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Improving the robustness of financial and economic analysis of sanitation systems

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Abstract

With a view towards improving the robustness of financial and economic analysis, this paper discusses current approaches towards the assessment of costs and benefits associated with sanitation improvements. Using results from a study that compares urine diversion dehydration toilets with conventional sanitation technologies in sub-Saharan Africa, the authors highlight challenges related to financial and economic modeling of sanitation systems. Excreta reuse is identified as a specific area where there is a need for further development. Specific attention is placed upon the quantification of the economic benefits of excreta reuse and the authors describe the approach for monetising these benefits. The authors offer specific recommendations for improving the robustness of this analysis, and propose a framework for categorizing financial and economic parameters for project design, sanitation programming, and policy-making. The authors argue that the consistent application of the proposed framework, combined with the standardisation of methodologies and the systematic collation of financial and economic data is required for future studies to assess the financial and economic costs and benefits of different types of sanitation systems.

Keywords

Costs, benefits, economics, sanitation, ecosan, excreta reuse.

INTRODUCTION

In order to enable decision makers to assess the relative value to society of a proposed investment and/or to assess the efficacy of alternative approaches to attain a desired goal, sanitation projects and programmes are increasingly subjected to financial and economic analyses (SuSanA, 2009). The type of analysis depends upon the type of activity that is being undertaken. These generally relate to one of the following:

i) *Project design* - Sound financial analysis is fundamental for good project design. To be able to appropriately cost a project within a given budget, sanitary engineers need to base estimates on accurate unit costs with a clear understanding of the uncertainties surrounding data sets.

ii) *Sanitation programming* - Financial analysis is also important to facilitate the comparison of capital investment (CAPEX) and operational and maintenance costs (OPEX) associated with different sanitation technologies in order to identify the most cost effective solution. Economic analysis is less common for sanitation programming but may also be required to justify the rationale for a project or programme.

iii) *Policy decisions* - Results from economic analysis can play an import role in influencing political decisions about the need to invest in improving sanitation. According to Hutton *et al.* (2007a), the benefit-cost ratios of some types of sanitation intervention may even surpass those of water interventions. The results of this type of analysis may therefore be instrumental in stimulating investments into sanitation, as has been the case in Indonesia (WSP 2008).

Broadly speaking, the costs and benefits can be divided into the following categories:

1) <u>Financial expenditures</u> including CAPEX and OPEX, sanitation and hygiene promotion, project management support costs and other capacity building activities. In addition to those directly connected with the ‘project’, these expenditures should also include household level investments and revenues associated with payments for services.

2) <u>Economic benefits that are not necessarily directly linked with the financial expenditures of a project</u> as described above, but having tangible financial impact on beneficiaries in the community where the project is targeted. Benefits in this category include costs of treating water and those related to illness (e.g. expenditure on medicine/health care or lost income due to loss in productivity). Other benefits include the increased productivity of water resources (e.g. increased fish populations due to improved water quality) and agricultural land where wastewater/excreta are reused to increase crop yields.

3) <u>Benefits that are essentially the same as those described in category 2</u> but whose potential beneficiaries are stakeholders located outside the area of the defined project.

4) Economic costs and benefits that cannot be attributed to financial expenditures or revenue but can be quantified in monetary terms. Based upon WSP (2008), the types of economic benefit that fall in this category include the following:

- *Health*: the full costs of health care from an institutional perspective.
- *Productivity*: income associated with lost time from caring for the sick.
- *Extended lifespan:* better health leading to extended lifespan and increased income potential.
- *Education*: increased attendance at school and improved cognitive ability.
- *Environment quality*: increased land value due to improved environmental conditions.
- *Time benefits:* as a result of closer access to a toilet and shorter waiting times at public toilets (resulting in additional time for work or study).
- *Tourism:* potential for increased revenue from tourism.

With a view towards improving the robustness of financial and economic analysis, this paper discusses current approaches that assess the costs and benefits associated with sanitation improvements. Examples of previous studies, which have taken different approaches in conducting financial and economic assessments are presented and examined based upon the study funded by the Water and Sanitation Program which involved the monetisation of the benefits of excreta reuse (WSP 2009). The WSP approach is used to highlight challenges related to the financial and economic modeling of sanitation systems, with the aim of making recommendations for improving the robustness of these analyzes.

EXAMPLES OF DIFFERENT TYPES OF FINANCIAL AND ECONOMIC ASSESSMENT

Based upon a review of existing literature, it is apparent that various researchers have applied different parameters for investigation in their analyses, and have categorised these in different ways. For example, Kreditanstalt für Wiederaufbau evaluate various sanitation projects, applying a financial cost-benefit analysis that examines capital and operational expenditures, costs of capacity building and sanitation/hygiene promotion (KFW 2009). Von Muench and Mayumbelo (2006) compare the Net Present Value (NPV) of capital and annual operational costs of different sanitation systems in low-income peri-urban areas in Lusaka, Zambia. Costs for capacity building or sanitation/hygiene promotion costs are not included in the analysis, but the study does apply a monetary value on excreta reuse based on estimates of the value per unit mass/volume of urine and composted excreta.

A study undertaken by Hutton *et al.* (2004) for the World Health Organization (WHO) analyses the costs of a range of interventions similar to those described by KFW 2009, but extends the scope of the research to also include the economic benefits associated with health care and increased productivity. In 2007, Hutton *et al.* (2007a) carried out a broader and more detailed study that expanded the categories for and range of economic benefits, such as those related to avoided deaths and time savings due to easier access to sanitation.

WSP (2008) developed the economic assessment further to monetise the impacts of poor sanitation and hygiene on health, water resources, tourism and other welfare indicators. In this study, the effects of poor sanitation on various qualitative dimensions including quality of life, user preferences and the quality of the surrounding environment are covered. The study incorporates an assessment of these economic impacts of sanitation and describes how these may be quantified using locally-derived and statistically valid data.

In 2009, the WSP funded a study to develop a model to compare urine diversion dehydration toilets (UDDTs) - a type of toilet that separates urine from feces at source to facilitate excreta reuse - with conventional sanitation systems (ventilated improved pit latrines and conventional sewerage) in terms of financial and economic costs and benefits (WSP 2009). The study suggested that the development of appropriate models required working with and analysing the input of capital expenditure (CAPEX) and operational expenditure (OPEX) including costs for hardware (e.g. the cost of the latrine itself) and software (including sanitation promotion, training and other capacity building activities). Within this analysis, a methodology that monetises the economic value of excreta based upon an estimated increase in crop yields was also offered.

MONETISING THE BENEFITS OF EXCRETA REUSE

As the methodologies to monetise economic value of excreta remain in their infancy, this paper is limited to an examination of three case studies in urban areas with relatively large-scale UDDT projects promoted and implemented -- Kabale in Uganda, eThekwini (Durban) in South Africa, and Ouagadougou in Burkina Faso. The analytical framework used for the paper is largely informed by the methodology and results from the WSP study of 2009.

Due to health concerns, excreta reuse is not practiced in eThekwini and therefore the results only show the potential for economic benefit. In Ouagadougou, the system is different from Uganda and most other situations where excreta reuse is being practiced in terms of the stakeholder group benefitting from excreta collection. In the case of Ouagadougou excreta is collected from each household by small-scale private sector operators and transported offsite for treatment and reuse by farmers. Therefore, the economic benefits of excreta reuse in Ouagadougou are not necessarily realised by the households, rather by farming communities.

To account for the fact that there are wide variations in costs of toilets depending upon the quality of construction, local consultants were asked to supply data for both high-cost and low-cost toilets. As subsidies distort the distribution of financial costs, the data analysis was limited to a review of systems that did not receive subsidies. This was purposely conducted to make more transparent the comparison of different sanitation technologies and ensure credibility in the results of the study. Economic benefits other than those associated with health, pollution and reuse were also not examined by this study.

The economic benefits for health were quantified using data borrowed from Hutton *et al* (2007b) study on the Africa region. The value of US$ 4.7 per person per year (inflated from 2000 to 2009) was assumed to be the same for all beneficiaries as it was assumed that different types of toilet offer the same level of service. Therefore the economic benefits associated with health are effectively the same in each case. To model the economic impact of the environmental damage caused by the discharge of untreated fecal sludge into the environment, costs were equated to the cost of remediation (calculated as the estimated cost of treatment) as a proxy.

The study used two approaches towards the monetisation of economic benefits of excreta reuse. The first approach was similar to that used by von Münch and Mayumbelo (2007) in which the calculation of the monetary value of fertilizer was based upon the value of synthetic fertilizer in the local market. This calculation was complemented by a more detailed methodology that modelled economic benefits associated with reuse, where the availability of land and the type of crops were known. This approach is described in the succeeding pages and the results presented are based on the application of this methodology.

An estimate of nutrients contained in excreta per person was used as input in the empirical equation to calculate additional crop yield. It was assumed that nitrogen/phosphorus derived from excreta has the same fertilizer potential as manufactured fertilizer. It was also assumed that the nutrient value of excreta (predominantly contained in urine) is the only cause for economic benefit. Thus the soil conditioning value of digested or composted feces or the potential for generation of biogas was not taken into consideration.

In addition to incorporating the area of cultivated land and type of crop as factors for analysis, other input parameters used to shape the model included agro-climatic conditions, crop yield response and the market value of produce. The analysis of the monetary value of excreta and its financial or economic benefits were also dependent upon the location where excreta was reused or utilised -- on site by the household, sold by the household as fertilizer or whether it is transported offsite for use on farms where it is assumed to be of economic benefit for farmers (as is the case in the case study from Mali).

Availability of land

Sensitivity analysis showed that the availability and size of land were key considerations. As shown in Figure 1, reducing the availability of land per household from 1.2 to 0.3 ha has had significant impacts on the production of potatoes (38% reduction in terms of mass of crop). This equates to a reduced economic NPV value from US$ - 354 to US$ -551 for the high cost UDD toilet and from US$ +111 to US$ -95 for the low cost UDD toilet. This indicates that it is more beneficial to apply fertilizer over a larger area (as opposed to concentrating the application in a smaller area). This is due to the fact that the equation that determines the increased crop production shows a reduction in additional yield per additional unit mass of fertilizer as the concentration of the fertilizer applied increases.

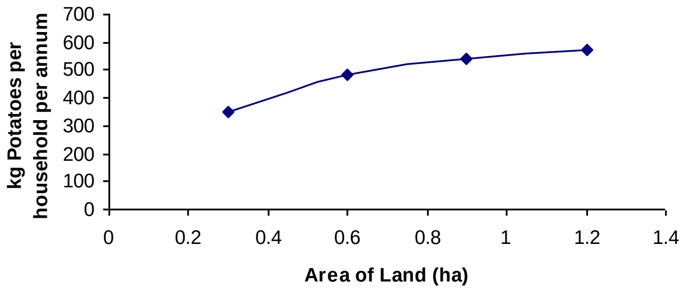

Figure 1 Impact of the availability of land per household for crop production and the quantity of produce in Kabale, Uganda

Source: WSP (2009)

Type and market value of crop

The amount by which the NPV is improved is also a function of the type of crop being cultivated due to the fact that different crops have different yields and different market values. Based upon the case study data from South Africa, Table 1 shows the impact on financial NPV at the household level for two different crops (potato and maize) and for different land areas. As mentioned earlier, results from the eThekwini case study must be considered potential values emerging from a hypothetical scenario. This is because at present excreta reuse is not actively promoted in eThekwini. Clearly, production of crops that have a higher market value is more beneficial in economic terms but as shown above, reuse of excreta in the urban environment is less economically beneficial as the density of housing increases and the availability of land for growing crops decreases.

Agricultural conditions

Good agriculture conditions promote increased yields and it is in these conditions that excreta reuse is most beneficial. The agricultural conditions in the Southwest of Uganda were assumed to be 'good' compared with eThekwini and Ouagadougou, which were assumed to be 'average' and 'poor' respectively. The study found that the economic NPV of ecosan is adversely affected by worsening agricultural conditions (see Figure 2). However, as mentioned above, digested or composted excreta also have added value as a soil conditioner as well as being a source of nutrients, which may provide additional economic gains in terms of increased crop production in areas where soil is poor.

Table 1 Financial and economic NPV at the household level in South Africa for different crops (potato and maize) and availability of land per household (WSP, 2009)

		Area of land available for reuse per household		
		0.2 ha	0.5 ha	1 ha
Financial NPV				
		US$	US$	US$
no reuse		-1376		
Reuse	Potato	-1050	-718	-487
	Maize	-823	-258	-134
Economic NPV				

		US$	US$	US$
no reuse		-1518		
Reuse	Potato	-1284	-1045	-879
	Maize	-1120	-714	-432

Source: WSP (2009)

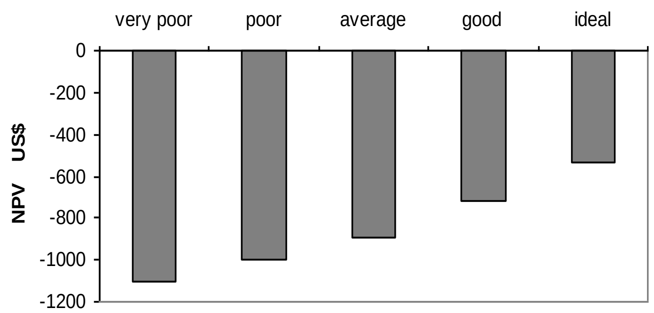

Figure 2 Impact on household level economic NPV in Kibale as a result of changes in agricultural conditions

Source: WSP (2009)

Net impact of reuse on overall NPV

The results described above show that excreta reuse has economic benefits associated with increased crop yield. This may be of financial benefit in areas where crops are sold. These benefits are dependent upon the area of land available for crop production, agricultural conditions, and the market value of crop that is grown. Poorer households are perceived to gain relatively more in proportion to their household income and therefore the results support the case that both financial benefits and/or economic benefits of ecosan can be greater for poorer households.

Although economic benefits were identified, as shown in Table 2, only one of the sanitation technologies generated a positive NPV. As shown by the results of the comparative study between low-cost latrines and high-cost latrines, the impact of the CAPEX costs is significant. The results do not show the impact of changes in the other investment costs associated with project management, capacity building and sanitation promotion. If these were to be reduced, notably for ecosan projects where these costs are often high, then the relative degree of economic benefit in terms of NPV would be increased.

Finally observing that the results do not seem to be congruous with other studies that show a definite positive net economic benefit as a result of sanitation investments (even without the additional benefit associated with reuse) -- as suggested by Hutton and Haller's (2004) study for example -- the researchers conclude that this result was due to the absence of and/or undervaluation of health, social and environmental benefits. The implications of this analytical gap are discussed further in the next section. Recommendations for model development are also offered.

RECOMMENDATIONS FOR MODEL DEVELOPMENT

Improving the components related to excreta reuse, water pollution and time savings

Based upon the experiences from the WSP (2009) study described above, the authors suggest a number of ways that may improve the robustness of the economic analysis of sanitation systems:

- ***Excreta reuse***: as described above, the benefits of excreta reuse were derived from first principles using the total estimated mass of nutrients excreted daily by individuals in the project area. However, existing data and the body of literature remains scarce. Further research is required to improve estimates of the amount of nutrients that are theoretically available. In addition, although there have been a considerable number of pilot ecosan projects in different parts of the world, assessing the economic benefits of excreta reuse is found to be particularly complex. As yet there exists no standardised methodology. While many researchers have had reported improvements in crop yields with urine application, further research is required to develop the empirical relationship between fertilizer and increased yields for different crops in different agricultural conditions.

		High Cost Toilet			Low Cost Toilet		
		Financial NPV		Economic NPV	Financial NPV		Economic NPV
		Household	Total		Household	Total	
UDDT	Uganda	-484	-607	-345	-55	-178	+111
	South Africa	-1217	-1376	-1518	-	-	-
	Burkina Faso	-342	-691	-560	-192	-349	-396
Pit latrine	Uganda	-647	-677	-492	-301	-331	-124
	South Africa	-1230	-1273	-1148	-	-	-
	Burkina Faso	-759	-850	-842	-336	-427	-380

Table 2 Comparison of financial and economic NPVs of different sanitation technologies in Uganda, South Africa and Burkina Faso for high and low-cost toilets

Source: WSP (2009)

- ***Pollution of water resources:*** The assumption that the economic cost for the discharge of untreated excreta into the environment equates to the cost of pollution and the latter's mitigation is not considered to be strictly accurate as this depends on the type of technologies that are utilised. While this analytical approach was considered to be appropriate for the purpose of comparing ecosan with the conventional sanitation system, this component of the model requires further improvement for application in future studies of this nature. In addition, the costs of groundwater pollution were also not included in the model. Although consumption of groundwater from shallow wells in urban areas is not recommended as a source of potable water, it is ubiquitously practiced throughout sub-Saharan Africa. Pit latrines have a higher potential for groundwater pollution in urban settings than UDDTs. Thus in situations where groundwater is used for drinking, then UDDTs should result in greater health benefits than pit latrines. Further work is therefore required to monetise these costs and to improve upon this component of the model.

- ***Benefits due to time saving*:** The benefits associated with time savings related to better access to sanitation was also not included in the model. This is perceived to be one of the main factors contributing to the result that most sanitation options were observed to have negative economic NPVs according to the analysis. It is recommended that future analyses should include time-saving as a parameter based upon estimates using local context data as opposed to assumed values based upon the literature, which are considered to be too generic.

Quantitative assessment of economic benefits in relation to improvements achieved in service level

The WSP (2009) study differentiates between low-cost and high-cost toilets and assumes that all investments result to the same level of benefits. This is not necessarily the case. The assumption that beneficiaries realise the full benefit of improved sanitation requires further investigation. Reality shows that many situation users already have access to some form of sanitation facility, which already is indicative of relative improvements compared to those with no access to sanitation at all. It is therefore proposed that the qualitative assessment of existing facilities should be linked to a rating system in order to arrive at more realistic, valid and credible data. The use of a rating system in entering a study offers more accurate baseline data that can then be used to analyse the level of economic benefit to the relative improved level of service.

Selecting the right parameters for financial or economic analysis

A fundamental area of complexity in all studies conducting financial and economic analysis is found in the need to clearly establish and delineate the boundary conditions, which define the categories of costs to be incorporated into the analysis. Therefore prior to embarking on any exercise involving financial and economic analysis, it is first necessary to define what the study aims to achieve. As mentioned above, these analyses may be employed for project design, sanitation programming or to support policy development. Table 3 proposes a framework that provides guidance to help decide which indicators should be included in the specific assessment. Cost items which are listed above and numbered as 3) and 4) are considered to be costs that should be included in the economic analysis only. As noted in the table, further differentiation of costs related to capital maintenance as proposed by Franceys and Pezon (2010) is recommended.

CONCLUDING REMARKS

Although many researchers and advocates of ecological sanitation report improved crop yields as a result of excreta reuse, quantifying sanitation benefits and converting these to monetary values to give reliable estimates remains a challenge. There is a requirement to undertake a systematic assessment (meta-analysis) of the increased crop yields in relation to the rate of fertilizer application to be able to derive and calibrate an empirical model.

Additionally there is a need for greater understanding on the assumptions that are made when deriving cost and benefit data, especially as many of the economic benefits of sanitation accrued outside of the water and sanitation sector and their monetary assessment requires considerable expertise from economists and health sector specialists. Monetisation of these benefits adds further uncertainties, which influence the interpretation of the results. These inherent assumptions may subsequently influence the credibility of economic studies. Therefore there is a need to exercise precaution before presenting the results to policy makers, as well as provide readers with a more transparent presentation of the uncertainties surrounding the findings of the study. The use of confidence grades as a means to present these uncertainties, for example could provide a reasoned basis to qualify the reliability and accuracy of the data.

Table 3 Proposed cost categories for financial and economic analysis used for project design, sanitation programming and policy making

		Project design	Sanitation programming	Policy making
Financial costs (including household investments)				
Hardware	Capital investment	•	•	•
	Operation and maintenance costs	•	•	•
	Capital maintenance costs	•	•	•
Software	Sanitation and hygiene promotion	•	•	•
	Capacity building (including project management support)	•	•	•
Local economic benefits tangible in terms of financial benefits				
Health	Reduced household expenditure on medicines and health care costs		•	•
	Increased productivity (both short-term and long-term)		•	•
Water resource	Reduced expenditure on drinking water supply (		•	•

	treatment and distribution)			
	Increased productivity of water bodies (e.g. for fishing)		•	•
Reuse	Increased agricultural productivity due to wastewater and excreta reuse		•	•
Economic benefits				
Health	Full health care costs			•
	Increased productivity costs			•
	Increase nutrition and cognitive ability			
	Increased lifespan			•
Water resources	Drinking and domestic water costs (financial + time for hauling water)			•
Land	Aesthetic value of living environment			•
	Increased business in the local areas			•
Other welfare	Time savings/loss (travel waiting time to toilets)			•
	Work/school absence			•
Tourism	Tourist sickness and number of visitors (revenue loss from low occupancy)			•

Using the proposed structured framework for data collection, the authors envisage that considerable benefits in the collation of a comprehensive data base of cost and benefit will be achieved. This in turn will provide more reliable data and benchmark for other analytical studies. To improve upon the robustness of analytical work that ensures consistency and makes results more credible for comparative studies -- there is a need to disseminate guidance for survey designs to standardise data collection procedures. The authors perceive a need for greater use of statistical tools and sensitivity analysis frameworks to assess uncertainties in relation to different input data reflected in studies.

The authors propose to enhance the model developed by the WSP funded study based upon the recommendations described above as the basis for future study to assess the financial and economic costs and benefits of different types of sanitation systems. The authors also encourage other interested parties to join the “Costs and Economics” working group of the Sustainable Sanitation Alliance (www.susana.org/lang-en/working-groups/wg02) and to collaborate in this initiative.

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