Decision-Making for Sanitation Systems

This Eawag project addresses the various decision-making aspects in sanitation system and technology selection as a support tool for choosing the best available options to secure sustainable sanitation systems.

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A sanitation system is a complex combination of technologies to treat human waste from its source of generation to its final reuse or disposal point. Selecting a sanitation system is not an easy task. In the past, the choice was tackled rather simplistically by using a top-down approach. Experts decided on the best sanitation system, the local authority was put in charge of its implementation and the target population was told how to use and what to pay. This type of supply-driven sanitation has led to frequent failures and is one of the reasons why the situation worldwide has not progressed as anticipated.

From a decision analysis viewpoint, selecting an appropriate and sustainable sanitation system and its corresponding technologies is a complex and multiple criteria group decision-making problem.

This brief article presents the activities of the WISDOM (Wastewater Infrastructure Systems DecisiOn Matrix) project involving: (i) collecting and structuring existing knowledge on Sanitation Systems (SanSys) and (ii) developing an approach that can be used to generate, evaluate and compare different SanSys alternatives. The method developed should:

- Use existing literature and expert knowledge on SanSys
- Evaluate the suitability of potential SanSys alternatives in a local context
- Consider the preferences of the different stakeholders, such as SanSys users and authorities
- Apply a multiple criteria approach to compare and rank the different feasible SanSys alternatives by assessing the different technical, economic, social, environmental, and institutional criteria
- Be flexible enough for application to various cases

The definition of SanSys alternatives relies on the classification of the SanSys into 'inputs & products', 'function groups' and 'technology options' (Fig. 1). Each system comprises different technologies capable of carrying out different functions for specific waste products. The products used in this work comprise human waste (urine, faeces) along with anal cleansing materials and the water to transport the waste. Depending on the technologies, greywater and stormwater may be co-treated along with the other aforementioned waste. The list of technology options in Fig. 1 is not necessarily exhaustive but is shown to illustrate the structural concept of SanSys.

Each SanSys alternative comprises one choice of technology at the "User Interface" and a maximum of one (i.e. one or none) technology option for each of the other SanSys functions and waste products. Thus, a first step in structuring alternatives is to determine all compatible combinations. These can then be depicted by a compatibility matrix to gain further knowledge on compatibility relationships between the different technology options.

The compatibility relationship between two technology options following each other must be understood as the possi-

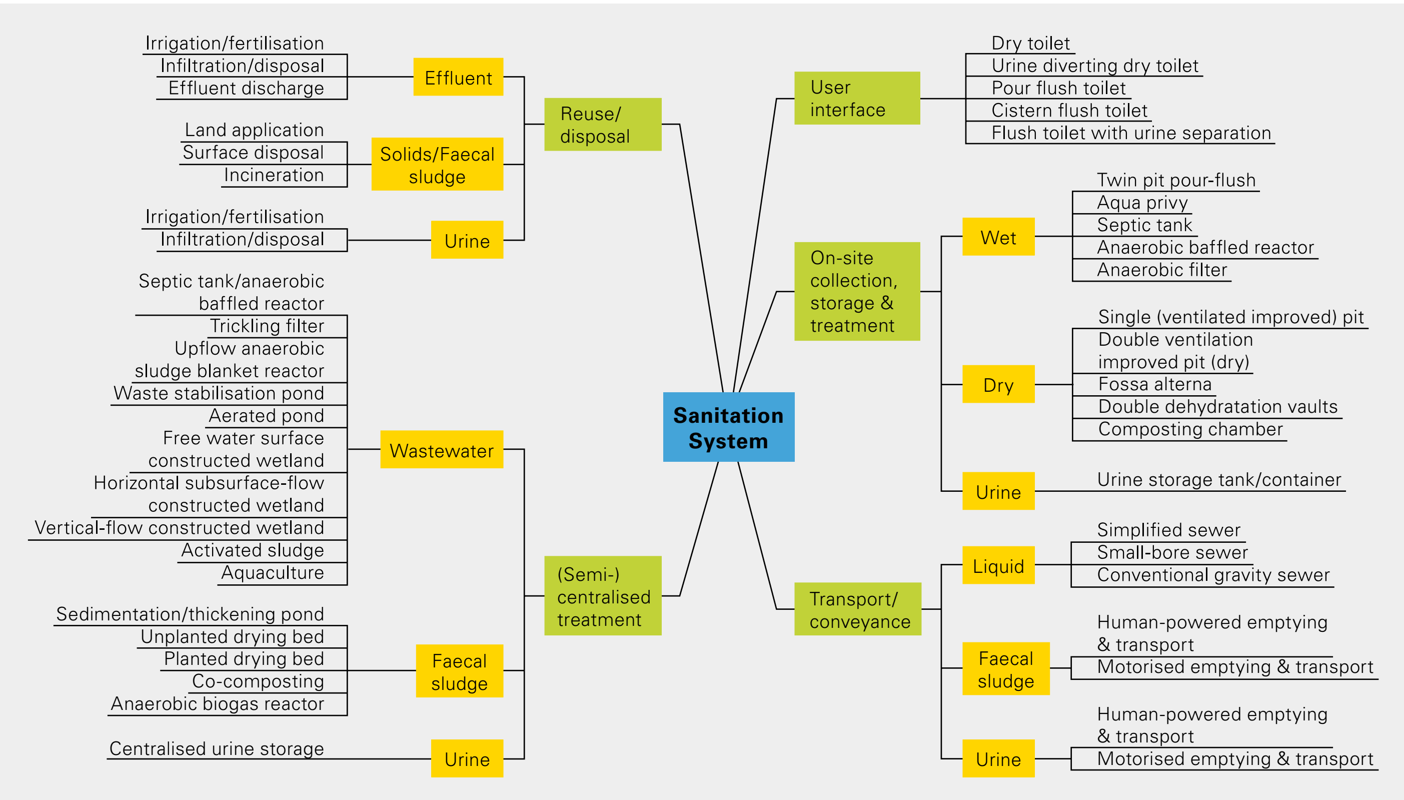

Figure 1: SanSys functions and technology options.

bility for the two options to coexist in the same SanSys. Two options are said to be compatible if at least one output from one of the two options can become an input of the other option. For example, the urine diverting dry toilet (User Interface Technology) is compatible with the urine tank/container (on-site collection, storage and treatment technology) as urine, which is an output of the urine diverting dry toilet, is also an input for the urine tank/storage container.

Once compatibility between technologies is established, the next step is to conduct a feasibility assessment based on case-independent attributes (e.g. land or amount of water required in order for this system to actually work), and set attributes as a function of the main characteristics of the application case (e.g. how much land or water is available in our specific application case).

Sustainability of SanSys alternatives is accounted for through consideration of the economic, environmental, social, technical, and institutional dimensions. To obtain predefined lists of criteria, the dimensions are classified into categories subsequently divided further into aspects, which are then broken down into criteria. For example, a dimension of the SanSys alternative selection problem is the environment. In the environmental dimension, a category can be natural resources. Within the category "natural resources", the energy consumption is an aspect and within this aspect "total non-renewable energy consumption" is identified as a criterion. The procedure for using these criteria is: (i) to select relevant criteria from the environmental, social, technical, institutional, and economic dimensions specific to an application case and (ii) weigh these selected criteria.

Seven main aspects are considered to represent a SanSys application case (Fig. 2).

The aspects can be categorised differently, however, their use in the feasibility assessment approach remains the same. In most cases, since the strategy of information gathering is not geared towards applying the feasibility assessment procedure as developed in WISDOM, a significant amount of necessary data is lacking.

By applying the procedure on, for the example, the Chang'ombe settlement in Tanzania, it was possible to generate the following four diverse generic SanSys alternatives with multiple options per selected generic alternative:

1. Single pit dry system with (semi-)centralised treatment of faecal sludge
2. On-site dry system with land application of compost/ecohumus
3. On-site urine diverting dry system
4. Hybrid pour-flush toilet system

If all potential technology combinations of the different generic alternatives are taken into account, the resulting SanSys alternatives total 198 according to the list of technology options in Fig. 1. None are very expensive or highly water-intensive.

Certain attributes can negatively impact the feasibility of some SanSys alternatives: depth of groundwater table, proneness to flooding, water availability, and availability of skilled personnel. However, the negative impacts can be overcome if additional measures are adopted. A high groundwater table and proneness to flooding may be surmounted if the pit latrine alternative is adapted by raising the mounds for pits. Also the lack of available water, which influences the choice for pour-flush toilets, may be offset provided additional investments are made to bring the water to Chang'ombe; a technically feasible solution. For SanSys alternatives requiring skilled staff, the problem of limited skilled personnel can be solved through education, training or by involving external specialists, particularly for design tasks. Consequently, since all 198 SanSys alternatives resulting from the four generic SanSys alternatives are regarded as either feasible or almost feasible, they can all be considered further in the decision-making process. However, analysing the required measures as preconditions for sustainability and their potential for implementation and success allows to reduce the 198 potential alternatives to about six to eight feasible SanSys options.

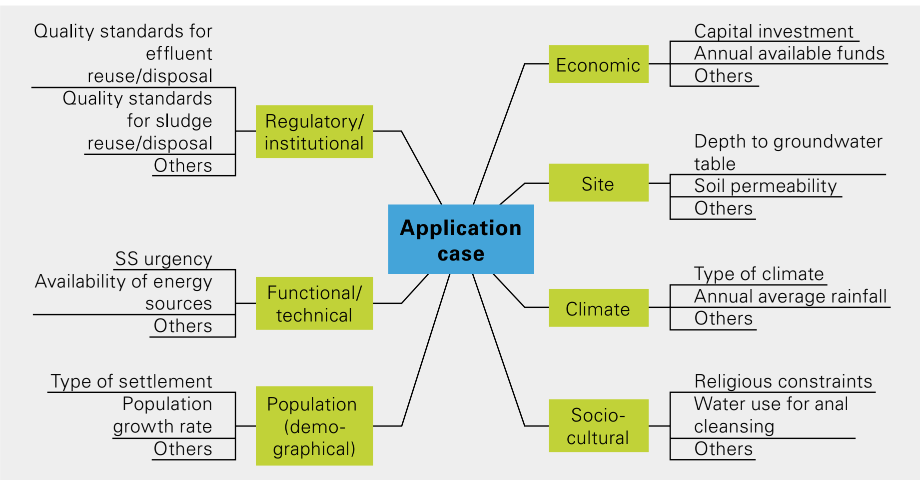

Figure 2: Application case aspects.

Conclusions

Despite its importance, the problem of generating appropriate alternatives is often neglected in the decision analysis literature. In WISDOM, this is achieved in three steps: (i) identification of all possible SanSys alternatives, (ii) determination of potential SanSys alternatives among all possible SanSys alternatives and (iii) determination of feasible SanSys alternatives among potential SanSys alternatives.

A lack of specific information often prevents planners from making a comprehensive feasibility assessment of the potential SanSys alternatives. The work conducted highlights the importance of developing assessment protocols and questionnaires for collection of information relevant to the evaluation of the different SanSys and attributes of the application case. Collection of data on different aspects of the application case needs to be planned properly. It is therefore advisable to develop questionnaires based on the relevant application case and SanSys attributes to allow collection of as much relevant information as possible for the feasibility assessment procedure.

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