Study for Financial and Economic Analysis of Ecological Sanitation in Sub-Saharan Africa

wsp
water and
sanitation program

partner of
sustainable
sanitation
alliance

Study for Financial and Economic Analysis of Ecological Sanitation in Sub-Saharan Africa

Table of contents

Index of tables

Index of figures

Acknowledgements

The study was financed by the Water and Sanitation Program (WSP), a multi-donor partnership administered by the World Bank, whose goal is to help the poor gain sustained access to improved water supply and sanitation services. WSP assists countries with capacity building, (including policy reforms), planning and implementing sustainable investments. WSP also commissions research studies to synthesize experiences from the field, and disseminates good practices to support programming and promote policy reforms.

The report was prepared by Richard Schuen, team leader, HYDROPHIL, and Jonathan Parkinson, sanitation specialist, ATKINS. Contributions were made by Philippa Ross, ATKINS, who was responsible for model development, and Graydon Jeal, ATKINS, who provided additional input and gave direction related to financial and economic analysis.

All data for the case studies was provided by Mr. Linus Dagerskog, Burkina Faso, Ms. Melanie Wilkinson, South Africa, and Ms. Victoria Abu Atukunda, Uganda.

Andreas Knapp, WSP-AF was the overall task team leader, provided overall guidance to the consultants and coordinated the input of various stakeholders to this report.

A team from the World Bank and WSP served as internal peer reviewers of the report. They were Eddy Perez, Guy Hutton, Harriet Nattabi, Ousseynou Diop, Pete Kolsky and Samuel Mutono.

The consultant team also benefited from valuable input and comments from a team of external peer reviewers, namely, Arno Rosemarin, Stockholm Environment Institute, Sweden, Barbara Evans, University of Leeds, United Kingdom, Elisabeth von Münch, GTZ, Germany, and Martin Regelsberger, AEE INTEC, Austria.

Additional comments were received from Cecilia Ruben, Elisabeth Kvarnström, and Madeleine Fogde from SEI, Arne Panesar from GTZ, and Barry Jackson from Development Bank of Southern Africa.

In conducting the study a wide range of experts and stakeholders provided valuable input and information from the field, which WSP-AF and the consultant team appreciate greatly.

Finally WSP-AF is very grateful to the mention the good collaboration with the working group on financing and economics of sanitation of the Sustainable Sanitation Alliance (Susana) during all stages of the production of this report.

Key concepts and terms used

Annuitization is the process of converting an investment into a series of periodic payments.

Assets include all forms of constructed facility and infrastructure.

Capital expenditure (CAPEX) is the money required at the beginning of a project to finance or purchase materials, land, labor and any other costs related to construction and project implementation.

Cost benefit analysis takes into account both financial and socio-economic costs and benefits to assess the comparative advantage of different options in monetary terms.

Design life is the estimated lifespan of an asset.

Discounting is a method used to convert future costs or benefits to present values using a discount rate.

Discount rate is the annual percentage rate at which the present value of a future dollar (or other currency) is estimated to lose its value over time.

Net Present Value (NPV) is an aggregated value used in whole life cycle analysis to measure the resultant financial and economic benefit of a good or service when all costs and benefits are taken into consideration. A positive NPV indicates a net benefit and a negative NPV a net loss.

Operational expenditure (OPEX) is the money that is required to sustain a facility or activity (including labor, fuel, and all other operation and maintenance costs).

Planning horizon is the duration over which the whole-life cycle costs are evaluated.

Whole life-cycle analysis involves a long-term perspective taking into account all the costs incurred and the benefits received over the total duration of a project up until the planning horizon is reached.

Acronyms and abbreviations

AEE INTEC	Institute for Sustainable Technologies (Austria)
ATKINS	International consulting company (United Kingdom)
CAPEX	Capital expenditure
CFA	Franc de la Coopération Financière en Afrique Centrale
CREPA	Centre Régional pour l'Eau Potable et l'Assainissement à faible coût
ecosan	short for Ecological Sanitation
ECOSAN_UE	Projet d'assainissement écologique dans les quartiers périphériques de Ouagadougou, Burkina Faso
GTZ	German Agency for Technical Assistance
HYDROPHIL	International consulting and knowledge development company (Austria)
NPV	Net Present Value
ONEA	National Water and Sanitation Authority, Burkina Faso
OPEX	Operational expenditure
SEI	Stockholm Environment Institute
SWTWSP	South Western Towns Water and Sanitation Programme, Uganda
UDDT	Urine Diverting Dry Toilet
UGX	Uganda Shilling
VIP	Ventilated Improved Pit
WSP	Water and Sanitation Program
ZAR	South Africa Rand

Currency exchange rates (September 2008)

United States Dollar	South Africa Rand	Burkina Faso Franc	Uganda Shilling
US$ 1	ZAR 8.52	CFA 463	UGX 1,626

Executive summary

This study on financial and economic analysis of ecological sanitation (ecosan) in Sub-Saharan Africa was financed by the Water and Sanitation Program (WSP). It focused on a comparison of sanitation technologies suitable for urban settlements.

The aim of the study was to compare ecosan with conventional sanitation systems in terms of financial and economic costs and benefits, in order to assist decision-makers and sponsors of development programs to make informed decisions about relative merits of different types of sanitation. To achieve this, an analytical framework and a computer model were developed to assess and compare different technologies in terms of financial and economic Net Present Value (NPV).

The economic benefits derived from improved sanitation include health and environmental benefits, as well as those which are associated to excreta reuse. The latter is modeled by taking into account the volume of excreta, the mass of nutrients produced, and the monetary value of increased crop yields.

Although there are a wide range of ecosan technologies, the study focused on those which have been implemented at sufficient scales, to enable a more robust analysis based, on a more extensive data set possible. The selected projects have all promoted Urine Diverting Dry Toilets (UDDTs), a form of sanitation that involves the separation of urine from feces at the source. Excreta separation facilitates the reuse of nutrients contained in urine and feces, which contributes to increased crop yields in local agriculture. In addition, there are other advantages related to reduced odors and ease of sludge removal from latrines.

The following case studies were selected:

1. **Kabale, Uganda.** Kabale has approximately 150 UDDTs, 6,000 conventional on site latrines and 483 connections to the sewerage network. Excreta are directly used by approximately 60 percent of all ecosan households. The cost of the UDDT's is US$ 892, without any subsidy. This cost is approximately 30 percent more than the highest cost VIP latrine. In the low-cost options, the CAPEX costs are reduced to US$ 390 and US$ 270 for ecosan and conventional VIP latrines respectively. The cost of a latrine connected to sewerage system is estimated to be US$ 295, but there are additional connection costs and considerable investments required for sewerage infrastructure and wastewater treatment facilities.
2. **eThekwini, South Africa.** This is a metropolitan area comprising the City of Durban and its surrounding areas. Approximately 74,000 households use UDDTs, another 90,000 use conventional on-site facilities (i.e., septic tanks and VIP's), and over 425,000 households are connected to the sewerage network. The municipality promotes UDDTs as a result of the difficulties and operational costs associated with desludging pits in remote peri-urban areas.

All sanitation options are heavily subsidized by the municipality.

3. **Ouagadougou, Burkina Faso.** The case study focuses on a communal ecosan system which is promoted by the ECOSAN_UE project operating in the peri-urban areas of Ouagadougou. This system has been implemented by CREPA, GTZ and ONEA, in collaboration with the local municipality. There are currently 930 ecosan toilets, 82,000 conventional on site facilities (mostly traditional latrines), and 200 connections to the sewerage network. The cost of the UDDTs (US$ 229 – US$ 410) is lower than for the conventional double vault VIPs (US$ 612), promoted by National Water and Sanitation Authority (ONEA). The cheapest option for the household is to rehabilitate their traditional latrine under ONEA's program (US$ 177, cost for traditional pit latrine plus rehabilitation). Excreta are reused off-site through a collection and storage system, and then distributed to farmers. Recently, the project started introducing a fee to collect a contribution from the recipients of the fertilizer.

The economic and financial performance of these projects is compared with traditional sanitation technologies such as ventilated improved pits (VIPs) and sewerage. The model requires input data in form of capital expenditure (CAPEX) and operational expenditure (OPEX), assigned to different elements of a sanitation system. These include costs for both hardware, such as the cost of the latrine itself and software, which includes all promotional, training and other capacity building activities.

The costs for the ecosan and on-site options are based on field data, whereas costs of sewerage and wastewater treatment infrastructure are calculated using empirical equations developed by Loetscher (1999), which are inflated to todays prices. Combined with hardware costs, the costs for sanitation promotion, capacity building and ongoing support derived from the case studies are included in the model.

For the financial analysis, the model enables a breakdown of the costs incurred by the household and those incurred by the external agencies to construct off-site waste management infrastructure and to promote improved sanitation (referred to as 'project costs'). The combined household and project costs sum-up to the total financial costs.

To enable a more consistent and fair comparison of the different options, the following principles were applied:

- **Removal of subsidies:** Household subsidies were removed on the basis that the no-subsidy analysis provides a more representative picture of the comparative costs of different sanitation options.
- **Capacity building and project infrastructure expenditure:** In cases where capacity building costs were identified to be spread out over a few years of the project, majority of these costs were attributed to capital investment expenditure at the start of the project.
- **Costs for waste treatment:** Ecological sanitation inherently includes a process of waste treatment. To enable a fair comparison between the costs of ecological sanitation and conventional sanitation, it is necessary

to include the costs of wastewater treatment. Where there is currently no provision for the treatment, an estimation of these costs (both CAPEX and OPEX) was included in the analysis.

- **Economies of scale:** To take into consideration economies of scale, the financial and economic analysis was undertaken using an equal number of households of 5,000 in each case. There are significant impacts on the model output when using a different population, on the costs of sewerage and treatment, but this factor does not influence the costs of the on-site technologies.

Main findings:

Although there are many examples of ecosan pilots and small-scale projects in Sub-Saharan Africa, only a few of these are large-scale urban projects. Consequently, ecosan toilets are only used by a relatively small number of the urban population. Even in towns well known for ecosan projects, the coverage is by no means universal, and not all households are necessarily actively involved in reuse. Only the program in eThekwini, South Africa is of significant scale, but in this situation, excreta reuse is not promoted due to potential health concerns, and consequently the program is not considered to be promoting ecosan.

There is a whole range of technologies and management arrangements that can be adopted to promote the reuse of excreta. But based on the case study analysis, none are seen to provide an obvious model for up-scaling without considerable external support. In South Africa and Burkina Faso, household latrines and off-site arrangements for excreta management are heavily subsidized. The only place where subsidies were not applied was Kabale, Uganda, where ecosan users are not considered to be poor.

The lower the capital costs, the higher are the benefits of reuse in ecosan option, in terms of Net Present Value (NPV). The operational expenditures have an impact on the overall financial and economic performance, but the impact is limited, compared to the influence of capital costs. The results show that operational and maintenance costs determine the financial performance (in terms of NPV) from a household perspective in situations where latrines are heavily subsidized. However, when subsidies are removed and overall project costs are taken into account, the picture changes remarkably, as the capital costs become the most critical factor which influences the financial performance of each option.

By reusing excreta, households with ecosan toilets can generate monetary benefits and increased crop production can have a positive impact on them financially. Evidently, poorer households seek to gain more in proportion to their household income. Although not only specific to ecosan, latrines may not be affordable for the poor without subsidies to reduce the extent of household investment. However, it needs to be recognized that all of the analyzed options may not be affordable for the poor without subsidies, and it is therefore important to consider the development of cheaper latrines that are ratified and promoted by government agencies.

The results from the model analyses demonstrate that various factors influence the crop yield, and this is a key determinant in the economic viability of ecosan. These factors include the availability of land, the type of soil, and climatic conditions. The results indicate that in the right environment, ecosan can provide a positive net benefit and therefore the UDDTs are an attractive technological option that requires further consideration in sanitation programming. In particular, UDDTs provide an appropriate sanitation technology in situations where the practicalities and operational costs of servicing conventional on-site sanitation means that desludging and off-site disposal are not considered to be viable.

The key factors influencing the viability of ecosan in urban environment are the amount of land available, and the agricultural conditions. As it is more beneficial to apply fertilizer over a larger area as opposed to concentrating the application on a smaller area, reuse of excreta in urban environment becomes increasingly less attractive, as the housing density increases.

The yield is also a function of the agricultural conditions. Good agriculture conditions promote increased yields and it is in these conditions that excreta reuse is seen to be most beneficial. It is also arguable that in situations where the agricultural conditions are poor, it is advisable to reuse excreta. Whether it is considered to be economically attractive will ultimately depend on the household's income.

Although not included in the study, it has to be recognized that there are potentially other factors that contribute to the attractiveness of ecosan from a household perspective (notably reduced odors). On the other hand, there are other behavioral constraints related to use of UDDTs and the handling of feces that may reduce the interest at the household level to utilize these technologies. Further research is required to assess which factors predominate under which situations.

The results indicate that the benefits from crop production can offset the higher capital and operational costs, but the benefits may not be sufficient to cover additional costs required for implementing ecosan. There are many factors at hand, and the study highlights the complexity of the systems involved. The answer to this depends on physical, environmental and social factors.

The study also points towards the need to reuse excreta as close to the point of generation as possible, whilst keeping the costs of installation down. Where this is not viable, a communal excreta reuse system becomes economically attractive, provided the project management and capacity-building costs associated with the promotion of ecosan can be lowered.

Based on the case study analysis, none of the currently implemented systems are seen to provide an obvious model for scaling up without considerable external support. It is apparent that there remains a lot of research required to assess the costs of marketing ecosan compared with conventional sanitation, and further work to look into the costs of different management arrangements. A communal excreta management system such as that in Burkina Faso may overcome some of these constraints, and is more appropriate in denser urban environments. There is need to look in more detail, at the different management arrangements and costs for setting up and operating house-to-house collection services. There may also be ways of introducing more cost effective technologies to enhance the efficiency of the operation.


URINES
ECO
SAN
URINES
ECO
SAN

1 Introduction

1.1 What is ecological sanitation?

Ecological sanitation, which is commonly referred to as ecosan, is an approach used towards the provision of basic sanitation, and aims to meet a number of key goals such as:

- Provide a barrier to the transmission of excreta related diseases and contribute to improved health of the community.
- Provide a form of sanitation that is accepted by users in terms of its level of comfort and hygiene.
- Reduce environmental impacts and costs associated with the disposal of human waste.
- Promote recycling of nutrients contained in excreta to grow fruits and vegetables; thus enhancing food security and reducing the need to rely on artificial fertilizers.

Although ecosan can potentially involve wastewater reuse, most ecosan systems incorporate 'dry' latrines without a flush system. There are a variety of technologies that fall under this umbrella. The most widely known in Sub-Saharan Africa are:

1. *Arborloo:* This is a pit latrine whereby a tree is planted when it is full, and another one is dug elsewhere. It is the cheapest option, and particularly appropriate for rural areas.
2. *Fossa Alterna (from Mozambique):* These latrines incorporate two vaults to store fecal material. Each is used alternatively, whilst the waste in one is left for a period long enough for digestion to deactivate pathogens and remove health risks.
3. *Urine Diverting Dry Toilet:* A UDDT separates urine from feces at source and facilitates excreta reuse and promotes recycling of nutrients. Particular focus is made on the reuse of urine that has a higher nutrient content and is therefore more important than feces in terms of its fertilizer value. Feces also has some fertilizer value in addition to being used as a soil conditioner. There are other advantages of UDDT such as reduced smell and improved manageability of excreta for disposal. In situations where excreta reuse is not considered to be an attractive option, urine can be disposed off into the soil through a soak-away.

The study focused on a comparison of sanitation technologies suitable for urban settlements. The review at the inception stage of the study revealed that the Urine Diverting Dry Toilets (UDDT[1]) as the only ecosan system that has been implemented at scale in such areas. The focus of the study was on the UDDT as shown below in Figure 1.

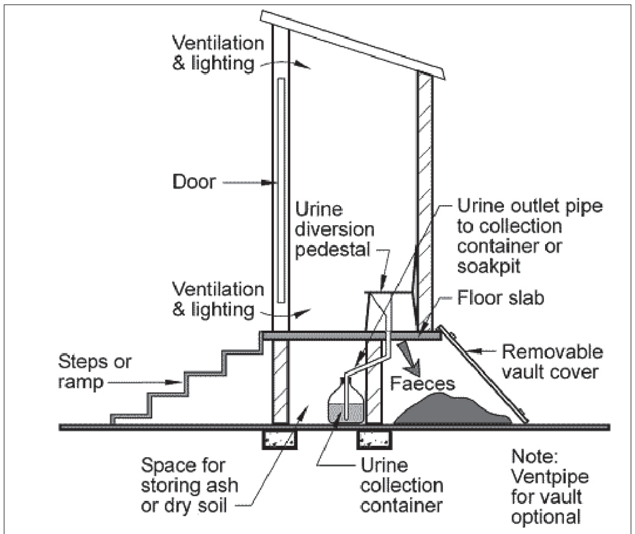
1.2 Context of the study

Notwithstanding, the success of various initiatives and pilot projeccts, and convincing environmental reasons to support the ecosan approach progress in rolling out ecosan systems at scale in Sub-Saharan Africa has been limited. In particular, there

[1]Otherwise referred to a Urine Diversion Dehydrating Toilet

are socio-cultural constraints related to the need for changes in sanitary behaviors, and the reuse of human excreta for food production. It is argued that urine diverting toilets are too expensive, making ecosan programs overly dependent on external finance to subsidize capital investment and project costs, to promote and provide ongoing support.

Figure 1: Urine Diverting Dry Toilet



(Source: www.training.gpa.unep.org)

Such concerns should be considered in the context of overall slow progress in scaling up of ecosan. There is extensive literature available that provides a detailed discussion on aspects of ecological sanitation relating to acceptability, safety and reuse. There is much less published information available on the financial and economic aspects related to the implementation of ecosan systems. This study can be seen as a first, but important step to fill this critical information gap.

1.3 Aims and objectives

The overall objective of the study was to assist decision-makers and sponsors of development programs to make informed decisions about the relative merits of different types of sanitation. More specifically, the aim was to compare ecosan with conventional sanitation systems in terms of financial and economic costs and benefits. For pragmatic reasons the study focused on the economic and financial aspects of these systems[2].

In order to carry out economic and financial analysis using real data, the study focused on case studies of existing programs that have been implemented on the ground. An analytical framework and a computer model were developed to assess and compare different technologies in terms of financial and economic NPV.

1.4 Scope

In accordance with the terms of reference, the study focused on the urban context and involved data collection from three countries in Sub-Saharan Africa. The study analyzed ecosan technologies that provide a similar level of service to other sanitation technologies commonly found in African cities, such as VIP and sewerage.

To enable a comparison, it was important to focus on technologies which are available in all three countries. Therefore, the study did not include simplified sewerage technologies and decentralized wastewater treatment systems. Although there is a possibility that these systems may be comparable in financial and economic terms with on-site systems,

[2]Readers should refer to other literature on issues of acceptability, safety and details about environmental impacts of different sanitation systems.

there is a need to undertake additional work to verify this hypothesis.

For this reason, the study focused on the following examples where UDDTs have been promoted:

1. In Kabale, Uganda, UDDTs that were promoted by the South-Western towns water and sanitation programs are managed by individual households, who reuse hygienized excreta on their plots of land.
2. In eThekwini, South Africa, due to the inherent problems and high costs associated with desludging conventional pit latrines, the municipality is promoting UDDTs in peri-urban areas. The municipality is however not promoting excreta reuse due to concerns about health risks. As such, the sanitation program in eThekwini is not referred to as ecosan.
3. In Ouagadougou, Burkina Faso, the research institute CREPA together with GTZ and ONEA under the ECOSAN_UE project has established UDDTs and a communal excreta collection service. The project supports local organizations to set up household collection services and sell the excreta to farming communities.

In Africa, many poorer households use latrines that are different from the official designs ratified by government authorities due to their lower cost. In light of this, combined with WSP's mandate to promote pro-poor solutions, the analysis considered not only officially-sanctioned systems, but also low-cost alternatives.

Evidently, there are many other important considerations which influence the at scale uptake of ecosan. These relate to social and cultural attitudes towards use of unconventional technologies and reuse of excreta. The viability of different options in the selected case studies was assessed from a financial and economic perspective only.

2 Overview of the model

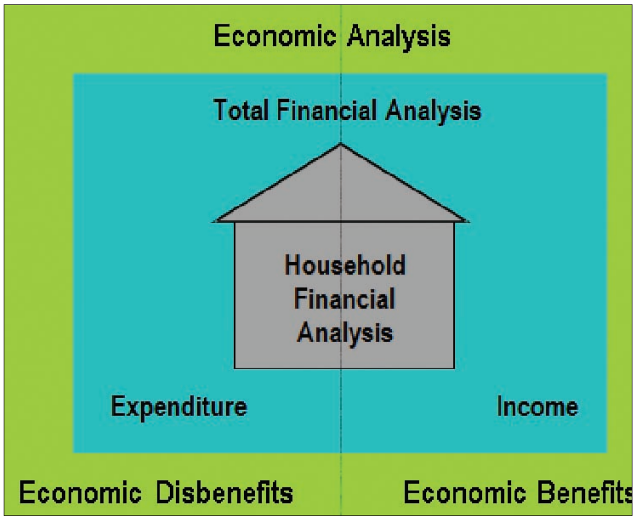
The model is a spreadsheet developed in Microsoft Excel to analyze the relevant data from each case study. The main parameter for comparing sanitation technologies is the Net Present Value (NPV), which is expressed in financial and economic terms. The calculation of these two values is similar, but the input data and costing factors are different in each case.

Whereas all costs and benefits are taken into account as part of economic analysis, financial analysis only considers subsets that are identifiable as financial transactions. The decision about which data to include in the financial analysis depends upon the boundary for the analysis. The most important boundary is between the private and public domains, which defines the costs and benefits to be allocated to the household, and those to be allocated to the 'project' respectively.

The project expenses include costs that are not incurred by households directly, but are instead incurred by any agencies or institutions, promoting and implementing sanitation projects and programs.

Figure 2 illustrates the interrelationship between economic analysis and different levels of financial analysis. From a household perspective, the main

Figure 2: Interrelationships between economic analysis and different levels of financial analysis



consideration is the expenditure related to sanitation facilities, and potential income generated by excreta reuse. Expenditures or costs may be subsidized with external financing in order to reduce household expenditure. Subsidies are included as part of the total financial analysis, and are expressed as a project cost.

Other project expenditures considered in the financial analysis include those related to the installation of shared infrastructure for example, sewerage and treatment facilities, and all additional project management costs. Project costs are therefore defined as the total financial costs, minus the household costs. All costs, including project related costs, are expressed in terms of a cost per household, even though costs may not be subsumed by the household.

Economic analysis takes a broader perspective, which encompasses all social and environmental costs and benefits that are ascribed as monetary value in addition to all financial expenditure and income. Economic benefits include those related to the mitigation of environmental pollution, and those related to improved health and excreta reuse. As with the project financial analysis, economic costs and benefits are attributed to the household or project, and are calculated in terms of the cost or benefit per household.

2.1 Whole life-cycle analysis

Whole life-cycle analysis involves a long term perspective which takes into account all costs incurred and benefits received over the total duration of a project. The planning horizon is the duration over which the whole life-cycle costs are evaluated. This is not necessarily the same as the estimated lifespan of an asset (design life). Depending on the type of asset, the quality of construction and the chosen planning horizon, the design life may be greater than or smaller than the planning horizon.

Table 1: Interpretation of Net Present Values

0	Implies that the costs and benefits over the total duration of the analysis are balanced.
+ve	Indicates that the activity is ‘profitable’. In financial terms, this means that there is a net monetary gain that is realized. In economic terms, a positive NPV means that the expenditure is beneficial – not necessarily for every individual but from the perspective of the overall public benefit.
-ve	Indicates that the activity is ‘non-profitable’, i.e. from a financial perspective the activity will result in households having to finance investment from other sources. In economic terms, a negative NPV suggests that there is no overall public benefit to be achieved.

2.2 What is Net Present Value?

The Net Present Value (NPV) of a project or investment is defined as the sum of all the present values of the annual cash flows during the life of the project, minus the initial investment. Annual cash flows are the net benefits (revenues minus costs) generated from the investment during its lifetime. These are discounted or adjusted by incorporating the uncertainty and time value of money. Table 1 summarizes the interpretation of NPV.

In most situations, there will be no overall direct financial benefit, and it is in these situations where financial NPV become negative. When comparing the results of the analysis in situations where all options produce a negative NPV, it is the option with the least negative value that is the preferred option. There is however a possibility that the economic NPV is positive if sufficient revenue can be generated from selling fertilizer or crops from the land that is fertilized using excreta.

2.3 Boundary conventions for analysis at two different levels

The following perspectives were considered for the analysis:

- From the household perspective, the main concern is the financial cost. Therefore, the financial NPV has been calculated at household level, with and without subsidies and includes other costs such as connection costs. From an economic perspective, there are benefits for households, results of improved health and results of excreta reuse.
- The project perspective includes costs associated with implementation and management and off-site infrastructure investments. As mentioned earlier, subsides are also considered to be a project cost. Project costs that serve multiple households are expressed as the cost per household, irrespective of the fact that the household may never contribute towards these expenditures. From an economic perspective, reduction of cost related to the proper waste disposal, and may include benefits associated with reuse if excreta are reused without any direct benefit at the household level, as is the case with Burkina Faso.

Transactions between the private domain (i.e. the household) and the service provider (i.e. a public entity, private company or NGO) include tariffs/ payments for a service (such as pit empting or sewerage). For the purposes of the analysis, it is assumed that these organizations operate in the same way insofar as the financial implications of service charges are the same from the household perspective.

2.4 Financial and economic discount factors

The discount rates used for calculation of financial and economic NPV are critical factors that determine the outcome of the financial and economic analysis. For the financial analysis, the inflation rate and the local nominal interest rates are used to calculate the real interest rate at household level. The real interest rates at the household level are different for each country since the underlying macroeconomic indicators are different as well (see Annex 1).

For the economic analysis, a discount rate of 10 percent[3] is used in all three case studies to calculate the economic viability of each sanitation option.

2.5 Design life and planning horizons

From a household perspective, the planning horizon equates to the duration that a family remains in one home, before moving to a different location. As well as being poorer, households living in insecure areas (where there may be a threat of eviction) are much less likely to invest in improving household sanitation, than households in formal planned settlements.

The design life will depend on the quality of the construction. For modeling purposes, the design life for household latrines is assumed to be 10 years, but the design life for sewerage and treatment infrastructure is assumed to be 50 years.

3 Input data requirements

3.1 Financial and economic costs

The model is designed to reflect the user input cost data for each sanitation option. These include both hardware and software costs, attributed to CAPEX and OPEX **(see Table 2)**. Many of the model inputs are aggregated values. For instance, although detailed data (in form of bills of quantities) are available to cost latrines, the two main cost items that are used as model input data are 'materials' and 'labor'.

Costs are split into those borne by the household (including tariffs), and those that are assumed by the external financing organization (including subsidies). Data was collected by local sanitation experts who also provided background information for each of the case studies. There was one major exception related to the cost of sewerage and treatment facilities. The approach towards estimating these costs is described below.

The model is comprised of the following worksheets contained in an Excel spreadsheet:

- A 'global' sheet containing the generic data about the case study (household occupancy, average area of land available to each household for growing crops, the number of households, exchange rate, local wages, market price of produce, etc).
- Data sheets describing the costs for each sanitation option (ecosan, conventional on-site and sewerage).
- Output data sheets showing the results from the financial and economic analysis.

Financial and economic cost data from each of the case studies is imputted into the model to compare the different sanitation options with a specific focus on a monetary valuation of the reuse of excreta. The user inputs CAPEX and OPEX costs assigned to different elements of each sanitation system, including both hardware and software costs.

3.1.1 Subsidy

It is common for projects to promote household investments in sanitation via the use of subsidies. Dealing with subsidies is problematic from the perspective of financial and economic modeling,

[3] This reflects international practice, where values between 8% and 12% are common.

insofar as they obscure an objective comparison of alternative options if there are different levels of subsidy involved as this ‘shields‘ users from the full household investment costs.

The level of subsidy is specific to each program and is a decision made by the financing organization in relation to an assessment of household income and their willingness and ability to pay. The subsidies were therefore removed so that a comparison of NPVs enables a more accurate and transparent comparison between the different case studies.

3.1.2 Costs of sewerage and wastewater / fecal sludge treatment

Although sewerage charges reflect the costs to the household, these rarely reflect the full cost of installation of sewerage and wastewater treatment infrastructure. Due to the difficultly of obtaining accurate estimates of the costs incurred, they were estimated by using an empirical model developed by Loetscher and Keller (1999) inflated to today’s prices. There are a range of treatment processes

Table 2: Input data - CAPEX and OPEX

		Household or project cost?	CAPEX	OPEX
Materials	Latrine	Latrine costs are household costs unless subsidized	Construction of latrines (including equipment costs)	Desludging costs (including cleaning materials) and cost of water for flushing (if used)
	Off-site waste management facilities	Capital investment costs are project costs but tariffs for O+M are household costs	Construction of sewerage and treatment facilities, desludging trucks and other equipment	Operational costs of sewerage and treatment facilities, desludging trucks and other equipment
Labor	Paid labor	Predominantly projects costs	Salaries of engineers and site supervisors during construction.	Labor and materials for operation, maintenance costs for desludging
	Non-paid labor	Household costs	Non-paid provided by the household	Unpaid labor associated with the operation and maintenance of the sanitation facilities
Management and promotion	Management and project supervision	Projects costs	Project management, supervision and support for establishing long-term operations	Labor and materials for operation, maintenance costs for desludging
	Promotion and capacity building	Projects costs	Sanitation promotion and training	Ongoing promotion and monitoring

that can be modeled. For this study, the waste stabilization pond was considered to be the most appropriate process.

The input parameters for the model are:

- the number of households in the area,
- land prices (US$/m^2),
- the estimated volume of wastewater (m^3),.

And for sewerage[4], there is a need to calculate

- the area of coverage, and
- additional factors to account for traffic disruptions and construction in rocky soil[5].

3.1.3 Capacity building costs

Conventional analysis assumes that costs are either capital or operational expenditures. CAPEX costs are one-off expenditures, whereas OPEX costs continue ad-infinitum until the planning horizon is reached. In many sanitation programs, there are three distinct phases relating to the 'management' costs:

1. **Initial startup costs.** During the initial phase of a project (generally within the first year), there is often a need for a concentration of expenditure to finance project infrastructure (both hardware and software), and establish the project.
2. **Costs associated with ongoing support during the lifecycle of a project.** After the project has been established, there is often a phase of support activities. This is a transitional phase, which may last for a few years. During this time, the focus of project activity is generally to provide support to local management operations with the aim to gradually diminish project involvement.
3. **Long-term costs after the 'project' has finished.** The aim of all capacity building activities is to ensure that local organizations, whether they are government agencies, private sector or community-based groups, are able to sustain the operation into the future. At this time, all project related costs have ceased and all 'management' costs are those related to the long-term operations.

In terms of financial and economic modeling, it is clear that the first phase can be attributed to capital costs, whereas the final phase can be attributed to ongoing operational costs. Long term project support costs cannot be clearly defined as CAPEX or OPEX. In this situation, part of these expenditures were allocated as CAPEX and part as OPEX[6].

3.2 Financial and economic benefits

There are three main areas where economic benefits are derived and modeled:

1. **Health benefits.** A benefit of sanitation of US$ 4.7[7] per person per year (inflated from 2000 to the current year) for the Africa region

[4]The volume of wastewater to be treated was estimated to be 50 liters cap-1 day-1.

[5]The model only provides very approximate estimates. Further work is required to improve the costing functions and to validate the model for application in sub-Saharan Africa.

[6]This was notably the case in the Burkina Faso.

[7]According to Hutton et al (2006).

was used for the analysis. It was assumed that this economic benefit associated with improved health is the same for each of the three sanitation options.

2. **Environment benefits.** An economic assessment of the discharge of untreated excreta into the environment was not possible within the scope of the project. Taking into account the environmental costs, the model includes a sub-component, which equates the cost of remediation (calculated as the treatment cost) as a proxy[8].

3. **Benefits associated with reuse.** There are various permutations of reuse that influence the approach towards the analysis. Either households reuse excreta on their own land to produce crops, which they consume or sell in the market, or alternatively, excreta are collected and transported offsite for reuse[9].

3.2.1 Modeling the benefits of excreta reuse

To model the benefits associated with reuse, the model includes the following calculations:

- Volume of excreta produced. Values for the quantity of urine and feces produced vary from country to country depending on diet[10].
- Mass of nutrients produced based on the average nutrient content in excreta (Earle 2001).
- Proportion of nutrients available for uptake. Not all defecation occurs at home. Therefore, it was assumed that 10 percent of toilet use occurs away from the home. To account for seepage and evaporation, losses of nutrients associated with urine and feces were estimated 20 percent and 8 percent respectively.
- The model offers flexibility to reuse urine and/or feces, and enables the user to estimate the proportion of each that is reused.
- The model incorporates an additional loss factor to account for the fact that nutrients are lost due to seepage, spillage or evaporation during storage and transportation.
- Once the mass of the nutrient has been calculated, a monetary value of excreta can be derived either on the basis that the crops grown have an equivalent market value or can be equated to the equivalent cost of the mass of nutrients contained in synthetic fertilizer.

3.2.2 On-site excreta reuse

In the first situation, where excreta reuse is on-site, the increased crop yield is estimated as a function of the quantity of fertilizer applied to the crop growth. For this, a simplified model defined by Mitscherlich's equation (Overman and Scholtz, 2002) was utilized. The yield response is defined as an exponential curve, which is influenced by crop and soil type, the agricultural conditions, and the rate of fertilizer application.

[8] These were calculated using Loetscher and Keller's (1999) empirical equations for a waste stabilization pond.

[9] The approach towards reuse influences whether it is valued as a financial or economic benefit.

[10] Default values are provided in the model from a study by Jönsson (1997).

A key factor which governs the amount of crop yield is the rate of application (expressed in terms of kg/ha). This suggests that it is more beneficial to distribute fertilizer over a wider area than to concentrate in a small area. The model also enables the user to choose between East Africa and West Africa, which influences the crop yield response to fertilizer application, in relation to climatic conditions.

Once the mass of crop has been calculated, its monetary value is estimated based on the market price. If the produce is sold then there is a financial benefit. But if the household consumes the produce, the benefit is either financial or economic, depending on the household income level.

If the household is sufficiently affluent and can already afford to sustain the family's nutritional requirements, then the cultivation of vegetables offers financial benefits as it enables them to purchase less vegetables from the market, and with the money saved, they can spend the income on other goods.

On the other hand if the household is poor and the family is undernourished, then the consumption of the vegetables does not offer any financial savings, because the household is likely to continue to spend the same amount of money in the market on other food items. In this case, the benefit is considered to be an economic benefit only.

3.2.3 Off-site excreta reuse

The other option for excreta reuse involves collection of the organic fertilizer and reuse off-site. If the fertilizer is sold, then it will have a financial value to the household. If there is no payment, then it is only an economic value. In the situation where households pay for the 'waste' to be collected, then it will have a cost, but it will also have a positive economic value.

To estimate the amount of yield associated with off-site reuse using Mitscherlich's equation requires data about the amount of available land. In the situation where the land area is not known, a pragmatic approach is required to estimate its value. In this case it is assumed that the costs per kilogram and fertilizing potential of organic fertilizer derived from excreta is the same as the equivalent mass of synthetic fertilizer.

4 Case studies analysis

In order to assess the impact of excreta reuse in financial and economic terms and compare with conventional sanitation, the study involved data collection and analysis from the following three case studies:

1. Kabale, Uganda
2. eThekwini Metropolitan Municipality, South Africa
3. Ouagadougou, Burkina Faso

These case studies were selected on the basis that they:

- are targeted towards urban and peri-urban settlements;
- promote the same type of ecosan[11] system comparable with conventional sanitation options;

[11]In South Africa the UDDTs are not promoted as ecosan because there is no excreta reuse for reasons described.

- reflect a range of alternative management and financing arrangements of excreta reuse;
- are reasonably well-documented already;
- are implemented at a sufficient scale to make meaningful analysis possible.

Sources of information

The main sources of data were project reports and existing studies. Other data and information was sourced from equipment suppliers, farmers and academic institutions. Local consultants interviewed householders and other local stakeholders to gather additional data and to cross-check reported data.

Scenario analysis

An analysis of the existing situation (referred to as the base case scenario), was carried out on various additional scenarios using the model. The objective was to highlight the impact of changes that may either adversely or positively influence the applicability and financial and economic viability of ecosan in different situations.

4.1 **Case study 1:** Kabale, Uganda

Kabale is a small market town in Southwest Uganda located on a main transport route between Kampala and Rwanda. It is a hilly area and the land is fragmented. Many households own more than one small plot of land.

Figure 3: Ecosan toilets in Kabale with a view inside the toilet chamber

Although agriculture is becoming more commercialized, most of the small-scale farming is still on a subsistence level[12].

The population connected to water supply is estimated to be approximately 53,000 (out of a total of 83,000), but there are less than 500 connections to the sewerage network in the center of the town. Therefore, pit latrines and other forms of on-site sanitation serve the majority of the population, approximately 6,000 households.

There are approximately 150 households with UDDTs promoted under the South Western Towns Water and Sanitation Program (SWTWSP). The households currently using ecosan toilets are relatively affluent and the average yearly household income from our sample was US$ 4,032, considerably higher than the average incomes of the bottom two quintiles quoted in the national statistics (US$ 1,223 and US$ 722 per year).

Unlike many other examples of externally funded projects, there were no subsidies used to finance the installation of latrines under the SWTWSP. The project only financed the promotion of ecosan to householders who were encouraged to construct UDDTs and reuse excreta. At the time of the study, 60 percent of ecosan households were estimated to be reusing excreta. The remaining households dispose off their urine into infiltration pits, and therefore the nutrient value of the urine is lost.

For the conventional on-site analysis, there is no desludging vehicle as the number of households is small and pits are cleaned manually. For the wastewater option, the household connection fee was taken as the household cost, combined with the output from Loetscher and Keller's model to estimate the downstream infrastructure expenditures (project costs).

The cost of the UDDT's (illustrated in Figure 3) promoted by SWTWSP is almost US$ 900, which is approximately 30 percent more than the highest cost VIP latrine (**see Annex 1**). In the low-cost options which uses less expensive construction materials, the CAPEX investments are reduced to US$ 340 and US$ 270 for ecosan and conventional sanitation respectively.

The cost of a latrine connected to the sewerage system is estimated to be US$ 295, which appears low compared with the cost of on-site latrines. But for these systems there is no need to dig and line the pit or alternatively to construct a vault above ground (as in the case of the ecosan latrine). However, there are additional costs associated with the installation, operation and maintenance of downstream sewerage and wastewater treatment facilities.

4.1.1 Benefits of reuse

On the basis that the area is characterized by a good rainfall regime and rich agricultural land with fertile soils, it was assumed that the agricultural conditions are 'good'. Based on a household size of seven, the model calculates that the additional crop that may be cultivated on a plot of land of 1.2 ha is 573 kilograms of potatoes per annum. This equates to approximately 0.5 tons per ha[13].

In the Uganda case study, the benefits of reuse are accrued directly by the household (for the 60

[12]Types of crops commonly grown include potatoes, beans, sorghum, vegetables and some high value fruit trees such as apples and avocado.

[13]The model does not predict the total crop produced but as a comparison the typical yields of potato crop in Africa is in the region of 10.8 tons per hectare per year according to the Food and Agriculture Organization (http://www.potato2008.org/en/world/africa.html).

percent of households that are reusing excreta). According to the model, the monetary value of reuse is US$ 102 per household per year, which equates to approximately 2.5 percent when compared with the average annual income in the community. This however increases significantly if associated with lower income households. According to official statistics the average incomes of the bottom two quintiles are US$ 1,223 and US$ 722 per year and the percentage benefit associated with excreta reuse increases to 8 percent and 14 percent respectively. In the case of Kabale this is only a hypothetical assumption since the actual ecosan users are not part of the lower income households.

As seen below in Table 3, for the higher-cost options, the UDDT option is seen to be the most favorable of the three options in financial terms for the household. Table 3 summarizes the results from the economic analysis. Clearly the flush toilet system is the most unattractive option. Out of the low-cost options, the low-cost UDDT returns a positive economic NPV of US$ 111. The better financial performance of the ecosan option is attributed to reduced household expenditure that is attained as a result of production of food, which substitutes food purchased in the market.

Figure 4 illustrates the impact of increasing size of the catchment (in terms of the population connected to the sewerage system) on financial and economic NPV associated with the wastewater option.

The results show the decreasing NPV values as the population increases, which suggest that the costs associated with sewerage are non-viable for small populations. These results are however based on empirical data from large centralized sewerage systems with large-scale wastewater treatment systems[14].

4.1.2 Scenario analysis

In the Uganda scenarios, the analysis focused on the implications of excreta reuse. These include:

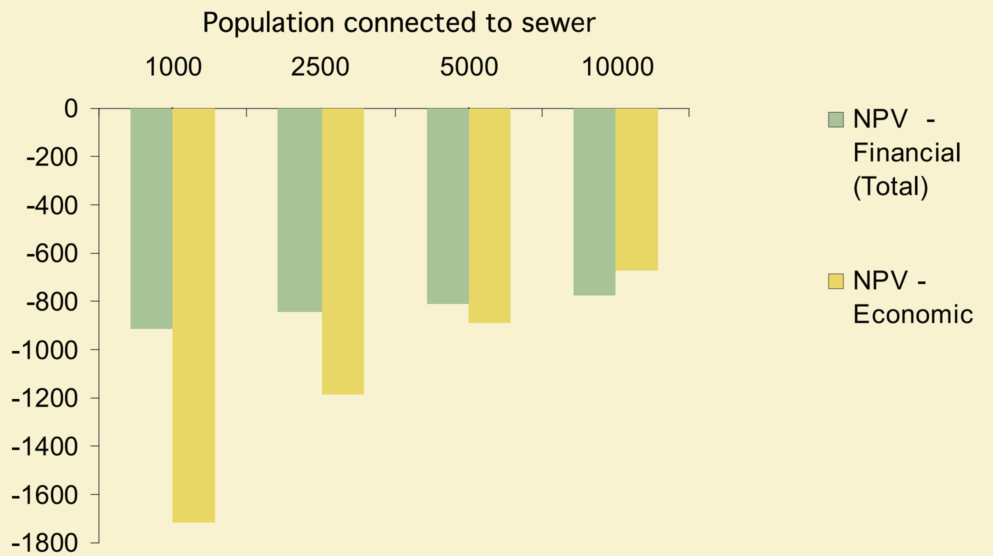
- No excreta reuse at household level
- Increase of price of the main commodity
- Influence on agricultural conditions

Table 3: Uganda: Financial and economic NPV (no subsidies)

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

[14]The use of simplified sewerage and more affordable treatment technologies that can be utilized at the decentralized level are likely to provide a more financially and economically attractive option.

Figure 4: Kabale: Economies of scale for sewerage and wastewater treatment (NPV plotted against population)



- Reduced availability of agricultural land due to urbanization

The results of these analyses are shown below and compared with the base case situation.

Scenario 1: No excreta reuse at household level

In this scenario, the excreta reuse component was removed and a marked decrease in the performance of the UDDTs, in terms of economic NPV from US$ -345 to US$ -881 and from US$ +111 to US$ -424 for the high and low cost options was observed respectively (see Table 4). These results clearly demonstrate the important influence of excreta reuse on the financial and economic viability of the ecosan option.

Table 4: Kabale: Impact of excreta reuse on financial and economic NPV

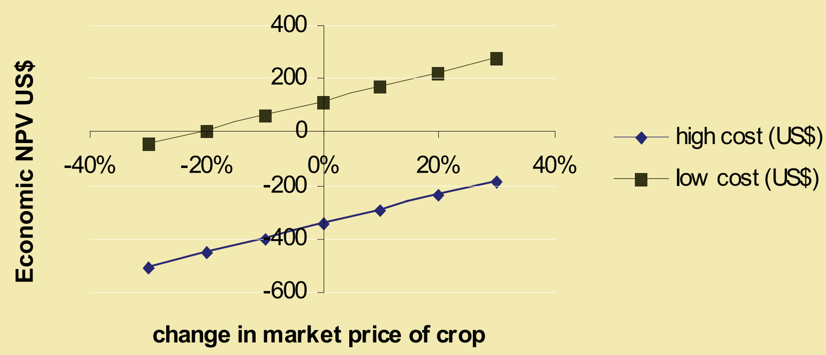
	UDDT	
	High cost	Low cost
	US$	US$
With reuse	+ 111	- 345
Without reuse	- 424	- 881

Scenario 2: Increase of the price for the main commodity

Figure 5 shows that the value of potatoes produced as a result of excreta reuse may decrease or increase depending on the market price (currently US$ 0.18) The results from the analysis show that the price of food stuffs in the market have a major influence on the NPV.

Figure 5: Kabale: Impact of price of food on the economic NPV

Change in food price	High-cost latrine (US$)	Low-cost latrine (US$)
-30%	- 506	-49
-20%	- 452	+ 4
-10%	- 399	+ 58
Base case	**- 345**	**+ 111**
+ 10%	- 292	+ 165
+ 20%	- 238	+ 218
+ 30%	- 184	+ 272



Scenario 3: Worsening of agricultural conditions

The impact of changing the agricultural conditions from good to very poor was explored. As can be seen in Figure 5, there is a marked decrease in the 'performance' of ecosan when the fertilizer is used for increasingly poorer agricultural conditions. It was observed that the economic NPV of ecosan is positively influenced by an increase of commodity prices, and negatively by the absence of excreta reuse and worsening agricultural conditions as shown in Figure 6.

Scenario 4: Reduced availability of agricultural land due to urbanization

The consequences of the availability of land for excreta reuse was looked into. In the case of a

Figure 6: Kabale: Impact of worsening agricultural conditions on the economic NPV

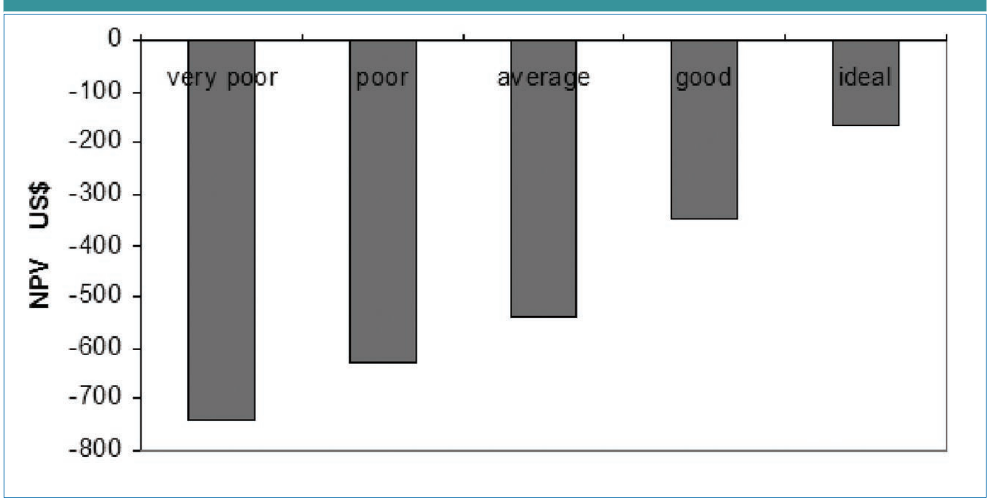
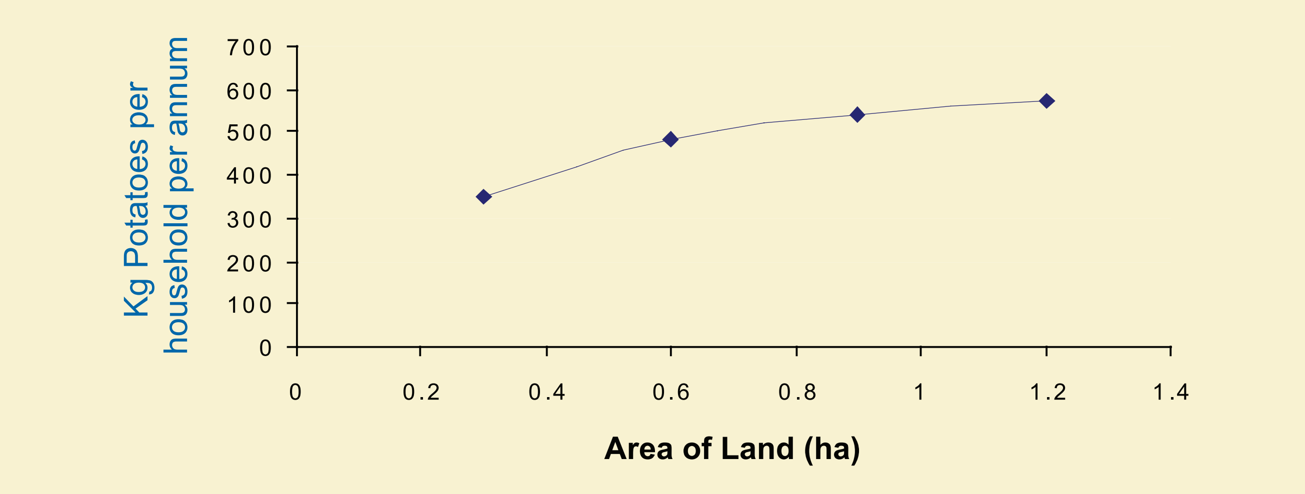


Figure 7: Kabale: Impact of the amount of land on the quantity of produced



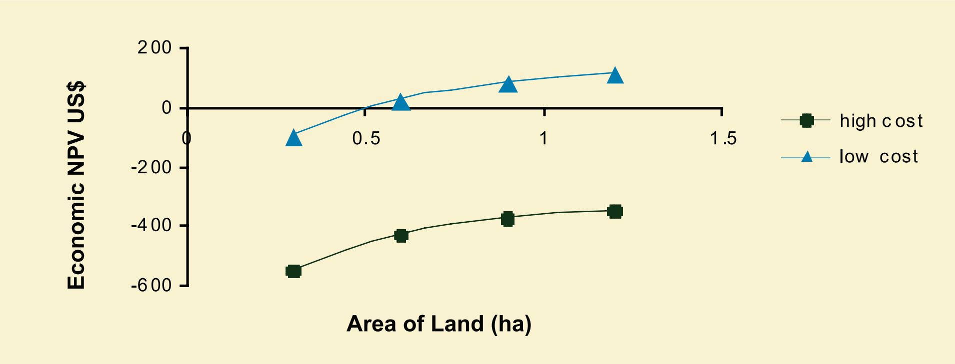
decrease of available land from 1.2 ha to 0.1 ha per household, the additional crop production decreases significantly (see Figure 7).

This is a similar, but more intensive impact compared to the worsening agricultural conditions as seen in Scenario 3.

Reduction of the availability of land from 1.2 to 0.3 ha in increments of 0.3 has significant impacts on the production of potatoes (38 percent reduction) and this can also be seen in terms of the steady reduction of the economic NPV value from US$ -345 to US$ -551 for the high cost UDDT and from US$ +111 to US$ -95 for the low cost UDDT (see Figure 8).

The availability of land is evidently a key factor when comparing ecosan with other sanitation options

Figure 8: Kabale: Impact of the amount of land on the economic NPV of ecosan



in the situation where land use is progressively becoming more urbanized. It is also of key concern for the urban poor for they are likely not to own the land on which they live in, and therefore any activity that is seen to be economically productive is more likely to commandeered by the landowner or alternatively may result in increased rental charges.

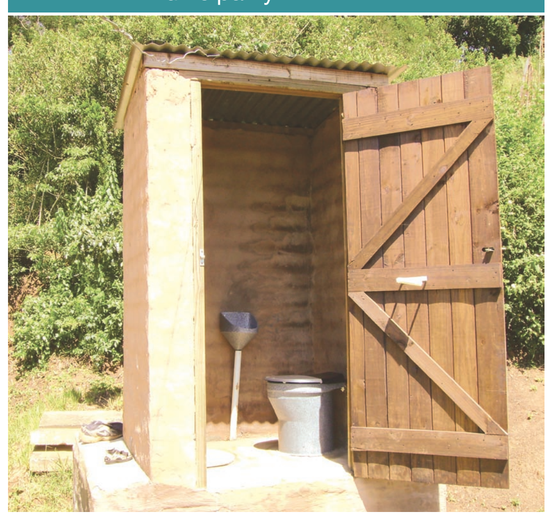
4.2 **Case study 2:** eThekwini Metropolitan Municipality - South Africa

eThekwini Metropolitan Municipality was created in 2000 and includes the city of Durban and the surrounding areas. With funding from Central government in form of municipal infrastructure or housing grants, the municipality assists low-income households to improve their latrines. Traditionally, eThekwini funded the construction of VIP latrines to eligible households and also provided an emptying service[15] free of charge once every five years. But pit emptying is expensive due to the remote locations and difficulties of access (see Figure 9) – approximately US$ 150 to empty a VIP latrine[16]. Due to the high costs for sanitation in these areas, the Municipality promotes UDDTs as an alternative to pit latrines to avoid the pit emptying costs.

Currently, there are estimated to be 90,000 households using conventional on site facilities, 30,000 connected to septic tanks and conservancy tanks, while 60,000 use VIP's. Throughout the municipal area, majority of households (circa 425,000 households) are connected to the sewerage network.

Figure 9: Problems of access by conventional desludging vehicles

Figure 10: Double-vault urine diversion toilet in the peri-urban areas of eThekwini Municipality.



[15]The pit emptying service is privately operated under contract from eThekwini municipality.

[16]This value is all-inclusive and includes the individual contribution towards the payback for the desludging vehicle and also the costs for treatment and disposal of the sludge in an environmentally safe manner.

Table 5: eThekwini: Financial and economic NPV (household and project perspective) with and without subsidies

		UDDT	VIP	Sewerage
		High cost	High cost	
With subsidies		US$	US$	US$
Financial NPV	Household	-9	-137	-652
	Project	-1,367	-930	-2,020
	Total	-1,376	-1,067	-2,672
Economic NPV	-	1,518	-1,148	-1,578
No subsidies		US$	US$	US$
Financial NPV	Household	-1,217	-1,230	-3,037
	Project	-158	-44	-215
	Total	-1,376	-1,273	-3,252
Economic NPV	-	-1,518	-1,148	-1,578

eThekwini's UDDT program has already funded the construction of 74,000 UDDTs (see Figure 10). Although, these households are given information about how to dispose of the waste hygienically, the program is not an ecosan program because the municipality does not promote excreta reuse due to health concerns.

Although the UDDTs cost less to maintain, they are considerably more expensive than the VIP options (US$ 1,245 as oppose to US$ 958). Since 2004 the VIP has not been provided as a sanitation option in the eThekwini municipality due to high emptying costs. In both situations, the latrines are fully subsidized for poor households and the only household contributions consist of unpaid labor. As mentioned earlier, for the purpose of a transparent and fair comparison of sanitation options, these subsidies were removed to enable the true cost of the different options to be assessed.

Table 5 shows the impact of subsidies in terms of the financial NPVs. As would be expected the subsidies transfers the costs from the household to the project financer. The table also shows that subsidies do not influence the total financial or the economic NPVs.

The results show that the UDDT option is the cheapest option from the household perspective when subsidies are applied, but when these are removed, the financial NPV increases significantly, and becomes almost as much as the VIP option. Due to the higher costs of UDDTs and the additional CAPEX costs associated with the UDDT promotion, the total project costs are higher for the UDDT option, even though operational costs are lower

Table 6: eThekwini: Financial and economic NPV (household perspective only) in the absence of subsidies with and without reuse of excreta

		Area of land available for reuse per household		
		0.2 ha	0.5 ha	1 ha
Financial NPV		US$	US$	US$
	no reuse	-1,376		
reuse	Potato	-1,050	-718	-487
	Maize	- 823	-258	-134
Economic NPV		US$	US$	US$
	no reuse	-1,518		
reuse	Potato	-1,284	-1,045	-879
	Maize	-1,120	-714	-432

(see Annex 1). The financial NPV for the UDDT option remains considerably lower than the sewerage option.

The economic analysis also shows that the UDDT is more expensive than the VIP option and is close to the cost of sewerage. The NPVs of all three options lie within a narrow range from US$ 1,148 to US$ 1,578.

4.2.1 Scenario analysis

In the base case situation in South Africa, there are no financial or economic benefits associated with the UDDTs, except those related to health (which are also common to all sanitation options). Making the assumption that the agricultural conditions are 'average' and assuming that the households receive a financial benefit for the sale of the crop, reuse enables a financial saving by reducing the amount of expenditure on food.

Clearly, the UDDT toilets become more attractive from both a financial NPV and economic perspective when excreta are reused. The amount by which the NPV is improved is a function of the type of crop being cultivated and the amount of land that is available for households. The results in Table 6 clearly show that access to land and the type of crops grown both play an important role in the determination of the NPV.

4.3 Case study 3: Ouagadougou - Burkina Faso

The case study focuses on a communal ecosan system promoted by the ECOSAN_UE project operating in peri-urban areas of Ouagadougou. The project started in June 2006 and is implemented by the research institute CREPA in partnership

Figure 11: Various types of urine diverting latrines in Ouagadougou

1a. Double vault in cement with cement brick superstructure (US$ 410)

1b. Double vault in cement with adobe brick superstructure (US$ 339)

2. Single vault integrated into the house (Variable cost)

3. Double vault with sub- and superstructure in adobe (US$ 279)

4. Box with adobe superstructure (US$ 229)

(Source: Salifou Boukary, ECOSAN_UEO)

Figure 12: A schematic view of the urine-circuit in the ecosan system implemented in Ouagadougou

(Source: Salifou Boukary, ECOSAN_UE)

Table 7: Financial and economic NPV (household and project perspective) with and without subsidies

		UDDT		VIP		Sewered option
		High cost	Low cost	High cost	Low cost	
With subsidies		US$	US$	US$	US$	US$
Financial NPV	Household	-198	-48	-682	-259	-1,721
	Project	-493	-493	-168	-168	-192
	Total	-691	-541	-850	-427	-1,913
Economic NPV		-560	-396	-840	-378	-1,055
No subsidies		US$	US$	US$	US$	US$
Financial NPV	Household	-342	-192	-759	-336	-1,721
	Project	-349	-349	-91	-91	-192
	Total	-691	-541	-850	-427	-1,913
Economic NPV		- 560	-396	-842	-380	-1,055

with GTZ, and the National Water and Sanitation Authority (ONEA), with financing from the European Union.

An estimated 930 households have had ecosan latrines installed. As shown below in Figure 11, there are various options available ranging from a low-cost option costing US$ 229 for a single vault UDDT to US$ 410 for a double vault UDDT constructed with cement bricks.

The cost of these UDDTs is lower than for the conventional double vault VIPs (US$ 612) promoted by ONEA. This is due to the fact that the VIPs have two large double vaults, which require higher costs for excavation and construction, especially since the pits need to be lined and a partition wall installed to divide the pits.

The most common latrine built in ONEA's program is the rehabilitated traditional pit latrine. The existing traditional latrine is then improved with a vent pipe, higher wall, roof and a door. The low cost version of an improved traditional latrine is US$ 177.

Cartage systems managed by local associations, which have been contracted by the project have been set up. These associations collect and transport urine and dried feces to eco-stations where it is stored for further sanitization. As shown in Figure 12, from these stations the ecosan fertilizers are distributed to peri-urban farmers. The project has promoted demand by participative experimentation and training among 800 farmers, on how to enhance crop production by using ecosan fertilizers.

Initially, the associations involved in the collection and transport were entirely subsidized by the ECOSAN_

Table 8: Impact on the financial and economic NPVs in Ouagadougou of a) 50% reduction in management costs and b) payments from farmers for fertilizer

		UDDT high cost			UDDT low cost		
		Free distribution	Reduced management costs	Fertilizer sold to farmers	Free distribution	Reduced management costs	Fertilizer sold to farmers
		US$	US$	US$	US$	US$	US$
Financial NPV	Household	-342	-342	-342	-192	-192	-192
	Project	-349	-288	-93	-349	-288	-93
	Total	-691	-630	-435	-541	-480	-285
Economic NPV		-560	-494	-161	-396	-330	+2

UE project for operating and salary costs. Since March 2009, urine is sold to urban farmers who pay 100 CFA (US$ 0.20) per jerry can and 50 CFA per kg of dry hygienized feces. In addition, households pay a small fee for collection services.

In Ouagadougou, the expenditures associated with project management are most significant in the start-up phase. Out of a total of US$ 164 for annual OPEX per household, 75 percent is associated with the project's management overheads. This OPEX is exclusive of economic costs associated with the unpaid labor contributed by the householders to maintain their latrines. These management costs are to be phased out and therefore do not reflect the longer-term management costs, that had been allocated on 25 percent to OPEX and 75 percent to CAPEX.

The total expenditure of the high cost UDDT (materials and labor) is US$ 410. These are subsidized heavily (US$ 237) and up until recently, the collection costs have been paid for under the ECOSAN_UE project.

Therefore, as can be seen in Table 7, not surprisingly this means that these are the most attractive options from a household perspective. When considering the no-subsidy option, the low-cost pit latrine is the most attractive option. The removal of subsidies has no impact in terms of the financial performance of the total costs of the different options. But as would be expected it has significant financial implications from a household perspective as shown in Table 7.

The total estimated value of nutrients in the excreta produced by households in Burkina Faso is calculated to be US$ 36.3 per year per household. This equates to <5 percent of the household income for the lower quintiles. CREPA, in its project calculations on the quantity of urine and feces actually entering the collection system, estimates that a household would achieve a benefit of US$ 1.7 per month, which corresponds to US$ 21 per year. Therefore, reuse is attractive from this perspective, but not as attractive as in Uganda where the agricultural conditions enable greater yields to be achieved.

The results from the no subsidy analysis indicate that out of the on-site options, the UDDT option is the most favorable in all cases from a household perspective. The UDDT option is also the most favorable from a total cost perspective when considering the high-cost latrine option, but not of the low cost option. From the project financing perspective, the costs of the VIP option are evidently considerably lower. In all situations, the sewered option is most expensive.

4.3.1 Scenario analyses

There are two main factors in addition to the cost of the latrine itself which influences the viability of ecosan in Ouagadougou. The first relates to the high management overheads to set up and support the excreta collection and distribution system, and the second relates to the financial returns that either can assist households directly, or more likely, may be fed back into the system to subsidize the costs of managing and operating the system, and therefore benefit them indirectly

From a household perspective, the reduction of the project management costs does not have any implications since these are funded by an external funding organization, and the costs are not passed on to the household as a charge. Reductions in project costs positively affect the total project financial costs and the overall economic performance.

Table 8 shows the impact that fertilizers have and the monetary value as manufactured fertilizer. These values are compared with the no-subsidy option as presented above. Clearly this has significant advantages insofar as the low-cost option returns a positive NPV.

5 Main findings

5.1 General observations

Although there are many examples of ecosan pilots and small-scale projects in Sub-Saharan Africa, there are only a few large-scale urban projects. Consequently, ecosan toilets are only used by a relatively small number of the urban population. Even in towns that are well known for ecosan projects, the coverage is by no means universal and not all households are necessarily actively involved in reuse. Only the program in eThekwini (South Africa) is of significant scale, but in this situation excreta reuse is not promoted due to potential health concerns and consequently the program is not considered to be promoting ecosan.

There is a range of different technologies and management arrangements that may be adopted to promote the reuse of excreta. But, based on the case study analysis, none are seen to provide an obvious model for scaling-up without considerable external support. In both the South Africa and the Burkina Faso cases, household latrines and off-site arrangements for excreta management are heavily subsidized. The only example where subsidies were not applied was in Uganda, but here, the ecosan users are not considered to be poor.

The case studies did not focus on social or cultural issues related to excreta reuse. One of the main benefits of these latrines from a user perspective is the reduced odours compared with a conventional pit latrine. These are important considerations that may weigh in favor of ecosan, which have not been included in the model. On the other hand, the fact that households like in the case of Ouagadogou do not need to 'handle' human waste may offer potential for scaling up without the problems associated with promoting reuse at the household level. Evidently there are also other factors such as access, convenience, privacy etc. that need to be taken into consideration, Due to limitations of time and resources, and the problems associated with quantifying these in monetary terms, these were not accounted for in the study.

Further research is required to assess which factors predominate under which situation.

5.2 Cross country comparisons

Table 9 summarizes the results of the analysis and these results are illustrated in Figures 13 and 14, which ranks the different options according to the financial and economic NPVs respectively. It is important to reiterate that for this analysis, the influence of household subsidies has been removed and the same number of households (5,000) has been used in each case in order to provide a more consistent basis for comparison.

It was observed that the sanitation options in Uganda have the lowest NPVs followed by Burkina Faso and then South Africa. This trend would follow the ranking of these countries according to GDP (nominal) per capita[17] where South Africa ranks 74th, Burkina Faso ranks 155th, and Uganda lies at 162nd position.

Only two options, the low-cost UDDT with excreta reuse in Uganda, and the low-cost UDDTs in Burkina Faso, return a monetary value of excreta (equivalent price of chemical fertilizer), which can be realized by the households or could potentially be used to reduce the cost of the operation. These low-cost options are not formally part of the ecosan programs and further work is required to ensure that these technologies are of sufficient standard to be ratified by the authorities.

In Uganda, there are a number of factors that contribute to this result. The low capital investment is a key factor. The total cost of the UDDT is US$ 390 (including materials and labor), and there are no additional off-site costs. In addition, and of key importance are the conducive agricultural conditions attributed to good soil and rainfall distribution throughout the year. This option also indicates the highest financial NPV making it the most attractive of all the options from a household perspective. As the results indicate, the relative performance of UDDTs with local reuse is highly dependent on the area of land available for crop production, the agricultural conditions and the type of crop that is grown.

The households in Kabale, Uganda have access to an estimated 1.2 ha of land, whereas there is only an estimated 0.2 ha and 0.1 ha of land available for the households in eThekwini, South Africa and Ouagadougou, Burkina Faso[18]. The situation in Kabale where only the central part of the town has urban features and proportionally large parts of the towns have more peri-urban or even rural characteristics, is advantageous to the ecosan option, i.e. households directly apply excreta on their own plot of land. Furthermore, the agricultural conditions in the Southwest of Uganda are estimated to be relatively good compared with eThekwini and Ouagadougou, which are considered to be average

[17]http://en.wikipedia.org/wiki/List_of_countries_by_GDP_(nominal)_per_capita

[18]As with all the data, these are only average values and may not be representative of all households in the locality.

Table 9: Cross country comparison of financial and economic NPVs for high and low cost latrines (with subsidies removed)

		Low Cost Latrine Option			
		Financial NPV			Economic NPV
		Household	Project	Total	
UDDT	Uganda	-55	-123	-178	+ 111
	South Africa	-	-	-	-
	Burkina Faso	-192	-349	-541	-396
Pit Latrine	Uganda	-301	-30	-331	-124
	South Africa	-	-	-	-
	Burkina Faso	-336	-91	-427	-380
		High Cost Latrine Option			
		Financial NPV			Economic NPV
		Household	Project	Total	
UDDT	Uganda	-484	-123	-607	-345
	South Africa	-1,217	-158	-1,376	-1,518
	Burkina Faso	-342	-349	- 691	-560
Pit Latrine	Uganda	-647	-30	-677	-492
	South Africa	-1,230	-44	-1,273	-1,148
	Burkina Faso	-759	-91	-850	-842
Wastewater system	Uganda	-605	-203	-808	-890
	South Africa	-3,037	-215	-3,252	-1,578
	Burkina Faso	-1,721	-192	-1,913	-1,055

and poor respectively. These are generalizations that have a significant influence on NPV, as shown by the sensitivity analysis from the Uganda case study.

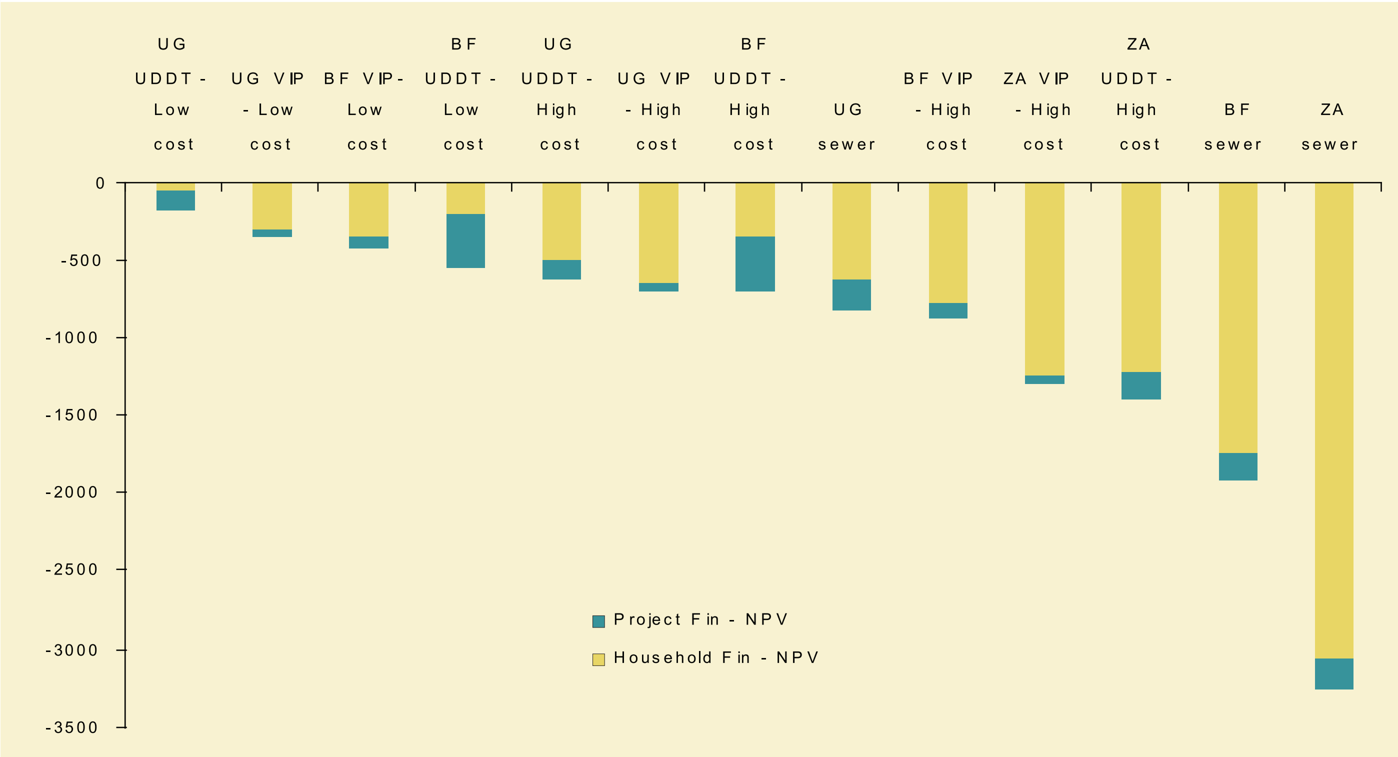
The higher cost option also shows a similar pattern to the low-cost latrines and UDDTs, although there are no positive economic benefits, and the financial costs are obviously considerably higher from the household perspective. The results indicate that ecosan has greater economic potential than conventional on-site sanitation, given the right environmental conditions (availability of land, type of soil and climatic conditions). The results also show that the relative benefits increase for poor households who practice excreta reuse, although poor households are more likely to be in need of subsidy to assist in the construction of latrines in the first instance. In Burkina Faso, the high-cost UDDT does not show a positive economic NPV due to the costs of establishing a system for collection and transportation of excreta, combined with the costs of capacity building, promotion as well as the cost of latrine construction. The high cost UDDT option is more attractive from an economic perspective than the high cost VIP latrine, and is also considerably more attractive than the sewerage system.

Looking at the low-cost latrine scenario and considering the situation where the full monetary value of the crops grown is included in the analysis, the results indicate potential for a positive NPV. Further data collection and more detailed analysis of various charging mechanisms and tariff structures for house-to-house collection is required, to better assess the financial and economic viability of the system. The recent introduction of user charges for household collection will inevitably improve the viability of this system.

Results from Burkina Faso suggest that there are merits associated with the communal collection and excreta reuse system, in situations where on-site reuse is not feasible. It also overcomes the problem that is highlighted in Uganda, that not all households are necessarily interested in excreta reuse (especially those that are more affluent for whom the economic benefits related to reuse are less significant). A more detailed research is required to illustrate how the perceived benefits influence the level of interest in excreta reuse at the household level.

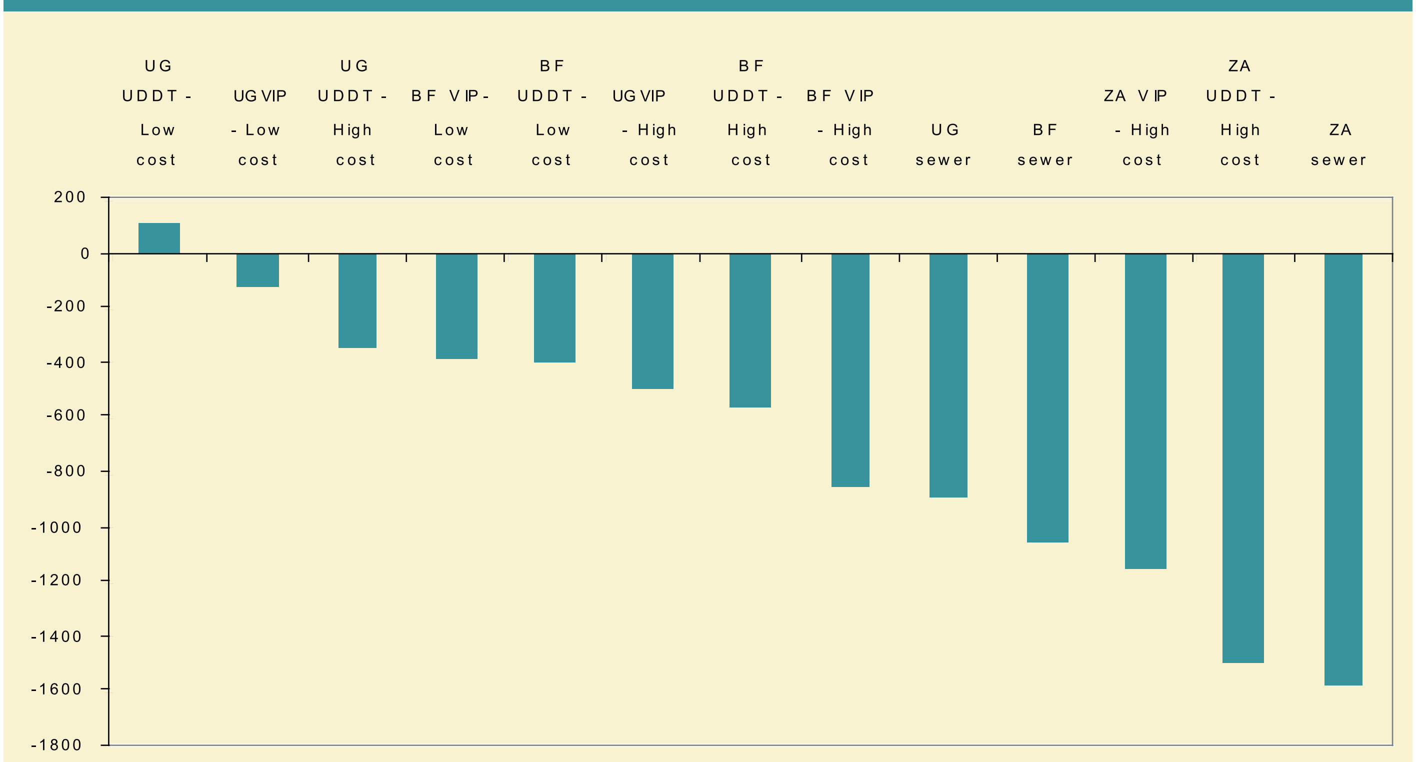
Availability of data for sewerage infrastructure was poor in each of the case studies, the results indicate however, sewerage is the most expensive option from both a financial and economic perspective. The financial costs for the sewerage option in South Africa is notably high, which is attributed to the fact that the cost of latrines and the household connection fees are very high. The high cost of latrines in South Africa was evident for all the technologies, and these are not considered to reflect on the costs of construction in most other countries in Sub-Saharan Africa. Further research is also required to assess the viability of low-cost sanitation options, including simplified sewerage as a comparative to conventional on-site sanitation options in urban areas.

Figure 13: Cross - country comparison: Ranking of sanitation options – financial NPV



(UG – Uganda, BF – Burkina Faso, ZA – South Africa)

Figure 14: Cross – country comparison: Ranking of sanitation options – economic NPV



(UG – Uganda, BF – Burkina Faso, ZA – South Africa)

5.3 Discussion

The lower the capital costs, the higher are the benefits of reuse in ecosan option, in terms of Net Present Value (NPV). The operational expenditures have an impact on the overall financial and economic performance, but the impact is limited, compared to the influence of capital costs. The results show that operational and maintenance costs determine the financial performance (in terms of NPV) from a household perspective in situations where latrines are heavily subsidized. However, when subsidies are removed and overall project costs are taken into account, the picture changes remarkably, as the capital costs become the most critical factor which influences the financial performance of each option.

By reusing excreta, households with ecosan toilets can generate monetary benefits and increased crop production can have a positive impact on them financially. Evidently, poorer households seek to gain more in proportion to their household income. Although not only specific to ecosan, latrines may not be affordable for the poor without subsidies to reduce the extent of household investment. However, it needs to be recognized that all of the analyzed options may not be affordable for the poor without subsidies, and it is therefore important to consider the development of cheaper latrines that are ratified and promoted by government agencies.

The results from the model analyses demonstrate that various factors influence the crop yield, and this is a key determinant in the economic viability of ecosan. These factors include the availability of land, the type of soil, and climatic conditions. The results indicate that in the right environment, ecosan can provide a positive net benefit and therefore the UDDTs are an attractive technological option that requires further consideration in sanitation programming. In particular, UDDTs provide an appropriate sanitation technology in situations where the practicalities and operational costs of servicing conventional on-site sanitation means that desludging and off-site disposal are not considered to be viable.

The key factors influencing the viability of ecosan in urban environment are the amount of land available, and the agricultural conditions. As it is more beneficial to apply fertilizer over a larger area as opposed to concentrating the application on a smaller area, reuse of excreta in urban environment becomes increasingly less attractive, as the housing density increases.

The yield is also a function of the agricultural conditions. Good agriculture conditions promote increased yields and it is in these conditions that excreta reuse is seen to be most beneficial. It is also arguable that in situations where the agricultural conditions are poor, it is advisable to reuse excreta. Whether it is considered to be economically attractive will ultimately depend on the household's income.

Although not included in the study, it has to be recognized that there are potentially other factors that contribute to the attractiveness of ecosan from a household perspective (notably reduced odors). On the other hand, there are other behavioral constraints related to use of UDDTs and the handling of feces that may reduce the interest at the household level to utilize these technologies. Further research is required to assess which factors predominate under which situations.

The results indicate that the benefits from crop production can offset the higher capital and operational costs, but the benefits may not be sufficient to cover additional costs required for implementing ecosan. There are many factors at hand, and the study highlights the complexity of the systems involved. The answer to this depends on physical, environmental and social factors.

The study also points towards the need to reuse excreta as close to the point of generation as possible, whilst keeping the costs of installation down. Where this is not viable, a communal excreta reuse system becomes economically attractive, provided the project management and capacity-building costs associated with the promotion of ecosan can be lowered.

Based on the case study analysis, none of the currently implemented systems are seen to provide an obvious model for scaling up without considerable external support. It is apparent that there remains a lot of research required to assess the costs of marketing ecosan compared with conventional sanitation, and further work to look into the costs of different management arrangements. A communal excreta management system such as that in Burkina Faso may overcome some of these constraints, and is more appropriate in denser urban environments. There is need to look in more detail, at the different management arrangements and costs for setting up and operating house-to-house collection services. There may also be ways of introducing more cost effective technologies to enhance the efficiency of the operation.

6 References

Earle, A. (2001) ***Ecological Sanitation***. Water Web Management Ltd. www.africanwater.org/EcoSan_main.htm (accessed 12.08.08).

Hutton, G., Haller, L., Bartram, J. (2006) ***Economic and health effects of increasing coverage of low cost household drinking water supply and sanitation interventions,*** Background document to the "Human Development Report 2006", United Nations Development Programme, World Health Organization, Geneva, Switzerland, Geneva 2007.

Loetscher, T. and Keller, J. (1999) ***Estimating the financial costs of sanitation systems.*** 25th WEDC Conference, Addis Ababa, Ethiopia, 1999. wedc.lboro.ac.uk/conferences/pdfs/25/048.pdf.

Jönsson, H. and Vinnerås, B. (2004) ***Adapting the nutrient content of urine and feces in different countries using FAO and Swedish data.*** *In: EcoSan –Closing the loop*. Proc. 2nd Intern. Symp. Ecological Sanitation, April 2003, Lübeck, Germany.

Overman, A.T. and Scholtz , R.V. (2002) ***Mathematical models of crop growth and yield.*** Marcel Dekker Inc. New York, USA.

Annex 1: Summary of financial cost data

	Uganda Kabale		Burkina Faso Ouagadougou		South Africa eThekwini
Inflation Rate	5%		2%		13%
Local level Interest Rate	22%		22%		16%
Conventional on-site	High cost	Low - cost	High cost	Low cost	-
CAPEX per household					
Total	$US 675	$US 270	US$ 612	US$ 177	US$ 958
Materials	$US 575	$US 225	US$ 536	US$ 112	US$ 841
Labor (paid)	$US 100	$US 45	US$ 149	US$ 62	USS$ 117
Labor (unpaid)	-	-	-	-	16 hours
Capacity building, sanitation and hygiene promotion	US$ 35[1]		US$ 109[2]		US$ 45[1]
OPEX per household per annum					
Management costs	-		US$ 11		-
Desludging [3]	US$ 15		US$ 45		US$ 30
Household Cost – unpaid labor	9 hrs		9 hrs		23 hrs

	Uganda Kabale		Burkina Faso Ouagadougou		South Africa eThekwini
UDDTs	High cost	Low - cost	High cost	Low cost	-
CAPEX per household					
Total	US$ 892	US$ 390	US$ 410	US$ 229	US$ 1245
Materials	US$ 760	US$ 310	US$ 367[4]	US$ 186	US$ 840
Labor	US$ 132	US$ 80	US$ 43		US$ 405
Labor (unpaid)	-	-	-		16 hours[5]
Additional items	US$ 20		US$ 130[6]		US$ 34
Capacity building and promotion	US$ 144		US$ 206 7		US$ 129
OPEX per household per annum					
Organizational costs (including fertilizer collection and delivery)	-	-	US$ 35[7]		US$ 10
Household Cost – unpaid labor to empty and bury the contents of the vaults	90 hrs		17 hrs		40 hrs
Ongoing promotion	US$ 20		-		-

	Uganda Kabale	Burkina Faso Ouagadougou	South Africa eThekwini
Wastewater systems[8]			
CAPEX per household			
Total	US$ 210	US$ 467	US$ 1,285
Materials	US$ 200	US$ 300	US$ 1,097
Labor	US$ 10	US$ 167	US$ 188
Connection fee	US$ 85	US$ 216	US$ 592
OPEX per household per annum			
Sewerage tariff	US$ 32.5	US$ 210	US$ 21
Cost of water for flushing	US$ 43.3	US$ 64.8	US$ 121

Notes:

1. To enable a fair comparison of options, costs for sanitation and hygiene promotion were assumed.
2. Costs for awareness raising and sanitation promotion costs by ONEA are reported to be US$ 145. We have assumed that 75 percent is for sanitation promotion and 25 percent is for promotion of grey-water leach pits.
3. It is assumed that the cost of desludging paid by the household pays back the capital investment for purchase of desludging equipment.
4. Household contribution is US$ 130.
5. Unpaid labor is estimated to be the same for UDDTs and VIPs.
6. The total cost of construction of the storage and facilities is US$ 130: US$ 8 for collection equipment; US$ 108 for storage and delivery equipment; and US$ 14 for reuse equipment at the farm.
7. The estimated cost of management support is US$ 140 per household per year during the course of the project. These costs have been allocated to CAPEX (75 percent and OPEX 25 percent). In addition, there is US$ 101 for household ecosan promotion and capacity building (US$ 89 per household for household training; and US$ 12 per household for training of the farmers). Therefore, the total values is US$206 (US$ 101 + US$ 140*0.75) for CAPEX and US$35 for OPEX.
8. Estimated costs of sewerage and wastewater treatment derived from Loetscher and Keller's (1999) empirical model. The values quoted here are calculated based on the size of the populations in the case studies of 5,000 people.

August 2009

WSP MISSION

The Water and Sanitation Program is an international partnership for improving water and sanitation sector policies, practices, and capacities to serve poor people

WSP-AFRICA'S FINANCIAL PARTNERS

Australia, Austria, Denmark, Finland, France, Ireland, Luxembourg, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom, The World Bank, and the Bill and Melinda Gates Foundation

Prepared by: Richard Schuen, Jonathan Parkinson and Andreas Knapp

Contributions by: Philippa Ross and Graydon Jeal

Task Team Leader: Andreas Knapp

Picture Credits: Cover and inside pages © WSP/Andreas Knapp, © Melanie Wilkinson, © Teddy Gounden/Durban Metro Water Services

Other photographs: Courtesy of EcoSan Club, CREPA, GTZ, ONEA and ECOSAN_UE project Ouagadougou

Created by: Eric Lugaka.

Water and Sanitation Program-Africa
The World Bank
Hill Park Building
Upper Hill Road
P.O. Box 30577 - 00100
Nairobi, Kenya

Tel: +254-20-322 6334
Fax: +254-20-322 6386
Email: wspaf@worldbank.org
Web site: www.wsp.org

wsp water and sanitation program

partner of sustainable sanitation alliance