Stage 3: Develop systems for sanitation improvement

There are many factors to consider when selecting the most appropriate systems to serve different areas of the city. Decisions need to be based on a good understanding of the existing situation taking into consideration the specific topographic, social, financial and institutional context from Stage 2. Specific attention is required to assure that proposed solutions provide services for all, including those who live in hard-to-serve areas. These are often the areas that challenge conventional service delivery approaches.

This stage in the planning process encourages stakeholders to consider various potential strategies for urban sanitation service delivery; building on existing investments and indigenous knowledge and expertise, but may also seek to embrace technological innovation where these enable a step–change in service level.

Activities in Stage 3 of the planning process involve:

- Delineate zones for system development
- Consider appropriate toilet facilities
- Develop strategy for treatment, disposal or reuse
- Collection and transportation of wastewater and faecal sludge
- Consider operational and maintenance requirements
- Assess cost of proposed improvement options

Outcome from Stage 3: The outcome from Stage 3 will be a clear understanding on what types of system are appropriate to serve different parts of the city with a well-developed plan for collecting, treating and reusing the residual waste streams. The cost implications and arrangements for operation and maintenance should also be defined.

Delineate zones for system development

To provide sanitation services for the city as a whole invariably requires a mixture of sanitation systems, which are appropriate for different parts of the city and can be implemented at different scales. It is unlikely that the same model of service delivery will be appropriate for all areas and therefore a city-wide sanitation plan is likely to consist of several components designed to meet the specific conditions in different parts of the city. It is therefore necessary to characterise the city into sanitation zones or clusters based on aspects such as topography, population density, user preferences, existing systems, water availability *etc.*); taking into account both the existing situation and expected changes due to urbanization. This will help to determine where on-site or off-site, networked or non-networked, dry or wet systems are most appropriate in the short and longer term. Box 7 provides a good example from South Africa of how the municipality eThekwini approached this situation.

Box 7: Experiences from eThekwini, South Africa

A mapping of sanitary conditions by eThekwini Water and Sanitation, a unit of the eThekwini municipality, is a good example of how a utility has met the demands of services from all types of customers, from informal settlements to rural areas to high-end full paying customers, with a variety of technologies and management systems. What makes the eThekwini experience particularly relevant is the contextualised decentralised approach, which divided the city into management units depending on incentives and technical feasibility. The approach allows for different elements of the system to be developed independently in response to prioritization based on i) health related incidences ii) technical feasibility and iii) availability of funds. In many situations in peri-urban areas, community based solutions which are not connected to the centralised system are easier to implement particularly as smaller amounts of finance are required. This enables an incremental development approach such as the addition of treatment to sewer networks developed by the community or the upgrading of shared facilities to household facilities at a later date.

Consider appropriate toilet facilities

Many sanitation master plans focus greatest attention on downstream infrastructure whilst paying insufficient attention to the most important component of the urban sanitation system; the toilet. In middle and high-income communities, improvements to toilet facilities are not generally required, but there will be a need to include a component in the sanitation plan for improving facilities in low-income and informal settlements.

The design of this component needs to consider aspects related to availability of space (especially relevant in dense urban slums), land tenure and access into the settlement with desludging equipment. Due to these constraints, it is often not possible for every household to have a separate toilet for their own private use. Communal toilets combined with washing facilities may be an appropriate improvement option in this situation.

Technological advances offer an increasing range of options that provide more efficient and sustainable solutions for sanitation service delivery. It is important to consider the benefits of different types of solutions but although more sophisticated solutions may appear to be more attractive, these technologies may be more expensive and are more likely to fail as a result of increased operational and maintenance requirements.

Develop strategy for treatment, disposal or reuse

It is important to consider the final destination for the waste considering the following questions:

- Where and how will it be collected/transported?
- What level of treatment is required? and,
- Is there a potential for reuse of the water and nutrients and or recovery of energy contained in the residuals from sanitation systems?

Technological advances for wastewater treatment, reuse and recovery of water, nutrients and energy resources open up a wider range of options than has been traditionally available. The economic viability for reuse in agriculture, or for energy production or as a low-grade source of water is becoming increasingly attractive due to reduced availability and rising costs of natural resources.

With adequate treatment, wastewater can meet specific needs and purposes, as long as concerns about reuse of wastewater due to potential health risks can be overcome. Treatment technologies make it possible to reuse wastewater for a variety of industrial uses such production of paper or for various non-potable purposes e.g. toilet flushing in business or commercial premises, car washing, garden watering, park irrigation or firefighting. Using treated wastewater may also provide a more reliable source of water than from other sources, which is important where industrial processes require continuity of supply.

Integrated sanitation systems have a high potential to recover energy in the form of fuel (biogas or biomass) which may be used directly or to produce electricity or direct heat recovery. However, as these systems rely upon a highly concentrated organic waste stream, it may be necessary to supplement with other sources of organic load. As the concentration of the waste is a key factor, sanitation systems that separate waste streams at source open up more opportunities for reuse. Examples where this has been put into practice include the collection of urine and dry faeces in Ouagadougou and El Alto and the reuse of faecal sludge in northern Ghana.

Collection and transportation of wastewater and faecal sludge

Systems for collection and transportation of toilet waste are influenced strongly by the type of toilet utilised because these determine the volumes and characteristics of the wastewater, septage of faecal sludge to be collected and treated. For instance, the water closet uses a lot of water for flushing and requires a sewerage connection or full size septic tank. But the most common forms of toilet only use a small amount of water for flushing or no water at all. In these situations, a sewerage system is likely to be inappropriate and the focus of attention needs to be upon improving the arrangements for collection and transportation of septage and faecal sludge.

Although there is likely to be a need to expand upon and strengthen conventional desludging operations, there is often a need for an alternative system for desludging pits in areas that are inaccessible by larger desludging trucks. In addition, there is often a need for some form of localized collection facility (transfer station) where the sludge can be discharged and stored prior to collection and transportation to the municipal processing facility. This is an area of rapid research and development and therefore it is important to consider new technologies that may be on the market during the planning process[1].

Consider operational and maintenance requirements

Operational and maintenance requirements for different technologies are important factors that need to be taken into account whilst reviewing alternative approaches for system improvement. Energy for electrical equipment such as for pumping needs to be considered due to the cost implications and especially in cities which are subject to power failures. The lack of availability of spare parts is another common reason why systems may fail. Therefore, although imported technologies may bring about a step change in operational performance, there should be careful deliberation if they are dependent upon foreign supply chains for spare parts. It is therefore generally better to use simpler technologies wherever possible and only resort to higher-technology solutions where the low-tech solutions are considered not to achieve the desired service level. In all cases, the key issue for sustainable operation and maintenance is the need for a commercially viable service delivery model that provides the necessary financial incentives to attract the suitably qualified managerial and technical staff to operate the service and also finance for capital investment in new facilities and equipment.

Assess costs of proposed improvement options

This activity involves an estimation of the approximate costs of each of the proposed solutions. Technologies should be costed in terms of their investment costs for construction, as well as operation and routine maintenance costs and capacity building costs. It is important to recognise that the least-cost option may not be the most appropriate solution as more affluent households may be willing to pay more for an improved level of service that they perceive to be significantly better that the current level of service.

This is often a necessary activity to be able to demonstrate to the financing institution that there is a sound business case in financial terms or to show that the investment has a positive internal rate to return to justify the project in economic terms. Thus, a realistic estimate of the cost implications and revenue streams from new or improved services over a period of time should be factored into the financial comparison of proposed interventions. These only need to be accurate enough for budgeting decisions to strategize implementation. More detailed cost estimates will need to be done by feasibility studies as part of project preparation.

As summarized in Table 4, the costing should also take into account costs associated with promotion and management, as well as hardware costs. These costs may then be used as the basis for a life-cycle assessment for each option in order and identify the most cost-effective option in the long term. The costing should also take into account the depreciation of assets and the need to ensure that capital maintenance costs are included. These are expenditures that are required for refurbishment of equipment that are often omitted in financial calculations because they are only required every few years.

As well as capital costs, the revenue from new or improved services should therefore be factored into the assessment of each technology to evaluate its financial viability. The most significant revenue stream is likely to be from service charges/ tariffs or taxes/levies, but additional revenue may be derived from the sale of treated wastewater or sludge, which can be used for various purpose.

1 Some of these new technologies are described in the 'Sanitation Compendium' published by Eawag-Sandec (See Annex on "Further Information")

Table 4: Types of cost associated with sanitation systems (from Schuen and Parkinson, 2009)

	Household or institutional cost	Capital costs	Operational and maintenance
Latrine	Costs of toilet facilities are incurred either by the household or landlord	Earthworks, construction pits or tanks, superstructure, septic tanks or connections to sewerage	Desludging costs (including cleaning materials) and cost of water for flushing (if used)
Off-site waste management facilities	Capital investment costs are institutional costs but tariffs for O+M are household costs	Construction of sewerage and treatment facilities, desludging trucks and other equipment	Operational costs of sewerage and treatment facilities, desludging trucks and other equipment
Management	Institutional costs	Project management, supervision and salaries of engineers	Labour and materials for operation, maintenance costs for desludging
Promotion and capacity building	Institutional costs	Sanitation promotion and training	Support for operation and maintenance arrangements

Financial tools are used to identify the most cost-effective sanitation solutions on the basis of life-cycle analysis, taking into account all costs incurred and revenues generated over the total lifespan of an investment. As described in Box 8, assessing the overall life-cycle costs to upgrade sanitation services is a necessary activity to develop a better understanding of the financial viability of the various options. This is important as options that are initially cheaper to install may turn out to be more expensive in the long term if they have high operational and maintenance costs. The outcomes of the analysis for each solution will be a better idea about how much users need to pay for services, what up-front capital investments are required and whether there is a need for a subsidy.

Box 8: Application of life-cycle analysis for financial assessment of sanitation service delivery options

In Dhaka, Water and Sanitation for the Urban Poor (WSUP) worked with Dhaka Water and Sewerage Authority (DWASA) and Dhaka City Corporation (DCC) to compare the long-term costs associated with networked and non-networked sanitation solutions as part of a sanitation planning activity in the District of Mirpur. A financial model was developed to compare the costs to improved transport and treatment components assuming that any investments to improve household facilities would be borne by the households. Using the Dhaka model as the starting point, WSUP has proceeded to adapt and develop the model for application in other locations to compare the costs associated with a range of sanitation systems, and taking into account alternative tariff structures and subsidy mechanisms.

Source: WSUP, 2013