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. Excreta reuse is identified as a specific area where there is a need for further development. 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 modelling of sanitation systems. Specific attention is placed upon the quantification of the economic benefits of excreta reuse and the authors describe the approach for monetising these benefits. As well as specific recommendations for improving the robustness of this analysis, the authors propose a framework for categorising financial and economic parameters for project design, sanitation program, and policy-making. The authors argue that a consistent application of this framework combined with the standardisation of methodologies and systematic collation of financial and economic data is required for further developments in this important area.

Keywords: cost, benefit, economics, sanitation, ecosan, excreta reuse

Introduction

In order to enable decision makers to assess the relative value to society of a proposed investment or to assess the efficacy of alternative approaches to attain a desired goal, sanitation projects and programs are increasingly subjected to financial and economic analyses. 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 cost a project within a given budget, sanitary engineers need to base estimates on accurate unit costs and to understand the uncertainty surrounding these data.

ii) *Sanitation programming* - Financial analysis is also important for comparison of the capital investment (CAPEX), 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 be required to justify the rationale for a project or program.

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

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. As well as those directly connected with

the ‘project’, these expenditures should also include household level investments and revenues associated with payments for services.

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

3) Benefits that are essentially the same as those described above in (2) but those who gain are stakeholders who are outside of the area of the defined project.

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

- *Health*: full costs of health care from an institutional perspective.
- *Productivity*: income associated with lost time caring for the sick.
- *Extended lifespan:* better health leading to extended lifespan and increased income potential.
- *Education*: increased attendance at school and improved cogitative 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, which result in additional time for work or study.
- *Tourism:* potential for increased revenue from tourism.

Examples of different types of financial and economic assessment

Based upon a review of the literature, it is apparent that different researchers have considered different parameters for inclusion in their analyses and have categorised these in different ways. For example, KFW (2009) document an evaluation of various sanitation projects that include financial cost-benefit analyses of capital and operational expenditures, costs of capacity building and sanitation/hygiene promotion. Von Muench and Mayumbelo (2006) compared the Net Present Value (NPV) of capital and annual operational costs of different sanitation systems. Costs for capacity building or sanitation/hygiene promotion costs were not included in the analysis but the study did include a monetary value of excreta reuse based on estimates of the value per unit mass/volume of urine and compost.

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 the researchers also include the economic benefits associated with health care and increased productivity. Building on this, Hutton *et al.* (2007a) carried out a more detailed study which incorporated the above but including an increased 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 monetize 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 describes how these may be quantified using locally derived statistical data based upon a set of assumptions.

WSP (2009) describe the development of a model to compare urine diversion dehydration toilets (UDDTs) - a type of toilet that separates urine from faeces 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. The model requires the input of capital expenditure (CAPEX) and operational expenditure (OPEX) including costs for hardware, such as the cost of the latrine itself and software, including sanitation promotion, training and other capacity building activities. In addition, as described below, the methodology monetizes the economic value of excreta based upon an estimated increase in crop yields.

Monetising the costs of excreta reuse

As the methodologies to monetize economic value of excreta remain in their infancy, this section focuses specifically on the methodology and results from the WSP (2009) study introduced above. Case studies were analysed in three urban areas where relatively large-scale projects promoting UDDTs have been implemented; Kabale in Uganda, eThekwini (Durban) in South Africa and Ouagadougou in Burkina Faso. Due to health concerns, excreta reuse is not actually practiced in eThekwini and therefore the results only show the potential for economic benefit. In Ouagadougou, the system is different from insofar as excreta is collected from each household by small-scale private sector operators and transported offsite for treatment and reuse. Therefore, unlike in Uganda (and in the majority of situations where excreta reuse is practiced), the economic benefits of excreta reuse in Ouagadougou are not realised by the households but by the farming community.

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 analyses were undertaken without subsidies to enable a more transparent comparison of different sanitation technologies.

Economic benefits other than those associated with health, pollution and reuse were not included. For health, the benefits were quantified using data from Hutton *et al* (2007b) from 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 economic impact of the environmental damage caused by the discharge of untreated fecal sludge into the environment was 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 fertilizer value was based upon the value of synthetic fertilizer in the local market. However, in addition to this, a more detailed methodology was developed to model the benefits associated with reuse where information about the availability of land and the type of crops is known. This approach is described below and the results presented are based on this methodology.

An estimate of nutrients contained in excreta per person was used as input into an empirical equation to calculate the additional crop yield. It was assumed that nitrogen/phosphorus derived from excreta has the same fertiliser 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 faeces or the potential for generation of biogas was not taken into consideration.

As well as the area of cultivated land and type of crop, other input parameters required by the model include the agro-climatic conditions, crop yield response and market value of produce. Whether the monetary value of excreta has a financial or economic benefit in the analysis depends on whether the excreta is reused 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.

Availability of land

Sensitivity analysis showed that the amount of land available is a key consideration. As shown in Figure 1, reducing the availability of land per household in increments of 0.3 from 1.2 to 0.3 ha has significant impacts on the production of potatoes (38% reduction). 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. The impact in economic terms indicates that it is more beneficial to apply fertilizer over a larger area (as opposed to concentrating the application in a smaller area).

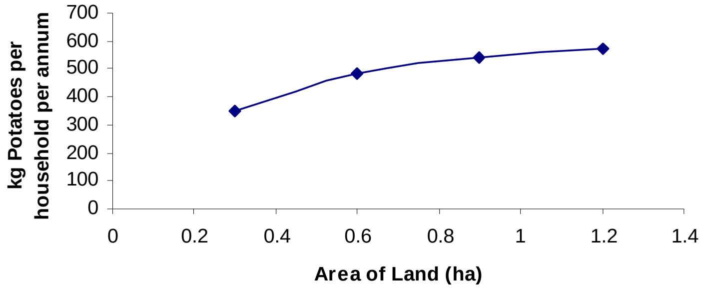

Figure 1: Impact of the availability of land per household for crop production and the quantity of produce in Kabale, Uganda (WSP, 2009)

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 different crops (potato and maize) and for different land areas. As mentioned above, these values are potential values only as this is a hypothetical scenario as at present excreta reuse is not 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.

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

Agricultural conditions

Crop 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 most beneficial. The agricultural conditions in the Southwest of Uganda were assumed to be relatively 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 composter excreta also have value as a soil conditioner as well as a source of nutrients, which may provide additional economic gains in terms of increased crop production in areas where soil is poor.

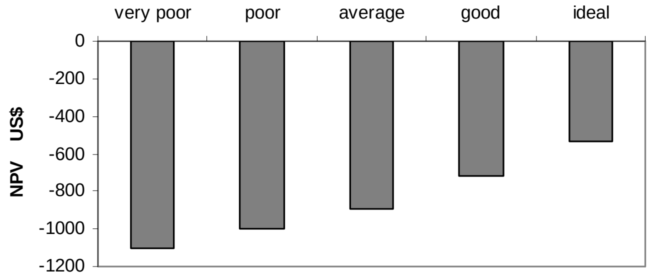

Figure 2 : Impact on household level economic NPV in Kibale as a result of changes in agricultural conditions (WSP, 2009)

Net impact of reuse on overall NPV

The results showed that excreta reuse has economic benefits associated with increased crop yield, which can be of financial benefit where crops are sold. As described above, these benefits are dependent upon the area of land available for crop production, the 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 when the same land area is available.

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 low-cost latrines compared with 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.

In addition, as the results are not congruous with other studies (e.g. Hutton and Haller 2004) that show a definite positive net economic benefit as a result of sanitation investments (even without the additional benefit associated with reuse), the researchers concluded that the health, social and environmental benefits were undervalued in the study. These implications are discussed below in the recommendations for model development.

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 **(WSP, 2009)**

		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

Requirements for further model development

In this section, based upon the experiences from the WSP (2009) study described above, we suggest ways to improve the robustness of the economic analysis:

- *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, the data is the literature data is scarce and further research is therefore required to improve estimates of the amount of nutrients that are theoretically available. In addition, aalthough 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 and as yet there is no standardized methodology. For example, many researchers have reported improved crop yields with urine application, but there remains a systematic assessment of the expected increased crop yields in relation to the rate of fertilizer application to be able to derive and calibrate an empirical model. Therefore, further research is required to develop the empirical relationship between fertilizer and increased yields for different crops in different agricultural conditions.

- *Pollution of water resources:* The assumption that the economic cost of discharge of untreated excreta into the environment equates to the cost of pollution mitigation is not considered to be strictly accurate as this depends on the type of technologies that are utilized. This approach was considered to be appropriate for the purpose of comparing ecosan with conventional sanitation but this component could be improved significantly. In addition, the costs of groundwater pollution were not included in the model. Although consumption of groundwater from shallow wells in urban areas is not recommended as a source of potable water, in many parts of the world it is ubiquitously practiced. Pit latrines have a higher potential to lead to 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 monetize these costs and to develop this component of the model.

- *Benefits due to time saving*: The benefits associated with time savings related to better access to sanitation was 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. Future analyses should therefore include this parameter based upon estimates using local context data rather than literature values.

One of the fundamental complexities for different types of financial and economic analysis is the clear definition of 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 is aimed 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 to provide guidance to decide how indicators should be included in the specific assessment. As noted in the table, further differentiation for costs related to capital maintenance as proposed by Franceys and Pezon (2010) is recommended.

The study differentiated between low-cost and high-cost toilets, but the assumption that all investments result in the same level of benefit is not necessarily the case. The assumption that beneficiaries realise the full benefit of improved sanitation also requires further investigation as in reality in many situations users already have access to some form of sanitation facility which already achieves a relative improvement compared with no sanitation. Therefore, we propose that there is a need for a qualitative assessment of existing facilities linked to a rating system which is used to factor the level of economic benefit to the relative improved level of service.

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

		Project design	Sanitation program-ming	Policy making
A – 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)	•	•	•
B- 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*		•	•
C- 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)*			•
External	*Aesthetics*			•
	Value of unusable land			•
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)*			•

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 is a challenging. 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 accrue outside of the water and sanitation sector and their monetary assessment requires considerable expertise from economists and health sector specialists. Monetization of these benefits adds further uncertainties which influence the interpretation of the results. These inherent assumptions may subsequently influence the credibility of economic studies and therefore there is a need for precaution before presenting the results to policy makers, without a transparent presentation of the associated uncertainties. The use of confidence grades as a means to present these uncertainties could provide a reasoned basis to qualify the reliability and accuracy of the data.

Using a structure framework for data collection, we envisage that there will be considerable benefits for the collation of a comprehensive data base of cost and benefit data which can be then used for benchmark for other analytical studies. To improve robustness of future studies, to ensure consistency and to make results comparable, there is a need to disseminate guidance for survey design to standardize data collection procedures. We perceive a need for greater use of statistical tools and use of sensitivity analysis to assess uncertainties in relation to different input data.

The authors encourage other interested parties to join the "Costs and Economics" working group of the Sustainable Sanitation Alliance (SuSanA) and to collaborate in this initiative. We propose to use the model developed by the WSP funded study as the basis for further developments in this important area. We encourage researchers to contribute their ideas for model development and to use the model for further research studies in this field.

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References

Franceys, R. and Pezon, C (2010) Services are forever: The importance of capital maintenance (CapManEx) in ensuring sustainable WASH services. WASHCost Briefing Note 1b. IRC International Water and Sanitation Centre. August 2010.

Hutton, G. and Haller, L. (2004) *Evaluation of the Costs and Benefits of Water and Sanitation Improvements at the Global Level,* World Health Organization, Geneva, Switzerland, Geneva 2004, Available at: *http://www.who.int/water_sanitation_health/wsh0404.pdf*

Hutton, G., Haller, L., Bartram, J. (2007a) *Global cost-benefit analysis of water supply and sanitation interventions*. *J Water Health* **5**:481-502. PMID:17878562 doi:10.2166/wh.2007.00910.2166/wh.2007.009

Hutton, G., Haller, L., Bartram, J. (2007b) *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

KfW (2009) *Clean water is not enough - Success factors for sustainable sanitation. Improved quality of life by combining affordable infrastructure, good service, hygiene awareness and environmental protection*. Discussion paper of KfW Development Bank, Frankfurt, Germany. http://www.susana.org/lang-en/library?view=ccbktypeitem&type=2&id=698

von Münch, E. and Mayumbelo, K. M. K. (2007). *Methodology to compare costs of sanitation options for low-income peri-urban areas in Lusaka, Zambia*, Water SA **33**(5), available on: http://www.wrc.org.za

WSP (2008) *Economic Impacts of Sanitation in Cambodia - A five-country study conducted in Cambodia, Indonesia, Lao PDR, the Philippines and Vietnam under the Economics of Sanitation Initiative (ESI);* available at http://www.wsp.org/wsp/sites/wsp.org/files/publications/Sanitation_Impact_Synthesis_2.pdf

WSP (2009) Study for financial and economic analysis of ecological sanitation in sub-Saharan Africa. Water and Safety Program Africa, The World Bank, Nairobi, Kenya; available: http://www.wsp.org/wsp/sites/wsp.org/files/publications/Ecosan_Report.pdf or http://www.susana.org/lang-en/library?view=ccbktypeitem&type=2&id=608