Valuing Sustainable Sanitation: the economic assessment of alternative sanitation programs

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Abstract This paper describes how an innovative costing method may be applied to compare the cost-effectiveness of alternative sanitation programs. The method is suggested as a tool capable of fairly comparing a broad mix of responses to sanitation challenges including capacity demand management and the full range of system scales.
Keywords Cost-effectiveness analysis; material flow analysis; decentralised wastewater systems

INTRODUCTION

The challenge of sustaining sanitation to rapidly sprawling cities has prompted a rethink in the way we manage our waste. In industrial countries, conventional centralised, large-scale wastewater systems have been the subject of renewed scrutiny in light of rising collection and treatment costs. In developing countries faced with limited financial and institutional capacity, the value of investing and maintaining conventional western sanitation solutions is also under serious question (Newman 2001). A revolution in sanitation is under way through reconsideration of existing technologies such as dry composting, and the arise of new technologies including urine diversion, pressurised effluent carriage and modular small-scale treatment which offer new opportunities for distributed systems with infrastructure scaled at the on-site and cluster scale (Pinkham et al. 2004).

A number of recent studies have sought to quantify the benefit of these new approaches and technologies (Kazaglis & Kraemer 2006; Pinkham et al. 2004; White 2004), however a holistic and rigorous cost-effectiveness analysis from both societal and stakeholder cost perspectives is yet to be achieved. Such a study is important in demonstrating the value of these new models to decision-makers and driving their uptake by the mainstream.

This paper describes how a new costing method developed by the Institute for Sustainable Futures in collaboration with five Australian water authorities (Mitchell et al. 2007) may be used to effectively demonstrate in which situations the benefits of decentralised systems render them cost-effective alternatives to conventional centralised systems.

The method is a form of cost-effectiveness analysis, which involves developing alternative sets of options to meet a set of agreed study objectives and assessing each alternative on the basis of its incremental life cycle cost. The benefits of this method include:

- a balanced comparison of all available options is enabled by outcome-based objectives;
- the full impact of options is accounted by intentionally defined system boundaries and thorough life cycle costing;
- both economically optimal and financially viable solutions are revealed by analysis of stakeholder and societal cost perspectives; and
- externalities and uncertainties are transparently treated.

The following section summarises our recent experience of how the method may be applied to compare decentralised and centralised sanitation options.

METHOD

1. Establish the analytical framework: *Define the objectives of the analysis and specify the economic criteria by which the alternatives will be assessed including an appropriate treatment of externalities*

The drivers and constraints of the study would ideally be decided on by stakeholders affected by the costing study, and therefore may require a water authority to initiate others' participation on this decision. Potential objectives may include complying with minimum environmental standards, reducing the disposal of nutrients to the receiving river system or conserving water or nutrients. The economic criteria are then formed to ensure a balanced comparison of all options is possible. For assessing sanitation systems, a key decision will be the time scale of the net present value calculation, as this will control whether the entire life of the assets is accounted. Stakeholders should also agree upon an appropriate discount rate that will reflect the time value of money and the cost of capital. An appropriate response is then defined for all significant actual or avoided societal costs that are not reflected in market exchanges (e.g. eutrophication of rivers). Externalities may be internalised within the costs using shadow pricing, embedded within the study objectives, or accounted externally using a quantitative or qualitative assessment.

2. Identify the system: *Inventory the key components of the system, identify their interactions and model them within a resource balance.*

Material flow analysis forms the foundation of the method as the best means of understanding a problem that is principally concerned with the management of resources (Brunner & Baccini 1992). This implies identifying the inputs, stocks and outputs of each system component and linking them within a model- a "resource balance model". For the purpose of this study water volumes have been the principal substance under review owing to their role in constraining treatment plant capacity. Recent research has also enabled us to quantify the key phosphorus flows (i.e. within excreta and detergents) that represent a key indicator of eutrophication and nutrient depletion (Esrey et al. 2000; Gumbo 2005; Rockström et al. 2005; Tangsubkul, Moore & Waite 2005). Gumbo (2005) has developed a useful series of water and phosphorus models for this purpose during a study of a micro-catchment in the city of Harare, Zimbabwe (see below).

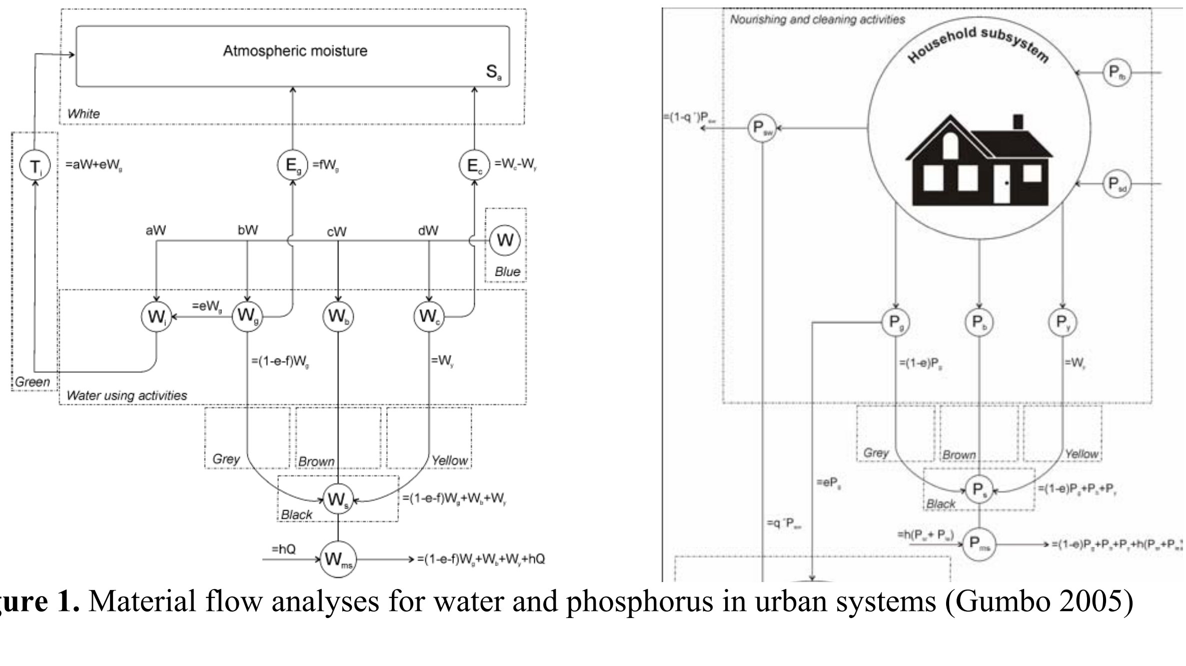

Figure 1. Material flow analyses for water and phosphorus in urban systems (Gumbo 2005)

When considering a sanitation system, the boundaries of the system are first carefully drawn to make clear which impacts associated with a given option have been included or excluded. For centralised sanitation projects, the boundaries should preferably be drawn inclusive of both the new development and any existing system components upon which the development may rely. The analysis is then applied by quantifying the waste flow and its constituent components from households (e.g. by estimating the wastewater generated per capita) and relating this to the capacity required by the sanitation system and the subsequent constraints associated with the receiving environment.

3. Specify the base case: *Define and model the system configuration that a conventional approach would imply in the future*
In order to later assess the incremental cost of an alternative, it is useful to first predict all future actions associated with following the conventional, centralised approach. In the case of a requirement for commission of a new centralised treatment plant, any staged augmentations as design flows increase, and all operation and maintenance of the system over the life of the components are included. In the case of extending an existing system, the base case will often involve extensive capacity upgrades to the collection system (e.g. trunk drainage) or treatment system. It is critical to include all such costs so that later when the base case is compared to alternatives (eg a decentralised system), it is possible to demonstrate which of these costs may be avoidable.

4. Identify the options and specify alternatives to the base case: *Inventory the broad suite of options available toward meeting the study objectives and estimate their costs*
The options may be modelled within the "resource balance model" to determine any base case investments that may be avoided or delayed. For example, a delay in the staging of existing centralised treatment capacity will have a significant impact upon the incremental cost of the alternative. Spreadsheet option models for both a hypothetical centralised base case and a decentralised alternative are presented below.

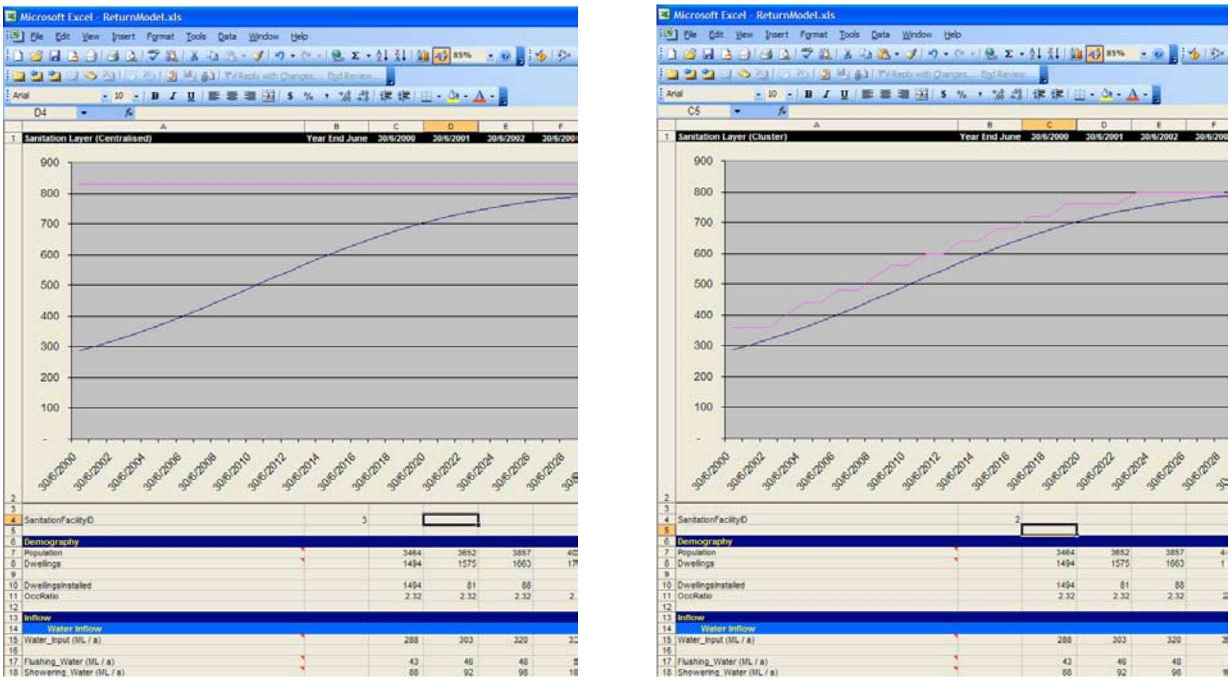

Figure 2. Spreadsheet output of annual capacity and demand for two alternative systems over time: the centralised base case (left) and the clustered alternative (right). Note the ability of the cluster-based system to respond to changes in demand as they arise.

In addition to considering smaller-scale or decentralised sanitation systems, capacity demand management options including water conserving devices and source separation may be considered.

5. Analyse the costs: *Apply discounted cash flow analysis to each of these alternatives*
The key innovation of the method is the extension of material flow analysis toward analysing financial flows from alternative cost perspectives. As the costs associated with each option are estimated, careful attention is paid to which stakeholder the cost burden will fall (e.g. the homeowner, the utility, the developer etc). In addition, all transfer payments (e.g. sewer fees, developer contributions) are accounted separately. Having estimated the costs for each option, the least cost alternative to society is assessed by discounting the economic costs upon all stakeholders (i.e. ignoring transfer payments) to present value terms. The impact of the least cost alternative upon each stakeholder's financial viability may then in turn be assessed by including all cost burdens and transfer payments from and to each stakeholder. This may then form the basis for re-negotiating transfer payments to ensure the avoided costs (and therefore the incentives toward economic efficiency) are shared equitably.

CONCLUSIONS

The assessment method presented within this paper presents a valuable tool to assessing the contexts under which decentralised systems are most suitable. The ongoing application of the approach will be important in driving the uptake of a broader range of system scales and achieving sustainable sanitation outcomes both within developed and developing nations.

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