sustainable sanitation alliance

SuSanA – factsheet

Operation and maintenance of sustainable sanitation systems

Version 2 (December 2010)

Key messages

1. Operation and maintenance (O&M) is of paramount importance for the durable implementation and function of sanitation systems, however it is often neglected.
2. Level of O&M is highly linked to ownership of a facility and the basic understanding of the technology and its functions.
3. Every technology that is implemented in a sanitation system requires proper O&M to function.
4. Different technologies at different steps of the sanitation chain need different people and different responsibilities for O&M.
5. Institutional responsibilities as well as effective mechanisms for cost recovery are needed to ensure sustainable O&M.

Aims of this factsheet

The aims of this factsheet are to introduce possible concepts of O&M for sustainable sanitation systems and to show successful implemented examples for O&M.

The target group for this fact sheet consists of sanitation practitioners, researchers and policy makers, as well as of development practitioners who are less familiar with the topic of O&M of sanitation systems. Readers are also referred to the factsheets of other working groups of SuSanA, e.g. costs and economics, productive sanitation systems.

Introduction

Appropriate sanitation facilities can provide critical improvement in community health, education, poverty and many other interlinked issues. However, maximum benefits will only be achieved when the sanitation facilities operate continuously and at full capacity in conformity with acceptable standards of quantity and quality. Accordingly, O&M tasks must be carried out effectively and efficiently.

In practise, O&M of sanitation systems receives less attention compared to the design and construction phases, or it is even completely neglected. Especially in developing countries, O&M of decentralised sanitation systems is neglected to a great extent. Among the consequences are poor or non-functioning systems that damage the environment and people's health. Without proper O&M, well designed and nicely constructed infrastructure will sooner or later break down.

Reasons for non-functioning O&M

The reasons for non-functioning O&M services range from a lack of ownership or delegated responsibility for O&M, or a lack of skilled labour, and high operating costs to excessive repair and replacement expenses. Additionally, the technical options chosen are not always the best suited to the environment in which they shall be operated. Other reasons are closely related to the set-up of projects, which often focus only on construction of hardware instead of software components, because it is simpler and less time consuming. Consultation with the local stakeholder and users regarding the most appropriate system for the local conditions is often low.

In most cases where the provision of sanitation services has failed, the root causes have been poor management, lack of planning and failure to generate revenue sufficient to operate and maintain systems (Bräustetter, 2007).

It is obvious the "*efficient and effective management of the system is most essential for their proper functioning*" (Oldenburg, et al., 2009). It is therefore indispensable that O&M of sanitation systems has to be seen in a holistic conceptual framework of sanitation planning. Tasks and responsibilities have to be made abundantly clear and divided among the involved actors/stakeholders e.g. between the municipality, CBOs, users and the private sector. Thus governments and external support agencies are starting to recognize the importance of integrating O&M components in all development phases of water supply and sanitation projects (Brikké and Bredero, 2003).

What is O&M?

Operation & Maintenance (O&M) in general refers to all activities needed to operate, maintain and manage a sanitation system, including the collection, transport, treatment and reuse and/or final disposal of the different sanitation products. Sanitation systems are defined according to the SuSanA WG4 Fact Sheet "Sanitation systems and technology options" (Zurbrügg et al., 2009) and to the "Compendium of Sanitation Systems and Technologies" (Tilley et al., 2008).

According to Sohail et al. (2001), operation refers to the daily activities of running and handling infrastructure. It involves the technical and service activities to run the infrastructure as well as the correct handling and usage of the facilities by users. In the sanitation context, operation includes the planning, control and performance of the collection, treatment and disposal or reuse of the waste flows.

Maintenance on the other hand involves the activities required to sustain existing assets in a serviceable condition (WHO, 2000) and includes according to Brikké (2000):

- *Preventive maintenance*: Systematic routine actions needed to keep the installations and equipment in a condition that will ensure they can be operated satisfactorily, function efficiently and continuously, and last as long as possible at lowest cost.
- *Corrective maintenance*: The range of activities starts with minor repairs and replacements as dictated by the routine examinations up to corrections of serious damages and malfunctioning
- *Crisis maintenance*: Maintenance which is undertaken only in response to breakdowns and/or public complaints.

An effective and efficient operation and maintenance requires a clear organization and financial management with explicit responsibilities.

Every technology needs O&M

All technologies require some form of O&M, no matter if they are considered low or high tech. Although, it can be presumed that increased levels of complexity of a sanitation system will also increase the demand for O&M. For example, the addition of pumps and other technical devices will increase the need for regular skilled maintenance and parts replacement. However, the most important thing to keep in mind is that the whole sanitation system (Figure 1) needs to be taken into account. O&M must be considered at each functional step from the user interface to the final reuse and/or disposal of the sanitation products.

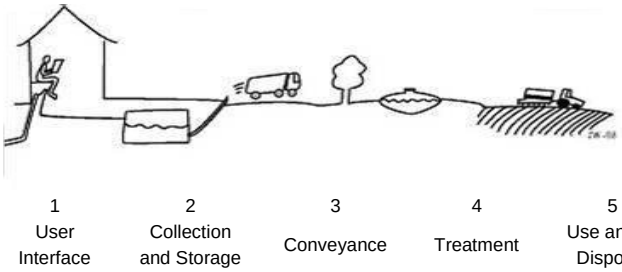

Figure 1: Representation of the five functional groups of a sanitation system. Each functional group requires O&M that must be planned for and linked to a clearly defined responsible party (Picture: Jan Wijkmark).

Planning for and implementing a functional O&M procedure requires looking at the technical and institutional needs of each step in the system. There are a variety of technologies that can be used for each functional group in the sanitation system (Tilley et al., 2008) and each of these technologies will have their own O&M requirements. For example, at the collection stage a complex vacuum toilet system would need specific O&M that would differ in technical complexity from the emptying and servicing schedules for urine-diverting dry toilets (UDDTs).

In addition, the responsibility for O&M of each functional group may be assigned to different stakeholders. For example, maintenance of the user interface is often the responsibility of the household, while the treatment process is usually run by a municipal authority. Clear delineation of O&M tasks and responsibilities is critical for achieving a sustainable system.

Independent from the technology chosen achieving proper O&M depends on integrating its requirements in the processes of planning, designing, implementation and management with particular emphasis on coordination of potential responsible parties, such as government, private agencies and residents. Of course, the selection of technical designs and supporting institutional structure must always be matched to local conditions, both with respect to technical and socio-economic feasibility and the management capacities and willingness of users and service providers (IRC, 1997).

Funding of O&M

Sustainable O&M requires planning and budgeting to carry out the necessary tasks. Who should fund sanitation O&M and how, receives far less attention than its design and construction (Sohail, 2001). Traditionally, municipalities and utilities are responsible for centralized O&M systems but research in the 1990s in India and Thailand (IRC, 1997) has already pointed

out that municipal budgets often fail to earmark funds for O&M of sanitation systems. Funds are thus rather spent on activities which are more visible than regular maintenance of existing structures. It is recommended to allocate a separate budget for routine O&M including funds which allow major replacements, upgrading and extensions. Sourcing this budget requires financial resources and clearly defined roles and responsibilities along the sanitation chain which should be defined from the planning stage.

Funding for day-to-day operation and basic maintenance (i.e. hiring a caretaker) can be sustainably sourced through revenue generating activities, as shown in the examples below,. This can be either directly or indirectly associated with the sanitation service, but needs to be clearly defined prior to implementation. Examples in this fact sheet include user fees, cost recovery through pit emptying, and total service packages. Another example comes from the Aga Khan foundation in India which assists communities in establishing shared bank accounts where community deposits funds for O&M of shared infrastructure (AKPBSI, 2007). However, crisis maintenance and large scale repairs may require substantial funding beyond day-to-day turnover and can place unrealistic demands on limited budgets. Funds are not always readily available for this, in which case microfinance institutions may be used to enable access to credit.

Responsibilities for O&M

For a well working sanitation system it is important to clarify and agree on roles and responsibilities already during the planning stage. During planning and design, division of responsibilities and definition of tasks and accountability require ample consideration and agreement between parties concerned. Creating conditions in which responsibilities can be implemented as intended may require awareness raising, motivation and incentives both for the agencies and the users (IRC, 1997).

Furthermore, the variety of stakeholders in the sanitation system goes beyond municipal responsibility alone. Small scale providers, communities and households also play an important role in O&M (Sohail, 2001). The choice of the management model is influenced by several framework conditions like capacity of community organisations, community skills, capacity of the private sector, etc. (Brikké, 2000).

In larger towns a town-wide management systems may be installed for the overall coordination of the system. In Vienna for example, a municipal department is responsible for O&M of the sewer system while a holding company operates the central treatment system through a mandate from the municipality. Decentralised systems on the other hand may have localised daily operations but should be monitored by higher level institutions. For example a school sanitation system may be managed by the school management, but monitored from a national authority.

Development of service chains in practice

The following examples describe examples of small-scale sanitation systems in which O&M works. The examples show the successful O&M can be organised in different ways.

1) The Kalungu Girls Secondary School (Uganda)

The boarding school of the “Sacred Heart Sisters” is located near Kalungu, a small rural village in Southwest Uganda. Around 450 girls between 14 and 18 years are attending the school and about 50 teachers and sisters are employed. Further staff members are responsible for diverse house keeping duties, like O&M of the sanitation system, gardening, animal keeping, etc.

The sanitation system of the school, which is in operation since 2003, consists of:

- 45 single vault urine diverting dry toilets for the pupils,
- a UDDT for teachers and visitors,
- a drying area for further dehydration of faeces,
- a horizontal sub-surface flow constructed wetland for treatment of greywater and blackwater.

A detailed description of the system is available as SuSanA case study (Müllegger et al., 2009).

Responsibilities for O&M

O&M activities are entirely managed by the school. The school administration has employed a caretaker, who is responsible for most of the O&M activities. Furthermore students are fully involved in O&M. They are organized in groups which have different tasks. They are responsible e.g. for cleaning the toilets, removing containers, and fertilization of plants. Teachers are responsible for training and awareness creation among pupils. A detailed description of the O&M responsibilities for collection and storage, pre-treatment, transport, treatment and use are given by Müllegger and Freiberger (2010a).

Income generation

Since the sanitation system has been implemented, the school became "famous" for its innovative sanitation concept. Delegations from all over the country and from abroad come to visit the school toilets regularly. The number of students increased to their maximum capacity from 350 to 450 over the last years. Furthermore the school administration even introduced an admission fee between 50.000 – 100.000 UGX (Ugandan Shillings, about 18 - 37 EUR at a rate of 2700 UGX per EUR), depending on the type of visiting delegation. That fee

is used to maintain the sanitation system, especially to keep the infrastructure in a good working condition.

Figure 2: Treatment area for faecal matter, Kalungu School, Uganda.

2) Lessons learnt from the ROSA project (East Africa)

Involvement of the private sector

Sanitation systems in which the products of the UDDTs can be treated and used on-site are the simplest examples of closed loop systems. But in many cases, like densely populated areas, storage and reuse on site is not possible so collection and transportation systems have to be implemented. Thus within the frame of the ROSA project (Langergraber et al., 2010) one focus of research was on O&M of resources-oriented sanitation systems. The main goal was to develop sustainable O&M management strategies for peri-urban areas. The following is a summary of the research results from Nakuru (Kenya) and Arba Minch (Ethiopia). More information on O&M research in ROSA is available in Müllegger and Freiberger (2010b).

Willingness to pay

During a baseline study carried out in Nakuru the results showed that 86 % are interested to use UDDTs if they are not responsible for O&M (Muchiri et al., 2010). This figure has been confirmed later on as further results showed that stakeholders, mainly landlords and owners of UDDTs, preferred to use a private operator and were willing to pay for the service.

Collection and transport

MEWAREMA (Menengai Waste Recyclers Management), a local CBO in Nakuru, is engaged in solid waste collection and composting and offers services for collection, transportation and composting of faeces and urine in a fee ranging from 100 - 300 KES (Kenyan Shillings, i.e. 1 - 3 EUR at a rate of 100 KES per EUR), depending on the amount to be collected and distance of transport.

In Arba Minch the 'Wubet le Arba Minch' Solid Waste Collectors Association is engaged in transporting and treating human faeces and urine. About 50 % of households that currently have a UDDT make use of collection service. The users are paying between 5 and 40 ETB (about 0.3 - 2 EUR at a rate of 18.5 ETB per EUR), depending on the amount of urine produced and distance to the composting site. The main problem is the urine transportation because of the large volumes produced.

Figure 3: Donkey cart for faeces and urine transportation in Arba Minch, Ethiopia.

In both towns the collected material is transported by using donkey carts.

Treatment and reuse

In Nakuru, the collected material is co-composted with organic waste at the dump site in Nakuru and afterwards sold to NAWACOM. NAWACOM is an umbrella NGO for local CBOs involved in composting. They buy the compost from local producers, further process the material, pack it and sell it as “Mazingira organic fertilizer” to farmers. Trials to increase the nitrogen content by adding urine during the composting process are on-going at Egerton University.

In Arba Minch the faeces and urine are used for co-composting by the 'Engan New Mayet' Compost Production Youth Association. Since no local market existed, at the start of the project demonstration plots were installed to convince farmers to use faecal compost and the compost was given to them for free. However, since the beginning of 2010 faecal compost have been sold for 0.01 EUR/kg at a market centre.

Financial considerations and up-scaling

The main challenge in involving private businesses is to make the business profitable. In Nakuru and Arba Minch existing

companies involved in solid waste transport have been involved in O&M services. This reduced the financial risk for the companies compared to new companies that would be needed for a business only offering services for UDDTs. Grambauer (2010) made a business plan for MEWAREMA in Nakuru and concluded that the emptying of UDDTs can be profitable only if a minimum number of costumers or UDDTs to be served is exceeded. However, this minimum number is dependent on the specific local boundary condition and can not be generalized.

3) The "*Sanitation as a Business*" program (Malawi)

The "*Sanitation as a Business*" program of *Water For People*, as described by Bramley and Breslin (2010) aims to combine the provision of new toilets with the O&M business for the sanitation system. The business concept starts with the household purchasing a composting toilet on loan from a sanitation entrepreneur. The entrepreneur constructs the toilet and afterwards collects the compost from the toilets. The household repays their loan with the compost. After the loan is repaid the household receives small, regular payments for their compost.

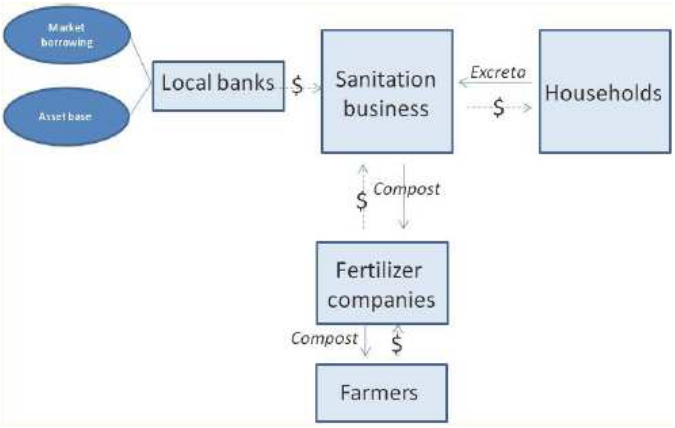

Figure 4: The rural "*Sanitation as a Business*" model in Malawi (Bramley and Breslin, 2010).

The entrepreneur further treats the compost and finally sells it to farmers, thus creating income. The main aim of the entrepreneur is selling the final product, i.e. compost. Therefore they have to make sure that the toilets are producing their raw product in a good quality, i.e. that the households are using the toilets in a right way and that they are properly maintained. The sanitation entrepreneur wants to attract large-scale compost buyers and thus needs to find new customers, i.e. builds new toilets on a loan basis as described above.

4) Institutional management of condominial sewers, Brasilia, Brazil

Since 1993 the federal district of Brazil (pop. 2.1 million) has been implementing condominial sewerage systems as a low-cost means of achieving universal sanitation coverage. These simplified sewerage networks serve more than 650,000 people and have been built in the city of Brasilia, as well as the surrounding peri-urban neighbourhoods and satellite cities. The basic function of the condominial sewers is to collect mixed wastewater from homes and transport it to a centralized treatment plant. Household connection pipes are grouped into block sewers before they feed into street sewers which are then pumped to treatment plants. The system is cheaper than conventional sewerages since pipe sizes are smaller and sewer laterals are installed under sidewalks or yards instead of streets (Melo, 2006).

Figure 5: Condominial Box, Riacho Fundo, Brasilia (Melo, 2006).

The initiative for construction and expansion of the condominial sewerage system came from the Brasilia Water and Sewerage Company (CAESB) with the strong support of the local authorities. CAESB is responsible for construction and maintenance of water and sewerage systems within the city, as well as the wastewater treatment plants. CAESB oversees all activities related to planning and implementation of the systems, including organizing neighbourhood meetings and establishing an elected body of residents responsible for facilitating agreements and inspecting the works. Once the system is in place responsibility for maintenance of the branch pipes is divided between the users and the utility.

Households are offered three alternatives for routing the branches of the condominial sewers: through the backyard, front yard or sidewalk. The backyard and front yard options are cheaper to construct, but also mean that responsibility for maintenance of that part of the system falls on the household. Users opting to assume maintenance responsibility of their connection receive a 40% discount on the standard user fees. The remainder of the network is the responsibility of the utility.

In practice there was one inspection box installed for each connection to the network which allowed for easy access for monitoring and removal of blockages. Comparison of the condominial and conventional sewerage networks in Brasilia found that there were fewer maintenance incidents per

customer for the condominial system. It is speculated that this is because the condominial branches are less prone to obstruction or that users are better placed to resolve simple blockages on their own. Success of the condominial system in Brasilia is also due to the ability of the utility company to make firm policy decisions and clearly communicate them to their customers.

5) Utility served public toilet in Naivasha; Kenya (Onyango and Rieck, 2010)

The provision of public toilets at markets, bus stops and other public places in Kenya was and still rests with the responsibility of municipal councils and the corresponding Ministry of Local Government. The use of the toilets is usually free of charge. It was noticed over the years that the quality of services was generally very poor and insufficient in terms of daily cleaning (e.g. littering of human waste) and maintenance (no repairs, broken water supply etc.). One of the main reasons why municipal council did not shown any interest in these facilities seems to be the lack of revenue that could be used to cover costs for O&M. In response to this lack of services, the newly structured and reformed water sector with the Water Services Trust Fund (state cooperation) has started to provide financial support for improved access to water and sanitation in areas without adequate services.

The Naivasha public toilet was financed by the Water Services Trust Fund, and is then owned by the public Regional Water Services Boards and run by the local water services provider (privatised water utilities). The utility has contracted a private operator to run and operate the toilet on a day-to-day basis.

Figure 6: The café that uses biogas for cooking is located adjacent to the public toilet (Onyango and Rieck, 2010).

The operator generates revenue on the basis of user fees (pay-per-use) and other incoming generating activities as designated in the service contract. Currently an average of 300 people uses the toilet and about 200 customers are buying 200 jerry cans of water from the attached water kiosk. The operator is obliged to pay for water bill (a subsidised water tariff), sewer, energy, rent and other expenses like toiletries as well as minor repair works. The earnings and the expenditures made by the operator show that two permanent staff can be employed to run the facility. At the same time the utility receives revenue through the water tariff, rent and limited biogas sales which are sufficient for maintaining and monitoring the facility over its life cycle. Hence this service model of shared responsibilities, with operation being carried out by private entrepreneurs and maintenance taken care of by utilities seems economically viable and promising in terms of good quality of service delivery.

6) Sustainable sanitation in Kyrgyzstan, Central Asia

From 2006 to 2008, a consortium of four Kyrgyz NGOs supported by WECF implemented the project "*A sustainable decentralized wastewater management for Kyrgyzstan*" to demonstrate sustainable sanitation solutions and to establish starting conditions for nationwide introduction of sustainable sanitation in Kyrgyzstan (Jorritsma, 2009). Three methods were used to achieve this goal: (1) knowledge transfer and gathering of practical experience, (2) construction and monitoring of demonstration objects, and (3) creating publicity and tools for up-scaling. The project focused on demonstrating, testing, and monitoring.

Barriers and level of acceptance

The following indicators were used to analyse reasons for acceptance or non-acceptance of the UDDTs:

- smell prevention,
- who constructed the toilet,
- who was trained,
- number of vaults for storing faeces,
- financial contribution of UDDT owner, and
- groundwater table.

Handling urine and faeces, and applying them to plants that will be eaten proved to be an idea most people met with much scepticism. People were especially reluctant to apply them to edible plants because of health and hygiene reasons. In some cases, women were reluctant because they would have to clean a UDDT. Many pit latrines are never cleaned – the idea to have to clean a toilet at all created rejection from these women.

Lessons learnt

This study showed that successful implementation of UDDTs required not only good technical quality of the construction but also adequate knowledge transfer and participation of owners and users. The following points have to be addressed:

1. *Training and support of the users by experts*: Proactive support of users in O&M is needed. Odour has been shown to be the most problematic issue regarding acceptance of the

UDDTs.

2. *Involvement and feeling of ownership for the toilet owners*: The decision to construct a UDDT for the household should be taken by wife and husband together. Households should significantly contribute both with labour and materials. Given the difficult economic situation, a system for financial support is needed. Micro-credit and revolving funds are a practicable option.

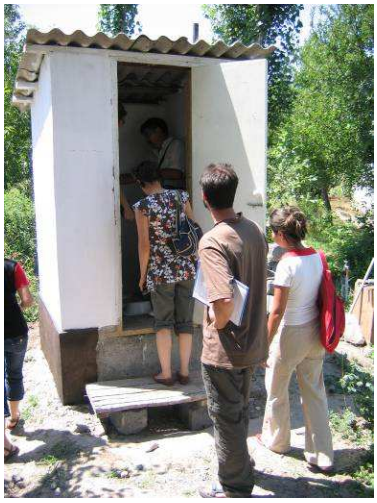

Figure 7: Training for users on O&M of a UDDT in Kyrgyzstan (Photos: M. Samwel).

Figure 8: Demonstration field for the reuse of human urine in Kyrgyzstan (Photos: M. Samwel).

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