sustainable sanitation alliance

SuSanA factsheet

Operation and maintenance of sustainable sanitation systems

July 2011

Key messages

1. Operation and maintenance (O&M) is extremely important for the sustainable implementation and long-term function of sanitation systems, however it is often neglected.
2. The 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 chain 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 concepts of O&M for sustainable sanitation systems and to show implemented examples of O&M with their strengths and weaknesses.

The target group for this factsheet are practitioners, researchers and policy makers as well as development practitioners who are less familiar with the topic of O&M of sanitation systems. Readers are also referred to the factsheets of other related working groups of SuSanA, such as the working groups on "Costs and economics", "Food security and productive sanitation systems" and "Sustainable sanitation for schools"[1].

Introduction

Appropriate sanitation facilities can provide critical improvements in community health, education, poverty and many other interconnected 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. Therefore, O&M tasks must be carried out effectively and efficiently.

Sadly, O&M of sanitation systems usually receives little or no attention unlike the design and construction phases. Particularly in developing countries and countries in transition, O&M of decentralised sanitation systems is neglected to a great extent. As a consequence, poor or non-functioning sanitation systems may pollute the environment and damage people's health. Without proper O&M, even well designed and constructed infrastructure soon breaks down.

Reasons for non-functioning O&M services

The reasons for non-functioning O&M services include lack of ownership or delegated responsibility for O&M, lack of skilled labour, high operating costs, 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 and management components. This is because it is simpler and less time consuming. Consultation with the local stakeholders and users regarding the most appropriate system for the local conditions is often not taking place sufficiently.

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 sufficient revenue to operate and maintain systems (Bräustetter, 2007).

It is obvious that the efficient and effective management of the system is most essential for its 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 very clear and divided among the involved stakeholders e.g. between the municipality, CBOs (Community-based Organisations), users and the private sector. Governments and external support agencies need to recognise 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, reuse or final disposal of the different sanitation products. Sanitation systems are defined according to the "Compendium of Sanitation Systems and Technologies" (Tilley et al., 2008).

[1] See www.susana.org/working-groups



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 excreta or wastewater flows.

Maintenance on the other hand involves the activities required to sustain existing assets in a serviceable condition (WHO, 2000) and includes three types 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*: This 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 or public complaints.

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

Every technology needs O&M

All technologies require some form of O&M, no matter if they are low or high tech. It can generally 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 issue 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 or disposal of the sanitation products.

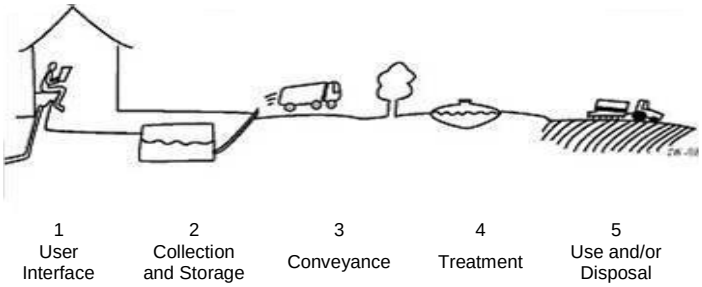

Figure 1: Representation of the five functional groups of a sanitation system. Each functional group requires O&M that must be planned for and linked to a clearly defined responsible party (picture: Jan Wijkmark).

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 diversion dehydration toilets (UDDTs).

In addition, the responsibility for O&M of each functional item may be assigned to different stakeholders. For example, maintenance of the toilet (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 of 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 users. The selection of technical designs and supporting institutional structures 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).

Figure 2: Two staff members from a service provider are emptying the faeces vaults of household UDDTs in Ouagadougou, Burkina Faso (source: Sandrine Tapsoba, 2009)[2].

Funding of O&M

Sustainable O&M requires planning and budgeting to carry out the necessary tasks. Decisions on who should fund sanitation O&M and how, receives far less attention than design and construction activities (Sohail et al., 2001). Traditionally, municipalities and utilities are responsible for the O&M of

[2] More photos from this project which was funded by the EU, and link to SuSanA case study see: http://www.flickr.com/photos/gtzecosan/sets/72157625719409533/with/5364060126/



centralised wastewater treatment 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 line for routine O&M including funds for 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 factsheet 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 the community members deposit 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 high 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, there are more stakeholders in the sanitation system beyond the municipality. Small scale providers, communities and households also play an important role in O&M. 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. In Vienna (Austria) for example, a municipal department is responsible for O&M of the sewer system while a holding company operates the central treatment plant 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 by a national authority.

Development of service chains in practice

The following examples describe the set-up for O&M for some small-scale sanitation systems to demonstrate how 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 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 housekeeping duties, like O&M of the sanitation system, gardening, animal keeping, etc. A detailed description of the system is available in a SuSanA case study (Müllegger et al., 2009).

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

- 45 single vault urine diversion dehydration toilets (UDDTs) for the pupils,
- One UDDT for teachers and visitors,
- One drying shed for further dehydration and storage of faeces,
- One horizontal sub-surface flow constructed wetland for treatment of greywater and blackwater.

Responsibilities for O&M activities

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 organised in groups which have different tasks such as cleaning the toilets, removing containers from the UDDT vaults and fertilising 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).

Figure 3: Drying shed for faecal matter from UDDTs at Kalungu School, Uganda. The caretaker has to take the containers with faeces from the UDDTs to this shed (source: EcoSan Club, 2009).

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, are coming to see the school toilets. The number of students increased to their maximum capacity from 350 to 450 over the last few years. Furthermore, the school administration even introduced a visitor's fee of 20 to 40 EUR, depending on the type of visiting delegation. This fee is used to maintain the sanitation system.

2) Lessons learnt from the ROSA project funded by the EU (East Africa)

Sanitation systems in which the products of the UDDTs can be treated and used on-site are the simplest examples of closed loop systems. However in many cases, like densely populated areas, storage and reuse on site is not possible, therefore 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 (ROSA stands for "Resource-Oriented Sanitation concepts for peri-urban areas in Africa").

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) and also in the SuSanA case studies on the ROSA project.[3]

Willingness to pay

A baseline study carried out in Nakuru showed that 86% of the surveyed residents are interested to use UDDTs if they do not have to be 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 this service.

Collection and transport, involvement of the private sector

MEWAREMA (Menengai Waste Recyclers Management), a local CBO in Nakuru, is engaged in solid waste collection and composting. They offer services for collection, transportation and composting of faeces and urine for a fee of 1 to 3 EUR depending on the amount to be collected and distance of transport. This fees is per trip or per emptying event and is negotiated with the clients.

However, this excreta collection system is currently not in place anymore. Due to various reasons, MEWAREMA stopped offering sanitation services, leaving behind toilet owners who do not know what to do with the full containers in their single vault UDDTs. The follow-on project from ROSA (called CLARA and also EU funded) will attempt to improve the situation and will look for sustainable solutions to have at least a working emptying service in place.

[3] There are 12 case studies on the ROSA project in Kenya, Ethiopia, Uganda and Tanzania: http://www.susana.org/case-studies (enter "ROSA" into the search field). Three of these case studies are about installations in Nakuru: http://www.susana.org/library?search=nakuru

In Arba Minch ROSA has constructed and supported seven Arborloos, 15 UDDTs, and 30 Fossa Alterna toilets for households by 2010. Two solid waste collection association - the "Wubet le Arba Minch Solid Waste Collectors Association" and the "Engan New Mayet Compost Production Youth Association" - are engaged in transporting and treating human faeces and urine by using donkey carts. About 50% of households that currently have a UDDT make use of the collection service. The users are paying 0.3 to 2 EUR per trip or emptying event, depending on the amount of urine produced and distance to the composting site. The main problem is the cost of the urine transportation because of the large volumes produced.

Treatment and reuse

In Nakuru it was planned that the collected material is co-composted with organic solid waste at the dump site and afterwards sold to NAWACOM, 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 fertiliser" to farmers. However, as NAWACOM has general problems to create a market for organic fertiliser, they refused to buy faecal co-compost due to hygienic reasons. Within the frame of the CLARA project it is planned to develop a concept for the co-composted material, for example working together with tree nurseries.

Figure 4: Sieved co-compost at the composting station of "Engan New Market Compost Production Youth Accociation" in Arba Minch, Ethiopia, ready to be used in the tree nursery or sold as organic soil conditioner (source: EcoSan Club, 2009).

In Arba Minch the faeces, urine and organic solid waste is 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. Since the beginning of 2010, faecal compost has been sold for 0.01 EUR/kg at a market centre. The service provider is collecting faeces, urine and organic solid waste to produce compost for his own tree nursery and a small-scale vegetable farm.

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 UDDTs to be served is exceeded. This minimum number is dependent on the specific local boundary conditions and cannot be generalised.

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 systems. The business concept starts with the household purchasing a "composting toilet" (Fossa Alterna or UDDTs) on loan from a sanitation entrepreneur. The entrepreneur constructs the toilet and afterwards collects the compost or dried faeces 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.

The entrepreneur further treats the compost and finally sells it to farmers, thus creating an income. The main aim of the entrepreneur is selling the final product, i.e. the compost. Therefore he or she has 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 the right way and that the toilets are properly maintained. The sanitation entrepreneur wants to attract large-scale compost buyers and thus needs to find new customers, i.e. build new toilets on a loan basis as described above.

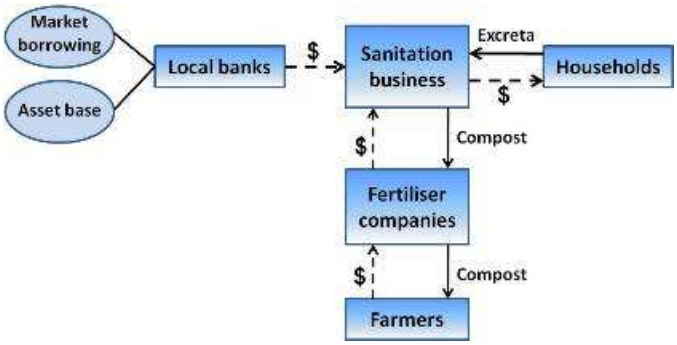

Figure 5: The rural "Sanitation as a Business" model in Malawi (Bramley and Breslin, 2010).

4) Institutional management of condominial sewers, Brasilia, Brazil

Since 1993 the federal district of Brasilia (population of 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 centralised 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 sewerage since pipe sizes are smaller and sewer laterals are installed under sidewalks or yards instead of streets (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 organising 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.

One inspection box was 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 (CAESB) to make firm policy decisions and clearly communicate them to their customers.

5) Public toilet served by privatised water utility in Naivasha, Kenya

The provision of public toilets at markets, bus stops and other public places in Kenya is under the responsibility of municipal councils and the corresponding Ministry of Local Government. The use of the toilets is usually free of charge. The quality of services is generally very poor and insufficient in terms of daily cleaning and maintenance, resulting in odour, dirty toilets, no repairs, broken water supply pipes etc.

One of the main reasons why municipal councils do not show any interest in these facilities is the lack of revenue that could be used to cover costs for O&M. In response to this problem, the newly structured and reformed water sector with the Water Services Trust Fund has started to provide financial support for improved access to water and sanitation in areas without adequate services (Onyango and Rieck, 2010).



Figure 6: Naivasha public toilet with water kiosk. In front is the water kiosk that functions as an operator room. Customers pay at the side window of it, where the two people stand. Behind you can see the gents section of the toilet (source: C. Rieck, 2008)[4].

The Naivasha public toilet was financed by the Water Services Trust Fund, is 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. The public toilet consists of flush toilets connected to a biogas plant which discharges the pre-treated wastewater to a sewer.

The operator generates revenue via user fees (pay-per-use) and other income generating activities as designated in the service contract. Currently about 300 people use the toilet per day and about 200 customers per day are buying 200 jerry cans of water from the attached water kiosk.

The operator is obliged to pay for the water bill (a subsidised water tariff), sewer discharge fee, energy, rent and other expenses like toilet paper as well as minor repair works. The earnings and the expenditures made by the operator allow the employment of two permanent staff members to run the facility. At the same time the utility receives revenue through the water tariff, rent and a small amount of biogas sales which is sufficient for maintaining the facility.

Consequently this service model of shared responsibilities, with operation being carried out by private entrepreneurs and maintenance under the responsibility of utilities seems economically viable and promising in terms of good quality of service delivery.

6) Sustainable sanitation in Kyrgyzstan, Central Asia

In 2006, UDDT technology was introduced in Kyrgyzstan to establish starting conditions for nationwide introduction of sustainable sanitation in Kyrgyzstan (Jorritsma et al., 2009). Since then, more than 100 individual UDDTs have been installed in different parts of the country. The methodology was as follows: (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 projects focused on demonstrating, testing, and monitoring.

The barriers and level of acceptance were analysed two years after the start up and the following indicators were identified to be crucial for acceptance or non-acceptance of the UDDTs (Jorritsma et al 2009):

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

Many critical issues related to O&M do not become apparent in the first years of an implemented project but rather much later, sometimes after the project monitoring is finished.

In some families in Kyrgyzstan, women were reluctant to embrace the new sanitation system because it requires regular cleaning. They had previously never cleaned their pit latrines – the need to clean the UDDT had to be well explained in awareness raising campaigns and trainings.

The handling of urine and faeces by the household for the application to plants provoked some scepticism. People were especially reluctant to apply the UDDT products to edible plants because of perceived health and hygiene reasons. The local NGO could solve these problems by raising more awareness for the reuse aspects and by organising a farmer who was willing to take the toilet products.

Figure 7: Cleaning a UDDT in Stara Zagora, Bulgaria (source: WECF, Margarita Torres).

After working 5 years one success factor for O&M could be clearly identified: The Kyrgyz NGO KAWS worked together with existing community based water users unions (CDWUU) in each village which supported the introduction and up-scaling of sustainable sanitation from the beginning. The CDWUU provide the trained expert staff that helped people construct

[4] For more photos of this project see: http://www.flickr.com/photos/gtzecosan/sets/72157623254082278/with/4918863019/



their own toilet. They have a pump and offer the service to pump out the urine from the tanks and apply it on the fields. They also offer the service to maintain the toilet facility.

The urine diversion seat most commonly used is made of concrete and must be re-painted from time to time. Also if there is a smell problem, the staff members from the CDWUUs are able to diagnose the root cause of the problem and solve it. For all these services, they require a small fee to cover their costs. Even poor people pay these fees to have a well maintained toilet. Some CDWUUs started recently to construct resource centres in the villages where they can even better support the construction and the O&M of the sanitation facilities.

Such an institution which is accepted and recognised by the community and which assists with the O&M tasks, ensures the long term success of sustainable sanitation.

Figure 8: Inspection of the faecal chambers of a UUDT school toilet block in Nizhyn, Ukraine, constructed by the local NGO Mama86 (source: WECF, Claudia Wendland).

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