Pre-selecting Sanitation Technology Options in Arba Minch, Ethiopia

Identifying appropriate, sustainable sanitation technologies is a complex multi-criteria decision-making problem. This systematic procedure has been developed to determine sets of sanitation technology options as input when structured sanitation planning frameworks are used. Dorothee Spuhler[1], Maria Rath[2]

Introduction

A sanitation system is a set of technologies, which in combination manage sanitation products, such as excreta and wastewater, from the point of generation to final reuse or disposal [1, 2]. A sustainable sanitation system provides appropriate technologies that protect human health and the environment, conserve natural resources, and is financially viable, socially acceptable, and institutionally appropriate [3]. Identifying an appropriate and sustainable sanitation system is a complex multi-criteria decision-making problem that involves many technology options and multiple criteria [4]. This is particularly challenging to do in informal or low-income urban areas of low-income countries, which is where most population growth worldwide is currently taking place.

Structured decision-making frameworks, such as CLUES or Sanitation 21, can help address such complex situations. They combine environmental engineering with multi-criteria decision analysis (MCDA) to evaluate trade-offs and to balance opposing stakeholder preferences. These approaches, however, focus on the selection and implementation steps and assume that the options to choose from are already given. Yet, decisions are only as good as the options presented and as novel technologies emerge, it becomes increasingly difficult to pre-select a good set of technology and system options to consider in planning processes. This systematic and transparent screening method has been developed as a means to determine technology options appropriate for contexts in which frameworks, such as CLUES or Sanitation 21, are being applied.

Approach

This approach was developed in the GRASP project (Generation and Assessment of Sanitation Systems for Strategic Planning [5]), and is based on previous work at Eawag on sanitation technologies and systems [1, 2, 3]. It involves three steps (Figure 1):

(i) identification of all potential sanitation technologies and corresponding system configurations;
(ii) identification of a set of screening criteria derived from the overarching objective of sustainable sanitation (based on the minimal requirement of being appropriate); and
(iii) evaluation of the appropriateness of the technology options in a given case.

The aim is to reduce the large number of technology options and corresponding system configurations to a smaller set, which is both locally appropriate and still covering a broad range of possibilities (i.e. on- and off-site, conventional and novel technologies, etc.). This set can then be further evaluated (e.g. by MCDA) to identify trade-offs and to weigh different stakeholder preferences (Figure 1).

The procedure acts as a first screening phase. It streamlines the process and enhances the transparency and accountability of initial planning phases. It can also work with uncertain information, which is common at initial planning phases, i.e. information about novel technologies or of newly developing urban areas.

Definitions and methods

A potential sanitation technology option (TechOp) is defined as any process, infrastructure, or service designed to contain, transform, or transport sanitation products. A sanitation system (SanSys) is defined as having (i) at least one source and one sink; and (ii) a number of TechOps in which every occurring sanitation product is either transformed, transferred or ends up in a sink. Figure 2 illustrates the structural concept of sanitation systems.

Screening criteria are used to evaluate the appropriateness of the TechOps in a given application case (AppCase). In order not to anticipate any decisions, only criteria, which can be exogenously defined and which do not involve trade-offs or depend on stakeholder preferences, are used (e.g. water or temperature requirements). Each criterion is defined by an attribute for the TechOp and one for the AppCase, which are compared in terms of their compatibility. To evaluate the attributes, we used probabilistic func-

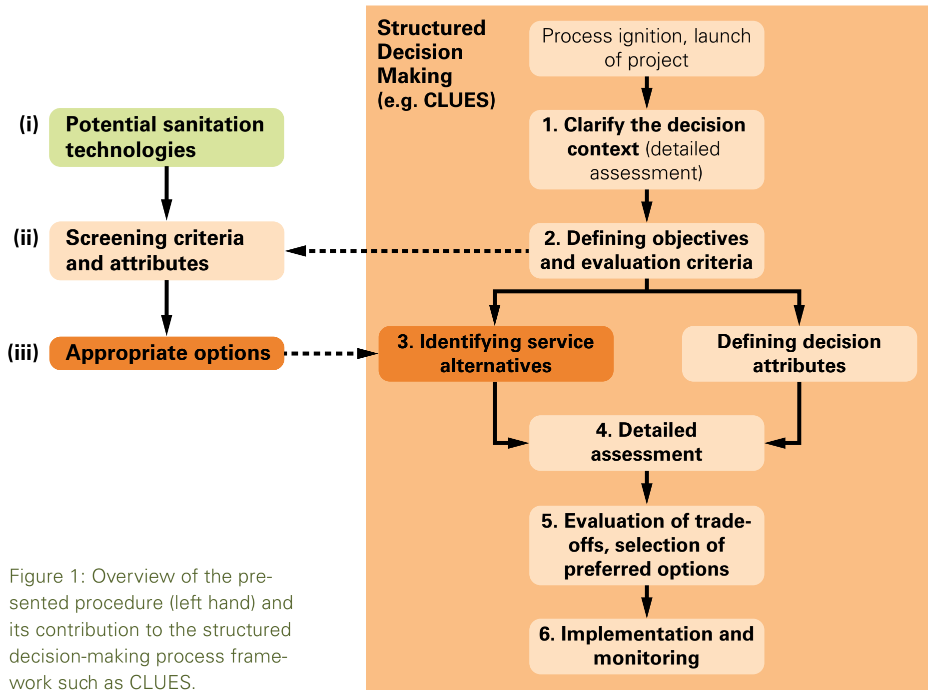

Figure 1: Overview of the presented procedure (left hand) and its contribution to the structured decision-making process framework such as CLUES.

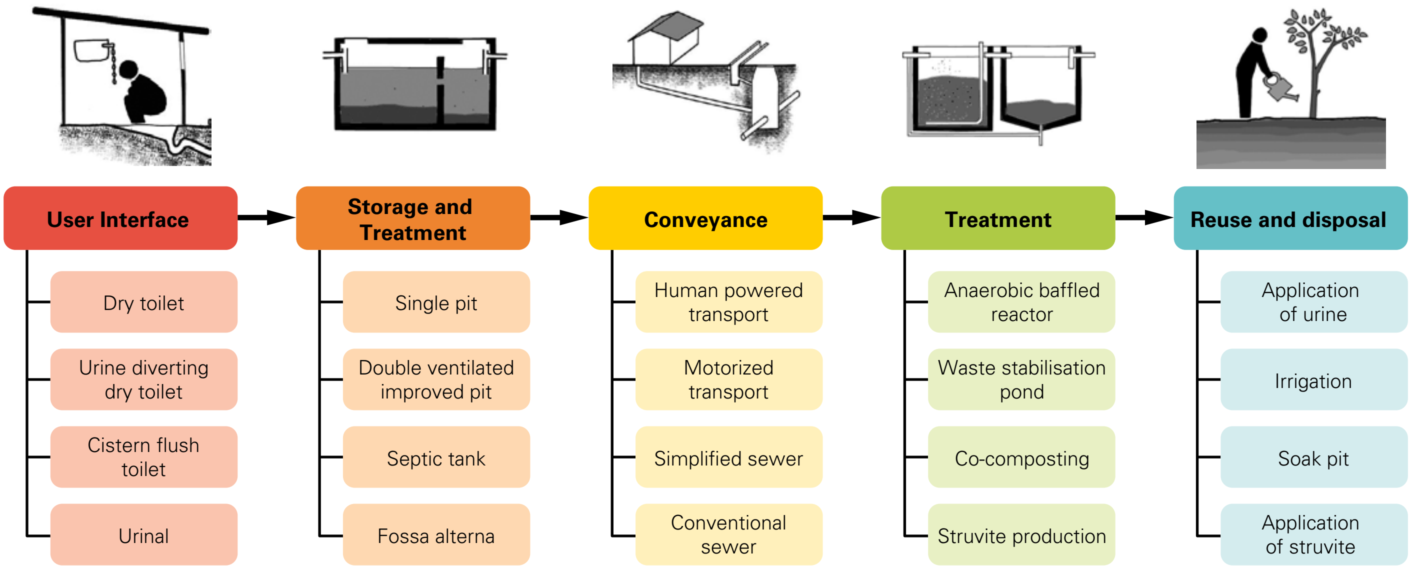

Figure 2: Examples of technology options along the sanitation chain. (Icons: [6])

tions because of the uncertain nature of the available information. For example, the performance of a special type of composting toilet at a certain temperature could be described by a function which shows a maximum of 100 % performance at around 20 °C and then decreases in efficiency as temperatures increase. The temperature in a given case could be presented as a normal distribution with minimum, maximum and mean annual values. By overlapping these two functions, a score between 0 (no compatibility at all) and 100 % (full compatibility) can be obtained.

Woze and Mehal Ketema Neighbourhoods in Arba Minch

The method was tested in two neighbourhoods of Arba Minch (a small town in Ethiopia) in collaboration with the Department of Water Supply and Environmental Engineering at the University of Arba Minch. As the list of all potential TechOps is very long (e.g. [2]), the procedure was only tested for a smaller set representative of a broad range of conventional and novel technologies (Figure 2). The screening criteria and attributes were identified in a workshop with local stakeholders and included legal, physical, technical, environmental, demographic, and to some extent socio-cultural aspects.

The results indicate that TechOps with low resource requirements (e.g. water, energy, or frequency of maintenance) scored higher. Examples include dehydration vaults, simplified sewers, human-powered transport, or co-composting. Technologies relying on pits for infiltration or storage (e.g. dry pit latrine or soak pit) have a lower flooding tolerance (e.g. drying bed), and rank lower in both neighbourhoods. The ranking varied between the two neighbourhoods, showcasing the model's sensitivity to different case conditions. Mehal Ketema is at the centre of the town and has a comparatively high population density, lower area availability, and higher water availability and consumption due to hotels and institutions. Woze is at the town outskirts, with mainly single floor residential buildings. Consequently, cistern flush toilets received a score 0 in Woze, while they had a relatively good score in Mehal Ketema (0.84).

A rapid sensitivity-check indicated that the number and nature of attributes highly influences the final outcome. It was found, for instance, that the more attributes used, the more similar are the scores, making it difficult to differentiate among them. Also, some attributes might strongly impact the results, and some involve trade-offs and, thus, should be evaluated based on stakeholder preferences at later planning stages. Therefore, it is important to select screening attributes with the local stakeholders who have a good understanding of the procedure, and to reduce the set of attributes to only the most relevant.

Conclusion

Our procedure can reduce the large number of available technology options to a small, and yet appropriate, set of options in a systematic way. It streamlines the planning process, enhances transparency, and contributes to the implementation of appropriate and eventually more sustainable sanitation options. This method also has the potential to overcome several gaps in current sanitation planning practices. It explicitly looks at the entire sanitation chain in the local context; it can systematically consider a broad range of technology options, including novel and conventional technologies; and it can work with uncertain information, the kind of information that is very prevalent in initial planning phases, i.e. information of newly developing urban areas or about novel technologies.

As this approach is generic, it can also be applied to other types of systems (e.g. solid waste) or application cases. However, its application requires a good understanding of sanitation technologies and is complex and time consuming. The procedure is being further developed to overcome these issues.

[1] Maurer, M., Bufardi, A., Tilley, E., Zurbrügg, Ch., Truffer, B. (2012): A compatibility-based procedure designed to generate potential sanitation system alternatives. Journal of Environmental Management *104*, 51–61.
[2] Tilley, E., Ulrich, L., Lüthi, C., Reymond, P., Zurbrügg, Ch. (2014): Compendium of Sanitation Systems and Technologies – 2nd revised edition. EAWAG, Dübendorf, Switzerland.
[3] SuSanA (2008): Towards more sustainable sanitation solutions – SuSanA Vision document, Sustainable Sanitation Alliance.
[4] Zurbrügg, Ch., Bufardi, A., Tilley, E., Maurer, M., Truffer, B. (2009): Decision-making for sanitation systems. Sandec News No. 10, 20–21.
[5] www.tinyurl.com/eawag-grasp
[6] Conradin, K., Kropac, M., Spuhler, D. (Eds.) (2010): The SSWM Toolbox. seecon international gmbh, Basel, Switzerland. URL: http://www.sswm.info.

[1] Eawag/Sandec, Switzerland
[2] BOKU University, Austria
Contact: dorothee.spuhler@eawag.ch