Journal of Engineering and Applied Sciences 2 (2): 391-400, 2007

Institutional Sustainability of Sanitation Systems in Peri-Urban Areas-a Multi-Criteria Decision Analysis (MCDA) Assessment

[1]Jimmy Zikusooka Muwuluke and [2]G. Ngirane-Katashaya
[1]Candidate, Makerere University, Faculty of Technology, Reg. Engineering MUIPE, Urban Planning Unit, Makerere University, Kampala, Uganda
[2]Department of Civil Engineering, Makerere University P.O. Box 7062 Kampala, Uganda

Abstract: Sustainability of some of the alternative technology options for the peri-urban areas has failed partly due to lack of institutional responsiveness of the selected options. There is a mismatch between the institutional framework in terms of policy, legal and regulatory parameters and institutional setup on the one hand and the requirements of the technologies on the other. Objective appraisal of the technologies at the onset with a view of predicting institutional sustainability is therefore important. Such analysis requires a Decision Support Tool (DST) for the decisionmakers which can address decision parameters of the institutional context. As part of an on- going study, this study examines the development of such a DST using MCDA techniques. It involved characterisation of the technology options, identification of appropriate institutional criteria, determination of criteria/indicator states and elicitation of criteria weights. Both the indicator state and characterisation information were used to score each option on each criterion which, together with the criteria weights were the two input variables to the model. The information synthesis using Hiview program gave the relative institutional responsiveness index score. Ironically, model analysis results showed that the index score for the common Simple Pit Latrine (SPL) was quite high (86%) compared to other options (VIP latrine-82%, ecosan systems-67% and non-conventional sewerage-16%). This could partly explain the falling to disuse by many of the facilities provided in the peri-urban areas.

Key words: Criteria, excreta management, indicator, institution, MCDA, peri-urban, responsiveness, sanitation, sanitation technology, sustainability

INTRODUCTION

Urbanisation in the developing world and Africa in particular is taking place at a rate unprecedented in human history. Peri-urban areas which serve as the main reception centres of the new urban citizens are experiencing enormous pressure on the already fragile infrastructure/service situation, particularly for sanitation. The prevailing peri-urban sanitation is deplorable and it gets worse by the day (Mehta, 2003). Kampala City's peri-urban area sanitation situation is not different. Access to adequate and effective sanitation for the majority of peri-urban dwellers is limited. The existing institutions and the supporting policy and legal framework neither match the enormous challenge nor adequately relate to the sanitation systems in place and those proposed. The net result is a very low level of sustainability of the services provided.

Lack of an enabling and responsive institutional framework to address the sanitation needs of the peri-urban communities is partly responsible for the low levels of sustainability of the sanitation facilities. The sanitation planners do not *adequately* consider those attributes of the institutional framework that promote effective provision, management and operation of the systems. Issues like relevancy and responsiveness of technical support, definition and consistency of responsibilities, legal structure reflecting the responsibilities, effectiveness of regulatory body; appropriateness of regulations, codes and standards; available data and capacity in form of skills among others ought to be addressed. These are important institutional framework aspects that influence service sustainability that should be considered at the onset-particularly during the technology selection process-such that the expected performance of the technology options and hence sustainability can be predicted.

Corresponding Author: Jimmy Zikusooka Muwuluke, Candidate, Makerere University, Faculty of Technology, Reg. Engineering MUIPE, Part-time Lecturer, Urban Planning Unit, Makerere University, Kampala, Uganda

This study, as part of an on-going study of the decision making process in sanitation planning, explores the choice of technology options for the peri-urban areas of Kampala and the responsiveness of institutional framework to enhance sustainability. The Multi-Criteria Decision Analysis (MCDA) technique is employed.

MATERIALS AND MATHODS

Data collection: Both desk based study and field surveys were carried out. The aim of the desk based study was twofold: 1) identification and determination of the relevant sustainability criteria and indicators and 2) appreciation and characterisation of the possible technology options. A critical review of the contemporary planning approaches was carried out-Strategic Sanitation Approach-SSA (Wright, 1997) and Household Centred Environmental Sanitation. Emphasis was put on the post water and sanitation decade era with a focus on how technologies were selected for the peri-urban communities.

Thereafter, a field survey was carried out in the case study area using various instruments, namely: questionnaires, transect walks with field observation, key informant interviews and Focus Group Discussions (FGDs). A general household survey questionnaire was administered to 558 respondents (about 1% of households) using 5 trained research assistants to establish the general sanitation planning context. The questionnaire design was aimed at capturing the general sanitation situation and socio-cultural information concerning community organisation, the concerns and beliefs, perceptions and opinions on the existing excreta management systems and policies and the population characteristics among others.

A second questionnaire was administered to various stakeholders (developers, residents, local leaders) with a view of capturing specific information on the institutional framework sustainability indicators. This questionnaire allowed for in-depth exploration of reasons for some of how the sanitation system functions; the policy regime, institutional structures and their organizational set up, the regulatory systems and the roles and responsibilities of various stakeholders. The aim of this questionnaire was to capture the qualitative issues pertaining to this sustainability dimension, but also give that information a level of objectivity with the help of categorical descriptive questions.

A third questionnaire was administered to experts and key stakeholders to establish the importance weights associated with the decision parameters by the decisionmakers. The ranking method was used to enlist the importance weight. In depth discussions with key informants (officials) were held both for weighting of decision parameters and information gathering. The key informants included officials from National Water and Sewerage Cooperation (NWSC), Kampala City Council (KCC) [Kampala Urban Sanitation Project-KUSP and Kampala Ecological Sanitation Project], Plan International, Ministry of Health (MoH) and some consultants and experts from Makerere University. The socio-economic data analysis was carried out using a Statistical Package for Social Scientists (SPSS).

Scoring options against the indicators: The scoring process was facilitated by carrying out a technology characterisation exercise by use of simple largely qualitative descriptions of each technology option taking into account each indicator. A descriptive categorical (graduated) ordinal scale was developed for each indicator highlighting the key issues under each indicator (Box 1 gives example) that would guide the scoring. The later was adapted to overcome the limitations of the subjective rating scales usually employed in scoring perceptions and feelings in survey research. The outcome of the analysis was a matrix of Design Based Appraisal Summary Table (DBAST) that gives the expected performance of each technology option.

Technical capacity (Staffing and skills availability): Measures the capacity and ability of key agencies to handle sanitation issues of peri-urban area communities

- Under staffed, not skilled to handle unique peri-urban problems
- Poorly staffed agency with very low skills to handle peri-urban issues.
- Reasonably staffed agencies but skills inadequate for the challenge
- Reasonably staffed, well skilled but inappropriate for peri-urban issues (not trained in this area).
- Well staffed, skilled, trained to address peri-urban issues.

Box 1: Technical capacity indicator categorical scale

Information from the DBAST and that from the assessment of the existing institutional framework conditions (the states) was combined to establish the option consequences. This was based on available literature and experiences from around the world, particularly in peri-urban areas similar to those in Kampala. The score represented preference value and not the utility because it only indicates the extent to which the consequence of the decision tries to achieve a given objective without taking into account the decision-maker's risk attitude (Catalyze, 2003).

Institutional framework responsiveness index assessment: A HIVIEW program-based MCDA model for

assessing institutional responsiveness index was developed based on 'value focused thinking', a form of multi-criteria analysis technique (Catalyze, 2003). Then performances of the options against indicators were established to gauge how well alternative technologies would achieve the desired objectives/values or overcome the barriers in the institutional framework. This was done by use of a judgment scale indicating the *favourableness* of each option in working in the conditions of the planning context, the state, based on literature survey and expert information.

Under given conditions, the institutional responsiveness index score was determined by evaluating the function below using the HIVIEW model, based on linear additiveness assumptions (DETR, 2000; Belton and Stewart, 2002):

Institutional Relevance/Responsiveness (IRR): = $f(aI_{s1}, bI_{s2}, \ldots, nI_{sn})$

$$= f(aI_{s1}, bI_{s2}, \ldots, nI_{sn}) = aI_1 + bI_2 + \ldots + nI_n \quad (2.1)$$

Where: a, b, …, n are the relative sub-criteria weights associated with the different indicators and

$I_{11}, \ldots I_{2n}; I_3, \ldots, I_n$, are the indicator- scores. (Indicator is a lower order criterion)

Box 2: Assessment of institutional framework responsiveness index

RESULTS AND DISCUSSION

Desk search and field results

Institutional framework sustainability indicators: The concept of institutional sustainability is a recent addition within the sustainable development philosophy which came with the realization that sustainability of service systems (sanitation inclusive) was critically hinged on the organizational framework in which the system operates. Argues that to keep sanitation systems operational, accessible and widely used, communities need institutions, which institutions have cultural characteristics, agreed and valued procedure and rules of operation and varying capacities for management and accountability. Thus an enabling environment must be available, which should address two elements; 1) how the institutions themselves function and the environment in which they operate and 2) the working environment for the human resource (staff).

The factors obtaining under each category and how they constrain or promote the achievement of the fundamental sanitation objectives by the selected technology determines the sustainability of the service offered. These factors act as the sustainability indicators. Determination and measurement of sustainability requires knowledge of these indicators and their objective assessment. The key factors most scholars have identified focus on the institutions responsible for sanitation service provision and their organisational structures. They examine the clarity of definition and breakdown of roles and responsibilities within the institution and between the public sector, the private sector and communities. Others have addressed the enabling environment as a whole where issues like policies, rule/ regulations and penalties and incentives have been explored (Wegelin-Schuringa (2002); Wright, 1997). Table 1 gives the criteria for institutional responsiveness as a sustainability principle. These criteria are broken down into lower level criteria guided by the objectives spelt out, using a decision tree concept as given in Fig. 1.

Table 1: Definition of Institutional Framework Decision Criteria and Indicators

Category	Criteria	Indicator	Indicator Description
Enabling organisational system (policy)	Prioritisation of sanitation	Budgeting for sector and actual funding committed	proportion of sector budget and actual funding in budget statements
	Political support for sanitation improvement	Level of political support to sanitation development	Extent to which administrative units address the issue of adequate sanitation development
	Differentiation (unbundling) of service development	Level of decentralisation of decision making	How far below in administrative hierarchy sanitation decisions are taken
	Private sector role	Support to CBO, NGO, and private sector participation	Effort to offer such services as pit emptying, etc
	Maintenance policy	Pit emptying, sewage treatment	Effort to offer such services as pit emptying, etc
Enabling organisational system (Rules and Incentives)	Legal aspects	Definition of adequate facility	Recognition of adequacy of a technology
	Incentives	Cost of facilities and funding support in various ways	Cost recovery and tariffs associated
Enabling organisational climate (institutional issues)	Technical capacity (staffing and skills availability)	Level of skills, mix of expertise	Availability of competent and trained personnel design and building
	Planning data availability	Data availability	Extent to which relevant data can be accessed for planning
	Monitoring and coordination	Mechanism of follow up and information sharing among various agencies	Existence of a kind of sanitation home institution
	Delineation of roles and responsibilities	Role and responsibility delineation	Clarity of role and responsibility definition
	Attitude of technical professionals towards non-conventional options	Level of promotion of non-conventional systems	How technical professionals encourage development and use of non-conventional systems

Table 2: Institutional Relevance - DBAST

	Institctional						
	Policy lssues					Incentives	
Technology	Prioritizayion needed 1	Political support needed 2	Private sector role possibility 3	Service differentiation effect 4	Maintenance policy needed 5	Rules enforcement needed 6	Incentives/subsidy support needed 7
Receptor device							
Simple pit latrines (SPL)	1	1	5	1	1	1	1
VIP latrine (VIP)	1	1	5	1	1	1	1
Aquaprivy (AP)	2	2	4	2	2	2	2
Ecosan dry (ESdry)	2	2	4	2	2	3	2
Ecosan wet (ESwet)	2	2	4	2	2	3	2
Pour Flush toilet (PF)	2	2	4	2	3	2	2
Collection device							
Vault/Cartage (VC)	2	3	4	3	2	5	3
Septic Tank (STK)	2	2	4	3	2	5	3
Settled Sewerage (STS)	3	4	2	5	5	5	4
Simplified Sewerage (SS/C)	3	4	2	5	5	5	4
Conventional Sewerage (CS)	5	5	1	5	5	5	5

Table 2: Continued

	Institctional				
	Institutional lssues				
Technology	Coordination and monitoring needed 8	Rolr delineation needed 9	Data availability needed 10	Professional attitude effect to effective use 11	Technical support needed 12
Receptor device					
Simple Pit Latrines (SPL)	1	1	1	2	1
VIP latrine (VIP)	1	1	1	3	1
Aquaprivy (AP)	2	1	2	4	2
Ecosan dry (ESdry)	3	2	2	5	3
Ecosan wet (ESwet)	3	2	2	5	3
Pour Flush toilet (PF)	3	2	2	5	3
Collection device					
Vault/Cartage (VC)	4	4	3	5	3
Septic Tank (STK)	3	3	3	2	3
Settled Sewerage (STS)	5	5	4	5	5
Simplified Sewerage (SS/C)	5	5	4	5	5
Conventional Sewerage (CS)	5	5	5	2	5

Key to performance rating: 5 - extremely high, 4- very high, 3- high, 2- low, 1 - very low; 0 - not applicable

Technology characterisation: Each technology is designed to work best under a given set of factors, institutional framework inclusive. Effective and objective appraisal of the technologies requires that the design based characteristics of each technology are mapped to the factors suited for its effective performance. The qualitative description and characterisation of the technology options, guided by available literature and experiences from around the world yielded the results given in Table 2.

Existing institutional framework settings (the States): The assessment of the existing institutional framework conditions helped to establish the *states* of the indicators which influence the performance of the technology options. Table 3 gives the indicator states.

Weighting of indicators: Weighting is the process by which MCDA allows the comparison of criteria/indicators with different units by normalizing the scores (Catalyze, 2003). The principle/key question that guided

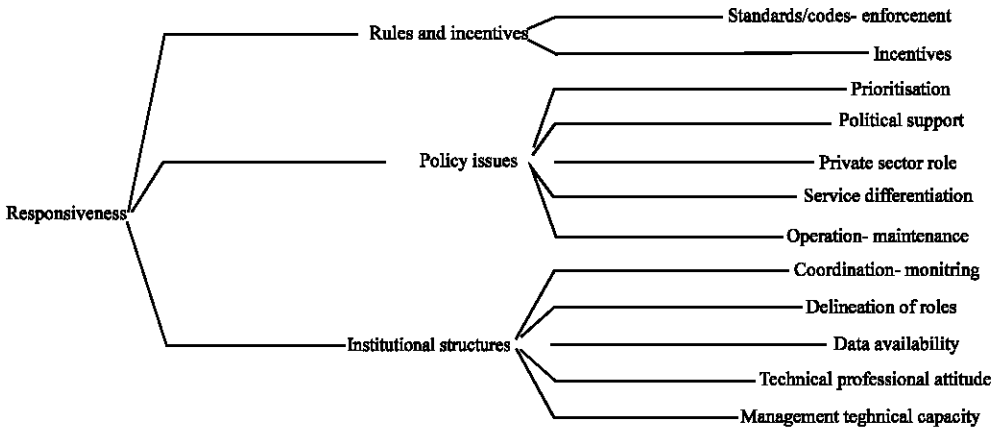

Fig. 1: Decision value tree for institutional framework

Fig. 2: Favourableness scoring scale-example

Table 3: Field preferences/conditions observed (state)

Indicator	Field preference or condition observed	State
Coordination and monitoring	Monitoring done on ad hoc basis with limited coordination at institutional level	Very Low
Roles and responsibility delineation	Clearly done but poorly coordinated	High
Planning data availability	No data available and access to limited data very difficult	Very Low
Management capacity	Good staffing but specific peri-urban needs skills not adequate	Low
Attitude of technical professionals to non conventional options	non-conventional options not well promoted by technical people	Poor Low
Standards and enforcement	Rules and regulations exist; somehow adapted to situation, but enforcement low	Low
Incentives	Some incentives exist but management is haphazard	Very Low
Prioritisation	Very low indeed, less than 5% of budget allocation, sometimes never comes	Very Low
Political support	Exists at all level, but no efforts to follow up. Depends on political climate / season (inconsistent)	Very Low
Private sector role	Participation reasonable and guidelines followed	High on individual basis
Service differentiation	Zoning practiced, plans exist, but no infrastructure to support	Low
Maintenance policy	No clear documented policy though maintenance is regarded as important	Population density

Table 4: Legal-institutional issues summary of weightings of criteria/indicators

Main sustainability objectives (criteria)		Legal/institutional sub-criteria	Legal/institutional Indicators			
Criterion	R Wt	Sub-criterion	Indicator	ANRE	ANRC	C N Wt
C1-social-cultural acceptability	18		Prioritisation level of sanitation	9.8	10.3	10.1
C2-legal/institutional responsiveness	25		Political support	9.8	8.0	8.9
C3-technical appropriateness	32	Policy issues	Private sector role	9.8	6.9	8.3
C4-financial affordability	25		Differentiation of service devolpment	8.7	5.7	7.2
Total	100		Maintenance policy	7.6	10.3	9.0
			Monitoring and coordination	9.8	9.2	9.5
			Delineation of rules and responsibilities	6.5	8.0	7.3
		Institutional structure and organization issues	Planning data availability	9.8	5.7	7.8
			Technical capacity availability	9.8	10.3	10.1
			Attitude of technical professionals	4.3	9.2	6.8
			Building standards enforcement	8.7	5.7	7.2
		Rules and incentives	Incentives	5.4	10.3	7.9
		Total	Total	100	100	100

(C Wt-Cumulative wei CNWt-Combined Normalized Weight; ANRE-Average Normalised Ranking Experts; ANRC-Average Normalized Ranking Community

Fig. 3: Index scores for institutional responsiveness for each option

the weight elicitation was 'On a 9-point scale representing relative importance, how would you rate the indicators in terms of their effect on the performance of the technology'. The responses were as given in Table 4.

The MCDA model output: The two input variables to the model were relative degree of favourableness scores (Fig. 2 for an illustration) and the criteria weights. Favourableness score for each technology option on each indicator was determined by combining the DBAST score of the option on the criterion (Table 2) and the criterion/indicator state assessed. The information was then synthesised to determine the overall institutional framework responsiveness index using the HIVIEW computer program by evaluating the relationship in Equation 2.1. The linear additive principle was assumed (Phillips, 2002).

Institutional responsiveness index score: The institutional relevance/responsiveness was defined as a measure of the extent to which the selected technologies match the policy, legal and institutional framework in the sanitation sector. Fig. 3 gives the institutional responsiveness index score for the technologies that were under investigation.

Using the 50-point mark as the threshold level for sustainability, which was implied in the categorical questionnaire, the sustainability implication for the options was as given in Table 5.

Table 5: Institutional sustainability implication for technology options

Option	Index score	Sustainability implication
Simple pit latrines (SPL)	86	ISL
VIP latrine (VIP)	82	ISL
Aquaprivy (AP)	62	ISL
Ecosan dry (ESdry)	67	ISL
Ecosan wet (ESwet)	67	ISL
Pour Flush toilet (PF)	62	ISL
Vault/cartage	50	ISC
Septic Tank (STK)	49	ISC
Settled Sewerage (STS)	16	ISU
Simplified Sewerage (SS/C)	16	ISU
Conventional Sewerage (CS)	10	ISU

ISL-Institutional sustainability likely; ISC-Institutional sustainability Uncertain; ISU-Institutional sustainability unlikely

Fig. 4: Technical capacity against institutional responsiveness

Further analysis

Mapping (efficient frontier analysis): Using the mapping tool within the Hiview model, which is essentially an efficient frontier analysis, the SPL option remains the dominant option on all the criteria, closely followed by the VIP latrine, as illustrated by Fig. 4.

The sewerage systems perform poorest on all the criteria as evidenced by being furthest from the efficiency frontier. The only exception was the case of the criterion of attitude of technical professionals where the conventional sewerage option locates on the efficient frontier, but still close to zero (about 12%).

Sorts (comparison of options): The sorts analysis, which allows the decision maker to compare the performance of any two technology options on the criteria was used to compared the SPL and the ESdry. The results as given in Fig. 5 show that the SPL was better than ESdry on technical professional attitude (professionals accept and promote it), technical capacity (existing skills can handle SPL effectively), political support (the limited support available was enough for SPL development) and service differentiation. The ESdry has no recognisable advantage over the SPL in the current institutional setting in Kawempe. This was confirmed by the display of weaknesses of ESdry as given in Fig. 6-the option was weak on almost all the criteria.

Sensitivity analysis: Sensitivity analysis was carried out to test the robustness of the results as regards the most relatively sustainable option. Sensitivity analysis highlights areas in the model that would influence the

Fig. 5: Comparison of SPL and ESdry options using sorts analysis

Fig. 6: Weaknesses of the ESdry option

overall preference ordering of the options in achieving the desired objective, in this case institutional responsiveness and hence institutional sustainability. It was used to examine the extent to which differences of opinion and vagueness in scoring and weighting leave the overall ordering of the options unchanged. It also allows for consideration of variability in the state. This is one of the strengths of the MCDA approach to decision making (Belton *et al*., 2002), namely that even with a weak information base, analysis can proceed and later subject the result to extensive sensitivity analysis to identify sensitive areas.

The results show that the SPL remains the most sustainable option under the current institutional setting. The goal sensitivity analysis showed that the SPL remains the most institutionally responsive option for defecation stage unless there was a large increase in the cumulative weight of most of the indicators (shown by green bar).

Fig. 7: Sensitivity down

The preference would mainly change to VIP except for the incentives indicator where ESdry (Ecosan Dry) was preferred show in Fig. 7.

CONCLUSION

- For Kawempe peri-urban area, given the current institutional framework, the DST shows that the Simple Pit Latrine (SPL) is the option with the highest relative institutional responsiveness index (86%) followed by VIP latrines (80%) for defecation stage.
- Sensitivity analysis of the results further showed that the SPL remains the dominant option under a wide range of weight variations. This implies that great effort was required to address the weaknesses within the institutional set so that the requirements of the other options may be met.
- Promotion of ecosan systems requires that the weaknesses like attitude of technical professionals to non-conventional options is changed, monitoring and coordination is improved and political support increases

Recommendation: The viability of SPL as the excreta management option for the peri-urban areas is questionable on demographic, health and environmental grounds and so is the VIP latrine despite their being the most institutionally responsive option under the current institutional framework. The institutional framework should be re-engineered with special focus on monitoring and coordination issues, attitudinal change for the technical professionals regarding non-conventional solutions and capacity building (skills development for the unique peri-urban challenges) to enhance the viability of the other options.

ACKNOWLEDGMENTS

The authors wish to extend their gratitude to all the people who volunteered information that has been used in this study, the experts and local people in their various apacities. We also appreciate the efforts of Dr. Kevin Bossley of Catalyze Limited for the effort made to ensure that the Hiview 3 program works properly.

REFERENCES

Belton, V. and J.T. Stewart, 2002. Multiple Criteria Decision Analysis. An Integrated Approach. Kluwer Academic Publisher, USA.

Catalyze, 2003. HIVIEW 3, Enabling effective decisions, Starter Guide. Cataltze Ltd., Winchester, UK.

Detr, 2000. Department for Transport, Local Government and Regions. Multi Criteria Analysis: A manual. www.dtlr.gov.uk/about/multicriteria/

Mehta, M., 2003. Meeting the financing challenges for water supply and sanitation-incentives to promote reforms, Leverage Resources and Improved Targeting. The World Bank, Water and Sanitation Program.

Wegelin-Schuringa, M., 2002. Strategic elements in water supply and sanitation services in urban low income areas. IRC International Water and Sanitation Centre.

Wright, A.M., 1997. Towards a strategic sanitation approach: Improving the sustainability of urban sanitation in developing countries. UNDP World Bank, Water and Sanitation Program. Washington, D.C. The World Bank.