Integrated Urban Sanitation Decision Support Tool

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CENTER FOR STUDY OF SCIENCE, TECHNOLOGY & POLICY

Table of Contents

Figures

Tables

Abbreviations

ABR – Anaerobic Baffled Reactor

BOD – Biological Oxygen Demand

BSUP – Basic Services to the Urban Poor

CPHEEO – Central Public Health and Environmental Organisation

CSP – City Sanitation Plans

DPRs – Detailed Project Reports

ECOSAN – Ecological sanitation

FAB – Fluidized Aerobic Bed

FWS CW –Free Water Surface Constructed Wetland

GDP – Gross Domestic Product

GIS - Geographic Information Systems

HPEC - High Power Expert Committee

IHSDP – Integrated Housing and Slum Development Project

JnNURM – Jawaharlal Nehru National Urban Renewal Mission

MBR – Membrane Bioreactor

MBBR/FABR - Moving Bed Bio-Film Reactor

MDG - Millennium Development Goals

MoUD - Ministry of Urban Development

NEERI – National Environmental and Engineering Research Institute

NUSP – National Urban Sanitation Policy

O&M – Operation and Maintenance

PAS – Performance Assessment System

PoC – Proof-of-Concept

RBC – Rotating Biological Contactor

SBR – Sequential Batch Reactors

SLB – Service Level Benchmark

SS – Suspended Solids

SSS –State Sanitation Strategy

SUSanA – Sustainable Sanitation Alliance

TF - Trickling Filter

UASB – Up flow Anaerobic Sludge Blanket

UDDT – Urine Diversion Dry Toilet

UIG – Urban Infrastructure and Governance

ULB – Urban Local Body

UDISSMT – Urban Infrastructure Development Scheme for Small and Medium Towns

VF CW – Vertical Flow Constructed Wetland

VIP – Ventilated Improved Pit Latrine

WATSAN – Water and Sanitation

Executive Summary

The pace and nature of urbanisation in India presents a significant challenge for Urban Local Bodies (ULBs) to effectively service the needs of an urban population. As a result of this inappropriate planning and management, urban infrastructure has not been able to keep up with the demands of the growing urban population. Most cities in India are currently facing an infrastructure gridlock. In this scenario, poor sanitation and its effects on the spread of diseases and pollution cannot be neglected. The current situation calls for a look at a range of solutions to address the current and future sanitation needs of cities.

In order to address the current and future sanitation needs of cities, the sanitation research community recognises the need for a portfolio approach to sanitation emphasising the importance that, decision-makers think beyond networked sewer systems to non-networked decentralised/on-site solutions. However, it has been made evident that there is a lack of capacity and effective resources, required to adequately address the needs of decision-makers in the Indian context.

There is thus a need to develop a broad resource base for decision-makers which will enable them to understand the sanitation needs of a city as well as provide them with a range of sanitation system options which can serve these needs. To effectively address community needs, approaches and technologies are required which are economically, ecologically, and socially appropriate and sustainable.

This report is a prelude to the development of a Proof-of-Concept (PoC) decision support tool 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.

This report reviewed around 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 save, update and retrieve data and scenarios for comparison. All these factors are considered essential in the development of a decision support tool.

Based on this report, a PoC decision support tool is planned to be developed, with an aim to facilitate an integrated approach to the sanitation investment planning process for ULB in India. The PoC tool is envisioned to provide stakeholders the information and knowledge of existing and new technologies in a manner that allows them to compare alternatives, assess cost/benefits and make informed decisions.

Introduction

Urbanisation patterns, population growth, and land use, influence the demand for sanitation, while features of various technologies influence the choice of infrastructure. Holistic and long-term urban sanitation planning requires an integrated assessment of various aspects (cultural, land availability, urbanisation, existing sanitation systems, financial & governance and demographics) and appropriate technologies. A multi-dimensional assessment of these aspects is therefore critical to understand and analyse the implications and the trade-offs involved.

Sanitation habits are influenced by deep-rooted socio-economic and cultural factors thereby making it essential to understand country contexts. In the Indian context, there are many technologies which provide on-site solutions, others which focus on small decentralised options and a third group which promote large scale centralised options. Success and failure stories exist in the sustainability and scalability of all of these.

Planning and sequencing has been seen as the key drivers for increased coverage. This needs a supportive institutional and policy framework. Additionally, there is a need for increased awareness, data collection, constant updating and knowledge collation. This so that the decision-maker is able to consider all the options, affordable and sustainable non-networked solutions that can be scalable in an urban context, in order to increase the rate of sanitation coverage in the cities.

The intent of this report is to give an overview of the sanitation technologies relevant to urban India, in the context of the increasing urban footprint, the nature of urbanisation, condition of urban infrastructure, finance and governance. This report is intended for decision-makers, planners, practitioner, civic societies and Non-Government Organisations (NGOs) to get an overview of the tools and technologies that are relevant in the Indian context. It represents a framework of how a criteria-based comparison of sanitation systems with defined goals/objectives and sustainability can be used to guide decision-makers and planners when making strategic decisions when planning for sanitation.

The first section of the report provides an overview of the urban scenario in India along with an introduction to the urban sanitation situation. The second section of the report is a review of the different support tools (guidebooks, manuals, case studies, etc.) that provides information in this realm in the Indian context. The objective of this review is to provide clarity on the information available in the sanitation sector which supports the decision making process in order to enable the identification of missing links and gaps that currently exists for an effective decision making support tool.

The third section provides a framework for the evaluation of technologies available at each stage of the sanitation chain. The evaluation is based on the three broad criteria namely access to sanitation facilities, safety and hygiene, and sustainability of the technologies. Although the evaluation is based on different stages of the sanitation chain, the report highlights the need for a systems approach for sanitation investment planning. The report also highlights that a suite of technologies can be considered at every stage, enabling decision-makers and practitioners to choose among this variety, in order to achieve the sanitation needs of a city.

The last section combines all the above by outlining the salient features that are considered necessary to be included in an integrated sanitation planning tool.

This report is a prelude to the development of a PoC decision support tool that will help cities in providing cost-effective and sustainable sanitation options for all, especially the urban poor, through an integrated assessment framework of alternative sanitation technologies, suited to a context, and satisfying some pre-determined criteria by the ULBs and the stakeholders.

The Indian Urban Context

The urban footprint in India is increasing. As the main hub of economic activity, great numbers of people are attracted to cities, leaving smaller towns in a state of neglect. This growth has not been accompanied by appropriate planning and management thus rendering cities the inability to absorb the growing urban population. Hence, cities are currently facing an infrastructure gridlock. In order to tackle this and due to their contribution to the country's Gross Domestic Product (GDP), the Central Government has prioritised and directed funding support to larger cities. A lack of capacity and continual mismanagement has resulted in the delivery of adhoc solutions which compromised sustainability. At the same time, smaller town's economic and infrastructural development has been ignored.
The following section sheds light on the urbanisation process in India.

A. Expanding Urban Footprint

- The urban population increased from 25.86 million to 377.11 million from 1901-2011 (Census of India, 2011)
- The share of urban population increased from 10.8% to 31.2% and the rural population share decreased from 89.2% to 68.8% from 1901-2011. The share of urban population is projected to be 38.2% by 2026 (Office of the Registrar General, 2006)
- Urban population in India is expected to be 590 million (McKinsey & Company, 2010), by 2030 with an increase of approximately 200 million.

B. Nature of Urbanisation

- ***Uneven rate of urbanisation spatially:***
  - The rate of urbanisation is not spread evenly across states. As per the 2011 provisional census 50% of the urban population share (187 million) is from the states of Maharashtra (13%), Uttar Pradesh (12%) and Tamil Nadu (9%), West Bengal (8%), Andhra Pradesh (8%)
  - Punjab , Gujarat , Tamil Nadu , Karnataka and Maharashtra states will be more than 50% urbanised, having an urban population of 238 million by 2030 (McKinsey & Company, 2010).

- ***Concentration of population in mega-cities:***
  - As per the 2011 census, there are 53 million-plus cities in India
  - 2 cities having a population between 3 to 5 million constituting about 5 % of the population
  - 5 cities having a population between 5 and 10 million constituting 23 % of this population

- 3 mega cities[1] having more than 10 million inhabitants are in Delhi, Kolkata and Mumbai. Together they comprise 30% of the million plus cities' population share.

- ***Growth of urban areas***:
  - The number of urban areas increased from 1827 in 1901 to 7935 in 2011. There was an increase in the number of urban areas by about 54% in the last decade (2001-2011)
  - The share of megacities remained the same in 2001 – 2011
  - The cities with a population range of ≥ 1 million and < 10 million registered more than 50% surge.
    (Census 2011)
- ***Migration***:
  - The main cause of the rising urban population was observed to be related to natural causes. Net rural – urban migration was the second major contributor to the increase in urban population. The expansion of urban areas was more during 1971-1981 (11.9 %) and 1991-2011 (9.9%) when compared to the 1980s (2.1%) (HPEC, 2011).

Concentration of economic output: It was estimated that by 2011, urban areas would contribute about 65% of GDP (Ministry of Urban Employment and Poverty Alleviation & Ministry of Urban Development, n.d.). Mumbai, Delhi, Chennai, Kolkata, Bangalore and Hyderabad – represent 6% of the population and contribute 14% to India's GDP (Price Waterhouse Coopers, 2006).

C. State of Urban Infrastructure

Given the relative importance of the contribution of urban areas to the country's GDP growth one would expect that the level of urban infrastructure would be of an acceptable standard. Yet what is observed is quite the contrary. As shown in Figure 1, the service level of infrastructure is less than satisfactory (McKinsey & Company, 2010).

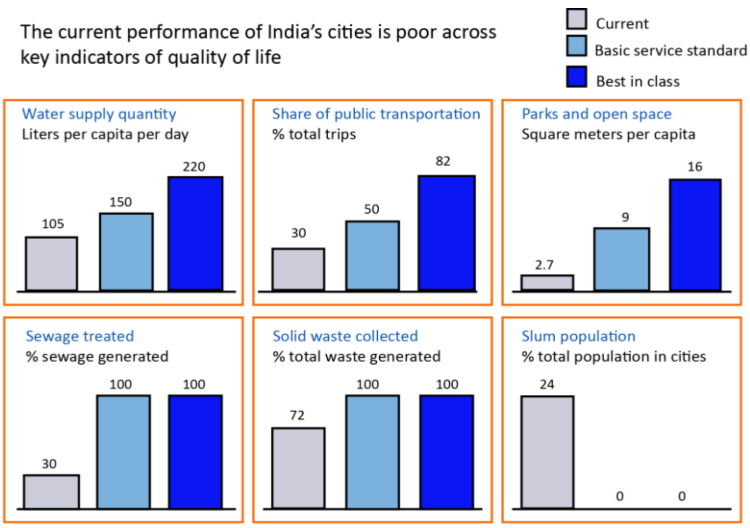

Figure 1: Current Performance of Urban Infrastructure Sectors

Source: (McKinsey & Company, 2010)

[1]Megacity definition – cities with population greater than 10 million

It is evident from the literature surveyed that the current service level delivery compares poorly with the Service Level Benchmarks (SLB) provided by the Ministry of Urban Development (MoUD). In the case of sewage treatment, Indian urban areas only treat 30% of the sewage generated as opposed to 100% of sewage treatment which is the acceptable norm. The same study states that if the current level of service is maintained, the gap between supply and demand will increase considerably. In the case of sewage treatment the gap is estimated to be 109 billion litres (McKinsey & Company, 2010).

D. Urban Finance

Clearly, business-as-usual is not an option, and substantial investments are required for bolstering urban infrastructure. A High Power Expert Committee (HPEC) suggests that urban investments will need to increase substantially (from the current 0.7% of GDP in 2011-2012 to 1.1% of GDP by 2031-2032). In absolute terms, the HPEC estimates that $638,375,845,511[2] will be the required investment from 2012-2030 (HPEC, 2011).

Keeping this in mind, governments have launched schemes to revitalise investments in urban areas. The Jawaharlal Nehru National Urban Renewal Mission (JnNURM) was launched in 2005 with four sub-missions:

- Urban Infrastructure and Governance (UIG)
- Basic Services to the Urban Poor (BSUP)
- Urban Infrastructure Development Scheme for Small and Medium Towns (UDISSMT)
- Integrated Housing & Slum Development Project (IHSDP)

The number of cities and towns covered by UDISSMT & IHDSP sub-missions are 640 whereas UIG & BSUP sub-mission covers 65 cities. It chalks out several reforms at the state and city levels which have to be implemented in order to obtain funding from the government. Some observations on the nature of investments:

- UIG and BSUP allocations were 75% and the remaining 25% was for the 640 towns under UDISSMT and IHSDP.
- On an average, bigger cities have a higher per capita investment.
- Population coverage under the UIG and UIDSSMT scheme decreases with class size[3], with smaller cities having low service delivery levels (Figure 2).

Central assistance released during 2006-2011 to the sewage sector was 14%, and the recommendation suggests a reduction to 6%, while transport sector allocations increase to 59% (from 11%, current JnNURM assistance). The HPEC recommendations indicate a bias towards larger cities.

There are two other challenges that the ULBs face currently in urban infrastructure financing.

- There is discrepancy in the sector wise released funds from the Central Government (for example, UIG) and the amount allocated. For the sewage sector (UIG), the pending central assistance was almost 50% of the allocation under this scheme (MoUD, 2013)

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[2]Conversion rate: $1=61.38 INR

[3]Class size city population- Class I (Population ≥ 0.1 million), Class II (50000 -99999), Class III (20000 – 49999), Class IV (10000 – 19999), Class V (5000 – 9999), Class VI (<5000)

- At the local level, ULBs often face difficulties in spending revenues (lack of capacity) from their accounts. In some of the Karnataka ULBs, 15% of their revenues were unspent.

The HPEC report (2011) suggests structural changes in the financing of the projects by 203, a potential distribution of the financing responsibility across the different levels of government and public and private sectors, with ULBs expected to increase their revenue net to finance the bulk of the burden.

E. Urban Governance

The 74th amendment of the Constitution aims at decentralising urban governance. This amendment passed in the early 1990s required that state governments should constitute municipal corporations, municipal councils and Nagar panchayats in urban areas (based on population and other characteristics) and held cities responsible and accountable for the delivery of services.

The 12th Schedule of the Indian Constitution stipulates 18 functions which are meant to be performed by ULBs. There is no function titled 'Urban Finance' in the 12th Schedule since urban finances are largely controlled by states governments. The major sources of revenue for city municipalities are usually property tax, octopi (if present), state government transfers (city's share of taxes) and a few other sources of revenue such as advertisements, parking fees, tariffs from service delivery etc.

Status of Urban Sanitation

The eight Millennium Development Goals (MDGs), each with a specific set of targets, were established by the United Nations in 2000. Goal number 7, i.e. Ensuring environmental sustainability, targets 7C states, that by 2015 the agreeing member states and organisations must ensure to halve the proportion of people without sustainable access to safe drinking water and improved sanitation facilities with respect to 1990. India is one of the 193 member countries that signed this pact and although the country is well on track to meeting the MDG on water coverage, the improvement in sanitation facilities has not recorded similar progress.

According to Census 2011, out of the 81.4% of people in urban areas that have toilets, 33% are connected to a sewerage network, 38% have septic tanks and 11% use latrines. This leaves a total of 18.6% of urban population without access to toilets in their households, a figure which is substantially higher than the 12.14% target set by the MDGs to be met by 2015 (Central Statistical Organisation, 2011).

Inadequate sanitation has far-reaching effects imposing significant public health costs in urban areas. The UN states that in India, diarrhoea alone causes more than 1600 deaths each day. 90% of these deaths could be prevented through safe drinking water and adequate sanitation and hygiene practices. Beyond health impacts, the Water Sanitation Program (WSP) estimated that the total annual cost of poor sanitation amounted to a loss of $54 billion or 6% of India's GDP (Water and Sanitation Program, 2011).

Challenges in the Sanitation Sector

In most urban areas of India, sanitation infrastructure, where existent, was designed in the late 80s and 90s. The growing influx of rural population in Indian cities over the last 10-15 years has not only exhausted these sanitation systems but also highlighted a need for more suitable infrastructure. Coupled with it is an inadequacy in investments in the urban sanitation sector with very minimal allocation to operational expenditure and capacity building. This hampers the sustainability of sanitation interventions increasing the gap between the demand for sanitation and the required supply. In addition to a lack of appropriate technology and inadequate investment, there are severe concerns regarding the institutional capacity of ULBs to manage the functions related to the sanitation sector effectively.

India's Urban Sanitation Initiatives

Following the creation of the JNNURM in 2005, cities were mandated to prepare the City Development Plans. To ensure the prioritisation of sanitation, the MoUD further launched the National Urban Sanitation Policy (NUSP) in 2008. This policy highlighted numerous issues including a general lack of awareness with regards to sanitation, fragmented roles and responsibilities of stakeholders in the sanitation sector, a lack of focus on the unserved poor and limited sanitation technology choices. With this and other factors in mind, the NUSP aims to transform urban India into community driven, total sanitation, healthy and liveable cities and towns focusing specifically on the following areas:

- Awareness generation and behaviour change:
    - Increase awareness on sanitation and its links to public and environmental health as well as promote mechanisms to sustain behavioural changes
- Open defecation free cities:
    - Encourage the construction and use of individual toilets and adequate upkeep and management of public facilities
- Integrated city-wide sanitation:
    - Reorient institutions and mainstream sanitation, sanitary and safe disposal, proper operation and maintenance of all sanitary installations.

These are to be achieved through the preparation and implementation of State Sanitation Strategies (SSS) and City Sanitation Plans (CSP).

A CSP is a visionary document with a horizon for 20-25 years, considered essential in making cities becoming free from open defecation by ensuring universal access to sanitation and safe disposal of human waste. They include short term action plans of 3-5 years duration which are geared towards meeting the guidelines and goals provided in the NUSP. This includes information on institutional roles and responsibilities, awareness generation and technical options.

The focus areas highlighted by the NUSP are intrinsically linked since an increase in awareness on the importance of sanitation is hoped to be linked to a change in behaviour. If this change is accompanied by appropriate infrastructure and governance the practice of open defecation is likely to reduce. This type of transformation can only be facilitated if sanitation is looked at in an integrated manner i.e. considering the entire value chain from collection to storage, transport, treatment and reuse/disposal (Figure 2).

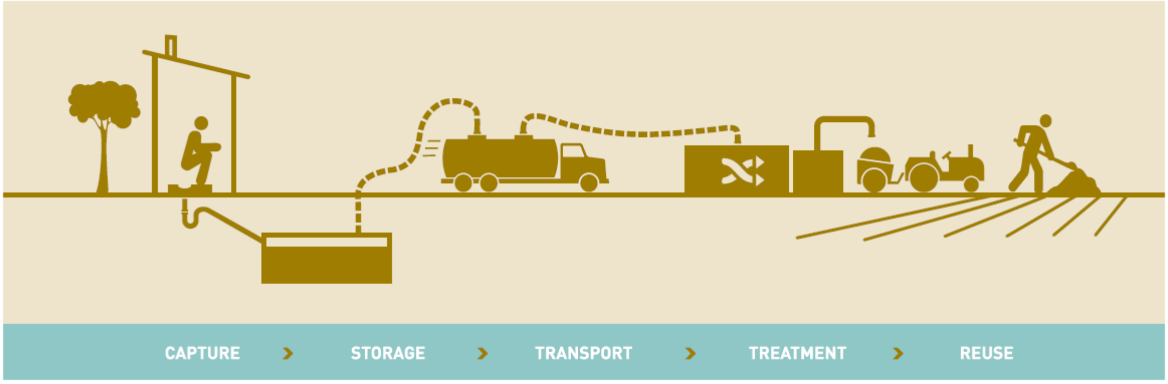

Figure 2: Sanitation Value Chain

National Rating of Sanitation

In an attempt to meet the goals set by the NUSP, a national rating for cities was launched by the Government of India (GoI). The exercise rated 423 cities for their performance across various aspects of sanitation, in 2009. Additionally, in order to encourage the accountability of the delivery of services, the MoUD developed a handbook on SLB. This handbook provides a framework with 28 performance indicators for the water and sanitation sectors (Ministry of Urban Development, 2013). In order to take this framework from concept to practice, the MoUD launched an SLB initiative in 2009 which was piloted across 28 cities in 14 states and one union territory viz. Andhra Pradesh, Kerala, Tamil Nadu, Karnataka, Maharashtra, Gujarat, Madhya Pradesh, Chhattisgarh, Orissa, Jharkhand, Manipur, Punjab, Himachal Pradesh and New Delhi (the latter being the Union Territory). Based on the SLB performance data collected, cities were informed on good practices.

This benchmarking principle has been further endorsed by the 13th Finance Commission which has included an allocation of performance based grants to ULBs for SLB during 2010-2015.

Governance of Sanitation Process Planning in India

For an appropriate delivery of sanitation services, a clear assignment of institutional responsibilities, resources and capacity is essential. In this effect and recognising that sanitation is a state subject, GoI (74th Amendment) emphasises that State Sanitation Strategies (SSS) must ensure clear ULB responsibility. In parallel, ULBs need to be conferred wide-ranging powers over agencies that are involved with city sanitation related activities but not necessarily accountable to them. Additionally, SSS must set the State Level standards (in line with national standards). Following are the responsibilities of the different agencies involved in the sanitation sector:

- Environmental outcomes to be overlooked by the State Pollution Control Board
- Public health outcomes to be overlooked by the State Health Departments
- Processes, infrastructure and coverage to be overlooked by the Public Health Engineering Department and para-statals
- Service delivery to be done by ULBs

In order to improve the sanitation situation, there is an urgent requirement for cities to adopt a portfolio approach to sanitation planning, looking at a range of options that meet the needs of the different cities/areas under consideration.

In order to understand these options, a review of decision-making resources relevant to the Indian urban context was undertaken. This is presented in the following section.

Review of Support Resources in Sanitation

Effective decision making support systems help decision-makers in identifying, evaluating and choosing a technology that best suits the context/conditions of the 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.

The existing support resources for decision making that were evaluated 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. This informs the decision making process.
Case Studies: Case studies are important sources of information that cover various aspects during implementation of a technology such as willingness of community to accept technology, socio-economic aspects that need to be considered and also adaptation/improvisation of technology suited to the local needs. These provide examples which can influence the decision-making process.

Guidebooks and Manuals: These documents provide guidance on sanitation technology design, construction, implementation and evaluation, either covering specific or all parts of the sanitation value chain.

A database was created containing information regarding these support resources introduced above. Research 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 case studies, benchmarks, guidelines and manuals which showcase sanitation systems in urban India. The focus was to highlight cases which presented technologies covering the sanitation value chain. Post the documents identification, an analysis was conducted to highlight the purpose of these documents, the context in which the information provided can be applied and the group of stakeholders the resource is intended for.

Evaluation Tools (for decision support): Different evaluation tools ranged from modelling project costs (the capital and operation and maintenance costs), with respect to a technology to more integrated costing (like life-cycle costing) and also planning tools that integrated project costs to municipal finances. The sanitation evaluation tools discovered/reviewed so far are predominantly Open Source and are freely available on the web. Some of the tools like the ones from Emergent Ventures and Boston Consulting Group (BCG), NewSAN, etc. for which resources are not available online, the organisation/person was contacted to understand the tools in more detail. The "Sanitation Hackathon" website also has new and innovative solutions for a variety of sanitation related problems (Sanitation Hackathon, n.d.). The decision support tools tries to address 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 – 22
- Case Studies - 13
- Evaluation tools - 33

A bibliography is included in Annexure1. Resources that are locally (specific to a city/ULB) available, and not available online are not included.

Table 1: Summary of Support Resources Reviewed

Type of Resources	Number	Topics covered/aspects	Region specificity	For whom
Benchmarks	3	Awareness of benchmarking,, SLBs for wastewater, sanitation, municipal solid waste, storm and drainage and water supply	India	Mostly for Planners and decision-makers
Guidebooks/ Manuals	22	Maintenance, CLTS, ECOSAN, Technology overviews, Design Construction and operation, CSPs, Financing, Pollution	India	Mostly for Planners and decision-makers
Case studies	13	Decentralised treatment, Reuse, ECOSAN, Toilets/storage, treatment, onsite, financing	India	For planners, designers, engineers, NGOs
Evaluation Tools	33	Sewerage modelling/planning, capacity building/training, financing, data collection/scheduling/monitoring, transport, decision-support tools	India	For planners, engineers, and for service delivery management

Benchmarks

The MoUD's 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 urban Indian context.

Both IBNET and PAS provide a comprehensive list of indicators pertaining to the water and sanitation (WATSAN) sector in comparison to 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. Further to this, PAS makes a reference to % of wastewater reuse, a factor which is not taken into account in IBNET.

IBNET however 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 IBNET indicators makes references to customers with regards to promotions and other marketing aspects. The complete list of benchmark resources reviewed can be found in Annexure 1. This analysis is summarised in Table 2.

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

Indicators	IBNET	SLB	PAS
Coverage of toilets			
Coverage of connections to sewerage			
Collection efficiency of sewerage network			
Cost recovery (O and M) in wastewater management			
Quality of wastewater treatment			
Extent of reuse and recycling of wastewater			
Efficiency in collection of sewerage related charges			
Coverage of household connections to sewerage network in slum			
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

Guidelines/Manuals

Guidelines/manuals were identified as possible decision support tools in the urban sanitation sector. The most frequent resource is observed to be a review of technologies. When looking further into the type of technologies presented 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 is comprehensive in introducing 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 second most frequent type of guideline/manual identified addressed the design, construction and operation of certain types of technologies. Out of these documents, ECOSAN was identified as a technology which was most referred to(Steven A Esrey Jean Gough Dave Rapaport Ron Sawyer Mayling Simpson-HÈbert Jorge Vargas Uno Winblad (ed), 1992,),(Kabir Das Rajbhandari, 2011),(S.Vishwanath and Chitra Vishwanath, n.d.),(MSc. Leonellha Barreto Dillon, 2010). The complete list of manuals/guidelines resources reviewed can be found in Annexure 1. This analysis is visually represented in Figure 3.

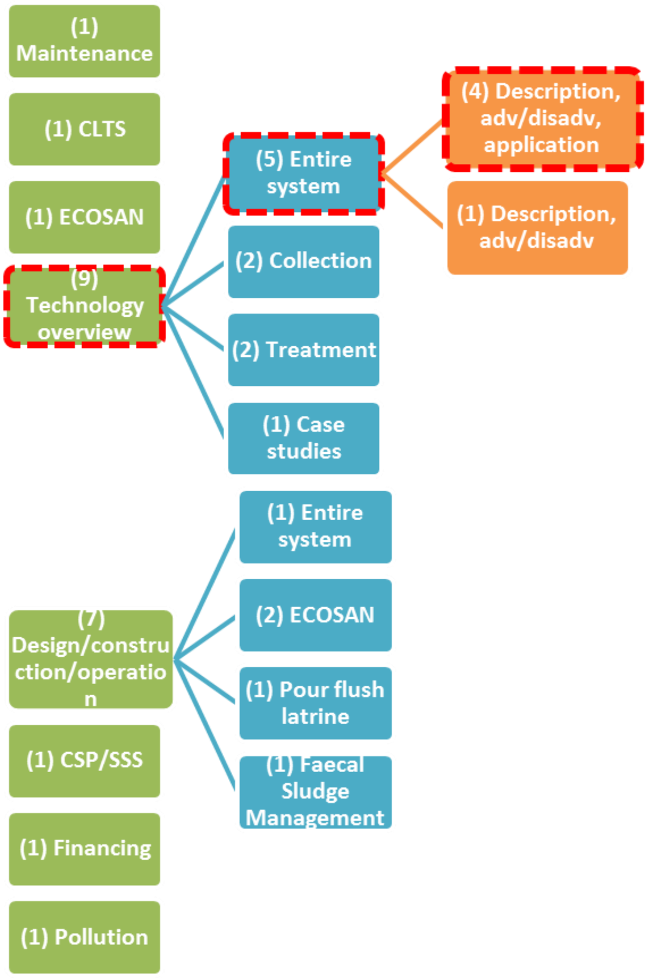

Figure 3: Analysis of Decision Making Manuals/Guidelines for Urban Sanitation.

Figures in brackets are representative of the number of documents found under that topic area.

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 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). This focuses on separating waste streams, diverting the urine from faeces. Whilst the former can be used on agriculture as fertiliser, the latter can be composted.

The second most frequent topic identified in these case studies pertain to the treatment of wastewater(2012; Zimmermann & Wafler, 2009). Out of these, the installation of decentralised wastewater treatment systems and sewage fed aquaculture in the form of fishponds were the most prevalent. The studies show the implementation of decentralised wastewater treatment systems in two specific contexts, a school and a township thus treating limited amounts of wastewater. The studies describing sewage fed aquaculture and focus on city-wide sewage and hence shed light on the treatment of larger volumes of wastewater. The case studies are mostly focused on traditional reuse options like aquaculture and irrigation. Case studies on new technologies seem to be lacking.

The complete list of case study resources reviewed can be found in Annexure 1. This analysis is visually represented in Figure 4.

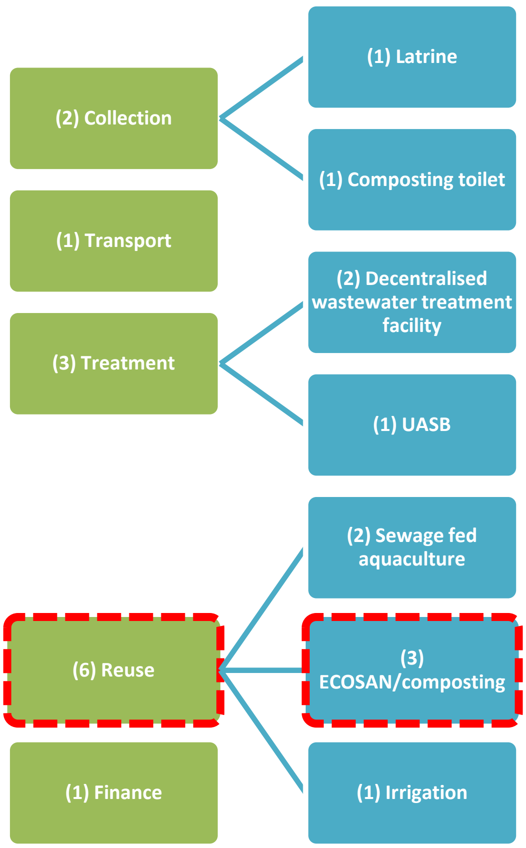

Figure 4: Analysis of Case Studies of Urban Sanitation.

Figures in brackets represent the number of documents found related to the topic in question.

Decision Support Tools

An 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. The study reviewed about 33 tools that aid sanitation planning. Most of the tools (15 out of 33) are data collection tools for monitoring and management of sanitation systems (sewerage). The next group of models (8 out of 33) are decision support tools; 4 are for planners, 2 are for decision-makers and 1 is for private businesses. Four of them have user interface, and the other three have no user interface. Others are specific to a technology or a part of the process (like sewage modelling / transport options modelling), and few are financial models. Two of the models (PIP and CSaP) are built specifically for Indian conditions, while the rest are more for developing countries, not specific to India at this time. The complete list of resources reviewed can be found in Annexure 1. The profiles of these tools are elaborated in Annexure 2.

The Performance Improvement Planning (PIP) model (PAS - Performance Improvement, n.d.) is an exhaustive tool for the evaluation of a city's performance, setting goals, and choosing actions accordingly and ensuring financial sustainability. It is very comprehensive and 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.

CSaP (City Sanitation Planning) Tool by WSP is a user interactive tool used to aid the choice of options for citywide sanitation planning. Unlike the PIP tool, it focuses on project finance, and does not link municipal finance. It also does not link the range of actions/technology choices to outcomes with regards to the goals of the plans. Further to this, it lacks 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 fluxes of nutrient, energy and water when comparing with 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 user interface and is being tested in Africa, South America and also India. It is designed for planners and engineers.

The WhichSan tool (*Resources & Tools - Free Software*, n.d.): is an Excel based decision support tool, based on questions on costs, and financial feasibility. It investigates the financial feasibility of any sanitation option. It has been developed for the 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 a combination of technologies. These technologies are evaluated based on the criteria 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 the 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 a useful tool for decision-makers, helping in the selection of the chain of technologies for the sanitation chain. The interactive user interface helps the user choose a system based on the context of a particular area/city (based on some 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. However, a complete sanitation system has to deal with all the 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 IWMI Model (Resource Recovery and Reuse)(IWMI Workshop, 2013) is based on an analysis of 50+ Resource Recovery and Reuse case studies. The model is based on the developing business models for resource recovery and reuse.

A complete list of evaluation tool resources reviewed can be found in Annexure 2. This analysis is visually represented in Figure 5.

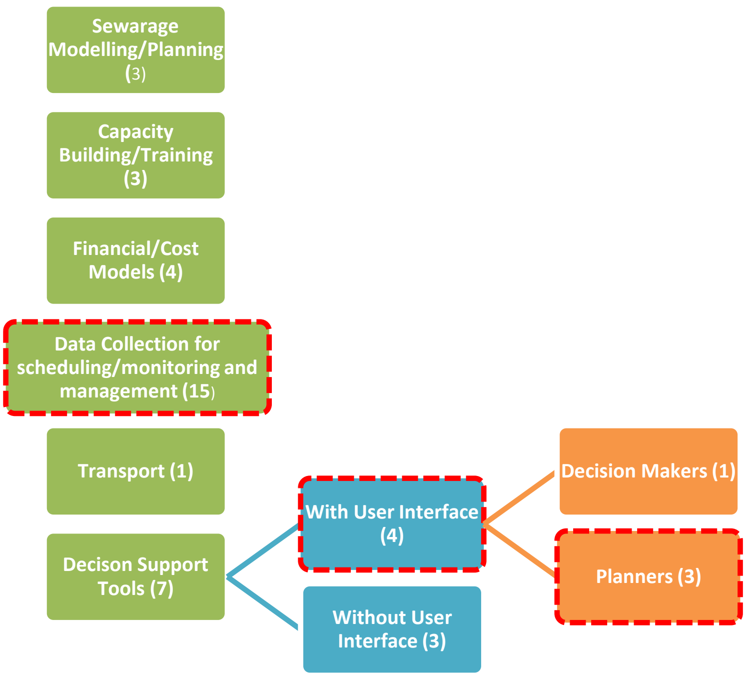

Figure 5: Analysis of Evaluation Tools of Urban Sanitation.

Figures in brackets represent the number of documents found related to the topic in question.

Challenges in Support Tools in Sanitation

Most of the support resources identified 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 to 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 of information regarding economic/cost of newer technologies, scalability and replicability, and information on past evaluations of the technology or approach. These are elaborated below.

Cost/Economics

The cost of implementing and maintaining different options is vital and is one of the major criteria of decision making, as these costs also affects the long-term sustainability of technologies. The cost models mostly address a part of the sanitation value chain. For example, the BCG transport model (Boston Consulting Group, Work in progress) demonstrates the economics of various transport option and the reuse and recovery models such as the IWMI (IWMI Workshop, 2013) and EVI PnP (EVI India, 2013). Another useful resource from the UNESCO-IHE WaterMill Working Paper series is the "Methodology to Compare Costs of Sanitation Options for Low-Income Peri-Urban Areas in Lusaka, Zambia"(Mayumbelo & Münch, 2008). However, there are very few technologies that have been time tested in the Indian context in terms of scalability and replicabilty such as sewerage systems and septic tanks. New technologies that are still in the product development stages will require more time to be fully tested for scalability and replicability. Thus there is 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 with implemented case studies. Accompanying business models are also critical to ensure success of some of the reuse and recovery technologies. These also may 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. 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 thus is 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 to appropriately aid decision-makers, resources have to be inclusive of all aspects of the sanitation value chain.

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 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.

Scalability and Replicability

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 a base for funding agencies and multilateral organisations. At the same time, it is important to include the risks involved in scaling up 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.

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 and at the same time aid replication of effective solutions, especially 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 made available to decision-makers. This is generally not the case leaving decision-makers unaware of which 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 systems that include technology options at 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 2 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 many a time systems are 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 saved. Data collection efforts connected to the database will facilitate updation of the support tool, as soon as new data has been incorporated. This will make the platform more robust.

Summary of Analysis

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

- Less number of integrated systems that enable the comparison of various sanitation technology options linked to evaluation criteria for decision support in the Indian urban sanitation sector
- Lack of user interface for decision-makers
- No GIS compatibility
- No database support.

In order to improve the decision making process in the urban sanitation sector in India it is considered necessary to create a tool which addresses the above. This tool will intend to 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 as designed will be generic and can be used for any location provided sufficient data is available.

Most importantly, it will be created keeping in mind the potential users ULBs in India, the MoUD, and the GoI 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.

Evaluation of Sanitation Systems in India

In the Indian context, a sanitation system that is effective, efficient and affordable is one that increases access and coverage of sanitation to all, including the urban poor, and ensures safe disposal thereby minimising health-related risks.

In this section a system is defined as a combination of toilet type, collection/storage mechanism, transport mechanism, treatment process/es, and disposal system/reuse mechanisms. The context of this section identifies an approach for a decision support tool for decision-makers in the Indian urban local bodies (ULBs). As discussed in the previous section on review of support resources in sanitation in order for a support tool to be effective it must seek to adopt a portfolio approach, addressing all parts of the sanitation value chain when making recommendations on sanitation systems for an entire city. The portfolio approach addresses not only the issue of open defecation, but intends to find a solution that addresses safe sanitation, and the potential of reuse and recovery of nutrients and energy. This approach seeks to fulfil the objectives of identifying safe sanitation options for a city which are effective, efficient and sustainable.

The choice of sanitation systems for a city will be dependent on the priorities of the city, such as coverage, environmental and health benefits, elimination of open defecation, etc. These priorities influence the sanitation systems chosen by city planners.

There is however, not enough information and knowledge to understand sanitation systems that may be composed of a range of technologies. Technologies addressing a part of the value chain might address some benefits like open defecation, but not address septage management and/or safe disposal. Thus there is need to understand a total sanitation system and evaluate its impacts on cost, health, and environment, etc.

In Indian cities, award is an administrative unit of a city region/city area. A city consists of any wards. In this approach, we propose to understand the context of any spatial unit (ward) (socio-economic, geographic, etc. characteristics), and what system(s) is suitable/required for the unit in order to improve sanitation conditions of the unit, based on their priorities.

In this light, we propose an approach which is based on:

1. Ward context (any spatial unit): This determines the information on the ward-the socio-economic, demographic, and geographic characteristics, sanitation systems present, resource availability and any other relevant information needed for choice of sanitation systems.
2. System context: This determines the sanitation systems that are present and relevant for the city with its parameters and respective values.
3. Scenario context: An understanding of the impacts of groups of sanitation systems at ward and city levels through the use of scenarios using ward and city level indicators

This evaluation approach is an evolving methodology that aims to enhance the conventional urban sanitation investment planning process. Its focus is on alternative technology options to determine the best possible sanitation solutions, keeping in mind not only on the feasibility of a project but also the context in which the project is to be implemented.

This approach will be relevant to decision-makers influencing sanitation infrastructure decisions, by being exposed to a range of sanitation systems and at the same time will be able to see the impact of the decision on various indicators like accessibility, coverage, costs, environmental and health. It may also support decision making processes of government agencies such as the Central Public Health and Environmental Engineering Organisation (CPHEEO) and Ministry of Urban Development (MoUD). Other stakeholders such as technology developers and practitioners will not only have an overview of the broad choices available and can also refer to this approach to highlight the benefits of their technologies (as a system/ or part of a system), through their choice of indicators.

The next section, details the approach indicating the parameters and how they form part of the decision support tool.

Step 1: Ward Context

Sustainability is a context-specific matter; no sanitation system can be considered universally sustainable. Therefore each system needs to be assessed in a specific context. In order to facilitate this process, it is essential to understand the dynamics of a city. Variations exist between cities and within cities itself; therefore a suitable sanitation system depends on a number of locale specific parameters.

Broadly, these parameters may include (but not be limited to) the following:

Demographic Characteristics

- Level and nature of urbanisation
- Population density
- Water use

These parameters determine the demand for a sanitation system. This may vary within a city itself. For example, the average population density in New Delhi is ~29,000 people/ km^2, but within the city there is a wide range of population density variability, from areas with an average of over ~45,000 people/ km^2 to areas with less than ~15,000 people/ km^2. Similarly, sanitation systems that are designed to use large volumes of water for proper functioning such as conventional sewers, may not be useful in a water scarce area or where the source of water is far from the city (Boston Consulting Group, 2013).

Physical Characteristics

- Geography, geology and topography (soil permeability, height of water table, rainfall)
- Physical resource availability (land, water, etc.)

Soil types also influence the choice of sanitation technologies as they drive the cost of systems, which is an essential factor in ensuring sustainability. For instance, Table 1 below lists the drivers of capital costs for sewer-based sanitation systems.

Table 3: Drivers of Capital Cost for Sewer-based Sanitation Systems

S.No.	Factor	Driver of lower capital cost/person	Driver of higher capital cost/person	Magnitude of impact
1	Population	Higher density	Lower density	High
2	Topography	Sloped, no hills	Flat or very hilly	Moderate
3	Water table	Deep water table	High water table	Moderate

(Source: Boston Consulting Group, 2013)

Institutional/Economic Characteristics

- Financial capability of the ULBs (municipal finance)
- Availability of qualified staff for required tasks
- Institutional arrangements
- Discharge standards

In India, there is an increasing trend towards assigning more financial responsibility to ULBs. Smaller ULBs, with low financial capabilities, and human and other resource constraints, face additional burdens to service the population. Centralised sewer-based systems have high capital costs. In order to sustain them high tariff rates need to be set, which may not be affordable for below-poverty-level (BPL) people. Conventionally, these centralised systems are easy to fund. Funders often see on-site decentralised operators as fragmented. In the Indian context they are considered to be informal and thus more complex to fund (Boston Consulting Group, 2013).

There is therefore a need to include municipal finance in this approach, in order to judge the financial sustainability of the city/ULBs.

Additionally, innovative systems may require skilled labour to build and operate such system. This is an important criterion for the sustainably of a system since without these skills, the construction, operation, and maintenance of an entire system will be erratic. Hence, institutional coordination is an important factor that helps drive the success and effective/efficient implantation of a system.

Social/Cultural Characteristics

- Social environment and neighbourhood
- Willingness to pay

For a system to be sustainable, the local social context needs to be considered. For example, in many Indian cities, dry toilets may not be acceptable due to inherent cultural habits and characteristics. Community support is required in the process of planning and implementation. A demand needs to be created to ensure willingness to pay tariffs (for operation and maintenance, and management of waste) and connection fees. This is vital to the financial sustainability of a system, especially in the context of a changing financing structure of urban finance, where cities are more likely to provide for their operation and maintenance costs.

The set of ward parameters (sample) incorporated in the PoC tool are provided in Table 4 below:

Table 4: Ward Parameters

Parameter	Unit
Average household income range	INR/household/annum
Soil type	Clayey, Silty, Sand/Gravel, Rocky
Topography	Flat, Slope
Ground water table	Shallow, Medium, Deep
Vehicle accessibility	No access, limited access, full access
Flood prone	Not affected, frequent, not frequent
Water supply	None, other, connection
Susceptibility to natural disasters	Yes/no
Systems present	Uncovered-x%, System 1-y%, etc.
Health parameters	Number of incidences of ascariasis/ diarrhoea /hookworm per 1000 people
Physical resource availability	Land (m^2) Water (Litres per Household)

Some of the parameters described above can be mapped using the Geographic Information System (GIS) (as shown in Figure 6). Issues related to sanitation, like condition of sewerage connections, open defecation areas, etc. can also be represented using GIS.

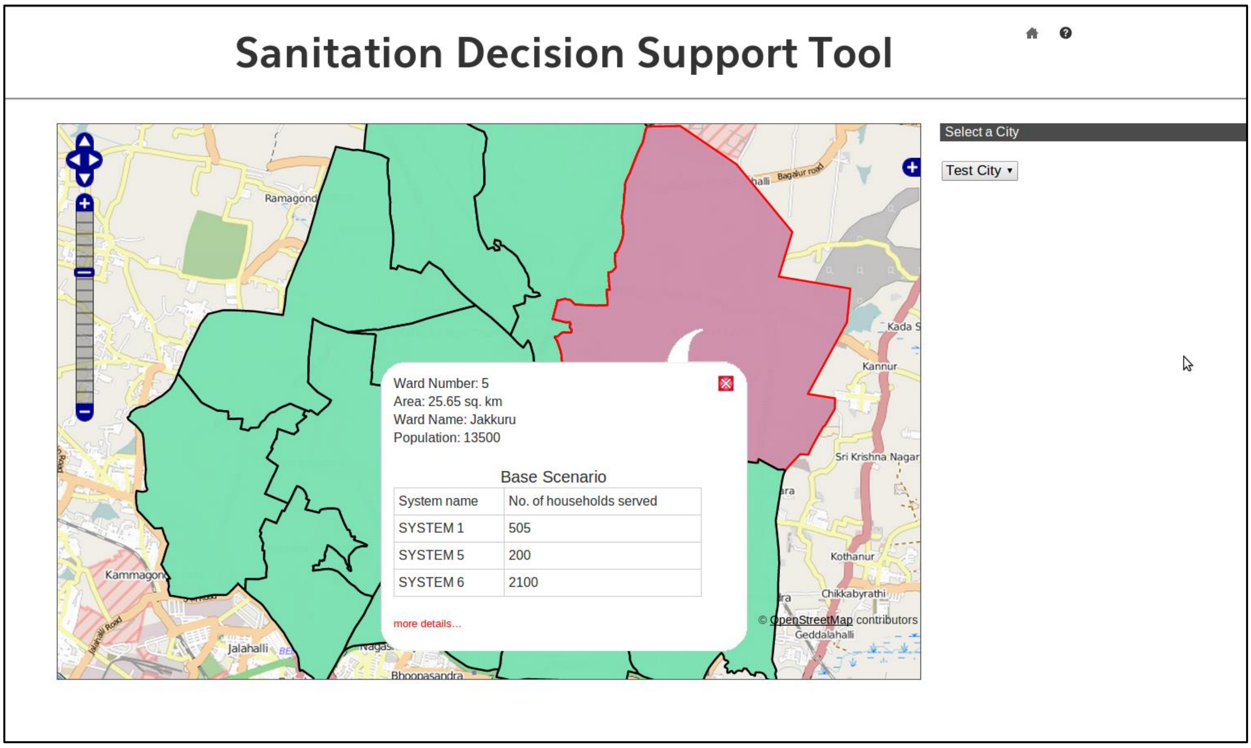

Figure 6: Mapping of Ward Parameters (Source: CSTEP Analysis, 2014)

Step 2: System context

As mentioned earlier, there is a need to think about the performance of systems, rather than approach sanitation solutions from 'a technology versus another' angle. A sanitation system, as considered in this tool, includes the total value chain, from user interface to reuse and recovery.

Defining the Systems

Once the context had been mapped, the relevant systems needed to be evaluated based on certain parameters. For this it was considered fundamental to first define a set of systems (both centralised and decentralised). Some examples of systems that may be in place in Indian cities are mentioned below in figure 7:

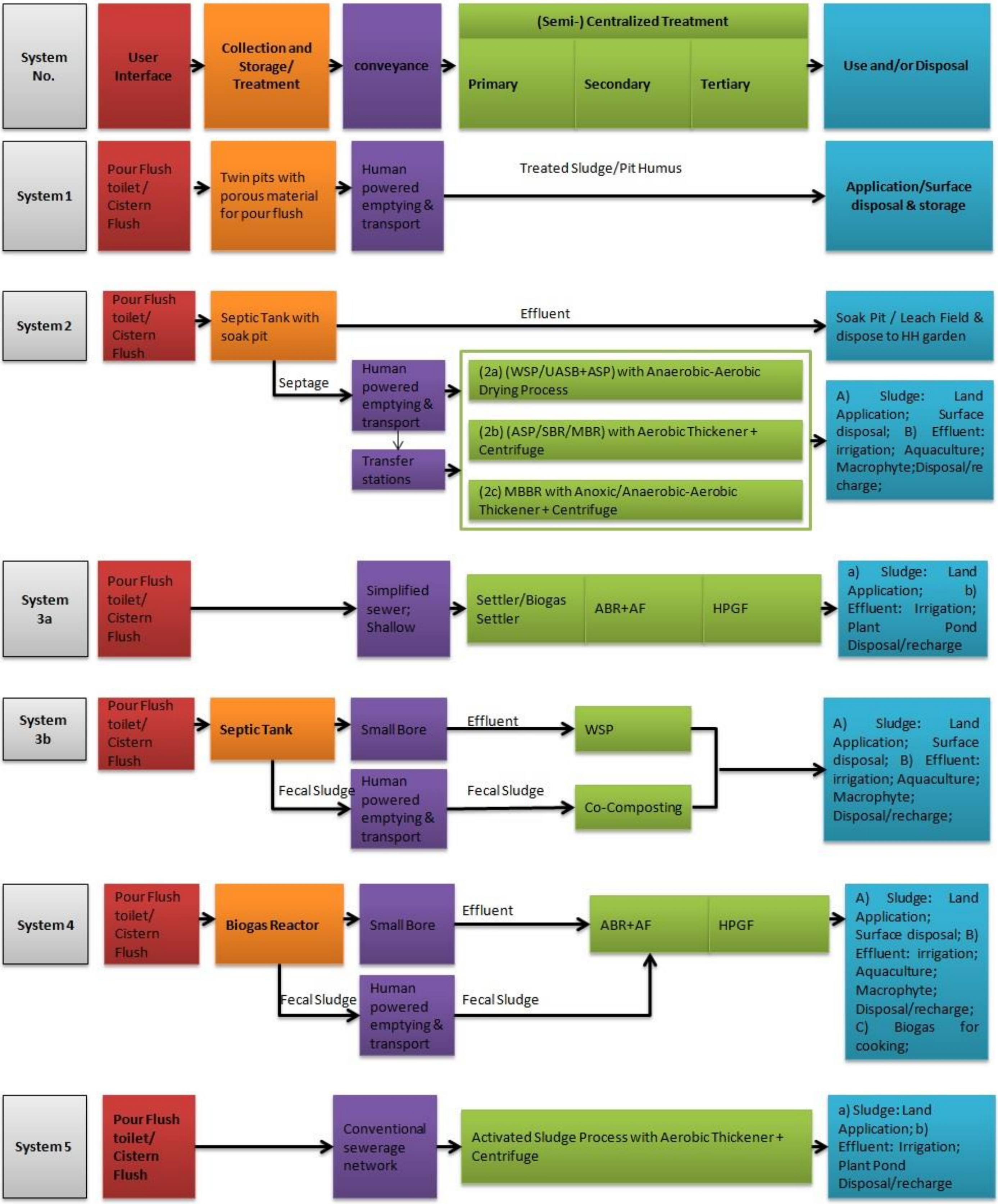

Figure 7: Sample of Sanitation Systems in Indian Cities

For chosen technologies detail description refer Annexure 3.

The systems that need to be compared and analysed for a ward and a city may be pre-defined by the planner/consultant, as part of the database.

System Parameters

After defining possible sanitation systems, the next step involved developing a set of parameters to enable an assessment of sanitation systems. Some of the system parameters that were identified for the PoC tool highlighted the performance of the system in question. Table 5 mentions the system parameters used in the PoC tool. These parameters provide the decision-maker/user with a comparison of the different systems as given in the table 5 below:

Table 5: Sample System Parameters – Per System Basis

System Parameters	Indicators	Unit of Assessment
Cost	Capital Cost (CAPEX)	Rs
	Operating Costs	Rs
	Cost recovery	High (0-2) – medium (3-4) – low (5-6)
System Specific	Energy required	kWh/day
	Land requirement	m^2
	Water requirement	KLD
	Extent of service	%
	Operating time	Days
	Groundwater	High – medium – low – all (qualitative
	Acceptability	0 – 10 (qualitative)
Health and environmental	ηBOD[4]	%
	System outlet:	mg/L
	per HH BOD	mg/L/HH
	ηCOD[5]	%
	ηTKN[6]	%
	ηTSS[7]	%
	ηE. Coli	%
	ηHookworm Eggs	%
	ηAscariasis	%
	Likelihood of contact	%

(Note: η denotes efficiency)

Once an understanding of the systems and the ward under consideration are provided to a user, the decision to implement particular systems will depend on the priority of the ward in question, and the constraints that a system might have in order for it to be implemented. For example, septic tanks may not be the best option for an area with a high groundwater table.

The PoC tool will have system constraints incorporated into the model so that they are evident to the decision-maker and only the relevant options for a particular ward may be chosen.

[4] Biological Oxygen Demand
[5] Chemical Oxygen Demand
[6] Total Kjeldahl Nitrogen
[7] Total Suspended Solids

Step 3: Ward/City Level Indicators

Based on ward constraints and priorities, systems that are in place may be improved. Further, the impact of the performance of these systems in the ward can be measured in terms of different indicators. Some examples of indicators are detailed in Table 4.

Table 6: Ward Indicators

Indicators	Sub-Indicators	Unit
Accessibility	Percentage Served	%
	Sewerage coverage	%
	Extent of service (EoS)	%
Cost	CAPEX	Rs/ward
	OPEX	Rs/ward
Environment	Land requirement	m^2/ward
	Daily water requirement	KLD/ward
	Energy requirement	kWh/day/ward
	Water quality	g/L
Health	Likelihood of contracting diarrhoea	%
	Likelihood of hookworm infestation	%
	Likelihood of contracting ascariasis	%

The above parameters enable decision-makers to make choices regarding systems based on the priorities identified. The indicators reflect not only the cost of the systems, but a holistic understanding of the performance of the sanitation systems in a ward and the city. The trade-offs of the systems will also be understood easily and enable decision-makers to make well-informed choices for the ward and the city.
A further explanation of some of the sub-indicators is provided below:

<u>% Served:</u>

It describes the fraction of the ward that has access to some form of sanitation facilities. Higher values of % Served imply that there is greater access to sanitation within the ward.
It is defined as:
$\%Served = (\sum HHx/HHTOT) \times 100\%$
Where HHx is households with system 'x' in place and HHTOT is the total number of households in a ward.

<u>% Networked:</u>

It describes the fraction of the ward being serviced by sewerage networks. It illustrates the extent to which centralised systems are in place. A ward with 40% networked systems indicates that a greater slice of the population is served by centralised sanitation systems than in a ward with say, 30% networked system.
It is defined as:

$$\%Networked = (HH6/HHTOT) \times 100\%$$

Where, HH6 represents households in a ward with system 6 in place.

<u>Extent of Service (EoS):</u>

The extent of service of any system indicates the completeness of a sanitation chain. For this purpose, a sanitation chain is broken into ten blocks with certain weightage assigned to each block. On the basis of how many such "blocks" are covered by a sanitation chain, the total extent of service is calculated as a percentage. Here, in order place greater emphasis on the importance of safety in contact and disposal, greater weightage was given to faecal sludge, along with secondary waste water treatment, which is generally regarded as a threshold for adequate treatment. The weights assigned to each system are given in table 7 below:

Table 7: System Analysis based on Weights Assigned

Block	SYS 0	SYS 1	SYS 2	SYS 3	SYS 4	SYS 5	SYS 6	WEIGHT
Storage								10
Transport								10
Pre-treatment								10
Primary WWT								10
Secondary WWT								10
Tertiary WWT								10
Faecal Sludge Curing								10
Effluent Reuse								10
Faecal Sludge Reuse								10
Safe Disposal								10
EXTENT (%)	0	20	50	80	90	100	70	

These values were then taken as weighted averages for a ward. The extent of service for a ward has been defined as:

$$\%\text{Extent of Service} = [\sum(HHx \times Ex)]/HHTOT$$

Where Ex is the Extent of service (in %) for a system

The significance of the extent of service indicator is to express, on an average, which ward has better overall sanitation facilities. This indicator highlights which wards to focus on. As an example, take wards 1, 2, 3 with % Extent of service as 35, 70 and 87 % respectively. Thus we can conclude that the majority of households in wards 2 and 3 have access to better and more complete sanitation chains than the households in ward 1. Thus, greater focus should be laid on ward 1 in terms of sanitation efforts. Moreover, say in ward 1, after certain changes in the constituent parameters the % Extent of Service changes to 65%, the increase is indicative of the fact that majority of the population now have access to more complete sanitation chains than in the base case.

Ward-wise representation of the indicators described in this section is shown in figure 8 below:

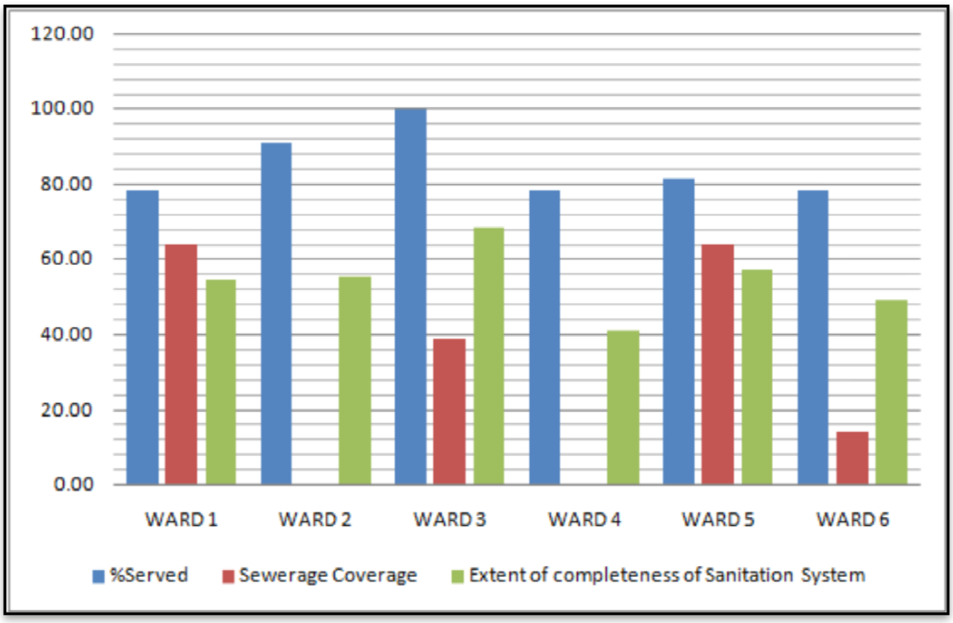

Figure 8: Ward-wise Representation of % Served, Sewerage Coverage and Extent of Sanitation System

As observed in figure 8, ward 3 has 100% sanitation coverage, which means that there are no unserved households in ward 3. The sewerage coverage varies from ward to ward, with ward 4 having no sewerage coverage, which illustrates the widespread use of decentralised options. The extent of service varies from ward to ward as well with ward 3 having the highest extent of service, implying that that a larger share of the population has is covered by sanitation facilities. In contrast, ward 4, where % Extent of Service is less than 40%, indicates that the major share of the population in this ward is serviced by a sanitation chain that covers less than half of the 'blocks'.

Indicators Derived from System Parameters:

Many indicators currently in use are derived from system parameters. For ease of calculation, the following parameters have been introduced:

Households served by unit system:

This parameter gives the number of households a unit system can serve. This value can be used to determine the number of units of a system that are in place in a ward. For example, when a septic tank system is installed, it can be shared by four households. Thus, each unit system services four households. This value is denoted by Nsx

Cost Indicators:

The cost indicators are used to calculate the total capital cost and the total O&M cost for a particular ward. Presently the cost calculated is based on the number of households and systems in use only. Other factors such as depreciation on existing systems, cost of replacement of a system, etc. have not been taken into account. For Opex, the Cost indicator, O, for a given ward is given by:

$O = \sum\{(HHx / Nsx) \times OX\}$

Where, OX is the O&M cost for a system 'x'

*Please note that the ceiling value for (HHx / Nsx) should be taken for further calculations.

The calculation for installing a new system (in areas where no systems are currently in place) can be calculated using a similar formula,i.e., installing a new system 'X' incurs the following cost:

$CX = \{(HHx / Nsx) \times CX\}$

Where, CX is the capital cost for a system 'x'

*Please note that the ceiling value for(HHx / Nsx) should be taken for further calculations.

When a system 'X' is replaced by system 'Y' two costs is incurred – the cost of building system Y (CY) and the cost of deconstructing system 'X' (DX). First the number of systems of both X and Y are calculated using:

$$PX = HH/NSX$$

$$PY = HH/NSY$$

Where HH is the number of households undergoing change in sanitation service,

And NSX and NSY are the number of households serviced by a unit system of X and Y respectively.

*Ceiling values are always taken for further calculation

The cost for replacing system X by Y is thus given by:

$$CY, X = (PXxDX + PYxCY)$$

Total Capex for both, system addition and replacement, is given by:

$$C = \sum CX + \sum CY, X$$

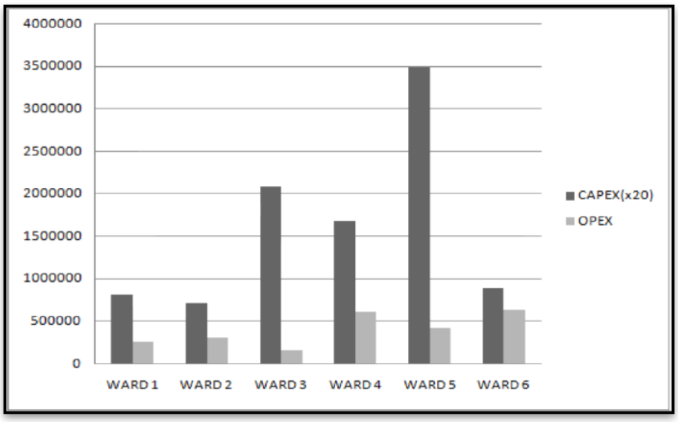

Figure 9: War-wise CAPEX, OPEX Representation

(For ease in comparison, the Capex value taken was 1/50th of the actual Capex.)

Environmental Indicators:

Land, Energy and Water use:

The land, water and energy use indicators are defined in a manner similar to the cost indicators. Land use is measured in terms of area (sq. metre or acres) while energy and water are recorded as daily consumption rates, in KWh/day and KLD respectively. Higher values indicate greater consumption, and hence less preferable options. Land use on the other hand takes into account a static value indicating initial land required.

For any resource R (Land/Energy/Water), the ward consumption is given by:

$R = \sum\{(RX/\ Nsx)\ x\ HHx\}$

Where Rx is the resource utilisation by system 'x'

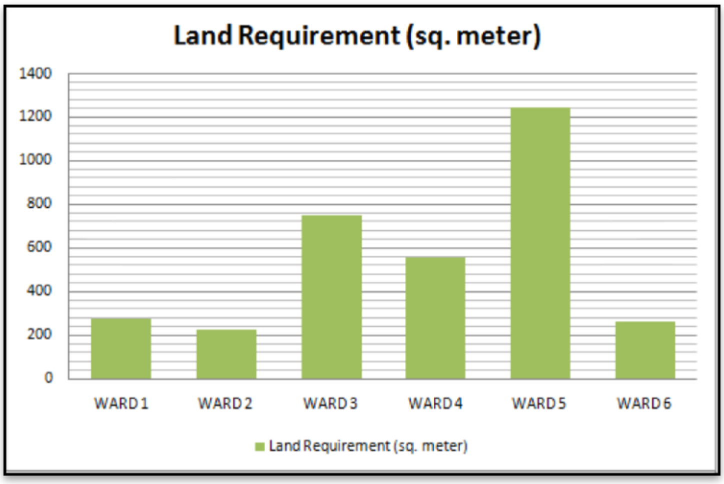

Figure 10: Ward-wise Land Requirement

Water quality (WQ):

This indicator is determined using a two-step calculation, which does the following operations:

→ Output Water Quality based on inflow water quality and efficiency of each system

→ Average effluent water quality in a ward

Water quality is currently measured in terms of Biochemical Oxygen Demand (BOD). The Output Quality, Ox for a system 'x' is given by

$$Ox = \{Ix - (Ix \times \eta x/100)\}$$

Where, Ix is the input water quality for system 'x',

And ηx is the BOD removal efficiency of system 'x' (in %)

Water quality for a ward is then calculated using an equation similar to the one for Extent of Service:

$WC= [\sum(HHx \times Ox)]/HHTOT$

Whilst comparing the Water Quality (WQ) value, a threshold value, as permitted by the governing body should be set in order to check whether the water meets the permissible standards. WQ values should not be greater than the threshold value to discharge.

Health and Social Indicators

The health and social indicators provide a commentary on the impact that any change in the sanitation conditions in a ward may have on the people of a particular ward or city.

Likelihood of contact (LC)

The likelihood of contact indicator is a ward-level weighted average based on a system parameter called %Contact. %Contact gives the number of blocks (out of 10) in a system that has direct human contact. Likelihood of contact, which lies between 0-1 is the ratio between the %Contact and the % EoS, thus giving the fraction of the blocks in a system that have human contact. It should be noted that %Contact will always be less than or equal to the %EoS

$$LC_x = \%Contact/\%EoS$$

Safety in contact							
	Absence of Direct Human Contact?						
Block	Sys 0	Sys 1	Sys 2	Sys 3	Sys 4	Sys 5	Sys 6
Storage	N/A	NO	YES	YES	YES	YES	YES
Transport	N/A	NO	YES	YES	YES	YES	YES
Pre Treatment	N/A	N/A	N/A	YES	YES	YES	YES
Primary WWT	N/A	N/A	YES	YES	YES	YES	YES
Secondary WWT	N/A	N/A	N/A	YES	YES	YES	YES
Tertiary WWT	N/A	N/A	N/A	N/A	YES	YES	N/A
FS Curing	N/A	N/A	N/A	YES	YES	YES	YES
Effluent reuse	N/A	N/A	N/A	NO	YES	YES	N/A
FS reuse	N/A	N/A	NO	N/A	N/A	YES	N/A
Disposal	NO	NO	NO	NO	NO	NO	NO
Extent of Service:	10	30	50	80	90	100	70
Contact %	10	30	20	20	10	10	10
Likelihood of contact	1	1	0.4	0.25	0.111111	0.1	0.142857

Figure 11: Safety in Contact Analysis

Similar to other system indicators, a weighted average for a ward can be taken to show the likelihood of contact (LC), in a ward:

$LC= [\sum(HHx \times LCx)]/HHTOT$

Where, LCX is the likelihood of contact for a system 'x'

The values for LC will be between 0 and 1.

Illustration of the Concept (Preliminary Version of the Tool)

Consider city "A" with 11 wards (wards being the spatial unit in this case). The city has a total population size (in terms of households) of 72000, with about 29% of its population unserved by any sanitation system. At a ward level, the geographic conditions are taken into consideration. Most wards are serviced by either pit latrines (S1), especially in the slum areas, networked systems (S6), most of which service non-slum regions, or DEWATS systems with faecal sludge reuse (S5), which serve both slum and non-slum areas. The following table represents the data collected from City "A":

Table 8: Ward-wise Existing Systems

WARD	*SLUM*				*NON SLUM*				TOTAL
	OD	**S1**	**S5**	**S6**	**OD**	**S1**	**S5**	**S6**	
Ward 1	1355	1345	0	0	0	0	1653	2345	6698
Ward 2	1267	578	0	763	134	58	764	3023	6587
Ward 3	997	698	1024	0	0	103	1456	2997	7275
Ward 4	1563	1678	0	0	234	0	0	1923	5398
Ward 5	2355	1005	0	0	0	88	677	3450	7575
Ward 6	1982	335	456	0	137	0	1302	1999	6211
Ward 7	1435	1179	0	698	289	0	0	1877	5478
Ward 8	687	346	1532	0	0	0	2033	1455	6053
Ward 9	3023	235	345	0	0	0	1554	1675	6832
Ward 10	3117	567	0	0	145	155	0	3345	7329
Ward 11	2189	433	330	0	199	176	1204	2033	6564
							CITY TOTAL		72000

The data above and other ward details are represented in Screen 1, which is shown in Figure 12.

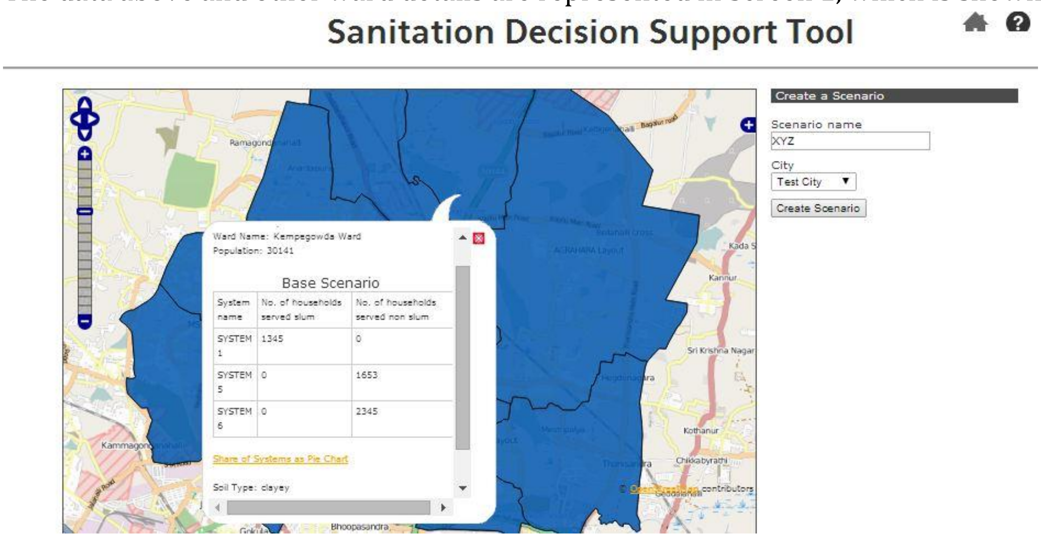

Figure 12: Screen 1

Ward-wise interventions allowed by the tool:

A user can commit a series of actions called interventions that may vary based on target population (slum/non-slum), action type (creation/modification) and systems (base case and improved case). Any set of interventions made in a ward or a series of wards is considered to constitute a scenario. Within the same scenario, multiple interventions can be carried out on multiple wards. The interventions may be of two forms:

- → System creation: System creation can be used to serve open defecation dependant population by "creating" systems in areas where no facilities are available. It cannot be used for households currently being served by some form of sanitation facility.
- → System modification: This option allows users to modify present sanitation systems to a selected number of improved or alternative systems. It should be kept in mind that only

certain modifications are allowed, i.e., systems including sewerage, like system 6 cannot be modified into systems 1 or 2.

Example Situation:

Assume a planner wants to make changes in at least one ward such that:

- The Open Defecation (OD) dependant population in slum area is reduced by 80% and in non-slum areas is eliminated.
- The share of the population dependant on pit latrines is reduced.

He formulates a set of five scenarios for this objective. He decides to first target ward 1 in which the entirety of the slum population either has access to system 1 or no system at all. He introduces scenarios 1 and 2, which are focused on slum populations of ward 1. For scenarios 3 and 4, he targets both slum and non-slum sections of ward 2 population. Finally, for scenario 5, instead of focusing all the amelioration efforts on one ward, he introduces changes in both wards 1 and 2. The 5 scenarios described above are given in the table below:

Table 9: Sample Scenarios

SCENARIO 1				
WARD	SECTION	BASE CASE	IMPROVED	DESCRIPTION
1	SLUM	50.2% OD	10% OD	80% decrease of OD in slum areas, 50% decrease of System 1 in Slum areas. Systems 2 and 3 were introduced in place of system 1 and for the unserved population.
			20.2% SYS 2	
			20% SYS 3	
	SLUM	49.8% SYS 1	25% SYS 1	
			24.8% SYS 3	
SCENARIO 2				
WARD	SECTION	BASE CASE	IMPROVED	DESCRIPTION
1	SLUM	50.2% OD	10% OD	Similar to Scenario 1, with interventions focusing on inclusion of systems 4 and 5 as opposed to systems 2 and 3.
			40.2% SYS 4	
	SLUM	49.8% SYS 1	25% SYS 1	
			24.8% SYS 5	
SCENARIO 3				
WARD	SECTION	BASE CASE	IMPROVED	DESCRIPTION
2	SLUM	48.6% OD	9.7% OD	Scenario 3 is targeted at ward 2 unlike the previous scenarios. 80% OD decrease in slum and 100% decrease in non-Slum areas along with significant decrease in ystem 1 are planned. Systems 2 and 3 are used to replace OD and system 1.
			18.5% SYS 2	
			20.4% SYS 3	
	NON SLUM	3.4% OD	0% OD	
			3.4% SYS 2	
	SLUM	22.2% SYS 1	8.2% SYS 1	
			14% SYS 2	
	NON SLUM	1.5% SYS 1	0% SYS 1	
			1.5% SYS 2	
SCENARIO 4				
WARD	SECTION	BASE CASE	IMPROVED	DESCRIPTION
2	SLUM	48.6% OD	9.7% OD	Similar to scenario 3, with interventions focusing on inclusion of systems 4 and 5 as opposed to systems 2 and 3.
			38.9% SYS 4	
	NON SLUM	3.4% OD	0% OD	
			3.4% SYS 5	
	SLUM	22.2% SYS 1	7.2% SYS 1	
			14% SYS 4	

	NON SLUM	1.5% SYS 1	0% SYS 1	
			1.5% SYS 5	
SCENARIO 5				
WARD	SECTION	BASE CASE	IMPROVED	DESCRIPTION
1	SLUM	50.2% OD	20% OD	Scenario 5 targets both wards 1 and 2 with 60% OD serving in slum areas of ward 1, 40% in slum areas of ward 2, and 100% serving in non-slum areas. In slum areas, 40% of system 1 of ward 1 and 45% of system 1 of ward 2 are improved to systems 2 and 3.
			30.2% SYS 3	
	SLUM	49.8% SYS 1	30% SYS 1	
			19.8% SYS 3	
2	SLUM	48.6% OD	20% OD	
			28.6% SYS 2	
	NON SLUM	3.4% OD	0% OD	
			3.4% SYS 2	
	SLUM	22.2% SYS 1	12.2% SYS 1	
			10% SYS 2	
	NON SLUM	1.5% SYS 1	1.5% SYS 1	

Every scenario defines a series of interventions made in a ward or wards. Scenario 2, for example, defines two interventions. The following screenshots (figure 13) show the visual representation of scenario 2.

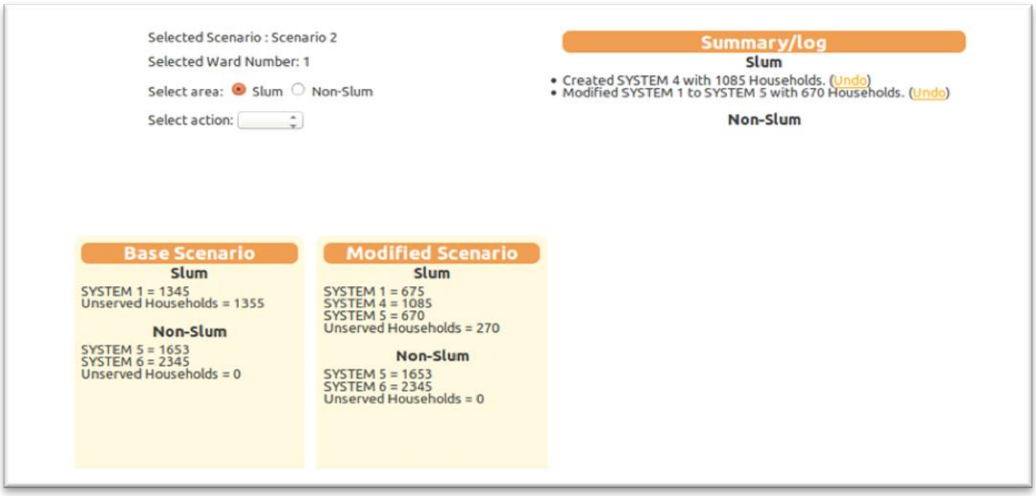

Figure 13: Screen 2 Functionalities

Impact of the interventions:

The impact of the above interventions is seen through the ward level indicators as well as the city level indicators. As every intervention is made, the changes in the indicators by ward is calculated and reflected in screen 3, and the city indicators are shown in screen 4 (figure 14):

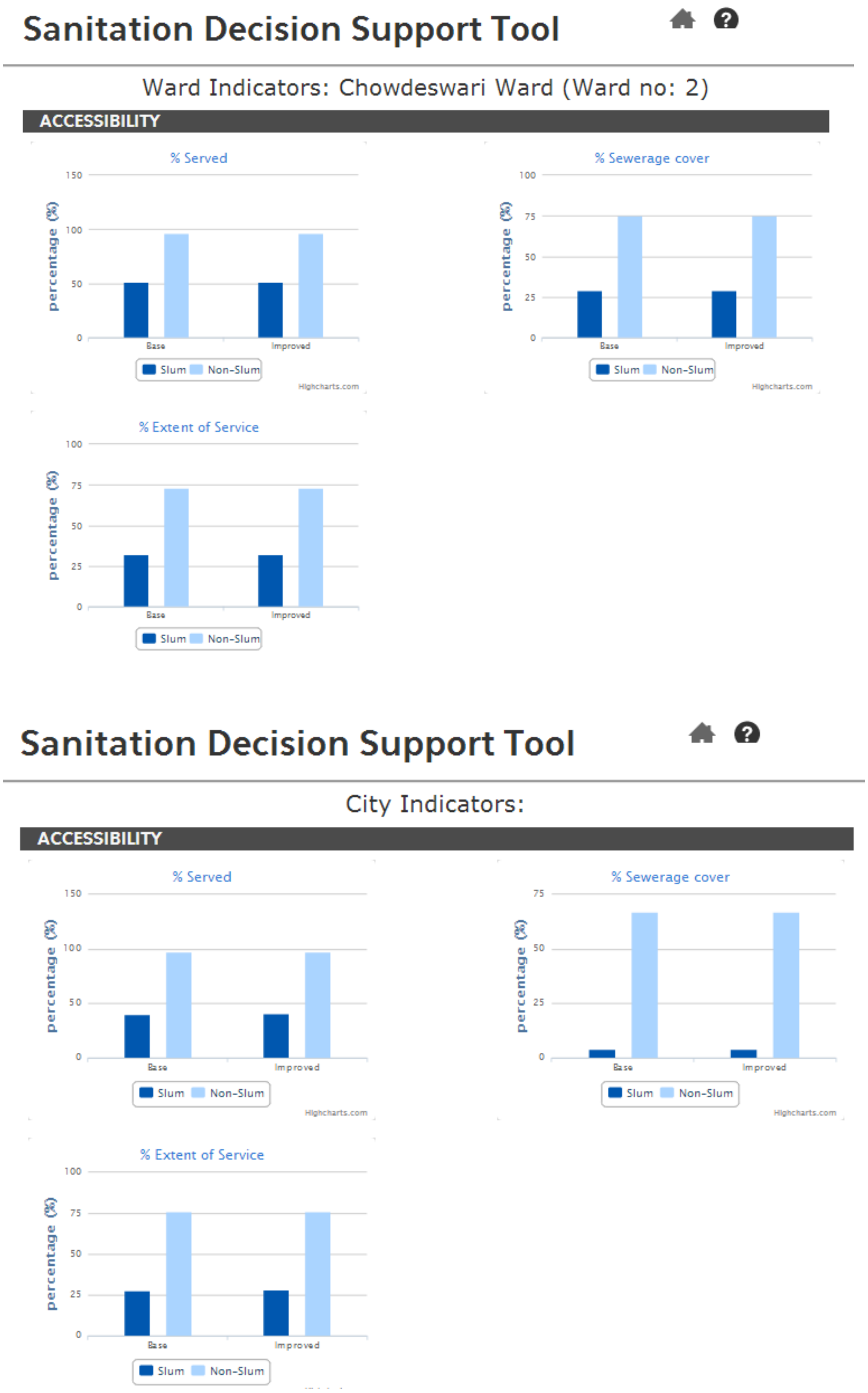

Figure 14: Ward Indicators and City Indicators

Comparing scenarios

Once the planner carries out these scenarios, they can be saved and compared. Depending upon which indicators the planner decides to consider as priority, the intervention can be selected. Up to five scenarios can be compared at a time. The comparison is based on the difference between the base case and improved scenario, i.e., the "delta" value. Scenarios can be compared against one another irrespective of:

- How many interventions (actions) were carried out in individual wards or on the whole
- Which ward(s) the scenarios target
- How many wards the scenarios target
- What systems are involved

Thus any five scenarios can be compared irrespective of how similar or dissimilar they are to each other. The five scenarios in the working example are compared as shown below in Figure 15:

Select Area: Non Slum

Select Scenarios: Scenario 2 Scenario 3 Scenario 4 Scenario 5

Change over the base scenario(Δ)

Indicators	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
% Served	0	0	0	0	0
% Sewerage cover	0	0	0	0	0
% Extent of Service	0	0	0.28	0.69	0.23
CAPEX (in million Rs)	0	0	17.93	83.21	14.74
OPEX (in 10,000 Rs/Year)	0	0	25.9	1.9	20.1
Land Required (sq. m.)	0	0	25.9	157.04	20.1
Daily Energy Required (KWD)	0	0	0	1280.64	0
Daily Water Required (KLD)	0	0	0	192	0
Water Contamination (g/L)	0	0	-1.11	-1.17	-0.77
Likelihood of Contact (with FS)	0	0	0	-0.01	0

Select Area: Slum

Select Scenarios: Scenario 2 Scenario 3 Scenario 4 Scenario 5

Change over the base scenario(Δ)

Indicators	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
% Served	3	3	3	3	5
% Sewerage cover	1	0	2	0	3
% Extent of Service	2.78	3.99	1.9	1.26	3.54
CAPEX (in million Rs)	119.9	563.03	115.66	136.07	174.86
OPEX (in 10,000 Rs/Year)	56.72	3.11	112.52	39.13	120.59
Land Required (sq. m.)	290.25	1067.11	215.2	214.95	380.95
Daily Energy Required (KWD)	242	6280.85	106.4	609.55	269.8
Daily Water Required (KLD)	1210	1755	532	365	1349
Water Contamination (g/L)	-7.31	-7.43	-5.65	-1.55	-9.74
Likelihood of Contact (with FS)	-0.04	-0.05	-0.03	-0.01	-0.05

Figure 15: Change in Indicators over the Base Scenario and Scenario Comparison

As seen in the above example, the best and worst performers for every indicator are highlighted. Thus, if the capital cost is a major constraint, the planner may avoid scenario 2 and prefer scenarios 3 or 1. On the other hand, if land availability is a constraint, he may prefer scenarios 4 or 3. (Please note that the numbers used for highlighting the tool's functionality are dummy values and may not be accurate)

Other Factors

Apart from the indicators listed above, there are many socio-economic indicators that may be important to the decision-making process. **Acceptability**, for example, will determine how the end-users feel about the sanitation systems in place. System 1, for example, may register lower acceptability ratings and thus the decision-maker should consider replacing system 1 with better systems (an action also supported by the high values of contamination) along with serving the OD dependant population. The **Time Taken for Operation** is useful in measuring the time lapse between the start of installation and the start of usage. Highly centralised options would generally take more time to be put in place, causing discomfort to the target population in the meantime. **Willingness to Pay (WOP)** will express how invested the users are in the installation and maintenance of the new/improved systems. Lower values of WOP usually reflect user apathy and/or dissatisfaction and such wards should organise awareness programmes to encourage people to take more interest in their sanitation systems.

Way Forward: Integrated Decision-making Support Tool

An ideal decision-making support tool for integrated sanitation investment planning would allow a user to compare and analyse potential investments in different types of sanitation technologies from financial, social, resource, and logistics perspectives. It would be a GIS enabled, user-interactive interface, to explore sanitation systems for a city. The interface would permit the decision-maker to vary certain parameters and examine their impact on the performance of a sanitation system. The tool would help analyse the impact of investment for different sanitation scenarios of networked and non-networked technologies. For example, an indicator to measure equity can be investment and time needed by a poor household for a networked connection compared with a non-networked solution. This indicator can be extrapolated to arrive at a rate of coverage of sanitation by a combination of networked and non-networked solutions.

Conceptual Framework

The tool allows a user to:

1. Enter various inputs and examine their impact on the performance of sanitation systems
2. Assess the impact of various technology options in sanitation
3. Open channels of collaboration and consultation with partners, stakeholders and decision-makers within this sector
4. Compare the cost/benefits of various technology options for sanitation

The broad structure of the PoC tool is shown in Figure 16: At the core of the system is the Model and Knowledge Bank, which contains data on available strategies for sanitation – thus capturing the economics, social and technical constraints, and other specific sanitation related issues. The system relies on other components such as GIS, domain-specific models (urban development, resource constraints, etc.), data repository, visualisation components, etc. Empirical data gathered over time can be made available for various computations.

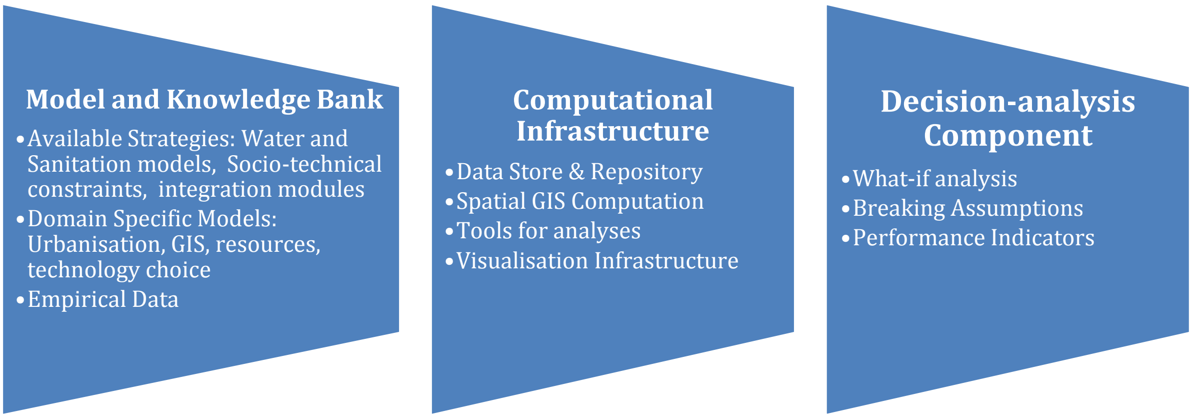

Figure 16: PoC Tool Components

Modelling of the various sanitation pathways involves the elements shown in Figure 16. The model includes:

- A repository of information on sanitation options where:

- Information about each technology is captured within the model and used for analysis
    - Technology aspect is a critical element in the model, especially from the perspective of "non-networked" solutions
- Dynamic environmental factors, socio-economic realities, urbanisation patterns, growth rate of the population, etc. of a region where:
    - Decision-maker is able to examine alternatives by specifying resource constraints (budget, land, water, etc.)
    - Traditional sanitation planning is bound and technological alternatives can be compared based on specified evaluation criteria
- Flexibility of defining the evaluation criteria, which allows various stakeholders to assess sanitation pathways from their own perspectives. Based on the inputs, the model computes the resource requirements (initial and life-time) and the deployment scenarios for several plausible sanitation pathways, which can be fed directly into a strategic plan
- Data on project implementation and performance assessment, which is can be given as input to this framework for analysis, visualisation, and 'self-learning', i.e., modification can be made to certain inputs based on new information

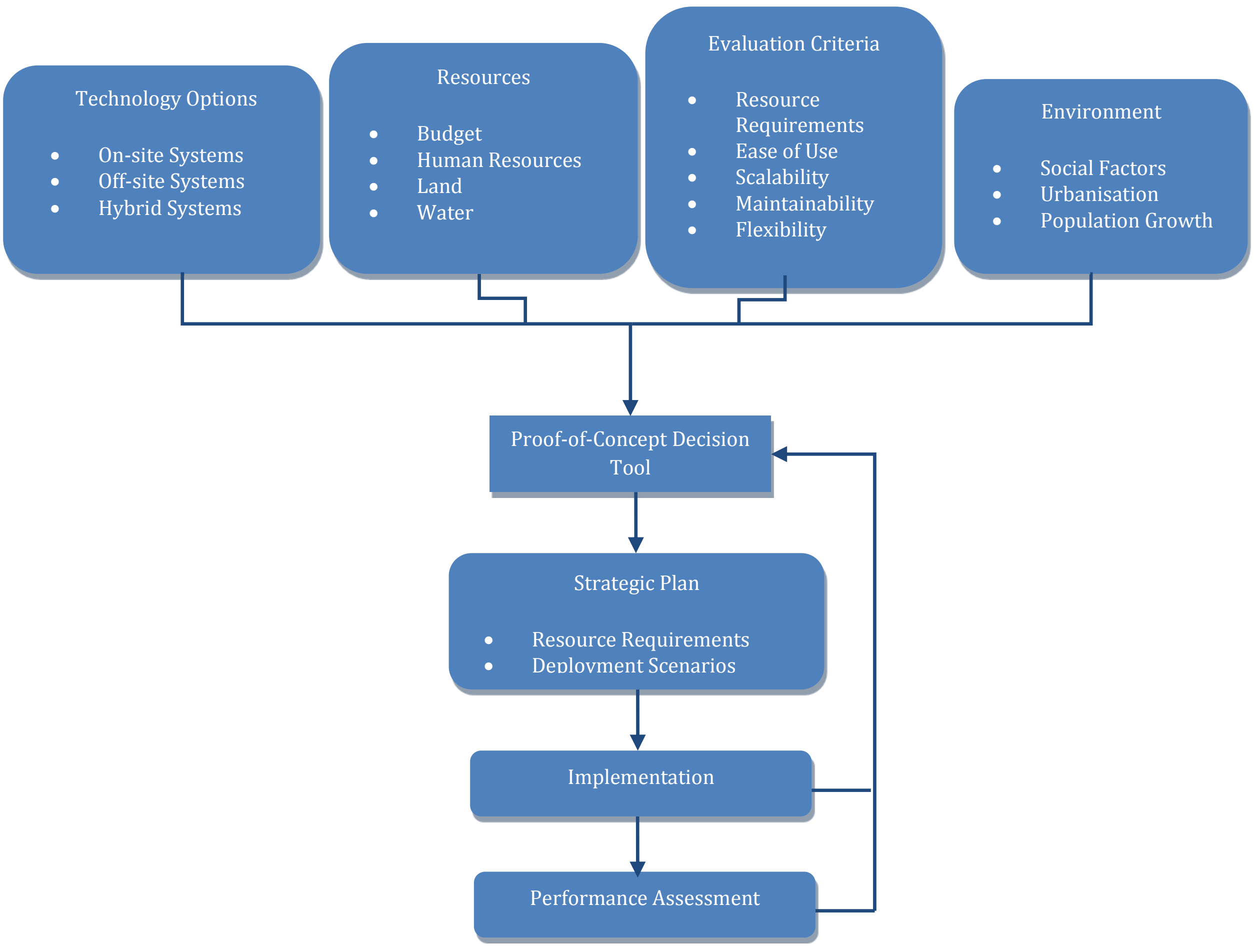

Figure 17 : Modelling Sanitation Pathways

The tool has been developed as a web-based system and designed in a way that module executions can be done and accessed from remote locations via a web browser. The decision-analysis component is the visualisation interface, via which stakeholders may examine alternative strategies for sanitation. "What-if" analysis, analysis by changing assumptions and their implications on the performance indicators are a part of this decision analysis component. This computational tool leverages the power of computation and visualisation to understand complex policy problems with spatial and temporal dimensions. The conceptual computational framework and software overview are described below.

The computational platform is the underlying engine enabling the capabilities of various sanitation decision-making modules. This platform provides the possibility to compose multi-level social and technical models to create appropriate policy trajectories.

The decision process involves framing the sanitation problem with select scenarios by comparing various sanitation systems, populating the variables with inputs from potential stakeholders and visualising changes when these variables are altered.

Software Framework

The software framework, (Figure 18) integrates models, data and visualisation tools. The models are pluggable into the system and can be easily integrated with minimum effort. The inputs from the screens are fed into the various models, which give outputs. These outputs/results can be fed into other models or saved into the database for querying and retrieving purposes. Based on the results or indicators, the decision-maker might like to tweak certain parameters to optimise the results. Various models within the framework can be associated with sanitation technologies, demographics, topology, finance, resource recovery/reuse, etc. All the inputs and outputs of the various models are coordinated by the Ruby on Rails web application, including GIS related queries and results.

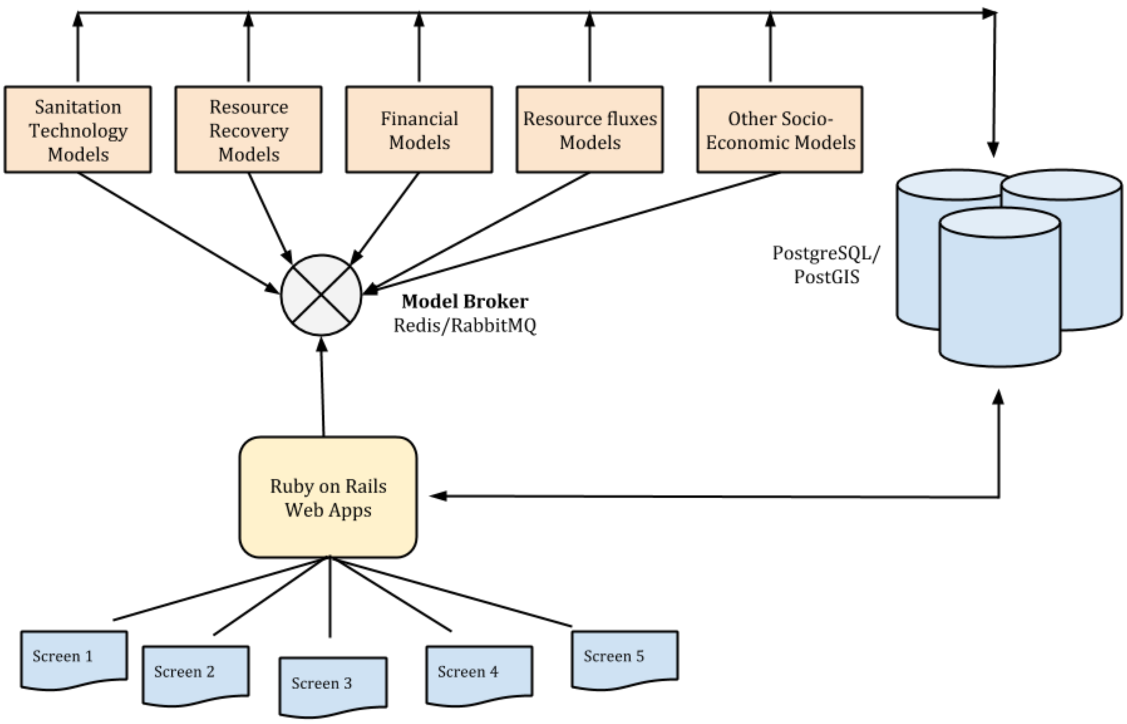

Figure 18 : Software Framework

The Ruby on Rails web application is based on Model-View-Controller (MVC) architecture (Figure 18). MVC is an object-oriented design pattern which attempts to divide an application into three components, namely Model, View and Controller.

Provided below is a short description of the different components:

Model: A model contains the application's business logic and represents the information (data) of the application and the rules to manipulate the data.

View: The user interface is represented by the view. In a web-based application, the view is implemented as a template which renders an HTML page.

Controller: The communication between the model and the view occurs via the controller. The incoming requests by the web browser are associated with controller actions which interact with the model for data and pass them on to the view for presentation.

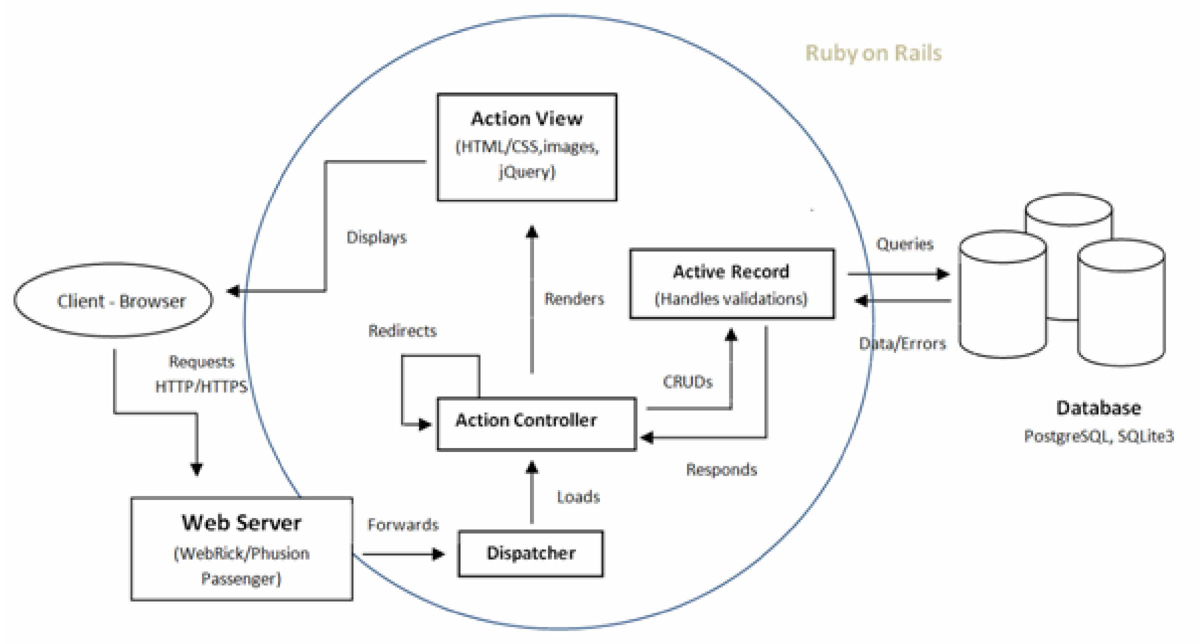

Figure 19 : Ruby on Rails – MVC Architecture

Other technologies that can possibly be used are Open Layers (GIS interface), JavaScript/jQuery (front-end design, AJAX support), PostgreSQL/Post GIS (spatial support), RabbitMQ (message broker), REDIS (key-value store with PUB/SUB mechanism), Scilab/Mat lab (Mathematical modelling), Web Sockets with HTML5, R (statistical analysis), etc.

Hardware Overview

The hardware platform that supports this tool should be sufficient for the computation and execution of the various models comprised in the tool within reasonable time. This implies that a high powered (super) computing system, juxtaposed with a cluster computing platform, which can execute distributable tasks is required. The system should provide suitable interfaces and scripting mechanisms to permit programming of routine decisions, standard operating procedures and generate responses based on programmed response logic, and past cases. This is aimed towards balancing human and machine capabilities, and to increase system response efficiency. Figure 19 depicts the overall system architecture proposed for the integrated sanitation investment planning system.

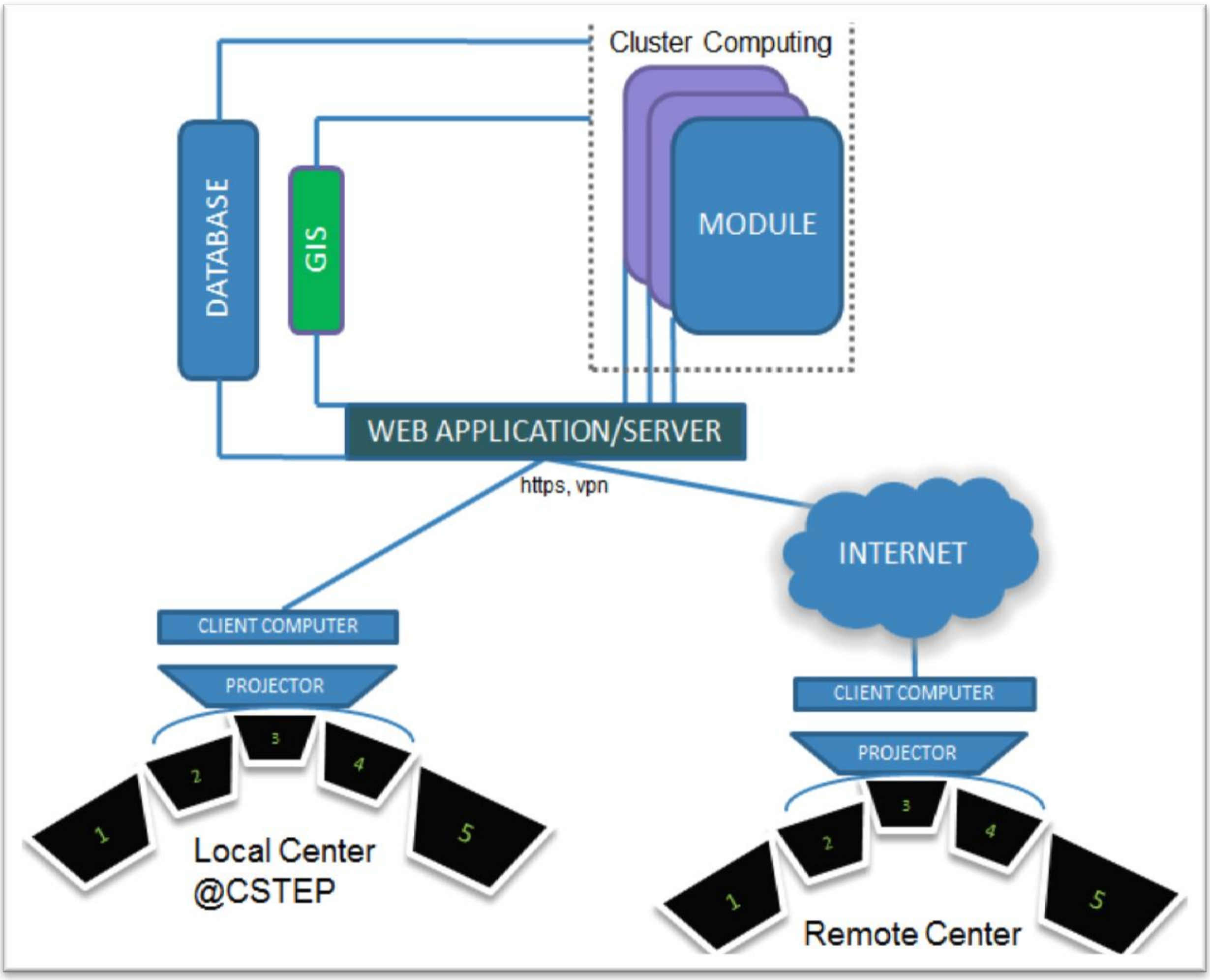

Figure 20 : System Architecture

It is to be understood that for the tool to be effective and relevant, it will need to be regularly updated. While the content, form, and usability of the tool is important, a comprehensive and on-going dissemination and support strategy that includes access through libraries, the Internet, regional workshops, and on-call technical support teams is equally critical. The design of the tool should be cognizant of the capacity constraints of the ULBs and the diverse approaches of various stakeholders.

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Annexure1: Summary of Resources

Benchmarking tools

Type of Resources	Locale	Topics covered/ aspects	Purpose	Region specificity	For whom	Case study
Handbook of SLB: **http://www.urbanindia.nic.in/programme/uwss/slb/handbook.pdf**	ULB/parastatal level - URBAN	Performance monitoring	Enable systematic and sustained monitoring of services using standardised indicators	Prepared for India	Mostly for Planners and decision-makers	WSP collected data for 13 utilities in 23 cities and towns in 2 phases. Data collection enabled cities to undertake an honest self appraisal of their performance from a service point of view. By carrying out a performance gap analysis using the data collected, proposals have been submitted to the MoUD for information systems improvement. (http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2011/03/10/000356161_20110310031719/Rendered/INDEX/600560WSP1naga10BOX358307B01PUBLIC1.txt)
International Benchmarking Network for Water and Sanitation Utilities (IBNET). Indicators **http://www.ib-net.org/en/texts.php?folder_id=96&mat_id=78&L=1&S=1&ss**	WATSAN utilities – not specified whether urban or rural	Performance monitoring	Financial, technical and process indicators capturing the institutional context in which the utilities are operating for the assessment of utility performance in	Support access to comparative information that will help to promote best practice among water supply and sanitation providers worldwide and eventually will provide consumers with	WATSAN utilities	Use of IBNET performance indicators in Bangladesh India and Pakistan – Phase I http://www.wsp.org/sites/wsp.org/files/publications/WSP_benchmarking.pdf phase II: http://www.wsp.org/sites/wsp.org/files/publications/Benchmarking_Report.pdf

Type of Resources	Locale	Topics covered/ aspects	Purpose	Region specificity	For whom	Case study
=6			the provision of water and sewerage services.	access to high quality, and affordable water supply and sanitation services. Phase I (2003-2004)- creating awareness of benchmarking, developing methodology and collecting and analyzing data or an initial sample of WSS utilities in India Phase II – build upon the key learnings from Phase I, work with a selected set of WSS utilities to collect fresh data and scale up the exercise to promote the concept amongst a		

Type of Resources	Locale	Topics covered/ aspects	Purpose	Region specificity	For whom	Case study
				larger number of WSS utilities across India through targeted dissemination and advocacy.		
Performance Assessment system (PAS) **http://www.pas.org.in/Portal/document/PerformanceAssessmentDoc/pdf/List%20and%20Definition%20of%20LAIs_Jan%2018%202011.pdf**	Urban	Performance monitoring	Water and sanitation performance at the local level	Performance indicators and benchmarks which facilitate reporting, monitoring, planning, budgeting and investing in water and sanitation services.	Decision-makers, planners..	Gujarat and Maharashtra: http://www.pas.org.in/web/ceptpas/performance?p_p_id=SLBPerformanceAssessment_WAR_Portal&p_p_lifecycle=1&p_p_state=normal&p_p_mode=view&p_p_col_id=column-1&p_p_col_count=2&actionVal=GetScreen&tabId=4

Guidelines/manuals

Type of Resources	Locale	Topics covered/aspects	Purpose	Region specificity	For whom	Case study
Compendium of sanitation system technologies	Rural and Urban	Sanitation systems technologies, low cost	Overview of different sanitation systems and technologies and describes a wide range of available low-cost sanitation technologies with advantages and disadvantages.	India, developing countries	Designers/Engineers	Site: http://www.sswm.info/sites/default/files/reference_attachments/TILLEY%202008%20Compendium%20of%20Sanitation%20Systems%20and%20Technologies_0.pdf
How to manage toilets and showers	Rural and Urban	Toilet maintenance	Provides practical advice and recommendations for managing toilet blocks situated in public places.	India, developing countries	Decision-makers, project planners and managers	Site: http://www.sswm.info/sites/default/files/reference_attachments/TOUBKISS%202010%20How%20to%20Manage%20Public%20Toilets%20and%20Showers-ENGLISH.pdf

Type of Resources	Locale	Topics covered/aspects	Purpose	Region specificity	For whom	Case study
Handbook on Community Led Total Sanitation (CLTS)	Rural and Urban	Implementation of CLTS	Guidelines on implementation of CLTS – plan, implement and follow-up for CLTS	India, developing countries	Particularly for field staff, trainers, facilitators	Approach described in: http://www.susana.org/docs_ccbk/susana_download/2-1814-clts-hand-bookenglish.pdf Case study where this primarily rural approach has been applied in an urban setting: http://www.communityledtotalsanitation.org/blog/urban-clts-establishing-roots-nairobi-county http://www.communityledtotalsanitation.org/sites/communityledtotalsanitation.org/files/cltshandbook.pdf

Type of Resources	Locale	Topics covered/aspects	Purpose	Region specificity	For whom	Case study
Construction of ecological sanitation latrine	Rural/peri urban-urban areas	Construction and operational manual	Sets out principles for adopting an ecological sanitation approach and provides guidance on constructing and operating ECOSAN latrines	Nepal, developing countries	Practitioners interested in promoting ECOSAN	Site: http://www.sswm.info/sites/default/files/reference_attachments/WATER%20AID%202011%20Construction%20of%20Ecological%20Sanitation%20Latrine.pdf
How to select appropriate technical solutions for sanitation.	Urban	Technology choice	Identification of best suited sanitation technologies that are suited to the different contexts existing within a town.	Developing countries	Local contracting authorities, planners	Site: http://www.sswm.info/sites/default/files/reference_attachments/MONVOIS%20et%20al%202010%20How%20to%20Select%20Appropriate%20Technical%20Solutions%20for%20Sanitation-ENGLISH_0.pdf
Sanitation systems and technologies	Urban	Technology choices	Comparison of different technological approaches of sanitation management	Developing countries	practitioners	Site: http://www.sswm.info/sites/default/files/reference_attachments/EAWAG_SANDEC%20Sanitation%20Systems%20&%20Technologies_0.pdf

Type of Resources	Locale	Topics covered/aspects	Purpose	Region specificity	For whom	Case study
A guide to development of on-site sanitation	Rural/Urban	Technology choices	Presents appropriate technologies for sanitation highlighting socio-economic aspects of planning and implementing.	Developing countries	Designer, planner	Site: http://www.sswm.info/sites/default/files/reference_attachments/WHO%201992%20A%20Guide%20to%20the%20development%20of%20on-site%20sanitation.pdf
National Urban Sanitation Policy	Urban	State sanitation strategies and city sanitation plans	Provides guidelines on areas which should be emphasised in state sanitation strategies and city sanitation plans	India	Policy makers, planners	Site: http://www.susana.org/docs_ccbk/susana_download/2-1584-giz-nusp-fact-sheet-1.pdf

Type of Resources	Locale	Topics covered/aspects	Purpose	Region specificity	For whom	Case study
Applying life cost costs approach to sanitation	Rural/Peri-urban	Financing	Explains an application of the life-cycle costs approach (LCCA) to sanitation in rural and peri-urban areas in four different countries India, Burkina Faso, Ghana and Mozambique	Developing countries	Designers	Site and case studies: http://www.sswm.info/sites/default/files/reference_attachments/Briefing%20Note%203%20-%20Applying_life-cycle_costs_approach_sanitation.pdf
Manual on design, construction and maintenance of low cost pour flush water seal latrines in India	Rural/Urban	Construction and operational manual	Salient features of design, construction, maintenance and admin of low-cost pour flush water seal latrines with off-set twin pits	Developing countries	Designers, contractors	Site: http://www.susana.org/docs_ccbk/susana_download/2-1411-manual-on-the-design-construction-and-maintenance-of-low-cost-pour-flush-waterseal-latrines-in-india.pdf

Type of Resources	Locale	Topics covered/aspects	Purpose	Region specificity	For whom	Case study
Composting toilets – the future of sanitation?	Rural/Urban	Process of ECOSAN	Describes the principle of ECOSAN and dry composting toilets applied to household.	Developing countries	Designers	Site: http://www.sswm.info/sites/default/files/reference_attachments/VISHWANATH%20and%20VISHWANATH%20ny%20Composting%20Toilets%20%E2%80%93%20The%20Future%20of%20Sanitation.pdf Case studies in Kenya and India http://www.susana.org/docs_ccbk/susana_download/2-898-en-ecosan-school-sanitation-kenya-india-2009.pdf http://www.susana.org/docs_ccbk/susana_download/2-252-waffler-et-al-2006-indian-case-studies-en.pdf
Operation and maintenance of DTS at Adarsh college Kukgaon Badlapur	Rural/Urban	Operation of ECOSAN	ECOSAN activities needed to be performed, frequency needed to carry them out.	India	Planners	Site: http://www.susana.org/docs_ccbk/susana_download/2-1263-l-barreto-adarsh-college-badlapur-om-manual-dtspdf-anlage.pdf
Sustainable sanitation in India	Rural/Urban	Case studies	Provides case studies on sustainable sanitation	India	Planners	Site: http://www.susana.org/docs_ccbk/susana_download/2-1136-en-ecosan-india-20081.pdf

Type of Resources	Locale	Topics covered/aspects	Purpose	Region specificity	For whom	Case study
Ecological sanitation	Urban/Rural	ECOSAN technology choices	Documents different options of ECOSAN based on dehydrating and composting toilets in use around the world	Global	Planners	Site: http://www.sswm.info/sites/default/files/reference_attachments/ESREY%20et%20al%201998%20Ecological%20Sanitation.pdf
Waterless Urinals for sustainable resource and environmental management	Urban/Rural	Waterless urinals technology choices	Showcases design of waterless urinals	Global	Designer	Site: http://www.susana.org/docs_ccbk/susana_download/2-737-iitwaterlessurinalmanuscript.pdf
Decentralized wastewater treatment methods for developing companies	Rural/Urban	DEWATS technology	Presents operation and maintenance options with respect to sustainable plant operation, use of local resources, knowledge and manpower.	Developing countries	Planners	Site: http://www.sswm.info/sites/default/files/reference_attachments/NATURGERECHTE%20TBW%202001%20Decentralised%20wastewater%20treatment%20methods%20for%20developing%20countries.pdf

Type of Resources	Locale	Topics covered/aspects	Purpose	Region specificity	For whom	Case study
Technology options for urban sanitation in India	Urban	Technology choices	Available technologies on sanitation	India	State government and ULB	Site: http://www.sswm.info/sites/default/files/reference_attachments/WSP%202008%20Technology%20Options%20for%20Urban%20Sanitation%20in%20India.pdf
Grey water management in low and middle income countries, review of different treatment systems for household or neighbourhood.	Rural/Urban	Technology choices – treatment	List of systems that vary significantly in terms of complexity, performance and costs and range from simple to complex systems	India and developing countries	Designers	Site: http://www.sswm.info/sites/default/files/reference_attachments/MOREL%20and%20DIENER%202006%20Greywater%20Management.pdf
Community-based technologies for domestic wastewater treatment	Urban	Technology choices - treatment	Review of low cost technologies in wastewater treatment	Global	Designers	Site: http://www.sswm.info/sites/default/files/reference_attachments/Rose%201999%20Community-Based%20Technologies%20for%20Domestic%20Wastewater%20Treatment%20and%20Reuse-%20options%20for%20urban%20agriculture.pdf

Type of Resources	Locale	Topics covered/aspects	Purpose	Region specificity	For whom	Case study
Water pollution control – a guide to the use of water quality management principles	Urban/Rural	Water pollution control	Discussed regulatory, financial and technical aspects illustrated with an extensive collection of case studies	Developing countries	Planners	Site: http://www.sswm.info/sites/default/files/reference_attachments/HELMER%20and%20HESPANHOL%20Eds%201997%20Water%20pollution%20control%20guide.pdf
Linking Technology Choice with Operation and Maintenance in the context of community water supply and sanitation. A reference Document for Planners and Project Staff	Urban/Rural	Technology choices – system	Main steps involved in choice selection of technologies for water supply, purification and water treatment at household and community level.	Developing counry	Planners/staff of water programmes	Site: http://www.sswm.info/sites/default/files/reference_attachments/BRIKKE%202003%20Linking%20technology%20choice%20with%20operation%20and%20maintenance%20in%20the%20context%20of%20community%20water%20supply%20and%20sanitation.pdf
Faecal Sludge (FS) Management, review of practices, problems and initiatives	Urban	Operational issues of FS.	Management and institutional aspects regarding the challenges and possible improvements in managing faecal sludge.	Developing countries	Planners	Site: http://www.sswm.info/sites/default/files/reference_attachments/STRAUSS%20MONTANGERO%20FS%202002%20Management%20Review%20of%20Pracitces%20Problems%20Initiatives.pdf

Type of Resources	Locale	Topics covered/aspects	Purpose	Region specificity	For whom	Case study
Technology options for urban sanitation – a guide to decisionmaking	Urban	Technology choices	Various technology options for provision of access, o&m and disposal arrangements related to sanitation services	India	Planners, Engineers	Site: http://moud.gov.in/sites/upload_files/moud/files/Urban_Sanitation.pdf
CPHEEO manual	Rural/Urban	Design considerations - system	Design considerations for wastewater collection, treatment and disposal	India	Designing	Site: http://urbanindia.nic.in/programme/uwss/Draft_Manual_SST%28Engg%29.pdf
Marketing compost a guide for compost producers in low and middle income countries.	Rural/Urban	Operational issues - composting	Step by step manual on how to initiate and operate small-scale composting facilities in developing countries to turn waste into jobs and food security.	India and developing countries	Engineers/designers	Site: http://www.sswm.info/sites/default/files/reference_attachments/ROUSE%20et%20al%202008%20Marketing%20Compost.pdf

Type of Resources	Locale	Topics covered/aspects	Purpose	Region specificity	For whom	Case study
Communal toilets in urban poverty pockets	Urban	Operational issues - collection	Evaluation of communal latrines	India	All	Site: http://www.wateraid.org/~/media/Publications/communal-toilets-user-satisfaction-bhopal-india-report.pdf
Global experiences on expanding services to the urban poor	Urban	Technological choices	Review of various initiatives which seek to improve service delivery	Global	All	Site: http://www.wsp.org/sites/wsp.org/files/publications/SA_GUIDANCENOTES_globaleg.pdf
Handbook on technical options for on site sanitation	Rural/Urban	Technological choices	Provides sustainable technology options for onsite sanitation for different hydrogeological conditions.	India	Planners	Site: http://indiasanitationportal.org/16933

Type of Resources	Locale	Topics covered/aspects	Purpose	Region specificity	For whom	Case study
Guidance notes on services for the urban poor	Urban	Service delivery barriers with solutions	The report identified barriers to service delivery for poor people living in urban areas in Africa, East and South Asia, and Latin America and recommends practical solutions to overcome them. It includes a compilation of 19 case studies from 12 countries as well as consultations with urban poor communities to analyze similar barriers and propose solutions.	India and other developing countries	All	Site: http://www.wsp.org/sites/wsp.org/files/publications/Main_Global_Guidance_Note.pdf

Type of Resources	Locale	Topics covered/aspects	Purpose	Region specificity	For whom	Case study
The Manual on the right to water and sanitation	Rural/Urban	Strategy development for WATSAN	Presents a tool to develop strategies for implementing the human right to water and sanitation.	India	All	Site: http://indiasanitationportal.org/24
Phytorid wastewater treatment of NEERI	Urban	Operational issues – treatment	Design and consutrction of system	Design	All	Site: http://neeri.res.in/pdf/Phytorid.pdf

Case studies

Type of Resources	Locale	Topics covered/aspects	Purpose	Region specificity	For whom	Case study
Decentralized wastewater management at adarsh college badlapur, Maharashtra, India	Urban	Treatment	This study seeks to evaluate the decentralised wastewater treatment system at Adarsh Vidyaprasarak Sanstha's College of Arts and Commerce, India.	India	Planners	Site: http://www.susana.org/docs_ccbk/susana_download/2-38-en-susana-cs-india-badlapur-adarshschoolfinal.pdf
Urban decentralised wastewater management, Badlapur, Maharashtra, India	Urban	Treatment	This study is about a large scale decentralised wastewater management and reuse project in Badlapur town.	India	Planners	Site: http://www.susana.org/docs_ccbk/susana_download/2-41-urban-decentralised-wastewater-management-badlapur-maharashtra-india.pdf
Improved traditional composting toilets with urine diversion, Leh Jammu and Kashmir State, India.	Urban	Collection – composting toilets	Introduces traditional ladhaki sanitation and reuse through composting	India	Designer/engineer	Site: http://www.susana.org/docs_ccbk/susana_download/2-42-en-susana-cs-india-leh-composting-toilet-2009.pdf

Type of Resources	Locale	Topics covered/aspects	Purpose	Region specificity	For whom	Case study
UASB Technology For Sewage Treatment In India: Experience, Economic Evaluation And Its Potential In Other Developing Countries	Urban	Treatment	Review of the overall implications of UASB (Upflow Anaerobic Sludge Blanket) technology in India. Introduces institutional and technical aspects with special reference to Yamuna Action Plan (YAP). Includes potential of UASB technology in other developing countries.	India and other developing countries	Designers, Planners	http://www.sswm.info/sites/default/files/reference_attachments/KHALIL%202008%20Uasb%20Technology%20For%20Sewage%20Treatment%20In%20India.pdf
Logistic aspects of ecological sanitation in urban areas	Urban	Transport	Transport system is presented for the collection and transport of excreta from households in a specific urban community to farmers outside specific city.	India	Designers, planners	http://www.susana.org/docs_ccbk/susana_download/2-452-slob-2005-logistic-ecosan-waste-en.pdf
Sewage fed aquaculture systems of Kolkata. A century old innovation of farmers.	Not specified	Reuse	Fishponds in sewage-fed lagoons in Kolkata	India	Planners	http://www.sswm.info/sites/default/files/reference_attachments/RAYCHAUDHURI%202008%20Traditional%20Aquaculture%20Practice%20at%20East%20Calcutta%20Wetland.pdf

Type of Resources	Locale	Topics covered/aspects	Purpose	Region specificity	For whom	Case study
Ecological sanitation and reuse of wastewater. Ecosan, a thinkpiece on ecological sanitation	Urban	Reuse	Introduces ecosan and provides advantages/disadvantages, ecosan in practice, dimensions of culture,gender and poverty as well as health aspects	India	Planners	http://www.sswm.info/sites/default/files/reference_attachments/JENSSEN%202004%20Ecological%20Sanitation%20and%20Reuse%20of%20Wastewater.pdf
Waste-fed fisheries in periurban kolkata	Peri-Urban	Reuse	Provides a study on perhaps the largest wastewater fed aquaculture	India	Planners	http://www.sswm.info/sites/default/files/reference_attachments/MUKHERJEE%202003%20Waste-Fed%20Fisheries%20in%20Periurban%20Kolkata.pdf
Decentralised composting lessons learnt nd future potentials for meeting the millennium development goals	Urban	Reuse	Presents a research programme on decentralized composting includes strengths and weaknesses and provides indicators for sustainable decentralised composting schemes.	India	Planners	http://www.sswm.info/sites/default/files/reference_attachments/DRESCHER%202006%20Decentralized%20Composting.pdf

Type of Resources	Locale	Topics covered/aspects	Purpose	Region specificity	For whom	Case study
Technical and economic analysis of compost enterprises in Bangalore - india	Urban	Reuse	Two compost plants in Bangalore are presented	India		http://www.sswm.info/sites/default/files/reference_attachments/ZURBRUGG%20et%20al%202002%20Decentralized%20Composting%20India.pdf
Financing on-site sanitation for the urban poor	Urban	Finance	Review of onsite sanitation financing in six case studies.	India and other developing countries	Planners	http://www.wsp.org/sites/wsp.org/files/publications/financing_analysis.pdf
Wastewater irrigation in Gujarat: an exploratory study.	Urban	Reuse	Recommendations by farmers on how to increase the benefits of wastewater irrigation	India	Planners	http://www.sswm.info/sites/default/files/reference_attachments/PALRECHA%20et%20al.%202012%20Wastewater%20irrigation%20in%20Gujarat.%20An%20exploratory%20study.pdf
Pit latrines and their impacts on groundwater quality, a systematic review.	Not specified	Collection	After calculating global latrine coverage, a review was completed on impact on groundwater quality and an evaluation of latrine standards was considered.	Global	Planners	http://indiasanitationportal.org/sites/default/files/Pit%20Latrines.pdf

Evaluation Tools

Tool	Functionality	Technologies	Who Uses	Notes	Tags
SewerGEMS V8i	Urban sewer planning	AutoCAD, ArcGIS, and MicroStation	Aqua America, PA Fort Pierce Utilities Authority, FL	Hydraulic and hydrology tools for sewerage modeling.	Sewer Planning, GIS
ICT for Sanitation Planning	Empowering Decision Making through Mobile Support	GPS, Java-based web app, MySQL	Four cities of Madhya Pradesh viz. Gwalior, Ashta, Raisen and Khajuraho.	Building a comprehensive GIS-based application for sanitation.	DST, mobile, GIS
PAS - Performance Improvement Planning (PIP)	Measure, monitor and improve delivery of water and sanitation services; Simulates the impact on service delivery, revenues and costs; Performance Assessment; Action Planning; Financial Assessment	Microsoft Excel	Urban Local Bodies (ULBs) in Gujarat and Maharashtra.	The Project has three major components of performance measurement, monitoring and improvement.	Planning, Monitoring,

Tool	Functionality	Technologies	Who Uses	Notes	Tags
Sanitation Window (SAWI)	SAWI connects demand and supply in the sanitation value chain, by offering matchmaking, risk lowering services, tailor-made supportive solutions, local networks and access to finance.		Emerging markets in Africa, Asia and Latin America		
Sanitation Decision Support tool (AKVO, WASTE)	Helps to explore sanitation systems, based on your own situation.	Open Source,Web application		A total of 54 sanitation options are combined to build a complete system.	DST
MIKE URBAN - modelling water in the city	GIS-based urban modeling system for water distribution systems and wastewater collection systems	ArcGIS	Boston Water and Sewer Commission, The StockHolm Water Company	Covers all water in the city, including: sewers - combined or separate systems or any combination of these; storm water drainage systems, including 2D overland flow; water distribution systems.	Sewer/water Planning

Tool	Functionality	Technologies	Who Uses	Notes	Tags
SANSYS	Sanitary Sewerage System Design, Analysis and Management Software	AutoCAD, Spreadsheets			Sewer planning
SANMAP	Sanitation mapping tool	Web application	South and South East Asia and Southern Africa	sanmap.org hosts data to help small scale private sanitation businesses build business plans, choose appropriate technologies and deliver quality sanitation services to low income urban areas.	GIS, Data collection
Sustainable Sanitation and Water Management Toolbox (SSWM)	The Sustainable Sanitation and Water Management (SSWM) Toolbox is an integrated tool for capacity development linking water management, sanitation and agriculture at the local level. Its a new educational software application that can answer (almost) all questions on the topic			In addition to planning and implementation methods, the constantly updated toolbox offers technical and behaviour-changing solutions to aid local level development of sanitation and water management that is more environmentally sustainable.	Capacity Building, Educational

Tool	Functionality	Technologies	Who Uses	Notes	Tags
	of sustainable water and wastewater management.				
WhichSan	The WhichSan Sanitation Decision Support System has been developed to assist planners and engineers to consider the relative merits and costs of different sanitation options for a given situation.	Microsoft Excel, Adobe Acrobat, Visual Basic		This software is developed on behalf of the Water Research Commission and is distributed at no cost in the public interest.	DST
WASHCost India	Aims at effectively and efficiently delivery WASH services by: 1. Developing appropriate methodologies for estimating life-cycle costs for sustainable service delivery; 2. Identifying the life-cycle costs and factors that affect them;		Andhra Pradesh	The app gives users access to reliable life-cycle costs information and can be used to run a quick financial sustainability check on water and sanitation programmes. It can also be used to evaluate value-for-money and compare costs and service level data across organisations.	DST, Financial Assessments

Tool	Functionality	Technologies	Who Uses	Notes	Tags
	3. Designing a range of decision support tools.				
WSP Software	City Sanitation Planning (CSP) - Decision Support Tool (DST)			The CSP Decision Support Tool builds investment scenarios for six possible citywide sanitation options. The tool computes investment requirements for three city sanitation components i) Household sanitation arrangements; ii) Wastewater conveyance; iii) Wastewater treatment.	Financial DST
NEWSAN Simulator (Simulating Nutrient and Energy Fluxes in Non-networked Sanitation Systems)	Based on material flow analysis to model resource fluxes related to human excreta from household to final disposal/reuse. It allows city engineers to assess the effect of different options of sanitation systems, particularly, new technologies. Special	C#, using Microsoft .NET Version 4, Integrates numerical solvers and integrators		The project aims at - developing a simulator to model resource fluxes related to human excreta based on material flow analysis - from household to final disposal/reuse - to aid in determining sustainable	

Tool	Functionality	Technologies	Who Uses	Notes	Tags
	emphasis is laid on non-networked sanitation systems, such as those which are prevalent in Africa.			sanitation solutions for a site at scale. The novelty of this work lies in the adaptation of an existing resource-flux simulator used on networked systems to calculate water, nutrient and energy fluxes specifically for on-site sanitation systems at scale. The model can also evaluate capex and opex expenditure, according to the water operator's cost categories.	
EVI - Plug and Play (PnP) Model framework	Basic framework of financial plug & play (PnP) models for resource recovery from FS (Fecal Sludge) using different technologies.	Microsoft excel		Various sizing and capacity estimates of waste water treatment plants, transport vehicles, storage. Calculation for financial indicators (NPV, project IRR, equity IRR, levelized cost) including sensitivity analysis can be done using this model.	Resource Recovery, Financial indicators
BCG Transport Options Model	The model provides analysis of various FS transport (Vacuum truck/ Omni-ingestor) and storage options	Microsoft excel	Dhaka, Khulna, Faridpur, Ouagadougou, Bobo Dioulasso, Fada N'Gourma, Phnom,		FS Transport

Tool	Functionality	Technologies	Who Uses	Notes	Tags
	(Septic tank/latrine pit), estimates of truck economics, water business economics, sludge business economics, etc for city specific data.		many more.		
SANEX - A Decision Support System for Assessing the Suitability of Sanitation Systems in Developing Countries	Supports planners in determining the suitability of sanitation systems, taking into account the situation and preferences of all stakeholders.	Desktop application - MS Windows		The knowledge base of this software contains more than 80 sanitation alternatives and uses around 50 criteria for their assessment. The costing component employs approximately 50 functions.	DST
COGZ (Sanitation Scheduling Software - Manages your Cleaning Schedule!)	- Preventive Maintenance; - Cleaning schedule can now be automated.. - Budgets and expenditures can be accounted.	Web based Computerised Maintenance and Management System (CMMS)		This software is meant for managers of organisations for preparing sanitation work order for their employees and scheduling the cleaning concerned.	Scheduling

Tool	Functionality	Technologies	Who Uses	Notes	Tags
ASIM (Activated Sludge Simulation Program)	Dynamic simulation of a variety of different biological wastewater treatment systems	Java			
NextDrop	- Smart water supply message service (water alerts) - Real time information about piped water Application (Hubli)	SMS			sms, mobile
Delhi Jal Board	Sewer Blockage, Missing Manhole Cover etc	SMS			sms, mobile
UrSMS (Urban Service Monitoring System)	- Monitoring and grievance re-address system - Water supply	SMS			sms, mobile, monitoring

Tool	Functionality	Technologies	Who Uses	Notes	Tags
	complaint system - Door to Door – Solid waste collection complaint system - Drainage & Sewerage complaints system - Water distribution quality monitoring system Health monitoring system				
Sanitation Mapper	The Sanitation Mapper is a participatory decision-support and monitoring tool which can provide information to inform local planning at district and sub-district levels. It has been designed to provide both area-based mapping, such as improved	GPS, Spreadsheets, Google Earth/Maps	Dhaka, Bangladesh	The Sanitation Mapper consists of a data collection sheet, which is then translated into a series of maps. The tool has been designed to provide both area-based mapping (e.g. village level coverage) and point-based mapping (e.g. for instance shared latrines in slums). The pilot will test both scenarios. The tool is intended to provide useful information that will feed into both decision-making and planning at district and sub district levels but also information on access to sanitation that	GIS, Data Collection, Crowd-Sourced.

Tool	Functionality	Technologies	Who Uses	Notes	Tags
	sanitation coverage at the village level, and point-based mapping, for identifying of the distribution and status of shared latrines in urban areas.			communities and NGOs can use for advocacy and accountability purposes.	
100% access by design: a financial analysis tool for urban sanitation	Reliably assessing the cost of different sanitation solutions is a key urban planning challenge. This Practice Note describes an Excel-based financial analysis tool which generates reliable costings of different options for achieving 100% sanitation access across low-income and non-low-income areas.	Microsoft Excel	Dhaka, Bangladesh	In the tool developed by WSUP and partners in Dhaka, the user inputs unit costs and local data (e.g. socio-economic status) into a series of worksheets in Microsoft Excel, and built-in formulas calculate outputs which are viewable in tabular and graphical formats. Before the data-input stage, the user is required to identify and determine the unit costs of different sanitation technologies appropriate for the context.	Financial analysis,
AKVO and Water for People's -	FLOW stands for Field Level Operations Watch. It's a system to collect, manage,	GPS, Web-based, Google Maps/ Google	Since first deploying in 2010, FLOW has been used around the world in 17 countries for	Akvo FLOW brings together three elements: 1. Handheld data collection – the	GIS, Data collection, mobile, Crowdsourced

Tool	Functionality	Technologies	Who Uses	Notes	Tags
FLOW	analyze, and display geographically-referenced monitoring and evaluation data.	Earth	monitoring.	FLOW Field Survey application runs on Android phones and devices with integrated GPS, camera, and custom adaptive surveys; 2. A web-based dashboard where users manage and analyze FLOW surveys and data; 3. Visual map-based reporting tools displayed in Google Maps and Google Earth.	
SaniFOAM: a framework to analyze sanitation behaviors to design effective sanitation programs	This conceptual framework is designed to assist program managers and implementers in analyzing sanitation behaviors to better design sanitation programs, such as limited use of latrines, and factors inhabiting or enabling individuals and communities to move up the sanitation ladder.			SaniFOAM framework is designed to assist program managers and implementers in understanding the challenges leading to continued open defecation despite the provision of latrines, and the factors enabling individuals or households to move up "the sanitation ladder".	
Sanitation Investment	The Sanitation Investment Tracker is a suite of applications	Android, Windows 8, Internet	Ghana, Bangui, Central Africa Republic,	Who has invested and how much in on-site sanitation is critical for designing, financing and	Investment tracker, GIS, mobile

Tool	Functionality	Technologies	Who Uses	Notes	Tags
Tracker (SIT)	that can be used to track investment (and associated expenditure) in sanitation at household level.	browser with HTML5 Support (for Geolocation API)	Tanzania	monitoring sanitation programmes as well as providing services to households which have on-site sanitation.	
Cablet	Cablet is a service to locate nearest public toilet along with the crowdsourced rating of the sanitation quality.	Android 2.2+ Internet browser with HTML5 Support (for Geolocation API) Python Backend Server	CrowdSourced		GIS, mobile
AquaMaps	With the objective of generating a versatile tool that supplies concise and real information about the situation of water availability and sanitation.	Android, iphone app	CrowdSourced	AquaMaps is created an open system that integrates data on water and sanitation from entities such as the World Bank and governments combined with data provided by NGOs and citizens in general.	GIS, Data collection, mobile, Crowdsourced, real time

Tool	Functionality	Technologies	Who Uses	Notes	Tags
Taarifa	Taarifa is an application for reporting, monitoring and aggregration, linking governments and organisations with citizens.	Django	CrowdSourced	It allows people to collect and share their own stories using various mediums such as SMS, Web Forms, Email or Twitter, placing these reports into a workflow. Where these reports can be followed up and acted upon, while engaging citizens and communities.	GIS, Data collection, mobile, Crowdsourced, monitoring
Monitoring of Street Cleaning Staff through Mobile	Citizen will report problem related to street cleaning to municipal. They will assign the problem to concern sweeper. He will work on that.	Mobile & Web technologies	CrowdSourced		GIS, Data collection, mobile, Crowdsourced, monitoring
mSewage	mSewage is a new app that helps save lives by addressing the number one way that water sources become contaminated: raw sewage flowing onto the ground and seeping into water sources. mSewage provides a platform to map sewage	Mobile & Web technologies	CrowdSourced	This data can be used by governments and local communities to identify high risk areas for diarrheal disease or stop water contamination before outbreaks can occur.	GIS, Data collection, mobile, Crowdsourced, realtime , monitoring

Tool	Functionality	Technologies	Who Uses	Notes	Tags
	outflows and sanitation infrastructure. This helps empower communities to identify water sources that are at risk and track efforts to improve the situation.				
SunClean (Sanitation Games)	Awareness on safe sanitation and hygiene remains generally low. To help people understand sanitation and hygiene issues, we have to start by educating children. Most approaches, however, fail to reach and gather children's attention for the topic. SunClean is a game that playfully teaches sanitation and hygiene behavior.	HTML5, Flash		SunClean, consists of 2 Mini Games: 1. Disposal Trash (Identifying organic inorganic wastes) 2. Hand Wash for Kids	Educational, Games

Annexure2: Details of Evaluation Tools

1. SewerGEMS V8i

Objective:

- Make water and sewer systems more efficient
- Preventing sewer overflow

Functionality: Engineers can analyse sanitary or combined conveyance sewer systems using built-in hydraulic and hydrology tools and a variety of wet-weather calibration methods. SewerGEMS provides an easy-to-use environment for engineers to analyse, design, and operate sanitary and combined sewer systems.

Technologies: AutoCAD, ArcGIS, MicroStation

Target users: Engineers

Who uses?

Aqua America, PA

Fort Pierce Utilities Authority, FL

City of Annapolis DPW, MD

Swinerton Management & Consulting

Gainesville Regional Utilities, FL

EAAB (Colombia)

City of Mansfield, OH

City of Chattanooga, TN

Interagua (Ecuador)

City of Round Rock, TX

ADSSC (Utd.Arab.Emir.)

City of Albury (Australia)

GESP Srl (Italy)

Source:

Sanitary sewer modeling and management – SewerGEMS for Bentley. (n.d.). Retrieved from http://www.bentley.com/en-US/Products/SewerGEMS/

2. ICT for Sanitation Planning

Objective:

- SAMS (Sanitation Amenities and Management Systems) - To provide spatial representation of the existing situation of the sanitation facilities to develop a comprehensive GIS based applications for sanitation.
- Mapper for participatory planning within a ward.
- Mobile Application for capturing field based sanitation data with location and pictures.

Functionality: Empowering Decision Making through Mobile Support: Promote mobile as open tool as which can be just plugged to any project based requirement. The Idea is to make this ICT tool user friendly so that any external interface is not required to use the same. It would act as handy tools for data /information collection in any project.

Mapper is developed as a self-learning mapping tool kit (limited version of Geographical information system-GIS) which is useful for data recording, updating, analysing parameters of natural & human resources in a village or a cluster of village in rural context and in a ward / slums or a cluster of the same in urban context.

Technologies: handheld GPS, mobile phones, java-based web app, mysql

Target users: Citizens, Decision-makers, Planners

Who uses?: The paper has been put together based on experience of using ICT tools during the development of City Sanitation Plan in four cities of Madhya Pradesh viz. Gwalior, Ashta, Raisen and Khajuraho.

Source:

Phansalkar, M. (n.d.). *Empowering Decision Making Through Mobile Support | Changemakers*. Retrieved from http://www.changemakers.com/project/empowering-decision-making-through-mobile-support

Phansalkar, M. (n.d.). ICT in City Sanitation Planning. Retrieved from http://www.geospatialworld.net/paper/application/ArticleView.aspx?aid=24446

Phansalkar, M. (n.d.). Taking ICT from Classes to Masses Employment generation through ICT based Self Learning Kits (for Rural and Urban youth), *Changemakers*. Retrieved from https://www.changemakers.com/economicopportunity/entries/taking-ict-classes-masses-employment-generation-through

3. PAS.org - Performance Improvement Planning (PIP)

Objective: The Performance Assessment System (PAS) project aims to develop appropriate methods and tools to measure, monitor and improve delivery of water and sanitation in urban India. The Project has three major components of performance measurement, monitoring and improvement.

Functionality:

- Measure, monitor and improve delivery of water and sanitation services
- Simulates the impact on service delivery, revenues and costs
- Performance Assessment
- Action Planning
- Financial Assessment

Technologies: Excel-based tool

Target users: Urban local bodies, Decision-makers, Planners

Who uses? Urban Local Bodies (ULBs) in Gujarat and Maharashtra.

Source:

PAS - Performance Improvement. (n.d.). Retrieved from http://www.pas.org.in/web/ceptpas/performanceimprovement?p_p_id=PerformanceImprovement_

WAR_Portal&p_p_lifecycle=1&p_p_state=normal&p_p_mode=view&p_p_col_id=column-1&p_p_col_count=2&actionVal=GetScreen&tabId=1

4. Sanitation Window

Objective:

"SAWI connects demand and supply in the sanitation value chain, by offering matchmaking, risk lowering services, tailor-made supportive solutions, local networks and access to finance."

Functionality: SaWi works in two ways: it finds solutions for a clear demand that already exists and it develops markets for solutions that are still unknown in sanitation.

Technologies: -

Target users: -

Who uses? Emerging markets in Africa, Asia and Latin America.

Source:

Sanitation Window. (n.d.). Retrieved from http://www.sanitationwindow.com/
SaWi , *WASTE*. (n.d.). Retrieved from http://www.waste.nl/en/project/sawi

5. Sanitation Decision Support tool

Objective: Sanitation Decision Support Tool helps you explore sanitation systems, based on your own situation.

Functionality:

The tool has the following options to choose from,

1. User interface (toilet – 6 options)
2. Collection & storage/Treatment (collection–12 options)
3. Conveyance (transport – 8 options)
4. (Semi-) centralized treatment (treatment – 15 options)
5. Use and/or Disposal (using products – 13 options)

A total of 54 sanitation options [9] are combined to build a complete system.

Following are the four steps of the tool,

1. Technical / physical feasibility / Screening
2. System assemblage
3. Cost assessment (to be developed)
4. Performance Indicators (on ISWM aspects) (to be completed by review committee)

Technologies: Web technologies

Target users: Decision-makers, Planners

Who uses? -

Source:

Sanitation Decision Support Tool. (n.d.). Retrieved from http://waste-dev.akvo.org/dst/sanitation/

Sanitation Portal - Akvopedia. (n.d.). Retrieved from http://akvopedia.org/wiki/Sanitation_Portal

6. MIKE URBAN - modelling water in the city

Objective: **MIKE URBAN** is a GIS-based urban modeling system for water distribution systems and wastewater collection systems.

Functionality:

MIKE URBAN covers all water in the city, including:

- sewers - combined or separate systems or any combination of these
- storm water drainage systems, including 2D overland flow
- water distribution systems

MIKE URBAN is a complete integration of GIS and water modelling. All GIS licenses and components required are embedded in the MIKE URBAN licence.

Technologies: ArcGIS

Target users: Engineers, Planners

Who uses?

Boston Water and Sewer Commission.

The StockHolm Water Company.

Source:

MIKE URBAN. (n.d.). Retrieved from http://www.dhisoftware.com/Products/Cities/MIKEURBAN.aspx

7. SANSYS

Objective: SANSYS will help you analyze, design and manage your sanitary sewerage system. It is a comprehensive graphic information system (GIS) for your sewer infrastructure.

Functionality: As a municipal planning tool, SANSYS will simulate the effects of zoning changes. As a design tool for land development, you may quickly determine suitable pipe sizes and velocities. As a maintenance management tool, your pipe and manhole inspections may be recorded and color-coded to help you to prioritize the work of your infrastructure upgrading projects. By using zoning classifications, population densities, industrial densities, contributing areas and infiltration allowances, you may size pipes for a new development or find infiltration problems of an existing system.

Technologies: AutoCAD, Spreadsheets

Target users: Engineers, Planners

Who uses? -

Source:

SANSYS For Sewerage - managing sanitary sewerage systems. (n.d.). Retrieved from http://pages.pacificcoast.net/~edc/sansys.html

8. SANMAP

Objective: SanMap.org hosts data to help small scale private sanitation businesses build business plans, choose appropriate technologies and deliver quality sanitation services to low income urban areas.

Functionality: Data collection and analysis.

Technologies: Web Technologies

Target users: Decision-makers, Planners, Citizens

Who uses? South and South East Asia and Southern Africa

Source: SanMap. (n.d.). Retrieved from http://sanmap.org/

9. Sustainable Sanitation and Water Management (SSWM)

Objective: The Sustainable Sanitation and Water Management (SSWM) Toolbox is an integrated tool for capacity development linking water management, sanitation and agriculture at the local level. It's a new educational software application that can answer (almost) all questions on the topic of sustainable water and wastewater management.

Functionality:

The SSWM Toolbox is an online, open-source capacity development support tool developed for promoting a more holistic approach to capacity development in the water and sanitation sector and to raise awareness on SSWM among different sectors.

The toolbox contains the following tools mentioned below:-

Exploring tools:

- the preliminary assessment of current status
- definition of boundaries
- Analysis of stakeholders.

Demand Creation tools:

- create demand in general
- And which awareness raising tools you can for this purpose.

Decision making tools:

- gathering ideas
- analysing the situation together with the local population
- deciding
- and planning further steps together with the stakeholders.

Implementation Support tools:

- conceptualising (writing concepts and proposals)
- financing
- And implementing programmes and projects.

Tools to ensure sustainability:

- ongoing participatory monitoring and evaluation
- operation and maintenance
- And ongoing follow-up and support.

Technologies: -

Target users: Decision-makers, practitioners

Who uses? -

Source:

Sustainable Sanitation and Water Management Toolbox. (n.d.). Retrieved from http://www.sswm.info/

IEES - The SSWM Toolbox. (n.d.). Retrieved from http://www.iees.ch/cms/index.php?option=com_content&task=view&id=147&Itemid=1

10. WhichSan

Objective: WhichSan enables a user to investigate the social, technical and financial feasibility of any sanitation option.

Functionality:

The WhichSan Sanitation Decision Support System has been developed to assist planners and engineers to consider the relative merits and costs of different sanitation options for a given situation.

Technologies: Microsoft Excel, Adobe Acrobat, Visual Basic

Target Users: Planners, Engineers

Who uses? -

Source:

Resources & Tools - Free Software. (n.d.). Retrieved from http://www.wrc.org.za/Pages/Resources_FreeSoftw.aspx

11. WASHCost India

Objective: WASHCost Calculator will ease the costing of the life-cycle of water and sanitation services at a critical moment when more than 50 governments, multilaterals, training institutions, International NGOs and donors are either using or planning to use the life-cycle costs approach.

Functionality:

WASHCost India aims to support governmental departments, private sector organisations, and NGOs effectively and efficiently delivery WASH services by:

- Developing appropriate methodologies for estimating life-cycle costs for sustainable service delivery;
- Identifying the life-cycle costs and factors that affect them;
- Designing a range of decision support tools.

Technologies: -

Target users: Planners

Who uses? Andhra Pradesh

Source:

WASHCost India - *WASHCost Project*. (n.d.).

Retrieved from http://www.washcost.info/page/146

WASHCost calculator - *WASHCost Project.* (n.d.).

Retrieved from http://www.washcost.info/page/2573

12. WSP software

Objective: City Sanitation Planning (CSP).

Functionality:

Identification of components of CSP.

The CSP Decision Support Tool builds investment scenarios for six possible citywide sanitation options. The tool computes investment requirements for three city sanitation components:

i) Household sanitation arrangements

ii) Wastewater conveyance

iii) Wastewater treatment.

Technologies: Desktop application

Target Users: City Planners, Engineers

Who uses? -Planners for City Sanitation Plans

Source: The software (CD) was provided by WSP.

13. NEWSAN

Objective: Based on material flow analysis to model resource fluxes related to human excreta from household to final disposal/reuse. It allows city engineers to assess the effect of different options of sanitation systems, particularly, new technologies. Special emphasis is laid on non-networked sanitation systems, such as those which are prevalent in Africa.

- Functionality:

  - NewSan allows to represent fluxes (and related costs) in the sanitation system.
  - Sanitation options can be compared on a case-study basis.
  - NewSan: flexible, resource-flux based simulator.

Technologies: C#, using Microsoft .NET Version 4, Integrates numerical solvers and integrators

Target users: Engineers, Planners

Who uses? -

Source:

Campos, L., & Schuetze, M. (n.d.). UCL Discovery - MODELLING THE NEXT GENERATION OF SANITATION SYSTEMS – NEWSAN SIMULATOR. Retrieved from http://discovery.ucl.ac.uk/1370877/

Campos, L., Jain, V., & Schuetze, M. (2012) (n.d.). Simulating nutrient and energy fluxes in non-networked Sanitation Systems.

14. EVI - Plug and Play Model framework

Objective:

Basic framework of financial plug & play (PnP) models for resource recovery from FS (Fecal Sludge) using different technologies.

Functionality: Various sizing and capacity estimates of waste water treatment plants, transport vehicles, storage. Calculation for financial indicators (NPV, project IRR, equity IRR, levelized cost) including sensitivity analysis can be done using this model.

Technologies: Excel Model

Target users: -

Who uses? -

Source:

EVI India. (2013). Plug and Play Model Framework for FS to Energy Recovery in India.

15. BCG Transport Options Model

Objective:

The model provides analysis of various FS transport (Vacuum truck/ Omni-ingestor) and storage options (Septic tank/latrine pit), estimates of truck economics, water business economics, sludge business economics, etc. for city specific data.

Functionality: -

Technologies: Excel Model

Target users: -

Who uses? -

Source:

BCG. (2013). The Economics of Omni Ingestor and Vacuum Trucks, *Boston Consulting Group*, Study for Bill and Melinda Gates Foundation. (Work in Progress)

16. SANEX

Objective: A Decision Support System for Assessing the Suitability of Sanitation Systems in Developing Countries.

Functionality: Supports planners in determining the suitability of sanitation systems, taking into account the situation and preferences of all stakeholders. The knowledge base of this software contains more than 80 sanitation alternatives and uses around 50 criteria for their assessment. The costing component employs approximately 50 functions.

Technologies: -

Target users: Decision-makers

Who uses? -

Source:

Loetscher, T. (2000). SANEX(TM) - A Decision Support System for Assessing the Suitability of Sanitation Systems in Developing Countries. *Computer-aided Evaluation of Sanitation Projects.*

17. COGZ

Objective: -

Preventive Maintenance;

- Cleaning schedule can now be automated..

- Budgets and expenditures can be accounted.

Functionality: This software is meant for managers of organisations for preparing sanitation work order for their employees and scheduling the cleaning concerned.

Technologies: Web Application

Target Users: Manager, Maintenance department

Who uses? -

Source:

CMMS Preventive Maintenance Work Order Software. (n.d.). Retrieved from http://www.cogz.com/

18. ASIM (Activated Sludge Simulation Program)

Objective: Dynamic simulation of a variety of different biological wastewater treatment systems.

Functionality:

ASIM (Activated Sludge SIMulation Program) is a simulation program, which allows for the simulation of a variety of different biological wastewater treatment systems:

Activated sludge systems with up to 10 different reactors in series (aerobic, anoxic, anaerobic), including sludge return and internal recirculation streams, batch reactors, chemostat reactors, etc. The demo version of the software is available for students.

Technologies: -

Target users: -

Who uses? -

Source:

AG, H. (n.d.). ASIM Software. Retrieved from http://www.asim.eawag.ch/

19. NextDrop

Objective:

- Smart water supply message service (water alerts)

- Real time information about piped water Application (Hubli)

Functionality: NextDrop collects and shares water delivery information with city residents and water utilities.

Technologies: Web application, Big Data, Texting

Target Users: Citizens

Who uses? -

Source:

Kulkarni, N. (n.d.). NextDrop Uses Big Data, Texting To Improve Water Distribution. *Huffington Post*. Retrieved from http://www.huffingtonpost.com/2013/09/09/nextdrop_n_3894586.html

20. Delhi Jal Board

Objective: Sewer Blockage, Missing Manhole Cover etc

Functionality: Registering complaints using mobile texting.

Technologies: SMS

Target users: Citizens

Who uses? Delhi

Source:

Department of Delhi Jal Board. (n.d.). Retrieved from http://www.delhi.gov.in/wps/wcm/connect/DOIT_DJB/djb/home

21. UrSMS (Urban Service Monitoring System)

Objective: Complaint and monitoring using mobile texting.

Functionality:

- Monitoring and grievance re-address system
- Water supply complaint system
- Door to Door – Solid waste collection complaint system
- Drainage & Sewerage complaints system
- Water distribution quality monitoring system
- Health monitoring system

Technologies: SMS

Target users:

Who uses? -

Source:

Urban Service Monitoring System (UrSMS) | ACCCRN. (n.d.). Retrieved from http://www.acccrn.org/resources/documents-and-tools/urban-service-monitoring-system-ursms

Rajasekar, U., Bhat, G., & Karanth, A. (n.d.). *Urban Service Monitoring System (UrSMS)*. Gandhinagar, India: TARU Leading Edge.

22. Sanitation Mapper

Objective: Mapping sanitation resources using GPS and location aware devices.

Functionality: The Sanitation Mapper is a participatory decision-support and monitoring tool which can provide information to inform local planning at district and sub-district levels. It has been designed to provide both area-based mapping, such as improved sanitation coverage at the village level, and point-based mapping, for identifying of the distribution and status of shared latrines in urban areas.

Technologies: GPS, Spreadsheets, Google Earth/Maps

Target users: Decision-makers, Planners

Who uses? -

Source:

Water Point Mapper. (n.d.). Retrieved from http://www.waterpointmapper.org/Sanitation.aspx

23. 100% access by design: a financial analysis tool for urban sanitation

Objective: Reliably assessing the cost of different sanitation solutions in urban context.

Functionality: This Practice Note describes an Excel-based financial analysis tool which generates reliable costing of different options for achieving 100% sanitation access across low-income and non-low-income areas.

Technologies: Microsoft Excel

Target users: Planners

Who uses? Bangladesh

Source:

100% access by design: a financial analysis tool for urban sanitation, *Water & Sanitation for the Urban Poor*. (2013). Retrieved from http://www.wsup.com/resource/100-access-by-design-a-financial-analysis-tool-for-urban-sanitation/

24. AKVO and Water for People's - FLOW

Objective: FLOW stands for Field Level Operations Watch. It's a system to collect, manage, analyze, and display geographically-referenced monitoring and evaluation data.

Functionality:

Akvo FLOW brings together three elements:

1. Handheld data collection – the FLOW Field Survey application runs on Android phones and devices with integrated GPS, camera, and custom adaptive surveys.
2. A web-based dashboard where users manage and analyze FLOW surveys and data.
3. Visual map-based reporting tools displayed in Google Maps and Google Earth.

Technologies: Web technologies

Target users: Citizens, Planners

Who uses? -

Source: Akvo FLOW. (n.d.). Retrieved from http://www.waterforpeople.org/flow-mapping/

25. SaniFOAM: a framework to analyze sanitation behaviors to design effective sanitation programs

Objective: This conceptual framework is designed to assist program managers and implementers in analyzing sanitation behaviors to better design sanitation programs, such as limited use of latrines, and factors inhibiting or enabling individuals and communities to move up the sanitation ladder.

Functionality: -

Technologies: -

Target users: -

Who uses? -

Source:

Devine, J. (2009). Introducing SaniFOAM: A framework to analyze sanitation behaviors to design effective sanitation programs. *World Bank, Water and Sanitation Program (WSP*), USA. Retrieved from http://www.susana.org/lang-es/library?view=ccbktypeitem&type=2&id=1448

26. Sanitation Investment Tracker (SIT)

Objective: The Sanitation Investment Tracker is a suite of applications that can be used to track investment (and associated expenditure) in sanitation at household level.

Functionality: The tool is used to track who has invested and how much in on-site sanitation is critical for designing, financing and monitoring sanitation programmes as well as providing services to households which have on-site sanitation.

Technologies: Android, Windows 8, Internet browser with HTML5 Support (for Geolocation API)

Target users: -

Who uses? -

Source:

Sanitation Investment Tracker (SIT), *Sanitation Hackathon*. (n.d.). Retrieved from http://www.sanitationhackathon.org/applications/sanitation-investment-tracker-sit

27. Cablet

Objective: Cablet is a service to locate nearest public toilet along with the crowd sourced rating of the sanitation quality.

Functionality: -

Technologies: Android 2.2+, Internet browser with HTML5 Support (for Geolocation API), Python, Server

Target users: Citizens

Who uses? -

Source:

Cablet , Sanitation Hackathon. (2012). Retrieved from http://www.sanitationhackathon.org/cablet

28. AquaMaps

Objective: With the objective of generating a versatile tool that supplies concise and real information about the situation of water availability and sanitation.

Functionality:

1. Crowd source sanitation and water sources points
2. Visualize information in the web site
3. Make the data open
4. Improve the data and information of organizations
5. Earn points and badges to contribute with correct data

Technologies: Android, iPhone

Target users: Planners, Citizens

Who uses? -

Source:

AquaMaps. (n.d.). Retrieved from http://aquamaps.cochavalley.com/pages/mobile

29. Taarifa

Objective: The Taarifa Platform is an open source web application for information collection, visualization and interactive mapping.

Functionality: It allows people to collect and share their own stories using various mediums such as SMS, Web Forms, Email or Twitter, placing these reports into a workflow. Where these reports can be followed up and acted upon, while engaging citizens and communities.

Technologies: PHP, MySQL, Apache Server

Target users: Planners, Citizens

Who uses? -

Source:

Taarifa - Building the infrastructure of nations. (n.d.). Retrieved from http://taarifa.org/

Taarifa, Sanitation Hackathon. (2012). Retrieved from http://www.sanitationhackathon.org/taarifa

30. Monitoring of Street Cleaning Staff through Mobile

Objective: Scheduling and monitoring of City Street cleaning.

Functionality: Citizen will report problem related to street cleaning to municipal. They will assign the problem to concerned sweeper so that he can work on that.

Technologies: Android, GPS

Target users: Planners, Citizens

Who uses? -

Source:

Monitoring of Street Cleaning Staff through Mobile, Sanitation Hackathon. (2012). Retrieved from http://www.sanitationhackathon.org/monitoring-street-cleaning-staff-through-mobile

31. mSewage

Objective: mSewage is a new app that helps save lives by addressing the number one way that water sources become contaminated: raw sewage flowing onto the ground and seeping into water sources. mSewage provides a platform to map sewage outflows and sanitation infrastructure. This helps empower communities to identify water sources that are at risk and track efforts to improve the situation. Because mSewage is free and open source, it also helps people working on this important problem coordinate with one another.

Functionality:

1. Sanitation facility monitoring
2. Identifying maintenance issues
3. Connecting sanitation businesses to potential customers
4. Building community awareness of open defecation

Technologies: Mobile & Web technologies

Target users: Planners, Citizens

Who uses? -

Source:

mSewage, Sanitation Hackathon. (n.d.). Retrieved from http://www.sanitationhackathon.org/applications/msewage

32. SunClean (Sanitation Games)

Objective: SunClean is a game that playfully teaches children sanitation and hygiene behaviour.

Functionality: SunClean, consists of two mini games:

1. Disposal Trash (Identifying organic inorganic wastes)

2. Hand Wash for Kids

Technologies: HTML5, Flash

Target users: Planners, Citizens

Who uses? -

Source:

Ramadhani, D. (n.d.). AppCircus SunClean (Sanitation Games) from SunSquare Studio | AppCircus. Retrieved from http://appcircus.com/apps/sunclean-sanitation-games-2

Annexure3: Technologies Description

Onsite Storage Technologies				Simplified Sewer	
	Twin Pits	**Septic Tank with Soak Pit**	**Biogas Reactor**	**Shallow Sewer**	**Small Bore Sewer**
Description	The twin pit system is an improved version of a single pit system wherein two pits are provided to hold fecal matter. This provides a long holding period for digestion of fecal matter since pits are used alternatively. These systems retain the simplicity of construction and maintenance and fulfil the low cost requirements of single pit systems in towns.	Septic tank is an underground watertight structure for containment and treatment of domestic wastewater. This is an improved treatment system compared to pit systems and mostly recommended where there is no sewerage network.	The biogas digester is a watertight underground tank working on the principle of anaerobic treatment. The technology is mainly used for digestion of organic matter present in wastewater, sludge and other biodegradable waste. Digested slurry and biogas is generated during the treatment process. Slurry can be used as soil conditioner and biogas supplements energy needs for cooking.	Shallow sewer system is an off-site sanitation technology used to convey all the wastewater from the household environment at a shallow depth for offsite and onsite treatment and safe disposal.	The small-bore sewer system is designed to collect and transport only the liquid portion of the domestic wastewater for off-site or on-site treatment and safe disposal. The solids are separated from the wastewater in septic tanks or interceptor tanks installed upstream of every connection (at household level) to the small-bore sewers. Since the small-bore sewers collects only settled wastewater, it needs reduced water requirements (for transportation) and reduced flow velocities.
Application	Suitable for semi-urban areas. In low to medium density areas, particularly per-urban areas, where there is space on or immediately outside the plot to install the pits and where the digested sludge can be applied to local fields and/or gardens as a fertilizer and soil conditioner. It can be used where, water supply is less and soil percolation capacity is good.	This technology is most commonly applied at the household level. Larger, multi-chamber septic tanks can be designed for groups of houses and/ or public buildings (e.g., schools).	Suitable at household level and cluster level. They can be used along with animal waste and other bio-degradable waste. They can be built in dense, semi dense and low density areas. Users require to be educated about the technology.	The shallow sewer system is mainly used for conveyance of large volumes of wastewater from different sources to cluster level decentralised wastewater treatment. Mainly applicable in large housing colonies, institutions like hospitals, schools and colleges etc.	The small-bore sewer systems are applicable where households have septic tanks for retention of solids in existing and newly developing areas.
Treatment performance	NA	20-30% BOD & TSS removal	BOD removal of 40-60% while removal of suspended solids 50-70% can be ensured.	NA	NA
O&M	Rings should be constructed water-tight (bottom and sides) and the outlet of the pit should be atleast 10 cm above the maximum ground water table (GWT during monsoon season – 3 feet, summer season – 5 feet). To avoid the clogging in the pipes as well as 'Y' junction a minimum of 1.5 to 2 L of water should be used for each flush.	Generally, septic tanks should be emptied every 2-5 yrs. It should be checked from time to time to ensure that they are watertight.	Desludging of settled solids needs to be carried out once in 2-3 years. The reactors should also regularly be checked for scum formation. Gas tightness of the BGD and the gas pipes needs to be checked regularly.	Homeowners and households should be responsible to maintain the interceptor tanks, the grease trap and the sewers. Alternatively, a private contractor or user's committee can be hired to assume responsibility for the maintenance. Blockages can usually be removed by opening the sewer and forcing a length of rigid wire through the sewer. Inspection chambers must be cleared periodically to prevent grit overflowing into the system.	Regular desludging of the septic/interceptor tank must be regularly done to insure optimal performance of the Solids-Free Sewer network. If the pretreatment is efficient, the risk of clogging in the pipes is low, but some maintenance will be required periodically. Flushing of sewers should be done once a year as part of the regular maintenance regardless of their performance

Onsite Storage Technologies				Simplified Sewer	
	Twin Pits	**Septic Tank with Soak Pit**	**Biogas Reactor**	**Shallow Sewer**	**Small Bore Sewer**
Additional treatment requirements	If digestion of fecal matter cannot be ensured due to high moisture content then it has to be transported for further treatment in sludge drying beds (or can be used in co- composting). Prior to reuse or disposal. Collection methods need to be hygienic, preventing contact between workers and feces.	A septic tank is appropriate where there is a way of dispersing or transporting the effluent. If septic tanks are used in densely populated areas, onsite infiltration should not be used, otherwise, the ground will become oversaturated and contaminated, and wastewater may rise up to the surface, posing a serious health risk. Instead, the septic tanks should be connected to some type of Conveyance technology, through which the effluent is transported to a subsequent Treatment or Disposal site.	The sludge accumulated in the digester needs to be desludged through appropriate mechanical means and transported to designated sludge treatment facility. The effluent from the biogas digester needs further treatment before disposal.	Should be connected to DEWATS or STP	Should be connected to DEWATS or STP
Limitations and risks	High space requirement in comparison to single pit system. If water for flushing is low, toilet/pipe can get clogged. Further treatment of sludge is required if it is not fully digested. Ground water contamination risk	Low reduction in pathogens, solids and organics. Regular desludging must be ensured. Effluent and sludge require further treatment and/or appropriate discharge	Expert design required along with skilled labour for construction. Slurry and sludge requires further treatment. Long start-up time	Requires expert design and construction supervision. Shallow sewer system is suitable where adequate ground slopes are available. As sewers are to be laid at flat gradients, solids are likely to get deposited unless flushed at peak flow conditions, failing which these sewers may clog and require frequent cleaning. Frequent repairs and removal of blockages. Households may be reluctant to allow sewers to be routed through their properties	Regular cleaning and desludging of interceptor tanks. Well planned maintenance system is required. Experience with the system is limited and mixed. Solids entering sewer system due to illegal connection.
Capital cost	The cost estimated for construction/installation of twin pit system is 50 to 75 USD for single household with 5 persons.	No data	The cost of biogas digester ranges from 500 to 1000 USD for a household size of 5 persons. If the digester is used in combination with other treatment modules the cost ranges from 350 to 500 USD per cu.m for a treatment capacity of 10 cu.m.	The cost ranges from 35 – 55 USD per running meter length	The cost ranges from 35 – 55 USD per running meter length
Source	*TA-8128 BAN: Preparing Coastal Towns Infrastructure Improvement Project – DFR Vol. 5: Infrastructure*				

Offsite Wastewater and Faecal sludge treatment							Hybrid Treatment Technology
	Anaerobic Baffled Reactor(ABR)/Baffled Septic Tank	**Upflow Anaerobic Filter(AF)/Fixed bed/fixed film reactor**	**Upflow Anaerobic sludge blanket (UASB)**	**Activated Sludge Process**	**Waste Stabilization Pond**	**Horizontal planted gravel filter**	**DEWATS**
Description	ABR consists of a settling compartment with the same dimensions as the first compartment of a conventional septic tank, followed by a number of smaller compartments arranged in series.	Aareobic filters provide additional treatment by bringing wastewater into contact with active bacteria attached to media as the wastewater flows upwards through the filter. Filter material, such as gravel, rocks, cinder or specially formed plastic pieces provide additional surface area for bacteria to form a slime.	Wastewater flows upwards through a blanket of flocculated biomass in a vertical reactor containing anaerobic bacteria which break down carbonaceous organic matter.	This process involves rapid mixing and aeration of the wastewater, either by mechanical surface aerators or a submerged compressed air system, to creat optimal condition for treatment. The aeration basin is followed by a secondary clarifier (settling tank) designed to remove suspended micro-organisms (flocs) prior to discharge. Active biomass is returned to the aeration tank.	There are 3 basic type of WSPs and these are normally connected in series to provide a 2 or 3 stage treatment process. They are: 1) Anaerobic ponds: Comparatively small and deep (3-4m) as there is no need for aeration. They receive raw sewage which is treated by anaerobic bacteria, while sludge that builds up in the bottom of the pond is digested by anaerobic micro-organisms. 2) Facultative ponds: Shallower (1.5-2 m) with a larger surface area than anaerobic ponds. They consists of an aerobic zone close to the surface and a deeper, anaerobic zone. 3) Maturation ponds: Shallow (1-1.2 m) with a large surface area to enable light penetration. they receive treatment effluent from the facultative pond and provide tertiary treatment to remove turbidity, pathogens and nutrients.	Horizontal planted gravel filter bed is a shallow over-ground open watertight tank filled with graded filter material. HPGF are also known as sub-surface wetland system or root zone treatment system. HPGF are simple and low maintenance treatment system provided they are well designed and constructed.	A combination of primary, secondary and tertiary treatment modules like Septic Tank, Biogas digester, Anaerobic Baffled Reactor, Anaerobic Filter and Horizontal Planted Gravel Filter can provide comprehensive wastewater treatment with organic load reduction up-to 95%. Some of the most commonly adopted and practiced combinations are described below: Combination 1: Primary treatment module (septic tanks or settler or bio-gas digester) with part of secondary treatment modules (anaerobic baffle reactor). Combination 2: Primary treatment module (septic tanks or settler or bio-gas digester) + Secondary treatment modules (anaerobic baffle reactor and/or anaerobic filter). Combination 3: (septic tanks or settler or bio-gas digester) + Secondary treatment modules (anaerobic baffle reactor and/or anaerobic filter) + Tertiary treatment modules (horizontal planted gravel filter). Polishing pond is added as a post treatment module to Combination 3.

Offsite Wastewater and Faecal sludge treatment							Hybrid Treatment Technology
	Anaerobic Baffled Reactor(ABR)/Baffled Septic Tank	**Upflow Anaerobic Filter(AF)/Fixed bed/fixed film reactor**	**Upflow Anaerobic sludge blanket (UASB)**	**Activated Sludge Process**	**Waste Stabilization Pond**	**Horizontal planted gravel filter**	**DEWATS**
Application	Suitable for small community schemes and housing developments with no access to municipal sewerage.	Appropriate for treating effluent from septic tanks (individual or shared/communal) in areas where infiltration is not possible due to low soil permeability, high water table and/or lack of space.	Best suited to higher strength wastewaters and appropriate for medium-size wastewater treatment plants. UASBs need less land than aerobic systems but require follow-up treatment to achieve comparable performance in terms of COD/BOD removal.	Widely used for the treatment of municipal wastewater from medium to large towns where land is scarce and power is reliable.	1) WSP are appropriate for medium to low density settlements with sufficient free space, but should not be located very close to houses due to possible odour. 2) They offer a robust treatment process that can deal with a wide variety of wastewaters of varying types and concentrations. 3) Ponds are particularly appropriate where pathogen removal is an important objective of treatment. 4) Waste stabilization ponds may be combined with aquaculture systems (water hyacinth or fish production).	Appropriate at household level and cluster level. Pre-treated wastewater from ABRs, AFs, and septic tanks can be further treated. It requires community involvement for proper functioning if applied at cluster level. It is a good option where land is cheap and available.	Appropriate for domestic wastewater from cluster level households, institutions, public/community toilets, Septage treatment etc.
Treatment performance	65% COD & 70% BOD removal.	When combined with pre-treatment, quality can be as high as 80% BOD removal.	Can bring down BOD of domestic wastewater to 70-100 mg/l and suspended solids as low as 50-100 mg/l, but removal of nitrogen and bacteria is poor.	Provided the reactor is well operated, a very good removal of BOD and suspended solids can be achieved, though pathogen removal is low.	Treatment efficiency of high-loaded ponds with long retention times ranges from 70-95% BOD removal (COD removal:65 -90%) depending on biodegradability of the wastewater).	HPGF are suitable for pre-treated domestic wastewater with BOD content less than 100mg/l. Wastewater must be pretreated especially with respect to suspended solids. The removal efficiency is based on surface area and cross-sectional area available for the flow. The quality of treatment in well-operated HPGF is in the range of 50-60% BOD removal. The enrichment of dissolved oxygen occurs	Organic load reduction up-to 95%.

Offsite Wastewater and Faecal sludge treatment							Hybrid Treatment Technology
	Anaerobic Baffled Reactor(ABR)/Baffled Septic Tank	**Upflow Anaerobic Filter(AF)/Fixed bed/fixed film reactor**	**Upflow Anaerobic sludge blanket (UASB)**	**Activated Sludge Process**	**Waste Stabilization Pond**	**Horizontal planted gravel filter**	**DEWATS**
						largely in this treatment module.	
O&M	Although desludging at regular intervals is necessary, it is important that some active sludge is left in each of the compartments to maintain a stable treatment process.	Active sludge (for example, from septic tanks) should be added to the filter before starting continuous operation. The bacterial film gradually thickens and must eventually be removed. This is usually done by back-washing with wastewater.	Careful monitoring and control of the reactor sludge levels and sludge withdrawal. Frequent cleaning or desludging of distribution or division boxes and influent pipes. Removal of sum and floating material from the settling zone.	A continuous supply of oxygen and sludge is essential; hence maintenance of the aeration equipment and sludge pump is important. Careful monitoring and control of concentrations of suspended sludge solids and dissolved oxygen levels in the aeration tank is required.	Routine o&m is easy but arrangements must be made for sludge removal. This is often done by emptying ponds and manually digging out the sludge. Alternatively, sludge can be removed under hydrostatic pressure using pumps mounted on rafts.	The flow of wastewater though the treatment unit should always be sub-surface or else algal formation may occur on the surface, which may lead to filter clogging. Filter bed needs regular visual checking for clogging. The filter material needs to be cleaned or replaced periodically (every 3-5 years). Trimming of vegetation and cleaning of dead leaf litter is required regularly.	The o&m requirements for each treatment module are described in previous sections.
Additional treatment requirements	The last chamber may consist of an anaerobic filter to improve treatment performance.	The filter should be preceded by a septic tank.	1) Pretreatment: Screening and degritting but no other form of primary treatment is required. 2) Posttreatment: Like other anaerobic treatment technologies, UASBs also provide partial treatment and rarely meet discharge standards unless appropriate post-treatment is provided. As yet, only a waste stablization pond system has been found to be an appropriate post treatment option. 3) Sludge production and treatment: Relatively low sludge production with good dewatering characteristics. Requires thickening, drying,	1) Pretreatment: There is usually a need for primary sedimentation, but in many cases it is omitted, with only preliminary screening provided. 2) Posttreatment: The treatment effluent from the secondary clarifier may require additional treatment depending on the discharge requirements. 3) Sludge production and treatment: Provision must be made to digest, dewater and dispose of excess sludge.	The 3 stage process is a complete treatment system. The only additional requirement is for sludge treatment after its removal from ponds.	In order to avoid clogging of filter media, pre-treatment system should be provided before HPGF.	It is a comprehensive treatment so there is no need for additional treatment.

Offsite Wastewater and Faecal sludge treatment							Hybrid Treatment Technology
	Anaerobic Baffled Reactor(ABR)/Baffled Septic Tank	**Upflow Anaerobic Filter(AF)/Fixed bed/fixed film reactor**	**Upflow Anaerobic sludge blanket (UASB)**	**Activated Sludge Process**	**Waste Stabilization Pond**	**Horizontal planted gravel filter**	**DEWATS**
			and safe disposal.				
Limitations and risks	O&M is easily ignored, leading to deterioration in performance.	Lack of attention to maintenance results in blockage of the filter. In addition, the perforations of the distribution pipe at the bottom of the filter get clogged easily.	Long start-up and high initial oxygen demand of effluent during this period may cause oxygen depletion in receiving water bodies. Sensitive to seasonal temperature variations and low removal efficiency in winter. Release of corrosive and odorous hydrogen sulfide and ammonia in the air. sludge washout from the reactor can result in instability leading to deteriorations in treatment performance and very high BOD and total suspended solids in the effluent.	1) High energy consumption results in high recurring costs. 2) Performance is adversely affected due to interruption in power supply, even for short periods of time, due to impacts on aeration process and sludge recirculation. Foaming, particularly in the winter, may adversely affect the oxygen transfer and hence performance.	1) Ponds require a lot of land, at least 5 sqm per person. 2) Underdesign, hydraulic short-circuiting, and poor operation and maintenance can all reduce performance.	Moderate capital cost. Pre-treatment is required to prevent clogging. Requires expert design and supervision. Requires ample space for installation	The treatment is less efficient with the weak wastewater. The tertiary treatment system requires larger space. Technical knowledge and care is required during the construction. Capital cost and the area required is more for the total infrastructure.
Capital cost	Rs 750000 (US$ 18,200) for a 14000 ltr/day plant.	No data	Rs 2.4-3.5 million/MLD (US $ 58,500-85000/MLD) depending on the capacity of the plant. Approximately 65% cost is civil works and remaining 35% is for electrical and mechanical works.	In the range of Rs 4.2-4.8 million/MLD (US& 0.10-0.12 million/MLD). Approximately 55% cost is for civil works and remaining 45% is for electrical and mechanical works.	Rs 1.5 million/MLD capacity (US$ 36500/MLD)	If HPGF is used in combination with other treatment modules (eg. In DEWATS), the cost ranges from 250-350 USD per cu.m for a treatment capacity of 10 cu.m	The cost ranges from 550-1000 USD per cu.m for a treatment capacity of 10 cu.m
Operation cost	Rs 12000 (US$300) per annum for a 14000 ltr/day plant, equivalent to Rs 0.86/ltr/day (US$ 0.02/ltr/day)	No data	Rs 0.07-0.15 million/MLD/annum (US$ 1700-3600/MLD/annum) depending on plant capacity.	In the range of Rs 0.43-0.52 million/year/MLD (US$ 10500-12600/year/MLD)		No data	No data
Source	*A guide to decisionmaking - technology options for urban sanitation in India, September 2008*					*TA-8128 BAN: Preparing Coastal Towns Infrastructure Improvement Project – DFR Vol. 5: Infrastructure*	

Glossary

Activated sludge – Microbial aggregates used in anaerobic waste water treatment process used to treat waste streams that are high in and biodegradable compounds.

Aerated pond - A natural or artificial waste-water treatment pond in which mechanical or diffused air aeration is used to supplement the natural re-oxygenation processes. Concentrations in wastewater are artificially elevated to facilitate rapid digestion of biodegradable organic matter.

Benchmarks - the process of comparing processes and performance metrics to industry/sector best practices.

Centralised options – a centralised collection system which collects wastewater from many sources and transports it to a unitary location.

Composting latrine - A latrine designed to receive both faeces and waste vegetable matter with the aim of reducing moisture content and achieving a carbon-to-nitrogen ratio that promotes rapid decomposition.

Decentralised options – A group of collection systems which collect and treat waste water from multiple sources locally.

Diarrhoea - It is the passage of loose or liquid stools more frequently than is normal for an individual. It is primarily a symptom of gastrointestinal infection.

Ecological Sanitation (ECOSAN) - A form of dry sanitation that involves separation of faeces and urine in order to facilitate recycling of nutrients in local agricultural systems.

Gross Domestic Product (GDP) – It represents the total currency value of all goods and services produced over a specific time period.

Millennium Development Goals (MDG) – Eight international development goals that were established following the Millennium Summit of the United Nations in 2000, following the adoption of the United Nations Millennium Declaration.

Ministry of Urban Development (MoUD) - The apex body for formulation and administration of the rules and regulations and laws relating to housing and urban development in India.

Onsite sanitation - A sanitation system that is wholly contained within a plot occupied by a private dwelling and its immediate surroundings. Commonly, on-plot sanitation is equivalent to 'household latrine', but may also include facilities shared by several households living together on the same plot.

Pit latrine - A form of on-plot sanitation with a pit for accumulation and decomposition of excreta from which liquid infiltrates into the surrounding soil.

Pour flush toilet - A type of latrine where a water seal trap is used to prevent smells and to reduce insects.

Proof-of-Concept (PoC) - A realization of a certain method or idea to demonstrate its feasibility or a demonstration in principle, whose purpose is to verify that some concept or theory has the potential of being used.

Sanitation - Interventions (usually construction of facilities such as latrines) that improve the management of excreta and promote sanitary (healthy) conditions.

Septic tank - A form of on-plot sanitation for the anaerobic treatment of sewage/black water.

Sewage - A mixture of waste water from all urban activities from residential, commercial properties. It may also contain a component of industrial waste water.

Urban Local Body (ULB) - In India, Urban Local Bodies are the constitutionally provided administrative units, who provide basic infrastructure and services in urban areas, i.e., cities and towns.

Ventilated Improved Pit Latrine - A dry latrine system with a dark interior and a screened vent pipe to reduce odour and fly problems.

Waste water - Liquid wastes from households or commercial or industrial operations, along with any surface water/storm water.

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