Modelling Chaos?
Sanitation Options; Support and Communication Tool

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Abstract

The selection of suitable sanitation options is a complex issue. There are many factors that influence the performance of each system. Sanitation suitable for use in low-income housing areas in developing countries is normally based on a combination of options specific to the local context. That makes it really difficult to develop an effective tool for decision-making. To date, decision support tools have failed to make a long-term impact on the choice for sanitation services in rural as well as urban and peri-urban settlements in developing countries. Most relate the choice of a sanitation option to one element (i.e. septic tank or pit latrine) rather than considering the sanitation system as a whole. Some lack transparency or are guided by personal choices and assumptions, which can include as well as exclude relevant aspects for the selection of sanitation systems. Decision-models are generally complex to understand and use and sometimes seem inconsistent. WASTE in collaboration with international experts is developing a practical support instrument to facilitate informed choice of sanitation systems. The tool is a knowledge sharing or awareness mechanism intended to provide a more comprehensive view of a settlement’s limitations on the one hand and available sanitation options on the other. It intends to assist a wide range of stakeholders from city officials, planners, CBO’s, users, service providers to financial and political authorities. Furthermore WASTE wants to present a practitioner’s tool that uses a three-step approach providing a simple interface, flexible framework and transparent outcome. This support tool can be used independently, integrated in strategic sanitation planning as well as provide the base-ground for the selection of sanitation options in a multi-stakeholder participatory process.

Keywords: effective, sanitation; decision-making

INTRODUCTION

The twentieth century has experienced the most astonishing growth of the world’s population and its urbanization. The world’s population increases from 1 billion at the beginning of the 19th century to a projected 8.2 billion in 2030 (UN, 2006). A parallel trend has been experienced by city growth and urbanization is projected to continue. In 1961 urban population reached the first billion and the projections estimate to arrive at around 5 billion by 2030. There are huge differences in the growth of cities between developed and developing countries. The less developed regions are facing the higher increase in their population and urbanization numbers. The most noticeable reason for the massive urban population growth in the developing world corresponds to its migration patterns from rural to urban areas, and the expansion of existing towns to urban settlements.

Urban areas in developing countries face and suffer most from the consequences of rapid urbanization trends. Escalating water demand, ageing infrastructure, increasing poverty and difficult settlement patterns are some of the challenges that urban planners are unable to handle with the traditional systems. In developing countries the conventional paradigm does not match with the development of existing urban, peri-urban and slum areas. Contrary to the
conventional approach based on the earlier planning of services and infrastructure, the current urbanization starts with the illegal occupation of unplanned and undeveloped land by the poorest and most vulnerable communities (Hogrewe et al., 1993).

Many centralised treatment systems directly copied from western societies have failed or ended up to be unsustainable in the developing world environment. Most of them were abandoned due to high operation and maintenance costs. (van Lier et al., 1998) While most local engineers educated under western development programs support the implementation of these systems, their lack of appropriateness is attributed to the disregard for the culture and traditions of the population, the characteristics of the land and the climate of the area where these technologies are intended to be used.

Moreover deficient data and knowledge available about the conditions of the slums, illegal settlements or highly dense peri-urban areas in developing countries impedes the proper implementation of any sanitation system. In the same line the lack of tools for urban planners to select appropriate sanitation technologies, compliant with the site-specific conditions, reinforce their over-reliance on conventional systems.

Since the 80’s, comparative criteria on the appropriateness of sanitation systems have been developed in order to assess its suitability on diverse environments. Such criteria include land and water availability, groundwater table, terrain conditions, housing density, operating costs, institutional requirements, reuse potential, etc. Each sanitation system is limited by different factors and values. Several authors such as Franceys (1992) or Kalbermatten (1980) agree to the same common limitations, where mainly the physical conditions correspond to the layout of the settlement. Physical site conditions are regarded as relatively permanent and consistent, offering the basic frame from where to operate. However less constant factors as population size and density, the availability of reliable water supply and distance to formal services, also play an extremely important role in the choice for appropriate implementation of any sanitation system.

Two of the main factors for success of a decision support tool is the approach to produce knowledge from the data acquired in its frame and the way it is presented to the end users. (Engelen, 2000) In order to achieve the most favourable application, decision support tools should enhance a set of criteria such as transparency, interactivity and level of detail. Additionally experience in the design of decision support tools identifies the significance of the factors flexibility, user-friendliness and adaptability (Henderson 1985). In this way a list of 6 criteria has been established in order to assess the weaknesses and strengths of the decision support tool described in this paper. The selected criteria aim to illustrate the distinctive features of the structural design as well as the implications for its operation and end-users.

Evaluative criteria:

- **User-friendliness**: the ease with which the system can be used by its intended end-user (simplicity).
- **Transparency**: the tractability of the results generated by the system as well as the documentation of the different tasks carried out by the system.
- **Flexibility**: the capability of incorporating user remarks, local knowledge and new information sensitive to the local context.
- **Versatility/Adaptability**: the ability to address more than one problem or situation and applicability in different settings for different purposes (Cloete, 2001).
- **Interactivity**: the ease with which the end-user can interact with the system. What tools are available to support the user in carrying out the assessment.
- **Level of Detail**: the level of completeness.
WASTE uses the Integrated Sustainable Waste Management (ISWM) framework in order to approach sanitation planning and implementation processes. It is based on bottom-up, participatory processes designed to improve management, livelihoods and urban governance in cities of developing countries and in transition. ISWM is based upon the principles of equity, effectiveness and efficiency and it combines three components to produce sustainable solutions to waste management problems.

1. The different elements of the whole waste trajectory from waste generation to final disposal are mapped out.
2. Not only the technical and financial aspects of the system are analysed, but also environmental, social, health, legal, political, institutional and economic aspects. This approach ensures that all the local issues affecting waste management in a specific area are taken into consideration.
3. All of the stakeholders involved and/or affected by the waste management trajectory are identified and encouraged to participate in the ISWM assessment and subsequent planning and implementation phases of projects as a means of creating consensus and ensuring commitment to the final ISWM solution.

The decision support tool follows the same principles and therefore evokes discussion and communication between the involved parties in order to achieve an informed decision-making based on site-specific conditions instead of bare technologies or costs.

Increased acceptability and suitability of a sanitation system requires the involvement of the community. Participation is a compulsory step in order to stress the behaviour, customs, hygienic practices and organization of the community as well as to provide the appropriate maintenance schemes and educational programmes. Considering this, providing adequate sanitation facilities implies much more than merely technical or economical aspects, it is a matter of human behaviour and community needs, values, dignity and culture. Decision-makers must understand the interest of all the parties involved in the provision of sanitation services in order to ensure an informed choice. Making a decision implies that there are alternative choices to be considered (Harris 1998). Therefore we want to identify as many of these alternatives as possible but choose the one that best fits with the local goals, objectives, desires, values, and capacity.

Along these lines this paper describes the development of a tool to support decision-makers in the implementation of sanitation systems. During the course of this article “sanitation system” is used to describe the path of the different sanitation practices from source to disposal or reuse involving collection, emptying/transport and treatment. WASTE’s intention is to present a practitioner tool that uses a three-step approach providing a simple interface, flexible framework and transparent outcome. Although this support tool can be used independently, it’s meant to be integrated in strategic sanitation planning and to provide the base-ground for the selection of sanitation options in a multi-stakeholder participatory process such as the HCES approach. In this way supporting a shift from the conventional linear model to a resource recovery circular model founded on people-centred solutions, on-site conditions, and economic and environmental balances.

The support tool described in this paper complements the Compendium of Sanitation Options (Eawag/Sandec, 2008), the Philippines Sanitation SourceBook and Decision Aid (WSP, 2005) and the Internet tool Akvopedia through its Sanitation Portal (www.akvo.org, 2008).
This section aims to provide the grounds for the design of a new decision-support tool. At the end of this paragraph the steps followed during the planning and execution of the sanitation support tool are outlined. Although the current support tool design is elaborated in hard copy format, the final goal of WASTE is to develop a software tool so that interactivity and level of detail can be greatly improved. The tool will be linked to the Akvopedia sanitation portal in an open source format. Akvopedia works as Wikipedia so that any user can add and update built-in data. Therefore the tool described in this paper basically focuses in maintaining a high degree of user-friendliness at the same time that intends to improve its transparency, flexibility and adaptability, by the means of:

- **Transparent**: to provide an interface where the criteria and values for the selection of appropriate sanitation systems can be consulted at any design stage. In addition a simple, clear and visual outcome must allow acknowledging the routine followed in the feasibility evaluation of each sanitation system.

- **Flexible**: to provide a frame where sanitation systems can be easily assembled through the combination of different sanitation system elements. The user depending on site-specific needs should be able to select, modify and exchange these elements to create alternative sanitation systems.

- **Versatile/Adaptable**: to provide a structure design that allows diverse settings such as community participation, decision-making, technical feasibility, performance suitability or economic assessment. The tool must be easily upgradeable and simple to accommodate to the local context.

The design approach of this tool is organised in the following steps:

**First step**: technical/physical feasibility or screening of sanitation options in order to eliminate non-appropriate elements. The potential limiting/constraining criteria were defined in compliance with the “Philippines Sourcebook and Decision Aid”. The site-specific data as well as demand factors such as preferences, skills and willingness to pay, can be collected through the survey included in the Annexes from the same publication. The characterization of sanitation systems and their limitations was developed consistent with the “Sanitation Compendium”. The physical conditions of the site introduced by the user are screened against the site-specific limitations of each sanitation system element (fact-sheet). By comparing the specific conditions of the settlement with the constraining values, the users can assess the feasibility of the sanitation options. The screening is based on the fulfilment of all criteria in order to be considered a feasible option; failing one single aspect limits its suitability. Only the feasible options proceed to the 2nd step.

**Second step**: Sanitation system assemblage. Based on the illustrations/icons in the fact-sheets the user combines the feasible sanitation elements (step 1) in order to assemble complete sanitation systems. Next to the main sanitation icon, made visible through smaller illustrations, the user can find the preceding and following compatible elements in the sanitation chain. Therefore the complete sanitation systems are assembled as block chains or trains (see figure 1). Descriptions, possible O&M and health implications, advantages/disadvantages of the different system elements and the costs (provisional), represented in the fact-sheets offer a better-informed choice. The users can assemble various sanitation systems combining the different feasible elements and view immediately the implications of the choices. During the participation process, stakeholders can assess the different options depending on their requirements such as priorities/goals or existing infrastructure and services. Therefore the possibility for open discussions between the interested parties is greatly enhanced.
Third step: Cost assessment. Although it is a work in progress, WASTE in collaboration with other organizations is collecting and producing Bills of Quantities (BoQ) specific for each sanitation element. Each fact-sheet would have embedded a table with the main items for construction, operation and maintenance. The amount of material to be used and the local unit costs have to be inserted in order to have the total investment and O&M costs. In this way the users can compare different sanitation options based on the cost estimate of the entire system and evaluate the choices depending on their affordability and willingness to pay. Additionally the users have relevant information at hand to judge and negotiate offers from potential contractors. BoQs are not always enough to define the financial viability of the implementable choices. This is why WASTE is trying to include other parameters and financial mechanisms to determine the investment, depreciation, interest in case of credits and loans.

The tool is being tested in all WASTE’s projects that aim to implement sustainable sanitation services. These projects intend to provide facilities to thousands of households and institutions in more than 15 different countries; under the Integrated Support for Sustainable Urban Environment Programme (ISSUE-2), the Resource-Oriented Sanitation concepts for peri-urban areas in Africa (ROSA from the EU 6th Framework Programme), the Sanitation in Peri-urban Areas in Africa programme (SPA) and the school sanitation programme. Once the tool is included into the Akvopedia portal (www.akvo.org) in an open source digital format, any organization, individual or project can make use of it and upgrade it with new sanitation elements, comments, experiences and/or images.
most hard-copy tools focuses on a sole solution, which is normally just a single part of the full sanitation system (i.e. pit latrine, septic tank or shallow sewer), instead of considering the whole system chain from source to reuse/disposal.

On the other hand software algorithms developed to assess the suitability of different sanitation options provide a relatively user-friendly interface in a complex mathematical frame. The big improvement in computer-based tools is the level of detail accomplished. They provide definite limiting values specific for each sanitation option in accordance to the local conditions. These models allow the user a higher interactivity. However the constraining values are fixed and concealed into the program, becoming hardly possible to follow the routine and understand the explicit limitations leading to the outcome (feasible sanitation systems).

While computer-based models are able to maintain a friendly user interface and improve considerably the interactivity and level of detail, it seems to partly weaken its transparency. In any case a common characteristic in the existing models is that none of them have the capacity to offer enough if any flexibility and versatility to the decision process. One of the reasons could be that they were designed for other purposes, for instance technology assessment for specific target groups such as experts and engineers. This, and the absence of a clear notion of a sanitation system approach has been the main reason for WASTE to develop a transparent and open tool, based on the understanding of sanitation as a system of linked components.

The weaknesses of previous models are used as guiding principles for the development of the new design. The Support and Communication Tool is organized in a set of A4 fact-sheets for each one of the different elements involved in the sanitation chain. The A4s can be piled up as fact-sheets in a folder, updated and added up. Each fact-sheet refers to a single sanitation option/element from the system (i.e. septic tank, simplified sewer, pit, composting, urine reuse…).

![Functional groups (user-interface, collection, conveyance, treatment and reuse/disposal)](https://iwaponline.com/wpt/article-pdf/6/3/wpt2011060/382941/60.pdf)

It also provides a distinction between the different in- and out-put flows (grey water, black water, storm water, faeces, urine…) and is divided in functional groups (user-interface, collection & storage, emptying & transport, treatment, reuse & disposal). In compliance with the Sanitation Compendium each functional group is assigned a different colour and categorization. The right combination of these elements creates a workable sanitation system (de Bruijne et al., 2007). The fact-sheets include: elements compatibility illustrations, table of site- and option-specific limitations, description of the element, operation and maintenance implications, strengths and weaknesses and reference pictures/drawings (see Figure 3). The tool also includes a table with option-specific performance assessment for each sanitation elements in order to broaden the comparison between the different feasible options. Every system element is assessed by means of a qualitative rating scale consistent with the “Philippines Sourcebook and Decision Aid”. Currently the financial/costs details are being produced and will be added in the near future.
Figure 3 | Lay-out of the fact-sheets.

Left: actual option and compatible elements, below site- and option-specific limitations
Right: description, advantages and disadvantages, technical drawing and picture of the option

The description of the sanitation element includes its adequacy, health aspects, acceptance and the major maintenance implications. It also provides the sources of the text and some links for further information. The text is extracted from the Sanitation Compendium.

Feasibility screening

For the purpose of running the tool the fact-sheet must be folded in half creating a small four-sided A5 booklet. All the fact-sheets are then turned with the site-specific limitations table on top in order to avoid bias or pre-established plans. In this way the user selects the feasible options based on pure technical grounds without knowing which element is being assessed.

There are nine site-specific limitations used for the screening of feasible sanitation options. They include water supply, space availability, flood prone, groundwater table, terrain/topography/slope, vehicular accessibility, soil type, road/path system and anal cleansing method. The table is filled with red, green, yellow and white cells to indicate respectively whether the option is not applicable, applicable, applicable with caution or not a factor to consider. A blank copy of this table is provided with the tool where the specific conditions of the site are punched/perforated by the user. The paper overlaps on top of the existing limitations table in the fact sheet (see Figure 4 below). In this way the physical conditions of the site intended to be assessed can be weighed against the limitations of the technology options. Whenever a red background appears in the table, the element is considered unfeasible.
The reasoning behind the red (unfeasible) and yellow (caution) cells is described below the site-specific limitations table. Therefore, the user is informed about the specific limitations related to each sanitation element. In this way, the tool provides a transparent outcome in a simple interface. If a yellow cell appears in the background of the perforated sheet, it is important to check the implications described in the fact-sheet to assess its feasibility. Besides being aware of the path followed by the tool, the user has the ability to decide whether to eliminate an unfeasible option or to change the local context in order to be able to increase the choices available. For instance, if a main limitation would be the inexistence of water supply, and the decision-maker plans to install a reliable water source, then all the sanitation options considered unfeasible because of this limitation could be used for the second step of the tool. Once all the element fact-sheets have been assessed through this process and the unfeasible options discarded, the user can proceed to the second step.

System assemblage

All the remaining element fact-sheets are then turned around with the main sanitation option illustration on top. They can be separated by colour (functional groups) and placed on a table or board for further dissemination. By doing so, the facilitation process is greatly enhanced. All the participants or stake holders involved in the decision-making are therefore granted the opportunity to participate in the assembly and selection of the best considered system.

To create full sanitation systems, from user interface to reuse/disposal, the users must combine the different elements based on their compatibility. In both sides of the main sanitation icon in each fact-sheet, there are the compatible elements with which that option can be combined. If a sanitation element cannot be connected to any other, then it is discarded from the assemblage step (Figure 5). The order or starting element to assemble each sanitation system is irrelevant. It depends mainly on the user’s interest and/or goals. The process can start with the sanitation element compliant with the on-site existing infrastructure (i.e., available gravity sewer, existing septic tanks). From that element, the preceding and succeeding compatible options can be attached. Alternatively, this activity can aim at the local objectives, such as urine reuse in agriculture. In this case, the starting element would actually belong to the final functional group.
(reuse/disposal). Therefore the support tool offers greater flexibility to the process at the same time that accommodates the needs of the local interests.

**Figure 5** | Sanitation system assemblage example

**Decision-making**

At this stage the different potential sanitation system/chains are evaluated making use of the descriptions, performance indicators, advantages/disadvantages, adequacy, health considerations, acceptance, maintenance requirements and costs. The potential sanitation systems must be judged based on the local context capacity. Consequently it is important to promote discussion and communication between decision-makers to take a well informed choice that best suits the interest of all parties. The different sanitation systems considered feasible and selected by the user should then be compared. Important aspects to consider are the O&M implications associated to the local capacity or availability, affordability as of capital and running costs perspective, social acceptance and adequacy of the sanitation system functionality related to the cultural background and local traditions.

This decision support and communication tool can be used for different purposes and in diverse environments. Whether is used for a single technical assessment or in a complex participatory exercise, the tool demonstrates to enhance the versatility of the process.

**CONCLUSIONS**

The communication and support tool intends to provide a substantial contribution to rational selection of effective sanitation systems and improve the delivery and flexibility of sustainable sanitation services. The user is able to recognise in a logical and transparent way the technical limitations for the feasibility of each one of the sanitation systems involved in the assessment. In addition the sanitation elements considered unfeasible during the screening process highlight the barriers that could be addressed in order to include that option in the second step. The tool provides an improved overview and considerable level of detail of the technical feasibility, explanation of the options limitations, general information (description, operation, maintenance,
advantages and disadvantages) in order to support an informed choice. It also offers a simple framework useful for participation and discussion. The addition of performance indicators specific for each sanitation element enables the comparison between options thus enhances the suitability of the choice. Although yet in progress, cost estimation through bills of quantities assists in acquiring a good indication of the involved costs and total investment. It also allows for the use of local currencies, making it more specific to the context where it’s intended to be used.

The decision support and communication tool is a work in progress and more features will be added in the near future. As well, in short it will be linked into the Avopedia sanitation portal, where updates of existing contents, new technologies, translations to other languages, documentation, case studies and many more components can be uploaded and shared in an open source format. That increases the adaptability and interactivity of the tool and expands the scope of its application.

Therefore the communication and support tool provides a substantial contribution to rational selection of effective sanitation systems and improve the delivery and flexibility of sustainable sanitation services.

REFERENCES

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