Integrated Urban Sanitation Decision Support Tool

Review of Support Resources in Sanitation

CSTEP
CENTER FOR STUDY OF SCIENCE, TECHNOLOGY & POLICY

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Executive Summary

This report is a prelude to the development of a Proof of Concept (PoC) decision support tool by Centre for Study of Science, Technology and Policy (CSTEP) that will aid cities in providing cost-effective, inclusive and sustainable sanitation options for all with a particular emphasis on the urban poor. This is proposed to be achieved through an integrated assessment framework of alternative sanitation technologies.

The report conducted a review of about 70+ existing support resources, including benchmarks, guides/manual, case studies, and evaluation tools. The analysis indicated that the support resources reviewed are mostly designed to cater to planners and/or engineers thereby not adequately serving decision makers. The major lacunae in the resources included a lack of integrated systems for decision support, that help compare various sanitation technology options (for each part of the sanitation chain) linked to a pre-determined evaluation criteria for a certain context. This includes an effective user interface; spatial representation and Geographical Information Systems (GIS) compatibility and database support to help saving, updation and retrieval of data and scenarios for comparison. All these factors are considered essential in the development of a decision support tool. Based on this review a Compendium with all the resources reviewed has been developed.

Introduction

Effective decision-making support systems help decision makers in identifying, evaluating and choosing a technology that best suits context/conditions of a city/area/ward. In order to develop a tool which is of use to decision-makers, an evaluation of the existing support resources was considered necessary to identify challenges/gaps pertaining to content, design and usefulness of the resource in question.

Centre for Study of Science, Technology and Policy (CSTEP) evaluated existing support resources for decision making, which include the following:

- **Benchmarks**: Benchmarks allow cities to understand and assess their performance. Through the use of sanitation indicators, cities are able to identify areas of strengths and weaknesses, shedding light on what can be improved, thereby allowing informed decision making.
- **Case Studies**: Case studies are important sources of information that cover various aspects of a technology during implementation, such as the community willingness to accept technology, socio-economic aspects that need to be considered and also adaptation/improvisation of a technology suited for local needs. These provide examples which can influence the decision-making process. This is mostly India specific.
- **Guidebooks and Manuals**: These documents provide guidance on advantages of sanitation technology design, construction, implementation and evaluation, either covering specific parts or the entire sanitation value chain.

It was predominantly based on an online search combined with inputs from stakeholders on various relevant resources. The major sources of information are listed below:

- Sustainable Sanitation Alliance (SUSanA): www.susana.org
- National Environmental Engineering and Research Institute (NEERI): www.neeri.res.in
- Central Public Health and Environmental Organisation (CPHEEO): http://cpheeo.nic.in/
- Ministry of Urban Development (MoUD): http://moud.gov.in/
- Eawag: http://www.sswm.info/
- Akvo: http://waste-dev.akvo.org/dst/sanitation/technologies/

Each of these sites were investigated with a specific focus on identifying benchmarks, case studies, guidelines and manuals which showcase sanitation systems in urban India. The focus was to highlight cases which presented technologies covering the sanitation value chain. Once documents were identified, an analysis was carried out to highlight the purpose of these documents, the context in which the information provided can be applied, and the group of stakeholders the resource it is intended for.

- **Evaluation Tools** (for decision support): Different evaluation tools, ranging from modelling of project costs (the capital, and operation and maintenance costs) with

respect to technology, to more integrated costing (like life-cycle costing) and also planning tools that integrated project costs to municipal finances have been included in this compendium. The sanitation evaluation tools discovered/reviewed so far are predominantly open source and are freely available on the web. Some of the tools from Emergent Ventures and Boston Consulting Group (BCG), NewSAN, etc., for which resources were not available online, the organisation/person in charge was contacted in order to understand the tool. The "Sanitation Hackathon" website was referred to have innovative solutions to a variety of sanitation related problems (Sanitation Hackathon, n.d.). The decision-support tools identified, try to recommend appropriate sanitation technologies based on the input situation. The mapping and data collection tools are mostly crowd sourced, where citizens are the primary data collectors.

The research undertaken resulted in the following number of support resources (see Table 1):

- Benchmarks- 3
- Manuals/Guidebooks – 30
- Case Studies – 12
- Evaluation tools – 32

A bibliography of the above mentioned types of resources is included in the *Compendium*. It is to be noted that resources that are locally (specific to a city/ULB) available, and/or not available online are not included.

Table 1: Summary of Support Resources Reviewed

Type of Resources	Number	Topics covered/aspects	For whom
Benchmarks	3	Awareness of benchmarking, Service Level Benchmarks for wastewater, sanitation, municipal solid waste, storm and drainage and water supply	For planners and decision -makers
Guidebooks /Manuals	30	Maintenance, Community Led Total Sanitation, ECOSAN, Technology overviews, Design Construction and operation, City Sanitation Planning, Financing, Pollution	For planners and decision-makers
Case studies	12	Decentralised treatment, Reuse, ECOSAN, Toilets/storage, treatment, onsite, financing	For planners, designers, engineers, NGOs.
Evaluation Tools	32	Sewerage modelling/planning, capacity building/training, financing, data collection/scheduling/monitoring, transport, decision-support tools	For planners, engineers, service delivery management

Evaluation

The resources mentioned above have been detailed in this section, addressing the focus and intent of the resources, highlighting the content, design and usefulness of the resources.

Benchmarks

The MoUDs State Level Benchmarks (SLB) (Ministry of Urban Development, n.d.), CEPT University's Performance Assessment System (PAS)(CEPT University, 2011) and the International Benchmarking Network for Water and Sanitation Utilities (IBNET) were identified as existing decision-making benchmarking support tools in the urban sanitation sector (IBNET, n.d.). All three resources focus on performance monitoring. However, whilst IBNET indicators can be used globally, SLB and PAS indicators are specific to the urban Indian context.

Both IBNET and PAS provide a comprehensive list of indicators pertaining to the Water and Sanitation (WATSAN) sector in comparison to the SLB. The indicators provided, however, differ on some aspects. Contrary to PAS, IBNET provides no information on toilet coverage (focusing mostly on sewage), reuse of waste water and does not distinguish between service delivery to high, middle and low income urban population. PAS on the other hand, accounts for toilet coverage and contains a separate category under the name "equity" which seeks to understand the sanitation situation of slum areas. PAS also makes a reference to the percentage of wastewater reuse, a factor which is not taken into account in the IBNET.

IBNET provides a detailed analysis on revenue and costs associated with sanitation. This type of detail is not included in the list of indicators provided in PAS, rather it is provided as a separate questionnaire to be filled when carrying out assessments. SLBs pay heed to end-users, taking into account the efficiency of redressal of consumer complaints. This particular aspect is not considered in either of the other two benchmarks; however, the IBNET indicators make references to customers with regards to promotions and other marketing aspects. The complete list of benchmark resources reviewed can be found in the *Compendium*. This analysis is summarised in Table 2.

Table 2: Comparison of Benchmarking Tools based on Indicators for Urban Sanitation

Indicators	IBNET	SLB	PAS
Coverage of toilets			
Coverage of connections to sewerage			
Collection efficiency of sewerage network			
Cost recovery (O&M) in wastewater management			
Quality of wastewater treatment			
Wastewater treatment adequacy			
Extent of reuse and recycling of wastewater			
Efficiency in collection of sewerage related charges			
Coverage of household connections to sewerage network in slum settlements			
Coverage of individual toilets in slum settlements			
Efficiency in redressal of customer complaints			
Length of sewer system			
Blockages in sewer system			
Volume of wastewater collected			
Volume of wastewater treated to primary level			
Volume of water treated to secondary level			

(Source: CSTEP Analysis, 2014)

Guidelines/Manuals

Certain guidelines/manuals were identified as possible decision-making support tools in the urban sanitation sector. The most commonly used resource is observed to be a review of technologies and their design, construction and operation. On further analysis of these two types of resources and their relation to the sanitation value chain, it is noted that most of the documents address the entire value chain, thereby mentioning technologies which collect, store, transport, treat and support the reuse of sewage. Almost all of these documents provide details which comprehensively cover a description, advantages/disadvantages as well as information

regarding the context in which every technology could be applied (Elizabeth Tilley and Sylvie Peters, 2008; François Brikké and Maarten Bredero, 2003; Government of India, 2008; Ministry of Drinking Water and Sanitation, 2012; Shikha Shukla, 2009). However, most of the technologies have been tested in Africa.

The complete list of manuals/guidelines reviewed can be found in the *Compendium*. This analysis is visually represented in Figure 1.

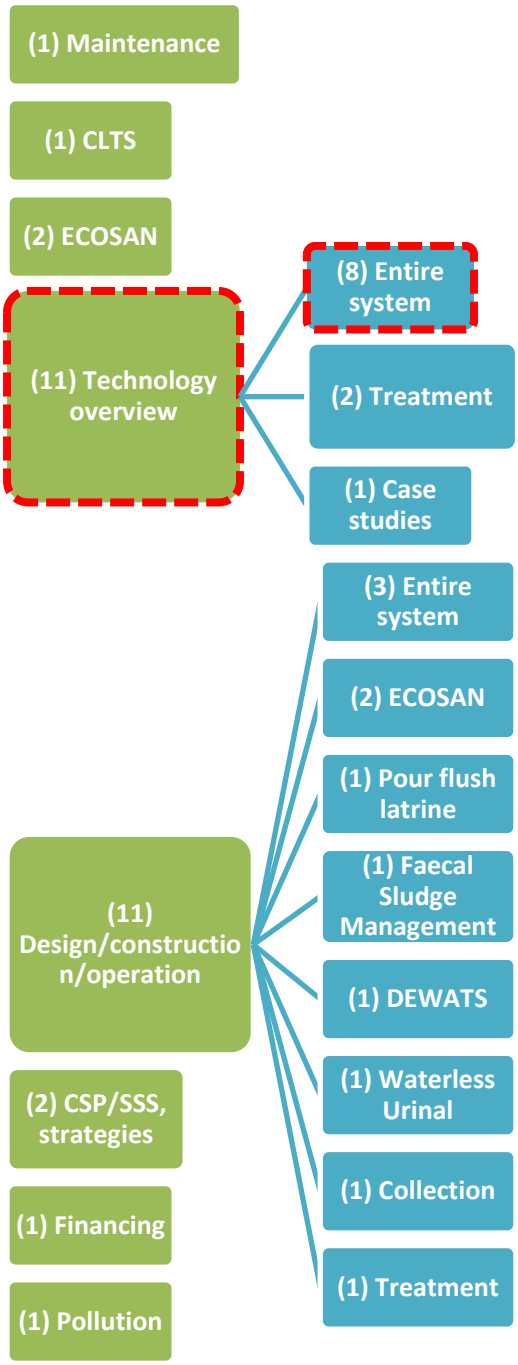

Figure 1: Analysis of Decision-making Guidelines/manuals for Urban Sanitation

(Note: Figures in brackets are representative of the number of documents covering that topic. Highlighted boxes show the most available resources.)

Case Studies

The most frequent topic covered in this set of case studies is observed to be the reuse of waste (Drescher&Zurbrugg, 2006; Jenssen et al., 2004; Mukherjee, 2003; Palrecha, Kapoor, &Malladi, 2012; Raychaudhuri, Mishra, Salodkar, Sudarshan, & Thakur, 2008). A further look into this highlights an emphasis on ECOSAN (ecological sanitation)and composting (Dawa&Panesar, 2009; Drescher&Zurbrugg, 2006; Steven A Esrey Jean Gough Dave Rapaport Ron Sawyer Mayling Simpson-HÈbert Jorge Vargas Uno Winblad (ed), 1992).

The second most frequent topic addressed in these case studies pertain to the collection/treatment of wastewater (2012; Zimmermann &Wafler, 2009). Out of these, ECOSAN and sewage-fed aquaculture in the form of fishponds were the most prevalent. The studies describing sewage-fed aquaculture focus on city-wide sewage and hence shed light on the treatment of large volumes of wastewater. The case studies analysed focuses mostly on traditional reuse options like aquaculture and irrigation. Case studies on new technologies seem to be lacking. A complete list of case study resources reviewed can be found in the *Compendium*. This analysis is visually represented in Figure 2.

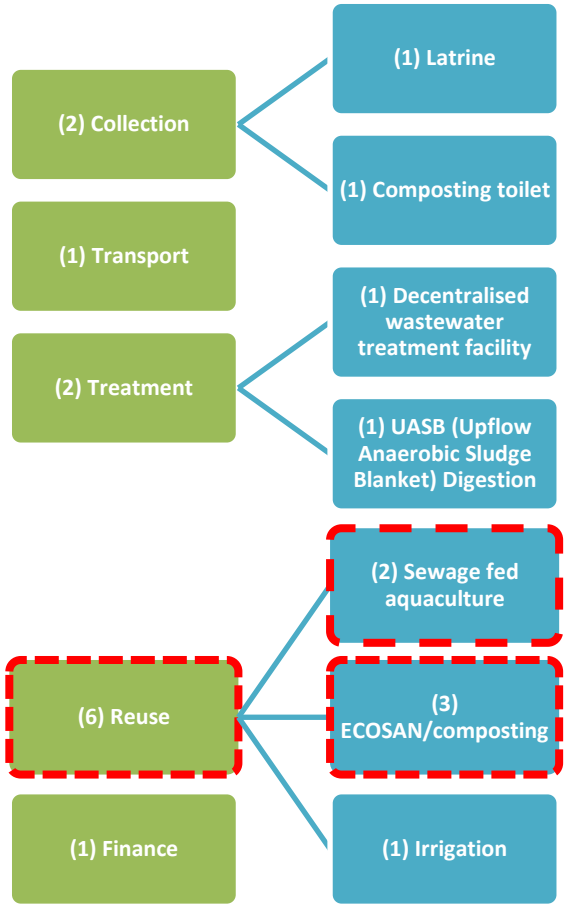

Figure 2: Analysis of Case Studies of Urban Sanitation

(Note: Figures in brackets represent the number of documents found related to the topic in question. Highlighted boxes show the most available resources.)

Evaluation Tools

The evaluation of the Decision Support Tools that address all the components of the sanitation chain indicates that they are mostly designed for planners and/or engineers. This study includes a review of about 32 tools that aid sanitation planning. A majority (13 out of 32) of the tools are data collection tools for monitoring and management of sanitation systems (sewerage). The next group of models (5 out of 32) are decision-support tools; 3 are for planners and 2 are for decision-makers. Two of the models, the Performance Improvement Planning (PIP) and the City Sanitation Planning (CSaP) Tool, are built specifically for Indian conditions, while the rest are more for developing countries, not specific to India at this time. The assessment of the tools is given below. The complete list of resources reviewed can be found in the *Compendium*. This analysis is visually represented in Figure 3.

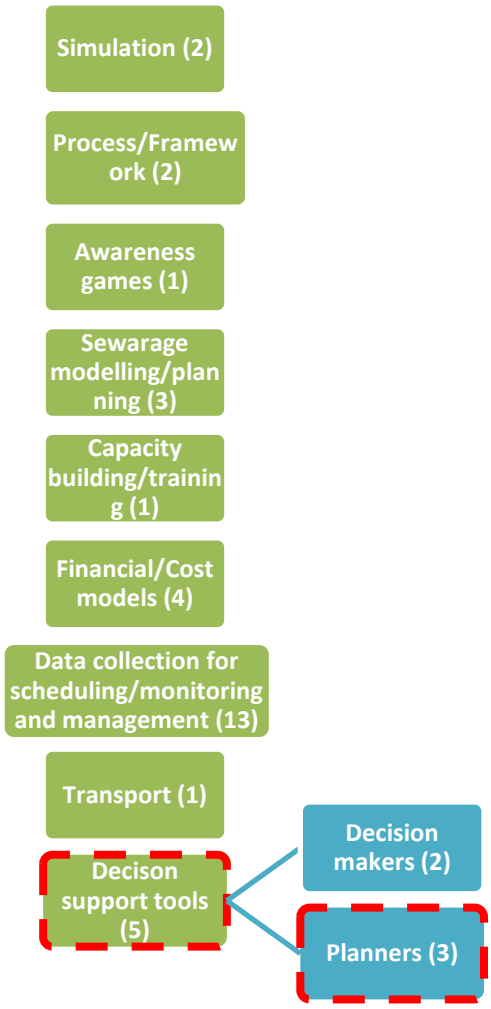

Figure 3: Analysis of Evaluation Tools for Urban Sanitation

(Note: Figures in brackets represent the number of documents found related to the topic in question. Highlighted boxes show the most available resources.)

The Performance Improvement Planning (PIP) Model (*PAS - Performance Improvement*, n.d.) is an exhaustive tool to measure, monitor and improve delivery of water and sanitation in urban India. Based on this evaluation, the model prescribes sanitation goal setting, and appropriate actions which will ensure financial sustainability. It is a very comprehensive model; it includes both project and municipal finance, and provides a more holistic inter-sectoral perspective. However, it is a complex model designed for planners and demands hand holding and extensive capacity building for ULBs to use the model. Hence, it is not for decision-makers and lacks an interactive user interface. Moreover, since it is an Excel based model, it does not have the capability to compare impacts of different action plans.

City Sanitation Planning (CSaP) Tool by Water and Sanitation Program (WSP), World Bank is a user interactive tool used to aid in choosing options for citywide sanitation planning. Unlike the PIP tool, it focuses on project finance, and does not link it city wide municipal finance. It also does not link the range of actions/technology choices to outcomes with regards to the goals of the city wide sanitation plans. Further to this, it lacks Geographic Information System (GIS) capability and is designed for planners and engineers, not directly decision-makers.

The NewSan Tool (Campos & Schuetze, n.d.) simulates the fluxes of human excreta from households to final disposal/reuse, focusing on nutrient, energy and water content in the fluxes as points of comparison between different systems. Hence, the focus of the tool is on material flow analysis, amount of nutrient and energy recovery, and quality of treated waste. It has a simple user interface and is being tested in Africa, South America and also India.

The WhichSan Tool (*Resources & Tools - Free Software*, n.d.) is an Excel-based decision-support tool based on cost, and financial feasibility; it investigates the financial feasibility of any sanitation option. It has been developed for consideration of relative benefits and costs of different sanitation options for a given situation. The tool is designed for planners and engineers.

The SANEX(Loetscher, 2000) tool was developed in 2000 in Australia. It takes into account the context (physical, demographic characteristics, etc.) and evaluates the impact of implementing a combination of technologies in specific contexts. These technologies are evaluated based on the criteria of possibility of implementation, sustainability and relative total annual cost. The tool has a user interface that gives a graphical comparison of sanitation systems showing the indicators that are considered under the mentioned criteria. A detailed output screen shows itemised figures for all indicators, thereby making it a comprehensive system.

The SaWi(*WASTE*, n.d.) tool was developed for private businesses in Europe. This is a process-oriented support tool that aids matching of western technologies with sanitation demand in low and middle income markets in Asia, Africa and Latin America. It is meant for matching buyers with sellers and vice-versa.

The Sanitation Decision Support Tool (AKVO, n.d.) is an useful tool for decision-makers as it helps the user select the chain of technologies for a sanitation chain. The interactive user interface helps the user choose a system based on the context of a particular area/city (based on criteria such as topography, ground water level etc.). It must be noted however that this tool enables selection of only one simple chain of technologies for one waste stream, whereas a complete sanitation system has to deal with different waste streams.

This is the only tool designed for decision-makers to choose technology options for sanitation planning. However, it does not guide the decision-makers to assess the merits and demerits of each of the systems, for effective decision making.

The Resource Recovery and Reuse Model of the International Water Management Institute (IWMI)(IWMI Workshop, 2013) is based on an analysis of more than 50 Resource Recovery and Reuse case studies. The model is based on the process of developing business models for resource recovery and reuse.

Challenges in Sanitation Support Tools

Most of the support resources referred to in this assessment pertaining to the sanitation sector have been identified to be designed for planners and engineers. The complexity and level of detail reflected does not render them suitable for decision-makers. In order to make these tools useful for this group of stakeholders, in addition to an effective user interface, there needs to be a provision for information regarding economic/cost of newer technologies, scalability and possibilities of replication, and information on past evaluations of the technology or approach. These are elaborated below.

Cost/Economics

The cost of implementing and maintaining different sanitation system options is vital. It is one of the major criteria of decision making, since these costs affect the long-term sustainability of technologies. The cost models to date mostly address one part of the sanitation value chain. For example, the Boston Consulting Group (BCG) Transport model (Boston Consulting Group, Work in progress) demonstrates the economics of various transportation options. On the other hand there are model like IWMI (IWMI Workshop, 2013) and Emergent Ventures International Plug and Play Model (EVI PnP)(EVI India, 2013) which focus on reuse and recovery of waste. Another useful resource is the "Methodology to Compare Costs of Sanitation Options for Low-Income Peri-Urban Areas in Lusaka, Zambia" (Mayumbelo&Münch, 2008) which is part of the UNESCO-IHE WaterMill Working Paper series. However, there are very few technologies that have been tested over a period of time in the Indian context in terms of scalability and possibilities of replication such as sewerage systems and septic tanks. Newer technologies that are still in the product development stages will require more time to be fully tested for scalability and possibilities for replication. Thus, there are very few applicable cost models suited for these technologies in various contexts. Similar is the situation with reuse and recovery models such as the IWMI and EVI PnP model, which are in the process of validation through implemented case studies. Accompanying business models are also critical to ensure success of some of the reuse and recovery technologies. These may also need to be tested in different local contexts to add validity to the outputs of the models.

Hence there is a general need to conduct case studies that support the cost and business models of the different technologies in the sanitation chain. This is especially the case with newer technologies.

Focus Areas in the Sanitation Value Chain

The sanitation value chain considers a sanitation system from the user-interface point till the reuse or disposal of waste stage. It was observed through this review that most resources refer to the latter components of the value chain, namely treatment and reuse. Most of the treatment

options presented focus on decentralised systems whilst reuse is mostly centred on composting. Almost no literature was found on transport and storage in the Indian context. The sanitation value chain is thus not well documented since resources were skewed towards one particular part of the sanitation system. In order to support integrated city-wide sanitation systems and appropriately aid decision-makers, resources have to be inclusive of all aspects of the sanitation value chain. This will be a key component of CSTEPs decision-support tool.

Financing Options

An array of resources can be found which pay heed to financing options. There are complete City Sanitation Plans (CSP) such as that of Shimla (GIZ, 2011), which provide adequate financing options for sanitation projects. Also the PIP Model and the WSP CSaP Tool have financial models embedded in them. The PIP model also links project finance to municipal finance and gives an intersectoral perspective that is very useful for decision-makers. The WhichSAN Tool investigates the financial feasibility of any sanitation option in an area. Another similar tool is the '100% access by design' which generates reliable costing of different sanitation options for achieving 100 percent sanitation access across low-income and non-low-income areas (Water & Sanitation for the Urban Poor, 2013). The WASHCost calculator gives users access to reliable life-cycle cost information and can be used to run a quick financial sustainability check on water and sanitation programmes. It can also be used to evaluate if the systems in place provide good value-for-money, and compare costs and service level data across organisations (IRC, n.d.). The EVI PnP Model does various sizing and capacity estimates of waste water treatment plants, transport vehicles and storage. Calculation for financial indicators like Net Present Value (NPV), project Internal Rate of Return (IRR), equity IRR, levelised cost, etc., including sensitivity analysis can be done using this model. The Sanitation Investment Tracker (Sanitation Hackathon, n.d.) includes a suite of applications that can be used to track investment (and associated expenditure) on sanitation at a household level. These are useful models that can be used for assessing the financial sustainability of a system/technology. These models can be used at various levels of sanitation investment planning and also address different parts of the sanitation value chain.

Region Specific Studies

An effective decision-making support tool should account for the regional differences in soil type, temperature, institutional landscape, social structure and cultural practices. Taking into account these details will help determine a range of suitable solutions. The review carried out sheds light on the lack of region specific studies tied to certain sanitation systems, especially those which are decentralised. These studies provide crucial inputs to technology assessment models and can be used to inform CSTEPs decision-support tool

Scalability and Possibilities for Replication

The extent to which a sanitation technology may be scaled up or replicated is considered to be an important piece of information for decision-makers. Keeping in mind the growth of urban areas in India, this type of information is essential so as to ensure long term coverage. Not only will these details aid decision-makers but also provide an informationbase for funding agencies and multilateral organisations. At the same time, it is important to include the risks involved in scaling up and accompanying these risks with possible strategies which seek to reduce or completely eliminate these risks. The resource review carried out reflects a lack of this information in the documents and tools studied and thus will be intended to be incorporated in CSTEPs decision-support tool.

Evaluation and Monitoring

Evaluation and monitoring of the success and long-term sustainability of different technologies and approaches is crucial since it allows an assessment of the technology in question. This type of information will help improve areas of weaknesses. At the same time, information of this kind will aid replication of effective solutions, especially those concerning new technologies that are in the early /pilot stage of development. It is important that evaluation and monitoring is completed by technology developers and/or academics and the analysis is made available to decision-makers. This is generally not the case leaving decision-makers unaware of what technologies are relevant to a particular context. The PIP tool does provide a framework for evaluation of sanitation action plans on a city level, but this is not based on individual sanitation technologies. However, an effective decision-support tool should include assessment of different technologies in different parts of the sanitation value chain.

User-friendly Interface

Most of the tools are designed by/for planners and engineers, and are very exhaustive and complex in nature, thus lacking a simple user friendly interface which would allow decision-makers to identify and understand the problems in a simpler manner. Consequently, action plans can be designed, compared and iteratively changed according to performance and goals.

For this, it is important for the interface to enable users to address the issues/problems on a spatial level as well. Thus spatial representation using GIS becomes extremely important in this context. Despite most data collection tools being GIS based, none of the decision-support tools have GIS compatibility. Most of the current tools reviewed are Excel based, thus making it challenging to iteratively compare two or more scenarios. Additionally, the current decision-support tools cannot be operated by multiple users from different locations. This is a requisite for such tools in the sanitation sector since they are often accessed by people working from

different areas of the world. This aspect could be resolved using a web-based system which allows universal accessibility.

Database Support

The reviewed decision-support tools lack database support for saving and retrieving results. This is essential in order to carry out statistical analyses and data mining when comparing scenarios which have previously been simulated. Data collection efforts connected to the database will facilitate updation of the any decision support tool, as soon as new data is incorporated. This will make the platform more robust.

Summary

Our initial review of resources highlights the following issues with regards to the support tools investigated.

- Integrated systems that enable the comparison of various sanitation technology system options linked to evaluation criteria for decision-support in the Indian urban sanitation sector are very few
- There is a lack of user interface for decision-makers
- There is very little/no GIS compatibility
- There is no database support

In order to improve the decision-making process in the urban sanitation sector in India, there is a need to create a tool which addresses the above issues. This tool will build and in turn support the discussion and development of new sanitation delivery models in urban areas so as to extend quality sanitation services to all residents, especially the urban poor. The tool will be designed so that it is generic and can be used for any location provided sufficient data is available.

Most importantly, it will be created keeping in mind potential users such as ULBs in India, the MoUD, and the Government of India and their needs. In addition to these main stakeholders, the tool will also have the potential to aid officials of the Water and Sanitation Department in the ULBs in building domain expertise, as some may not have the necessary expertise and experience in the sector.

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