons why a household had chosen to get an arborloo or not, the household members's positive and negative opinions on the arborloo, the respondent's experiences with their arborloo, and their experiences with planting on the arborloo pits. Respondents were asked about any assistance they had received from CRS in relation to sanitation. Households that had an arborloo at any point were asked why they initially chose the arborloo over another latrine design. When applicable, repondents were asked why the household chose not to adopt the arborloo or chose to stop using the arborloo. Interviewees from households who currently have arborloos were not asked about why they continued to use the arborloo because the research team did not feel that this would garner accurate and complete answers; however, interviewees were asked about why they initially chose the arborloo and what they felt the advantages of the arborloo were.

Twenty four key informant interviews were conducted with community and kebele leaders, health extension workers, WASH committee members, and health development army members. Community leaders and health professionals were able to articulate the community wide experience with the arborloo. Leaders were asked about where community members hear about the arborloo, why community members choose to construct the arborloo or not, what community members feel the advantages and disadvantages of the arborloo are, and what the community's attitude was towards the arborloo. Questions were also asked on the community's sanitation training, community member's pit usage, community member's experience with planting on the arborloo pits, and reasons why community members stopped using the arborloo.

3.4.4. Data analysis

3.4.4.1. Survey data

Data were entered into Excel 2010 then cleaned and analyzed using SAS 9.3 (Cary, NC). Multi-level categorical variables with one level having a frequency of less than 3% were recoded as binary where logical groupings existed. This process was done with the variables for household's method of pit usage, latrine type (combined non-arborloo responses), where a household got their slab (combined non-CRS responses), where a household got their seedling (combined non-CRS repsponses), and household's main income source (combined non-agriculture responses). Family size was recoded as a categorical variable using the mean family size for rural Oromia Region, which is 5 (*The Summary* 2007). Households with 5 or less membes were grouped as smaller households. Number of years ago a household built their arborloo was also recoded as a categorical variable with three levels: zero to two years ago, three to five years ago, and five to ten years ago.

Socio-economic status (SES) was included as an independent predictor variable. SES was assessed using principal component analysis (PCA); PCA necessitates the use of binary or continuous variables (Filmer et al. 2001, McKenzie 2005). All non-binary categorical variables used in the PCA were recoded as binary (Vyas et al. 2006). The number of hectares a household owned was included as a continous variable to help alleviate data truncation and clustering concerns. The number of various animals owned was recoded from a continous count to binary variables because these data were quite skewed. SES indicator variables that had frequences below 1% of the population were excluded. When households had a missing value for one of the categorical SES predictor variables, the household was assigned the median value for that variable; when a continuous variable was missing the mean value for that variable was assigned. Only 4.9% of households had a missing SES data point. SES is presented in quintiles with the lowest quintile (1) being the poorest of the poor and the highest quitine (5) being the least poor households.

In order to account for our sampling design, survey responses were weighted. Probability of selection at the cluster and strata levels were multiplied to obtain the survey weights for each household. Survey proceedures were utilized in SAS 9.3 to account for population variances in the survey design.

We conducted a bivariate analysis using logistic regression to assess determinants of surveyed households ever having an arborloo. Determinants analyzed included household and respondent characteristics. We used the responses to the households' present and past latrine types to establish sustained arborloo use. We conducted a bivariate analysis using logistic regression to assess characteristics of the households, their arborloo usage, and the sample that were associated with sustained arborloo use. Full and reduced multivariate logistic models of factors associated with sustained arborloo usage are presented. Since this is an exploratory study, we retained any variables that were significant (p-value ≤ 0.20) or related to a significant multi-level categorical variable in our reduced multivariate logistic model.

3.4.4.2. Interview data

Data, including field notes on responses and pertinent quotes that were collected on paper interview guides, was organized by respondent and question then entered into Excel 2010. The number of households and leaders expressing the same idea were enumerated and outliers were noted. When enumerated interview data was examined, trends in the interview responses could be perceived and themes emerged. These trends and themes are presented below with the number of respondents who expressed that opinion noted or in ranked order. This allows the reader to establish if the presented opinion was an outlier or if a large number of the interviewees expressed this opinion.

3.5.Results

3.5.1.Demographic characteristics

We conducted a total of 690 surveys in 20 communities. The goal of surveying a minimum of 30 households per community was achieved in all but two instances where only 26 and 28 interviews were conducted due to time constraints.

Overall, 352 (51.0%) of the respondents interviewed were female, median age was 35 years (range 18–88 years). The median age was 40 years (range 18-88) for males and 35 years (range 18-75) for females. Around 44% of male and 26% of female heads of household reported that they had attended some school or could read. The median household size was six (range 1–17). Similar proportions of respondents reported the head of their household's religion to be Ethiopian Orthodox (45.7%) or Islam (44.1%), and the remaining 10.3% reported their head of household's religion to be Catholic, Protestant, or Animism (Table 1).

In the communities surveyed, 558 (80.9%) of respondents stated that their household currently had a latrine in their home, 58 (8.4%) said their household had a latrine in the past but had stopped using it, and 74 (10.7%) stated their household never had a latrine. Among the 558 surveyed households that were currently using a latrine of any kind, 63.1% were utilizing the arborloo and 36.9% were using a traditional or improved pit latrine. Of all respondents, 462 (67%) reported that their household had an arborloo presently or in the past (Table 1).

Table 1: *Characteristics of survey respondents and their households; Oromia Region, Ethiopia, 2013 (N=690)*

Characteristic	n (range or %)
Respondent	
Median Age (Range)[a]	35 (18- 88)
Female[b]	352 (50.1)
Female Head of Household[c]	
Median Age[d]	35 (18-75)
No education	492 (71.3)
Non-formal education (literate)	57 (8.3)
Some school (1-12)	127 (18.4)
Male Head of Household[e]	
Median Age[f]	40 (18-88)
No education	307 (44.5)
Non-formal education (literate)	96 (13.9)
Some school (1-12)	212 (30.7)
Median household size (persons per household)[g]	6 (1-17)
Head of household's reported religion	
Ethiopian Orthodox (Christian)	315 (45.7)
Islam	304 (44.1)
Other (Catholic, Protestant, Animism)	71 (10.3)
Household reported they currently having a latrine at their household	558 (80.9)
Household reported they currently had an arborloo at their household	352 (51.0)
Household reported they currently had a traditional/improved latrine at their household	206 (29.9)
Household reported stopping use of their l latrine and returning to open defecation	58 (8.4)
Household reported never having any type of latrine at their household	74 (10.7)
Households reported ever having an arborloo at any point in time	462 (67.0)

3.5.2.Unadjusted predictors of arborloo adoption

We found evidence to suggest that there was a meaningful difference in adoption of the arborloo by the partner organization. The odds of households having an arborloo were 1.73 times as high for households in HCS as compared to the odds for households in MCS (Prevalence Odds Ratio (POR) 1.73, 95% Confidence Interval (CI) 1.19-2.52).

We found evidence of an association between a household ever having an arborloo and practice of Islam as compared to Ethiopian Orthodox Christianity (POR 2.21, 95% CI 1.12-4.36), but no evidence for Catholicism, Protestantism, and Animism as compared to those who practiced Ethiopian Orthodox Christianity (Table 2). We found evidence to suggest that there was a meaningful difference in adoption of the arborloo by socioeconomic status (Table 2).

We found an association between ever having an arborloo and median household size (POR 1.12, 95% CI 1.01-1.23), female head of household's age (POR 1.02, 95% CI 1.00-1.04), and the respondent's age (POR 1.03, 95% CI 1.00-1.06). The evidence did not suggest a meaningful difference between the groups' gender of respondent, male head of household's age, or both male and female head of household's educational status (Table 2).

Table 2: *Unadjusted bivariate analysis of determinants of households having an arborloo at any point in time for all surveyed households; Oromia Region, Ethiopia, 2013 (N=690)*

Characteristic	Household had arborloo (N=462) n (range or %)	Household never had arborloo (N=217) n (range or %)	POR	95% CI	p
Partner organization (unweighted)					
Meki Catholic Secretariat (MCS)	84 (12.4)	116 (53.5)	Ref.	--	--
Hararghe Catholic Secretariat (HCS)	172 (37.2)	56 (25.8)	1.73	1.19-2.52	0.005
Wongi Catholic Church (WCC)	206 (44.6)	45 (20.7)	1.05	0.68-1.61	0.82
Respondent					
Median Age (range)	38 (18-80)	35 (18-86)	1.03	1.00-1.06	**0.04**
Female[c]	334 (72.3)	167 (77.0)	0.99	0.68-1.43	0.95
Female Head of Household					
Median Age (range)	36 (18-66)	33 (18-75)	1.02	1.00-1.04	**0.02**
No education	335 (72.5)	153 (70.5)	Ref.	--	--
Non-formal education (literate)	39 (8.4)	18 (8.3)	1.15	0.49-2.71	0.74
Some school (1-12)	77 (16.7)	44 (20.3)	1.34	0.89-2.02	0.16
Male Head of Household (range)					
Median Age	43 (18-80)	41 (20-86)	1.01	1.00-1.03	0.16
No education	201 (43.5)	103 (47.5)	Ref.	--	--
Non-formal education (literate)	62 (13.4)	33 (15.2)	0.95	0.42-2.14	0.90
Some school (1-12)	142 (30.7)	65 (30.0)	0.85	0.59-1.22	0.37
Median household size (range)	6.2 (1-16)	5.7 (1-17)	1.12	1.01-1.23	**0.03**
Head of household's reported religion					
Ethiopian Orthodox (Christian)	180 (39.0)	129 (59.5)	Ref.	--	--
Islam	240 (51.9)	62 (28.6)	2.21	1.12-4.36	**0.02**
Other (Catholic, Protestant, Animism)	42 (9.1)	26 (12.0)	1.34	0.77-2.33	0.30
Socioeconomic status (SES)					
Poorest households (1st quintile)	91 (19.8)	41(19.0)	Ref.	--	--
2nd quintile	89(19.3)	48(22.2)	1.09	0.67-1.75	0.73
3rd quintile	98(21.3)	37(17.1)	1.87	1.09-3.19	**0.02**
4th quintile	95(20.7)	42(19.4)	1.16	0.57-2.38	0.68
Least poor households (5th quintile)	87(18.9)	48(22.2)	1.09	0.58-2.04	0.80

3.5.3. Determinants of arborloo adoption as discussed in the interviews

Leaders mentioned that households chose not to adopt the arborloo because they never received a slab (10 respondents), they did not understand the importance of sanitation and hygiene (4 respondents), or the household already had a different latrine design (2). Leaders also mentioned that households chose not to adopt the arborloo because they did not feel like digging the pit, they were unable to dig the pit, they felt the arborloo took up too much space, or the households felt the arborloo could be too easily flooded during the rainy season (1 respondent each).

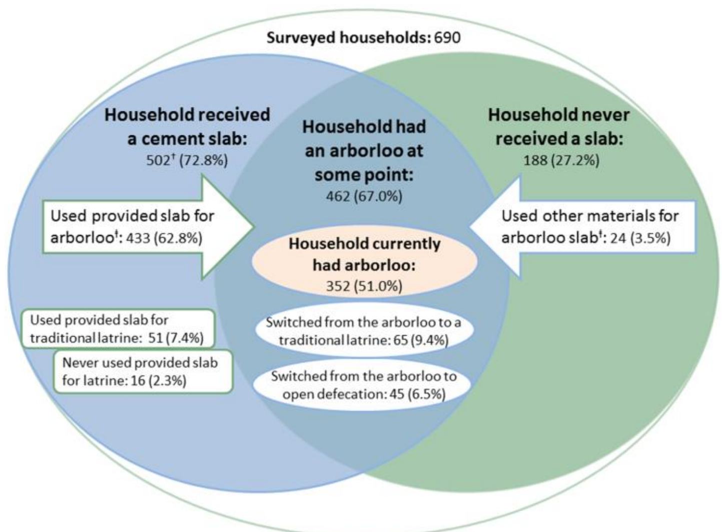
Two in-depth interview respondents said they did not get an arborloo because they did not like the arborloo design because it must be moved often, which makes it more difficult to invest in a superstructure. Other respondents said they chose not to get an arborloo because their household moved too often, they felt they were too old to dig an arborloo pit, or that their compound was too small for an arborloo. Another respondent said they felt the arborloo was not safe from flooding, which could spread feces, during rainy season due to its shallow depth.

3.5.4. Characteristics of arborloo intervention households

In the communities surveyed, 502 (72.8%) households received a slab from CRS. Most respondents stated that they used that slab for an arborloo (62.8%), but 51 (7.4%) used the slab for a traditional latrine and 16 (2.3%) did not use a slab for a latrine at all. Of the 188 (27.2%) respondents who never received a slab, 24 (3.5%) used other materials to construct an arborloo (Figure 1). Households who used other materials to construct their arborloo were less likely to sustain arborloo use (0.21 95% CI: 0.06-0.81) (data not shown).

The majority of respondents (67.0%) stated that they had an arborloo at some point in time. Among the 462 households that had an arborloo at some point, 352 (76%) were currently using an arborloo (Figure 9). Those households had sustained their arborloo usage from 1 to 10 years, depending on when they first adopted the arborloo intervention. Of all respondents in the communities surveyed, 352 (51.0%) households currently had an arborloo, 65 (9.4%) had switched from the arborloo to a traditional latrine, and 45 (6.5%) had switched from the arborloo back to open defecation (Figure 1).

Figure 9: Household slab allocation, slab usage and arborloo continuance



†2 households missing information on slab usage ‡5 households missing information on slab material

Of the 462 respondents who reported their household ever having an arborloo, 424 (91.8%) reported filling one or more arborloo pits; 232 (50.2%) used the arborloo pit compost for agricultural purposes while 192 (41.6%) did not use the pit compost (Table 3).

Table 3: *Characteristics of households' arborloo usage for households who reported ever having an arborloo; Oromia Region, Ethiopia, 2013 (N=462 unless otherwise noted)*

Characteristics	n (%)
Households' arborloo status	
Household reported they currently had an arborloo at their household	352 (76.2)
Household who currently had a traditional latrine reported previously having an arborloo	65 (14.1)
Household reported stopping use of their arborloo and returning to open defecation	45 (9.7)

Reported age of original arborloo the households built	
Household reported the arborloo pit was built 2 years ago or less	297 (40.0)
Household reported the arborloo pit was built from 3 to 5 years ago	276(43.0)
Household reported the arborloo pit was build more than 5 years ago	105 (17.0)
Household reported filling one or more arborloo pits	424 (91.8)
Household reported never using the arborloo pit compost for any agricultural purposes	192 (41.6)
Household used the arborloo pit compost for planting on top of or for compost in a garden	232 (50.2)
Got seedling for planting on the arborloo pit from a CRS Partner	118 (25.5)
Household reported that the planted seedling(s) survived	131 (28.4)

3.5.5.Unadjusted predictors of sustained arborloo usage

We found evidence of an association between sustained arborloo usage and the household's religion. The odds of sustained arborloo usage were twice as high (POR 2.01, 95% CI 1.27-3.08) for households who practiced Catholicism, Protestantism or Animism as compared to those who were Ethiopian Orthodox (Table 4). The odds of sustained arborloo usage were 80% higher for households who practiced Islam as compared those who were Ethiopian Orthodox, though this association was not statistically significant (95% CI 0.91-1.08) (Table 4). It is notable that the doing nothing with the arborloo pit was significantly associated with households who practiced Islam (POR 3.52, 95% CI 1.62-7.66) (data not shown).

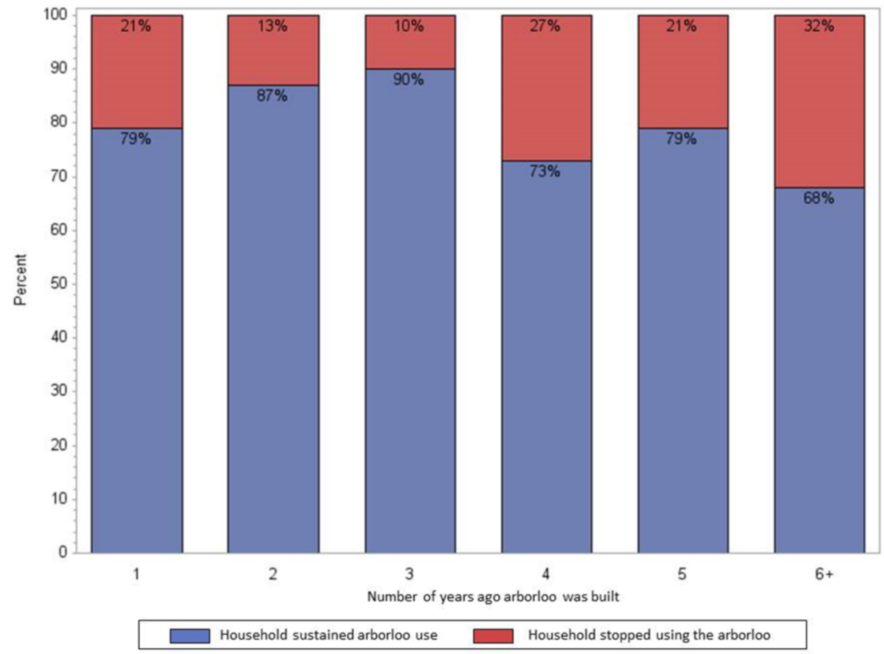
We found an association between sustained arborloo use and type of material used for the arborloo platform (POR 4.59, 95% CI 1.24-16.97) and usage of the filled arborloo pit for planting purposes (POR 2.00, 95% CI 0.86-4.63), though this association was not significant in the bivariate analysis. There was no evidence to suggest that sustained arborloo use differed by age of arborloo, though a higher percentage of households who built their arborloo 6 or more years ago had stopped using the arborloo at the time of the survey (Figure 10). The evidence did not suggest a meaningful difference between groups who sustained arborloo usage or not based on where households got the seedlings they planted, survival of seedlings, family size, female or male's educational attainment, female or male head of household's age, or socioeconomic status. There was no evidence to suggest that sustained arborloo use differed between HCS and MCS (POR 1.38, 95% CI 0.85-2.22) or between WCC and MCS (POR 1.25, 95% CI 0.65-2.26) (Table 4).

Table 4: *Unadjusted bivariate analysis of household and arborloo usage determinants of sustained arborloo use households who reported ever having an arborloo; Oromia Region, Ethiopia, 2013 (N=262 unless otherwise noted)*

Characteristics	POR	CI	p
Partner Organization (unweighted)			
Meki Catholic Secretariat (MCS)	Ref.	--	--
Hararghe Catholic Secretariat (HCS	1.38	0.85-2.22	0.19
Wongi Catholic Church (WCC)	1.25	0.69-2.26	0.47
Socioeconomic status (SES)[a]			
Poorest households (Quintile 1)	Ref.	--	--
2nd quintile	1.00	0.59-1.68	1.00
3rd quintile	1.85	0.78-4.81	0.16
4th quintile	1.21	0.52-2.81	0.65
Least poor households (5th quintile)	0.63	0.35-1.14	0.13
Family size ≤ rural Oromia median (5 people) vs. family size > median			
Family size greater than 5 people (rural Oromia median)	Ref.	--	--
Less than or equal to 5 people	1.04	0.70-1.55	0.85
Head of household's reported religion			
Ethiopian Orthodox	Ref.	--	--
Islam	1.80	0.91-3.58	0.09
Other (Catholic, Protestant, Animism)	2.01	1.37-3.08	0.0005
Male head of household's level of educational attainment[c]			
No education	Ref.	--	--
Some formal education (grade 1-12)	0.51	0.24-1.08	0.08
Some informal education (literate)	2.30	0.44-12.12	0.32
Female head of household's level of educational attainment[d]			
No education	Ref.	--	--
Some formal education (grade 1-12)	0.98	0.45-2.17	0.96
Some informal education (literate)	1.57	0.50-4.91	0.44
Female head of household's age[e]	0.99	0.96-1.03	0.76
Male head of household's age[f]	1.00	0.96-1.03	0.88
Type of material household used for arborloo platform[g]			
Constructed platform with other materials (non-cement)	Ref.	--	--
Used cement slab from CRS	4.59	1.24-16.97	0.02
Usage of composted arborloo pit material for agricultural purposes[h]			
Never used their filled arborloo pit compost for anything	Ref.	--	--
Used filled arborloo pit compost for agricultural purposes	2.00	0.86-4.63	0.11
Number of years ago households built their first arborloo			
Built arborloo more than 5 years ago	Ref.	--	--
Built arborloo 3 to 5 years ago	1.53	0.54-4.30	0.42
Built arborloo 3 to 5 years ago	1.37	0.49-3.83	0.55
Where households who planted on their arborloo pit(s) reported getting the seedling(s) (N=228)			
Got the seedling the household planted from another source	Ref.	--	--
Got the seedling the household planted from a CRS partner	1.40	0.49-3.98	0.53
Survival of seedlings for households that planted seedling(s) on their arborloo pit (N=227)			
Planted seedling(s) that died	Ref.	--	--
Planted seedling(s) that survived	0.43	0.13-1.40	0.16

Missing data: [a]2 [b]1 [c]57 [d]11 [e]6 [f]54 [g]5 [h]42

Figure 10: Percent of arborloo users who sustained usage by arborloo age



3.5.6. Determinants of sustained arborloo usage discussed in the interviews

Three interviewees said their households had no reason other than their pit filling up for stopping arborloo usage and returning to open defecation. One respondent said,

> "The cycle of sanitation might break in transferring the pits so often. The community does not want to move the pits so often so they might just go back to open defecation instead of digging another pit at that time. To avoid people breaking the sanitation cycle when the pits are filled, we switched from the arborloo to the traditional latrine" (Female, 40, WCC).

Three respondents said that they switched to the traditional latrine because it lasts longer and they did not want to dig a pit so often. Two of those respondents also noted that they felt the pit filled up too often because for their large family. One interviewee noted that they decided to switch because they did not receive a seedling from CRS; without a seedling they did not see the benefit of having an arborloo. Similarly, another household switched to a traditional latrine because they saw no benefit to the arborloo design after their seedling died. Finally, a household noted that they felt that digging the arborloo pit was too difficult because of their infirmity and another noted that the soil type in their community was not strong enough to support the arborloo slab.

Community leaders were interviewed about reasons why community members stop using the arborloo. The reason most often cited (6 times) for community members discontinuing arborloo usage was that the household did not want to dig a new pit as often as the arborloo required it, especially when the household had a large family size since it increased the frequency of moving the arborloo. Respondents also said that households stopped using the arborloo after not receiving seedlings; the said households felt the arborloo was not better than the traditional latrine without seedlings. Other reasons leaders noted for households stopping arborloo usage were the slab breaking or because the pit simply filling up.

Another aspect to consider in regards to households stopping arborloo usage is problems that users have experienced in using the arborloo. When asked about problems households experienced with the arborloo, many of the community leaders (11) and household members (20) stated that they had not had any problems. Of the problems that were raised by respondents (listed in order of times mentioned), there was concern that the pit fills too quickly, which was said to be especially inconvenient for those with larger family sizes. Interviewees reported that households sometimes delay digging a new pit when the old one fills, that the slab can break in transport to a new pit, that the pits take up too much space in smaller compounds, and that there is a lack of seedling availability. However, some leaders noted that arborloo adoption had increased after community members saw the success early adopters were having with the seedling planting. Most community leaders felt that the community attitude and acceptance of the arborloo was good overall.

While qualitative data on specific reasons why households *continue to use* the arborloo was not collected, data on what households considered to be the advantages of the arborloo may help us understand why households continued to use the arborloo. The 18 household members who currently had an arborloo and all 24 leaders reported that they found the arborloo to be advantageous to themselves or their communities. The following advantages are listed in order of times mentioned by leaders and/or household members in the interviews. The most important benefit of the arborloo was the ability to plant on the filled arborloo pit. One leader stated, "It has been helping to solve the food shortage issue as well with the seedlings" (Male, WCC). Leaders also said that the arborloo is safer than the traditional latrine, especially for children, since it is shallow and there is no fear of collapse with the cement slab. A head of household noted, "It is better for small children to use because the hole is smaller. Small kids can't use the traditional latrine because it is dangerous for them and we tell them not to use it" (Male, 55, MCS). Leaders mentioned that it is easier and cheaper to construct as compared with the traditional latrine, which, some leaders indicated, made it more likely that community members would actually build the arborloo as compared with the traditional latrine, which they delay building. Leaders felt that the arborloo had increased sanitation coverage in the village and improved health. Household members liked its' lower cost as compared to the traditional latrine, as stated, "I paid 300 birr for the traditional latrine to be built, but I can construct the arborloo myself in an hour" (Male, WCC). One arborloo user noted that she liked the arborloo because it provided privacy. She said, "Before I had a latrine I had to go to the field to defecate, with the arborloo nobody sees my body and I have privacy" (Female, 64, MCS). Respondents also mentioned that the arborloo has less flies/smell. One head of household said, “Because of (the) ash and water that we use there are no flies or bad smells” (Female, 45, HCS). These explanations of what households like about the arborloo speak to the likely reasons for the high rate of sustained arborloo usage that was seen in the survey data.

3.5.7. Multivariate analysis of sustained arborloo use including all determinant variables

Controlling for age of arborloo, use of arborloo pit for planting (adjusted (a) POR 2.98, 95% CI 1.37-6.75), male head of household having no education (aPOR 0.33, 95% CI 0.16-0.67), use of a cement slab from CRS for arborloo platform (aPOR 7.19 95% CI 1.05-49.19), and being in SES quintile 3 (aPOR 3.73, 95% CI 1.07-12.99) were the strongest predictors of sustained arborloo use. There was also evidence that sustained arborloo use was associated with the head of household’s religion being Catholic, Protestant, or Animist as compared to Ethiopian Orthodox (aPOR 1.99, 95% CI 0.92-4.28).

In the reduced model, use of arborloo pit for planting (aPOR 2.67, 95% CI 1.30-5.49), male head of household having no education (aPOR 0.38, 95% CI 0.19-0.77), use of a cement slab from CRS for arborloo platform (aPOR 6.89 95% CI 1.07-44.21), and being in SES quintile 3 (aPOR 3.41, 95% CI 1.13-10.24) continued to be the strongest predictors of sustained arborloo use. The evidence suggested that practicing Catholicism, Protestantism, or Animism (aPOR 2.12, 95% CI 1.06-4.25) was a stronger predictor of sustained arborloo use in the reduced model. In this model, there continued to be modest evidence to suggest (p-value ≤ 0.2) that other determinants of sustained arborloo use included female head of household having some informal education (aPOR 3.19, 95% CI 0.65-15.68). In the reduced model, there was no longer evidence to suggest that family size (aPOR 1.77, 95% CI 0.79-

4.09) and being in the 4th SES quintile (aPOR 1.98, 95% CI0.57-6.63) were modest predictors of sustained arborloo use; however, female head of household having some formal education (aPOR 2.29, 95% CI 0.68-7.77) was modestly associated with sustained arborloo use in the reduced model.

Table 5: *Determinants of sustained arborloo use in the household compounds of respondents who ever had an arborloo; Oromia Region, Ethiopia, 2013 (N=361)*

	Full Model			Reduced Model		
Household Characteristics	POR	95% CI	*p*	POR	95% CI	*p*
Did not use arborloo pit compost in agriculture	Ref.	--	--	Ref	--	--
Used arborloo pit compost in agriculture	2.98	1.32-6.75	0.009	2.67	1.30-5.49	0.01
SES Quintile 1	Ref.	--	--	Ref	--	--
SES Quintile 2	1.27	0.64-2.502	0.50	1.14	0.57-2.29	0.71
SES Quintile 3	3.73	1.07-12.99	0.04	3.41	1.13-10.24	0.03
SES Quintile 4	2.24	0.69-7.28	0.18	1.95	0.57-6.63	0.28
SES Quintile 5	1.26	0.41-3.85	0.69	1.14	0.39-3.31	0.81
Ethiopian Orthodox head of household	Ref.	--	--	Ref	--	--
Islamic head of household	1.43	0.66-3.06	0.36	1.55	0.72-3.35	0.27
Catholic/ Protestant/ Animist household head	1.99	0.92-4.28	0.08	2.12	1.06-4.25	0.03
Family size > median (5 people)	Ref.	--	--	Ref.	--	--
Family size ≤ rural Oromia median (5 people)	1.89	0.86-4.14	0.11	1.77	0.73-4.29	0.21
Used other materials for arborloo platform	Ref.	--	--	Ref	--	--
Used cement slab for arborloo platform	7.19	1.05-49.19	0.04	6.89	1.07-44.21	0.04
Household built arborloo > 5 years ago	Ref.	--	--	Ref	--	--
Household built arborloo ≤ 5 years ago	1.85	0.79-4.32	0.16	1.80	0.79-4.09	0.16
No education for male household head	Ref.	--	--	Ref	--	--
Some formal education (grade 1-12) for male	0.33	0.16-0.67	0.002	0.38	0.19-0.77	0.01
Some informal education (literate) for male	2.15	0.32-14.37	0.43	2.19	0.23-20.61	0.49
No education for female household head	Ref.	--	--	Ref	--	--
Some formal education (grade 1-12) for female	2.10	0.56-7.86	0.27	2.29	0.68-7.77	0.18
Some informal education (literate) for female	3.45	0.70-17.04	0.13	3.19	0.65-15.68	0.15
Male head of household age	0.97	0.90-1.04	0.37			
Female head of household age	1.02	0.93-1.13	0.64			

3.6.Discussion

3.6.1.Arborloo adoption

The arborloo had high rates of adoption in study areas, though there were differences between the populations that chose to adopt the arborloo as compared to those that did not. Adoption was associated with household size, practice of Islam as compared to practice of the Ethiopian Orthodox faith, and female head of household's age. This evaluation also showed that socio-economic inequities in access to initial program benefits and arborloo sustainability existed. In a study on eco-san in Uganda, the factors found to be significantly associated with adoption included education, occupation, religion and age (Tumwebaze et al. 2011). Tumwebaze notes that program implementers and policy makers should take the influence of these factors on eco-san programs into consideration in their work to ensure equitable access to eco-san interventions (Tumwebaze et al. 2011).

Studies have found that presenting the agricultural benefits of composting latrines in sanitation education has increased adoption of eco-san interventions in Burkina Faso, Niger, and Ivory Coast (Dagerskog et al. 2014, Dankelman & Advice 2009, Sugden 2006). This strategy might be applied successfully in this context as well.

3.6.2.Sustained arborloo use

We found strong evidence that arborloos were sustained in intervention communities. Of households who ever had the arborloo, about three-fourths had sustained their arborloo use from 1 to 10 years at the time of the survey. Sustainability was most strongly associated with use of the arborloo pit for planting, male head of household's education, receipt of a cement slab, and socio-economic status. In the interviews, most respondents reported that households liked the arborloo design and found it to be beneficial; this could explain the high rate of arborloo sustainability that was seen in the surveyed households.

Similar findings were seen in other studies with arborloo users in Ethiopia and elsewhere. In afocus group of arborloo users conducted by CRS in Ethiopia, participants reported liking the arborloo because of ease of construction, the benefit of being able to use the compost as fertilizer, and the slab's durability and portability (Tolessa 2013). In a South Indian study, women expressed appreciation for the arborloo because it can be built closer to the household and can be used for planting; men in this study said they liked the arborloo design because it is shallow and requires less labor to construct (Dankelman & Advice 2009). Interviewed households expressed the same reasons for liking the arborloo.

Respondents also mentioned in the interviews that they liked the arborloo because they felt that being able to use it for planting was beneficial to their household. Other studies have found that arborloos offer a potential added economic value in the form of rich compost and healthy crops that can be sold or consumed, which can improve nutrition availability (IFAD 2008, Mara 2008).

Arborloos were found to be cost effective by interviewees, which could be an important reason for both the arborloo's adoption and sustainability. They have lower initial investment costs than pit latrines or VIP latrines, since the slab is smaller and therefore cheaper, and no hired labor is required to dig the pit (Morgan 2005, Smet 2007). They also have lower operations and maintenance costs than other latrine options. If the deeper pit collapses, households may need to replace the pit, slab, and superstructure; they may also need to pay medical costs in the event of a pit collapse, since the deeper pit can be dangerous to fall into. When full pit latrines require someone to be hired to dig a new pit or empty the old one. The only maintenance costs associated with the arborloo are replacement of the slab or superstructure materials if they break since the household can re-dig the pit if it is full or if the pit collapses. The likelihood of injury and associated medical costs is also smaller with the arborloo due to the shallow pit depth (Evans et al. 2009, Morgan 2005, Smet 2007, Zhou et al. 2008). The arborloo's lower cost could decrease the barrier to acquiring household sanitation; it therefore has the potential to increase the rate rural sanitation adoption in Ethiopia (Simpson-Hebert 2007).

Interviewees mentioned a number of reasons why household's stopped using the arborloo. Many of these reasons have been seen in other studies as well. The Rosa Project (Resource-Oriented Sanitation concepts for peri-urban areas in Africa) in Arba Minch, Ethiopia identified a number of potential problem with the arborloo design; these include the fact that users might not want to move their pit more than once every two years ("Arba" 2009). This was also expressed in the qualitative interviews with household members and community leaders. This sentiment could cause improper application of too little soil and ash in order to prevent the toilet from filling up as quickly ("Arba" 2009). In Malawi, correct management and use of the arborloo including activities such as frequent movement of the pits and addition of ash as well as safe handling of composted excreta was a challenge (Lungu et al. 2008). It is possible that this is the reason for household's stopping arborloo usage when the pit was filled as was noted in a number of the interviews. Province notes, "New technologies should be easy to understand and operate. The moment it poses challenges and complications for the intended beneficiaries, then the tendency is for them to develop a negative perception and, thus, shun it" (Province 2009). Repetition of training may be helpful if households are not implementing the arborloo as intended. An arborloo pilot project in Brazil found that participants were not adding ash or sawdust as taught during training; in this case the training was repeated with better adoption of hygiene and usage techniques after the second training (Galbiati et al. 2007).

Some interviewees said their households had switched to a traditional latrine because they never received a seedling or the seedling died, which made them assign less value to the arborloo design. This association was not apparent in the survey data, but a 2010 rapid assessment of CRS' arborloo programs in east Africa found that access to seedlings influenced whether or not arborloos were adopted (Herbert, 2010). In a focus group of arborloo users conducted by CRS Ethiopia in 2011, respondents attributed households failing to dig pits after the old one filled to people being unable to purchase seedlings to plant on the old pit immediately (Tolessa 2013).

Respondents reported that few people replace traditional or broken concrete slabs with new concrete slabs because of lack of access to new slabs. This could be an important challenge to the sustainability of arborloo usage, since the Ethiopian government recently mandated a zero subsidy model, which precludes CRS form providing slabs at a free or reduced rate. In Malawi, sustainability of the program after donor support ends was found to be an important challenge (Lungu et al. 2008). However, this could also be an opportunity for the program; it could encourage development of a local market for slabs, which could potentially provide more routine access to slabs and generate jobs (Dagerskog et al. 2014).

Planting on the pits was associated with sustained arborloo usage. However, it is important to differentiate between the practice of planting on the pits and the actual consumption of the trees' products (Duncker et al. 2007). Planting on the pits can be done safely since no contact with excreta is necessary, but there may still be a fear or taboo associated with planting on the pits or consumption of any plants grown on the pits (Duncker et al. 2007, Lines-Kelly 2010). Only half of surveyed households who used an arborloo at some point in time planted on their arborloo pit. A number of studies have examined participants' feelings on consumption of agricultural products grown on human excreta. The majority of people interviewed in one South Africa survey (78%) said they would eat the food grown with composted human excreta, however none of the participants had actually used the composted excreta on their gardens at the time of the survey (Duncker et al. 2007). The Rosa Project found that 92.5% of respondents reported they felt that reuse of human excreta was acceptable, though actual use of the pits was not reported (Hailu 2010). In this study, it is notable that pit usage varied by religion, with households who practiced Islam planting on their arborloo pits significantly less than households who practiced Ethiopian Orthodoxy. This finding should be examined further to examine both why Islamic households are not using the arborloo for planting and the other reasons they are choosing to use the arborloo design since they are not utilizing the arborloo's planting benefit.

3.6.3. Limitations

There are a number of limitations that could impact the internal and external validity of our findings. We used the responses to the households' present and past latrine types to establish sustained arborloo use, which was subject to recall bias. Ideally, the proportion of households in an individual community that initially received a slab could have been used as an indicator for sustained arborloo use; however, this indicator could not be utilized in this case because the slabs were not distributed at the community level.

Since this is a cross sectional study, no causal relationship can be established. There were a number of missing data points in this study which limited our analysis capacity at times. Our multivariate model provided limited analysis since this cross sectional study is meant to be hypothesis generating. Seedling survival and where households obtained seedlings could not be used in the multivariate analysis of arborloo sustainability because these data were only recorded if a household reported pit usage.

4. FINAL THOUGHTS

4.1. Conclusions

Our study should be considered an exploratory study on arborloo adoption and sustained use in a certain place and time. It can help inform research questions for future work, contribute to the body of peer-reviewed literature on the adoption and sustainability of ecological sanitation interventions, and provide evidence for implementation of arborloo interventions in rural areas including for Catholic Relief Services' work. This study should not be considered definitive study that is applicable to all settings.

In this study, we found compelling evidence for high rates of arborloo adoption, though there were significant differences in the groups that adopted the arborloo. We also found strong evidence of sustained arborloo usage in intervention communities. Adoption was most strongly associated with household size, practice of Islam, socio-economic status, and female head of household's age. Sustained arborloo use was most strongly associated with use of the arborloo pit for planting, male head of household's level of education, receipt of a cement slab, and socio-economic status. While this research found that a number of factors were associated with arborloo adoption and sustained use, further research is needed to better understand *why* and *how* these factors are associated with adoption and sustained usage. Better understanding why and how these factors impact arborloo adoption and sustained use could help program implementers inform how they can address these factors in current and future programs in order to improve and adoption and sustainability for the groups that were seen to have lower rates of adoption or sustained use.

4.2. Recommendations

4.2.1. Arborloo design

Since the arborloo had high rates of adoption and sustained usage, I recommend that the arborloo design continue to be utilized in program areas. However, there are a number of programmatic changes that could be implemented in the current intervention and future arborloo programming in order to improve adoption and sustainability overall and for specific populations.

4.2.2.Recommendation to improve equity of arborloo program

This evaluation showed that socio-economic inequities in access to initial program benefits and arborloo sustainability existed. It would be beneficial to seek out these populations in this and other arborloo interventions in order to reach the poorest of the poor with this sanitation intervention.

4.2.3. Recommendations to improve pit use

Use of arborloo pits for agricultural purposes was significantly associated with arborloo sustainability. Therefore, improving pit usage for groups that are not utilizing the pit might impact arborloo sustainability for those populations. One of the most common reasons households reported stopping usage of the arborloo was that they simply filled the pit and simply never dug a new one. Increasing the focus, during training and in follow-up visits, on planning for future pit construction and placement could help households think through the process they will go through while moving the arborloo to a new pit once the old pit is filled. Studies have shown that people are more likely to sustain behavior change if they have an action plan in place (Bandura 1989, Rollnick et al. 2001). Planning for future pit construction placement during training could therefore potentially decrease the rate of return to open defecation.

Some leaders also noted that planting on human feces was a concern for some community members, though others noted that it was not. Continuing community discussions on this subject can be helpful in encouraging community members to utilize there arborloo pit for planting (Mariwah & Drangert 2011). Increasing acceptance of the practice of planting on human excreta could increase usage of the filled arborloo pits for planting. It could therefore improve sustainability since usage of the pit for planting was associated sustained arborloo usage.

4.2.4.Recommendations to improve slab sustainability

An arborloo pit that is too wide strains the arborloo slab, since the slab is not resting on a solid surface on all sides. Arborloo slabs can break if not supported by earth or bricks on all sides because of this strain. Slab breakage can cause a return to open defecation in some cases, as mentioned in the interviews. Emphasizing the correct pit width during training or follow up visits could potentially decrease slab breakage. It should be emphasized that slabs must overlay the ground by at least 0.1m on every side (Morgan 1998a). In areas with weak soils, training should emphasize that slabs must overlap with the ground or ring beam more than the recommended 0.1m (Morgan 1998a). If these changes were discussed during training or follow-up visits and implemented by households it could could decrease slab breakage.

Other arborloo programs in East Africa use a moveable brick base to rest the slab on. The ring beam is designed to provide support for the slab, keep the arborloo from collapsing, and raise the pit level to protect it from flooding during heavy rains (Morgan 2004b, 2007a). It is particularly useful in areas with weak soils (Morgan 1998a). This design feature could be adopted by the CRS arborloo program and other arborloo program implementers to increase slab stability and protect the pit from flooding.

Some households mentioned their slab broke while moving their slab to a new pit and that they stopped using the arborloo when this occurred. One way to decrease slab breakage during transportation from pit to pit is to build metal handles into the slab design (Morgan 1998a). Having handles on the slab makes it easier to transport the unwieldy slab from pit to pit. The addition of handles to aid in this process could be helpful in decreasing slab breakage and stoppage of arborloo use.

When slabs do break, it is important to ensure that households are able to replace their slab if they wish. There are currently no time of replacement measures in place for broken slabs within CRS program areas. If a slab breaks, community members in these areas often have no way of getting a new slab. If there is no way for households to replace their slab they must choose between switching to a traditional material latrine top or returning to open defecation. Increasing access to slabs at the local level via sanitation marketing will help alleviate this problem. CRS Ethiopia has prioritized sanitation marketing since the Ethiopian government mandated a zero-subsidy policy for sanitation. The focus on sanitation marketing should be continued in order to increase access to slabs for those who wish to replace their slabs as well as new sanitation adopters.

4.2.5. Recommendations to minimize the microbial risks of arborloo use

The arborloo, as with most other sanitation interventions, presents a number of microbial risks if it is not used or managed properly. There are a number of concrete ways these issues can be addressed, which will be discussed below.

A possible risk associated with the arborloo, as with most latrines, is fly breeding. Steps for safe implementation of arborloo use include addition of ash and soil after each usage. This step is critical to minimize a potential health hazard. Fly breeding can occur if the mixture becomes too wet from not enough organic matter (leaves, soil, and ash) being added and/or too much urine or water being added (Winblad et al. 2004). Use of ash on excreta to suppress odors and fly breeding is a common cultural practice outside of ecological sanitation intervention areas (Hailu 2010). This pre-established cultural practice decreases the behavior change needed to successfully adopt this aspect of the arborloo's use. However, this issue was seen in program areas during this survey and it should be addressed with further training or follow-up visits in program areas. Additional training was successful in improving adherence to the practice of using ash and soil after each use in other studies (Galbiati et al. 2007).

Another health hazard might present itself if rain enters the arborloo pit. This could create a risk of overflow since the arborloo pits are shallower, which is dangerous because microbes can enter the environment from the not yet composted feces. Entrance of water into the pit can also disrupt or halt decomposition of the excreta. Using ring beams to elevate the pit above ground level can decrease the risk of water entering the arborloo pit (Esrey et al. 2001, Morgan 1998a). Another simple solution to this issue is placing the arborloo on high ground (Esrey et al. 2001). This is especially important to consider in areas with shallow water tables, since pits can more easily flood in these areas and groundwater contamination can also occur (Esrey et al. 2001).

Some households in the study choose to excavate the composted excreta from the arborloo for usage in other agricultural pursuits. Therefore, this section will report on how households can minimize the microbial risks associated with handling composted excreta from the arborloo. If the household wishes to excavate the arborloo compost, it is important to let the excreta sit for a number of months before excavation to allow the excreta to fully compost in order to decrease risk of microbial infection (Hailu 2010). It is best to wait 4 months before excavating the arborloo pit. One specialist suggests waiting an additional 12 months before using that excavated compost on a garden to be absolutely sure that all microbial risk has been eliminated (Esrey et al. 2001, Hailu 2010, Winblad et al. 2004). If plants are to be eaten raw from the garden, households should wait an additional 1 month after mixing the compost into the garden before planting any of those plants (Winblad et al. 2004). If households intend to excavate their arborloo pits, additional training or follow is likely needed as part of arborloo interventions to help ensure that these safety measures are being practiced.

There are a number of things households can do to minimize the microbial risks associated with the arborloo. These include adding organic matter to the pits after each use, designing and placing the arborloo in such a way as to decrease risk of flooding, and waiting an appropriate amount of time before excavating the arborloo pit. Program implementers should encourage households to practice these behaviors in trainings and during follow-up visits in order to minimize the microbial risks associated with the arborloo.

4.2.6. Seedling sustainability related recommendations

Interviews indicated that the death of seedlings planted on arborloo pits may contribute to a lower valuation of the arborloo approach by households. The following recommendations might improve the survival of seedlings planted on arborloo pits. This purpose is valuable in its own right outside of the arborloo sustainability goals, since fruit seedlings can be a valuable commodity for households.

More consideration should be given to which trees are provided according to climate. This was especially apparent in MCS and WCC, were seedling survival was low (data not shown). In these program areas, program implementers and households expressed frustration with the survival rate of seedlings planted on the arborloo pits. Some individuals felt that the seedlings that were provided were not appropriate for the climatic conditions in the program areas. Fruit trees that have been proven to thrive on the arborloo pits given enough moisture include avocado, mulberry, guava, mango, paw paw, banana, and citrus (Ogunyoku 2008). Vegetables such as tomatoes and pumpkins as well as non-fruit trees have also been proven to grow well on the arborloo pits (Morgan 2007a). However, all of these tree and plant varieties many not be appropriate for the climates where the arborloo program is implemented in Ethiopia. If seedlings are to be sold to communities by program implementers (given the governments zero-subsidy policy), CRS should work with the agricultural extension officers and others to determine the types of trees that are most likely to survive given the climatic conditions in each of the communities.

Ensuring proper placement of the arborloo in consideration of future of seedling growth is a very important aspect of seedling survival. Arborloo training should include more focus on seedling placement especially in areas where fruit trees have not historically been grown.

Planning for arborloo placement may help ensure the seedling is placed in a location that is good for seeding growth and accessible for care. Households should consider whether the location they choose has enough sun, is able to be protected from animals, and can be reached for watering (Morgan 1998a). If households consider placement of their seedlings during training or follow-up visits, it could improve seedling survival (Morgan 1998a).

Households should also be encouraged to think about how they will care for their seedlings once they are planted during the training or follow up visits. Seedlings must be watered and protected from animals in order to survive. Some interviewees mentioned that they did not water their seedlings, and encouragement to do so would likely help improve survival. An option for increasing watering of seedlings in water scarce areas is utilization of gray water on seedlings as is promoted with the keyhole garden (Winblad et al. 2004). Some precautions for using gray water have been suggested to minimize microbial risks; these include: application to soil instead of sprinkling on plants and not using gray water on crops directly before harvesting, (Winblad et al. 2004). If these suggestions are mentioned to households, use of gray water for watering seedlings could be very beneficial to seedling survival. Seedling survival could also be improved if all households planted their seedlings prior to the rainy season. Trees do the best when they are planted prior to the rainy season, so households should be encouraged during training or on follow up visits to plant their seedlings at these times (Ogunyoku 2008). This discussion of seedling care during training or follow-up visits could also include ways to protecting seedlings from animals. Interviewees noted that small ruminants (especially goats) ate their seedlings and that they were not anticipating this issue from the training. Households should be encouraged during training or follow-up visits to use a natural materials fence to protect the seedlings from animals when they are small and vulnerable. Encouraging households to water their seedlings more with gray water and protect them from animals with a fence could increase seedling survival.

4.2.7.Setting of Arborloo Implementation

The arborloo is better suited for implementation in rural areas since space is required for movement of the pits and tree planting (Esrey et al. 2001, Winblad et al. 2004). Other ecological sanitation options should be considered for more urban or peri-urban environments. In the one peri-urban community visited as part of this survey, arborloo adoption (33.3%) and sustainability (46.2%) were quite low(data not shown). Community leaders attributed this fact to the small household compound size in their community. The leaders for this community reported that households had been trained in arborloo use, but many households had switched to the deeper pit latrine because they felt their compound was too small to accommodate the arborloo pits. Other ecological sanitation options, such as the fossa alterna, might be more appropriate for such peri-urban settings (Winblad et al. 2004). Another option households in peri-urban settings can employ is to dig a deeper pit (1.5m) to increase the length of time one arborloo pit could be used (Morgan 1998a). Some interviewed households mentioned doing this. However, the arborloo is a more appropriate sanitation intervention in areas where households have plenty of space to move their arborloo pit (Winblad et al. 2004).

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6. APPENDICIES

6.1. Survey Tool and Consent

CRS Ethiopia stained Presence and Utilization of the Arborloo in Rural Ethiopia: A Cross-Sectional Study

➨ *IMPORTANT NOTE TO ENUMERATOR: For the Interview ID number the first two numbers are **your given** ID number for this study (ex 01, 08, 15). For the third space, put the partner code (1 for Meki, 2 for Wongi, 3 for Hararghe. For the last two, put the household number (number in order ex. 01, 02, 03, 04, etc.).*

➨ *IMPORTANT NOTE TO ENUMERATOR: The desired and preferred respondents are the female head of household over 18 years old. If the female head of household is not available, please interview another household member **who is over age 18**. This person can be the male head of household or any other household member who is over 18.*

➨ *IMPORTANT NOTE TO ENUMERATOR: Please get CONSENT BEFORE you start filling in the questionnaire*

SAY: Hello, my name is __________I am working for [CRS Partner]. We are doing a survey to learn more about sanitation and hygiene practices – especially using Arborloo latrines in this village and district. Your household has been randomly chosen to participate in this study. The survey is confidential and your name will not be disclosed anywhere. It will take approximately 45 minutes to complete. Would you be willing to have a discussion with me?

- ***If YES**, mark 01 here to acknowledge that consent for respondent was given.* |___|___|
- ***If NO** consent, or if eligible person over age 18 is not at home, mark it in your "survey ID tracking form" and go the next neighbor's household.*

1. BASIC INFORMATION:		**ALL HOUSEHOLDS**
1.01	Partner Organization	
1.02	Date of interview (dd/mm/yyyy)	|___|___||___|___||_2_|_0_|_1_|_3_|
1.03	Name + Code of Person Collecting Data	|___|___|
1.04	Woreda:	
1.05	Kebele name	
1.06	Got:	

2. HOUSHOLD COMPOSITION: "I would like to ask you about the people in this household."		**ALL HOUSEHOLDS**		
2.01	*OBSERVE:* Gender of respondent	1. Male 2. Female		
2.02	What is the respondent's relationship to the head of household?	1. Self 2. Husband/Wife 3. Father 4. Mother 5. Another man		
2.03	What is (your/the male head of this household's) age? |__|__| Years *(00 = dead; 99 = n/a; **estimate if***	**2.05**	What is (your/the female head of this household's) age? |__|__| Years *(00 = dead; 99 = n/a; **estimate if***	

	unknown)		***unknown)***
2.04	What is (your/the male head of the household's) level of education? Write the highest grade completed |___|___| grade *00 = illiterate (does not read and write)* *55 = for non-formal education (read and write)* *66 = for college or University complete* 88. Don't know	**2.06**	What is the (your/the female head of this household's) level of education? Highest grade completed |___|___| grade *00 = illiterate (does not read and write)* *55 = for non-formal education (read and write)* *66 = for college or University complete* 88. Don't know
2.07	***If respondent is not head of household:*** What is your age? *(**estimate if unknown**)*	|___|___| years	
2.08	How many males 18 years or older live in this household?	Adult males: |___|___|	
2.09	How many females 18 years or older live in this household?	Adult females: |___|___|	
2.10	How many children age 5-17 years old live in this household?	Children 5-17: |___|___|	
2.11	How many children under 5 years old live in this household?	Children < 5: |___|___|	

3. OTHER HOUSEHOLD CHARACTERISTICS:		**ALL HOUSEHOLDS**
3.01	What religion does the head of this household practice?	1. Ethiopian Orthodox 2.Islam 3. Catholicism 4. Protestantism 5. Wakifata 88. Don't know 77. Other________________
3.02	Does this household own this house?	**1.** No **2.** Yes **88.** Don't know **99.** Unwilling to say (N/A)
3.03	What type of fuel does your household **mainly** use for cooking? ***(Choose only one)***	1. Electricity 2. Gas/biogas **3**. Parafin/ Kerosene 4. Charcoal from wood/ coal **5.**Firewood/ straw/ dung 77. Other______________
3.04	What is your major source of income	1. Agriculture (farming land) 2. Cattle raising 3. Merchant 4. GOV/NGO employee 77. Other (specify)____________________
3.05	Does this household own land?	1.No →skip to 4 2. Yes
3.06	What is the size of the different plots of your land (*please write in both local and conventional [ha] measurements*)	____________(Cartii) Qarxii/ 'Fiinyo'/Xindii (Safartuucaqasan irratti marsi) ____________hectares (4 carti = 1 hectar)

4. SANITATION "I would now like to talk about arborloos and latrines." **<u>ALL HOUSEHOLDS</u>**		
4.01	Does this household have a latrine of any kind (including an arborloo)?	1. No 2. Yes → **Skip to 4.03**
4.02	Did this household **EVER** have an latrine of any kind (*including an arborloo*)?	1. No → **Skip to 7** 2. Yes
4.03	How often do adult men in this household use the latrine?	1. Always 2. Sometimes 3. Never 88. Don't know 99. Not Applicable (adult men)
4.04	How often do adult women in this household use the latrine?	1. Always 2. Sometimes 3. Never 88. Don't know 99. Not Applicable (adult women)
4.05	How often do boy children in this household use the latrine?	1. Always 2. Sometimes 3. Never 88. Don't know 99. Not Applicable (no boy children)
4.06	How often do girl children in this household use the latrine?	1. Always 2. Sometimes 3. Never 99. Not Applicable (no girl children)
4.07	How often do elderly/disabled people in this household use the latrine?	1. Always 2. Sometimes 3. Never 99. Not Applicable (no elderly/disabled people)
4.08	Are there times when the latrine (is/was) not used? (at night, when working, in the rainy season, etc) *Remember to probe:	
4.09	(Is/was) the latrine you have/had an **arborloo** which has a thinner slab, a shallow (less than 1 Meter) pit, and can be moved yearly for using compost or planting **OR** is it a **traditional pit latrine** that has a thicker slab a deeper pit (more than 1 M), and possibly a more permanent structure **OR** is it an **improved pit latrine** but has some improvements over the traditional latrine including concrete slab and mesh wire, or has ventilation	**IF ONLY ONE LATRINE/ARBORLOO: MARK IT HERE** 1. Arborloo 2. Traditional Pit Latrine 3. Improved Pit Latrine 4. VIP (Ventilated Improved Pit Latrine) **→Skip to 4.09.2 if only one latrine**

4.09.1	***If there currently are two latrines in use at the household*** *mark what design the other is here:* Is this other latrine an arborloo which has a thinner slab, a shallow (less than 1 Meter) pit, and can be moved yearly for using compost or planting **OR** is it a **traditional pit latrine** that has a thicker slab a deeper pit (more than 1 M), and possibly a more permanent structure **OR** is it an **improved pit latrine** but has some improvements over the traditional latrine including concrete slab and mesh wire **OR** is it a **Ventilated improved pit latrine (VIP)** that is an improved latrine which also has ventilation	**IF THERE IS A SECOND LATRINE/ARBORLOO: MARK IT HERE** 1. Arborloo 2. Traditional Pit Latrine 3. Improved Pit Latrine 4. VIP (Ventilated Improved Pit Latrine)
4.09.2	Was there previously an arborloo at the household?	**1. Yes** **2. No**
4.09.3	***If there is an arborloo AND latrine:*** Did you build non-arborloo latrine before or after building the arborloo?	1. Before 2. After 99. N/A
5.02	Where did you get the first Arborloo slab? ***(Circle ONLY one)***	1. [Mission/MCS/WCC/HCS] 2. Made it 3. Community member 4. Market Other (specify)________________________
IF ANY OF THE LATRINE(S) ARE/WEREAN ARBORLOO CONTINUE TO SECTION 5 **IF THERE ARE NO ARBORLOOS AT THE HOUSEHOLD SKIP TO SECTION 7**		

5. ARBORLOO USE/SUSTAINABILITY<u>CURRENT OR PREVIOUS ARBORLOO HOUSEHOLDS ONLY</u>		
5.01	How many years ago did you build your first arborloo?	________ years ago
5.03	What material was the original slab made of?	1. Cement 2. Local materials: wood, stone, etc. 77. Other (specify)__________
5.04	(Did you) Have you ever needed to replace an arborloo slab?	1. No →**Skip to 5.06** 2. Yes
5.04.1	How many arborloo slabs did you replace ?	___________ Slabs
5.04.2	Where did you get the new slab(s)? **(Multiple responses possible)**	1. Made slab 2. Community member 3. Market 4. Mission 88. Don't know 77. Other ______________________ 99. N/A didn't replace
5.04.3	How much did you pay for the last replacement slab (specify if 0)?	__________ Birr

5.05	Did you replace the slab every time it was needed?	1. No 2. Yes
Answer 5.06-5.09 if they switched from an arborloo to another latrine type OR if they stopped using the arborloo Skip to 6 if they have not stopped using the arborloo design/switched to another latrine type		
5.06	Did you discontinue arborloo use because you built an improved latrine/VIP?	1. No 2. Yes
5.07	*For those that discontinued use:* Where do people in your household most often defacate now since you stopped using the arborloo?	1. Bush/ open defecation 2. Permanent Traditional Pit Latrine 3. Permanent Improved Pit Latrine /VIP 77. Other___________
5.08	What are the reasons you discontinued use of the arborloo? **(Multiple Responses Possible)**	1. Got improved latrine style 2. Lack of access to new slabs 3. Lack of access to tree seedlings 4. Did not like the arborloo design / technology 5. Too much work to move arborloo every year 88. Don't know7 7. Other ___________
5.09	How many years ago did you discontinue use of the arborloo?	_______ years ago

6. ARBORLOO AND ECOLOGY		**ARBORLOO HOUSEHOLDS ONLY**
6.01	How many arborloo pits has your household filled?	_________ pits
6.02	What have you used the Arborloo pits for after they are full? /have you planted **(Multiple responses possible)**	1. Compost used in a separate garden 2. Planting on top of pit 3. Nothing →**Skip to 7** 77. Other ___________ 88. Don't know
6.03	What types of plants have used the pits for? **(Multiple responses possible)**	1. Fruit Tree 2. Shade Tree 3. Vegetables 4. Non-edible plants 88. Don't know (hin beeku 77. Other (kan biro)___________
6.04	Where did you get the seedling(s)? **(Multiple responses possible)**	*1. [CRS Partner]* 2. Cutting from another tree 3. Community member 4. Market 5. Government Nurseries 88. Don't know 77. Other ___________
6.05	How much did you pay for the seedling(s)?	_______Birr
6.06	How often have seedlings been available	1. Never available 2. Sometimes

	when you wanted to plant them on a filled pit?	available 3. Always available
6.07	Did all of the tree(s) you planted survive?	1. No 2. Yes
6.07.1	*If NO:* Did you plant another tree in place of the one that died?	1. No 2. Yes
6.08	Have the trees or plants from your arborloo pit produced fruit or vegetables?	1. No → **Skip to 7** 2. Yes
6.08.1	Has this household used the fruit or vegetables from the trees or plants for eating yourselves?	1. No 2. Yes
6.08.2	Have you sold or bartered any of the fruit or vegetables from the trees or plants?	1. No 2. Yes

7. CRS AND ARBORLOOS		**ARBORLOO <u>HOUSEHOLDS ONLY</u>**
7.01	Where did you hear about arborloos? **(Circle all that apply)**	1. *[Mission/MCS/WCC/HCS]* 2. Relatives/friend who has an arborloo 3. Relatives/friend who does not have an arborloo 4. Health extension workers 88. Don't know 77. Other ________________________ 99. N/A/ don't know what arborloo is
	Where did you hear about hygiene and sanitation/latrines?	1. *[Mission/MCS/WCC/HCS]* 2. Relatives/friend who has an arborloo 3. Health extension workers 88. Don't know 77. Other ________________________ 99. N/A/ don't know about latines
7.02	Did *[Mission/MCS/WCC/HCS]* help in any way with your arborloo?	1. No → ***Skip to 8*** 2. Yes 88. Don't know
7.02.1	How did they help? **(Circle all that apply)**	1. Supplying first slab 2. Training how to build arborloo 3. Helping to build arborloo 4. Money payments to buy slab 5. Supplying seedlings 77. Other (specify)____________________

8. HOUSEHOLD QUESTIONS AND OBSERVATIONS				**ALL HOUSEHOLDS**
8.01	Have you received slabs a slab before at all?	**1. No**		**2. Yes**
8.02	ASK: How many of the following does the household own? *(Write the number owned next to each)*		**Type of animal *(read each one)***	**Number owned**
		8.02a	Chickens	
		8.01b	Cows	
		8.01c	Oxen	
		8.01d	Goats	8.01

		8.01e	Sheep	
		8.01f	Camels	
		8.01g	Mules	
		8.01h	Donkeys	
		8.01i	Horses	
8.03	ASK: Which of the following items does the household have in working order? *(Read each one)*		**Household ítems**	**Yes or No?**
		8.02a	Electricity	1) Yes 2) No
		8.02b	Solar power	1) Yes 2) No
		8.02c	Mobile phone	1) Yes 2) No
		8.02d	Bicycle	1) Yes 2) No
		8.02e	Radio	1) Yes 2) No
		8.02f	TV	1) Yes 2) No
		8.02g	Refrigerator	1) Yes 2) No
		8.02h	Motorcycle / scooter	1) Yes 2) No
		8.02i	Vehicle	1) Yes 2) No
		8.02j	Electric mitads	1) Yes 2) No
		8.02k	Kerosene / pressure lamps	1) Yes 2) No
8.03	*OBSERVE*: Type of roof on the main house: *(Choose only one: If mixed record the predominate one)*	1. Thatched roof 2. Corrugated metal roof 3. Wood and mud 77. Other ____________		
8.04	OBSERVE: Type of floor in the main household: *(Choose only one: If mixed record the predominate one)*	**1.** Earth/mud/ dung **2.** Cement **3.** Wood plank 77. Other____________		

9. OBSERVE: conditions of the latrine/arborloo <u>**LATRINE /ARBORLOO HOUSEHOLDS**</u> DO NOT ASK THE FOLLOWING QUESTIONS: RECORD WHAT YOU SEE. ---- If the household **has only latrines**, answer from 9.01 ---- ASK: "Can I please see your latrine?" ---- If the household **has only arborloos** answer from 9.02 --- ASK: "Can I please see your arborloo?" ----If the household has **BOTH an arborloo and latrine** in use, Answer question 9.01 about the latrine----- ASK: "Can I please see your non-arborloo latrine first?" Then answer 9.02-9.18 about the **arborloo**---- ASK: "Can I see your arborloo now?"		
9.01	*OBSERVE:* Is the latrine (not the arborloo) improved or unimproved?	1. Improved/VIP 2. Unimproved
9.02	OBSERVE: Wall presence	1. No wall → **Skip to 9.06** 2. Has wall, not private (some holes) 3. Has wall, fully private (no holes)
9.03	OBSERVE: Wall materials	1. More permanent durable materials (iron, cement) 2. Not durable materials (sticks, mud, stone, etc) that could be moved 77. Other ____________
9.04	OBSERVE: Roof presence	**1.** No roof **2.** Has roof, some cracks or holes **3.** Has roof, no cracks or holes
9.05	OBSERVE: Door	**1**. No door **2.** Door that does not give privacy **3.** Door

		that gives privacy 4 facing fence
9.06	OBSERVE: Slab material	1.Washable / cement/stone 2. Not washable / local/ natural materials
9.07	OBSERVE: Slab condition	1. No cracks 2. Some cracks 3.Many cracks/crumbling
9.08	OBSERVE: Is the arborloo or latrine in use? *(Signs of use: some smell, no spider webs on hole, clear path to latrine/arborloo)*	1. No *(mark "No" if pit is full or not used)* 2. Yes
9.09	OBSERVE: Smell from outside	1. No smell 2. Smell
9.10	OBSERVE: Cleanliness	1. No visible feces or paper on slab 2. Feces or used paper on slab
9.11	OBSERVE: Flies	1. No flies 2. A few flies (4-5) 3. Many flies

10 OBSERVE: Conditions of the hand washing station **ALL HOUSEHOLDS** • *ASK:* "Can I see where you wash your hands after defecation if you do so? (If not readily observable)		
10.01	OBSERVE: Is there a place for hand washing?	1. No→ **Skip to 11** 2. Yes
10.02	OBSERVE: Is it within reach to children?	1. No 2. Yes
10.03	OBSERVE: What type of container is it?	1. Direct from tap 2.Container with tap local taps count 3. Container with no tap 4. Tippy-tap 77. Other______________
10.04	OBSERVE: Is there water at this location for hand washing?	1. No 2. Yes
10.05	OBSERVE: Is the ground wet near the hand washing location?	1. No 2. Yes
10.06	OBSERVE: Is there soap or ash at this location?	1. No 2. Yes
10.07	*If no soap or ash present* ASK: "Do you have soap in the household? Can I see it?	1. In Drawer 2. Accessible 77. Other ______________

11 GPS DATA		**ALL HOUSEHOLDS**
11	GPS Waypoint: GPS ID ____________ GPS File ____________	*(do units of degrees, minutes!)* **Lat:** N ______ ° ____________' **Long:** E ______ ° ____________' *(do in units of meters!)* **Altitude:** [____________] meters

999. Do you have any comments related to the arborloo for me?

____

____

This is the end of the survey. Thank you very much for your time.

6.2. Key Informant Interview Guide and Consent

CRS Ethiopia Key Informant Interview Guide (Leaders)   Interview ID Number 0 6 __ __ __

Interviewer: For the Interview ID number the first two numbers are ***the interviewer code****, the partner code, and the ID number for the second two numbers are the interview number (number in order ex. 01, 02, 03, 04, etc.).*

SAY: SAY: Thank you for taking the time to do this interview today. My name is ________ and I am from ______. We are talking to household members such as yourself about your personal opinions of your arborloo, latrine, or sanitation as part of our research on arborloos. This is part of a Catholic Relief Services project Your participation in this interview is completely voluntary and you can stop at any time.. Please let me know if you want to stop at anytime, if you don't feel comfortable answering a question or if you don't want to continue in our conversation. Our conversation will remain confidential and our research team is the only ones who will have access to the information you provide. The information you contribute will only be used for this research project to provide a detailed understanding of arborloos. This interview will take approximately 45 minutes. Would you be willing to have a discussion with me?

If YES*, mark 01 here to acknowledge that consent for respondent was given.* |__|__|

If NO *consent is given, find another community leader.*

I have a list of topics to discuss with you but please bring up any issues you feel are important or related. Before we begin, I will need some basic information about you and the woreda. Do you have any questions for me?

1. BASIC INFORMATION:		
1.01	Partner Organization	
1.02	Date of interview (dd/mm/yyyy)	|___|___| / |___|___| / |__|__|__|__|
1.03	Name + Code of Person Collecting Data	|___|___|
1.04	Woreda:	
1.05	Kebele name and code	
1.06	Got:	
1.07	Respondent's age	|__|__| years
1.08	Ask: What is your role in the community?	
1.09		Male/Female

SAY: I have a number of questions about arborloos now.

- Arborloos are a latrine, which has a thinner slab, a shallow (less than 1 meter) pit, and can be moved yearly for using compost or planting on top of the pit
- These are different from traditional or improved pit latrines, which have a thicker slab, a deeper pit (more than 1 meter), and a more permanent structure (if there is a structure). These latrine types are not moved yearly.

2	**HOUSEHOLDS WHO CURRENTLY/PREVIOUSLY HAD AN ARBORLOO** *"I would first like to speak about those people who have an arborloo."*
2.1	Where do community members hear about arborloos?
2.2	What are the most important reasons that community members choose to construct arborloos over another latrine type?
2.3	What do you think community members feel are the major advantages of the arborloo?
2.4	What do you think community members feel are the major problems/issues with the arborloo?
2.5	Have people had any hesitation about planting fruit trees on human feces?
2.6	What do you think about the community attitude towards the use of arborloos? *Please probe to reason out for the positive and negative attitudes*.
2.7	What types of training on arborloos have community members had?
2.8	What kinds of training on arborloo uses do community members want/wish they had?

2.09	What do community members use their filled pits for?
2.10	Are there some community members who do not use the filled pits? Why not?
2.11	Do most of the trees survive?
2.12	Are there enough seedlings each year for those who need them?
2.13	Are there people in the community who have built arborloos without [CRS partner]'s (*interviewer: please mention the name of the partner in that locality*) help (help could be providing slabs , giving training or other)?
2.14	Is there anything else that community members wish Mission provided in relation to your arborloo? ? If so, please describe. (I.E. training on , more seeldings, seedling nursery help, different kinds of slabs, sanitation committees, etc)
3	**HOUSEHOLDS THAT HAVE DISCONTINUED USE OF THE ARBORLOO**
3.1	Are there people who have stopped using the arborloo?
3.2	Why do people stop using the arborloo? (I.E. build different latrine, did not like arborloo design, not enough access to seedlings or slabs, etc.)
3.3	Have people used the arborloo slab to build a more permanent latrine type? Why?

4	**HOUSEHOLDS THAT HAVE NEVER HAD AN ARBORLOO**
4.1	Are there people who don't have an arborloo or latrine?
4.2	Did people those who do not have an arborloo or latrine attend to heath training days?
4.3	What are the most important reasons that community members have not constructed arborloos?
5	**ALL respondents**
5.1	Do you have any thing else you would like to mention about the arborloo?

This is the end of our discussion and I would like to thank you again for your participation.

6.3. In-depth Interview Guide and Consent

CRS Ethiopia stained Presence and Utilization of the Arborloo in Rural Ethiopia: A Cross-Sectional Study

Interviewer: For the Interview ID number the first two numbers are the interviewer code, the partner code, and the ID number for the second two numbers are the interview number (number in order ex. 01, 02, 03, 04, etc.).

SAY: Thank you for taking the time to do this interview today. My name is ________ and I am from ______. We are talking to household members such as yourself about your personal opinions of your arborloo, latrine, or sanitation as part of our research on arborloos. This is part of a Catholic Relief Services project Your participation in this interview is completely voluntary and you can stop at any time.. Please let me know if you want to stop at anytime, if you don't feel comfortable answering a question or if you don't want to continue in our conversation. Our conversation will remain confidential and our research team is the only ones who will have access to the information you provide. The information you contribute will only be used for this research project to provide a detailed understanding of arborloos. This interview will take approximately 45 minutes. Would you be willing to have a discussion with me?

***If YES**, mark 01 here to acknowledge that consent for respondent was given.* |___|___|

***If NO** consent, or if eligible person over age 18 is not at home, <u>go the next neighbor's household.</u>*

I have a list of topics to discuss with you but please bring up any issues you feel are important or related. Do you have any questions for me?

1. BASIC INFORMATION: "Before we begin, I will need some basic information about you and the woreda."		
1.01	Partner Organization	
1.02	Date of interview (dd/mm/yyyy)	|___|___| / |___|___| / |__|__|__|__|
1.03	Name + Code of Person Collecting Data	|__|__|
1.04	Woreda:	
1.05	Kebele	
1.06	Got:	
1.7	Respondents age	
1.8	Gender of Respondent	**Male/ Female**

SAY: I have a number of questions about arborloos now.

- Arborloos are a latrine, which has a thinner slab, a shallow (less than 1 Meter) pit, and can be moved yearly for using compost or planting on top of the pit
- Traditional or improved pit latrines have a thicker slab, a deeper pit (more than 1 M), and possibly a more permanent structure. They are not moved yearly.

3	**ARBORLOO PRESENCE**	
3.1	Do you currently or have you ever had an arborloo in your household compound?	*(Circle One)* 1. No (Never Had Arborloo) 2. Yes (Have / Had Arborloo) **-> Skip to 5**
4	**HOUSEHOLDS THAT HAVE NEVER HAD AN ARBORLOO** *Interviewer: If NO to 3.1 [have never had arborloo] ASK:*	

4.1	What are the most important reasons that you **have** not constructed an arborloo in your compound?
4.2	Have you heard about latrines/arborloos and hygiene and sanitation from mission?
4.3	Do you feel you need an arborloo/latrine?
4.4	What would you need to build an arborloo? -> Skip to 7
5	**HOUSEHOLDS WHO CURRENTLY OR WHO PREVIOUSLY HAD AN ARBORLOO** *Interviewer: If YES to 3.1 [have/had arborloo] ASK:*
5.1	Where did you hear about arborloos?
5.2	What are the most important reasons that you constructed an arborloo in your compound over another latrine?
5.3	What do you think are major advantages of the arborloo?
5.4	What are the problems/issues with the arborloo?
5.5	What types of training on arborloo use have you had?

5.6	How did mission help you with your arborloo?	
5.7	How many pits have you filled?	
5.8	Have you planted trees/plants on the pits?	
5.9	If Yes to 5.8, Have the trees survived?	
5.10	If no to 5.08, Why haven't you planted a tree on the filled pits?	
5.11	Have you gotten any fruit/veggies? -- Did you eat the fruit/veggies or sell them?	
5.12	Have you been able to get seedlings when you needed them?	
5.13	Is there anything you wish [CRS partner] provided in relation to your arborloo? If so, please describe. (I.E. training on , more seedlings, seedling nursery help, different kinds of slabs, sanitation committees, etc)	
6	**HOUSEHOLDS THAT <u>HAVE DISCONTINUED USE OF THE ARBORLOO</u>**	
6.1	ASK: Do you still use the arborloo currently or have you discontinued use? (circle one)	1. Still Use Arborloo **-> Skip to 7** 2. Discontinued Use
6.2	Why did you stop using the arborloo? (I.E. built different latrine, did not like arborloo design, not enough access to seedlings or slabs, etc.)	

6.3	Have you built a different latrine type?
7	**ALL RESPONDENTS**
7.1	Do you have any thing else you would like to mention about the arborloo?

This is the end of our discussion and I would like to thank you again for your participation.

6.4.IRB Letter

EMORY UNIVERSITY

Institutional Review Board

May 21, 2013

Dionna Fry,
Public Health

RE: Determination: No IRB Review Required
eIRB#: IRB00065867
Title: *Arbor Loo Uptake, Sustained Use and Diffusion in Rural Ethiopia*
PI: Dionna Fry

Dear Ms. Fry:

Thank you for requesting a determination from our office about the above-referenced project. Based on our review of the materials you provided, we have determined that it does not require IRB review because it does not meet the definition(s) of "research" with human subjects or "clinical investigation" as set forth in Emory policies and procedures and federal rules, if applicable. Specifically, in this project, you will conduct a survey of 250 households in an area of the Catholic Relief Services (CRS) Arbor Loo Sustainable Sanitation Program in rural Ethiopia for the primary purpose of program evaluation and improvement. Individual identifiers will not be placed on the survey responses nor listed in the subsequent report to the CRS.

Please note that this determination does not mean that you cannot publish the results. If you have questions about this issue, please contact me.

This determination could be affected by substantive changes in the study design, subject populations, or identifiability of data. If the project changes in any substantive way, please contact our office for clarification.

Thank you for consulting the IRB.

Sincerely,

Regina Drake

Regina Drake, M. Div, CIP
Senior Research Protocol Analyst

Emory University
1599 Clifton Road, 5th Floor - Atlanta, Georgia 30322
Tel: 404.712.0720 - Fax: 404.727.1358 - Email: irb@emory.edu - Web: http://www.irb.emory.edu
An equal opportunity, affirmative action university