Monitoring & Evaluation of decentralised wastewater treatment projects in Tanzania

M&E of the technical, social, financial and institutional performance of project areas for the UNEP-UNHABITAT-BORDA Project:

"Demonstration of decentralised wastewater projects in non-sewered areas of Dar es Salaam"

L. D. Bernado, L. Bright-Davies, E. Schoell, J. Camargo, A. Wolf, E. Rodriguez, N. Reynaud, P. Siemsen

One of the decentralised wastewater treatment systems visited in Dar es Salaam: BORDA office

Table of Contents

Executive Summary

This report provides the M&E results of 24 wastewater treatment systems: 15 located in Dar es Salaam and 9 located in other regions (Iringa, Dodoma, Kilimanjaro and Arusha). Out of 24 treatment systems, 21 are decentralised, 2 are centralised and 1 is a Faecal Sludge Treatment plant (FSTP). Two data sets were collected during dry and rain seasons to compare the behaviour and performance of these treatment systems during different seasons. The systems were selected through criteria defined by BORDA and approved by stakeholders. BORDA also developed the method of data collection, by using their 'Global Monitoring Forms' (GMF), which comprises four sections; Baseline survey, Field survey I - Observation questions, Field survey II - Interview questions and Field survey III - Analysis questions. Financial, operational & maintenance, social and design & construction aspects related to each system were assessed. Analysis methodology was based on sustainability criteria for small-scale sanitation systems. Nine (9) Statements of Change (SoC) have been identified as crucial for the comprehensive evaluation of decentralised wastewater treatment projects. We assume that those are equally suitable to a variety of small-scale sanitation systems beyond DEWATS (Decentralised Wastewater treatment System). These statements of change reflec target project impacts (SoC 1-3), the essential elements for successful governance of community scale sanitation (SoC 4-8) and direct project outputs (SoC 9). More details of the duration of the data collection, people involved in the monitoring and evaluation campaign, and the methodology used can be found in Chapter 1-3 of this report. In Chapter 4, each statement of change (SoC) is introduced and analysed. First, the evaluation structure is shown for the particular SoC. Second, two pie charts for the first and second site visit are shown with the distribution of average SoC scores. Details on objectives, priority indicator and parameter results, are shown in Chapter 6. A conclusion of the report is drawn in Chapter 5

By comparing the performance of centralised and decentralised systems, it has found that the dilutions of rain and storm water to the ponds lead to a semingly better performance of the centralised systems during the rainy season. Regular O&M activities for most systems seem to be an issue, this could be either a lack of knowledge on day-today activities related to regular changes of the management entity (m.e) and the employees or financial constraints of the owners. Lack of proper tools for O&M activities and project/treatment system documents was also observed as a challenge for most visited sites. All decentralised wastewater systems were in a good physical condition, but small cracks in the building structure or manhole cover where usually found. However, they do not affect the performance or safety of the system. There were not much differences in the overall performance of the decentralised systems. However, regular O&M training workshops, a budget for conductiong O&M activities and a proper operation of the treatment systems are crucial factor for the sustainability of the implemented decentralised wastewater treatment projects in Tanzania.

Abbreviations

ABR	Anaerobic baffled reactor
AF	Anaerobic filter
BGD	Biogas digester
BOD_5	Biological oxygen demand
BORDA	Bremen Oversea Research and Development Association
CCBRT	Comprehensive Community Based Rehabilitation in Tanzania Hospital
COD	Chemical oxygen demand
CW	Constructed Wetland
DAWASA	Dar es Salaam water and sewerage authority
DAWASCO	Dar es Salaam water and sewerage corporation
DEWATS	Decentralised wastewater treatment system
DO	Dissolved oxygen
DUWASA	Dodoma urban water and sewerage authority
FSTP	Faecal sludge treatment plant
HHE	Health Hygiene Education
HQ	Head quarter
HRT	Hydraulic retention time
ISF	Institute for Sustainable Futures
IST	International School of Tanganyika
KCH	Kibosho Council Hospital
m.e.	Management entity
M&E	Monitoring and Evaluation
MoWI	Ministry of Water and Irrigation
NM-AIST	Nelson Mandela African Institution of Science and Technology
O&M	Operation and Maintenance
PPE	Personal protective equipment
SME	Small medium enterprises
SoC	Statement of Change
SS	Settleable solids
ST	Septic Tank
TSS	Total suspended solids
TBS	Tanzanian Bureau of Standards
UASB	Upflow anaerobic sludge blanket
VGF	Vertical Gravel Filter
VSF	Vertical Sand Filter
WWSP	Wastewater stabilization pond

1 Introduction

1.1 Motivation

Dar es Salaam's population of 4.36 million (2012 Census) is growing at the annual rate of 6.63% (UN-HABITAT, 2014), meaning that the population will more than double within the next ten years. Currently less than 10% of the city is connected to a public sewer network, and more than 50% of wastewater from these sewer networks is being discharged into the ocean untreated. The remaining 90% of the population use on-site sanitation options, with more than 90% of this wastewater being discharged via soak-aways into the ground, or into storm water drainage and rivers. This lack of wastewater treatment leads to groundwater contamination, public health risks and environmental degradation. The planned extension of the centralised sewerage network and installation of advanced treatment plants by the water authority is expected to increase coverage up to 40% within the next decade. However, the city continues to expand into the surrounding areas with new housing schemes that lack essential public services.

1.2 Duration

Mission 1, Rainy season: 4th April – 19th May, 2017

Mission 2, Dry season: 11th July – 04th August, 2017

Generally, the exercise of data collection took almost 10 weeks including travel days with public holidays and weekends in it.

1.3 Members involved

Table 1: Involved members for this project

Name	Organisation	Task
Laura Bright-Davies	BORDA Africa	Project Coordination
Jutta Camargo	BORDA Africa	Regional Coordination
Eng. Leonidas D. Bernado	BORDA Africa	M&E Team, Data analysis
Eva Schoell	BORDA Africa	M&E Team, Data analysis
Dennis Wolter	BORDA Africa	Expert on Guideline Development
Eng. Frank Kibumo	TBS	Standard Officer
Rose Sachole	MoWI	Principal Laboratory technician
Alex Wolf	BORDA HQ	Data analysis
Nico Reynaud	BORDA HQ	Data analysis
Elli Rodriguez	BORDA HQ	Data analysis
Pascal Siemens	BORDA HQ	Data analysis

1.4 Purpose

This report aims to identify aspects with a greater influence on the sustainability of DEWATS projects and provide recommendations for future implementation of decentralised sanitation systems in Tanzania. To achieve these goals, following specific objectives were developed:

- To collect baseline data of existing centralised and decentralised wastewater treatment systems in Tanzania, in order to make a comparison of the system types
- To monitor the institutional, financial, social and technical performance of 24 selected systems in the Dar es Salaam, Iringa, Dodoma, Arusha and Kilimanjaro regions during the rainy and dry season.
- Compare the treatment efficiency and performance of wastewater treatment systems in the rainy and dry season.

Specifically, this report will focus on the evaluation of project outcomes and impacts in the areas of:

- Environmental health
- Improved living conditions of served communities
- Functioning technology
- Functioning maintenance
- Sustaining Demand
- Effective Management
- Sustainable Financing
- Program specific impact (BORDA's internal objective)
- Planning, design and construction during implementation (BORDA's internal objective)

2 BORDA's evaluation methodology for M&E data

The underlying methodology has been developed with experts from ISF (Institute for Sustainable Futures) and is based on sustainability criteria for small-scale sanitation systems. Nine (9) Statements of Change (SoC) have been identified as crucial for the comprehensive evaluation of decentralised wastewater treatement systems. We assume that those are equally suitable to a variety of small-scale sanitation systems beyond DEWATS. Each SoC is defined by 1 to 3 objectives, shown in Table 2. In Chapter 4, the structure of each SoC is discussed in more details. Similarly, the objectives are associated with indicators to assess performance and parameters to distinguish performance outcomes.

Table 2: Statement of Change structure

Statement of Change	Objective
1. The sanitation service maintains or improves environmental health	1.1 Effluent meets discharge standards
	1.2 Removed waste is safely disposed or reused
2. The sanitation service improves the living conditions of communities	2.1 Underserved people are connected to the sanitation service
	2.2 Potential exposure to faecal pathogens for surrounding communities is managed
3. The service achieves program specific impact	3 Sanitation service achieves intended objectives
4. Functioning Technology - systems are operating as intended	4.1 System operating as designed - acceptable loading and system hydraulics
	4.2 Systems operating as designed - treatment meets BORDA requirements
5. Functioning Maintenance - systems are maintained as intended	5.1 Systems maintained - no major damage
	5.2 Maintenance activities occurring as intended
6. Sustaining Demand - system is available, used to capacity and acceptable	6.1 Service is adequately available to users
	6.2 Utilisation rate: Service is used to capacity
	6.3 Acceptability: Culturally acceptable, users satisfied with system
7. Effective management: Existing, active and accountable management entity and operator	7.1 Active and accountable management entity
	7.2 Trained and equipped operator
8. Sustainable Financing: Sufficient ongoing income to cover all short and long term costs	8.1 Regular income
	8.2 Sufficient income to cover all short and long term costs
9. Planning, design, construction	9.1 Project design appropriate to context
	9.2 Systems built to design
	9.3 Acceptable investment cost per user

Data collection for the monitoring and evaluation of decentralised wastewater treatment systems is conducted through the following surveys:

- **Baseline survey:** This questionnaire can be completed before the site visits with information from technical drawings, fact sheets and other project related documents. Here, basic information about the project type, size, costs, users and implementer are gathered.
- **Field survey I – Observations:** The Field survey I questionnaire gathers observations about the system, which are answered in the field. It is divided into questions about the sanitation facility (just if it has been part of the project), the optical and structural appearance of the treatment system and biogas digester (just if it has been part of the project). This questionnaire was answered by the M&E team through visible site inspections.
- **Field survey II – Interview:** The Field survey II involves observations with the community. An operator and a representative of the management entity shall be interviewed. This part focuses on O&M issues like solid waste removal and repairs, financial managing, responsibilities of each representative in the system and received trainings for hand over.

- **Field survey III – Analyses:** The Field survey III monitors the treatment efficiency of each treatment module as well as gathering parameters of the final effluent. Water samples were taken on-site and analysed in the Ministry of Water and Irrigation (MoWI) laboratory. Temperature, dissolved oxygen and pH of the sample was measured, on-site, while COD, settleable solids, BOD_5 and TSS were measured in the laboratory.

3 Overview of data evaluated in this report

3.1 Site selection process

Through workshops, stakeholders were asked to come up with a list of decentralised projects throughout Tanzania, which had been in operation for at least one year. From this process, over 30 decentralised projects were proposed. BORDA shortlisted 24 projects (22 decentralised; 2 centralised) from Dar es Salaam, Iringa, Dodoma, Arusha and Kilimanjaro regions, based on the following selection criteria:
Being in operation for at least one (1 year) period of time

- Being in operation for at least one (1 year) period of time
- No single household systems
- No industrial wastewater
- Focus on decentralised treatment systems
- Treatment systems located in institutions like schools, universities, hospital or housing states

The list with the 24 projects were shared and approved by the stakeholders during the second sector-level workshop which took place at Protea Hotel in Dar es salaam on 19th of January 2017.

Despite this study focuses on decentralised wastewater treatment systems, two centralised wastewater stabilisation ponds (WWSP) were also monitored in order to compare their performance.

3.2 Sites visited

The selected systems were visited twice in April – May 2017, rainy season, and July – August 2017, dry season, as listed in Table 3 and

Table 4.

Table 3: Overview of visited sites inside Dar es Salaam including the dates of both site visits

Name of visited site	Date visited Rainy season	Date visited Dry season	Region
Majani ya chai Secondary School	04.04.2017	01.08.2017	Dar es Salaam
International School of Tanganyika (IST)	05.04.2017	27.07.2017	
Ardhi University	06.04.2017	28.07.2017	
St. Antony Secondary School	10.04.2017	31.07.2017	
Comprehensive Community Based Rehabilitation Tanzania Hospital (CCBRT)	11.04.2017	27.07.2017	
NSSF-Estates	12.04.2017	04.08.2017	
Kigamboni Faecal sludge treatment plant (FSTP)	13.04.2017	26.07.2017	
Buguruni Flour mills	18.04.2017	04.08.2017	
BORDA Office	19.04.2017	26.07.2017	
Anne Outwater	22.04.2017	28.07.2017	
Vingunguti Waste stabilization pond (WWSP)	12.05.2017	03.08.2017	
Kurasani Waste stabilization pond (WWSP)	12.05.2017	03.08.2017	
Chamazi Community	19.05.2017	02.08.2017	

Table 4: Overview of all visited sites in Irigna, Dodoma, Arusha and Kilimanjaro including dates of both site visits.

Name of visited site	Date visited Rainy season	Date visited Dry season	Region
Ruaha Secondary School	25.04.2017	12.07.2017	Iringa
Iringa girls Secondary School	26.04.2017	11.07.2017	
Kleruu Teachers College	27.04.2017	11.07.2017	
Dodoma University	29.04.2017	14.07.2017	Dodoma
St. Jude Secondary School	01.05.2017	17.07.2017	Arusha
Nelson Mandela African Institution of Science and Technology (NM-AIST)	02.05.2017	18.07.2017	
Sakila Secondary School	03.05.2017	19.07.2017	
Kibosho Council Hospital (KCH)	04.05.2017	20.07.2017	Kilimanjaro
Shokony Secondary School	05.05.2017	21.07.2017	

Figure 1 shows the year of implementation vs. the number of implemented systems. While the centralised systems have the oldest operating time of 47 years, the decentralised systems have an average operating time of three years. To cover an user spectrum as broad as possible, BORDA included as many different decentralised system types as possible, see Figure 2. Institutions such as schools, universities and hospitals account for the highest number of decentralised wastewater treatment systems installed. Figure to Figure 6 show the location of each visited site per region for Dar es Salaam, Iringa, Dodoma, Arusha and Kilimanjaro. The colour codes of the pins show the system type as in Figure 2

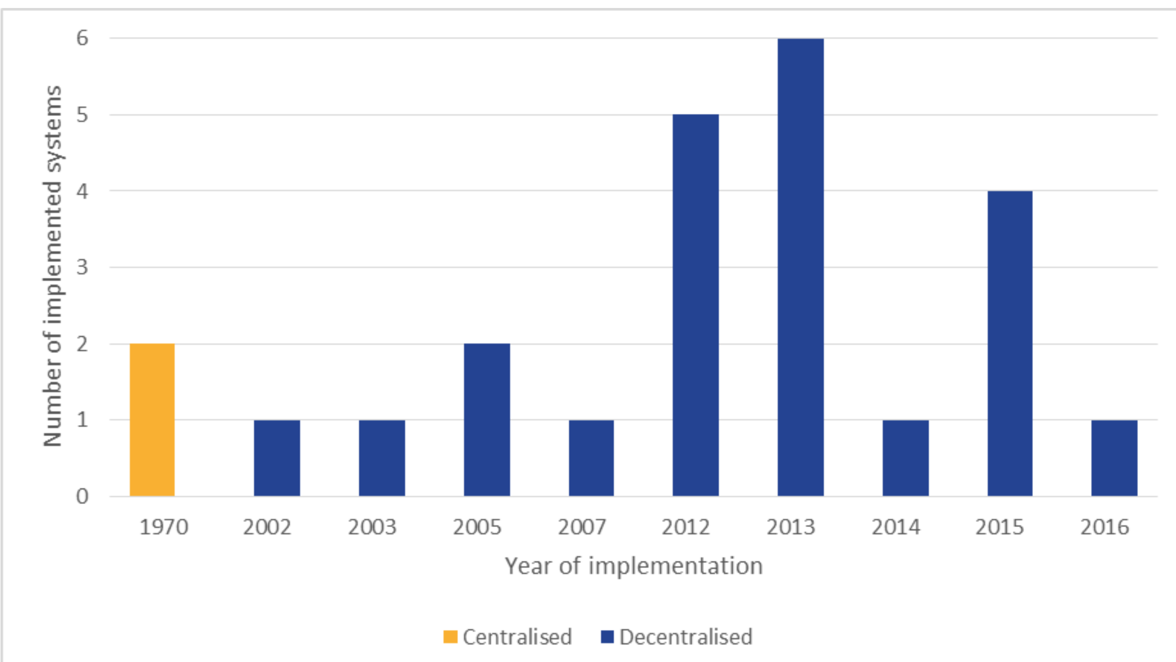


Figure 1: Year of implementation vs. Number of visited sites.

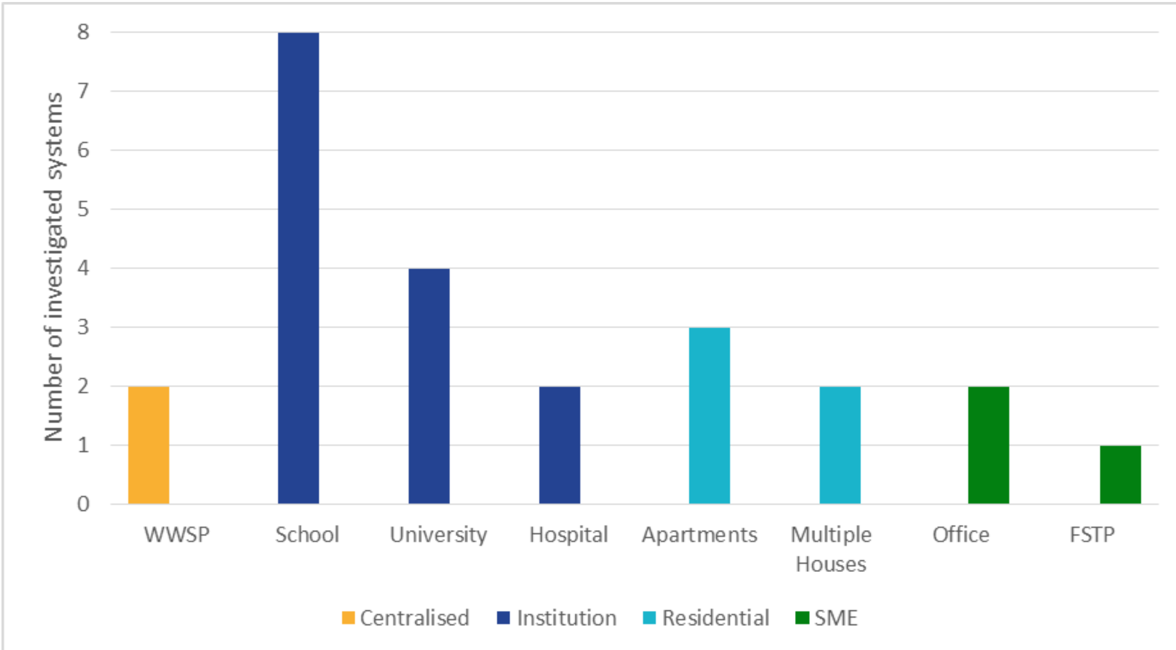


Figure 2: System type vs. number of visited systems.

Figure 3: Locations of visited systems in Dar es Salaam. Institutions (dark blue), Residential (light blue), SME (green), centralised (yellow).

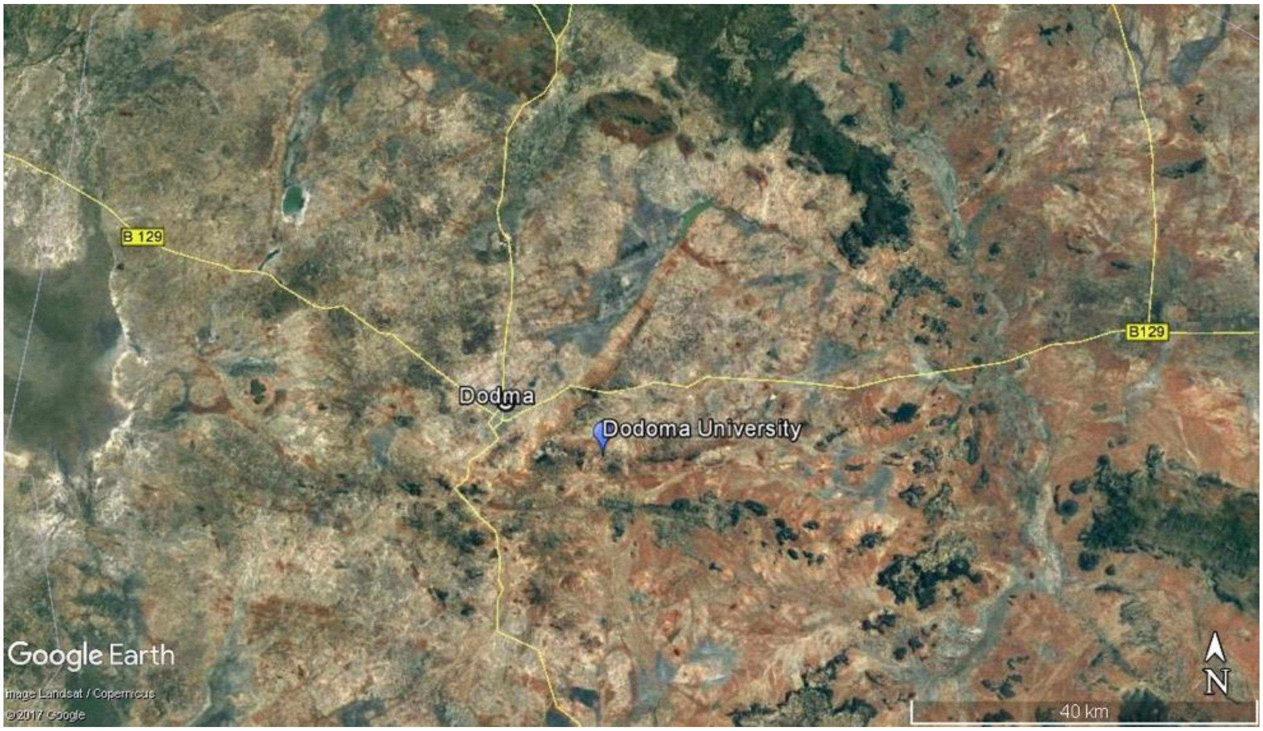


Figure 4: Location of visited system in Dodoma.

Figure 5: Locations of visited systems in Iringa.

Figure 6: Locations of visited systems in Arusha and Kilimanjaro.

4 Decentralised system analysis

In this chapter, all decentralised systems will be analysed in terms of the improvement of the environmental health, living conditions of communities as well as the elements for successful governance of community scale sanitation. For the analysis, each parameter is rated with a score from 0 to 3. The analysis of these scores leads to an overview of the performance of each statement of change (SoC) of one specific system or all decentralised systems in average. For a more detailed analysis, results for the subordinate objectives and priority indicators can be looked at in detail.

For an easier interpretation of the results scores < 1.5 are rated as “Bad” (red), scores from >= 1.6 to < 2.5 as “Caution” (yellow) and scores >= 2.5 indicate a “Good” result (green). Cases, where the data is not available are shown in grey i.e. due to a lack of information of the interviewee. Unrelevant data is is marked in white.

Bad (score < 1.5)	Caution (1.5 <= score < 2.5)	Good (score >= 2.5)	Dataset incomplete	Not relevant for project

Figure 7 and 8 show the average percentages, with standard deviation as error bars, of good, caution and bad results for each SoC.

The results can read as e.g. *“In average, across the 22 systems, 25% of the responses relevant for SoC 1 are scored with “bad”.*

In the following sections, each statement of change (SoC), introduced in Chapter 2, is analysed separately. First, the evaluation structure is shown for the particular SoC. Second, two pie charts for the first and second site visit are shown with the distribution of average SoC scores. For all details on objectives, priority indicator and parameter results, refer to Appendix X (Chapter 6).

Last, the influencing parameters, which have the worse rankings in absolute numbers (see Appendix X, Chapter 6) are listed and needed corrective actions are discussed. After the SoC analysis, the laboratory parameters are discussed in detail.

Figure 6: Average percentage of “good” (red), “caution” (yellow), “good” (green) and “data not available” (grey) results per SoC across 22 visited systems, first visit, error bars indicate standard deviation

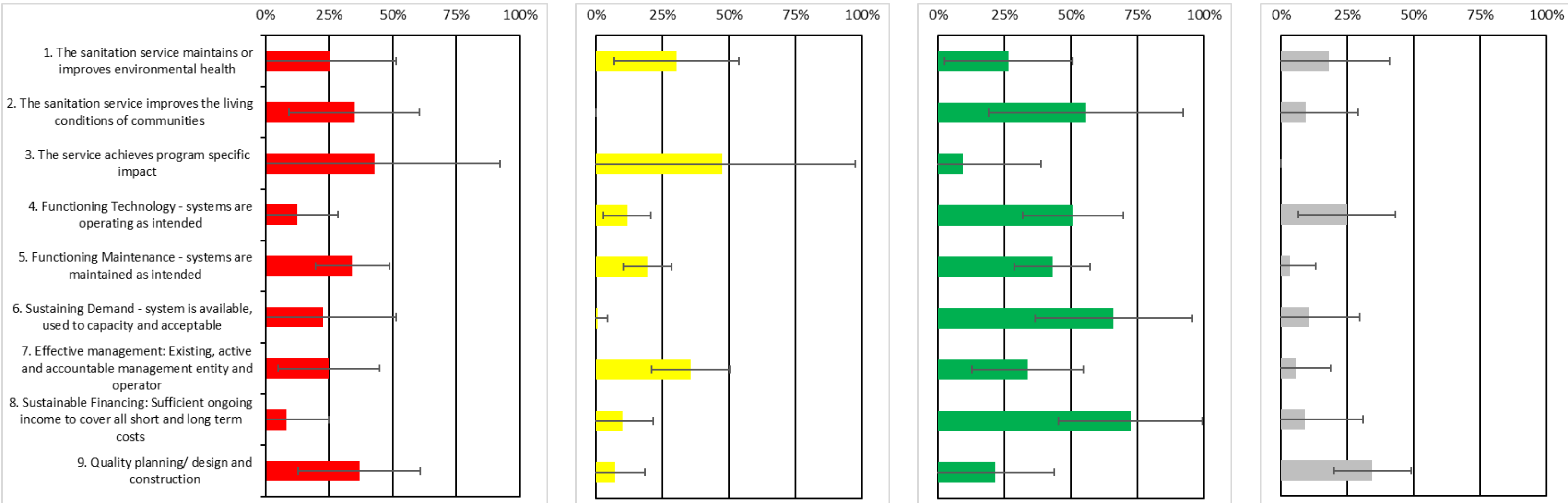
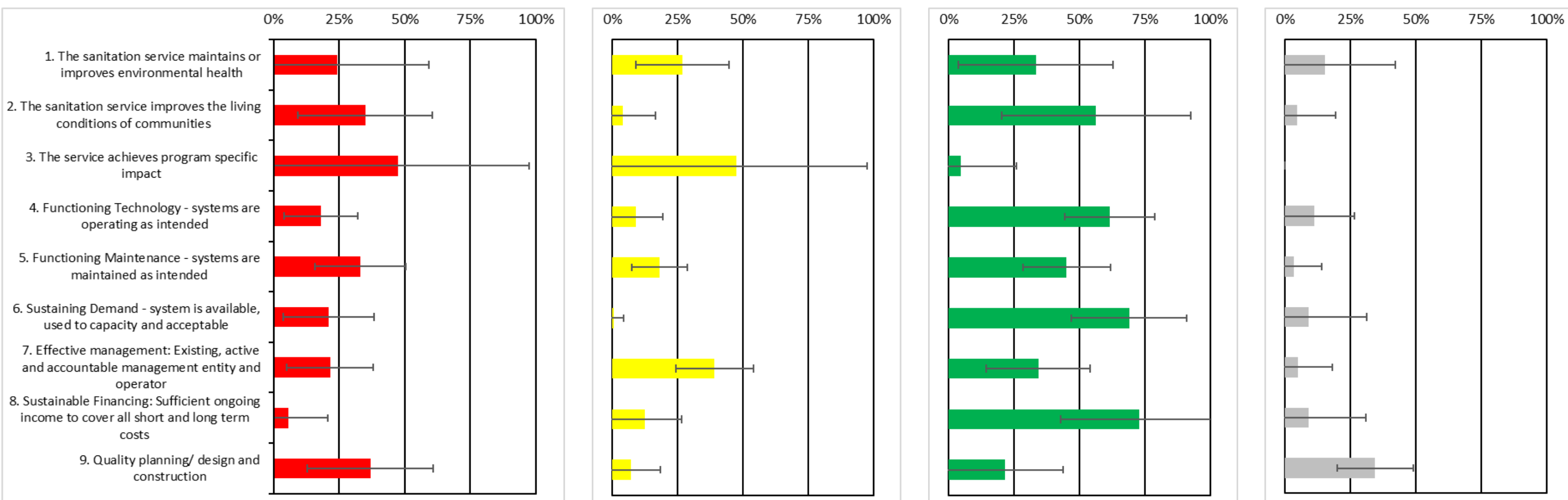


Figure 7: Average percentage of “good” (red), “caution” (yellow), “good” (green) and “data not available” (grey) results per SoC across 22 visited systems, second visit, error bars indicate standard deviation



4.1 The sanitation service maintains or improves environmental health

4.1.1 Statement of Change structure

The evaluation structure of this Statement of Change is shown in Table 5. This SoC evaluates the change in the environmental health after implementing the sanitation system. Here it is surveyed, if the systems meet local and BORDA internal discharge standards, as well as if removed waste and by-products such as sludge, scum, solid waste and biogas, are safely disposed or reused.

Table 5: Structure of SoC 1: The sanitation service maintains or improves environmental health.

Statement of Change	Objective	Priority indicators	Parameters
1. The sanitation service maintains or improves environmental health	1.1 Effluent meets discharge standards	1.1A The most recent effluent analysis complies with BORDA Standards	If data available and reliable, does the average effluent COD meet relevant BORDA discharge standards (200mg/L or 80 mg/L depending whether anaerobic or aearobic effluent)?
		1.1B The most recent effluent analysis complies with Local Standards	If data available and reliable does the average effluent, COD meet relevant local discharge standards.
	1.2 Removed waste is safely disposed or reused	1.2 Evidence that waste or by-products (sludge, scum, trash, biogas) is safely disposed or reused	Where is the sludge disposed to after desludging?
			Where is the scum disposed to after descumming?
			Where is the solid waste disposed to after removal from reactors or piping?
			For BGD, is unused biogas burned off?

4.1.2 Result overview on Statement of Change level

Figure 2 shows the distribution of average scores for SoC 1.

The incomplete data sets comes from the fact that sometimes no sample of the aerobic or anaerobic effluent could be taken, i.e. due to blockages, too little flow or the interviewed person could not provide us the information.

Bad (score < 1.5)	Caution (1.5 <= score < 2.5)	Good (score >= 2.5)	Dataset incomplete	Not relevant for project

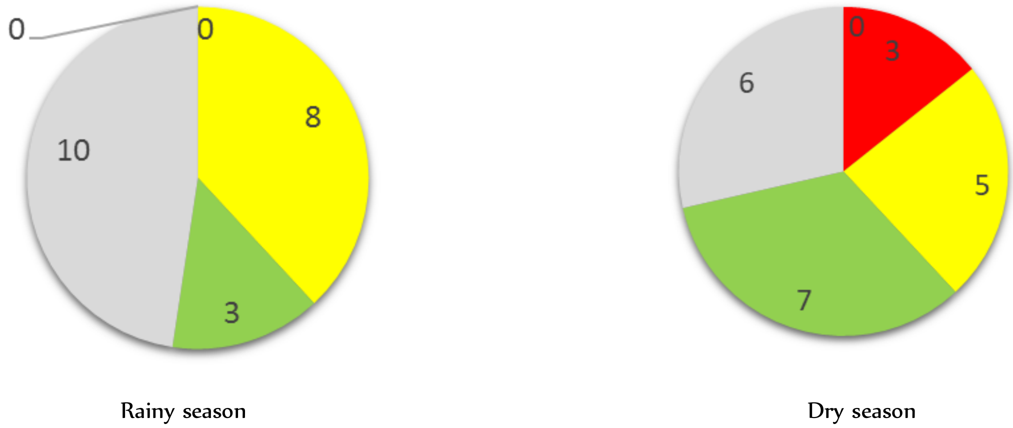


Figure 2: Pie charts with distribution of average scores for SoC 1: Environmental health for the rain season (left) and dry season (right).

For all details on objectives, priority indicator and parameter results, refer to Appendix X in Chapter 6.

4.1.3 Influencing parameters

- From all available data, 40% of the systems during the rainy season and 33 % during the dry season do not meet the Tanzanian standard. The systems are usually performing better in the dry season, as more than 50 % of the systems are within the discharge standards. During the rainy season, the hydraulic loading of the system might be higher caused by rainwater intrusion into the system. This in turns leads to lower hydraulic retention times (HRT) and therefore to shorter treatment times. Furthermore, more active bio sludge with microorganisms could be washed out.
- The solid waste, which is taken out of the system is mostly not handled properly. It's either safely stored or buried, which is acceptable but no long-term solution, or stored unburied.
- In systems, which include biogas, the gas is mostly not used but also not burned off. This causes a lower retention time in the system, as much of the biogas digester volume is occupied by the gas. As mentioned above, a reduced HRT, leads to a worse treatment performance.

4.1.4 Corrective action required for "worst impact parameters"

- More research about storm water management in small-scale decentralised wastewater treatment systems needs to be conducted. During rains in the rain season, the load can exceed the design load several times, depending on the design of the system.
- More detailed and more frequent trainings for the operators are recommended to ensure a proper and safe handling of the by-products.

4.2 The sanitation service improves the living conditions of communities

4.2.1 Statement of Change structure

The evaluation structure of this Statement of Change is shown in Table 6:. This SoC checks, if the living conditions of the severed users increases. This is i.e. influenced by the sanitation option the user had before the implementation of the system, the accessibility for elderly or disabled people and the exposure to faecal coliform to the severed users.

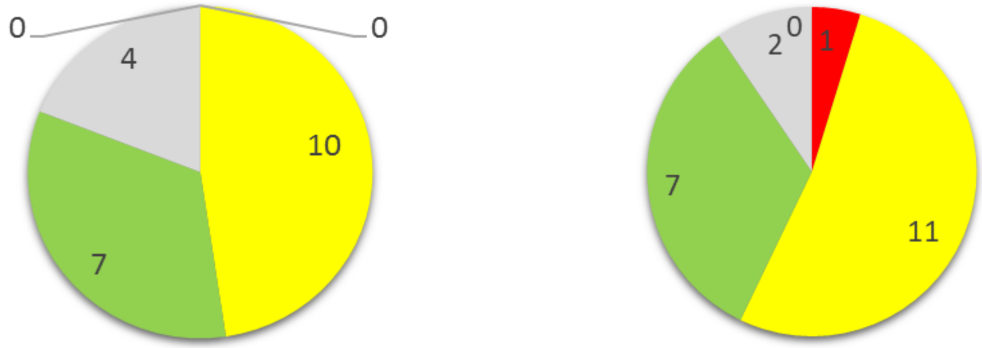
Table 6: Evaluation structure for SoC 2: The sanitation service improves the living conditions of communities.

Statement of Change	Objective	Priority indicators	Parameters
2. The sanitation service improves the living conditions of communities	2.1 Underserved people are connected to the sanitation service	2.1A Majority of sanitation users previously had no or basic access to sanitation	Before this system existed, what was the sanitation option used (or if SME, the wastewater discharge method) by the majority of users connected to the system?
		2.1B Majority of sanitation users are classified as disadvantaged (ie. Income)	What proportion of users are classified/registered as low income according to Project planning/FS?
		2.1C Unrestricted CSC access for disabled and elderly	Is access to the sanitation facility difficult or impossible for disabled/ elderly?
	2.2 Potential exposure to faecal pathogens for surrounding communities is managed	2.2 Exposure to faecal pathogens for surrounding communities is managed	Is the exposure to faecal pathogens for surrounding communities managed?

4.2.2 Result overview on Statement of Change level

Figure 3 shows the distribution of average scores for SoC 2.

Bad (score < 1.5)	Caution (1.5 <= score < 2.5)	Good (score >= 2.5)	Dataset incomplete	Not relevant for project



Rainy season   Dry season

Figure 3: Pie charts with distribution of average scores for SoC 2: Improved living condition for the rain season (left) and dry season (right).

For all details on objectives, priority indicator and parameter results, refer to Appendix X in Chapter 6.

4.2.3 Influencing parameters

- The previous sanitation option was mostly improved i.e. like sealed and functioning septic tanks.
- Only in two cases, the construction of sanitation facilities was part of the project, but those systems do not allow an easy access for elderly or disabled people as the path is either rough or has steps.
- The exposure to fecal pathogen for the surrounding communities is well managed. Only two sites during the dry season show a cautions result.

4.2.4 Corrective action required for “worst impact parameters”

- The access to the sanitation facilities should be made easier, so that elderly and disabled can use the facilities as well.

4.3 Functioning Technology - systems are operating as intended

4.3.1 Statement of Change structure

The evaluation structure of this Statement of Change is shown in Table 7. This SoC is surveying, if the system is operating as intended. Therefore, i.e. the designed and actual loading of the system and the flow of the system at the inlet and outflow are checked as well as if the effluent meets BORDA internal discharge standard.

Table 7: Evaluation structure for SoC 4: Functioning Technology - systems are operating as intended.

Statement of Change	Objective	Priority indicators	Parameters
4. Functioning Technology - systems are operating as intended	4.1 System operating as designed - acceptable loading and system hydraulics	4.1A Users within acceptable range of design	Is the utilisation (design/actual connected user) equal or above acceptable range?
			Is the intended wastewater type discharged to treatment?
		4.1B Influent flow to the treatment system is observed	Do you observe flow or signs of recent flow at plant inlet (wet piping, wet inlet chamber)?
		4.1C The system does not experience severe flow surges	Does the system experience any flow surge issues?
		4.1D Evidence of effluent flow	Do you observe flow or signs of recent flow (wet piping, etc.) at plant outlet?
	4.2 Systems operating as designed - treatment meets BORDA requirements	4.2A Anaerobic, and where applicable aerobic, effluent quality meet BORDA requirements	Does the average COD concentration of the anaerobic effluent comply to BORDA design value (200 mg/ l)?
			Does the average COD concentration of the aerobic effluent comply to BORDA design value (80 mg/ l)?
		4.2B There are obvious signs of biogas production from the biogas digester	When you open the gas valve closest to the BGD, do you hear or smell gas release?

4.3.2 Result overview on Statement of Change level

Figure 4 shows the distribution of average scores for SoC 4.

Especially during the first site visit, many data sets were incomplete. Heavy rains experienced during the site visit difficulted the water sampling. Hence, , the laboratory parameters from the effluent were not representative. Therefore, they were left out for this analysis. A more detailed analysis of the performance in rainy and dry season will be done in Section 4.9. Also during the second visit, some data could not be taken, as for example some points of the plants were not accessible.

For all details on objectives, priority indicator and parameter results, refer to Appendix X in Chapter 6.

Bad (score < 1.5)	Caution (1.5 <= score < 2.5)	Good (score >= 2.5)	Dataset incomplete	Not relevant for project

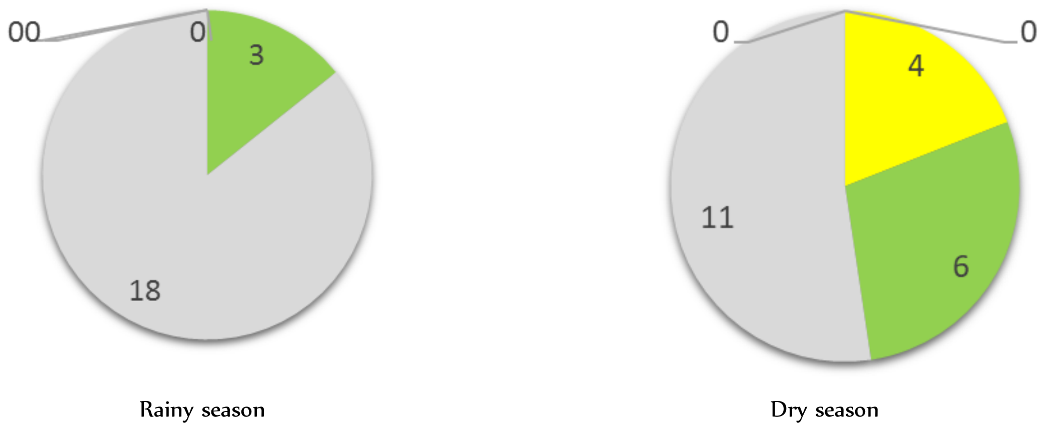


Figure 4: Pie charts with distribution of average scores for SoC 4: Functioning Technology - systems are operating as intended for the rain season (left) and dry season (right).

4.3.3 Influencing parameters

Despite data set was incomplete for most of the systems and it was not possible to make a conclusion for them, those with the complete information are performing well under this SoC.

- For only 57 % (rainy season) and 52 % (dry season) of the systems, the utilization is within an acceptable range of above 66 %. A more detailed distribution of the utilization is shown in Figure 5.
- Some systems did not show signs of flow at the inlet of the system during the first visit, mostly due to blockages, which were removed afterwards.
- Ca. 50 % of the systems show minor surge flow issues like changes during strong rains.

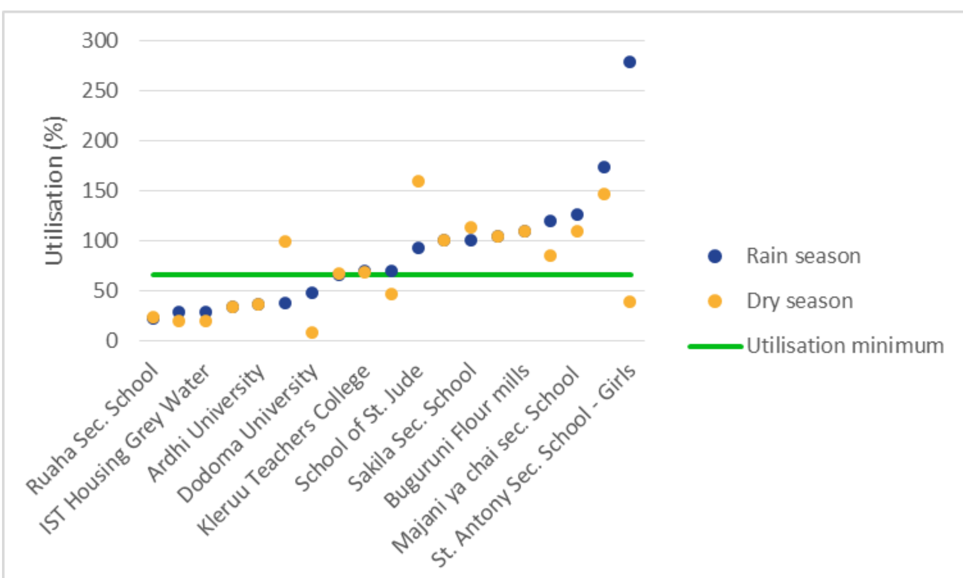


Figure 5: Utilisation in % for all systems, where the data of design and actual user number is known. The data for the rain season is shown in blue and for the dry season in yellow.

4.3.4 Corrective action required for "worst impact parameters"

- In case that the utilisation varies significantly from the design value, an adaption of the system has to be considered.

4.4 Functioning Maintenance - systems are maintained as intended

4.4.1 Statement of Change structure

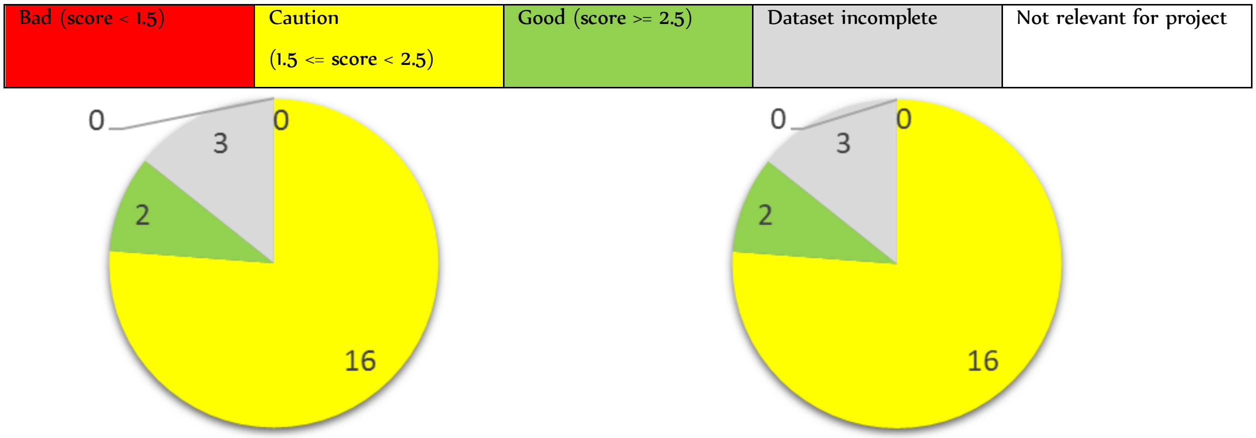
The evaluation structure of this Statement of Change is shown in Table 8. In this part, the maintenance of the system is checked. The system is checked for damages and if maintenance activities are conducted. It is asked for example, if issues with the sewer network are fixed and if the system was ever desludged.

Table 8: Evaluation structure for SoC 5: Functioning Maintenance - systems are maintained as intended.

Statement of Change	Objective	Priority indicators	Parameters
5. Functioning Maintenance - systems are maintained as intended	5.1 Systems maintained - no major damage	5.1A No signs of structural damage compromising functionality or warranty aspects	What building structure problems do you observe at treatment system (digester, settler, ABR, AF, PGF)?
			Do you observe problems with existing pumps (wastewater or water pumps)?
			What structural problems with the sanitation facility(ies) (walls, roof and floor) do you observe?
	5.2 Maintenance activities occurring as intended	5.2A Maintenance is adequate	Do you observe flow or signs of recent flow at plant inlet (wet piping, wet inlet chamber)?
			In the past, were maintenance issues with the sewer network fixed (clogging, blockage, bad smell or overflow)?
			In the past, were major issues with the sewer network fixed (broken pipes or manhole, leakages, other major damage)?
			In the past, were maintenance issues with the household grease-traps fixed (clogging, bad smells)?
			Can the manhole covers of the treatment system be opened? Please try at least 5 manhole covers. In case they were opened before the start of the field visit, please ask the m.e. or operator.
			Could a local desludging service provider access the treatment system with his cart, truck, etc.?
			Has the system been desludged?
			How thick is the scum in the second (or if too difficult to open, third) ABR chamber?
			Do you see much plastic waste (more than 20 items) inside the second (or if too difficult to open, third) anaerobic reactor chamber (can be settler, ABR or AF chamber)? (single selection)
			Do you observe problems concerning the planted gravel filter?
			What functional problems do you observe about the sanitary installations?
			Do you observe problems with the water trap?
			When you open the gas valve furthest away from the BGD (e.g. at the stove), do you hear or smell gas release?
			Is the biogas appliance working (lamp/ heater/ stove)?
			Do you observe problems with the pressure gauge?
			For BGD, is unused biogas burned off?

4.4.2 Result overview on Statement of Change level

Figure 6 shows the distribution of average scores for SoC 5.



Rainy season

Dry season

Figure 6: Pie charts with distribution of average scores for SoC 5: Functioning Maintenance - systems are maintained as intended for the rainy season (left) and dry season (right).

For all details on objectives, priority indicator and parameter results, refer to Appendix X in Chapter 6.

4.4.3 Influencing parameters

- Most systems have minor damages like small cracks in the building structure or manhole covers, which do not affect the performance or safety of the system.
- During the rainy season, three systems showed no signs of recent flow. It has to be considered, that one system of a school is barely used, as they have no fresh water supply from the municipality since six months.
- Maintenance issues (i.e. blockages) as well as major issues (i.e. broken pipes) in the sewer network were fixed on most systems, but for 16 % (rainy season) of the systems, only some maintenance issues were solved and 25 % (dry season), solved only some major issues.
- For 25 % of the systems, more than half of the manholes cannot be opened within 10 minutes each or not at all. This is due to sealed manhole covers, missing handles or missing tools to open them. In less than 50 % of the systems, all manholes can be opened. Furthermore, some systems do not have any manholes i.e. in the ABR structure.
- Most of the systems (> 80 %) which are older than three years have never been desludged. During the first visit, the interviewees replied equally, that they were not aware of the need of desludging, that the levels are too low or that there are no funds to desludge the system. During the second visit, almost 50 % of the interviewees said, that they were not aware of the need for desludging.
- 20 % of the systems allow no access to chambers, what makes removing scum and solid waste impossible. Only 15 % of the system, which can be opened show much plastic waste in the system.
- Most of the constructed wetlands are not functioning flawlessly. The problems which occur most, is stagnant water on the surface of the gravel, probably due to filter blockages. Even if there was no water stagnant on the surface, often soil could be observed between the gravel, which indicated a blockage as well. Furthermore, often dead or too many plants or old leaves.
- For only two systems the construction of sanitation facilities was part of the project. One of those shows no problems, but the other one shows many problems like missing bins, many broken or missing doors or missing HHE posters.
- The use of the biogas seems to be not so appreciated by the users. Only two of 7 systems with biogas, have functioning appliances. In the other cases, the stove is either broken, not existing or no gas reaches the appliance. Furthermore, no system burns off unused gas. As mentioned above, unused biogas accumulates in the biogas digester and displaces the wastewater. This leads to a reduced HRT and a worse treatment performance. If much gas accumulates, it bubbles out at the in- and outlet of the digester and releases into the atmosphere. Methane, which is a great fraction of biogas, is a very strong greenhouse gas. Through burning off the biogas, the methane reacts to carbon dioxide, which has a smaller impact on the greenhouse effect.

4.4.4 Corrective action required for "worst impact parameters"

- Small damages should be repaired, before they affect the system.
- To perform adequate maintenance on the systems, easy access to every part of the system is required. Therefore, proper, easy to open, manhole covers should be installed at all systems and needed tools like hooks provided. Additionally, permanently closed manhole covers should be reopened and systems with too little manholes should build more at relevant positions.
- A better and more frequent training has to be provided for the operators to make them aware of all their tasks, also the less frequent and obviously visible tasks like desludging or descumming.
- To maintain the constructed wetlands, old and too many plants have to be taken out and living plants have to be cut regularly. If there is soil between the gravel, the gravel has to be replaced or washed.
- All problems on the sanitation facilities can be fixed relatively easily and should be done to ensure privacy and hygiene.
- The biogas stoves should be repaired or installed so that the gas can be used. Otherwise, the unused gas should be burnt off at least, as explained above.

4.5 Sustaining Demand - system is available, used to capacity and acceptable

4.5.1 Statement of Change structure

The evaluation structure of this Statement of Change is shown in Table 9.

SoC 6 intends to show the adequate availability, the utilisation rate and the cultural acceptance of the system by the users. Therefore, i.e. the flow at the inlet and outlet is checked as well as the availability and use of biogas.

Table 9: Evaluation structure for SoC 6: Sustaining Demand - system is available, used to capacity and acceptable.

Statement of Change	Objective	Priority indicators	Parameters
6. Sustaining Demand - system is available, used to capacity and acceptable	6.1 Service is adequately available to users	6.1A For systems with SSS, system receives and processes wastewater	Do you observe flow or signs of recent flow at plant inlet (wet piping, wet inlet chamber)?
		6.1B For systems with CSC, ratio of users to functioning toilets is acceptable	Acceptable ratio of users per functioning toilets (20 users per toilet)
		6.1C DEWATS processes wastewater	Do you observe flow or signs of recent flow (wet piping, etc.) at plant outlet?
		6.1D For biogas systems, biogas can be used	When you open the gas valve closest to the BGD, do you hear or smell gas release?
	6.2 Utilisation rate: Service is used to capacity	6.2A Utilisation is close to full capacity (ie. actual/design users)	Is the utilisation (actual/design users) equal or above acceptable range?
		6.2B For biogas systems, biogas is used to full capacity	How often is the biogas of this system being used?
	6.3 Acceptability: Culturally acceptable, users satisfied with system	6.3A Satisfaction indicated by high utilisation or no evident issues of low acceptance	If the utilisation is below 66% design value, what are the reasons?

4.5.2 Result overview on Statement of Change level

Figure 7 shows the distribution of average scores for SoC 6.

Here, the incomplete data is caused by lacking information i.e. about the number of users connected to the system or no access to parts of the system to check the flow or production of biogas.

Bad (score < 1.5)	Caution (1.5 <= score < 2.5)	Good (score >= 2.5)	Dataset incomplete	Not relevant for project

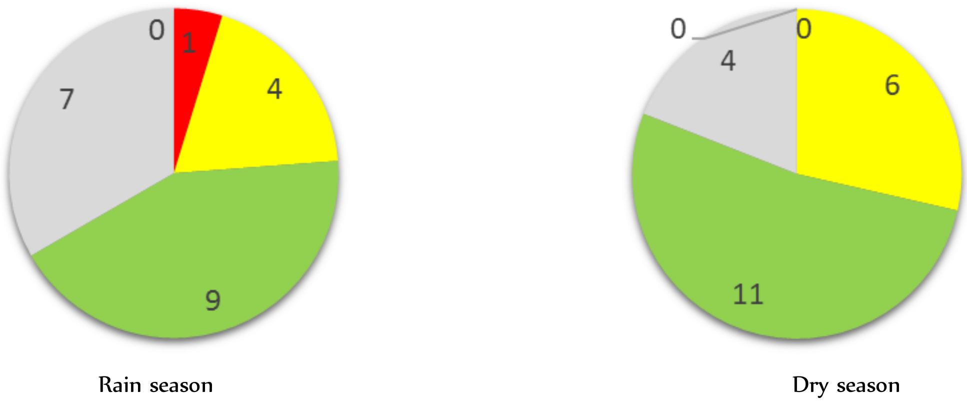


Figure 7: Pie charts with distribution of average scores for SoC 6: "Sustaining Demand - system is available, used to capacity and acceptable" for the rain season (left) and dry season (right).

For all details on objectives, priority indicator and parameter results, refer to Appendix X in Chapter 6.

4.5.3 Influencing parameters

- Three systems do not show recent flow into the system during the first site visit. This was i.e. due to blockages, which were solved at the second visit.
- Only one of the two projects, where sanitation facilities were installed as part of the project, have an acceptable ratio of users per functioning toilets (20 users per toilet). The other one, a secondary school is far below that ratio. This has two reasons, First, too little toilets were planned from the beginning and second, many are not functioning or they are having i.e. no doors.
- 3 of 18 (rain season) resp. 5 of 19 (dry season) systems which could be checked show no signs of recent flow at the outlet.
- Less than 2/3 of the systems with sufficient data have a utilisation (actual user number/design user number) of > 66 %. The distribution is shown in Figure 5. It is often difficult to influence the number of users after the construction i.e. in case of schools or universities.
- Only one system during the rain season shows indications, that it is not used due to a water cut for several months.

4.5.4 Corrective action required for "worst impact parameters"

- To ensure an adequate service for the users, O&M activities like removing blockages and repairing broken toilets must be carried out regularly.
- Available space is sometimes not ensured. Nevertheless, enough toilets, or as many as possible have to be planned from the beginning.

4.6 Effective management: Existing, active and accountable management entity and operator

4.6.1 Statement of Change structure

The evaluation structure of this Statement of Change is shown in Table 10. In SoC 7, the effectiveness of the management entity (m.e.) is surveyed. Parameters like received trainings, awareness of their responsibilities, defined O&M responsibilities and proper managing of the operator including salary, responsibilities and available tools influence this SoC.

Table 10: Evaluation structure for SoC 7: "Effective management: Existing, active and accountable management entity and operator".

Statement of Change	Objective	Priority indicators	Parameters
7. Effective management: Existing, active and accountable management entity and operator	7.1 Active and accountable management entity	7.1A Existence of trained management entity with clarified responsibilities	Does a management entity (m.e.) exist?
			Did the management entity receive the required trainings (Financial, O&M, HHE)?
			Is the management entity aware of its responsibilities?
			Does management entity have documentation of legal registration to carry out its responsibilities (e.g. officially registered with appropriate government department)?
		7.1B Management entity is active and accountable	Does the management entity meet regularly?
			Are O&M responsibilities of the operator defined and documented?
			Is the operator regularly paid an agreed salary (in cash, in kind or both)?
			Are income and/or expenses documented in financial administration logbook or elsewhere?
			Is there documentation of conducted O&M activities?
	7.2 Trained and equipped operator	7.2A Existence of trained, equipped operator who knows his responsibilities	Is there a person/caretaker/operator assigned and responsible for O&M activities? (in the following called "operator")
			Has the operator received O&M training?
			Is the operator aware of his responsibilities?
			Does the operator have all necessary tools required to perform O&M activities (opening manholes, deblocking sewer system, scum and solid waste removal from reactors)?

4.6.2 Result overview on Statement of Change level

Figure 8 shows the distribution of average scores for SoC 7.

The incomplete information is caused by the fact, that sometimes nobody from the m.e. and or the operator are available to answer the questions.

Bad (score < 1.5)	Caution (1.5 <= score < 2.5)	Good (score >= 2.5)	Dataset incomplete	Not relevant for project

Rainy season

Dry season

Figure 8: Pie charts with distribution of average scores for SoC 7: "Effective management: Existing, active and accountable management entity and operator" for the rain season (left) and dry season (right).

For all details on objectives, priority indicator and parameter results, refer to Appendix X in Chapter 6.

4.6.3 Influencing parameters

- All visited systems have an existing management entity (m.e.), but not available for an interview in one case.
- Only 25 % of the all m.e. received all required trainings. Another 40 % (rainy season) resp. 35 % (dry season) received only parts of the training. The rest received no training. Mostly the m.e. has changed since start of operation and there was no handover training given.
- 60 % of the m.e. are aware of all their responsibilities, but 40% are not aware that one of their responsibilities is managing the operator.
- In 40 % of the systems, the operator or m.e. cannot give any details about the responsibilities of the operator. Only 33 % have a written document about the responsibilities, the rest can at least give some details.
- One third of all visited systems have no operator. 70 % of those are having someone without O&M responsibilities taking care of the system. This is in many cases the gardener or security guard of the school.
- Amongst the 13 systems with an adequate operator, 8 got properly trained, the others only partially. Only 20 % of the operators are aware of all their responsibilities.

4.6.4 Corrective action required for "worst impact parameters"

- Trainings of the m.e. and the operators are crucial. They should always be conducted at least at start of operation. But also repetitive trainings are recommended, as the m.e. and operators often change.
- The role and tasks of the operator need to be defined and understood by both operator and m.e., preferably as part of the contract.

4.7 Sustainable Financing: Sufficient ongoing income to cover all short and long term costs

4.7.1 Statement of Change structure

Table 11 explains the evaluation structure of SoC 8.

Regular income and the availability of funds for regular and irregular expenses is surveyed in this part.

Table 11: Evaluation structure for SoC 8: "Sustainable Financing: Sufficient ongoing income to cover all short and long term costs".

Statement of Change	Objective	Priority indicators	Parameters
8. Sustainable Financing: Sufficient ongoing income to cover all short and long term costs	8.1 Regular income	8.1A O&M budget and/or user fees have been agreed on and are collected	Was a fixed O&M budget defined?
			Were the user fees set by local authority or agreed on by users themselves?
			Is someone responsible for the user fee collection process and is this documented?
			Are user fees collected?
			What proportion of users pay fees?
	8.2 Sufficient income to cover all short and long term costs	8.2A Regular operation and maintenance expenses (operator salary, material, equipment, electricity and water costs) are covered by income	Is the operator regularly paid an agreed salary (in cash, in kind or both)?
			Are regular expenses other than operator salaries (e.g. material, equipment, electricity, water) paid through the available income?
		8.2B Irregular expenses (replacing major parts, desludging, structural damage) are covered by income	Do solutions exist for irregular expenses in the future (replacing major parts, desludging, structural damage)?
			In the past, have irregular expenses been paid?

4.7.2 Result overview on Statement of Change level

Figure 9 shows the distribution of average scores for SoC 9.

Bad (score < 1.5)	Caution (1.5 <= score < 2.5)	Good (score >= 2.5)	Dataset incomplete	Not relevant for project

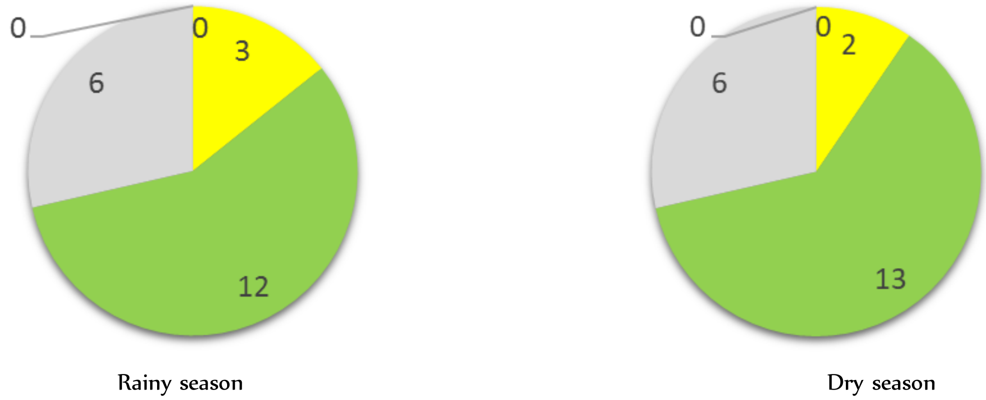


Figure 9: Pie charts with distribution of average scores for SoC 8: "Sustainable Financing: Sufficient ongoing income to cover all short and long term costs" for the rain season (left) and dry season (right).

For all details on objectives, priority indicator and parameter results, refer to Appendix X in Chapter 6.

4.7.3 Influencing parameters

- Most systems do not directly rely on user fees. Only one FSTP relies on the emptying fees and one community system with several houses connected. Here they founded a community fund, where every users contributes monthly. In all other cases, the funds come i.e. from school fees or the government.
- 67 % of the systems have a solution to cover irregular expenses in the future, like big repairs or desludging; less than 10 % have no solution (23 % of the interviewees could not provide the needed information).
- All systems could pay all irregular expenses in the past, even though only after a long wait in 40 % of the cases.

4.7.4 Corrective action required for "worst impact parameters"

- For the institutions in which most of them cost for repair and maintenance comes from government, priority on sanitation facilities has to be set. But also m.e as to set aside budget for O&M of sanitation facilities and treatment plant.
- For the other cases where by funds doesn't come from the government, particular m.e has to be trained on financial aspects before project handover. Also during project planning and implementation training on impact of financial aspects on projects, sustainability has to be discussed and agreed.

4.8 Planning, design, construction

4.8.1 Statement of Change structure

The evaluation structure of this Statement of Change is shown in Table 12.

This SoC checks, if all important planning documents are available and if the design and constructed systems match. Furthermore, the actual investment cost is compared with an acceptable investment cost per user.

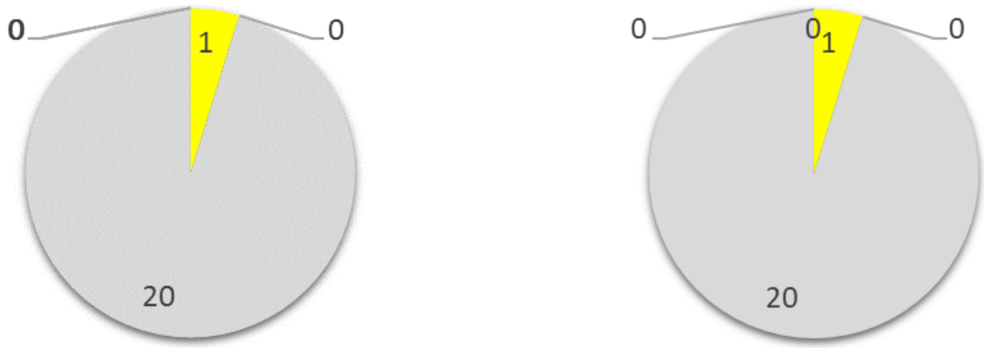
Table 12: Evaluation structure for SoC 8: "Planning, design, construction".

Statement of Change	Objective	Priority indicators	Parameters
9. Quality planning/ design and construction	9.1 Project design appropriate to context	9.1A Project documentation is available and specific to project	Are all important project documents available (design drawings, design spread sheet, feasibility study)?
		9.1B Project documentation includes appropriate information on O&M costs	Does documentation include cost estimations of required O&M activities?
	9.2 Systems built to design	9.2A Constructed systems matches design	Does type and the number of reactor chambers (for settler, ABR and AF) observed in the field, match the design?
	9.3 Acceptable investment cost per user	9.3A The investment cost per actual user is within acceptable range for system type and country	Does the per capita construction cost comply to BORDAs (country and system type specific) standard?

4.8.2 Result overview on Statement of Change level

Figure 10 shows the distribution of average scores for SoC 8.

Bad (score < 1.5)	Caution (1.5 <= score < 2.5)	Good (score >= 2.5)	Dataset incomplete	Not relevant for project



Rainy season Dry season

Figure 10: Pie charts with distribution of average scores for SoC 9: "Planning, design, construction" for the rainy season (left) and dry season (right).

For all details on objectives, priority indicator and parameter results, refer to Appendix X in Chapter 6.

4.8.3 Influencing parameters

- Only one project has all needed project documents available. Most (67 %) systems have most document not available or none at all. The other projects have some documents.
- Only one third have cost estimations for O&M costs of the systems included in the documents.
- In 80 % of the systems with required documents available and access to count the reactor chambers, the design matches the actual constructed system.

4.8.4 Corrective action required for "worst impact parameters"

- Because, there is regular changes of m.e. in most of the visited sites, there should be proper handover between new m.e. and old one. This will help to keep project documents and other information related to project available.
- Remanding consultancies, contractors or experts who were involved in project planning designing and construction to keep their contacts (in case they are required can be called) and all potential documents to m.e.

4.9 Effluent parameter analyses

In this section, the analysed laboratory parameters of the effluent will be discussed.

4.9.1 Chemical Oxygen Demand

The Chemical Oxygen Demand (COD) indicates the amount of oxygen needed to oxidise all organic matter in the water sample. Therefore, it is a sum parameter for all organic particles in the water. It is usually given, as a concentration in mg O_2/l. The effluent standard from TBS for Tanzania is 60 mg/l.

Figure 11 shows the COD of the effluent of all sites, where a sample after the last treatment step could be taken. For few samples, this was not possible due to different reasons like no access or too little flow. The graph combines the data from the rainy and the dry season for decentralised systems and compares it to the data from the centralised WWSPs. For a help to rate the results, the Tanzanian standard from TBS (60 mg/l) and the proposal from BORDA for a new standard for decentralised systems (200 mg/l) are also plotted.

Only 32% of all tested decentralised systems in the rainy and 42% in the dry season meet the Tanzanian standard, whereas more than 80% (84% in the rain and 89% in the dry season) would fulfil the new proposal from BORDA.

Explanations for the bad treatment performance of few systems might by overloading in the case of St. Antony Sec. School Girls and Buguruni flour mill. For the system of IST black water, only black water enters the system, therefore the COD concentration of the inflow wastewater is much higher than for other systems. Furthermore, in this system the biogas is not used, which can cause a reduced HRT and a worse treatment efficiency.

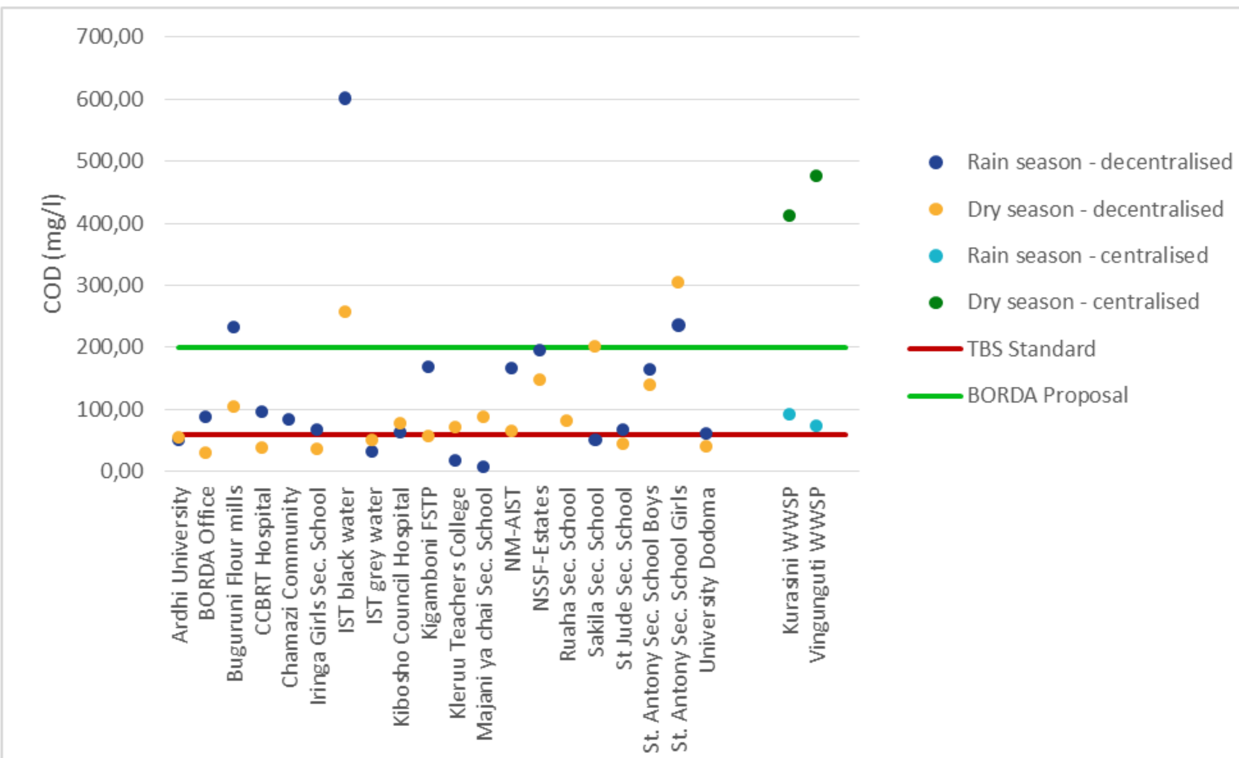


Figure 11: COD of the effluent for the decentralised systems in the rainy season (blue) and dry season (yellow), as well as for centralised systems in the rain season (turquoise) and dry season (green). Additionally, the TBS standard for Tanzania (60 mg/l) is plotted with a red line, as well as BORDA's proposal for a new standard (200 mg/l) in green.

4.9.2 Biological Oxygen Demand

While the COD measures all chemically oxidised matter, the Biological Oxygen Demand (BOD_5) is more specific, as it measures only the biologically degradable organic matter. Usually, the biological oxygen demand is measured after a 5 day incubation at 20 °C of the sample. Therefore, it is typically shortened as BOD_5. Due to the complicated and time consuming procedure, the BOD_5 was only analysed for five representative projects within Dar es Salaam.

Figure 12 shows the BOD_5 results of the effluent for five selected sites during the rainy and dry season. The TBS standard for Tanzania of 30 mg/l is also shown. Only 50 % of the samples meet the standard. The trend shows, that the systems seem to perform better during the dry season. The bad result of IST black is probably due to that fact, that only black water is treated in this system, which means that the BOD_5 concentration at the inlet is higher than in other systems, where both black- and grey-water is treated. Furthermore, the biogas of this system is not used or burned off. This leads to a lower HRT in the biogas dome and thus to a shorter treatment time and a worse treatment efficiency.

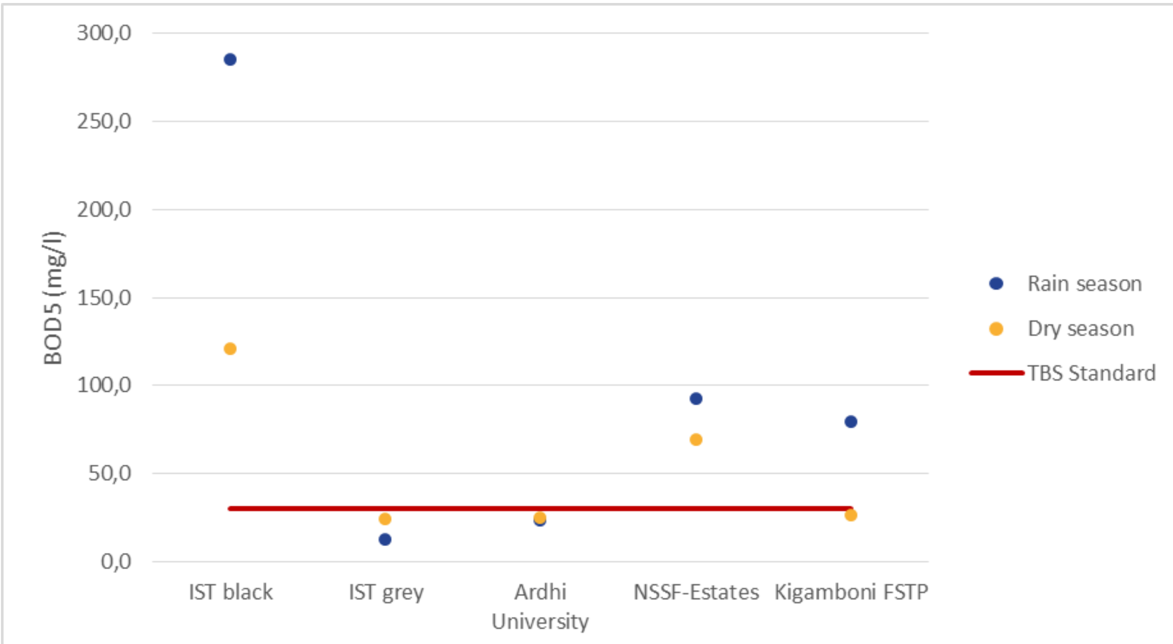


Figure 12: BOD_5 of the effluent of five representative sites within Dar es Salaam for the rainy season (blue) and dry season (yellow). The TBS standard of 30 mg/l is shown in red.

4.9.3 Dissolved Oxygen

The digestion process of organic matter with the help of microorganism can either be performed without oxygen (anaerobic) or with oxygen (aerobic). Depending on the process and the kind of bacteria, a certain concentration of dissolved oxygen (DO) is required in the water. In general, a minimum concentration of 0.3 mg/l is needed for an aerobic process, even though most wastewater treatment systems try to achieve 2 mg/l or more. Therefore, the measured DO concentration of a wastewater sample gives an insight if probably anaerobic or aerobic processes are taking place.

Figure 13 shows the measured DO for all samples. Blue dots show samples which were taken after a treatment module, which should perform an aerobic process, yellow dots show samples from aerobic treatment steps. The red solid line shows the minimum DO concentration for aerobic processes, therefore, all measurements below are from anaerobic processes. The green solid line shows the recommended DO concentration for aerobic processes, which means that data points above show aerobic processes. All measurements in between these boundaries are probably a mix of both processes.

It can be seen, that samples from some treatment modules, which should perform an aerobic process clearly perform an anaerobic process and vice versa, but most value are in the expected range.

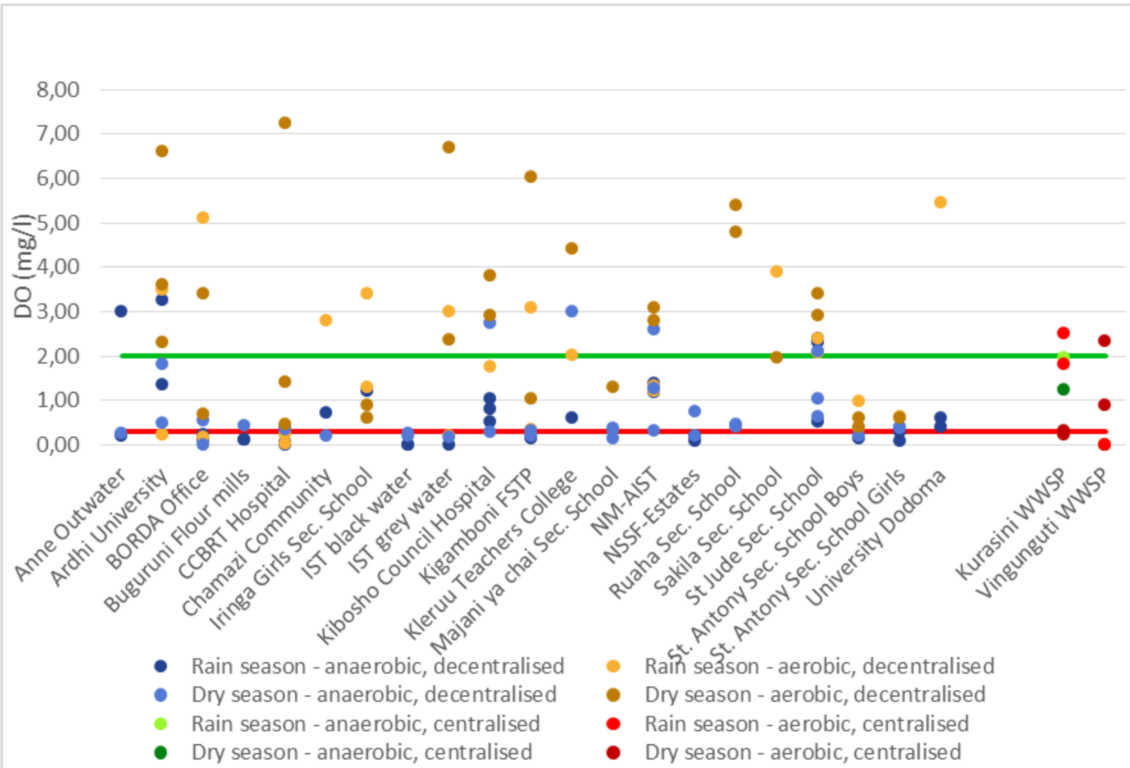


Figure 13: Dissolved oxygen measurements of all samples. Blue (decentralised) and green (centralised) dots show measurements from anaerobic treatment steps, yellow (decentralised) and red (centralised) dots show measurements from aerobic treatment steps. The rainy and dry season is shown with light and dark shades of each color as described in the legend.

4.9.4 pH Value

The pH value of an aqueous solution gives the acidity or basicity. The scale of this parameter reaches from 0 to 14. An acidic solution has a pH below 7, a neutral solution has pH=7 and a basic solution has a pH greater than 7.

The effluent pH of all visited decentralised systems, where an effluent sample could be taken is shown in Figure 14. The TBS standards allows water with a pH between 6.5 and 8.5 to be discharged into the environment. Almost all systems lay within this range, even though they tend to be on the lower edge.

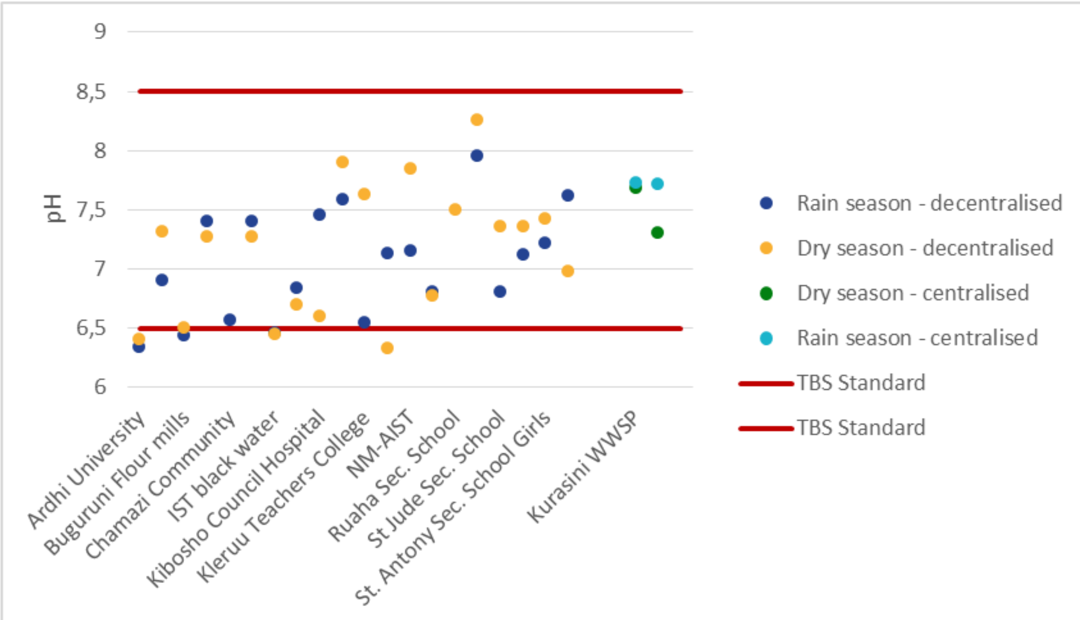


Figure 14: Effluent pH of visited decentralised systems during the rainy (blue) and dry (yellow) season as well as for the centralised WWSP (rain, turquoise; dry, green). The TBS standard for the effluent is 6.5-8.5 and is shown in red.

4.9.5 Temperature

Figure 15 shows the temperature of the effluent during the rainy and dry season. Almost all samples are within the range from TBS of 20-35 °C. Only four samples taken in the dry season cannot fulfil the standard. All those projects are in Iringa or Arusha, which have a significantly colder climate. Especially at night, the temperature can drop below 15 °C, which causes low effluent temperatures.

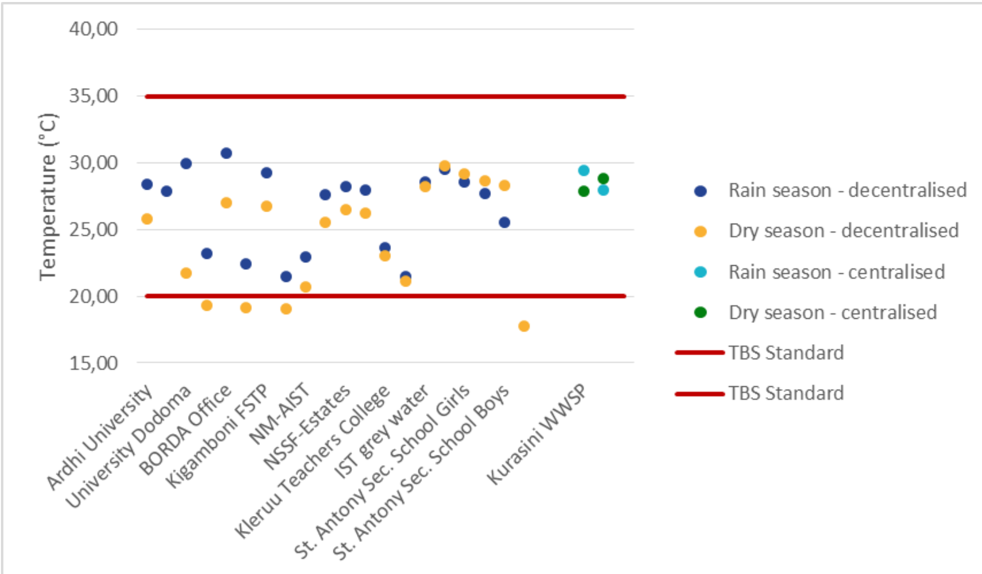


Figure 15: Temperature of the effluent of visited decentralised systems during the rain (blue) and dry (yellow) season as well as for the centralised WWSP (rain, turquoise; dry, green). The TBS standard for the effluent is 20-35 °C and is shown in red.

4.9.6 Total suspended solids

Total suspended solids (TSS) is the dry-weight of particles trapped by a filter. It is a water quality parameter used for determination the quality of wastewater after treatment in a wastewater treatment plant.

It is also a measure of effluent turbidity. Presence of total suspended solids in a treatment system can cause clogging of following treatment units or damage of pumps (if any). Figure 22 shows the total suspended solids of the effluent during the rainy and dry season.

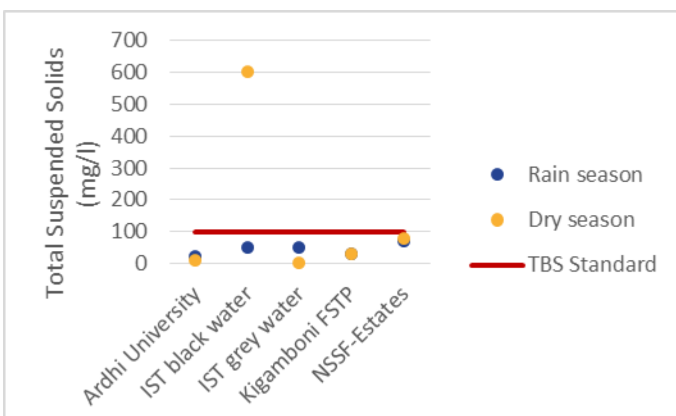


Figure 22: TSS of five selected projects within Dar es Salaam. The blue dots show the data during the rain season, the yellow ones during the dry season. The TBS standard of 100 mg/l is shown in red.

Most of the samples are within the TBS standard of 100mg/l. Only one project during dry season did not fulfil the standard. This could be due to an error during sample taking and analysis. On this parameter the technician who took the samples from the site was not the same as the one who analysed the sample, which makes an human error more probable.

4.9.7 Settleable Solids

The settleable solids is a measure of the amount of solids in ml per liter, which will settle in a given period of time in an Imhoff cone or a graduated cylinder. Total solids in wastewater includes suspended, dissolved, settleable, and organic as well as inorganic solids.

The settleable solids test on wastewater can tell the operator a lot about what kind of wastewater is coming into the plant and how the solids are settling. In addition, the settleable solids test can help the operator estimate the volume of sludge to be expected in the clarifier. Either grab or composite samples will work for this test. Figure 16 shows the settleable solids of the effluent during the rainy and dry season. Unfortually we couldn't find stipulated TBS standards for settleable solids. Speaking about solids values (TSS and SS) in wastewater should fit with organic concentration (COD and BOD_5) i.e. the higher the values of TSS and SS, the higher the value of COD and BOD.

This means that in our case TSS and SS values are lower (Meet TBS standard) during both seasons while 50% of COD and BOD values are higher especially during dry season. Reason for this could be, that during rain solids are flushed out due to rainwater intrusion. And samples was started to be taken in rain season later in dry season of which most of the solids were flushed away.

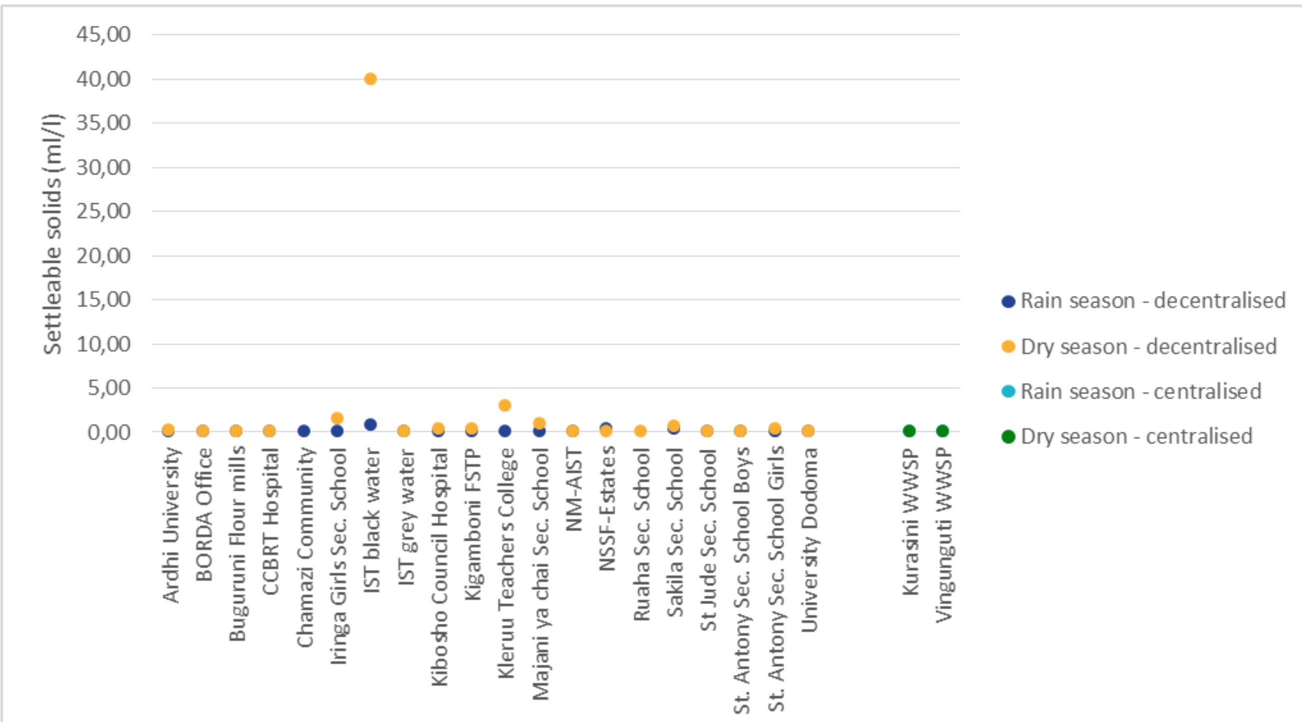


Figure 16: SS of tested during dry, rain seasons for both centralised and decentralised system

5 Conclusions

5.1 The strengths of investigated projects

- Most visited sites are overall in a good physical condition, but it happens relatively often, that there are small cracks in the building structure or manhole cover, which are probably not affecting the performance or safety of the system.
- Many systems have an operator to take care of the system, though operator were not sufficiently trained for undertaking necessary tasks, either because there was no training provided during handover or staff changed since the start of operation.
- In general, the operators and managers of the institutions showed interest to improve their systems, and were willing to undertake O&M training to improve the performance and appearance of their systems.

5.2 The major challenges of investigated projects

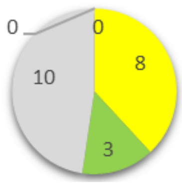
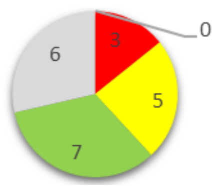
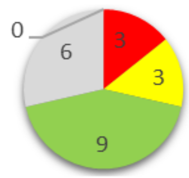
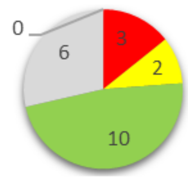
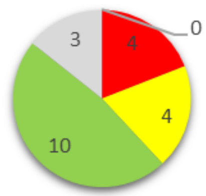
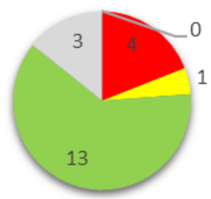
- Lack of regular trainings to both operators and managers to undertake necessary tasks for the treatment system. This is either due to training was not done during project handover or staff (Operators/Managers) changed since the start of operation.
- In most of the plants visited, there were not enough or proper tools for conducting O&M activities, because of financial constraints. There is no priority set for setting up budget of sanitation activities.
- Missing of potential project documents for O&M activities, like O&M manual, drawings, project reports etc. It was either given to the respective m.e. representative and then get lost or it was not given to the m.e. at all.
- Most of the project visited had financial problems in term of procedures to get money to implement something or to do O&M activities. Money comes from government with direct instructions on how to spend it, as m.e. becames challenges diverting the uses of money as it was instructed.
- No active clubs (for the case of schools), committee which take care of sanitation issues and example programs that will make users aware about sanitation challenges are set up.
- O&M activities are not included in operator's contract.

5.3 Future implementations

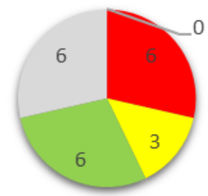
- Regular O&M trainings workshops with representatives from all systems should be conducted.
- Management should set priority on budget for conducting O&M activities of sanitation issues especially the treatment system. Part of this budget should be used to purchase tools for O&M activities.
- Establishing committees, which will deal with the treatment system and sanitation issues at that particular site (at school, university, estate etc.).
- Employ an operator who's contract includes O&M activities, in their day-to-day tasks.
- For sustainability of the treatment systems, there should be a clear and proper O&M plan of the treatment system, and led by assigned personnel.
- Academic institutions, which are in this sector, should be consulted, to conduct research on these systems for the benefit of the academicians, developers as well as owners of the treatment facility.
- Since comparisons are based on a very small number of systems, this study could not draw conclusions, as to whether the one or the other approach is more applicable to the Tanzanian context. Moreover, methodology used were developed for small-scale decentralised systems and does probably not cover completely all relevant technical and operational aspects of larger scale plants and not for centralised systems. Besides it is important to clarify that the evaluation of two centralised systems were done just to get an impressions on how large centralised systems works in term of technical and operational aspects compared to decentralised systems.

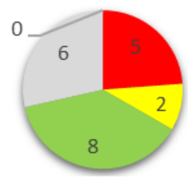
6 Appendix X: M&E Matrix structure and parameter responses

In this Appendix, the results of each SoC with its objectives, priority indicators and parameters is shown. The first graph is the result of the visit during the rain season, the second from the visit in the dry season, accordingly for tables: the first and second row give the number of answers for each answer possibility for the rain season (first visit) and dry season (second visit). If there are no differences between the first and second data set, only one graph is displayed.

Statement of Change	Objective	Priority indicator	Parameter
1. The sanitation service maintains or improves environmental health  	1.1 Effluent meets discharge standards  	1.1A The most recent effluent analysis complies with BORDA Standards  	If data available and reliable, does the average effluent COD meet relevant BORDA discharge standards (200mg/L or 80 mg/L depending whether anaerobic or aerobic effluent)? (Caution, yellow, means <20% above standard)

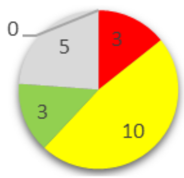
1.1B The most recent effluent analysis complies with Local Standards

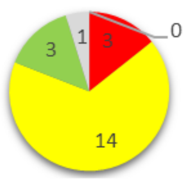




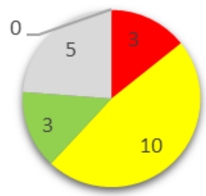
If data available and reliable, does the average effluent COD meet relevant local discharge standards? (Caution, yellow, means <20% above standard)

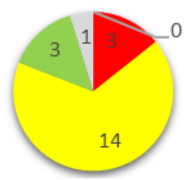
1.2 Removed waste is safely disposed or reused





1.2 Evidence that waste or by-products (sludge, scum, trash, biogas) is safely disposed or reused





Where is the sludge disposed to after desludging?

Trucked to STP - no manual handling	Trucked to solid waste site - no manual handling	Manually collected with solid waste	Reused	Safely buried	On land, not safely reused or buried	Waterbody or river	Other	Interviewee does not know	Interviewee not av.or sludge never removed
1	0	0	0	1	0	0	1	0	18
1	0	0	0	0	0	0	1	0	19

Where is the scum disposed to after descumming?

Scum never removed	Sealed into domestic solid waste collection	Unsealed into domestic solid waste collection	Safely stored	Safely buried	On land, not buried	Waterbody or river	Other	Interviewee does not know	Interviewee not available
12	0	0	0	0	2	0	2	4	1
18	0	0	0	0	1	0	1	0	1

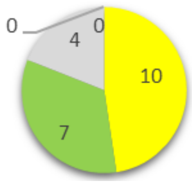
Where is the solid waste disposed to after removal from reactors or piping?

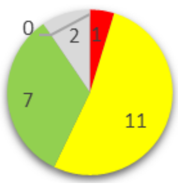
Solid waste never removed	Sealed into domestic solid waste collection	Unsealed into domestic solid waste collection	Safely stored	Safely buried	On land, not buried	Waterbody or river	Other	Interviewee does not know	Data not available
6	1	0	3	4	4	0	6	0	1
3	1	0	2	8	4	0	5	0	1

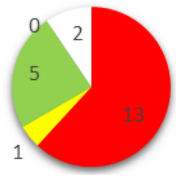
For BGD, is unused biogas burned off?

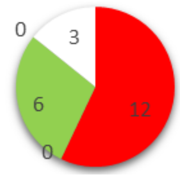
No BGD - not relevant	Biogas is always used	Yes, unused biogas is always burned off	Unused biogas is sometimes burned off	No, unused biogas is never burned off	Interviewee doesn't know	Interviewee not available
13	2	0	0	5	0	1
13	3	0	0	4	0	1

Statement of Change	Objective	Priority indicators	Parameters
2. The sanitation service improves the living conditions of communities	2.1 Underserved people are connected to the sanitation service	2.1A Majority of sanitation users previously had no or basic access to sanitation	Before this system existed, what was the sanitation option used (or if SME, the wastewater discharge method) by the majority of users connected to the system?



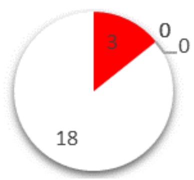






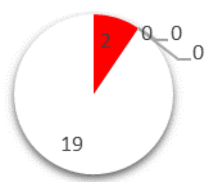
Open defecation	Pit/Unimproved latrine	Toilet directly to waterbody	Flush-toilet connected to soak pit	Other unimproved sanitation option
0	3	0	2	1
0	3	0	2	1
Other improved sanitation option	**Flush-toilet connected to functional and sealed septic tank**	**Not relevant, wastewater-stream did not exist before**	**Info not available**	**Project documentation not available**
3	9	3	0	0
3	9	3	0	0

Priority indicators	Parameters
2.1B Majority of sanitation users are classified as disadvantaged (ie. Income)	What proportion of users are classified/registered as low income according to Project planning/FS?



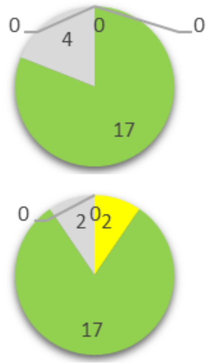
Not relevant, system does not have users, e.g. some SME	Majority (> 50%)	Some (25 - 50%)	Few (<25%)	Info not available	Project documentation not available
18	0	0	0	3	0
18	0	0	0	3	0

Priority indicators	Parameters
2.1C Unrestricted CSC access for disabled and elderly	Is access to the sanitation facility difficult or impossible for disabled/ elderly?

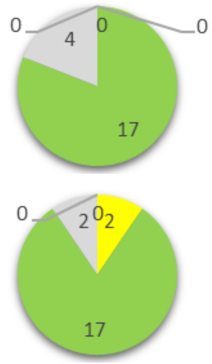


Yes, difficult. Access by stairs (not ramp), rough or uneven path	Yes, difficult. Distance too far for easy access	Yes, difficult. Other observed/reported access issues	Good access. No issues observed	No sanitation facility
2	0	0	0	19
2	0	0	0	19

2.2 Potential exposure to faecal pathogens for surrounding communities is managed



2.2 Exposure to faecal pathogens for surrounding communities is managed

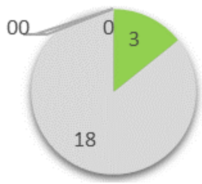


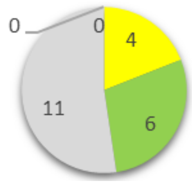
Based on post treatment and effluent discharge location, can the pathogen exposure for surrounding communities be considered managed?

Yes	Somewhat	No	Information not available
17	0	0	4
17	2	0	2

Statement of Change

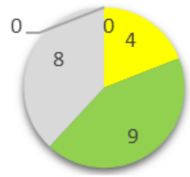
4. Functioning Technology - systems are operating as intended

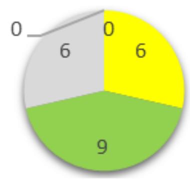




Objective

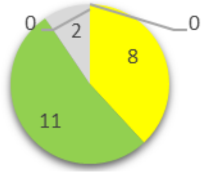
4.1 System operating as designed - acceptable loading and system hydraulics

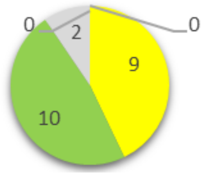




Priority indicator

4.1A Users within acceptable range of design





Parameter

Is the utilisation (design/actual connected user) equal or above acceptable range?

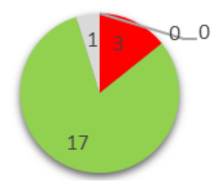
>=66%	<66%	No data
11	8	2
10	9	2

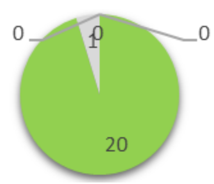
Is the intended wastewater type discharged to treatment?

Information not available	Yes	No, grey-water is discharged to system but it was not designed for it	No, grey-water is not discharged to system but it was designed for it	No, black-water is discharged to system but it was not designed for it	No, black-water is not discharged to system but it was designed for it	No, non-communal wastewater is discharged to system but it was not designed for it	No, non-communal wastewater is not discharged to system but it was designed for it
1	20	0	0	0	0	0	0
1	19	1	0	0	0	0	0

Priority indicator

4.1B Influent flow to the treatment system is observed



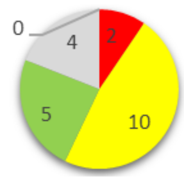


Parameter

Do you observe flow or signs of recent flow at plant inlet (wet piping, wet inlet chamber)?

Yes	No	No, plant not conctd to piping	No access to plant inlet	TM not sure
17	3	0	1	0
20	0	0	1	0

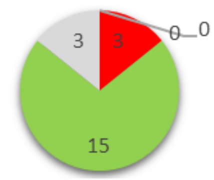
4.1C The system does not experience severe flow surges

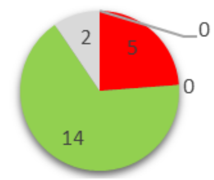


Based on observations about water level fluctuations inside reactors, observed changes during strong rains and occurrences of backflow from discharge waterbody - does the system experience any flow surge issues?

No	Minor issues	At least one type of issue	Information not available
5	10	2	4
5	10	2	4

4.1D Evidence of effluent flow

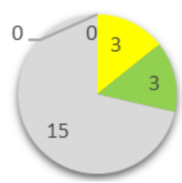


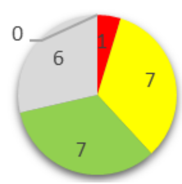


Do you observe flow or signs of recent flow (wet piping, etc.) at plant outlet?

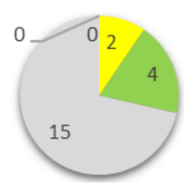
Yes, signs of recent flow	No signs of recent flow	No, because piping system is not connected to the plant	No access to plant outlet	TM not sure
15	3	0	3	0
14	5	0	2	0

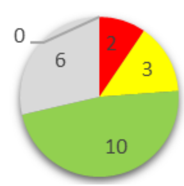
4.2 Systems operating as designed - treatment meets BORDA requirements





4.2A Anaerobic, and where applicable aerobic, effluent quality meet BORDA requirements





No rain	Rain	Strong rain
8	9	4
21	0	0

Does the average COD concentration of the anaerobic effluent comply to BORDA design value (200 mg/ l)?

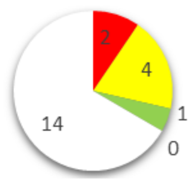
Yes	Almost <20% above standard	No	No data or no reliable data	There is no aerobic treatment step	Data-source not reliable and/or data probably affected by rain
5	1	1	2	0	12
11	1	5	4	0	0

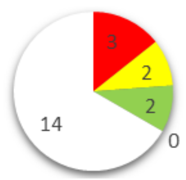
Does the average COD concentration of the aerobic effluent comply to

BORDA design value (80 mg/ l)?

Yes	Almost <20% above standard	No	No data or no reliable data	There is no anaerobic treatment step	Data-source not reliable and/or data probably affected by rain
3	3	0	1	2	12
11	1	3	2	4	0

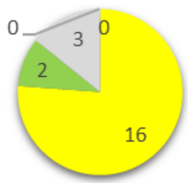
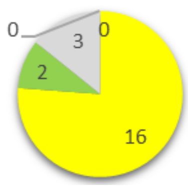
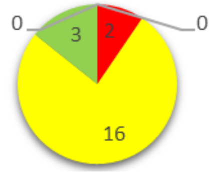
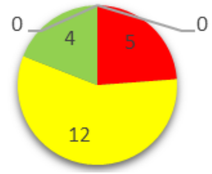
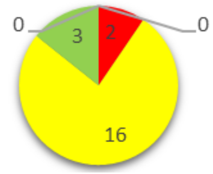
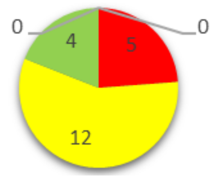
4.2B There are obvious signs of biogas production from the biogas digester





When you open the gas valve furthest away from the BGD (e.g. at the stove), do you hear or smell gas release?

Yes	No access to gas valve	No	Biogas piping has not been installed	Not relevant
1	3	2	1	14
2	1	3	1	14

Statement of Change	Objective	Priority indicator	Parameter
5. Functioning Maintenance - systems are maintained as intended  	5.1 Systems maintained - no major damage  	5.1A No signs of structural damage compromising functionality or warranty aspects  	What building structure problems do you observe at treatment system (digester, settler, ABR, AF, PGF)?

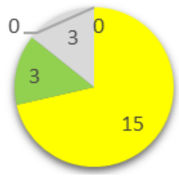
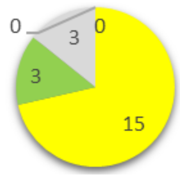
Minor physical damage (e.g. small cracks); does not affect operation or safety	Major physical damage (e.g. large cracks, leakages, broken divider walls, floating bioballs in prefab-AF); affects operation or safety	Damaged manhole cover (cracked, partly missing); covering most of the manhole	Severely damaged or missing manhole cover	System is clearly not connected to piping	No noticeable damage
18	2	7	1	0	2
17	4	8	5	0	2

Do you observe problems with existing pumps (wastewater or water pumps)?

There are no pumps	No, all pumps work	Yes, at least one pump is broken but it does not affect plant treatment	Yes, at least one pump is broken and it affects plant treatment	No access to pumps	TM not sure
17	2	0	0	2	0
17	4	0	0	0	0

What structural problems with the sanitation facility(ies) (walls, roof and floor) do you observe?

Minor physical damage (e.g. small cracks), not affecting operation, use or safety.	Major physical damage (e.g. large cracks), affecting operation, use or safety.	No noticeable damage	No CSC
1	0	1	19
0	0	2	19

	5.2 Maintenance activities occurring as intended 	5.2A Maintenance is adequate 	See tables below

Do you observe flow or signs of recent flow at plant inlet (wet piping, wet inlet chamber)?

Yes	No	No, plant not connected to piping system	No access to plant inlet	TM not sure	Data not available
17	3	0	1	0	0
20	0	0	1	0	0

In the past, were maintenance issues with the sewer network fixed (clogging, blockage, bad smell or overflow)?

No sewer network - not relevant	No maintenance issues so far	Yes, all issues fixed	Some isses fixed	No issues fixed	Interviewee does not know	Interviewee not available
5	3	10	2	0	0	1
5	3	10	2	0	0	1

In the past, were major issues with the sewer network fixed (broken pipes or manhole, leakages, other major damage)?

No sewer network - not relevant	No maintenance issues so far	Yes, all issues fixed	Some isses fixed	No issues fixed	Interviewee does not know	Interviewee not available
5	3	7	3	0	2	1
5	3	7	3	0	2	1

In the past, were maintenance issues with the household grease-traps fixed (clogging, bad smells)?

No household grease traps - not relevant	No maintenance issues so far	Yes, all issues fixed	Some isses fixed	No issues fixed	Interviewee does not know	Interviewee not available
19	0	0	0	0	1	1
19	0	0	0	0	1	1

Can the manhole covers of the treatment system be opened? Please try at least 5 manhole covers. In case they were opened before the start of the field visit, please ask the m.e. or operator.

All can be opened within 10 min each	Majority (≥ 50%) can be opened within 10 min each	Majority (> 50%) can NOT be opened within 10 min each	Majority (> 50%) can NOT be opened at all
9	7	4	1
11	5	5	0

Could a local desludging service provider access the treatment system with his cart, truck, etc.?

Yes	No	TM not sure
18	3	0
18	2	0

Has the system been desludged?

Yes, within the last 3 years	Yes, but more than 3 years ago	Never, system is younger than 3 years	Never, system is older than 3 years	Interviewee does not know	Interviewee not available
3	0	4	13	0	1
2	0	4	14	0	1

How thick is the scum in the second (or if too difficult to open, third) ABR chamber?

There is no ABR	There is no scum	Less than 2 cm	2 cm or more	No access to chambers
13	3	1	1	3
13	3	0	2	3

Do you see much plastic waste (more than 20 items) inside the second (or if too difficult to open, third) anaerobic reactor chamber (can be settler, ABR or AF chamber)? (single selection)

No	Some waste (< 20 items)	Yes, much waste (> 20 items)	No access to chambers	Settler, ABR and AF are not part of the design
10	2	2	4	3
8	6	0	4	3

Do you observe problems concerning the planted gravel filter?

No PGF	Dead plants	Slime on surface	Stagnating water on the surface - because swivel pipe is set too high	Stagnating water on the surface - probable reason: filter blockage	Swivel pipe broken, water level very low	No plants	Large amounts of solid waste	Other problems (e.g. smell, dead leaves, few plants)	No problems
6	6	0	1	4	0	1	1	9	2
6	7	3	0	5	0	1	0	9	2

What functional problems do you observe about the sanitary installations?

Some toilets/ bathrooms seem unused	Laundry area seems unused	Facility does not have functioning lights	Electricity is not available	Water is not available	Blocked floor-drains	No waste bins with covers are provided inside cubicles	Some toilets/ bathrooms are blocked/broken	Some toilets/ bathroom doors are missing/broken/can't be locked	Some toilets/ bathrooms are unclean (rubbish, dirty, not cleaned in past 2 d)	No O&M or HHE posters are hung up	Broken handwashing-basin or tap	No handwashing facility	No problems	No CSC/Not relevant
0	0	1	0	0	0	1	1	1	0	1	1	0	1	19
1	0	1	0	0	0	1	1	1	0	1	1	0	1	19

Do you observe problems with the water trap?

There is no water trap	No access to water trap	No problem, the current water trap setting allows free biogas flow	Yes. Water trap has not been emptied, although required by design	Yes. Water trap is not at the lowest point of the biogas piping	Yes, other problem	Not relevant
3	0	4	0	0	0	14
3	1	3	0	0	0	14

When you open the gas valve furthest away from the BGD (e.g. at the stove), do you hear or smell gas release?

Yes	No access to gas valve	No	Biogas piping has not been installed	Not relevant
1	3	2	1	14
2	1	3	1	14

Is the biogas appliance working (lamp/ heater/ stove)?

There is no appliance and/or biogas piping	Yes	Not accessible, cannot be checked	No, appears broken, corroded or clogged	No, because gas does not reach	No, because of other problem	Not relevant
1	2	1	1	2	0	14
2	2	0	1	2	0	14

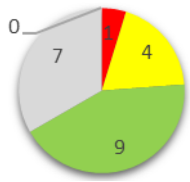
Do you observe problems with the pressure gauge?

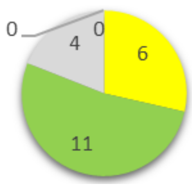
No pressure gauge installed	No. it contains water and is well calibrated	Yes. it contains water but is not well calibrated	Yes. it is empty (no water)	Not relevant
4	1	1	1	14
4	2	0	1	14

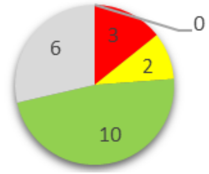
For BGD, is unused biogas burned off?

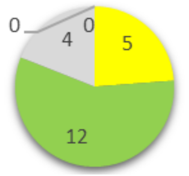
No BGD - not relevant	Biogas is always used	Yes, unused biogas is always burned off	Unused biogas is sometimes burned off	No, unused biogas is never burned off	Interviewee doesn't know	Interviewee not available
13	2	0	0	5	0	1
13	3	0	0	4	0	1

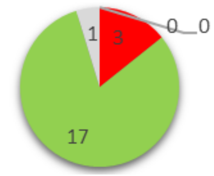
Statement of Change	Objective	Priority indicators	Parameters
6. Sustaining Demand - system is available, used to capacity and acceptable	6.1 Service is adequately available to users	6.1A For systems with SSS, system receives and processes wastewater	Do you observe flow or signs of recent flow at plant inlet (wet piping, wet inlet chamber)?

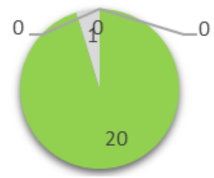






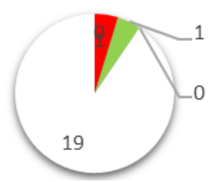






Yes	No	No, plant is clearly not connected to piping system	No access to plant inlet	TM not sure
17	3	0	1	0
20	0	0	1	0

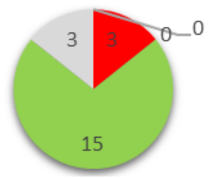
6.1B For systems with CSC, ratio of users to functioning toilets is acceptable

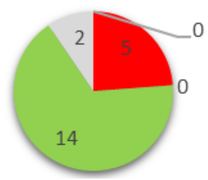


Is the ratio of users per functioning toilets acceptable (max. 20 users per toilet)?

Defined ratio and below	Above defined ratio	No data	No CSC
1	1	0	19
1	1	0	19

6.1C DEWATS processes wastewater

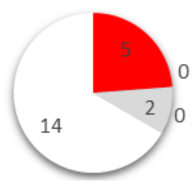


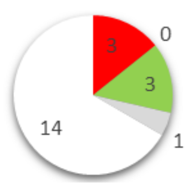


Do you observe flow or signs of recent flow (wet piping, etc.) at plant outlet?

Yes, signs of recent flow	No signs of recent flow	No, because piping system is not connected to the plant	No access to plant outlet	TM not sure
15	3	0	3	0
14	5	0	2	0

6.1D For biogas systems, biogas can be used

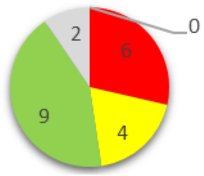


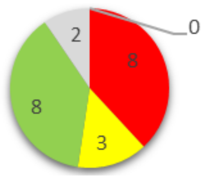


When you open the gas valve closest to the BGD, do you hear or smell gas release?

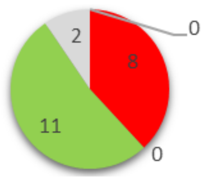
Yes	No access to gas valve	No	Not relevant
0	2	5	14
3	1	3	14

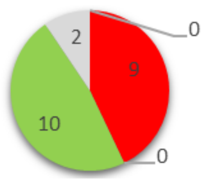
.2 Utilisation rate: Service is used to capacity





6.2A Utilisation is close to full capacity (ie. actual/design users)

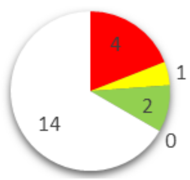




Is the utilisation (actual/design users) equal or above acceptable range?

>=66%	<66%	No data
11	8	2
10	9	2

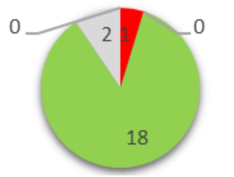
6.2B For biogas systems, biogas is used to full capacity

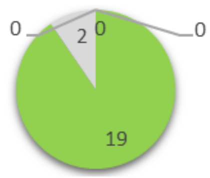


How often is the biogas of this system being used?

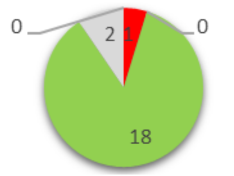
No BGD - not relevant	Daily	Not daily but regularly	Seldom (less than once a week)	Never	Interviewee does not know	Interviewee not available
13	2	0	1	4	0	1
13	1	1	1	4	0	1

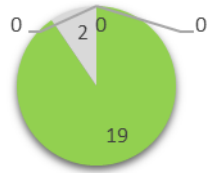
6.3 Acceptability: Culturally acceptable, users satisfied with system





6.3A Satisfaction indicated by high utilisation or no evident issues of low acceptance

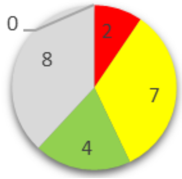


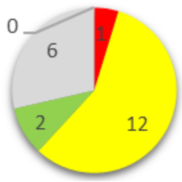


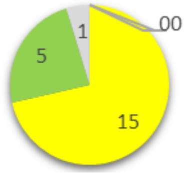
If the utilisation is below 66% design value, what are the reasons?

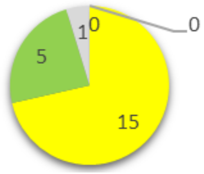
High utilisation rate (> 66%)	Low utilisation rate (<= 66%) but reported reasons do not indicate low acceptance	Low utilisation rate (<= 66%) and reported reasons indicate low acceptance	Low utilisation rate (<= 66%) but no information available about reasons	No data
11	7	1	0	2
10	9	0	0	2

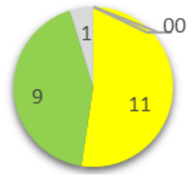
Statement of Change	Objective	Priority indicators	Parameters
7. Effective management: Existing, active and accountable management entity and operator	7.1 Active and accountable management entity	7.1A Existence of trained management entity with clarified responsibilities	See tables below

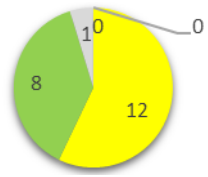












Does a management entity (m.e.) exist?

Yes, members of the served community	Yes, members of the institution (e.g. school) or SME	Yes, external agency	Yes, other (e. g. owner)	Yes, but not available for personal / phone interview	No management entity exists
1	17	1	1	1	0
1	17	1	1	1	0

Did the management entity receive the required trainings (Financial, O&M, HHE)?

Yes, all required trainings were received	One or two out of three trainings were received	None - m. e. has changed since start of operation	None - m. e. has not changed since start of operation	M.e. received other type of training	There is no management entity	Management entity not available for interview
5	8	6	1	0	0	0
5	7	8	0	0	0	0

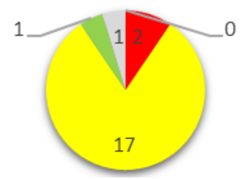
Is the management entity aware of its responsibilities?

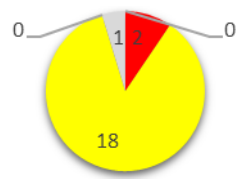
Yes, aware of all responsibilities above	Aware of some responsibilities (including managing operator)	Aware of some responsibilities (but not managing operator)	Not aware of any responsibility	Aware of other responsibilities	There is no management entity	Management entity not available for interview
0	12	7	0	1	0	1
0	13	6	0	1	0	1

Does management entity have documentation of legal registration to carry out its responsibilities (e.g. officially registered with appropriate government department)?

Not applicable as no legal registration necessary	Yes and legal documentation is shown (photograph must be taken)	Yes, but legal documentation is not shown	No	Interviewee does not know	There is no management entity	Management entity not available for interview
19	0	1	0	0	1	19
18	0	2	0	0	1	0

7.1B Management entity is active and accountable





Does the management entity meet regularly?

No, but m. e. exists of only 1 person (owner household system)	Yes and meting documention is shown (photograph must be taken)	Yes, but meeting documentation is not shown	No, m. e. does not meet regularly	There is no management entity	Management entity not available for interview
2	0	16	2	1	1
1	0	18	1	1	1

Are O&M responsibilities of the operator defined and documented?

Yes, as part of a contract	Yes, in a printed document	No documents, but interviewee can provide detail on operator role	No documents and interviewee cannot provide details on operator role	There is no management entity and nobody is available for interview	Management entity not available for interview
6	1	5	8	1	1
7	0	8	5	1	1

Is the operator regularly paid an agreed salary (in cash, in kind or both)?

Yes, regular agreed salary	Irregular payment	No payment	There is no management entity and nobody is available for interview	Management entity not available for interview
12	1	0	8	1
12	1	0	8	1

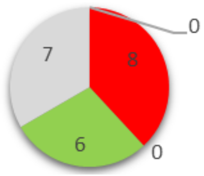
Are income and/or expenses documented in financial administration logbook or elsewhere?

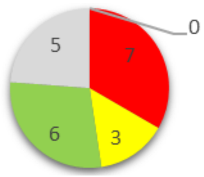
Yes, documentation is shown	Yes, but documentation NOT shown	No documentation exists	There is no management entity and nobody is available for interview	Management entity exists but nobody is available for interview
1	14	5	1	1
0	19	1	1	1

Is there documentation of conducted O&M activities?

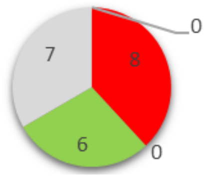
Yes, logbook or documentation shown (photograph must be taken)	Yes, but documentation NOT shown	No documentation exists	There is no management entity and nobody is available for interview	Management entity exists but nobody is available for interview
0	10	10	1	1
0	10	10	1	1

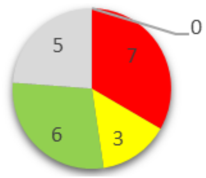
7.2 Trained and equipped operator





7.2A Existence of trained, equipped operator who knows his responsibilities





Is there a person/caretaker/operator assigned and responsible for O&M activities? (in the following called "operator")

Yes, operator is community member, SME employee or owner	Yes, operator is external service provider	No, but one or more people WITHOUT O&M responsibility take care of facility	No, nobody is assigned and responsible for O&M activities	There is most probably no operator (no interviewee available)
8	5	5	2	1
8	6	4	2	1

Has the operator received O&M training?

Yes	Only limited/brief training	No, operator has changed since start of operation	No, operator same since start of operation	There is no operator	Operator exists but nobody is available for interview	There is most probably no operator (no interviewee available)
8	5	1	0	6	0	1
8	5	1	0	6	0	1

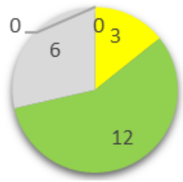
Is the operator aware of his responsibilities?

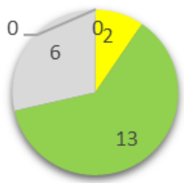
Yes, aware of all responsibilities above	Aware of most responsibilities	Not aware of most responsibilities	Not aware of any responsibility	No operator available to answer this question	There is no operator	Operator exists but nobody is available for interview	There is most probably no operator (no interviewee available)
1	5	0	0	7	7	0	1
1	6	2	0	5	6	0	1

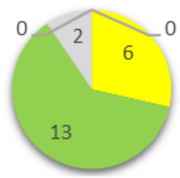
			Does the operator have all necessary tools required to perform O&M activities (opening manholes, deblocking sewer system, scum and solid waste removal from reactors)?

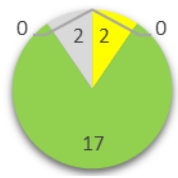
Yes, all tools	Most but not all	No tools	Interviewee does not know	There is no operator	Operator exists but nobody is available for interview	There is most probably no operator (no interviewee available)
4	14	2	0	7	0	1
4	14	2	0	6	0	1

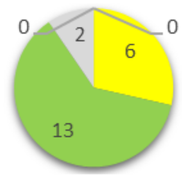
Statement of Change	Objective	Priority indicators	Parameters
8. Sustainable Financing: Sufficient ongoing income to cover all short and long term costs	8.1 Regular income	8.1A O&M budget and/or user fees have been agreed on and are collected	See below

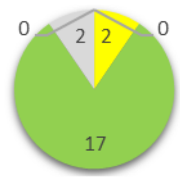












Was a fixed O&M budget defined?

Yes, O&M budget defined by local authority	Yes, O&M budget defined by m.e.	No O&M budget defined	Interviewee does not know	There is no managemen t entity	Managemen t entity not available for interview
1	13	2	4	0	1
0	18	2	0	0	1

Were the user fees set by local authority or agreed on by users themselves?

Yes, user fees set by local authority	Yes, user fees discussed and agreed on by users	User fees discussed but not agreed on by users	No set user fees	Interviewe e does not know	There is no managem ent entity	Managem ent entity not available for interview
0	1	0	19	0	0	1
0	1	0	19	0	0	1

Is someone responsible for the user fee collection process and is this documented?

Yes, responsibi lity is defined and document ation is shown (photogra ph must be taken)	Responsib ility is defined but document ion is NOT shown	Responsib ility is not defined	Interview ee does not know	No set user fees	There is no managem ent entity	Managem ent entity not available for interview
0	1	0	0	19	0	1
0	1	0	0	19	0	1

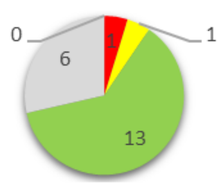
Are user fees collected?

Yes, regularly	Yes, but irregularly / on demand	No	Interviewee does not know	No set user fees	There is no management entity	Management entity not available for interview
1	0	0	0	19	0	1
1	0	0	0	19	0	1

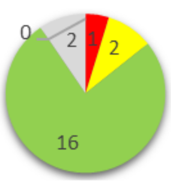
What proportion of users pay fees?

Almost all (> 66%)	Some/half (33 - 66%)	Few/None (< 33%)	Interviewee does not know	No set user fees	There is no management entity	Management entity not available for interview
0	0	0	1	19	0	1
0	0	0	1	19	0	1

8.2 Sufficient income to cover all short and long term costs



8.2A Regular operation and maintenance expenses (operator salary, material, equipment, electricity and water costs) are covered by income



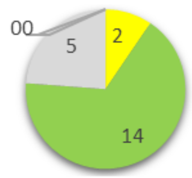
Is the operator regularly paid an agreed salary (in cash, in kind or both)?

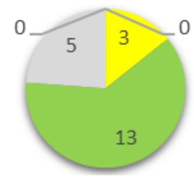
Yes, regular agreed salary	Irregular payment	No payment	There is no management entity	Management entity not available for interview	There is no operator
12	1	0	0	1	7
12	1	0	0	1	6

Are regular expenses other than operator salaries (e.g. material, equipment, electricity, water) paid through the available income?

Yes, all regular expenses are paid	Yes, some regular expenses are paid	No income to pay regular expenses	Interviewee does not know	There is no management entity	Management entity not available for interview
15	2	2	1	0	1
14	4	1	1	0	1

8.2B Irregular expenses (replacing major parts, desludging, structural damage) are covered by income





Do solutions exist for irregular expenses in the future (replacing major parts, desludging, structural damage)?

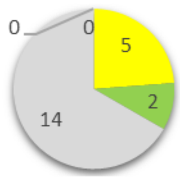
Yes (e.g. via regular income, extra community contribution, local government support)	No solution exists	Interviewee does not know	There is no management entity	Management entity exists but nobody is available for interview
14	2	4	0	1
13	3	4	0	1

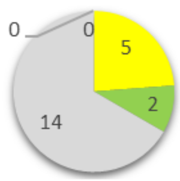
In the past, have irregular expenses been paid?

Yes, all	Yes, all - but after long wait	Yes, some irregular expenses were paid	No irregular expenses were paid	No major repairs	Interviewee does not know	There is no management entity	Management entity exists but nobody is available for interview
12	8	0	0	0	0	0	1
12	8	0	0	0	0	0	1

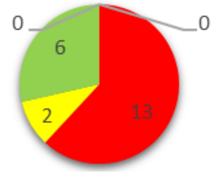
Statement of Change	Objective	Priority indicators	Parameters

9. Quality planning/ design and construction

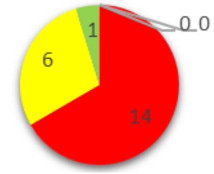




9.1 Project design appropriate to context



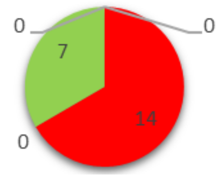
9.1A Project documentation is available and specific to project



Are all important project documents available (design drawings, design spread sheet, feasibility study)?

Yes, all	Some	Most are not available	None is available
1	6	6	8
1	6	6	8

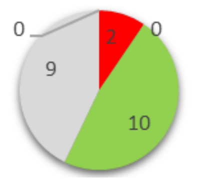
9.1B Project documentation includes appropriate information on O&M costs



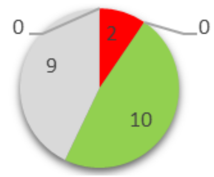
Does documentation include cost estimations of required O&M activities?

Yes	No	No access to design documentation
7	14	0
7	14	0

9.2 Systems built to design



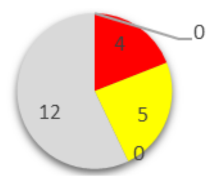
9.2A Constructed systems matches design



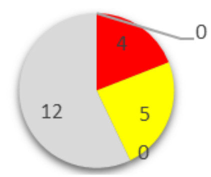
Does type and the number of reactor chambers (for settler, ABR and AF) observed in the field, match the design?

Yes	No	No access to count reactor chambers	No access to documentation or documentation insufficiently detailed
10	2	1	8
10	2	1	8

9.3 Acceptable investment cost per user



9.3A The investment cost per actual user is within acceptable range for system type and country



Does the per capita construction cost comply to BORDAs (country and system type specific) standard?

Yes	Almost, <20% above standard	No	No data
0	5	4	12
0	5	4	12

7 Appendix Y: Single system results

7.1 Decentralised wastewater treatment projects

7.1.1 Dar es Salaam

7.1.1.1 Majani ya chai Secondary School

Majani ya chai Secondary School is a day school in Vingunguti in Dar es Salaam. BORDA, EEPCO and the school implemented a DEWATS consisting of a BGD, ABR, AF, CW and a French drain in 2012.

Laboratory results:

No.	Sampling Point	pH		Temperature (C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
1	BGD out	8	7.95	28	28.6	--	0.38	0	0.2	137	840
2	ABR out	7.74	7.92	27.5	27.4	--	0.31	0.05	<0.1	58	275
3	AF out	7.91	8	28.5	28.7	--	0.15	0.03	0.1	51	98
4	PGF out	7.22	6.33	27.9	26.2	--	1.3	0	1	0	86
5	Storage Tank	7.13	--	29.1	--	--	--	0	--	6.88	--

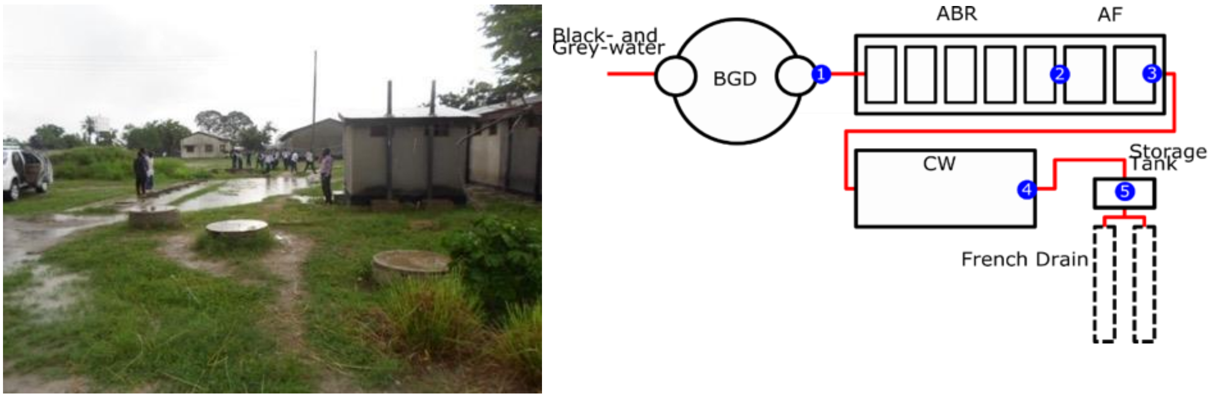


Figure 17: Majani ya chai Secondary School. a) Photo of the system. b) Schematic drawing including sampling points.

7.1.1.2 International School of Tanganyika (IST)

IST is a day school in Upanga in Dar es Salaam. BORDA, APC/MECPLAN Ltd. and the school implemented a DEWATS for the teachers housing in 2012. There are two separate systems for black-water from the toilets and grey-water from the showers and kitchen sinks. The black-water system consists of a BGD with expansion chamber and a French drain. The grey-water system consists of a septic tank and CW. The treated water from this system is stored in an underground tank and is used to flush the toilets.

Laboratory results:

Black-water system

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
1	BGD out	6.47	6.46	27.00	28.40	0.00	0.19	0.10	0.00	644	296
2	Exp. Chamber out	6.46	6.45	27.60	25.50	0.00	0.26	0.80	40	602	256

No.	Sampling point	TSS (mg/l)		BOD (mg/l)	
		Rain	Dry	Rain	Dry
1	BGD out	10	40	309.0	140.0
2	Exp. Chamber out	50	600	285.0	121.0

Grey-water system

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
3	ST out	6.76	6.88	28.00	27.90	0.00	0.16	0.00	0.00	950	304
4	PGF out	7.20	7.25	27.50	26.10	0.20	2.36	0.00	0.00	87	133
5	Storage Tank	6.84	6.70	28.50	28.20	3.00	6.70	0.00	0.00	30.25	50

No.	Sampling point	TSS (mg/l)		BOD (mg/l)	
		Rain	Dry	Rain	Dry
3	ST out	30	20	450.0	144.0
4	PGF out	50	10	41.0	63.0
5	Storage Tank	50	0	12.4	24.0

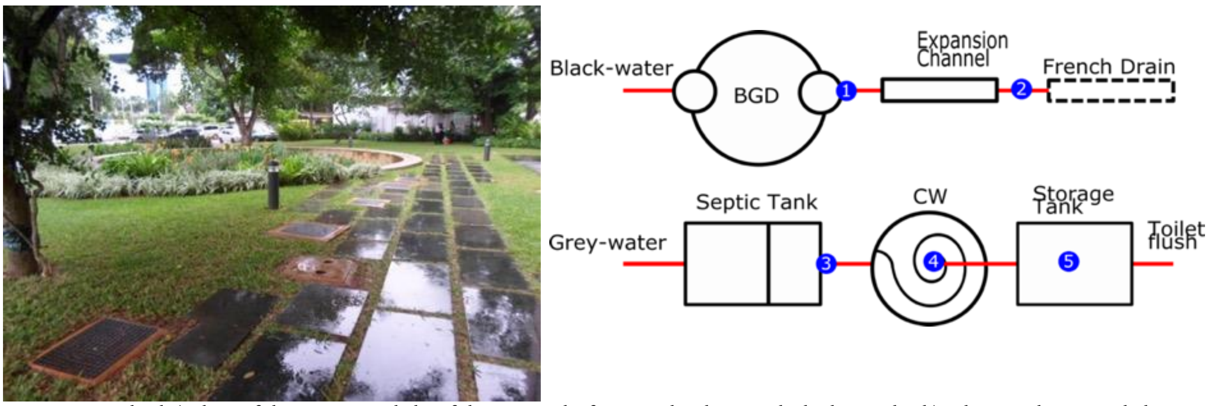


Figure 18: IST School a) Photo of the system. Manholes of the BGD in the foreground and CW in the background b) Schematic drawing including sampling points.

7.1.1.3 Ardhi University

The Ardhi University and Real Estate Department implemented a treatment system for student housings at the university in Survey in Dar es Salaam in 2015. The system consists of an UASB, two ponds with macrophyte plants and a cascade aeration before it is discharged to the Mlalakua River.

Laboratory results:

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
1	UASB In	6.60	6.22	28.20	26.90	3.27	1.80	4.00	15	384	147
2	UASB out	6.09	6.14	28.50	27.90	1.34	0.50	0.50	<0.1	228	143
3	Pond 1 out	6.10	6.18	29.00	27.70	0.23	2.30	0.10	60	144	145
4	Pond 2 out	6.12	6.18	28.00	26.30	0.24	3.60	0.20	0	84.4	99
5	Final effluent	6.34	6.40	28.40	25.80	3.50	6.60	0.05	0.20	49	53

No.	Sampling point	TSS (mg/l)		BOD, (mg/l)	
		Rain	Dry	Rain	Dry
1	UASB In	30	160	181.0	69.6
2	UASB out	30	10	108.0	67.7
3	Pond 1 out	60	700	68.2	68.7
4	Pond 2 out	50	20	40.0	46.0
5	Final effluent	20	10	23.0	25.0

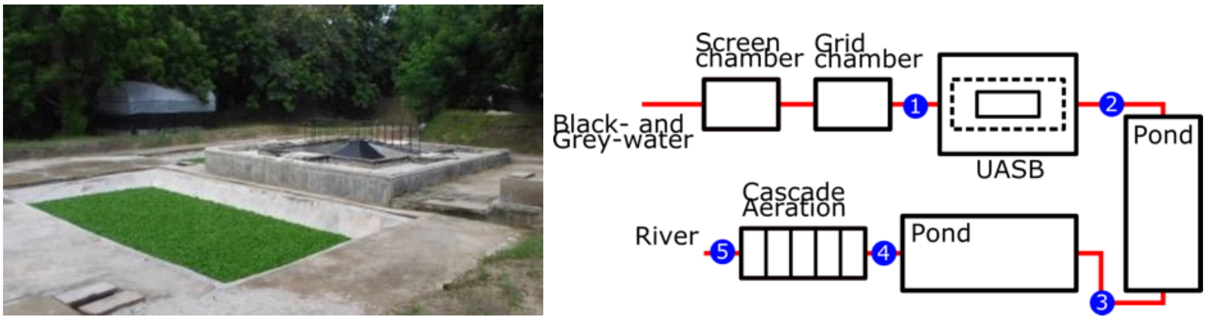


Figure 19: Ardhi University a) Photo of the system. One of the macrophyte ponds and UASB in the background. b) Schematic drawing including sampling points.

7.1.1.4 St. Antony Secondary School

St. Antony Secondary School is a boarding school in Mbagala in Dar es Salaam. The WSP & CW Research Group and the school implemented two separate wastewater treatment systems for the girls and boys dormitories in 2013. The girls system consists of a settler with soak away, another settler, a CW and a soak away for the effluent. The boys system consists of two septic tanks, three CWs and a soak away.

Laboratory results:

Girls system

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
1	Settler in	6.84	7.20	29.30	29.40	0.09	0.38	3.50	0.50	1152	790
2	Settler out	6.84	7.06	29.50	28.80	0.29	0.40	4.30	0.00	1056	390
3	CW out	7.22	7.42	28.50	29.10	0.63	0.60	0.00	0.41	236.2	304

Boys system

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
4	CW1 in	6.81	7.08	27.60	28.40	0.13	0.20	0.00	1.50	211.2	230
5	CW1 out	7.21	7.26	27.40	28.40	0.38	0.60	0.10	6.00	581	142
6	CW2 out	7.12	7.36	25.50	28.30	0.98	0.40	0.10	<0.1	162.8	138

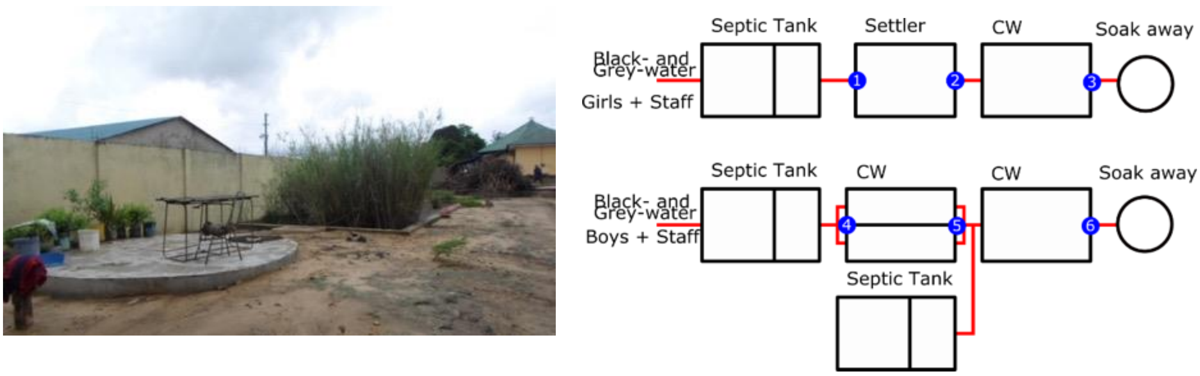


Figure 20: St. Antony Secondary School. a) Photo of the system. b) Schematic drawing including sampling points.

7.1.1.5 CCBRT Hospital

Comprehensive Community Based Rehabilitation in Tanzania (CCBRT) is a Hospital in Msasani in Dar es Salaam. BORDA, Estim construction co ltd and CCBRT implemented a DEWATS system for the hospital in 2013. The system consists of a Septic tank, ABR, AF, CW, Oxidation channel and a pond.

Laboratory results:

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
1	ST out	7.20	6.90	27.80	27.50	0.00	0.36	0.10	3.00	352	278
2	ABR out	7.01	6.93	28.20	27.50	0.04	0.40	0.00	0.20	278.4	215
3	AF out	5.32	6.99	28.70	27.20	0.02	0.33	0.00	0.40	124	105
4	CW out	7.23	7.22	27.20	26.00	0.03	1.40	0.10	0.10	105.6	93
5	Ox. Channel out	7.40	7.27	27.70	28.60	0.22	0.46	0.00	0.00	96	84
6	Pond	--	7.90	--	26.30	--	7.25	--	0.00	--	38

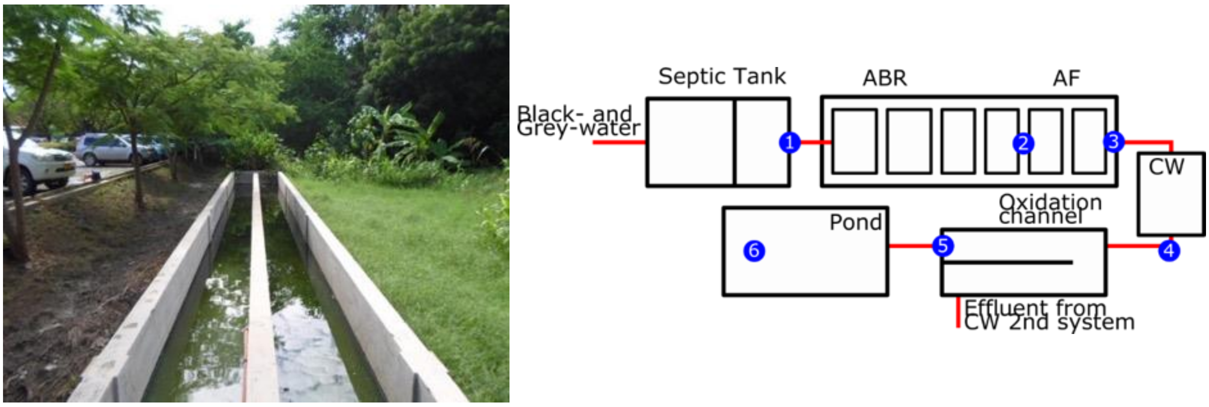


Figure 21: CCBRT Hospital a) Photo of the system. b) Schematic drawing including sampling points.

7.1.1.6 NSSF Estates

NSSF estates in Tabata, Dar es Salaam are apartment buildings, where each block of houses has a separate system. Each of the 10 systems are identical and consists of a settler, ABR, AF and a French drain. The systems were implemented by Waste Water Solutions and started operation in 2012. The samples were taken from three of the systems (Housing block A, C and D combined and G) to compare the results.

Laboratory results:

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
1	A ABR in	6.87	6.80	28.20	26.10	0.14	0.31	4.00	34	1056	443
2	A AF out	6.74	6.79	28.30	26.40	0.30	0.53	0.00	<0.1	180	115
1	C&D ABR in	6.60	--	27.90	--	0.00	--	7.00	--	1392	--
2	C&D AF out	6.81	6.69	27.60	27.20	0.20	0.55	0.40	<0.1	230.4	190
1	G ABR in	7.15	7.08	27.20	26.20	0.13	0.10	35	3.50	880	1368
2	G AF out	6.86	6.84	28.80	25.70	0.13	1.20	0.50	<0.1	172	133

No.	Sampling point	TSS (mg/l)		BOD (mg/l)	
		Rain	Dry	Rain	Dry
1	A ABR in	490	400	500	209.0
2	A AF out	110	100	85.0	54.0
1	C&D ABR in	600	--	660	--
2	C&D AF out	30	50	109.0	90.0
1	G ABR in	100	200	417.0	648
2	G AF out	70	80	82.0	63.0

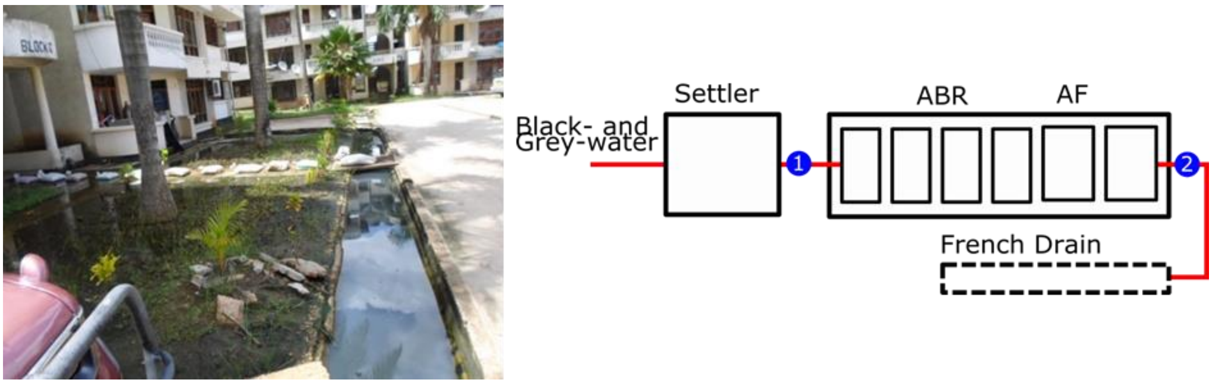


Figure 29: NSSF Estates a) Photo of the system. b) Schematic drawing including sampling points

7.1.1.7 Kigamboni FSTP

Kigamboni FSTP is a faecal sludge treatment plant in Kigamboni, Dar es Salaam. It was implemented by BORDA and UMAWA in 2013. It consists of a BGD, sludge drying bed, ABR, AF, sandfilter and a pond, where the effluent is stored before it is used for irrigation of banana plantations.

Laboratory results:

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
1	BGD out	7.10	7.60	29.10	26.30	0.17	0.26	1.00	0.50	448	228
2	ABR out	--	7.22	--	26.00	--	0.20	--	0.30	--	125
3	AF out	7.60	7.44	27.20	25.50	0.15	0.30	0.00	0.30	112	129
4	Sandfilter out	6.69	6.90	27.40	26.10	0.34	1.04	0.00	0.00	268.8	50
5	Pond	7.59	7.90	29.20	26.70	3.09	6.03	0.05	0.30	168	55.20

No.	Sampling point	TSS (mg/l)		BOD (mg/l)	
		Rain	Dry	Rain	Dry
1	BGD out	30	40	212.0	108.0
2	ABR out	--	30	--	59.4
3	AF out	20	10	53.0	61.2
4	Sandfilter out	30	10	127.3	23.7
5	Pond	30	30	79.0	26.2

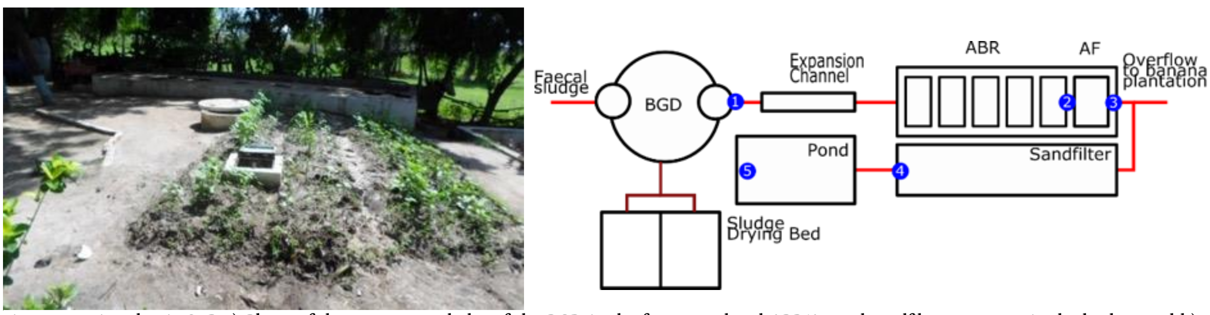


Figure 22: Kigamboni FSTP a) Photo of the system. Manholes of the BGD in the foreground and ABR/AF and sandfilter structure in the background b) Schematic drawing including sampling points.

7.1.1.8 Buguruni Flour Mill

Buguruni Flour mill has a decentralised wastewater system for their staff toilets. It was implemented by Waste Water Solutions in 2016. The system consists of a settler, two parallel streets of ABRs and AFs and a French drain.

Laboratory results:

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
1	Settler out	6.07	--	31.20	--	0.11	--	15.00	--	1870.4	--
2	AF 1 out	6.48	6.50	30.30	30.70	0.14	0.41	0.05	<0.1	240	111.50
3	AF 2 out	6.40	6.49	28.60	28.80	0.10	0.42	0.10	<0.1	224	97.00

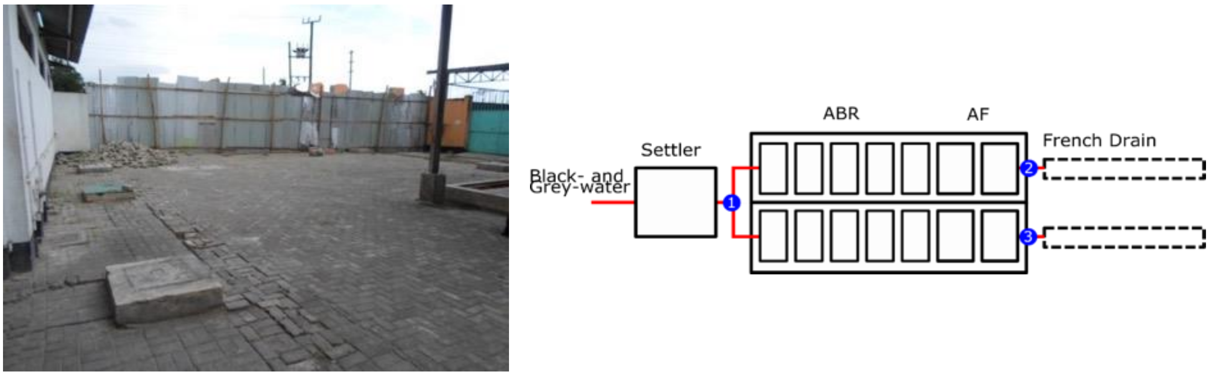


Figure 23: Buguruni Flour mill a) Photo of the system. b) Schematic drawing including sampling points.

7.1.1.9 BORDA Office

BORDA has built a DEWATS system on their own office compound in 2013. It consists of the following treatment modules: BGD, ABR, AF, CW, French drain and a pond.

Laboratory results:

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
1	BGD out	6.61	6.82	30.4	28.40	0.23	0.00	0.00	<0.1	218.9	150
2	ABR out	6.81	6.87	31.60	27.80	0.18	0.55	25.00	10.00	146.4	100
3	AF out	6.70	--	30.8	--	0.10	--	0.05	--	124	--
4	CW out	6.45	6.91	28.50	26.60	5.10	0.69	0.00	0.00	87.5	89.90
5	Pond	6.90	7.31	30.70	27.00	0.16	3.40	0.00	0.00	206.1	30.0

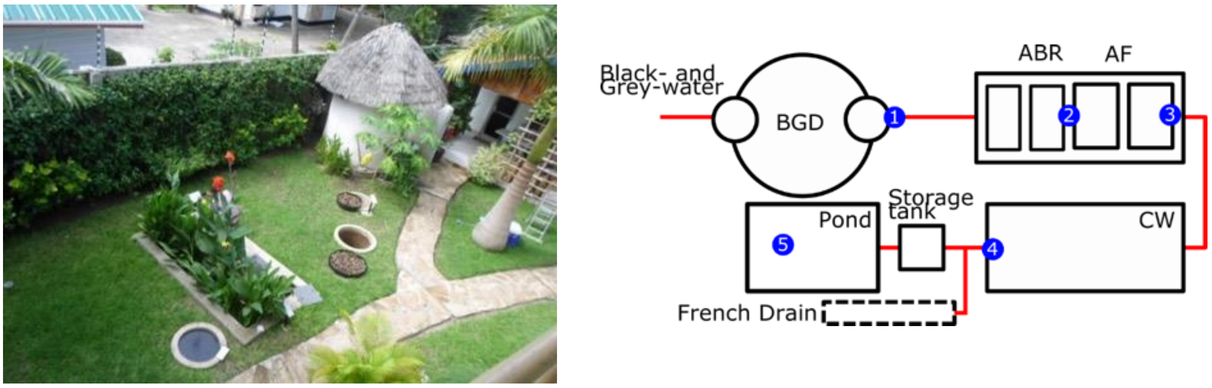


Figure 24: BORDA Office DEWATS a) Photo of the system. b) Schematic drawing including sampling points.

7.1.1.10 Anne Outwater

The wastewater treatment system of Anne Outwater connects three houses and treats black-water of three households and consists of septic tanks, a CW and a French drain.

Laboratory results:

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
1	ST Out	7.49	7.65	27.20	26.70	3.00	0.26	0.20	0.00	94.94	76.00

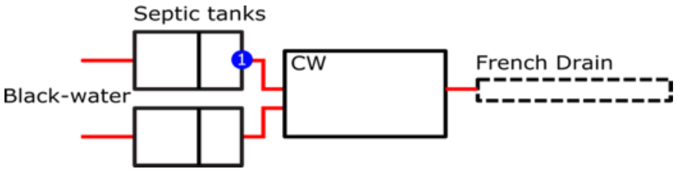


Figure 25: Anne Outwater system a) Photo of the system. b) Schematic drawing including sampling points.

7.1.1.11 Chamazi Community

The system treats the wastewater of the Chamazi community in Dar es Salaam. It was implemented by CCI and WSB Consult in 2012 and consists of a system of septic tanks and a CW.

Laboratory results:

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
1	STs out	7.35	7.50	29.00	29.10	0.71	0.20	2.00	1.00	382.3	748.00
2	CW out	6.57	--	27.80	--	2.80	--	0.00	--	83	--

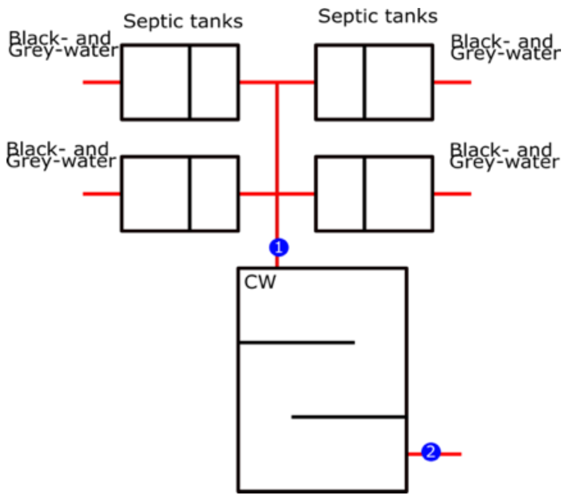


Figure 26: Chamazi Community a) Photo of the system. b) Schematic drawing including sampling points.

7.1.2 Iringa

7.1.2.1 Ruaha Secondary School

The Ruaha Secondary School in Ruaha, Iringa has a wastewater treatment system for a mix of day and residential students. The system was implemented by WSP & CW research in 2003 and consists of a system of septic tanks and CWs.

Laboratory results:

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
1	STs out	7.11	7.05	22.10	20.10	0.20	0.40	0.50	0.30	134	100
2	ST2 out	--	7.36	--	18.60	--	0.46	--	0.10	--	130
3	CW1 out	--	7.18	--	17.60	--	5.40	--	0.00	--	40
4	CW2 out	--	7.50	--	17.70	--	4.80	--	<0.1	--	80

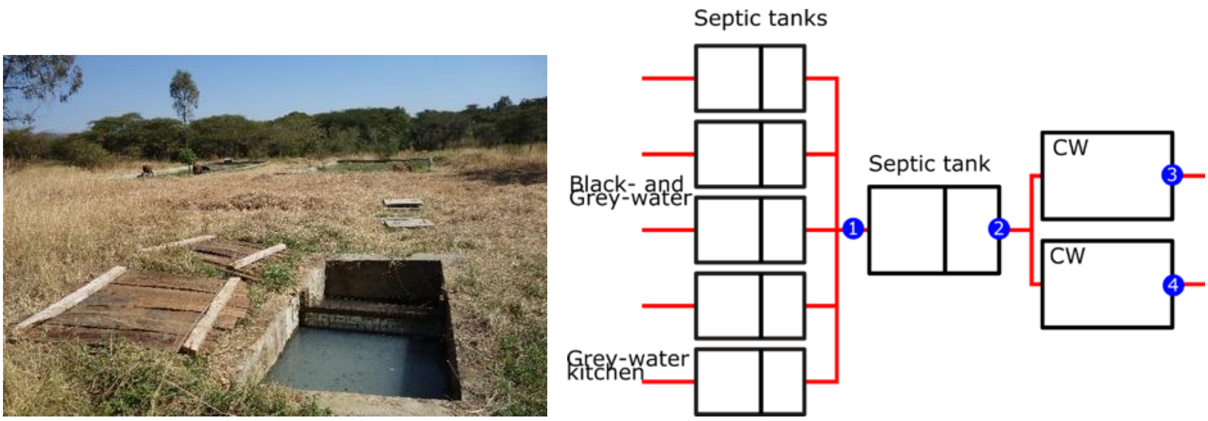


Figure 27: Ruaha Secondary School a) Overview photo of the system. It shows the last septic tank and the two parallel CWs. b) Schematic drawing including sampling points.

7.1.2.2 Iringa girls Secondary School

The Iringa girls Secondary School is a residential school, which has a decentralised wastewater treatment system implemented by WWS Designs and started the operation in 2013. The system consists of a septic tank system, a CW and a pond.

Laboratory results:

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
1	STs out	7.97	--	21.80	--	1.21	--	0.10	--	94.2	--
2	CW out	7.09	8.07	20.40	16.10	1.30	0.61	0.05	0.00	83.2	273
3	Storage chamber	7.40	7.27	22.40	19.10	3.40	0.90	0.00	1.50	67	34.52

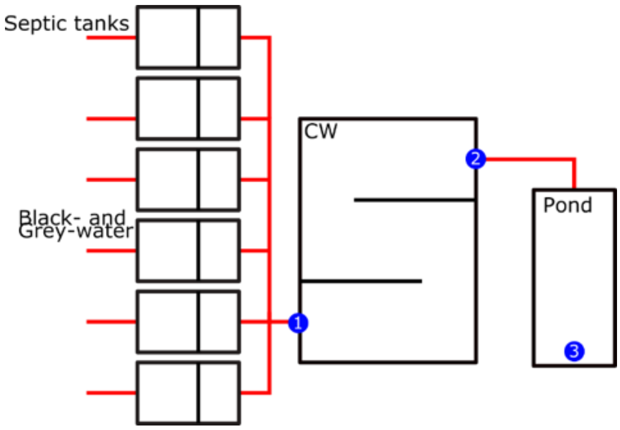


Figure 28: Iringa Girls Secondary School a) Photo of the CW. b) Schematic drawing including sampling points.

7.1.2.3 Kleruu Teachers College

The Kleruu Teachers College in Iringa has a wastewater treatment systems implemented by WSP & CW Research Group in 2005. The system consists of the following treatment modules: Steering tank, constructed wetland and a French drain.

Laboratory results

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
1	ST out	7.10	7.68	24.40	25.30	0.60	3.00	0.50	0.20	104	116.10
2	CW out	6.54	7.63	23.60	23.00	2.03	4.40	0.10	3.00	16.64	69.63

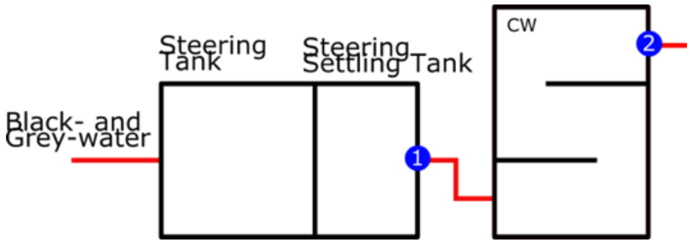


Figure 29: Kleruu Teachers College a) Overview photo of the system with the flooded CW in the foreground and the steering tank in the background. b) Schematic drawing including sampling points.

7.1.3 Dodoma

7.1.3.1 Dodoma University

The Dodoma University implemented a wastewater treatment system together with DUWASA with start of operation in 2015. The system consists of a screening chamber, ABR and CW.

Laboratory results:

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
1	ABR in	8.11	7.15	24.50	28.40	0.40	--	8.00	30.00	554.1	800.00
2	ABR out	7.37	6.90	25.60	26.00	0.60	--	0.10	<0.1	99.21	80.00
3	CW out	7.62	6.98	29.90	21.70	5.45	--	0.00	<0.1	59.9	40.00

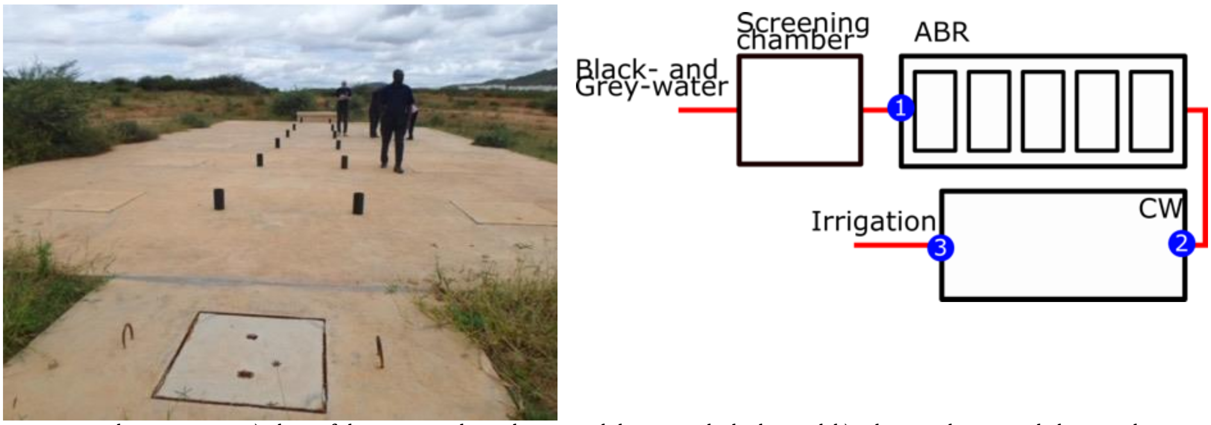


Figure 30: Dodoma University a) Photo of the system. It shows the ABR and the CW in the background. b) Schematic drawing including sampling points.

7.1.4 Arusha

7.1.4.1 The School of St. Jude

The school of St. Jude is a residential school in Arusha. They have a DEWATS system implemented by AB Contractors and BORDA in 2012. The system consists of the following treatment modules: Grease trap, 2 BGDs, 4 parallel streets of ABR and AF chambers and two CWs.

Laboratory results:

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
1	ABR in	7.09	7.45	21.00	21.00	0.52	0.62	0.00	<0.1	240	348.00
2	AF in	6.66	7.58	25.40	21.00	2.31	2.10	1.00	8.00	160	326.00
3	AF out	6.61	7.37	21.90	20.50	2.40	1.03	0.00	0.00	80	130.60
4	CW1 out	6.52	7.35	21.50	50.50	2.07	2.90	0.10	<0.1	90	101.80
5	CW2 out	6.81	7.36	21.40	19.00	2.40	3.40	0.00	0.00	67.2	43.52

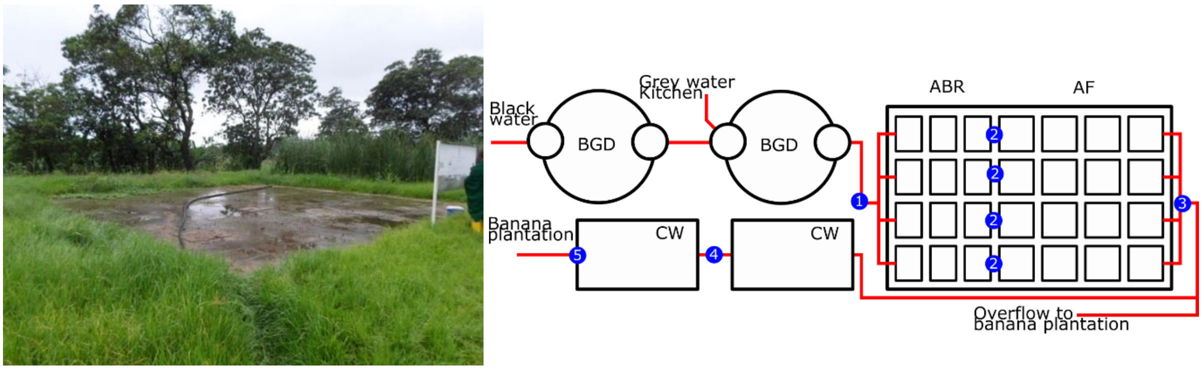


Figure 31: St. Jude Secondary School a) Photo of the system. b) Schematic drawing including sampling points.

7.1.4.2 NM-AIST

The Nelson Mandela African Institution for Science and Technology (NM-AIST) in Tengeru, Arusha implemented a wastewater treatment system in 2014. It consists of septic tanks, soak away and CWs. NM-AIST is doing research on the constructed wetlands, therefore they installed two different kinds parallel.

Laboratory results:

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
1	ST 1 out	7.52	7.98	23.30	24.00	1.18	0.32	0.10	<0.1	416	319.20
2	Soak away out	6.84	7.67	23.78	23.00	1.30	1.31	0.70	1.50	372	362.60
3	ST 2 out	7.11	7.69	23.45	24.00	1.45	1.20	2.00	7.50	166.4	261.20
4	CW in	7.31	7.71	23.59	23.60	1.30	2.60	0.00	<0.1	332.8	195.80
5	CW 1 out	7.16	7.82	23.45	20.60	1.31	3.08	0.00	<0.1	83.2	43.50
6	CW 2 out	7.13	7.86	22.40	20.70	1.20	2.80	0.00	<0.1	249.6	87.04

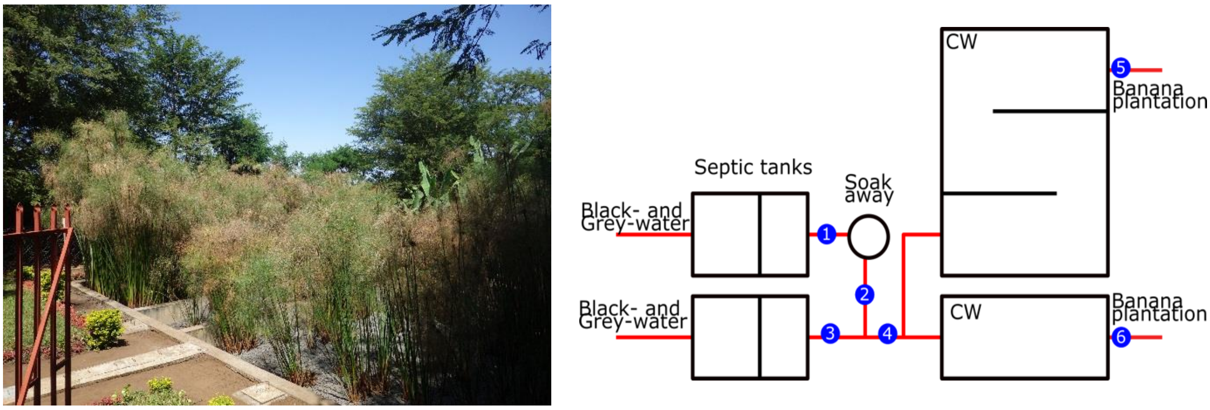


Figure 40: NM-AIST a) Photo oft he system. b) Schematic drawing including sampling points

7.1.4.3 Sakila Secondary School

The Sakila Secondary School in Meru, Arusha is for both day and residential students. There are two separate systems for the students and teachers toilets. Both consist of a septic tank with soak away and one resp. two ponds. The ponds were added, because the soil could not soak enough water and the area around was flooded.

Laboratory results:

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
1	Pond students	8.60	8.26	22.10	21.30	5.50	1.20	0.50	1.20	34.2	296.00
2	Pond teachers	7.30	8.26	20.80	20.90	2.30	2.70	0.10	0.00	67.2	104.00

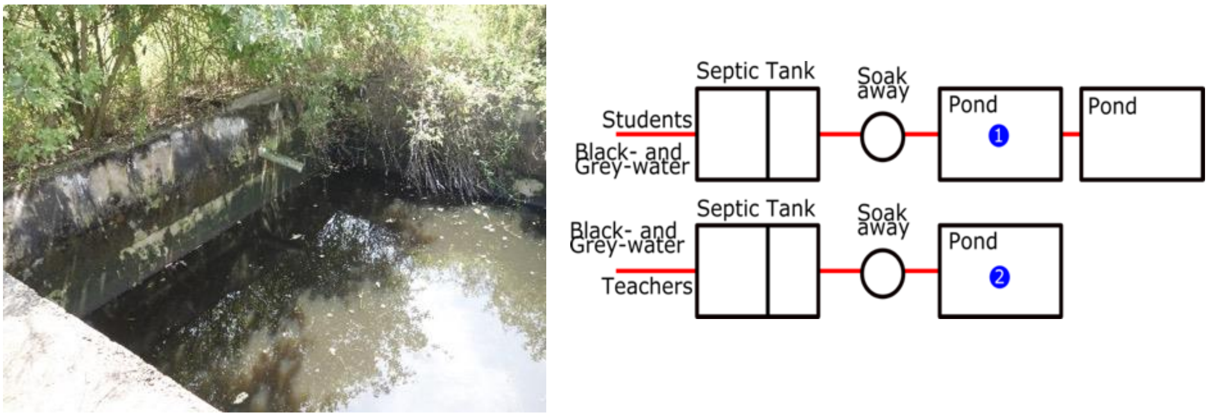


Figure 32: Sakila Secondary School a) Photo of the system. b) Schematic drawing including sampling points.

7.1.5 Kilimanjaro

7.1.5.1 Kibosho Council Hospital (KCH)

Kibosho Council Hospital (KCH) in Kibosho, Moshi has a wastewater treatment plant implemented by ABContractors in 2002. It consists of a screen, a BGD, ABR, CW and soak away. Additionally to the hospital, a school and a nursing school are connected to the system.

Laboratory results:

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
1	ABR1 in	6.40	6.50	20.40	17.10	0.52	2.75	0.20	0.50	315	128.00
2	ABR1 out	6.91	6.50	24.00	17.50	0.80	0.29	0.05	2.00	133	149.00
3	ABR2 out	7.21	6.52	22.20	19.60	1.04	2.90	0.00	12.50	102	96.00
4	CW out	7.45	6.60	23.20	19.30	1.75	3.80	0.00	0.30	61.25	76.00

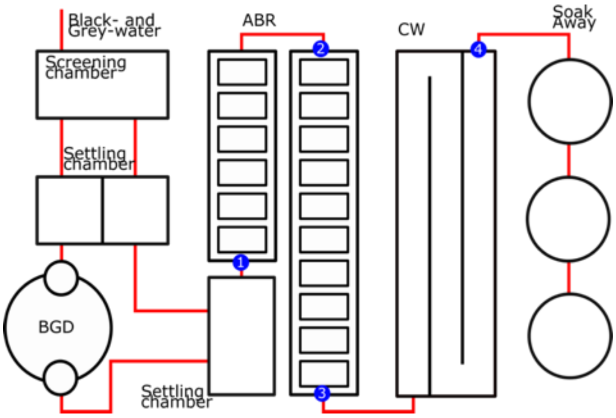


Figure 33: Kibosho Council Hospital a) Photo of the system. b) Schematic drawing including sampling points.

7.1.5.2 Shokony Primary School

Shokony Secondary School is located in Mwika, Kilimanjaro. In 2012, a DEWATS consisting of a BGD with expansion chamber and a French drain was implemented by the school, EEPCO and BORDA.

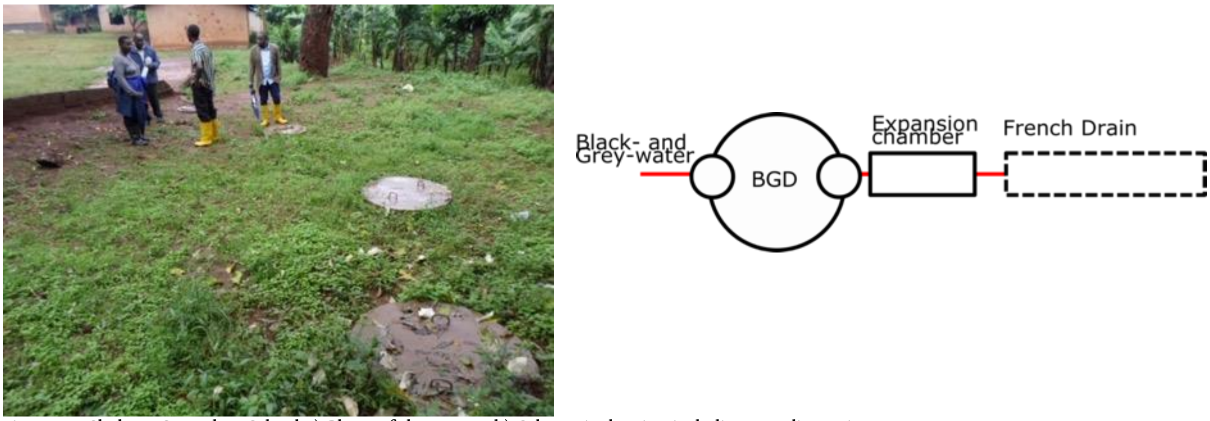


Figure 34: Shokony Secondary School a) Photo of the system. b) Schematic drawing including sampling points.

7.2 Centralised wastewater treatment projects

The scope of this project is to showcase the suitability of decentralised wastewater treatment plants in Dar es Salaam.

Most households and institutions in Tanzania rely on pit latrines and septic tanks, which have to be emptied when they are full. Therefore, vacuum trucks are emptying the containment and bringing the faecal sludge to a centralised system. Those systems receive faecal sludge from pit latrines and septic tanks all over Dar es Salaam.

To get an impression of the performance of existing centralised systems as well as to compare them with decentralised solutions, two centralised wastewater stabilisation ponds in Dar es Salaam were monitored in the course of this M&E campaign: Vingunguti and Kurasini.

7.2.1 Dar es Salaam

7.2.1.1 Vingungti WWSP

The Vingunguti WWSP is a centralised system of anaerobic, facultative and maturation ponds in Ilala, Dar es Salaam. It treats the faecal sludge, which is brought there by vacuum trucks and the black- and grey-water of a neighbouring community. The ponds were implemented by SPENCO, JW RADWA and the government in 1970.

Laboratory results:

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
1	Facultative pond out	6.70	7.46	30.60	29.00	0.00	0.90	0.20	<0.1	108	750.00
2	Maturation ponds out	7.30	7.71	27.90	28.80	0.00	2.32	0.10	<0.1	72	475.00

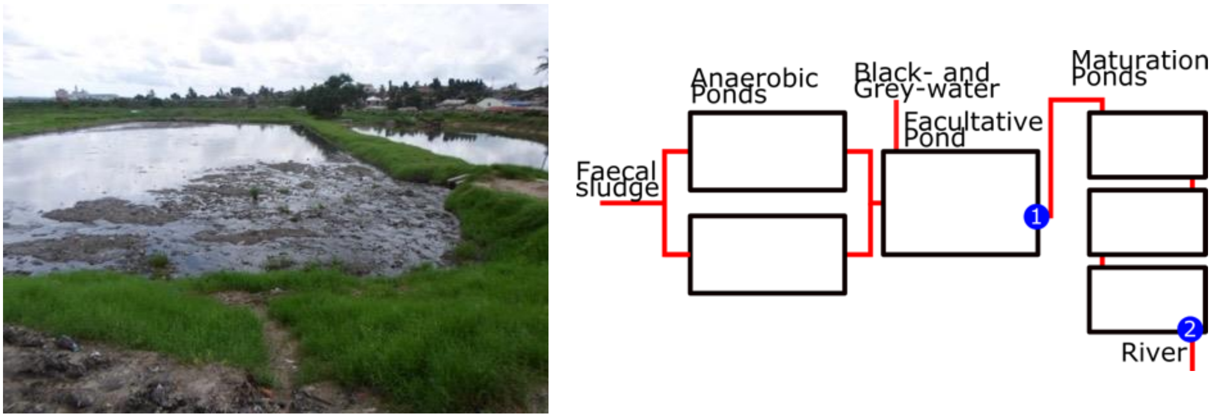


Figure 35: Vingunguti WWSP a) Photo of the system. b) Schematic drawing including sampling points.

7.2.1.2 Kurasini WWSP

The Kurasini WWSP is a centralised system of anaerobic, facultative and maturation ponds in Ilala, Dar es Salaam. It treats the faecal sludge, which is brought there by vacuum trucks. The ponds were implemented by DAWASA/DAWASCO in 1970.

Laboratory results:

No.	Sampling point	pH		Temperature (°C)		DO (mg/l)		SS (ml/l)		COD (mg/l)	
		Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry	Rain	Dry
1	Anaerobic ponds out	7.13	7.42	30.60	31.20	1.95	1.23	2.50	0.50	163.2	823.00
2	Facultative pond out	7.63	7.74	26.80	27.60	1.80	0.23	0.50	<0.1	108.8	842.0
3	Maturation ponds out	7.68	7.73	29.40	27.80	2.50	0.30	0.10	<0.1	90.8	411.00

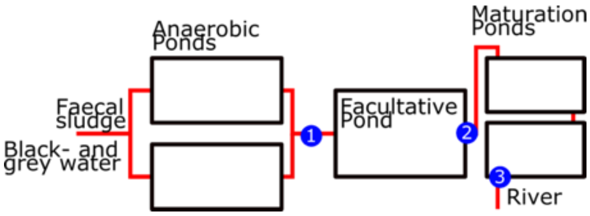


Figure 36: Kurasini WWSP a) Photo of the system. b) Schematic drawing including sampling points