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Benefit-Cost Analysis

Pit Latrines or Container Based Toilets?:

A Cost-Benefit Analysis comparing two approaches to improving sanitation access in urban areas of Haiti.

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Haïti Priorise
Un plan de développement alternatif

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Canada

Academic Abstract

The present study aims to estimate the costs and benefits of sanitation interventions to attain universal sanitation coverage in Haiti's urban areas. Haiti has the lowest rate of access to improved sanitation infrastructure in the western hemisphere. Haiti has the lowest rate of access to improved sanitation infrastructure in the western hemisphere. Natural disasters such as the earthquake in 2010 further the consequences of this sanitation gap by contributing to the spread of waterborne diseases such as the cholera epidemic that followed the earthquake[1].

Two interventions were identified: 1) pit latrines connected to septic tanks and 2) a container based sanitation (CBS) service. These interventions are examined in this analysis for their potential to eliminate open defecation and provide universal access to an improved sanitation system that separates human excreta from human contact (UN, 2015). A cost-benefit analysis was carried out to measure economic value of the two interventions by comparing the expected benefits (reduction in diarrheal cases and deaths, education, health care, productivity) with the cost of the intervention (capital and operational expenses of each intervention system).

The intervention using the container based sanitation service yields the higher benefit cost ratio (BCR), providing benefits that are approximately equal to the costs, though economies of scale in increased coverage would drive benefits above costs. The CBS intervention is also the option that may promote intervention compliance and ecological benefits that are not included in this analysis due to the lack of specific quantitative data.

[1] Gelting et al

Policy Abstract

Overview and Context

Problem

Haiti has the lowest rate of access to improved sanitation infrastructure in the western hemisphere. The continuing lack of basic water and sanitation services has contributed to spread of water borne disease epidemics over the years. Among the worst was the cholera outbreak that began in Haiti in October 2010. In addition to the direct health effects of poor sanitation on a population, disease attributable to poor sanitation contributes to lost work, lost school productivity, and high health care costs. Because the primary pathway of cholera and other water borne pathogens is through the consumption of fecally contaminated water, improving sanitation services in Haiti is critical to ensuring population health and paving the way for future economic development.

Intervention

Two interventions were selected and evaluated for this cost benefit analysis: 1) pit latrines connected to a septic tank, and a 2) container based sanitation service (CBS). Pit latrines are the most common form of improved sanitation in Haiti and CBS has been recently introduced to urban neighborhoods in two of Haiti's largest urban centers. Although pit latrines have been widely regarded as a standard low cost method for increasing sanitation access to low income populations, pit latrines may be insufficient and dangerous in crowded areas as they are impossible to build in the densest areas and they require emptying which is often done unhygeinically due to the lack formal services to serve latrines in dense areas (Carter, 2013). The use of pit latrines without adequate emptying and transport of waste materials from communities means that a sizeable percentage of the waste ends up contaminating the environment due to haphazard emptying and dumping behaviors. For these reasons, CBS has emerged in Haiti as a sanitation strategy that utilizes stand-alone toilets that store waste in removable containers, which are removed by a trained service team.

Implementation Considerations

Costs

The costs associated with manufacture and installation of the toilet interface as well as the cost of waste collection and transport from the household to a safe disposal site were considered for both of the interventions.

The ecological costs associated with use of pit latrine systems were not considered for this analysis. Such costs include the discharges of chemical and microbial contaminants to groundwater as well as the public and occupational health risks associated with manually emptying a pit latrine and dumping the waste in the surrounding environment.

Income

The CBS service has a source of income built into the intervention as households pay for a service including a weekly collection of full containers of waste replaced by a clean empty container and cover material to promote dessication and reduce odors.

Implementing Partners

Implementation of the intervention can be done in collaboration with partners such as local sanitation organizations and NGOs, and financial partners such as the World Bank or the Inter-American Development Bank. Existing partners with a history of executing or funding pit latrine projects include the National Directorate for Potable Water and Sanitation (DINEPA), the Ministry of Public Health (MSPP). Existing partners with a history of implementing CBS projects include the Haitian NGO SOIL in collaboration with DINEPA, and MSPP.

Precedent

Pit Latrines have been widely deployed across urban areas in Haiti and the number of CBS users has risen to over 1,000 households.

Risks

One problem with the pit latrine intervention is that despite the investment in pit latrine hardware, public health goals may be compromised if households improperly use or empty latrines. For example, waste in pits may leach into the ground water or get dumped into surrounding

water bodies during unsanctioned emptying events. Such activities cause major negative health impacts on communities and the environment. A regular emptying program would reduce this type of risk and involve individual households paying a monthly fee to receive a scheduled pit emptying service at regular frequencies. The program could be managed by an agency such as DINEPA. Servision provision may be carried out by DINEPA or by local private sector exhauster companies such as Sanco or Jedco in Port-au-Prince. However, even with a regular emptying program, risks of unhygienic emptying methods may persist for households that have pits that are inaccessible to exhauster trucks because of their locations in dense and narrow alleyways.

The risks associated with the CBS service are related to its financial sustainability, if certain factors such as optimal household scale are not achieved.

Rationale for Intervention

Benefits

The benefits associated with providing urban populations in Haiti with an improved sanitation system include avoidance of diarrheal illness and death, welfare due to avoided lost school days and work days avoided, time saved for caretakers due to less diarrhea, time saved due to avoided time lost seeking open defecation locations or waiting in public toilet cues, and avoided costs of hospital/clinic visits and stays due to diarrheal disease.

Beneficiaries

The beneficiaries of this intervention include the urban population in Haiti who currently lack access to an improved sanitation system, a total of 741,379 households.

Unmeasured benefits

CBS utilizes a source separating toilet CBS which facilitates resource recovery of collected wastes. Currently, wastes collected from CBS users in Haiti are used to generate compost which is sold for agricultural use. The ecological benefits achieved through the transformation of waste to compost such as improving agricultural output, reducing the reliance on chemical fertilizers, and increasing overall food security were not included in this analysis.

Table 1. Benefits and Costs of pit latrine and CBS interventions for acheiving improved saniation for urban Haiti

Interventions	Annualized Benefit, HTG	Annualized Cost, HTG	BCR
Pit Latrines	1,654,298,617	1,845,496,433	0.90
Container Based Sanitation	1,654,298,617	**1,676,253,363**	**0.99**

Notes: 5% discount rate and DALY value of 3 x GDP are assumed

Background

The sanitation target of the Millenium Development Goals (MDGs) proposed in the late 1990s was to halve the proportion of the population without access to a toilet. This target resulted in 2.1 billion people gained access to an improved toilet since the 1990s.

The Sustainable Development Goals (SDGs) propose a new sanitation target reflecting an emerging global consensus that toilets alone are not a sufficient sanitation solution. Without effective management of the wider sanitation chain including containment, emptying, transport, and treatment, the waste contained in toilets ends up in the environment causing major environmental and public health hazards.

The sanitation targets set in the SDGs draw a focus to the emptying, transport, and treatment components of the sanitation chain. The SDG indicator 6.2.1 under the sanitation and hygiene target 6.2 highlights the importance of "safely managed sanitation services" which go beyond the "access to improved sanitation" target of the MDGs. Included in target 6.2 of the SDGs is a sub-target on halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally (UN, 2015).

Haiti has the lowest rate of access to improved sanitation infrastructure in the western hemisphere and achieving universal sanitation coverage for the urban areas an urgent priority to ensure human health and overall economic development. The following report uses a cost benefit analysis framework to evaluate methods for achieving the sanitation SDG targets in urban Haiti. The interventions examined include 1) the provision of pit latrines connected to a septic tank and 2) the provision of a household container based sanitation service.

Methods

The analysis in this paper provides the benefit-cost ratios (BCRs) for interventions to achieve universal improved sanitation for Haiti's urban population. Financial data was obtained from a mix of peer-reviewed literature; grey literature from agencies including but not limited to UNICEF, UNDP, and WHO; and interviews with experts, sanitation service providers, and NGO

personnel in Haiti. The quantitative model that was used to estimate the benefit cost ratios was constructed in Microsoft Excel.

Country Context: Haiti Population and Sanitation Status

Population estimates of Haiti's rural and urban population were drawn from the Haiti National Survey for the latest year (IHSI Haiti, 2015). Approximately 52% of the total population is urban (Table 2).

Table 2. Urban and Rural Population in Haiti

Urban Population	5,667,686
Rural Population	5,224,133
Total Population	10,911,819

Source: Haiti National Survey, 2015

Table 3 shows the sanitation coverage varying by urban and rural areas in Haiti. "Improved" sanitation facilities are defined according to the JMP definition as those that hygienically separate human excreta from human contact. The JMP definition includes flush toilets, piped sewer systems, septic tanks, flush/pour flush latrines, VIP pit latrines, pour flush latrines, pit latrines with a slab, and composting toilets as improved sanitation systems (WHO, 2010). Unimproved sanitation by the JMP definition includes technologies such as pour flush toilets excreta in the environment, pit latrines without a slab, bucket toilets, hanging toilet or hanging latrines, shared latrines, and open defecation.

According to the latest estimates by the JMP monitoring program, 72% of Haiti's population lack access to improved sanitation facilities and use either shared facilities, other improved facilities, or openly defecate. In urban areas, 66% of the total population lacks access to improved facilities while in rural areas, 81% of the total population lacks access to improved facilities. Although the percentage of coverage in rural areas is currently much lower than urban in urban areas, the rate of coverage is increasing at a more rapid pace in rural areas. Between 1990 and 2015, rural population coverage increased by 8% from 11% to 19%. In the same period, urban population coverage increased 1% from 33% in 1990 to 34% in 2015.

Table 3. Sanitation Coverage Estimates

	Urban (%)		Rural (%)		Total (%)	
	1990	2015	1990	2015	1990	2015
Improved facilities	33	34	11	19	18	28
Shared facilities	38	38	8	13	16	28
Other unimproved	16	20	18	33	18	25
Open defecation	13	8	63	35	48	19

Source: JMP Update 2015

Urban areas are a focus for this paper due to the ongoing and rapid urbanization, which started during the 1980s and has led to the growth of haphazard dwellings in unplanned areas, many of which lack basic sanitation facilities. The beneficiaries of this intervention include the urban population in Haiti who currently lack access to an improved sanitation system. Given that 38% of the total unimproved sanitation population use shared facilities, a household size of 4.4 persons, and an average of 4.5 households using each shared facility, an average of 4.5 improved toilets is currently needed for every 4.5 households. The total number of households that will be targeted for the intervention include households currently sharing, using another unimproved method, or currently openly defecating—a total of 741,379 households (Table 4).

Table 4. Intervention beneficiaries: Haiti's Urban Population with Unimproved facilities

Urban population 2015 [Persons]	5,667,686
Percent of urban population with unimproved facilities [%]	66
Population with unimproved facilities [Persons]	3,740,673
Average household size [Persons]	4.4
Households per shared facility	4.5
Intervention households	741,379

Interventions

Two interventions were selected and evaluated for this cost benefit analysis: 1) pit latrines connected to a septic tank, and a 2) container based sanitation service. Pit latrines are the most common form of improved sanitation in Haiti and CBS has been recently introduced to urban neighborhoods in two of Haiti's largest urban centers.

This analysis serves to quantify and compare the BCRs of achieving universal sanitation access by two different intervention systems. A description of the two interventions is shown in Table 5.

Table 5. Interventions for Achieving Universal Access to Improved Sanitation in Haiti's Dense Informal Settlements

Intervention	Technology/Service Description
Pit Latrine connected to a septic tank	Household latrine connected to septic tank; emptied by a professional exhauster company who transports waste to a safe disposal site
Container Based Sanitation	Container based household toilet with a once per week collection service which transports waste to a safe disposal site

Pit Latrine

Pit latrines are the main form of sanitation in unplanned areas of Haiti because they are affordable and easy to build. The specific pit latrine system evaluated for this analysis includes a pit latrine connected to a septic tank and an emptying service that occurs once every 4.5 years. Basic pit latrines (those that are not connected to a septic tank) often overflow in the rainy season or leak their contents into the ground and surface waters (Graham, 2013). This renders them inadequate under the SDG target 6.3 to reduce the inadequate disposal of waste in the environment. When pit latrines in dense urban areas fill, they need to be emptied to sustain sanitation access. Thus, a requisite component of an improved sanitation system using pit latrines in an urban area is the provision of an emptying service.

Although pit latrines continue to be the most commonly deployed option for improving sanitation conditions, emerging technologies and sanitation paradigms may be more favorable for achieving sanitation in Haiti's urban context for several reasons (Tilmans, 2015). For one, in dense settlements, the availability of space often prohibits individual households from building a pit latrine. Sharing amongst households and flooding contribute to frequent fill rates. When full, pit latrines must be emptied. In dense urban settlements, most families can't afford exhauster services or live in households that are inaccessible to exhauster vehicles. In these places, manual

pit emptying remains the cheapest and often only means of removing pit waste.[i] Without the resources to transport the waste away from the community, the excavated waste is dumped or buried in nearby streams or ditches, contaminating drinking water sources and exposing the community, the emptiers, and the environment to fecal pathogens.

Container Based Sanitation Service

CBS sanitation systems present an alternative model for sanitation service delivery in which wastes are managed and transformed into products such as animal feed, fertilizers, and compost for agricultural applications. CBS has been gaining traction in urban centers of Kenya, Ghana, Haiti and Peru, where issues like land tenure or lack of available space preclude households from having a safe sanitation system within their homes. Since a CBS toilet requires little modification to the house, it is suitable for tenants and single room dwellings.

The first set of peer-reviewed study on the cost effectiveness of CBS systems was conducted in Haiti in 2012 (Tilmans, 2012). Since then, other studies have come about that highlight the role of CBS systems in the sanitation provision for dense and resource strapped urban areas. In Nairobi, Over 500 CBS toilet units have been installed in Kibera, one of Africa's biggest slums (O'Keefe, 2015). In Ghana, a study was done of household CBS toilets which shows that use of the CBS toilet is likely to reduce fecal contamination of the household environment (Greenland, 2016). Other recent reports highlight CBS as a sanitation solution that is uniquely suited to the challenges of dense urban populations because of it provides low-income urban populations with safe collection, transport and treatment of waste, at costs that are far lower than those associated with managing fecal sludge from pit latrines or building sewers.[ii]

As opposed to pit latrines and other water based sanitation systems, CBS provides source separation of waste streams which facilitates resource recovery at lower costs than systems that rely on waste streams that are mixed or dilute (Zeeman, 2011). Because CBS promotes the generation of waste derived compost for agriculture, the National Directorate for Potable Water and Sanitation (known by its French acronym DINEPA), in collaboration with various Haiti based NGOs have been supporting pilot CBS systems to explore their potential to close Haiti's sanitation gaps and add valuable products to the Haiti's resource strapped economy.

The CBS service configuration discussed in this paper is based on the CBS toilet service which is being currently being delivered by to households in dense settlements of in Port-au-Prince and Cap-Haitien (Remington, 2017). Users pay a monthly subscription fee. In return, they receive an in-home toilet and a weekly service that collects waste and transports it from the community to a location for safe disposal and waste transformation.

Calculation of Costs and Benefits

Estimation of Costs

The breakdown of cost types for each of the two interventions included in this study are presented in Table 6. For each intervention, the cost of the toilet interface as well as the cost of waste collection and transport from the household to a safe disposal site was considered.

Table 6. Costs of Interventions to Expand Urban Sanitation Access in Haiti

Intervention	Costs
Pit Latrine	Hardware: -Pit Latrine hardware -Septic Tank hardware O & M: -Pit Emptying
Container Based Sanitation	Hardware: -Source separating household container based toilet O & M: -Household collection service -Waste conveyance to treatment facility

The cost of providing each intervention for the current urban population that lacks access to improved sanitation was determined for all intervention households-- urban households who currently lack access to improved sanitation services (Table 4).

All cost data that was originally reported in USD was converted to the current value in HTG by 1) using the USD/HTG exchange rate for the year in which the data was reported to get the HTG value for that year, 2) updating costs to reflect value in 2016 by calculating the cumulative inflation rate for HTG since the year in which the data was reported.

This analysis is limited to the capture, storage, and transport of human waste to a safe disposal site. The cost of treatment and waste transformation was not considered. A different analysis would be necessary to evaluate the BCRs of a complete sanitation system provided by pit latrines and CBS services. Such an analysis would require data on the difference in costs of treating excreta from CBS systems versus waste from pit latrines which is a current gap in the literature. The estimated costs of achieving universal urban sanitation coverage in this analysis do not factor in the timescale required to reach households in the intervention population.

Pit Latrine Intervention Costs

Data on the capital costs of building pit latrines connected to septic tanks was sourced from a report of country specific costs of achieving water and sanitation goals (Hutton, 2016). The operating costs associated with a pit latrine connected to a septic tank were assumed to be the costs of emptying the pit each time it fills. Data on the cost and frequency of pit latrine emptying services per household shown in Table 7 was sourced from reports released by SOIL, DINEPA, and interviews with Port-au-Prince based service providers (SOIL, 2016).

Table 7. Key parameters and assumptions used to estimate the cost of a pit latrine sanitation intervention

Pit Latrine Capital Cost/Person [HTG]	2226
Pit Emptying Cost/Event (O&M) [HTG]	8,071
Frequency of pit emptying event [Years]	4.5
Useful life [Years]	15

Source: Reports from DINEPA, SOIL (Haitian NGO), and private sector service providers

Although pit latrines are widely known as a cost effective method for improving human waste containment, the negative effects associated with their use such as overflow, leakage, water contamination, and subsequent disease are well documented (Graham, 2013). The costs

associated with such negative externalities are not included in this analysis due to the lack of specific data on the frequency and drivers of such events. However, because cholera and other water related disease outbreaks have been a consistent problem in Haiti, it is important to note this gap in this analysis and highlight the future research need for a parameter that can account for costs associated with pit latrine overflow and pathogen spread.

Container Based Sanitation Intervention Costs

The capital and operating cost of the CBS service was derived from expense reports of an NGO that operates a household CBS service in Port Au Prince and Cap Haitian, Haiti. Costs of the service include:

- Manufacture, marketing, and installation of the household toilet.
- Regular marketing and promotional events
- Weekly collection of full containers from households and delivery of clean containers to households
- Conveyance of waste from households to safe disposal site
- Responding to maintenance requests and other complaints as needed
- Removal of the toilet and related equipment upon the termination or cancellation of the service contract.

The conveyance costs were based on transporting waste from households within the current household CBS service zones in Port-au-Prince and Cap Haitien to existing waste disposal sites in both of the cities.

All costs used for this analysis were based on data from a social enterprise that currently serves 965 households in Port-au-Prince and Cap Haitien. As a result, the costs presented in this analysis are conservative estimates for the economies of scale that will result for the intervention population of 7.4 thousand households.

Table 8. Cost Assumptions for CBS Intervention

Cost per household per year including hardware, collection, and disposal [HTG]	2261
Useful life [years]	10

The annual costs per household are significantly lower in the CBS system as compared to the pit latrine system in Table 7. Although pit latrines are often considered the cheapest sanitation option, including the cost of emptying significantly drives up annualized costs.

Table 9. Annualized costs per household of a pit latrine intervention versus a CBS intervention, HTG

	3% Discount	5% Discount	12% Discount
Latrines	2415	2489	2838
CBS	2236	2261	2356

Note: Assumes pit latrines are emptied every 4.5 years and CBS service collection service is once a week.

Estimation of Benefits

A large range of economic and social benefits can result from improving access to sanitation services in urban areas. Table 10 presents the benefits that are included in this study.

Table 10. Economic Benefits of Improving Urban Sanitation

Benefit Type	Variables
Health	Diarrheal disease deaths DALYs caused by diarrheal disease
Education: lost school days avoided	Days away from school/case of diarrhea Days lost per case of diarrhea Mean earnings by level of education Years of Primary Schooling
Productivity: lost work days avoided	Diarrheal incidence in working adult population Work days lost/adult Value of work day lost
Productivity: time saved for caretakers due to less diarrhea	Diarrheal cases in school aged children Days of ill time/child Value of caretaker days lost
Productivity: Avoided time lost due to seeking open defecation location or public toilet cue	Open defecation journey time Public toilet wait time
Healthcare: Avoided costs of hospital/clinic visits and stays	Diarrheal cases per year Percentage of cases that seek care Percentage of care inpatient and outpatient Days/inpatient stay Cost/day inpatient Cost/visit outpatient

Health Benefits

The most significant waterborne and water-washed disease in Haiti and worldwide is infectious diarrhea (Hutton, 2015). The health benefits that were included in this analysis include the reduction in diarrheal incidence rates and premature mortality from diarrhea. Avoided deaths and illness from the interventions were monetized by using the approach of GDP per capita per avoided "disability adjusted life year" or DALY.

To estimate the DALYs avoided resulting from the two sanitation interventions, a relative risk value for improved over unimproved sanitation on diarrhea was used based on meta analysis of low and middle income countries (Prüss-Ustün 2014 & Wolf 2014). A risk ratio of 1.39 (risk of

disease associated with unimproved sanitation or no sanitation relative to basic improved sanitation) is simply (1/0.72) the inverse of 0.72 associated with basic improved sanitation relative to unimproved (Prüss-Ustün 2014; Wolf 2014).

Then, the population attributable fraction (PAF) of diarrheal disease and mortality from unimproved sanitation was estimated using the following equation:

$$PAF = \left(\frac{P_i\text{-}\,(\mathrm{RR}-1)}{P_i\text{-}\,(\mathrm{RR}-1)+1}\right)$$

where P_i is population share using unimproved sanitation and RR is the corresponding relative risk.

Table 11. Key Parameters used for the valuation of health benefits of achieving improved sanitation access in Haiti

Parameter	Value
Risk Ratio of Unimproved Sanitation relative to improved sanitation	1.39
Population Attributable Fraction (PAF)- No improved facility [%]	20

Source: Prüss-Prüss-Üstün 2014

Mortality Reduction

To estimate the number of deaths per year from using unimproved sanitation in urban areas in haiti, the following equation was used:

$$M = PAF * D$$

Where PAF is the fraction of diarrheal disease caused by unimproved sanitation and D is the annual incidence of diarrheal disease in urban areas of Haiti. A recent peer reviewed paper on the distribution of diarrheal disease deaths between urban and rural areas in Haiti was used to estimate the number of urban diarrheal diseases deaths from the reported diarrheal diseases at the national level (Luquero, 2010). The value of total DALYs lost from diarrheal disease was

sourced from the Global Burden of Disease (GBD) database and used to estimate the average YLL per diarrheal death using the following formula:

$$DALY = YLL + YLD$$

To determine the monetary value of the DALYs avoided, the relevant discount rate was applied and the benefit was valued as the GDP per capita in the year of the illness avoided.

Morbidity Reduction

The number of diarrheal diseases avoided per year was estimated using the PAF and the annual YLDs caused by diarrhea was used from the GBD data (Global Burden of Disease, 2015). The value of the DALY was then estimated as 1x, 3x, or 8x the GDP per capita in the year of illness avoided as described above.

The number of lives saved per year, days of diarrheal illness avoided, and diarrheal cases avoided due to improved sanitation are shown in Table 12. Improved sanitation for the intervention population has the estimated potential to save 265 million HTG per year.

Table 12. Summary of the health benefits resulting from access to improved sanitation access

Diarrheal Deaths Avoided/Year	254
Days of Diarrheal Illness Avoided/Year	4,559,301
Cases of Diarrhea Avoided/Year	796,893
DALYS Avoided/Year	2000

Education Benefits

Education benefits associated with access to improved sanitation services include the avoidance of educational time loss due to diarrheal disease. This benefit applies to children of school age and makes the assumption that each case of diarrhea in school aged children results in missing 3 days of school (Hutton, 2007). The education benefits are premised on the assumption that a reduction in total school days leads a linear, proportional reduction in future wages. The mean earnings by level of education are shown in the appendix. The value of each day of school is the

difference in the daily annual wage rate associated with a primary school education versus the wage rate for no education.

The analysis, based on one year to reflect the possibility of kids getting sick on any day of the year, estimates a loss of 3.2 million school days per year due to diarrhea in urban populations(Table 13). This results in losses between of 94 million HTG annually.

Table 13. Key Parameters used for the Valuation of Education Benefits Resulting from Access to Improved sanitation access

Days Away From School/Case of Diarrhea	3
Annual Wages, no education 2012 HTG	42,828
Increase from fully completed primary schooling	58%
# years of primary school	6
Increase from one year of primary school	8%
Days lost per year from diarrheal disease	3,195,141
Equivilant years lost to diarrheal disease	1,053

Health Care Benefits

The health care benefits associated with improved sanitation systems result from cost savings related to patient treatment and care, admission to healthcare facilities, and transport to care facilities. Assumptions about the cost of inpatient and outpatient care and the proportion of cases admitted to hospital were derived from WHO country specific estimates of unit costs for patient services in Haiti and shown in Table 14 (WHO 2010).

Table 14. Key parameters used for the valuation of health care benefits associated with improved sanitation access

Diarrheal disease cases per year	6,622,298
Cases averted due to improved sanitation	796,917
Percentage of cases that seek care	30%
Hospitalization of diarrheal cases	8.2%
Average inpatient stay [Days]	5
Non-healthcare costs (transport,food) outpatient [HTG/visit]	408
Non healthcare costs (transport, food) inpatient [HTG/visit]	102

The cost of outpatient visits and inpatient days as a result of diarrheal disease illnesses are assumed to equal the economic value of the health care services including consultation and treatment. The total cost savings were calculated by multiplying the health service unit cost by the number of cases averted. It was assumed that 30% of cases of diarrhea would visit a health facility once. The analysis assumes that 8.2% of the diarrhea cases seeking care are hospitalized, with an average length of stay of 5 days. Additional non-healthcare costs related to visiting the healthcare facility include transportation to a place of care and the food costs while staying at the place of care (Hutton 2007).

Productivity Benefits

Two types of productivity benefits associated with improved sanitation are included in this analysis: 1) productivity related to avoiding lost days at work and 2) the productivity related to avoided time spent cueing for shared facilities and open defecation locations.

The benefits related to the increased work productivity due to improved sanitation are due to the avoided loss of work days for those of working age, the avoided loss of time spent caring for sick children, and the avoided loss of time accessing shared facilities or an open defecation location. The value of time is taken as half the average output per person of working age in Haiti in 2016 (Haiti Priorise assumption). For working aged adults, the time loss is assumed to be two days per case of diarrhea.

The loss of time associated with caring for sick children is estimated as the cost of time of the expected ill days per case of childhood diarrhea, in this case assumed to be three days. This avoided time costs of current practices among those who practice open defecation and those who use shared toilet facilities. For switching from open defecation to improved facilities, time is saved journeying to an open defecation site. For those switching from shared facilities to improved facilities, time is saved in terms of avoiding queues for use of shared toilet facilities. A list of the key parameters used for estimating the productivity benefits is shown in Table 15.

Table 15. Key parameters and assumptions for valuation of productivity benefits resulting from access to Improved Sanitation

Diarrheal cases averted 15-49 years (Adults)	165,969
Work days lost/adult case	2
GDP/Capita/Day [HTG]	182
Total value of work days lost [HTG]	60,723,922
Lost time/day/person to openly defecate [Minutes]	10
Lost time/day/person to access shared toilet [Minutes]	3

Several known benefits associated a CBS system such resource recovery and transformation of human waste were not included in this study. Resource recovery benefits are likely to be higher for the CBS system as source separated waste from has been shown to be more valuable than fecal sludge from pit latrine systems because it is less decomposed and contains more recoverable nutrients and calorific value (Ingallinella, 2002). The CBS system that currently services 5,400 users across Haiti is transforming collected waste into compost for agricultural use. However, these benefits were not considered in this analysis due to the lack of a complimentary body of literature on the recovery of resources and nutrients from pit latrine waste.

Results

Overall Results

The annual costs and benefits of providing the intervention population with pit latrines and household CBS for urban populations in Haiti are shown by category in Table 16 and Table 17 respectively. Benefits estimated for the pit latrine and the CBS interventions are equal as uptake of both interventions is assumed to lead to the same benefits. A discussion of the difference in the compliance rates and the effect on the difference in benefits achieved by the two interventions will follow. Avoided death and illnesses account are the highest contributers to the overall benefits of both interventions.

Table 16. Benefits and costs of pit latrine intervention

	3% Discount	5% Discount	12% Discount
Death avoided	1,008,635,347	664,841,900	285,039,290
Illness avoided	269,424,845	269,424,845	269,424,845
Health care costs avoided	240,684,714	240,684,714	240,684,714
Productivity Loss Averted and Time Saved	433,785,619	433,785,619	433,785,619
Education Benefit	94,271,410	57,119,001	15,440,120
TOTAL BENEFITS	**2,046,801,935**	**1,665,856,079**	**1,244,374,587**
TOTAL COSTS	**1,790,101,918**	**1,845,496,433**	**2,104,117,672**
BCR	**1.14**	**0.90**	**0.59**

Note: DALY Value= 3 x GDP/Capita: 108,135 HTG (1,594 USD)

Table 17. Benefits and costs of a container based sanitation intervention

BENEFITS	3% Discount	5% Discount	12% Discount
Death avoided	1,008,635,347	664,841,900	285,039,290
Illness avoided	269,424,845	269,424,845	269,424,845
Health care costs avoided	240,684,714	240,684,714	240,684,714
Productivity Loss Averted and Time Saved	433,785,619	433,785,619	433,785,619
Education Benefit	94,271,410	57,119,001	15,440,120
TOTAL BENEFITS	**2,046,801,935**	**1,665,856,079**	**1,244,374,587**
TOTAL COSTS	**1,658,037,900**	**1,676,253,363**	**1,746,715,956**
BCR	**1.22**	**0.99**	**0.71**

Note: DALY Value= 3 x GDP/Capita: 108,135 HTG (1,594 USD)

Summary

A comparison of the BCRs that are achieved through the pit latrine and CBS service is shown in Table 18. Considering all discount levels, the BCR of the household CBS intervention is 8-20% higher than that of the pit latrine intervention.

Table 18. Summary Of BCR of Pit Latrine and CBS intervention to Acheive Improved Sanitation Coverage in Urban Haiti

Interventions	Discount	Annualized Benefit	Annualized Cost	BCR
Pit Latrine	3%	2,026,206,087	1,790,101,918	1.13
	5%	1,654,298,617	1,845,496,433	0.90
	12%	1,242,802,199	2,104,117,672	0.59
CBS	3%	2,026,206,087	1,658,037,900	1.22
	5%	1,654,298,617	1,676,253,363	0.99
	12%	1,242,802,199	1,746,715,956	0.71

Note: DALY Value= 3 x GDP/Capita: 108,135 HTG

Sensitivity Analysis

Sensitivity analysis was done on the three parameters that have the greatest impact on the overall BCR: pit latrine emptying frequency, cost of the container based sanitation service, and the valuation of the health benefits.

Pit Latrine Emptying Frequency

Pit emptying frequency has been shown to vary greatly as a response to factors such as family size and pit latrine volume (Jenkins, 2015). The value of pit emptying frequency used for this analysis was 4.5 years, based on an average of reports from service providers and data reported by DINEPA. Table 19 shows how BCRs change as a result of emptying frequencies on the lower and upper end of the reported frequencies (every year, every 8 years) as well as the average reported emptying frequency (4.5 years) when DALYs are valued at 3 times the GDP. The pit latrine intervention discussed in this paper is likely to require emptying on the high end of the frequency spectrum shown in Table 19 because pits connected to septic tanks are likely to retain volume and require more empties. In order to increase the overall value of a pit emptying

intervention system, a focus should be placed on the development of more cost effective pit latrine emptying mechanisms.

Table 19. Impact of Emptying Frequency on BCR of Pit Latrine Intervention

	3% Discount	5% Discount	12% Discount
Every year	0.31	0.25	0.17
Every 4.5 years	1.13	0.90	0.59
Every 8 years	1.92	1.44	0.82

Note: DALY Value= 3 x GDP/Capita: 108,135 HTG

Cost of container based sanitation systems

Cost estimates for the CBS system were based on the financial reports of a CBS system currently serving over 1,000 households across Haiti were used for this study. However, it is likely that a CBS system serves the intervention population of 741,349 households, will result in significant cost reductions due to economies of scale that arise with higher customer volumes. Table 20 shows the impact of a modest and significant cost reduction on the overall BCRs for the CBS system.

Table 20. Impact of scale on CBS BCR

	BCR 3% Discount	BCR 5% Discount	BCR 12% Discount
Current Price	1.22	0.99	0.71
10% Cost Reduction	1.36	1.10	0.79
20% Cost Reduction	1.53	1.23	0.89

Note: DALY Value= 3 x GDP/Capita: 108,135 HTG

Health Benefit Calculation

The type of valuation measure considered for estimating the benefits of avoided illness and mortality significantly impact the resulting BCRs of the interventions. Table 21 and Table 22 show the effect that valuing the DALY as 1 x GDP, 3 x GDP, or 8 x GDP has on the overall BCRs.

Table 21. Impact of DALY Valuation on BCR of Pit Latrine Intervention

Daly Value	BCR 3% Discount	BCR 5% Discount	BCR 12% Discount
1 X GDP	0.77	0.66	0.50
3 X GDP	1.13	0.90	0.59
8 X GDP	2.05	1.48	0.81

Table 22. Impact of DALY Valuation on CBS

Daly Value	BCR 3% Discount	BCR 5% Discount	BCR 12% Discount
1 X GDP	0.83	0.73	0.61
3 X GDP	1.22	0.99	0.71
8 X GDP	2.47	1.89	1.23

Other Considerations

Intervention Compliance

Evidence of imperfect compliance with other sanitation interventions in various contexts indicates that compliance rates may have an impact on the overall benefits a sanitation intervention (Angrist, 1996). Several reasons may explain why some portion of the intervention population may fail to comply with the intervention strategy and continue using unimproved sanitation facilities, shared latrines, or open defecation. Possible reasons underlying non-compliance may include the cost of building or using a toilet, untimely emptying services, inconvenience, or culturally inappropriate design of sanitation facilities (Chase, 2015 & Holm 2016).

For the subgroup within the intervention population that currently has no sanitation facilities, non-compliance with the pit emptying intervention may entail a failure to use a toilet, a failure to empty full toilets, or both.

For the subgroups of the intervention population who use shared facilities, non-compliance for the pit emptying intervention will likely entail continued use of a shared facility as opposed to an

improved household toilet. Finally, for the subgroup of the intervention population that already use a toilet, non-compliance for the pit emptying intervention may entail failure to empty the toilet. We assume that current toilet users will continue to use a better toilet if it is available.

Non-compliance with the CBS intervention may occur due to the same reasons as in the pit latrine intervention—cost of the service or untimely collection of full containers of waste. Recent evidence from a conducted in Haiti to determine the willingness of households to pay for CBS services suggests that uptake and compliance with a CBS service be higher than for other methods of sanitation as participants in the study gave the system high ratings for safety, convenience and modernity. Almost three out of four users who participated in a 3-month study chose to pay to continue the service The same trial was shown to reduce the amount of unmanaged feces in a Haitian slum by a factor of 3.5 as well as eliminate open defecation and flying toilets[2] (Russel, 2015; Tilmans 2012). More research is needed to make explore the causal mechanisms between non-compliance in pit latrines versus CBS so that either system may be better designed to maximize use and uptake in the intervention population.

Excluded Costs and Benefits

Excluded from this study are costs associated with the negative impacts of latrine systems and benefits associated with a resource recovery system. This suggests that actual BCRs of the two systems would diverge more than reported in this paper. It is likely that the BCRs for CBS would be higher and BCRs for pit latrines would be lower if these excluded costs were included in this analysis.

Also excluded from this study are the costs of providing water for a latrine connected to a septic tank. The cost of water used for flushing is likely to be significant in Haiti where it is very rare for households to have a piped water supply. This further suggests that the BCR of the pit latrine system would be significantly lower if the cost of water was included in this analysis.

[2] Flying toilets are a common practice for those who lack improved sanitation access in which plastic bags full of feces are thrown into waterways

Conclusion

From an economic and health perspective, the CBS system is the preferred option for the 3.7 million urban Haitians who lack improved sanitation access. It is also the option that requires the least maintenance, lower upfront investments by households, and higher compliance.

This analysis challenges the commonly held belief that pit latrines are the easiest and most cost effective way of delivering sanitation services. The inclusion of pit latrine emptying in the annualized costs of a pit latrine sanitation system have a significant effect on the BCR and cost effectiveness of the system. If pit emptying was chosen as the intervention, the development of more affordable and effective pit latrine emptying mechanisms will be needed to discourage households from emptying in ways that endanger human and environmental health.

The potential for household non-compliance with any intervention delivered suggests that a focus should be placed on elucidating the causal factors relating to non-compliance in different sanitation paradigms. More work is also necessary to identify the additional costs and economies of scale associated with delivering CBS across a broader range and higher number of households than the pilot studies.

Appendix

Table 23. Mean Earnings by Level of Education, 2012

	Monthly Earnings [HTG]
No education	3569
Primary	5636
Lower secondary	6571
Vocational	8365
Upper secondary	12314
Tertiary	12680

Source: Based on ECVMAS 2012

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Haiti faces some of the most acute social and economic development challenges in the world. Despite an influx of aid in the aftermath of the 2010 earthquake, growth and progress continue to be minimal, at best. With so many actors and the wide breadth of challenges from food security and clean water access to health, education, environmental degradation, and infrastructure, what should the top priorities be for policy makers, international donors, NGOs and businesses? With limited resources and time, it is crucial that focus is informed by what will do the most good for each gourde spent. The Haïti Priorise project will work with stakeholders across the country to find, analyze, rank and disseminate the best solutions for the country. We engage Haitans from all parts of society, through readers of newspapers, along with NGOs, decision makers, sector experts and businesses to propose the best solutions. We have commissioned some of the best economists from Haiti and the world to calculate the social, environmental and economic costs and benefits of these proposals. This research will help set priorities for the country through a nationwide conversation about what the smart - and not-so-smart - solutions are for Haiti's future.

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