SFD Promotion Initiative

Dar es Salaam
Tanzania

Final Report

This Shit Flow Diagram (SFD) report was created through field-based research by Sandec (the Department of Sanitation, Water and Solid Waste for Development) at Eawag (the Swiss Federal Institute of Aquatic Science and Technology) as part of the SFD Promotion Initiative.

Date of production: 03/09/2015
Last update: 26/10/2015

SFD Promotion Initiative

sustainable sanitation alliance

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of Federal Ministry for Economic Cooperation and Development

UNIVERSITY OF LEEDS

WORLD BANK GROUP Water

wsp water and sanitation program

WEDC Loughborough University

CSE

eawag aquatic research

Sandec Sanitation, Water and Solid Waste for Development

BILL & MELINDA GATES foundation

SFD Dar es Salaam, Tanzania, 2015

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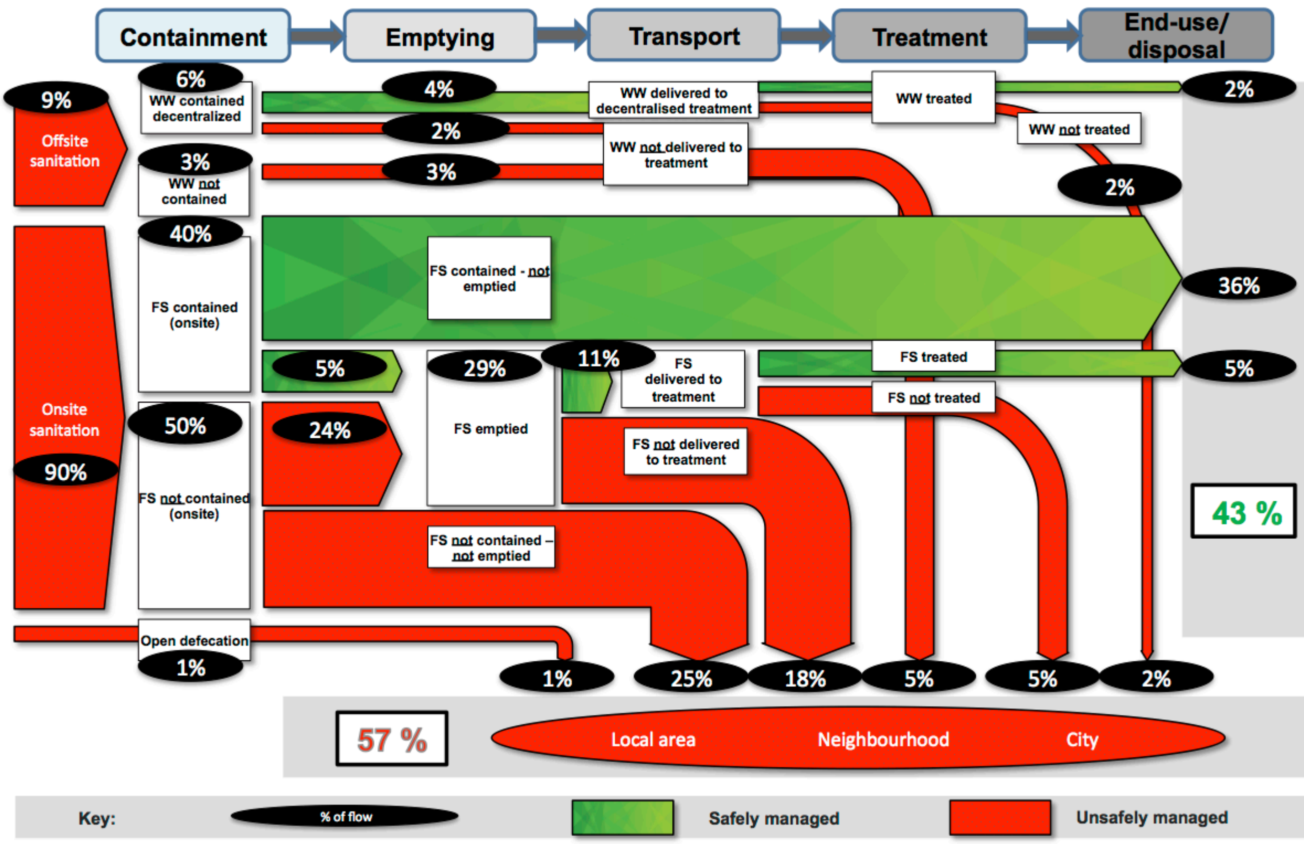
1. The Diagram

Dar es Salaam, Tanzania, 03.09.2015
Field based assessment



Note: Percentages do not add up to 100 due to rounding.

2. Diagram information

The Shit Flow Diagram (SFD) was created through field-based research by Sandec (the Department of Sanitation, Water and Solid Waste for Development) at Eawag (the Swiss Federal Institute of Aquatic Science and Technology).

Collaborating partners:
University of Dar es Salaam (UDSM)

Bremen Overseas Research and Development Organization (BORDA) Southern Africa / SADC

Ifakara Health Institute (IHI)

Status:
Final SFD.

Date of production:
03/09/2015

3. General city information

Dar es Salaam lies on the coast of the Indian Ocean and is the largest city and economic hub of Tanzania (DCC, 2004). For the SFD project, the political boundary of the city was chosen as no other boundaries were easy to distinguish.

The 2015 population is estimated to have reached more than 5 million inhabitants (NBS, 2013). It is reported that the work day population increases to 7 million people because workers from surrounding towns travel to the city, and Dar es Salaam inhabitants commute to the centre (EEPCO, 2015).

More than 70% of the population lives in informal settlements; however, the income structure in the wards is diverse, i.e., middle- and high-income households also live in informal settlements. Dar es Salaam's population density is 3,133 people/km^2, ranging from 46 to 46,721 people/km^2 in the different wards; the peri-urban outskirts have rural characteristics (Andreasen, 2013).

Dar es Salaam is generally flat with hilly areas further away from the coast. During the two rainy periods each year, onsite sanitation technologies are affected by flooding due to the rising groundwater level. Faecal sludge emptying methods and frequency vary depending on the season (Van Camp et al., 2013).

4. Service delivery context

Tanzania's National Water Sector Development Strategy 2006-2015 describes access to safe and hygienic methods of excreta disposal as a basic need and right for all human beings (MoWI, 2006). In the past, more consideration was given to the number of consumers served, rather than the minimum levels of required service. However, now more focus is lying on providing low-income households with context specific solutions by including non-governmental organisations and community-based organisation in financing, developing and managing these services to ensure long-term sustainability (MoWI, 2006).

National policies and guidelines generally exist, but adaptation into local, concrete strategies is lacking, as is enforcement. Guidelines and manuals are not readily available online, but are distributed by the city council to local government authorities, which disseminate the documents through workshops and meetings. There are increasing efforts to provide faecal sludge management by municipalities, however 57% of faecal sludge is still not safely contained or disposed of. Policy documents acknowledge the importance of pro-poor support, however, low-income areas remain the most unserved areas, practising unhygienic manual emptying methods and direct disposal of faecal sludge into the environment.

Access to sewers and improved sanitation are clear goals, and sanitation and hygiene awareness raising campaigns are common, however, targets specifically referring to collection, transport and treatment of faecal sludge are lacking. Emptying and transport service providers exist, however, they are not able to provide services to all districts and types of settlements. Improved access will require coordination and support from government authorities. There are plans to build three centralized treatment plants for wastewater however, there are currently not any plans to construct faecal sludge treatment plants. This is especially important, as the sewer network cannot and most likely will not be able to keep up with population growth.

Routine monitoring of access to sanitation services is carried out by environmental health officers at the sub-ward level, while the water and sewerage corporation monitors the performance of wastewater treatment plants. Further information on access to sanitation services is collected through census and surveys conducted every few years under the National Bureau of Statistics. However, the existing monitoring processes are not utilized to full capacity. A common definition of improved sanitation exists but is not executed in practise, which complicates the monitoring process (WB, 2015) Furthermore, wastewater volumes through the sewer network are not measured (DAWASA, 2015).

To increase safe disposal, treatment and enduse of excreta will require clear policy guidelines, clear institutional accountability with targets and indicators along the whole sanitation service chain. This could create ownership by local government authorities and increase implementation at all levels (Trémolet and Binder, 2013). In addition, it is necessary to "revisit the policy of only using public funds for sewerage expansion in favour of a pro-poor approach that supports urban household sanitation promotion with public solutions to facilitate better faecal sludge management" (WSP 2011).

5. Service outcomes

In Dar es Salaam, it was estimated that 43% of excreta is managed safely, of which 36% result from faecal sludge being contained and not emptied in areas with low risk of groundwater pollution. However, the SFD reflects the current status of excreta, which does not translate to future recommendations. For example, safely capping of pit latrines in the future will not be possible due to increased population density. In total, 57% of the excreta ends up directly in the environment without adequate treatment. 90% of the population rely on onsite sanitation technologies for containment of excreta (75% pit latrines, 15% septic tanks) (NBS, 2015). However, half of the excreta from these onsite sanitation technologies is not contained; for example, pit latrines with outlets that directly discharge into open drains or water bodies, and partially lined pits and septic tank soakpits in areas with high groundwater (Jenkins et al., 2014, EHOs FGD, 2015). 50% of onsite systems are in areas with high groundwater, where groundwater is the source of drinking water.

The remaining 10% of excreta flows are 1% open defecation, 3% pour flush toilets going directly to open drains or water bodies (NBS, 2015, EHOs FGD, 2015), and 6% containment by sewers (DAWASCO, 2015a, NBS, 2015).

Emptying of onsite sanitation technologies is carried out by service providers with 120 privately owned vacuum trucks who deliver faecal sludge to treatment sites, and five community based organizations using the gulper technology. Nevertheless, large quantities of faecal sludge are discharged directly into the environment, for example manual diversion of pit latrine contents by so-called "frogmen", and flooding out of pit latrine contents in the rainy season (Trémolet and Binder, 2013, BORDA, 2015, Jenkins et al., 2014). Many onsite containment systems have not been emptied in the last 10 years or more and are thus fall under the categories of contained, not emptied (36%), or not contained, not emptied (25%)(Mkanga and Ndezi, 2014, EHOs FGD, 2015).

66% of wastewater transported through sewers is delivered to treatment sites, and the remainder is discharged directly into the ocean through an outfall, or directly into the environment as a result of frequent overflows due to blockages of solid waste in the sewer (AAW et al., 2008, EWURA, 2014).

The wastewater and faecal sludge that is delivered to treatment sites is treated in waste stabilization ponds. It is estimated that 50% of the wastewater and faecal sludge delivered to treatment is effectively treated.

6. Overview of stakeholders

Local governmental authorities are responsible for enforcement of regulations for the use of appropriate containment technologies and the emptying of onsite sanitation technologies (URT, 2000). These include the three municipal councils of Kinondoni, Ilala and Temeke (see Figure 1), which oversee the authorities at the ward and sub-ward level. The councils are administered by the Dar es Salaam City Council and the Prime Minister's Office of Regional Administration and Local Government (PMO-RALG) (START et al., 2011). The Dar es Salaam Water and Sewerage Authority (DAWASA) under the Ministry of Water (MoW) and the Energy and Water Utilities Regulating Authority (EWURA) has contracted the Dar es Salaam Water and Sewerage Corporation (DAWASCO) to operate the water and sewerage services, including operation and maintenance of the sewer network and appropriate treatment of wastewater. The MoW and PMO-RALG signed a Memorandum of Understanding with the Ministry of Health and Social Welfare (MoHSW), as well as the Ministry of Education and Vocational Training (MoEVT), to improve coordination and cooperation in access to sanitation services and set standards for improved sanitation (S&H MoU, 2009).

As stated above, there are privately owned vacuum trucks and community gulper based groups providing collection services (TMC, 2015). To discharge at DAWASA's faecal sludge treatment site (waste stabilization ponds), service providers have to register with DAWASCO. The municipalities encourage and support the development of new manual emptying service providers by providing necessary equipment to the gulper businesses. Support for low-income Households is provided by non-governmental organizations (NGOs) like the Center for Community Initiatives, Sanitation and Water Action, WaterAid Tanzania and others, who implement context specific solutions, such as simplified sewers and decentralised wastewater treatment.

International financing institutions, such as the World Bank or the African Development Bank, disburse their funds through a basket fund to the Ministry of Finance. Multilateral organisations and international NGOs, such as UNICEF or Plan International, support projects by municipalities financially, e.g., by providing training for the construction of onsite sanitation technologies.

Overall, the sanitation sector in Dar es Salaam is fragmented without clear responsibilities, making it difficult to coordinate, define and enforce activities.

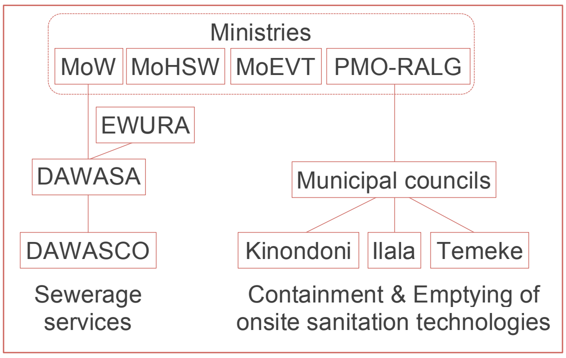


Figure 1: stakeholders responsible for enforcing and carrying out sanitation services.

7. Credibility of data

Estimations were based on a literature review of journal articles, research reports and national policy documents. If adequate information was not available in these sources, then unpublished reports and presentations were used. For triangulation to verify the validity of data, 14 key informant interviews and two focus group discussions were conducted. Observations on settlement structures, emptying service providers and treatment facilities were also used to verify credibility of data. Where assumptions were made, they were backed up by interview statements or results from focus group discussions. In addition, internal records from DAWASCO and DAWASA supplied useful information that assisted the analysis of offsite sanitation.

For low-income regions, a number of surveys was available for review and comparison. However, they tend to focus on issues such as user interface. In the future it would be more useful to include design and construction of containment technologies. Assumptions had to be made mainly for the middle/high income households due to the lack of data.

Existing mapping of soil and groundwater characteristics is limited. Thus, the following assumptions were made: 50% of residents reside in areas with high groundwater pollution risk. It was also assumed that 10 people are served per sewer connection (DAWASCO, 2015a), and that emptying service providers using vacuum trucks or the gulper technology deliver faecal sludge to treatment sites.

8. Process of SFD development

Local Government Authorities and municipal councils were actively engaged in the process of data collection. For example, a focus group discussion with seven Environmental Health Officers from wards of each of the three municipal councils in Dar (Ilala, Temeke, Kinondoni) was conducted. These officers are directly responsible for service provision and monitoring in the respective council and for example support the implementation of the gulper technology in low-income areas. Additional focus group discussions were held with emptying and transport service providers, as well as local NGO's. Interviews were conducted with the Ministry of Health and Social Welfare, who is responsible for public health and sanitation, and additional key informant interviews were performed with the National Environmental Council. The Water & Sewerage Authority und Water & Sewerage Corporation (DAWASA/DAWASCO) participated by providing information for the SFD, and were supportive of the assessment. The final SFD was presented to collaborating partners, and shared electronically with stakeholders that were actively involved in gathering information.

9. List of data sources

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SFD Dar es Salaam, Tanzania, 2015

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Table of Content

List of tables

List of figures

Abbreviations

BOD	Biological Oxygen Demand
BORDA	Bremen Overseas Research and Development Association
CBO	Community Based Organization
COD	Chemical Oxygen Demand
DCC	Dar es Salaam City Council
DAWASA	Dar es Salaam Water and Sewerage Authority
DAWASCO	Dar es Salaam Water and Sewerage Corporation
DEWATS	Decentralized Wastewater Treatment System
EEPCO	Environmental Engineering and Pollution Control Organization
EHO	Environmental Health Officer
EWURA	Energy and Water Utilities Regulating Authority
FGD	Focus Group Discussion
FS	Faecal Sludge
FSM	Faecal Sludge Management
FSTP	Faecal Sludge Treatment Plant
GW	Groundwater
HH	Household
KII	Key Informant Interview
LGA	Local Government Authority
MC	Municipal Council
MoHSW	Ministry of Health and Social Welfare
MoW	Ministry of Water
NGO	Non-Governmental Organization
NEMC	National Environmental Management Council
NSC	National Sanitation Campaign
NWSDS	National Water Sector Development Strategy
OD	Open Defecation
PHA	Public Health Act
PMO-RALG	Prime Minister's Office - Regional Administration and Local Government
PPP	Public Private Partnership
SFD	Shit Flow Diagram
TBS	Tanzanian Bureau of Standards
TZS	Tanzanian Shillings (average[1] in 2015: 1USD ≈ 2,000TZS)

[1] http://www.exchangerates.org.uk/USD-TZS-exchange-rate-history.html (accessed 17th July 2015)

UDSM	University of Dar es Salaam
USD	US Dollar
WB	World Bank
WSDP	Water Sector Development Programme
WSP	Waste Stabilization Pond
WSSA	Water Supply and Sanitation Authority
WT	Water Table
WW	Wastewater
WWTP	Wastewater treatment plant

1 City context

This Shit Flow Diagram (SFD) report presents results from field-based research done in the city Dar es Salaam, Tanzania. Tanzania's capital is Dodoma, but the country's largest city and economic hub is Dar es Salaam, which lies on the coast of the Indian Ocean. The city has three districts (or municipalities) Kinondoni, Ilala and Temeke (see Figure 15, appendix 7.8), covering a total area of 1,393 km^2.

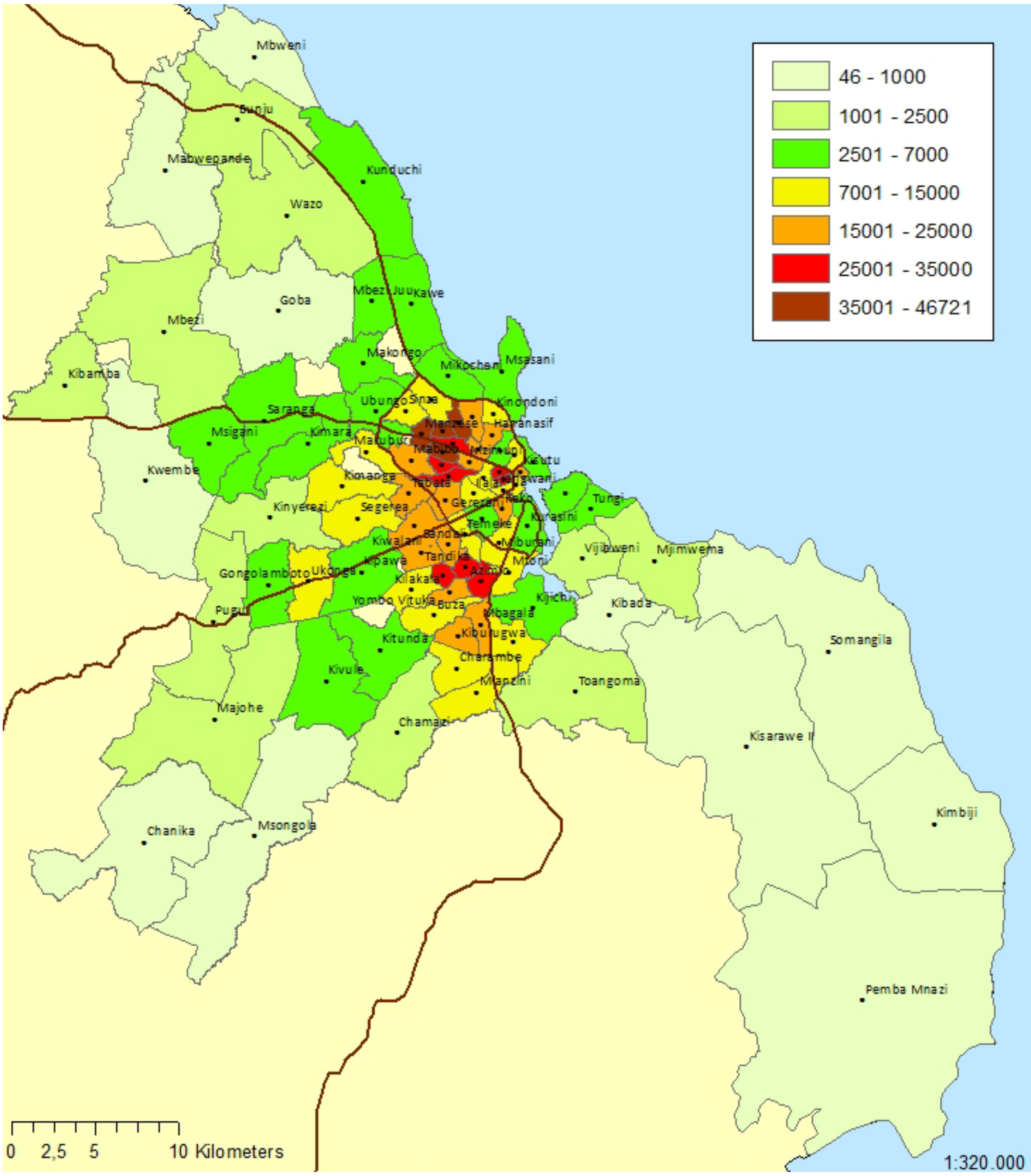

Figure 1: Wards of Dar es Salaam according to population density in 2012 (in people per km^2) (Andreasen, 2013).

According to the Population and Housing Census 2012 (NBS, 2013), Tanzania had a population of 44,928,923 and Dar es Salaam had 4,368,541. With an estimated population growth rate of 5.6% in Dar es Salaam (NBS, 2013), the population in 2015 could be estimated to have reached around 5,167,707 people. The census reports a household (HH) count of 1,095,095 HHs with an average HH size of four. Dar es Salaam's population density is 3,133 people/km^2, ranging from 46 to 46,721 people/km^2 in the different wards [(Andreasen, 2013), see Figure 1]. It is estimated that Dar es Salaam has a night time population of more than 5 million, and a day time population of 7 million. This difference can be explained because people commute to the city for work, for instance, from surrounding towns like Bagamoyo (EEPCO, 2015). More than 70% of Dar es Salaam's inhabitants live in informal settlements (Mkanga and Ndezi, 2014, Jenkins et al., 2014b) where unplanned urbanization poses a challenge to the delivery of appropriate (sanitation service) infrastructure. The settlement structure is diverse in the sense that the high-income and low-income population reside in the same areas. Unplanned growth has created dense informal settlements in the central parts of the city where appropriate planning is a challenge (NGOs FGD, 2015).

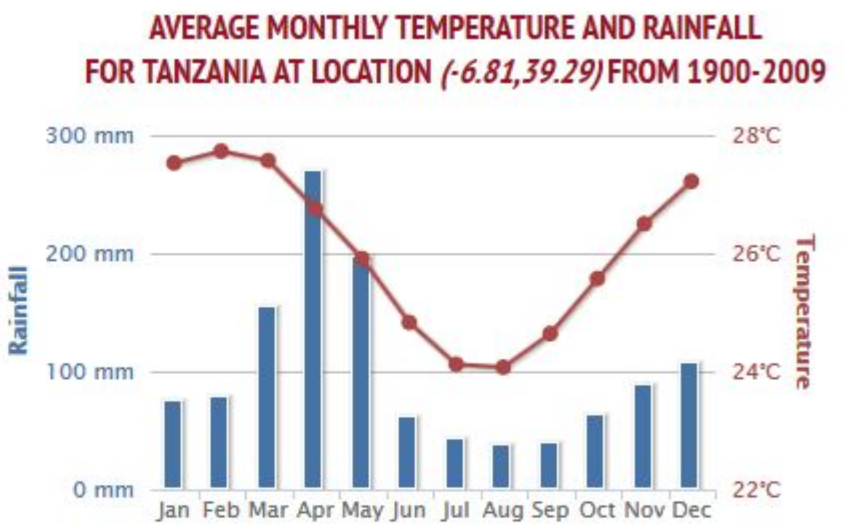

Figure 2: Average monthly temperature and rainfall for Dar es Salaam (WB, 2015a).

Dar es Salaam experiences a monsoon climate with two distinct rainy periods during the year, in the months of March, April and May, and November and December (Van Camp et al., 2013), see Figure 2. Heavy rainfalls have an impact on excreta management due to rising groundwater (GW) levels, the flooding of onsite sanitation technologies and, therefore, the resulting contamination risk of GW. Furthermore, faecal sludge (FS) emptying methods vary depending on the season, and emptying services are affected by congested traffic. During rainy days, smaller roads are not accessible, which causes traffic congestion on larger asphalt roads (Observation, 2015, Motorized Emptying & Transport Service Providers, 2015a).

Dar es Salaam's topography can be characterized as generally flat, with hilly areas further away from the coast (Van Camp et al., 2013, Observation, 2015, Mtoni, 2013), compare Figure 13, Appendix 7.7.1, 7.7.2). Dar es Salaam's water bodies are characterized by four main rivers (Mzinga, Kizinga, Msimbazi and Mbezi) and several seasonal streams (Van Camp et al., 2013). A generally high water table (WT) and seasonal flooding events pose challenges to the housing and sanitation situation with GW levels ranging between 10-50 m according to Van Camp et al. (2013). However, local stakeholders reported during discussions that many areas in Dar es Salaam have water tables of less than 1.5 m, where in rainy periods the GW rises up to the surface (NGOs FGD, 2015).

The soil characteristics are described as 95% loam, 4% sand, and 1% clay (Chaggu et al., 2002). Mtoni (2013) describes the geology of Dar es Salaam by differentiating between coastal plains and river deltas: “Coastal plain soils are yellowish red, brown to dark-brown sandy loam, with a fairly thick loose sandy top with good porosity and well drained with a fairly low capacity to retain moisture. An alternation of fine and coarse grained sands occurs within the valleys, creeks, deltas and mangrove sites.” Other sources show Dar es Salaam as characterized by mainly sandy soils (compare geological maps in appendix 7.7.1). For further information on geology and groundwater, refer to chapter 3.2.1.

2 Service delivery context analysis

2.1 Policy, legislation and regulation

2.1.1 Policy

A range of national policies exist on different cross-cutting sanitation issues. A sanitation policy has been under development since 2008; however, adoption has not yet been achieved for various reasons (Chaggu et al., 2002, MoHSW, 2015).

The National Water Sector Development Strategy (NWSDS) 2006-2015 describes the “availability of clean and safe water” and “access to safe and hygienic methods of excreta disposal” as “a basic need and right for all human beings” (MoWI, 2006). Yet, the strategy acknowledges that in the past “sewerage and sanitation schemes have been developed with more consideration being given to the number of consumers served and the financial resources available, rather than the minimum levels of service that are required by different categories of consumer”. Therefore, the strategy aimed at establishing criteria to define low-income groups and to promote the use of “appropriate and cost-effective solutions to the provision of (…) sanitation services”. One method to achieve an improvement of sanitation services is understood to be the participation of Non-Governmental Organizations (NGOs) and Community Based Organizations (CBOs) in “financing, developing, and managing” such services (MoWI, 2006).

Guidelines and manuals can hardly be found online, as they are distributed through the city council to the local government authorities, which disseminate the documents at workshops/meetings. The Prime Minister's Office - Regional Administration and Local Government (PMO-RALG), as the leading body of Local Government Authorities (LGAs), is responsible for implementing this (MoHSW, 2015). Thus, the list in Table 5, (appendix 7.2) should not be seen as exhaustive, as other guidelines might exist that the authors were not aware of. However, Table 5 lists the main policies, acts, regulations and guidelines regulating excreta management in Dar es Salaam/Tanzania. Although it was found that many important national policies and guidelines exist, enforcement is a challenge.

Containment is laid out as a HH responsibility in the Public Health Act (PHA) (URT, 2009a). LGAs are responsible for enforcement of the usage of proper sanitation technologies and of emptying methods (URT, 2000). This starts with regular latrine inspections by environmental health officers (EHOs) and giving fines for illegal emptying and disposal of liquid waste (TMC, 2015, IMC, 2015). However, liquid waste management is hardly included in the by-laws of LGAs, the focus of which is solid waste (IMC, 2011, TMC, 2012).

WAT (2012) summarizes the legal situation for emptying and transport service providers and states that there is an “absence of policy guidelines and regulations for facilitating the pit emptying business”. Emptying service providers are supposed to register at DAWASCO in order to be allowed to dispose FS at their treatment sites; however, there is no environmental management authority that observes this sector. The Local Government (Urban Authorities) Act defines the role of LGAs regarding excreta management (including safe disposal) (URT, 2000), whereas treatment of wastewater (WW) is set out as the responsibility of Dar es Salaam’s Water and Sewerage Authority (DAWASA) (URT, 2001a, URT, 2009c).

The Public Health Act (PHA) (URT, 2009a) and municipal by-laws declare that the disposal of liquid waste into the environment/open drains/water bodies is a hazardous, illegal act. LGAs can impose fines for illegal disposal of waste. However, in practice this is not commonly done.

The Guidelines on Management of Liquid Waste (VPO, 2013) acknowledge that there is illegal and haphazard disposal of sludge into the drainage and open environment, and that there is no FS treatment system in the city. The re-use of WW is recognized as beneficial in the guidelines, and this is promoted by the National Environmental Management Council (NEMC) (NEMC, 2015). The re-use of liquid waste is sometimes practised in the city, e.g., shower water is disposed of on banana plants or other urban gardening locations (Observation, 2015). However, for black water, re-use is hardly practiced or regulated.

In general, national regulations are only partially adopted at the local level and enforcement is one of several challenges (WB, 2015b, NGOs FGD, 2015, NEMC, 2015).

2.1.2 Institutional roles

Dar es Salaam has a decentralized service delivery structure with a variety of stakeholders having different responsibilities for sanitation service delivery (compare stakeholder map, appendix 7.5). According to the National Water Policy (NAWAPO) (URT, 2002), “regulatory and executive (i.e. service provision) functions will be separated” (VPO, 2013). Executive functions are decentralized to local government authorities down to the sub-ward level. DAWASA manages water supply and sewerage services, while community organizations can own and manage decentralized water supply and sanitation schemes. “The government’s role will [is] limited to co-ordination, policy and guideline formulation, and regulation” (VPO, 2013).

LGAs are responsible to ensure appropriate sanitation behaviour by the population, and include the three municipal councils (MCs) of Kinondoni, Ilala and Temeke. The MCs are administered by the Dar es Salaam City Council (DCC) and the Prime Minister’s Office of Regional Administration and Local Government (PMO-RALG) (START et al., 2011). Under the municipalities, two more local government levels exist: ward and sub-ward (called mtaa) offices (see Figure 3) (DCC, 2004). Each LGA has different technical and administrative departments. The MCs have environmental health departments, where EHOs are responsible for preventing the outbreak of disease by monitoring and enforcing proper excreta management. At the ward and sub-ward level, environmental health committees deal with sanitation related topics (TMC, 2015).

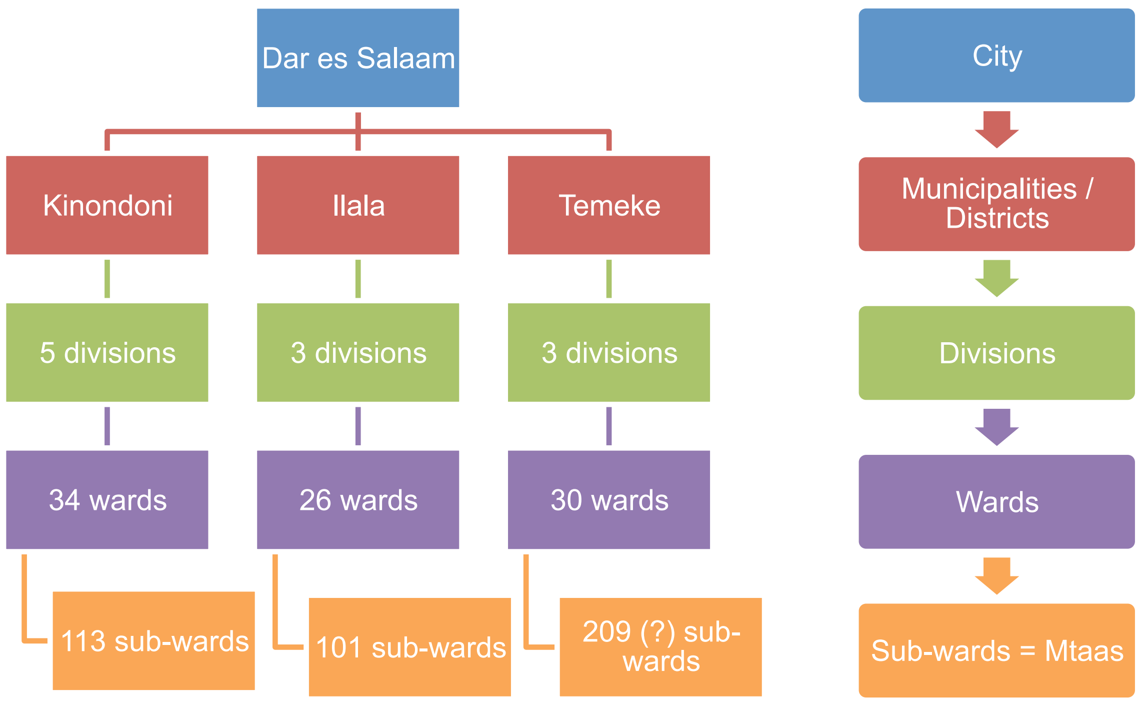

Figure 3: Administrative structure in Dar es Salaam districts (DCC, 2004, NBS, 2013, TMC, 2015, IMC, 2015, KMC, 2015).

The Local Government (Urban Authorities) Act (URT, 2000) defines the tasks of the LGAs amongst other things as follows:

- Prevention of disease outbreaks, e.g., through control of the spread of flies or mosquitoes,
- Establishment and maintenance of public toilets,
- Establishment, maintenance and carrying out "service for the removal and destruction of and otherwise dealing with night soil".

DAWASA is the Water Supply and Sewerage Authority (WSSA) of Dar es Salaam under the Ministry of Water (MoW), and has contracted its assets out to the Dar es Salaam Water and Sewerage Corporation (DAWASCO), which is the operator for water and sewerage services. The Energy and Water Utilities Regulating Authority (EWURA) is the regulating authority of Tanzania's WSSAs. It has to approve (sewerage) tariffs and monitor the performance of DAWASA and DAWASCO.

Four different ministries are directly involved in the co-ordination of sanitation service delivery: the MoW, the Ministry of Health and Social Welfare (MoHSW), the Ministry of Education and Vocational Training (MoEVT) and the Prime Minister's Office of Regional Administration and Local Government (PMO-RALG). A Memorandum of Understanding (S&H MoU, 2009) "for the integrated implementation of sanitation and hygiene activities" was signed in 2009 to "facilitate discussion and harmonization" through a national sanitation and hygiene technical committee and technical working groups (see Figure 19, appendix 7.13). The MoW takes over administration of the technical components of WW programs (like the Water Sector Development Programme (WSDP), coordinates WW facilities/infrastructure/services and monitors WSSAs. The MoHSW is responsible for the soft components (sanitation and hygiene legislations), including awareness raising campaigns, such as the National Sanitation Campaign (NSC). The MoEVT oversees school's Water, Sanitation and Hygiene (WASH) activities and the PMO-RALG supervises and monitors the performance of the LGAs (Chaggu, 2009, Thomas et al., 2013, S&H MoU, 2009).

The MoU has increased coordination among these four ministries. Yet, in the city of Dar es Salaam, gaps appear in the operation of sanitation service delivery, especially in the context of faecal sludge management (FSM). Also, in WW projects, further improvements in coordinated planning is needed to include stakeholders not directly involved in sanitation related issues, such as the Ministry of Lands and different administrative levels, as well as the private sector (WB, 2015b).

The biggest remaining challenge though is adequate FSM. The FS emptying and transport service sector is unregulated and no stakeholder feels responsible for FSM. Many officials in the LGAs and the utilities do not know or do not understand the difference between FS and WW. The word "maji taka" (dirty water) is used by the stakeholders for WW and FS alike; thus, no differentiation is made between the liquid waste from offsite or onsite sanitation technologies. However, the utilities differentiate between "maji taka" flowing through their sewer network and "maji taka" from onsite sanitation technologies by noting that everything not concerned with sewers is MC's responsibility. However, a gap in responsibility for FSM remains. On the one hand, DAWASCO feels responsible for WW treatment, and even though FS is also termed WW in this context, they do not feel responsible for FSM. DAWASCO considers the fact that motorized and manual emptying service providers are allowed to discharge FS at their WW treatment sites as a generosity towards these service providers. On the other hand, MCs reject taking over full responsibility for liquid waste management and consider this to be the responsibility of the utilities (TMC, 2015, IMC, 2015, KMC, 2015, DAWASCO, 2015d, DAWASA, 2015a).

When comparing institutional roles with the sanitation service chain, it is apparent that it remains HHs' responsibility to construct their own sanitation facility. Other stakeholders may provide financial or technical support (NGOs), or raise awareness and ensure compliance to latrine standards (LGAs) (TMC, 2015, IMC, 2015, KMC, 2015). Defined by the Local Government Act, the establishment of emptying services is the responsibility of the LGAs (URT, 2000). To support HH accessibility and affordability of hygienic emptying services, MCs in Dar es Salaam need to further improve the management of the emptying sector by making better plans and regulating the sector. DAWASCO is taking over the management of the sewer network, including its WW treatment sites, the waste stabilisation ponds (WSPs). (For further information on the treatment infrastructure, compare chapter 3.1.4.) Vacuum truck drivers who want to dispose FS at DAWASCO's WSPs have to register at the sewerage section of this corporation (DAWASCO, 2015d). From this, the conclusion can be drawn that it would be possible to construct a privately operated FS treatment plant without the need to register trucks with DAWASCO.

2.1.3 Service provision

In the S&H MoU (2009), the signing parties commit to "support and empower civil society and community based organizations to engage in implementation of sanitation and hygiene related activities", as well as encourage "engagement of private sector in sanitation and hygiene service provision". One objective of Tanzania's Water Supply and Sanitation Act (URT, 2009c) is the "promotion of public sector and private sector partnership in the provision of water supply and sanitation services". In general, many stakeholders in Dar es Salaam talk about public-private-partnerships (PPP) as a possible solution. For example, public toilets owned by municipalities are managed by private contractors (IMC, 2015, KMC, 2015) and FS disposal by vacuum trucks at DAWASCO's WSPs was managed by a private company until April 2015 (although the company was regarded as unreliable) (DAWASCO, 2015d). The motorized emptying service provision is operated by individual vacuum truck owners or managers (Motorized Emptying & Transport Service Providers, 2015b). Manual emptying service providers, using gulper equipment, are CBOs led by a single manager (as in the case of the organization Newanga Usafishaji Mazingira Group (NUMAGRO)) or a group of people (as at the Tuma Iniletu Federation Keko Machungwa (TFKM)) (Manual emptying & motorized transport service providers, 2015).

The regulation on permissible discharge standards of WW (TBS, 2005) limits the involvement of small scale service providers in treatment services. The standards are very strict, which can be seen as positive, but make it difficult to get an allowance for new treatment plants because this may not comply with the standards. BORDA (2015) notes that it would be beneficial to lower discharge standards to allow for a wider range of treatment technologies. This would lead to higher amounts of WW or FS being treated, instead of there being only a few treatment sites, which do not, at present, meet the standards. The standards were made so that WW can be reused, but this is not practiced (NEMC, 2015).

2.1.4 Service standards

The Tanzanian Bureau of Standards (TBS, 2005) published "General Tolerance Limits for Municipal and Industrial Wastewaters (TZS 860: 2005)" (compare appendix 7.10.3), which were developed with the support of NEMC (NEMC, 2015). This outlines systematic monitoring; however, this is only sporadically executed (NEMC, 2015, DAWASCO, 2015d). Environmental impact assessments (EIAs) of new construction projects (e.g., of a new WW treatment site) have to be submitted to the NEMC, which is responsible for reviewing and accepting or rejecting the EIAs (NEMC, 2015, URT, 2004).

A building plan may not be approved if the "drainage system is unsatisfactory" or "building or premises will not be accessible for (solid, gaseous, hazardous and) liquid waste removal or facilitate access to fire and rescue services" (URT, 2009a). A building plan has to go through many municipal departments, where, for example, the planned containment system is analysed and has to be approved. However, as more than 70% of Dar es Salaam is comprised of informal settlements, this procedure is not followed (BTC, 2015).

The MoU between MoWI, MoEVT, MoHSW, PMO-RALG (S&H MoU, 2009) presents a definition of an improved toilet. Nevertheless, it is not binding and the World Bank still criticizes the missing common definition (WB, 2015c). According to the MoU, the acceptable type of pit latrine should provide privacy, a self-cleansing floor (a floor with sufficient slope (1-2%) and a roof. “However, this definition is still under discussion and will have to include difficult conditions like high water table and problems of contamination of groundwater” (Chaggu, 2009).

EHOs do regular latrine/dwelling inspections and note down the condition of the sanitation technology. However, the category “bad” has mainly to do with the superstructure – e.g., no door or broken slab (IMC, 2015), and the structure below ground can hardly be inspected. An additional task of the inspectors is to give recommendations to house owners to empty the pit if FS accumulates 3 ft. below ground level (TMC, 2015). Illegal emptying methods are to be reported by (sub-)ward officers; however, they are “often executed during the not-working hours” (IMC, 2015). This information is reported from the ward level to municipalities, which prepare quarterly reports for the city council and MoHSW (MoHSW, 2015, IMC, 2015). A challenge remains the “lack of consistency on definition of certain indicators, especially on the definition of ‘improved sanitation’; some were not addressing the JMP / MKUKUTA II / NSC needs” (WB, 2015c). If the monitoring of access to sanitation technologies would also take the containment technology and applied emptying methods into consideration, more significant planning achievements would occur.

DAWASCO sets some rules for FS trucks (DAWASCO, 2015d) and ward EHOs are supposed to perform regular inspections of the condition of trucks (MC KII 2015); however, it is unknown to what extent this is implemented. At the existing WSPs, DAWASCO has no meters installed to measure WW flow. Private companies were documenting FS volumes, but DAWASCO quit working with them due to trust-related issues (DAWASCO, 2015d).

Sporadic monitoring of influent and effluent at the WSPs is executed by the water quality section of DAWASCO (DAWASCO, 2015d, DAWASCO, 2014b). However, this is not systematically done, at a maximum only once per year, sometimes for influent and effluent, and sometimes only for one of them (DAWASCO, 2015d, Observation, 2015). EWURA carries out spot tests to verify the reported BOD and COD parameters (EWURA, 2014a). And NEMC does not monitor municipal WW flows: “why, if you can already smell it. And what should we do if they do not comply, if they cannot change the situation anyways?” (NEMC, 2015). They note that the water bodies are overloaded and that it is necessary to find new disposal methods (NEMC, 2015).

2.2 Planning

2.2.1 Service targets

The “National Water Policy (2002) has a target of providing universal access to safe water and sanitation by 2025 with the involvement of communities and the private sector” (Bayliss and Tukai, 2011). The NSGRP II (also called MKUKUTA II) is seen as the “vehicle for realizing Tanzania’s Development Vision 2025 and the Millennium Development Goals (MDGs)”. It has operational targets on sanitation and hygiene, e.g., to increase “improved toilets at HH level (…) to 45%” in urban areas (MoFEA, 2010). However, 2015 has almost come to an end, and this target has not yet been reached. The target of HH sewer connections was set to 22% in 2015 and sanitation at public facilities/places was set as a priority. The focus of cluster II is the poor and vulnerable, to improve the quality of life of the poorest and to address inequities. However, concrete strategies were not laid out (MoFEA, 2010). The National Water Sector Development Strategy (NWSDS) points out the importance of community managed water supply schemes, which in Dar es Salaam also may be involved in sanitation issues (MoWI, 2006). The WSDP targets concentrate on containment (access to improved latrines) and the expansion of the sewer network. The National Sanitation Campaign “aims to improve 1,300,000 HH sanitation facilities” for all of Tanzania (TAWASANET, 2013).

It can be concluded that national service targets for some parts of the sanitation service chain are available (compare chapter 2.1.1). However, there is a clear bias towards sewerage services and access to improved sanitation facilities, with a clear lack of targets concerning FS emptying and treatment. Furthermore, adoption of targets and indicators at the city or municipal level is limited (Trémolet and Binder, 2013).

2.2.2 Investments

“Public sector budgets in Tanzania frequently do not distinguish between investments in water supply and investments in sanitation. This makes it hard to estimate anticipated public investments in sanitation.” (WSP, 2011)

WAT (2012) and key informant interviewees report that “financing institutions and investors in sanitation business initiatives have remained critically low. For instance, support by DAWASA and respective municipalities for pit latrine emptying businesses are very low, if there are any at all.” According to DAWASCO’s own statement, 0.82% of the total corporation’s budget (which includes, e.g., 31.59% expenses on water supply, other percentages on daily operating costs, etc.) is “sewerage disposal and sanitation expenses” (DAWASCO, 2015d).

There is public investment in sanitation and hygiene promotion activities and into the construction of sanitation facilities in public institutions (WSP, 2011). Trémolet and Binder (2013) estimate that 0.3% of the total budget of the municipality of Temeke was spent on sanitation related matters in the FYs 2007/08 and 2008/09 (around 2% of the Health Department budget). Activities financed include administrative expenses, such as payments for EHOs, and spending on health promotion activities, such as public meetings and training of in construction of onsite sanitation technologies. Furthermore, it is apparent that public funding is biased towards sewerage services, as less than 1% of the total public funding on capital expenditures went to onsite sanitation (calculating part of expenditures on WSPs as used for FS treatment) (Trémolet and Binder, 2013). The bias towards expansion of the sewer network can also be seen in the investments of the WSDP. Component 3 (Urban water supply and sanitation) has received the most funds during the WSDP I phase (see Figure 4). This is due to the Dar es Salaam Water Supply and Sewerage Project, which received most of the budget (Quinn and Tilley, 2013).

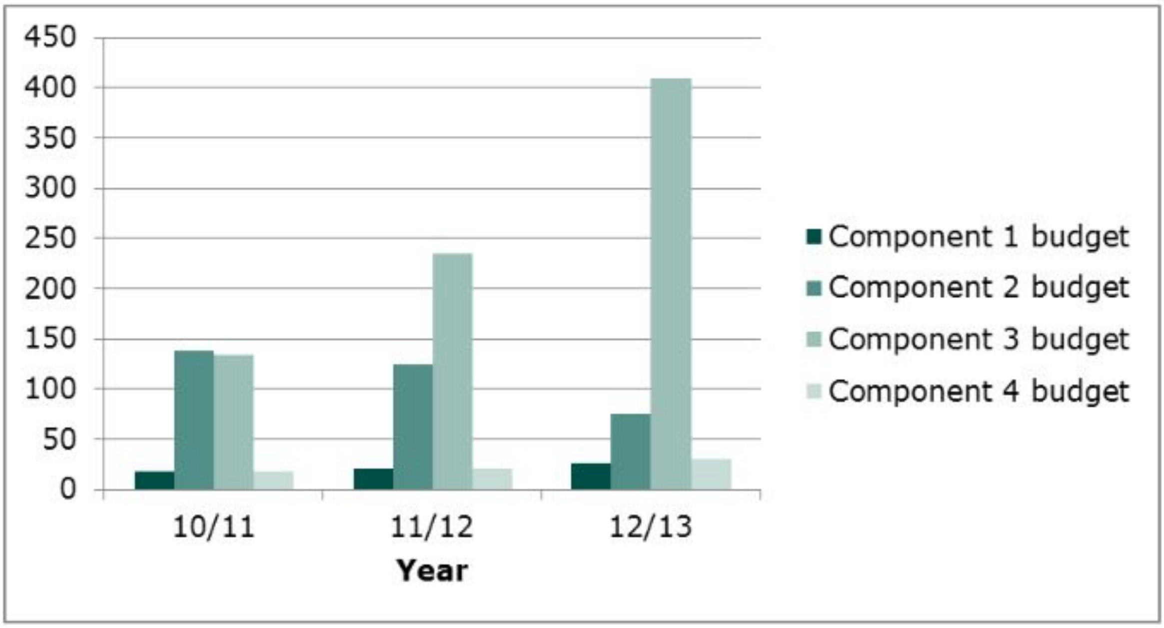

Figure 4: WSDP I Component[2] budgets, billion TZS (1USD equals around 2000TZS) (Quinn and Tilley, 2013).

To sum up the situation in the words of Trémolet and Binder (2013): "In order to address the sanitation service deficiency, public funding could be better targeted to address the entire spectrum of the value chain so that services alongside the whole chain can be provided effectively." In general, funding for sanitation is low compared to other sectors, as sanitation is not set as a priority in planning at the national or the local level (TAWASANET, 2013, KMC, 2015). As sanitation is only part of a sub-directorate in the MoHSW, there is less advocacy power to change the situation (GIZ, 2015).

2.3 Reducing inequity

2.3.1 Current choice of services for the urban poor

Although there is a range of containment technologies available in Dar es Salaam, containment technologies that safely contain FS are not affordable to the urban poor. Pit latrines are constructed to allow for the possibility that FS will drain away in order to save emptying costs (Jenkins et al., 2014b, EEPCO, 2015). Being connected to the sewer network results in lower sanitation related expenses for a HH than having to rely on onsite sanitation. It has been calculated that the instalment of sanitation technologies poses a high burden on low-income HHs.

DAWASCO's WW fee is 275 TZS/m^3 (0.14 USD/m^3) (with WW production being estimated at 80% water consumption) (DAWASCO, 2013b, DAWASCO, 2015d), while the minimum fee is set to 13,500 TZS/month (6.75 USD/month) (DAWASCO, 2015d). This minimum would equal a disposal of 49 m^3 of WW per month into the sewerage system. For apartment

[2] Component 1 = Water resources management, Component 2 = Rural water supply and sanitation, Component 3 = Urban water supply and sanitation, Component 4 = Institutional strengthening

buildings with many HHs, this number may be low, but for individuals interested in a sewer connection, this number is high. The connection fee is 26,000 TZS (13 USD), plus material and workmanship costs (depending on distance to main sewer) (DAWASCO, 2015d), which is problematic for low-income HHs as such amounts of money are not readily available (EEPCO, 2015, CCI, 2015). Therefore, CCI and BORDA are advocating simplified sewer systems (by supporting pilot projects) as a low cost alternative (CCI, 2015, BORDA, 2015). By law, the UWSSA "shall take into account the existence and needs of the economically disadvantaged persons" (URT, 2009c). DAWASA is also interested in this option and oversees some related activities; however, it would like to see further proof of the sustainability of these technologies (including DEWATS) (DAWASA, 2015a).

As there is a limited number of treatment sites available that officially allow FS to be discharged, emptying and transport service providers have to travel long distances, increasing HHs emptying costs. Furthermore, the treatment sites for FS are limited despite the number of WSPs. Only two of the nine WSPs are allowed to receive FS, which results in an overload of these systems because 90% of DSM's inhabitants rely on onsite sanitation technologies. In addition, HHs have to carry the disposal costs charged by DAWASCO for FS disposal at the ponds. However, this is only a marginal fraction compared to the transport costs, which decreases the choice of appropriate emptying services.

Jenkins et al. (2014b), Jenkins et al. (2015) and WAT (2012) report that the reasons why HHs are not able to make use of hygienic emptying and transportation services include the high costs for these services and the inaccessibility of their systems. Other limiting factors are knowledge about the services; for example, only one of the seven EHOs that participated at the Focus Group Discussion (FGD) at Kinondoni MC, knew about the gulper technology (EHOs FGD, 2015). In contrast, emptying services by frogmen is widely known, available and comes at similar cost as the other emptying methods (Manual emptying & motorized transport service providers, 2015, Trémolet and Binder, 2013, WaterAid, n.d.). However, due to the long transport times between certain areas and FS discharge locations, especially for peri-urban regions, the costs for emptying are very high, which results in unhygienic manual emptying decisions.

2.3.2 Plans and measures to reduce inequity

Policy documents acknowledge the importance of pro-poor support. However, tangible strategies and significant successful implementation examples are scarce. Support for sanitation services for the urban poor is predominantly implemented through awareness raising programs, while little to no innovative financing mechanisms exist (TAWASANET, 2013, Trémolet et al., 2015). The NSC focuses on the improvement of HH latrines through awareness raising campaigns and on the training of construction of onsite sanitation technologies to increase the availability of sanitation services. The Community Infrastructure Upgrading Programme by the World Bank targeted unplanned areas in their aim to upgrade infrastructure and services. However, the sanitation component failed to be implemented. Instead, the focus together with DAWASA was on drainage, solid waste collection, and the construction of water kiosks (Bayliss et al., 2012, WB, 2015b).

DAWASA's pro-poor strategy is focused on collaboration with CBOs and Water User Associations, and in supporting them with knowledge and project coordination. During the

Community Water Supply and Sanitation Programme, activities were targeted at low-income communities with “high demand and willingness to pay for improvements” (Bayliss et al., 2012). This programme has raised access to affordable water supplies for parts of Dar es Salaam’s low-income population. These types of approaches need to be scaled up, while including strategies to improve access to sustainable and affordable sanitation services. Nevertheless, Bayliss et al. (2012) describe the need for “capacity building of [DAWASA] staff in pro-poor approaches and perhaps developing a broader approach to joint planning of pro-poor services” as the work of the LGAs. The MCs are actively involved in expanding the emptying service with the gulper technology. Equipment for six new gulper businesses was available at the time of field research at the three MCs, and it was planned to deliver this equipment to newly trained gulper groups (TMC, 2015, IMC, 2015). The WSDP focused on expansion of access to sewer services. DAWASA’s past and current expansion plans mainly focus on high- and middle-income areas. However, there is an interest to implement simplified sewers in existing ongoing projects (DAWASA, 2015a); this could contribute to low-cost sanitation service delivery to the urban poor. It has been acknowledged that low-income HHs are willing and can pay for water services, and it is time to support them with affordable sanitation schemes.

2.4 Outputs

2.4.1 Capacity to meet service needs, demands and targets

Access to improved sanitation facilities is increasing. It appears that more people get access to safe containment technologies and emptying methods. A trend of increased usage of septic tanks can be identified when looking at older sources of information, such as the overview from Chaggu et al. (2002). Nevertheless, previously set service provision targets could not be achieved. The expansion of the sewer network lags behind the actual population growth and the number of WSPs in Dar es Salaam has not increased in 25 years or more – Yhdego (1989) mentioned the nine currently existing WSPs already in 1989. On a positive note, further sewer networks and three new WWTPs are planned to be built in the upcoming years in the urban areas of Dar es Salaam, although there is nothing planned in peri-urban areas (DAWASA, 2015a, DAWASA, 2015b). For future planning, it can be suggested to assess the feasibility of FS treatment infrastructure in such areas. Growth in the number of motorized emptying service providers has been observed; Chaggu et al. (2002) mentioned 28 privately owned and 14 city council vacuum trucks, while around 120 trucks are currently registered at DAWASCO (two of which are under municipal ownership). The manual emptying approach with gulpers, which was started in 2008 and promoted by WAT, has been taken up by the MCs which support the service providers (TMC, 2015, Manual emptying & motorized transport service providers, 2015). Yet, for various reasons, large numbers of HHs rely on FS emptying methods that use open channels or rivers as transport channels. It can be observed that the rivers as transport/disposal channels are filled with liquid (and solid) waste and “different disposal ways” are needed (NEMC, 2015). If the emptying and transport service providers receive greater political and administrative support, more HHs might be able and willing to use these emptying methods.

2.4.2 Monitoring and reporting access to services

Apart from routine data collection by LGAs and WSSAs, further information is collected through the census and surveys conducted every few years under the NBS. The involved stakeholders, however, use different indicators, which result in difficulties in comparing the surveys (MoW, 2014b).

On the LGA level, reporting is performed in different stages from (1) sub-ward to (2) ward to (3) municipal council to (4) city council to (5) ministry. It can be expected that some information is misinterpreted and/or lost along these reporting steps, especially as the system is electronic only at steps 4 and 5. However, this is a beneficial system that, if utilized correctly, can become an effective monitoring tool which would create evidence-based advocacy. Monitoring from top to bottom is only sporadically executed, e.g., ward EHOs have to verify the regular execution of dwelling inspections by writing weekly reports that are checked by municipal EHOs. Trémolet and Binder (2013) report that the PMO-RALG and the MoHSW monitor performance and inspect the LGAs, e.g., the MoHSW works "once or twice a year in a 'supportive supervision' capacity to organise training sessions and enhance sanitation promotion".

The WSSA is obliged to submit monthly and annual performance data to the regulating authority EWURA through the Water Utilities Information System called Majls and has to prepare an annual report for EWURA and the MOW (EWURA, 2014a, MoW, 2014b, URT, 2001a). This reporting is undertaken by DAWASCO (DAWASCO, 2015d, DAWASA, 2015a). However, EWURA indicates in their annual report for the financial year 2013/2014 that DAWASA and DAWASCO have "failed to submit some of their monthly data due to various reasons" (EWURA, 2014a). EWURA has specific indicators (e.g., on financial, distribution or production parameters) by which they assess the performance of the utility, but no indicators exist to assess the pro-poor performance of the utility (DAWASCO, 2015d).

The regulating authority EWURA carries out occasional site inspections on WW quality monitoring (EWURA, 2014b, EWURA, 2014a); however, actions towards non-compliance of these requirements are limited due to various reasons. In addition, NEMC, another monitoring body, points out that monitoring has only a marginal benefit in situations where challenges can be easily spotted, and that fining non-compliance would be of no benefit if the root causes are not tackled (NEMC, 2015).

Computer based monitoring and data management is being utilized. For example, DAWASCO is using a EDAMS billing and customer information system and recently a National Sanitation Management Information System (NSMIS) has been rolled out which should enhance the monitoring of the NSC and "provide a solution to the historical problem of lack of accurate routine data on sanitation and hygiene." (MoW, 2014a). Nevertheless, further capacity building is needed to be able to fully use the existing resources. BORDA, for example, is training DAWASCO officials in the use of Geographic Information System (GIS) software (BORDA, 2015, DAWASCO, 2015d).

DAWASCO implements rules for motorized emptying service providers, which require that pipes/hoses of trucks do not have leakages and additionally require record-keeping of the trips to DAWASCO's WSPs (DAWASCO, 2013a). During the data collection process at

DAWASCO, it could be observed that these records exist; however, they are kept in a non-consistent format and are not being utilized as a monitoring tool to ensure safe and functioning facilities and services. The municipalities are responsible for the monitoring of undamaged vacuum trucks (DAWASCO, 2015d), which pass this responsibility on to the ward offices (MC KII 2015) where the applications could not be assessed.

DAWASCO (2015d) reports that there is no system in place to monitor WW volumes; meters are only installed at clean water pipes. DAWASCO and the municipalities rely on the customers/community to report failures in the system. For example, customers complain every day about blockages in the sewer system (which lead to overflow of WW); whereupon, the utility carries out unblocking activities. One municipal EHO explained one challenge as being that inhabitants in mainly high-income areas complain about the dirtiness of the environment, but that in low-income areas people often do not complain, although the municipalities rely on such complaints to determine their actions.

2.5 Expansion

2.5.1 Stimulating demand for services

Stimulating demand for improved sanitation facilities and appropriate emptying methods is undertaken through EHOs' regular dwelling inspections. Disposal of liquid and/or solid waste into the environment is illegal (as set by the PHA) and the municipalities set fines for violations. According to the EHOs, this has increased the emptying frequency, although it is difficult to punish poor HHs when they have no other options available.

Awareness raising campaigns are promoting the construction of improved latrines and hygienic emptying methods. Such activities, partially implemented by MCs, are often funded by NGOs, such as UNICEF or Plan International (TMC, 2015, IMC, 2015, Trémolet and Binder, 2013). Sharpe (2010) points out that ward leaders play an important role in sanitation communication, as 79% of the people surveyed reported to have heard about (pit emptying) services from their mtaa government.

The National Sanitation Campaign (NSC) was established under the WSDP II in order to increase the usage of improved sanitation facilities (MoHSW, 2015, GIZ, 2015). The first phase of this campaign targeted rural areas, but also included peri-urban areas in Dar es Salaam, which have rural characteristics. In the second phase, more urban areas shall be included.

2.5.2 Strengthening service provider roles

Andreasen (2013) reports that average annual population growth rates (comparing 2012 with 2002 population numbers) are highest in the peri-urban wards of Dar es Salaam (see Figure 16, appendix 7.8). This trend will most likely continue in the future and poses further challenges to sanitation service delivery as these areas are the ones least served with emptying, transportation and treatment services. The government supports the idea of Public Private Partnerships (PPPs); yet, concrete strategies are not in place. Private companies are being contracted for the operation of public toilets by MCs and have to deliver a certain percentage of the generated income to the MCs (IMC, 2015, KMC, 2015). The motorized emptying service providers receive very little supervision from utilities or

LGAs; yet, this would be beneficial for holistic service provision. Although the gulper business is promoted by municipalities, and training by municipalities is mandatory for anyone interested in starting a gulper emptying business, many of the businesses struggle to maintain sustainability (TMC, 2015, Manual emptying & motorized transport service providers, 2015, IMC, 2015). Furthermore, there is still limited awareness of the gulper pit emptying technology in Dar es Salaam – out of the seven ward EHOs that participated in the FGD, only one knew about this technology (EHOs FGD, 2015). MCs support local NGOs, such as EEPCO, financially (from basket funds supported by international NGOs) or implement trainings for the construction of onsite sanitation technologies (IMC, 2015, EEPCO, 2015). However, there is still little attention being paid to FS treatment.

3 Service Outcomes

3.1 Overview

This section presents the range of infrastructure/technologies, methods and services designed to support the management of FS and/or WW through the sanitation service chain in Dar es Salaam. For details on quantitative estimations, refer to chapter 3.2, p. 21.

3.1.1 Containment

The sanitation facilities used in Dar es Salaam are pit latrines (75%), septic tanks (15%) and a small number of urban dwellers connected to DAWASA's sewer network (6%) (DAWASCO, 2015a, NBS, 2015). The remaining 4% of excreta flows are 1% open defecation and 3% pour flush toilets going directly to open drains or water body (NBS, 2015, EHOs FGD, 2015). However, the design of the facilities can have various forms. One interviewee mentioned that "there is nothing that you cannot find in Dar es Salaam". The list in appendix 7.9 presents an overview of the sanitation technologies existing in Dar es Salaam as reported by different stakeholders or found in reports and other documents.

The sewer network covers central areas of the city and has only small sections outside of the centre (compare Figure 17, appendix 7.11). This network is a collection of 11 sub-systems with pipes of 100 to 1000 mm, comprising a total length of around 170 km (AAW et al., 2008, Kombe and Lupala, 2004). Nevertheless, even in the area serviced by DAWASCO, unconnected HHs can be identified. UN-Habitat (2003) noted that "the system is old and unreliable, owing to deferred maintenance". However, during the Dar es Salaam Water Supply and Sanitation Project (DWSSP) in the years 2004 to 2010, sewerage facilities were extended and rehabilitated (including sewers, pumping stations and WSPs) (AFD, 2010). DAWASCO's number of sewerage connections was reported at 18,568 in 2011/12 and 23,771 in 2013/14 (EWURA, 2014b), while for 2014/2015 the number of sewerage connections is reported at around 18,100 (DAWASCO, 2015b).

Septic tanks are the primary onsite sanitation technology utilised by the middle- to high-income population living in unplanned settlements or areas that are not situated near the sewer network. The remaining population relies on pit latrines, predominantly semi-lined and partly raised above ground in high WT areas. However, NGOs have doubts about the construction of these sanitation facilities because, to have a cheaper price, HHs employ untrained workers to construct them who lack knowledge of the appropriate construction of septic tanks. Additionally, HHs prefer to have un- or semi-lined pits, which allow for the infiltration of FS and result in less frequently required emptying services (NGOs FGD, 2015).

Excreta accumulates also in sanitation facilities at people's workplaces (institutions, etc., see also emptying chapter) and in public toilets. Ilala municipality has 25 public toilets under their supervision, plus a maximum of 20 privately owned community facilities (IMC, 2015). The former receive a lot of excreta, as emptying frequency is reported to be one to (absolute max.) six times per month. Kinondoni and Temeke report 15 and seven to nine public toilets in their municipalities, respectively (TMC, 2015, KMC, 2015).

The average pit depth in Dar es Salaam is three to four and a half meters. Manual emptying services with the gulper technology are able to remove FS up to a depth of 2.4 meters, which inhibit full emptying of the containment system and makes the gulper less favourable to HHs than the complete emptying service offered by frogmen (Manual emptying & motorized transport service providers, 2015). Furthermore, the high solid waste content or very liquid FS makes the emptying process challenging. It was reported that for one pit up to 50 to 80 ten litre buckets of solid waste may have to be removed. Very liquid FS can result from GW infiltration due to high WT, rainwater inflow due to the lack of a roof or from greywater entering the system. (Jenkins et al. (2014a) present findings from low-income areas in Dar es Salaam where 75% of the HH latrines lack roofs.) Manual emptying service providers, therefore, have to rent additional pumps and charge higher emptying fees for the removal of very liquid FS/the solid waste.

The risk of collapsing pits exist during the emptying process of FS from unlined pit latrines with vacuum trucks, which is one reason why they are less frequently emptied than septic tanks. Additionally, narrow streets and steep slopes contribute to the inaccessibility of onsite sanitation technologies. Trucks with hoses of around 50 m length could access most of the latrines in the city. However, in areas which are not even accessible by pushcarts (due to steep slopes or dense settlement structure), excreta has to be carried in buckets to the nearest place of disposal (Observation, 2015).

3.1.2 Emptying services

Legal emptying services in the city consist of vacuum trucks and the gulper technology. Around 120 motorized emptying and transport service providers (vacuum trucks) work in the city with capacities of around 2,000 to 25,000 (on average 7,400) litres capacity. The largest registered business has ten trucks; many owners just possess one truck and Kinondoni MC is the only remaining LGA owning (two) trucks (DAWASCO, 2015c, Observation, 2015, KMC, 2015). Furthermore, five manual emptying service providers are working in Dar es Salaam as of June 2015. They are emptying onsite sanitation technologies with the gulper technology and are transporting the FS in 300 or 350 litre tanks on motorized tricycles (TMC, 2015, IMC, 2015).

Unhygienic emptying methods include the manual emptying services by frogmen (so-called "vyura"). The law prohibits this method, which is one reason why it is often practised during the night. Frogmen climb into the pit and empty its contents with buckets. The collected FS gets buried into a newly dug hole close to the pit, or released into a nearby open drain or water body. Other emptying methods are practised by the HHs themselves and include pit diversion (digging another hole next to the old pit where the FS is drained or flushed into), flooding out (opening a pipe on (or breaking) the side of a containment system – often on days of heavy rain), or abandoning an old pit and constructing a new one. The latter is predominantly practised in the peri-urban outskirts of the city, where space is still available. This method can also be found in the central parts of the city, but it is becoming less common (Jenkins et al., 2015, EHOs FGD, 2015).

It is reported that some containment systems have never been emptied/never got full (Jenkins et al., 2014b, Mkanga and Ndezi, 2014), which can be due to the porous soil conditions or illegal emptying practices, which are not reported by the HHs. On the other hand, systems in areas with high groundwater tables may require emptying services once a month. For public toilets in Ilala, it is reported that some need emptying once a month, and others up to four to six times per month This depends on the number of users and the depth of the water table (IMC, 2015).

Onsite sanitation technologies emptied by vacuum trucks or frogmen are emptied to the owner's preference, who favour the complete removal of FS. The possibility of total emptying is one reason why HHs prefer these two emptying methods. The gulper technology can only empty a fraction of the pit content and is not employed for septic tanks. The high solid waste content in all systems (sewer network and onsite sanitation technologies) is a challenge for all emptying methods (Manual emptying & motorized transport service providers, 2015, Motorized Emptying & Transport Service Providers, 2015a).

It is known that currently around 120 trucks with an average size of 7.5 m^3 can empty FS from onsite sanitation systems. Around 75% of the emptied systems are septic tanks (whereas it was reported that both the septic tank itself and the soak pit are emptied), and 25% are pit latrines. This can be explained by the fact that pit latrines, which are not lined, often cannot get emptied by vacuum trucks as there is a high possibility that the pits would collapse during the process. HHs using septic tanks also have higher income than HHs using pit latrines, which is another contributing factor to this distribution.

During interviews with motorised emptying service providers, it was reported that one truck can accomplish two to three trips on average per day, during the rainy season three to four, and during the dry season one to two (or on some days none) (Motorized Emptying & Transport Service Providers, 2015b, Motorized Emptying & Transport Service Providers, 2015a). This would mean an average number of two to three trips per day, which would lead to 1800 to 2700 m^3 collected FS per day (7,500 litres * two trips per day * 120 trucks), or around 54,000 to 81,000 m^3 collected FS per month. FS delivered to WSPs are reported at 35,000 to 65,000 m^3 (DAWASCO, 2015c, EWURA, 2014b). The emptying service providers mention that around 60% of the systems emptied are HH facilities. Therefore, the remaining 40% are institutions, restaurants, commercial areas or industries (see Figure 5).

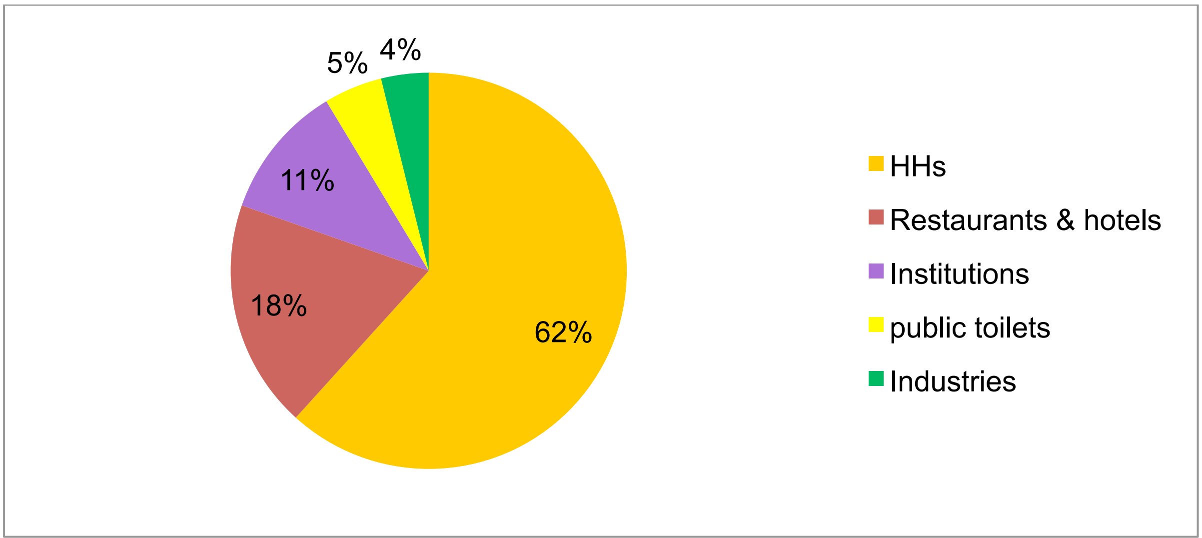

Figure 5: Types of sanitation facilities emptied by vacuum trucks (Motorized Emptying & Transport Service Providers, 2015b).

From the interviews with vacuum truck drivers and helpers, it can be assumed that vacuum trucks mainly serve in an area up to 10 km around the ponds. This radius depends on the customer's willingness to pay. Emptying fees range from 50,000 TZS (25 USD) to 200,000-300,000 TZS (100-150 USD) per trip[3], with the main influencing factors being the travel distance between the customer and the disposal site, as well as the size of the truck's tank (Motorized Emptying & Transport Service Providers, 2015b, Motorized Emptying & Transport Service Providers, 2015a). The same applies for the gulper service, although there is a lack of knowledge about how much these services contribute to the areas being served (Manual emptying & motorized transport service providers, 2015, EHOs FGD, 2015).

According to Jenkins (2014b, 2015) research, income affects the chosen emptying method. Some emptying methods come at low financial costs (flooding out or pit diversion). Additionally, residents living far away from the legal FS disposal sites (Vingunguti and Kurasini WSPs) are charged the highest emptying fees by motorized emptying service providers and the gulper groups; thus, this service is not affordable to Dar es Salaam inhabitants living at the outskirts of the city (Motorized Emptying & Transport Service Providers, 2015b, Manual emptying & motorized transport service providers, 2015, Motorized Emptying & Transport Service Providers, 2015a). Last but not least, it is the low-income population who live along flood prone river banks in areas with steep slopes and dense settlement structures with narrow, unpaved roads where motorized emptying services have no access. Jenkins et al. (2015) reports that around one third of the low-income properties are not accessible to hygienic emptying services. Furthermore, HHs "in the lowest income quintile compared to the highest were 85% less likely to use a hygienic method and

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[3] The very low emptying fee of 50,000 TZS is the absolute minimum and is more an exception than the rule; this was the reported price for a small tanker of 5,000 litres for a region in the immediate surroundings of the WSP, e.g., Buguruni. The highest emptying fee is for very distant regions, such as Kigamboni, Kibaba, Bunju or Tegeta.

nearly four times more likely to use flooding out, independent of hygienic access” (Jenkins et al., 2015).

3.1.3 Transport by sewers

Water demand for DAWASA’s area is estimated to be around 188 million m^3 per year for the FY 2013/14 (517,000 m^3/day). Water production is estimated at 90 million m^3 for the year 2013/14, which amounts to 248,000 m^3/day. Average monthly consumption for DAWASCO’s domestic water connection is reported at about 17 m^3, “with per capita consumption of 22.8 litres/day”. The “population living in area with water network” decreased from 67.5% in 2012/13 to 57.6 in 2013/14, with water production ranging between 48% to 50% of the water demand (EWURA, 2014b).

In general, DAWASCO (2015d) estimates WW production as 80% of their customers’ water consumption. Volumes of WW through sewers or at the influent of WW treatment plants cannot be assessed as no flow meters have been installed. During the interview, DAWASCO (2015d) referred to the report by AAW et al. (2008), which provides flow estimations at the pumping stations. On the basis of this report, WW flows can be estimated at 18,593 m^3/day (around 557,798 m^3/month) delivered to the ponds and 6,558 m^3/day (about 196,733 m^3/month) discharged through the sea outfall. However, some of the manually operated 15 pumping stations are not working at the moment. Furthermore, some sewers transport WW by gravity; thus, the accuracy of these volume estimations is difficult to judge.

Frequent overflow of containment systems and of the sewer network is reported and can be observed during the rainy season. EWURA (2014b) records 0.6 pipe breaks per km per year for water and sewerage pipes combined, and 2247 sewer blockages during the FY 2013/14, whereas blockages mainly lead to the overflow of WW at manholes. At times, manholes get stolen, and then rainwater enters the separate/foul sewers, which also leads to the overflow of the system (DAWASCO, 2015d).

3.1.4 Treatment

A total number of nine WSPs exist in the city (AAW et al., 2008, Kombe and Lupala, 2004), most of which are managed by DAWASCO. However, the quarterly WW reports (DAWASCO, 2015a, DAWASCO, 2014a) state that one WSP (Airwing WSP) is not operating at the moment because the Airwing II pumping station is not functioning. The actual design reports for DAWASA’s existing treatment facilities could not be obtained (DAWASA, 2015a).

According to DAWASCO’s Strategic Plan 2013/14 – 2016, WW production is estimated at 322,000 m^3 per day, with a collection and treatment capacity of 38,000 m^3 per day (11.8%) at DAWASCO’s systems (DAWASCO, 2013b). Kombe and Lupala (2004) estimate 25,833 m^3 treatment capacity of the WSPs. As mentioned before, AAW et al. (2008) estimates that 18,593 m^3 of WW arrive at the treatment sites per day.

FS collected by vacuum trucks or gulper groups is also delivered to the WSPs. EWURA (2014b) reports that the average FS volumes disposed at the two WSPs, Vinunguti and Kurasini, are 2,000 m^3/day and 135 m^3/day, respectively. This would be about

65,000 m^3/month for both ponds. DAWASCO (2015c) reports no increase in FS collection volumes over the last six years (with FS volumes of 30,000 to 40,000 m^3/month disposed at the ponds), while interviews with Motorized Emptying & Transport Service Providers (2015b) revealed an increase in the vacuum truck business sector.

As the WSPs were not designed for FS treatment, other stakeholders in the city (BORDA and WaterAid) have been implementing a decentralized WW treatment system (DEWATS) adapted to FS treatment in Kigamboni ward. The DEWATS (compare appendix 7.15.1) is operated by the manual emptying service provider UMAWA and has the capacity to receive 4 m^3 of FS per day (BORDA); however, it sometimes receives more when a vacuum truck is allowed to dispose FS (BORDA, 2015). Furthermore, other small-scale DEWATS exist in the city, e.g., at the office of BORDA (Observation, 2015, BORDA, 2015), at the simplified sewer system project of CCI (CCI, 2015), at a school or a hospital and there is an up-flow anaerobic sludge blanket technology with constructed wetlands at Ardhi University (Thomas et al., 2013). The lack of DEWATS and of a large FS treatment plant in the city leads to long travel distances to disposal points for emptying and transport service providers, resulting in high operational costs (WAT, 2012). This is the main contributor to the high emptying fees for motorised emptying services (Motorized Emptying & Transport Service Providers, 2015a).

As mentioned in chapter 2.4.1, all of the currently existing WSPs in Dar es Salaam built before 1990 were not designed for FS treatment (Yhdego, 1989) and receive infrequent maintenance. The WSP at the University of Dar es Salaam is reported to have never been desludged (Kimwaga, 2015) and at least "Vingunguti, Kurasini and Mikocheni are full of sludge hence require immediate desludging to improve treatment" (DAWASCO, 2014a, DAWASCO, 2015a). The lack of regular maintenance activities inhibits effective treatment. From DAWASCO's WW analysis results (DAWASCO, 2010a, DAWASCO, 2010b, DAWASCO, 2014b) and from observation (compare pictures, appendix 7.15) and expert statements (NEMC, 2015, DAWASCO, 2015d, BORDA, 2015), it becomes obvious that the WSPs are not fully functioning. The WW analyses from DAWASCO (2007), DAWASCO (2010a), DAWASCO (2010b), DAWASCO (2014b) show that a high number of BOD, COD and total solid effluent concentrations do not fulfil the WW standards of the TBS (2005). The total solids and COD (for all WSPs in all analyses at hand) are far above the effluent discharge limits. Higher effluent than influent concentrations can be found for some parameters, but it can be noted that the WSPs achieve partial treatment, sometimes to a great extent (up to 90% reduction). In EWURA's annual report for 2013/2014, it is pointed out that "WW effluent […] did not comply with BOD_5 and COD standards. DAWASCO's non-compliance is mainly due to poor condition and inadequate capacity of the WW treatment plants." (EWURA, 2014a). However, it can be said that the Tanzanian WW standards are quite strict, stricter than, for example, in Germany (BORDA, 2015). Thus, due to the new WWTPs, and regular and proper rehabilitation activities, the WSPs could achieve far greater effectiveness.

3.1.5 End-use / Disposal

After (partial) treatment at the WSPs, the effluent is transported by rivers to the ocean, while some WW is directly disposed in the ocean through the sea outfall without any treatment. DAWASA is planning to build three new WWTPs in Dar es Salaam with the support of the

WB, intending to divert all the WW which is currently going to the sea outfall to one of the WWTPs (DAWASA, 2015a, DAWASA, 2015b). Some FS is disposed at two of the WSPs or small-scale FS treatment sites, while some is dumped directly into the environment.

During rehabilitation of the WSPs, the settled sludge is dumped next to the ponds (at least for Vingunguti), which poses a significant health risk to the communities that practise urban farming at this location (Observation, 2015). KMC (2015) reports that Dar es Salaam's solid waste dumping site was designed with an area for sludge disposal, but it is unknown whether it has ever been used for this purpose. Water from rivers is being used for urban farming and could, therefore, be categorised as informal end-use due to the fact that rivers contain WW, FS and effluent from WSPs. The Kigamboni DEWATS produces biogas and the de-watered sludge is sold as soil conditioner. The effluent from the DEWATS is used for irrigation (of banana trees). Biogas production and effluent end-use can also be observed at other small-scale DEWATS. According to the operator UMAWA, demand for their dried sludge is high (Manual emptying & motorized transport service providers, 2015).

3.2 SFD Matrix

The final SFD for Dar es Salaam is presented in appendix 7.1.

3.2.1 Risk of groundwater contamination

According to the geological map of Tanganyika[4] published by the Geological Survey Department of the Ministry of Mines and Commerce in 1959 (MoMC, 1959), the main geological formation in Dar es Salaam is kainozoic rocks: fluviatile-marine: sand, gravel, silt, and limestone; and a few alluvial rocks: sand, gravel, silt and mud (see Appendix 7.7). Dar es Salaam stakeholders report that the soils in Dar es Salaam are mainly sandy, but that one can find clay within just a few meters distance (NGOs FGD, 2015, EHOs FGD, 2015). Msindai (2004) reports that "sandstones and carbonate rocks are two dominant groups of rocks that typify the Dar es Salaam region.…Sandstones occupy over three quarters of the region and comprise seven main types. The massive terrace sandstone is the bedrock that limits the extent of terraces." Jenkins et al. (2014a) report that 59% of their surveyed residential plots lie in high water table areas. Low water tables can be observed in the hilly areas whereas high water tables are near the rivers and in the valleys, with water tables below 2 m (NGOs FGD, 2015). The water table is influenced by the season and the frequency of flooded pits also depends on the season.

No information about the distance between sanitation facilities and groundwater sources was obtained from reports or interviews. However, due to the dense nature of the city[5] and the lack of space, it can be estimated that more than 25% of the sanitation facilities are within a 10 m radius of the next groundwater source.

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[4] Tanganyika describes the mainland of Tanzania, which was ruled by British powers, and later formed together with Zanzibar the United Republic of Tanzania. http://www.britannica.com/place/Tanganyika

[5] Average density of 3,133 persons per km^2, with 50% of Dar es Salaam's population living in 28 of the 90 wards. – NBS 2013. 2012 Population and Housing Census. Dar es Salaam: National Bureau of Statistics (NBS), Ministry of Finance.

The 2012 population and housing census reports that more than 25% (31.2%) of Dar es Salaam's HHs use GW as their main source of drinking water (NBS, 2015). The main GW technology used are tube wells or boreholes (compare appendix 7.6). The census does not state whether the tube wells or boreholes are protected or not, but of the remaining two GW sources (dug well and spring) around 36% are unprotected. However, if it is assumed that all tube wells or boreholes are protected, the total number of unprotected ones goes down to 14%. Thus, the water production technology for Dar es Salaam is assumed to be mainly protected boreholes, protected dug wells or protected springs. However, even if adequate sanitary protection exists at the surface for most of the GW technologies, pollution by excreta was detected in all sampled shallow wells and in 30% of the boreholes by Mdoe and Buchweishaija (2014), with the total and faecal coliform loads increasing during the wet season.

To conclude: the areas in Dar es Salaam where groundwater contamination risk is low are usually in the high-income regions where people are connected to the sewer network, or in the very low density regions of up-hill peri-urban areas of Dar es Salaam. In the higher income areas, GW is rarely used for drinking, and in the peri-urban regions, the water table and population density is low. Therefore, it can be estimated that at least 50% of the population lives in areas of significant GW contamination risk. This estimation conforms to the findings of Jenkins et al. (2014a), who report that 59% of the survey respondents live in high or very high water table sub-wards and 70% experience frequent flooding.

3.2.2 SFD Matrix Explanation

The next section explains how the decisions were made concerning calculating the values that were fed into the SFD calculation tool, which creates the SFD Matrix. More detailed information can be found in appendix 7.10.

Containment Technologies

The numeric estimations made for the containment technologies are presented below. As it is based on many different sources, a more detailed presentation can be found in appendix 7.10.1.

DAWASCO's EWURA reports from FY 2014/15 (DAWASCO, 2015b) state that around 18,100 domestic sewer connections exist. DAWASCO (2015b) estimates that the "average number of people served per domestic sewer connection" is ten. Thus, around 181,000 people are served by domestic sewer connections in Dar es Salaam, which is 3.5% of the total (estimated) population of 5,140,000, or 4% of the 2012 population reported in the 2012 census (NBS, 2013). Because NBS (2015) and other literature suggest that a higher number of the population is served by sewers, this number is adjusted to 6%, taking into account the part of the population who commute to the city centre every day for work and whose excreta is partly contained by sewers, although they might only have a pit latrine at home. The HHs connected to simplified sewers are too small to have an impact on the SFD Matrix (less than 100 HHs (CCI, 2015) – less than 0.001% of total HHs).

Based on interviews, survey reports and national census data (NBS, 2014, NBS, 2015), it is assumed that 1% of the population practises open defecation (OD) in Dar es Salaam. As official survey reports probably underestimate this (HHs may not want to admit to practice illegal OD), more weight than usual is given to interview statements. Analysis of the literature (NBS, 2015, Pauschert et al., 2012, Mkanga and Ndezi, 2014, Trémolet and Binder, 2013) and of the interview statements (DAWASCO, 2015b, EHOs FGD, 2015, TMC, 2015, IMC, 2015, KMC, 2015) led to the following quantitative estimations for containment systems in Dar es Salaam:

Table 1: General containment estimations

Decentralised sewers	6%
Flush toilets to open drain / water body	3%
Septic Tanks	15%
Pit latrines	75%
Open Defecation	1%

During FGDs and interviews, it was noted that more than half of the septic tanks are not properly partitioned and more than 50% are not fully watertight. As no exact number is known, it is estimated that at least 60% of the septic tanks in Dar es Salaam are not properly constructed (a combination of being not properly partitioned and not watertight). The differentiation between septic tanks connected to either sewers, soakpits or open drain/water bodies was estimated during the NGOs FGD (2015).

For pit latrines, the estimations were more challenging, as a lot of different systems exist in the city. Currently, the SFD calculation tool does not allow for more than ten systems to be included, which resulted in the need to group similar systems into broader categories (for both septic tank and pit latrine systems). Generally, it is estimated that 50% of Dar es Salaam's inhabitants use pit latrines in areas with significant groundwater contamination risks. However, unlined pits were reported to be built only in low water table areas because otherwise they would collapse. Therefore, it is estimated that 80% of the unlined pit latrines are built in areas with low GW contamination risk. Fully lined pits/tanks were reported to be built only in high water table areas because people prefer to build semi-lined pit latrines where possible in order to save on construction and emptying costs. Of the fully lined pits/tanks, it is estimated that 60% are not watertight (EEPCO, 2015, NGOs FGD, 2015). Combining the three estimations from the NGOs FGD (2015), EHOs FGD (2015) and Jenkins et al. (2014b), the following systems are differentiated for the SFD calculations:

Table 2: Estimations on differentiating between different pit types

No.	Explanation	SFD Reference Variable	Percentage
1	(Partially) lined pit with open bottom, low GW risk	T1A5C10 & T1A4C10	23 %
2	Unlined pit, no overflow, in low GW risk areas	T1A6C10	23 %
3	Fully lined tank (sealed), no outlet or overflow (fully lined tank)	T1A3C10	4 %
4	Lined tank with impermeable walls and open bottom, to open drain/water body (pits with pipes letting FS discharge to open drain / water body	T1B10C6 & T1B10C7-10	15 %
5	(Partially) lined pit with open bottom, significant GW risk & Containment failed, damaged, collapsed or flooded - no overflow (fully lined tank not watertight) & unlined pits in significant GW Risk areas	T2A5C10 & T2A4C10 & T1B1C10 & T2A6C10	35 %

Combining the estimations for the offsite and onsite sanitation facilities, the following table summarizes the obtained information:

Table 3: Final estimations for the SFD matrix calculations on containment

T1A1C2	User interface discharges directly to a centralised foul/separate sewer	6%
T1A1C6	User interface discharges directly to open drain or storm sewer	3%
T1A2C5	Septic tank connected to soak pit	3%
T2A2C5	Septic tank connected to soak pit, where there is a 'significant risk' of groundwater pollution	12%
T1A3C6	Fully lined tank (sealed) connected to an open drain or storm sewer	11%
T1A3C10	Fully lined tank (sealed), no outlet or overflow	3%
T1A5C10	Lined pit with semi-permeable walls and open bottom, no outlet or overflow	18%
T2A5C10	Lined pit with semi-permeable walls and open bottom, no outlet or overflow, where there is a 'significant risk' of groundwater pollution	26%
T1A6C10	Unlined pit, no outlet or overflow	17%
T1B11 C7 TO C9	Open defecation	1%

As mentioned before, some systems were combined. For example, for system 3 “septic tank to soakpit in low GW pollution risk”, septic tanks to open drains and sewers are included. However, this will not be represented in the matrix. The description “to soakpit” is chosen for the calculation tool because it is the dominant septic tank system. The definition “fully lined tank (sealed) connected to an open drain or storm sewer” does not completely reflect the existing containment system in Dar es Salaam, which is a partially lined pit connected to an open drain or a water body. However, as this description fits the existing systems most accurately, the decision to include this typology was made.

In the SFD matrix, the different containments systems are combined into the variables presented in Table 4.

Table 4: Estimations on containment of off- and onsite sanitation

Variable	Percentage	Description
W3	6%	WW contained decentralised (offsite)
W15	3%	WW not contained (offsite)
F2	40%	FS contained (onsite)
F10	50%	FS not contained (onsite)
OD9	1%	Open Defecation

Emptying & Transport Technologies & Methods

The SFD project differentiates between the following streams:

Variable	Explanation	Dar es Salaam context
W4b	WW contained delivered to decentralized treatment plants	Going to WSPs (i.e. fraction of W3)
W11b	WW contained not delivered to decentralized treatment plants	Sea outfall, leakage/overflow (i.e. fraction of W3)
W11c	WW not contained and not delivered to treatment	WW flowing directly to open drains or rivers (i.e. W15)
F8	FS contained, not emptied	The fraction of F2 which is not emptied
F3a	FS contained, emptied	The fraction of F2 which is emptied
F3b	FS not contained, emptied	The fraction of F10 which is emptied
F15	FS not contained, not emptied	The fraction of F10 which is not emptied
OD9	Open Defecation	i.e. OD9

Similar to the estimations on containment, the different sources were identified, compared and analysed according to their reliability.

For the variables W4b, W11b and W11c, the following estimations were made: W11c equals W15 from the containment estimations (WW from flush toilets directly disposed in open drains or water bodies). The amount of WW delivered to treatment versus WW disposed through the sea outfall (fractions of W3) is estimated from the data in the Strategic Sanitation Plan by AAW et al. (2008). Average inflow estimations show that at least 26% of the total WW is disposed through the sea outfall directly into the Indian Ocean without further treatment. Trémolet and Binder (2013) report that, from interviews with DAWASA officials, they estimate that 70% of all WW is disposed through the sea outfall. However, as no further background information on this estimation is given, the estimation for W11c is based on the inflow estimations from AAW et al. (2008) and set at 30%. This includes the fact that frequent blockages and overflows occur in the city (on average, 6 sewer blockages per day (leading to WW overflow) during the FY 2013/14) (EWURA, 2014b).

Jenkins et al. (2014b) state that 64% of the survey respondents (in low-income informal settlements) reported to have never emptied their systems. Comparing this value to statements by Mkanga and Ndezi (2014), the EHOs FGD (2015) and an unpublished survey by BORDA (BORDA, 2015), it is estimated that 50% of the onsite sanitation systems are not emptied. Furthermore, it is assumed that all FS emptied by vacuum trucks or the gulper technology is delivered to treatment sites, while all other emptying methods lead to FS being dumped in open drains, water bodies or other parts of the city's environment. Using percentages reported by Jenkins et al. (2014b), Mkanga and Ndezi (2014), Trémolet and Binder (2013), Mwalwega (2010), the EHOs FGD (2015) and an unpublished survey by BORDA (BORDA, 2015), a combined percentage is calculated for FS disposed at treatment sites. The calculation for all of Dar es Salaam is based on the information that at least 70% of Dar es Salaam's inhabitants live in informal settlements. As expected, it can be observed that in unplanned areas, the predominant emptying methods result in FS not being delivered to treatment plants, whereas in middle/high-income areas onsite sanitation technologies are mainly emptied by vacuum trucks, which are assumed to deliver FS to treatment. For all of Dar es Salaam, different sources agree that 45% of the FS emptying services are executed by vacuum trucks or gulper groups who deliver the FS to treatment sites. The remaining 55% of FS is emptied by frogmen, through waste drain pipes or by other emptying methods, which lead to FS being dumped in the environment.

Unlined pit latrines cannot be emptied by vacuum trucks as the suction force from the vacuum pumps in combination with unstable soil conditions may result in the collapse of pits. Furthermore, it is known that emptying is more prevalent in high WT areas because of regular flooding of the systems during the rainy season. Unlined pits are rarely built in high WT areas, which confirms the before mentioned estimate (NGOs FGD, 2015, EHOs FGD, 2015, Manual emptying & motorized transport service providers, 2015). Trémolet and Binder (2013) estimate that less than one third of the pit latrines, but more than two thirds of the septic tanks are emptied by vacuum trucks, and Motorized Emptying & Transport Service Providers (2015a) report that 75% of the emptied systems are septic tanks. In Dar es Salaam, 15% of the containment systems are septic tanks. It is estimated that overall 50% of all onsite sanitation systems are emptied, while the emptying for septic tanks is 70 to 75%. In addition, it is estimated that 45% of all the emptied containment systems are emptied with hygienic emptying methods (vacuum trucks or gulper technology) with which FS is delivered to treatment. Table 26 in appendix 7.10.2 displays in detail the emptying estimations for the different containment systems. Different assumptions are made for the different containment systems; for example, it is assumed that unlined pits are not emptied by vacuum trucks and that the effects of emptying by the gulpers are too small to show an impact in the SFD matrix. As the SFD variables also differentiate between the proportions of tank/pit content being FS and not effluent, supernatant or infiltrate, the value F3 (FS emptied) is less than 50% of all

FS. Overall, it is calculated that FS delivered to treatment (F4) is 11%, while FS not delivered to treatment (F11) is 13%.

Treatment Technologies & Disposal

Nine WSPs exist in Dar es Salaam to treat WW. Two of them (Vingunguti and Kurasini) also receive FS from emptying and transport service providers. For five of the ponds, influent and effluent parameters analysed by DAWASCO were obtained during field research (DAWASCO, 2007, DAWASCO, 2010a, DAWASCO, 2010b, DAWASCO, 2014b). The analysis shows that total solids content, BOD and COD is partially reduced up to more than 50%. However, most of the values are still far from the effluent discharge limits set by the TBS (2005). Therefore, the amount of WW and FS treated is estimated at a maximum of 50%, although it can be assumed that the actual FS treatment efficiency is lower because the ponds were not designed for FS treatment. This can also be observed from the parameters at Vingunguti and Kurasini, where the parameters are generally higher than at the other ponds.

The functioning of the DEWATS at the HH and institutional level could not be assessed. Because their percentage contribution to the SFD Matrix is very small and the effect negligible, it was decided to not include this information in the final SFD Matrix. The DEWATS managed by the UMAWA in Kigamboni is estimated to be functioning (Manual emptying & motorized transport service providers, 2015, BORDA, 2015).

Because a significant amount of WW is not delivered to treatment plants, but directly disposed through the sea outfall, the overall percentage of treated WW (W5b) is 2.1%. The estimation for FS treated (F5) results in 5%.

Therefore, 57% of the overall excreta in Dar es Salaam is considered not contained or not safely managed, while 43% is considered contained/safely managed. However, only 7% (W5b plus F5) of the excreta is estimated to be effectively treated. The large chunk of safely managed excreta (F8: 36%) is determined by the SFD definition that all FS contained onsite and not emptied is considered to be safe. However, when these systems are full, the FS has to be emptied, and preferably, this would be done by the available hygienic emptying services that are affordable and that can deliver the FS to effective treatment sites. Nevertheless, the main challenges are onsite sanitation technologies which do not contain FS (F10, 50%), as well as ensuring that the emptying and transport methods that are employed deliver FS to treatment sites. For this, FS treatment plants are needed.

3.3 Discussion on quality of data

The sources that were available for a service delivery context analysis were diverse and reported similar results. Those references with high quality information include: Trémolet and Binder (2013), Thomas et al. (2013), Chaggu (2009); their information could be triangulated by interviews with stakeholders in Dar es Salaam. However, quantitative data for the creation of the SFD varied greatly and, thus, quality issues are discussed below.

For a detailed analysis of containment technologies, a diverse number of information sources were missing. The published surveys mostly differentiate between different types of user interfaces or between septic tanks and pit latrines, but not about the design of the containment systems below ground. Therefore, the estimations on septic tank and pit latrine designs are based on the FGDs with NGOs and EHOs. But, these stakeholders also had difficulties in making estimations because the design of the containment systems is difficult to assess. Furthermore, the definitions used by different stakeholders or authors may not have the same meaning for everyone. For example, the differentiation between lined and unlined pit latrines was not always used in the same way by Dar es Salaam stakeholders. Some pits in Dar es Salaam were called unlined when they are lined only on the top to stabilize the pit (two thirds of the pit wall lined, the bottom third not). Others have lined walls, which have not been intentionally constructed to be semi-permeable, but in practice actually are (EEPCO, 2015).

When questioned about the amounts of WW disposed at the different ponds versus sea outfall, DAWASCO officials referred to the information presented in the report by AAW et al. (2008). Average inflow estimations are presented in this report; however, it remains unclear how these estimations have been calculated and the report is seven years old.

The decision on treatment effectiveness is based on the WW analysis results received from DAWASCO that depicts influent and effluent parameters for five of the nine WSPs existing in the city. However, background information is missing about the sampling location and the methodology, and sampling is carried out only every few years. To make a credible decision, influent and effluent data should be taken at FS inflow, WW inflow and effluent outflow a few times per year to take into account the difference between FS and WW, as well as seasonal fluctuations.

4 Stakeholder Engagement

4.1 Key Informant Interviews

Overall, 14 key informant interviews (KIIs) were conducted with different stakeholders in the city, such as government authorities, utilities and NGOs (see appendix 7.4). An introduction letter was delivered to the utilities DAWASCO and DAWASA, as well as to the municipal councils Ilala, Kinondoni and Temeke. This letter was necessary to receive permission for an interview and for data collection because it provided information about the project and the data needs. Contact with NGOs was established more informally, by e-mail, phone or direct visits. Apart from KIIs, other interviews were also conducted, which included interviews with two motorized emptying and transport service providers and three manual emptying and motorized transport service providers. For the case of the vacuum trucks, ten short, structured interviews were held with the men working in the vacuum truck business, such as the drivers or helpers. Furthermore, an SFD research seminar was organized with the Dar es Salaam partners on the 12th of May 2015, at which general information about the project and excreta management in Dar es Salaam was shared.

One of the benefits of field based research is the direct stakeholder engagement, which also enables enhanced data collection. Some data (e.g. WW quality effluent performance data or sewer extension design plans) are preferably shared during face-to-face meetings rather than conversations through email. This also increases the understanding of stakeholder relations, as well as knowledge sharing. Some organisations share a lot of information online, while others are less active in publishing online. The local NGOs are often easily disregarded as many do not have a strong online presence, although they have important impact in the field.

Little information was known prior to the field-based research about the emptying service providers in the city. Interviews with these stakeholders provided additional insight into the service delivery context, and stakeholder responsibilities and local knowledge could be assessed. The statements by different stakeholders could also, thus, be better judged as to their credibility. For example, almost every interviewee mentioned that the lack of coordination among the stakeholders is a challenge that makes appropriate planning difficult.

Only one KII with a ministerial representative (of the MoHSW) was conducted. For the future, it is suggested to involve these stakeholders at an earlier stage to understand the political interest and willingness to support excreta management in the city. In addition, consent from high-level stakeholders can facilitate improved data collection.

4.2 Focus Group Discussions

Two FGDs were held to better understand the city and the triangulation of data, as well as to obtain more detailed information on the containment systems and emptying methods. The former was achieved by doing an FGD with NGOs working in the sanitation sector in Dar es Salaam. The latter was achieved by an FGD with EHOs of different wards from Kinondoni district. Both FGDs were useful to receive information about stakeholder engagement, as well as data triangulation. In addition, they provided information not available in the literature, including detailed information on the actual design and construction of onsite sanitation technologies. As different stakeholders may use different wordings for certain systems, the definitions could be clarified to have a common overall understanding.

Both FGDs were conducted towards the end of the field-based research. For the future, it is suggested to start (and end) the field based data collection with a FGD with NGOs, as they can provide a quick overview about the city and point out knowledge gaps, as well as identify who the most important stakeholders are to meet. An earlier NGO FGD could have assisted the researcher in identifying those organisations where KII would be most beneficial and could also have made the KIIs with NGOs more focused. If time allows, it is suggested that further FGDs with EHOs or ward officers from the other municipalities take place. It was reported that the leaders from the lower administrative levels (mtaas) would have very useful knowledge as they live in the areas where they also work.

4.3 Field Observations

Observations during the field-based research included general observation of the city's situation, such as the topographic and traffic conditions, which influence emptying and the transport service providers. As the researcher was based in Dar es Salaam in May and June 2015, she was able to observe the differences between the rainy and dry seasons and their effects on sanitation service delivery. This included observation of frequent flooding of streets and of premises, and the overflowing of open drains and manholes.

Furthermore, field trips to one pumping station and to four of the nine WSPs were executed to make a visual assessment of the performance of the ponds. At the Vingunguti WSP, FS disposal by vacuum trucks could be observed. Furthermore, an emptying process with the gulper technology was observed and the DEWATS in Kigamboni was visited; BORDA experts went along to explain the processes. A visit to an informal settlement (Tandale) was done to understand the settlement structure of the low-income population.

The observations are important because they provide a credible cross-checking of information and were carried out with very little to no prior arrangements. If allowed, photographs were taken, of which some are presented in appendix 7.15. People were interviewed during the observations (e.g., WSP or pump operators) to understand the operation of the systems.

Observations in the city also benefitted the data collection process because they gave the researcher a better understanding of the city context. Furthermore, they allowed for more reliable judgements to be made about the credibility of statements by stakeholders and about what was learned in the literature.

4.4 Conclusion on stakeholder engagement

An overall benefit of the field-based research was the improved stakeholder engagement, which is key for future uptake of the advocacy tool. However, stakeholder engagement should be initiated at an earlier stage of the SFD process in a city even if the stakeholders cannot provide data in order to improve the process. Lastly, it can be said that because the SFD tries to analyse excreta management in much detail, field-based data collection is very helpful to find all the different sanitation technologies used in the city. Although the SFD is not influenced by these small numbers, knowledge of the information is anticipated to benefit future excreta management support in Dar es Salaam.

5 Acknowledgements

This report was compiled as part of the SFD Promotion Initiative project, funded by the Bill & Melinda Gates Foundation (BMGF). The field research to compile this report was carried out in collaboration with the University of Dar es Salaam (UDSM), the Bremen Overseas Research and Development Association (BORDA), and the Ifakara Health Institute (IHI). We would like to thank DAWASA and DAWASCO, as well as the Local Government Authorities and municipal councils (Ilala, Temeke, Kinondoni) for being available and providing necessary information for the assessment. Thank you especially to Dr. Joel Nobert, Miriam Esanju, Nuhu Moto, Francis Koroma, Larissa Duma and Dr. Jacqueline Thomas for your assistance, support and contributions.

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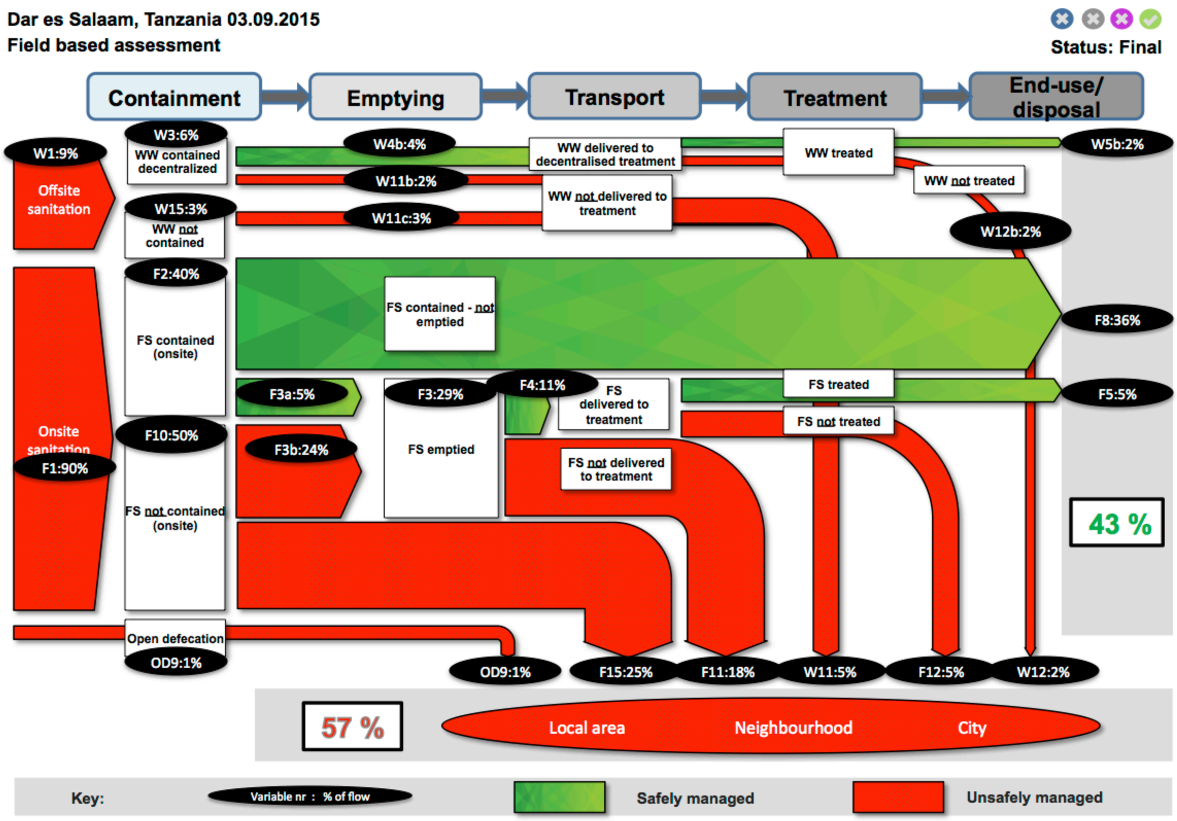
7 Appendix

7.1 Appendix 1: SFD matrix



7.2 Appendix 2: Policies, Acts, Regulations, Guidelines related to excreta management in Dar es Salaam

Table 5: List of policies, acts, regulations, guidelines related to excreta management – adapted from Chaggu (2009) and own research.

Policy / Act	Content
The Water Works Regulation 1997	"Allows Water Supply and Sewerage Authorities to be set up as an autonomous body, a public or private company, a water user association, a co-operative society, and NGO, or any other body as approved by the Minister [of Water]."
The National Environmental Policy (URT, 1997)	
The Local Government (Urban Authorities) Act 1982, including its amendments until 2000 (URT, 2000)	Sets out responsibility of LGAs on
The Energy and Water Utilities Regulatory Authority Act (URT, 2001b)	Establishes EWURA's roles, e.g. to regulate WSSAs
The Dar es Salaam Water & Sewerage Authority Act (URT, 2001a)	Setting out responsibilities of DAWASA under regulation of EWURA, with an operator to be appointed, that is DAWASCO
The National Water Policy 2002 (URT, 2002)	NAWAPO
The Environmental Management Act (URT, 2004)	Setting out role of NEMC
Draft National Environmental Health, Hygiene and Sanitation Strategy (2006-2015) – NEHHASS	Setting out how MoHSW and stakeholders will implement the National Health Policy to achieve TDV (2025), MDGs (2015) and NSGRP (2010) targets
The National Water Sector Development Strategy 2006 to 2015 (MoWI, 2006)	"The NWSDS was developed to support re-alignment of the water related aspects of other key sectoral policies with the NAWAPO, and to provide a focus on specific roles of the various through clear defined roles and responsibilities and hence to

	remove duplications and ommissions."[6] Defines responsibilities for water supply and sewerage to urban water supply and sewerage authorities, and sanitation responsibility to city and municipal councils.[7]
The Water Resources Management Act (URT, 2009b)	"Prohibits discharge of waste into any water body including GW without written permit. Requires adherence to environmental standards of receiving water bodies when legally discharging wastes and DAWASA and contractor [DAWASCO] should observe this legal provision" (DAWASA, 2010)
The Water Supply & Sanitation Act 2009 (URT, 2009c)	"States obligations of water supply and sanitation authorities to provide water supply and sanitation services, indicates their functions, powers and duties. Gives responsibilities for provision of adequate and reliable water supply and sanitation services in urban areas to urban water supply and sanitation authorities (UWSAs)", which is in Dar es Salaam DAWASA. (DAWASA, 2010) One objective of Tanzania's Water Supply and Sanitation Act (2009) is the "promotion of public sector and private sector partnership in the provision of water supply and sanitation services" (Bayliss and Tukai, 2011).
Public Health Act 2009 (URT, 2009a)	PHA is on liquid waste management by authority and pollution control by HHs
National strategy for growth and reduction of poverty II (NSGRP II) (MoFEA, 2010)	Called MKUKUTA II in Kiswahili, this strategy is aiming to improve the lives of the poor and vulnerable. It sets out operational targets on sanitation and hygiene, such as 45% improved toilets at HH level and 22% connected to public sewerage system in 2015. It set out the base to start a sanitation

[6] http://www.ewura.go.tz/newsite/index.php/2012-03-09-08-22-52/water

[7] However, a clear definition of sanitation is not given.

	and hygiene policy and other guidelines and manuals.
The Water Supply and Sanitation Service Rules 2010 (URT, 2010)	
Latrine Options and Construction Guide (MoHSW, 2010)	
National strategic plan for school water, sanitation and hygiene (SWASH) 2012-2017 (MoEVT, 2012)	
Guidelines on management of liquid waste (VPO, 2013)	
Water Sector Development Programme Phase (WSDP) II (2014/2015-2018/2019) (MoW, 2014a)	The WSDP is under the MoW. But the one (sanitation) of the five components is under the MoHSW (MoHSW, 2015)
Draft Sanitation Policy (not yet adopted)	A sanitation strategy had been prepared many years ago but has not been adopted yet (MoHSW, 2015).

7.3 Appendix 3: Stakeholder identification

Table 6: Stakeholders identified in Dar es Salaam related to excreta management

No.	Stakeholder Group	In DSM Context:
1	City council	DCC
	Municipal authority	MCs of Ilala, Kinondoni & Temeke
	Utility	DAWASA & DAWASCO
2	Ministry in charge of urban sanitation and sewerage	MoW
3	Ministry in charge of urban solid waste	N/A
4	Ministries in charge of urban planning,	Minstry of Lands, Ministry of Transport, Ministry of Works, PMO-RALG
	Ministry for environmental protection/health,	MoHSW
	Ministry of finance, economic development	MoF
	Other ministries involved in sanitation matters	MoEVT
5	5 Service provider for construction of onsite sanitation technologies	N/A
6	Service provider for emptying and transport of FS	Various vacuum trucks and gulper groups (latter: KARAKATA, KIPAWA, NUMAGRO, UMAWA, TFKM – more to come)
7	Service provider for operation and maintenance of treatment infrastructure	DAWASCO
8	Market participants practising end-use of FS end products	N/A
9	Service provider for disposal of FS (sanitary landfill management)	Not existing
10	External agencies associated with FSM services: e.g. multilateral organisations, international NGOs, academic institutions, international financing institutions	NGOs: BORDA, CCI, EEPCO, IHI, PEVODE, PDF, SAWA, UNICEF, WAT, WEPMO
		Academic institutions: Ardhi University, UDSM, WDMI
		International financing institutions: AfDB, BTC, Plan, KfW, WB
		Others: NEMC, GIZ

7.4 Appendix 4: Tracking of Engagement

Stakeholder	Date of engagement	Purpose of engagement
IHI	13.04.2015	Getting to know each other, Introducing SFD
UDSM	20.04.2015	Getting to know each other, Planning the time together
UMAWA	28.04.2015	Interview
BORDA	29.04.2015	Interview
IHI	29.04.2015	Interview
BORDA	08.05.2015	KII
Sandec/Eawag, UDSM, BORDA, IHI	12.05.2015	Research Seminar
DAWASCO Sewerage Section	20.05.2015	KII
Temeke MC	26.05.2015	KII
Ilala MC	27.05.2014	KII
NEMC	28.05.2015	KII
WAT	29.05.2015	KII
BTC	02.06.2015	KII
CCI	02.06.2015	KII
Temeke MC	04.06.2015	KII
TFKM - various	04.06.2015	Interview
NUMAGRO	04.06.2015	Interview
GIZ	05.06.2015	KII
10 Vacuum Truck Drivers & Helpers	08.06.2015	Interviews
2 Vacuum Truck Operators/Owners	09.06.2015	Interviews
EEPCO	10.06.2015	KII
DAWASA	11.06.2015	KII
Kinondoni MC	16.06.2015	KII
DAWASCO HQ	16.06.2015	Interview / Data Collection
WB - Mr. Kaposo	19.06.2015	KII

Kibamba ward EHO	23.06.2015	FGD with EHOs
Kigogo ward EHO		
Kijitonyama ward EHO		
Makumbusho ward EHO		
Manzese ward EHO		
Mbezi ward EHO		
Sinza ward EHO		
DAWASA	24.06.2015	Interview / Data Collection
DAWASCO Sewerage Section	25.06.2015	Interview / Data Collection
DAWSCO HQ	25.06.2015	Data Collection
Kinondoni MC - Mr. Esra Boya	26.06.2015	Interview
DAWASCO HQ	26.06.2015	Data Collection
DAWASA	29.06.2015	Interview / Data Collection
BORDA	30.06.2015	FGD with NGOs
CCI		
EEPCO		
IHI		
PDF		
SAWA		
WEPMO		
DAWASCO HQ	01.07.2015	Data Collection
DAWASCO Vingunguti Pond Operator	01.07.2015	Data Collection
MoHSW	02.07.2015	KII
DAWASCO HQ	02.07.2015	Data Collection
DAWASCO - Temeke Section	03.07.2015	Data Collection

7.5 Appendix 5: Stakeholder Mapping

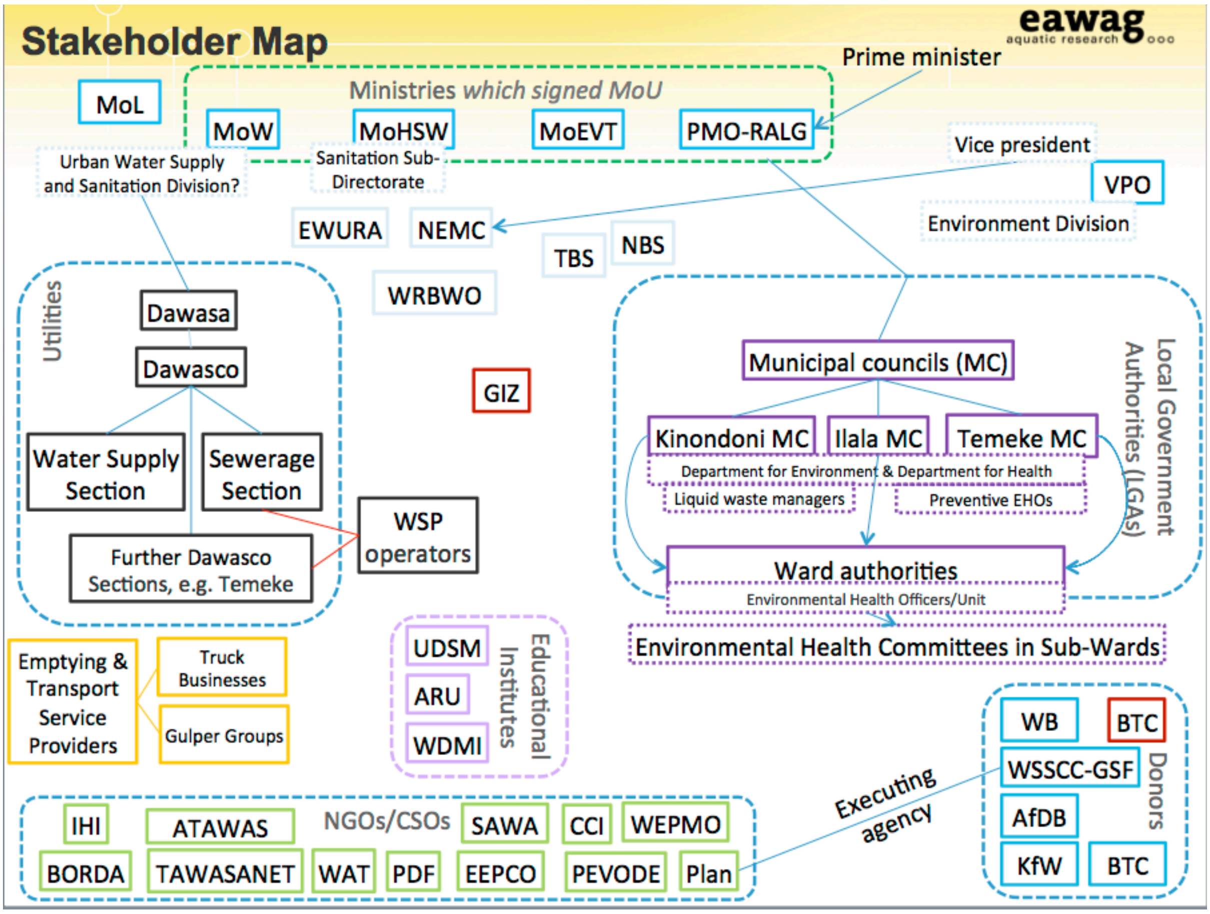


Figure 6: Stakeholder map.

The stakeholder map is non-exhaustive

7.6 Appendix 6: Groundwater

Table 7: Main source of drinking water for Dar es Salaam **HHs (NBS, 2015).**

Main Source of drinking water	% of Dar es Salaam HHs
Piped water into dwelling	20.1
Piped water to yard/plot	12.9
Public tap/standpipe	18.8
Tube well / borehole	18.9
Protected dug well	7.6
Unprotected dug well	4.2
Protected spring	0.3
Unprotected spring	0.2
Rain water collection	0.1
Bottled water	1.2
Cart with small tank / drum	7
Tanker truck	8.4
Surface water (river, dam, lake etc.)	0.1

⇨ Groundwater is main source of drinking water for 31.2% of Dar es Salaam HHs (NBS, 2015)

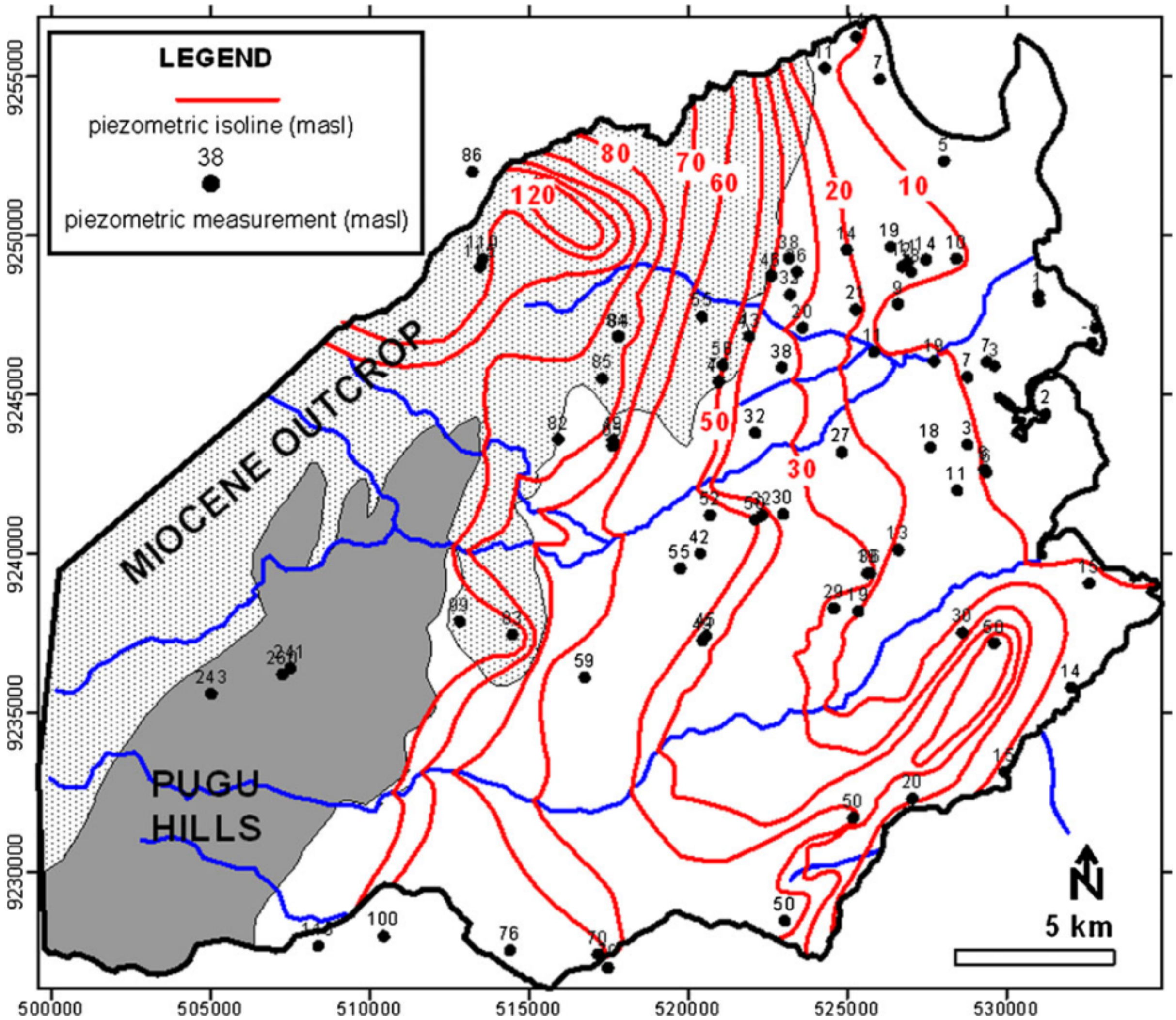


Figure 7: Water table map Dar es Salaam **(Van Camp et al., 2013).**

7.7 Appendix 7: Geology, Topography

7.7.1 Geological Map

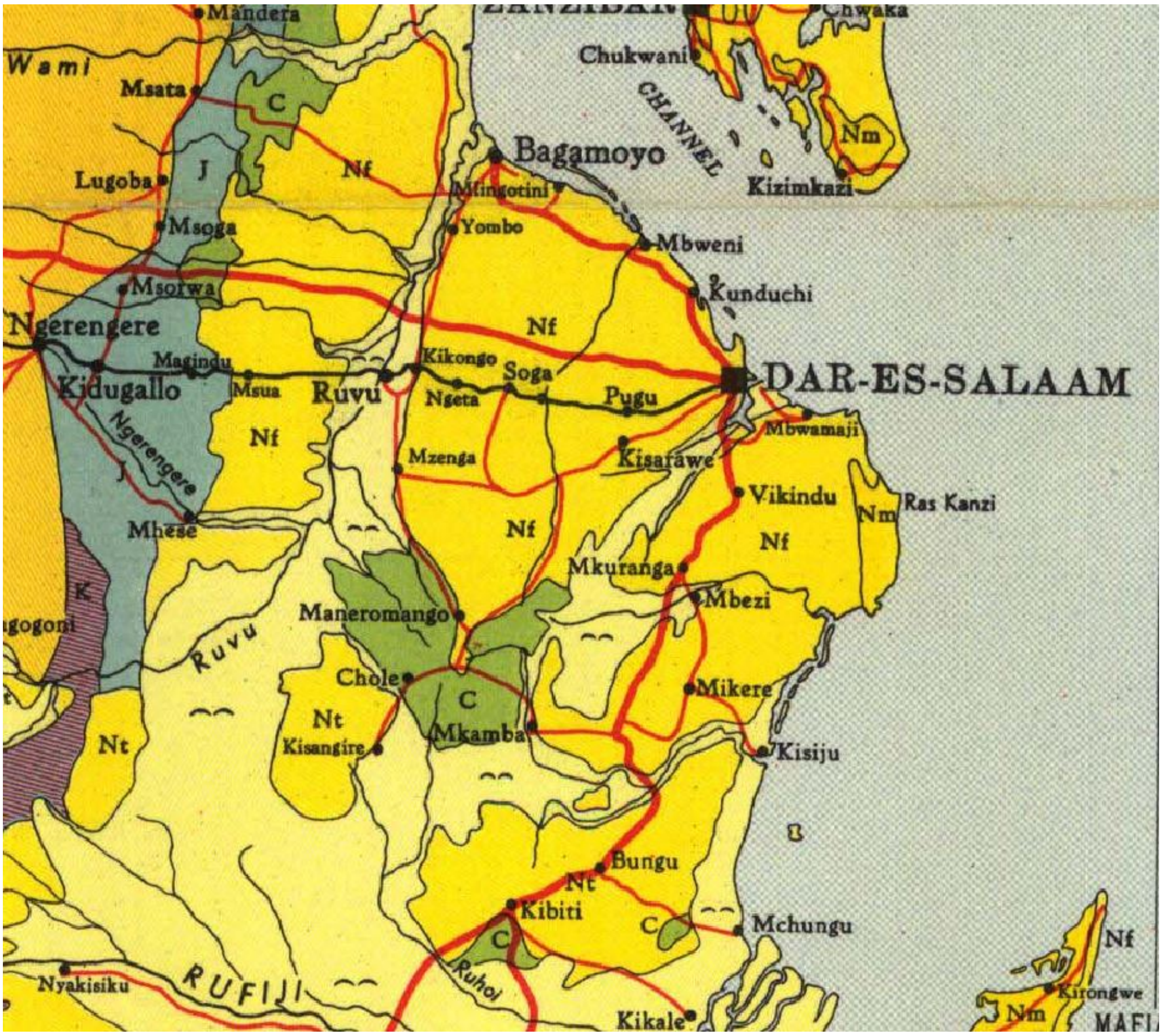


Figure 8: Geological map of Dar es Salaam **region - excerpt of Geological map of Tanganyika by (MoMC, 1959).**

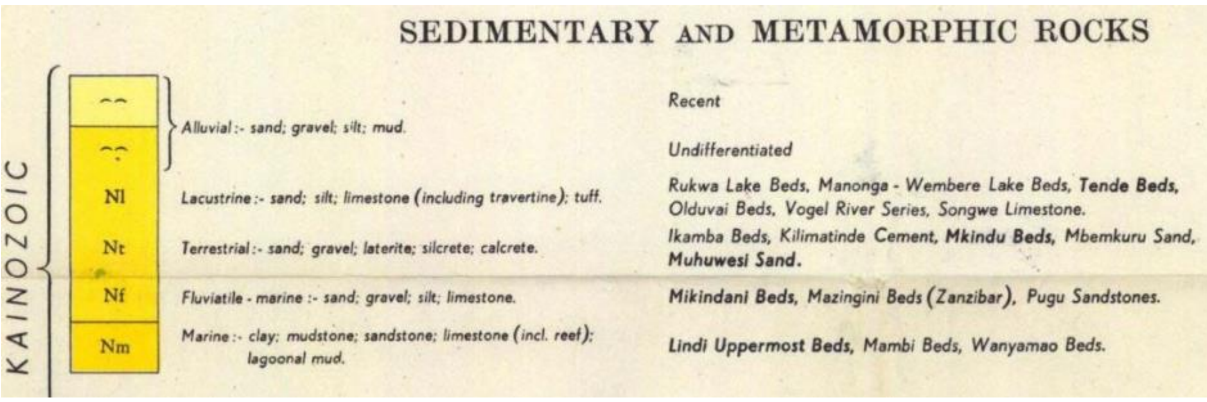


Figure 9: Legend for Figure 8 (MoMC, 1959).

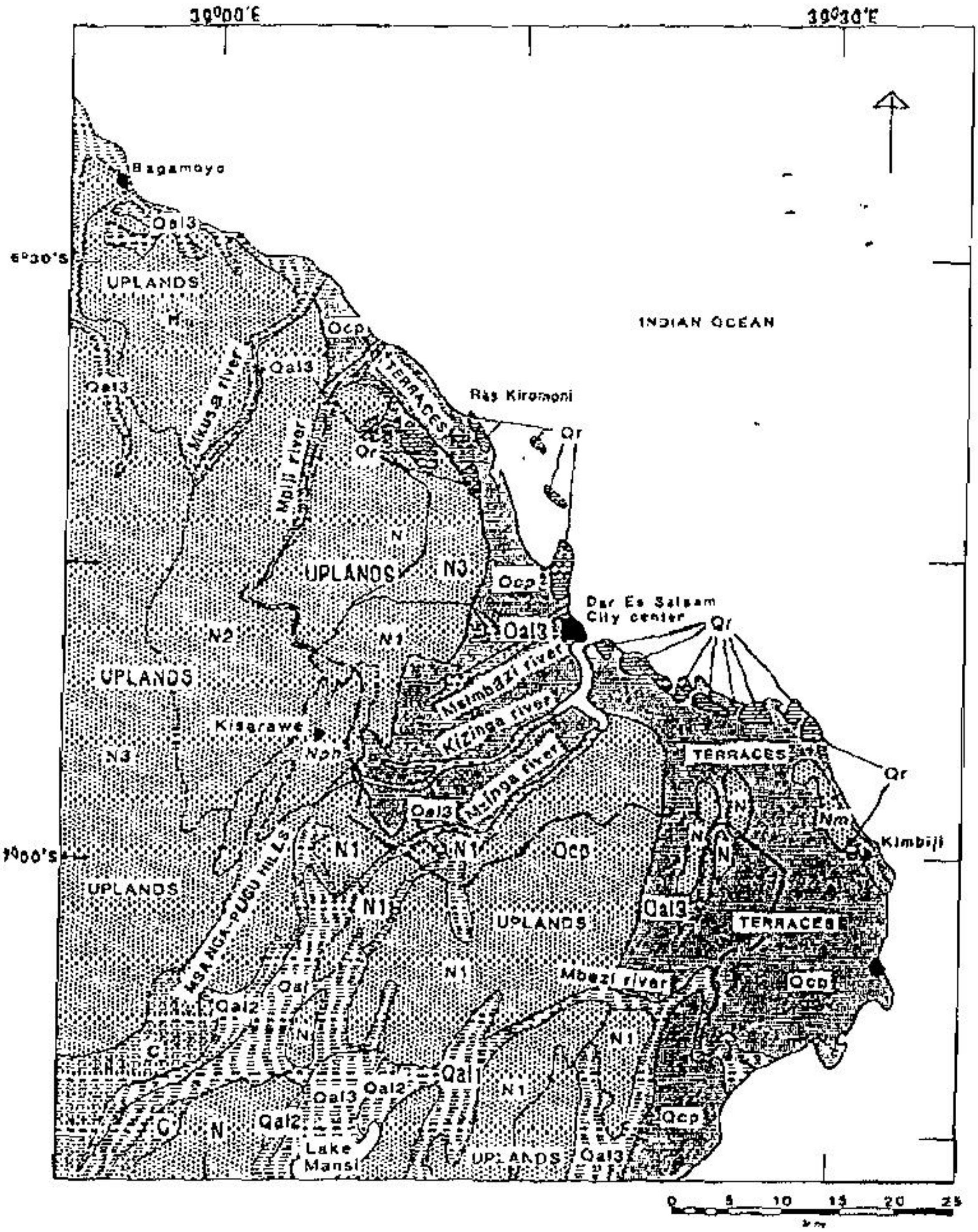


Figure 10: Geological map of Dar es Salaam **region (Msindai, 2004).**

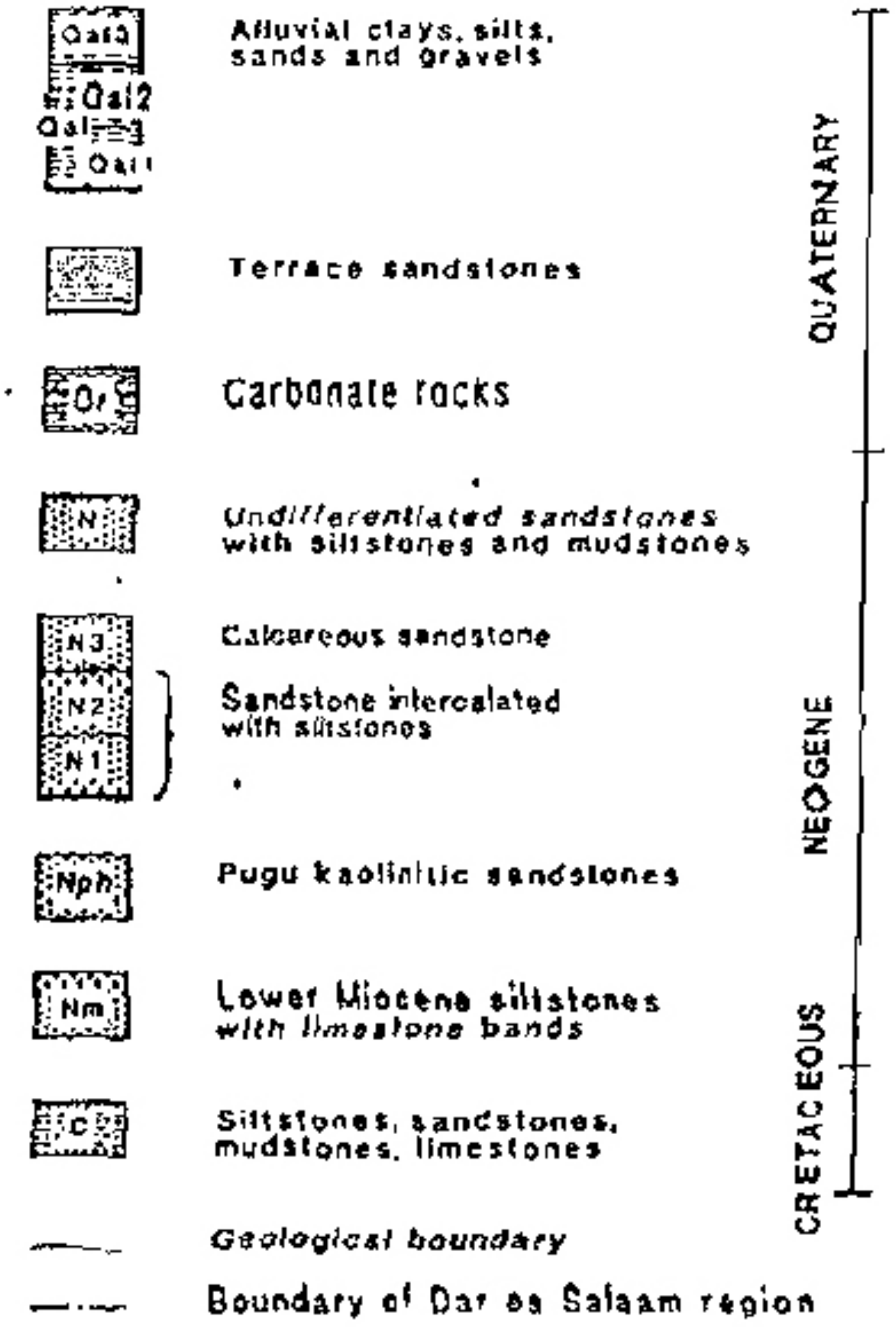


Figure 11: Legend for Figure 10 (Msindai, 2004).

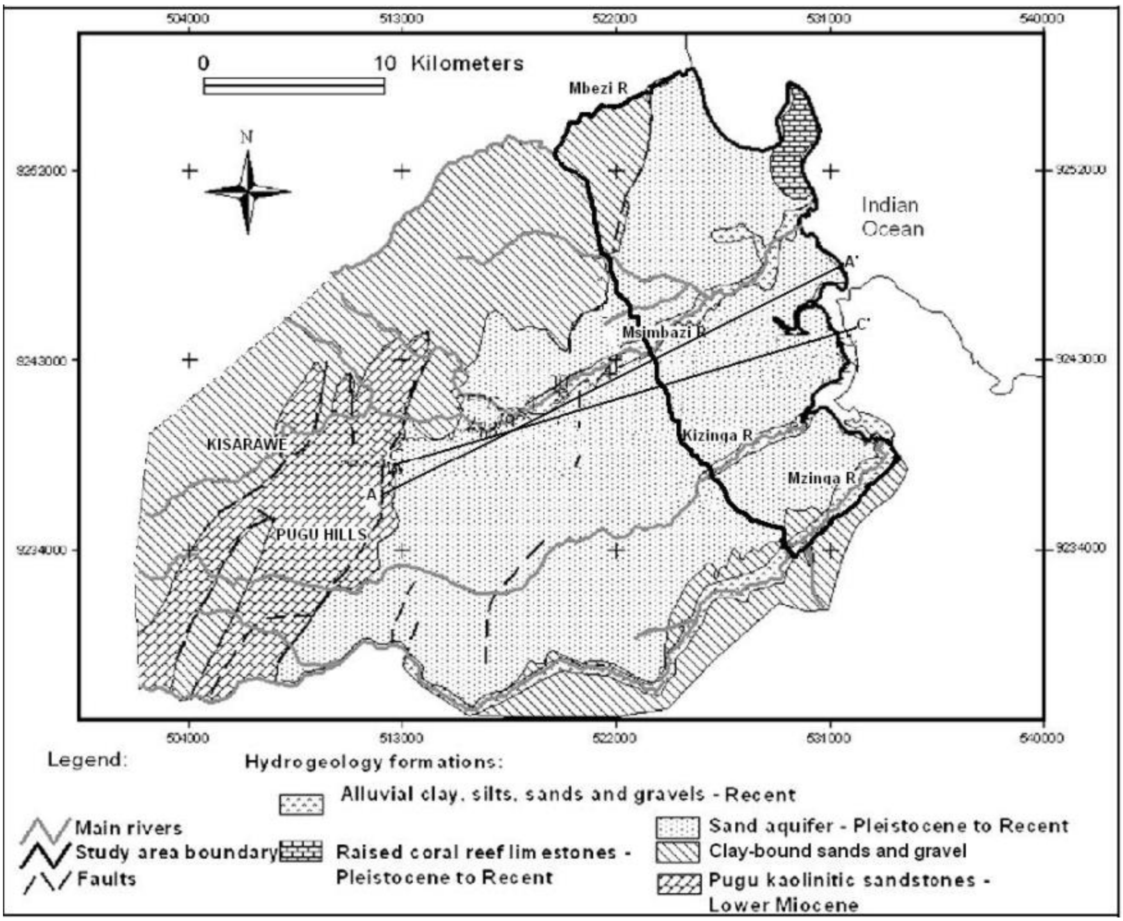


Figure 12: Hydrogeological map for parts of Dar es Salaam (Mtoni et al., 2012)

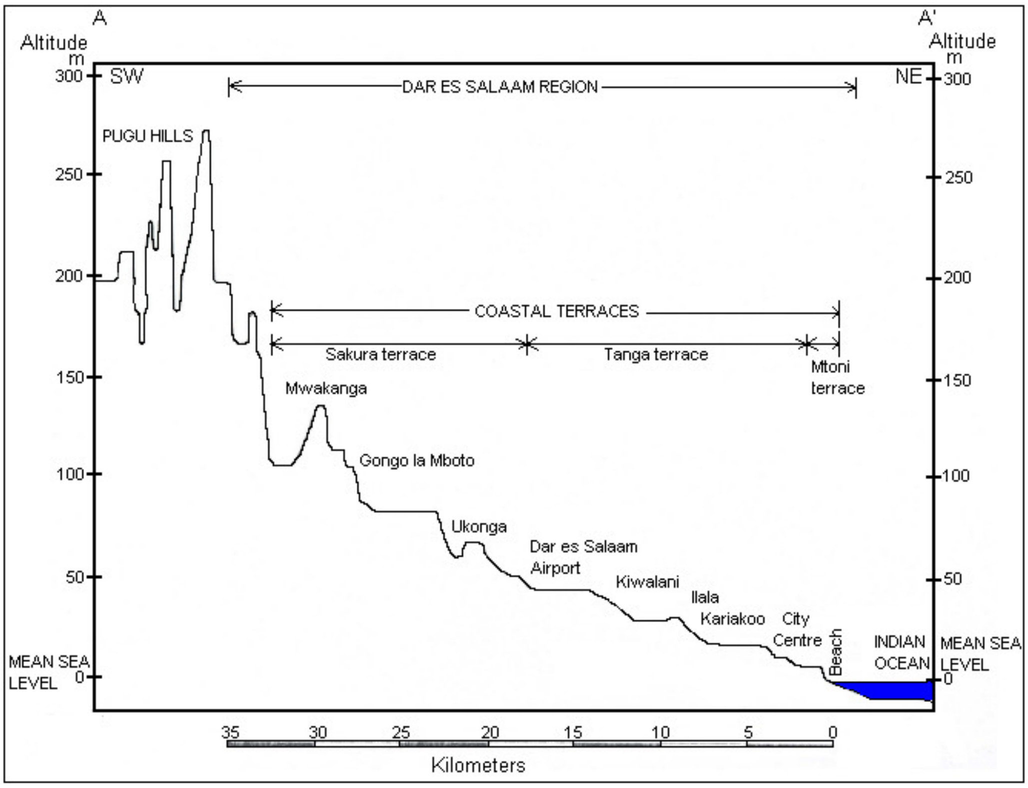


Figure 13: Cross-section showing minimum and maximum elevation of Dar es Salaam (Mtoni et al., 2012).

7.7.2 Geomorphological Map

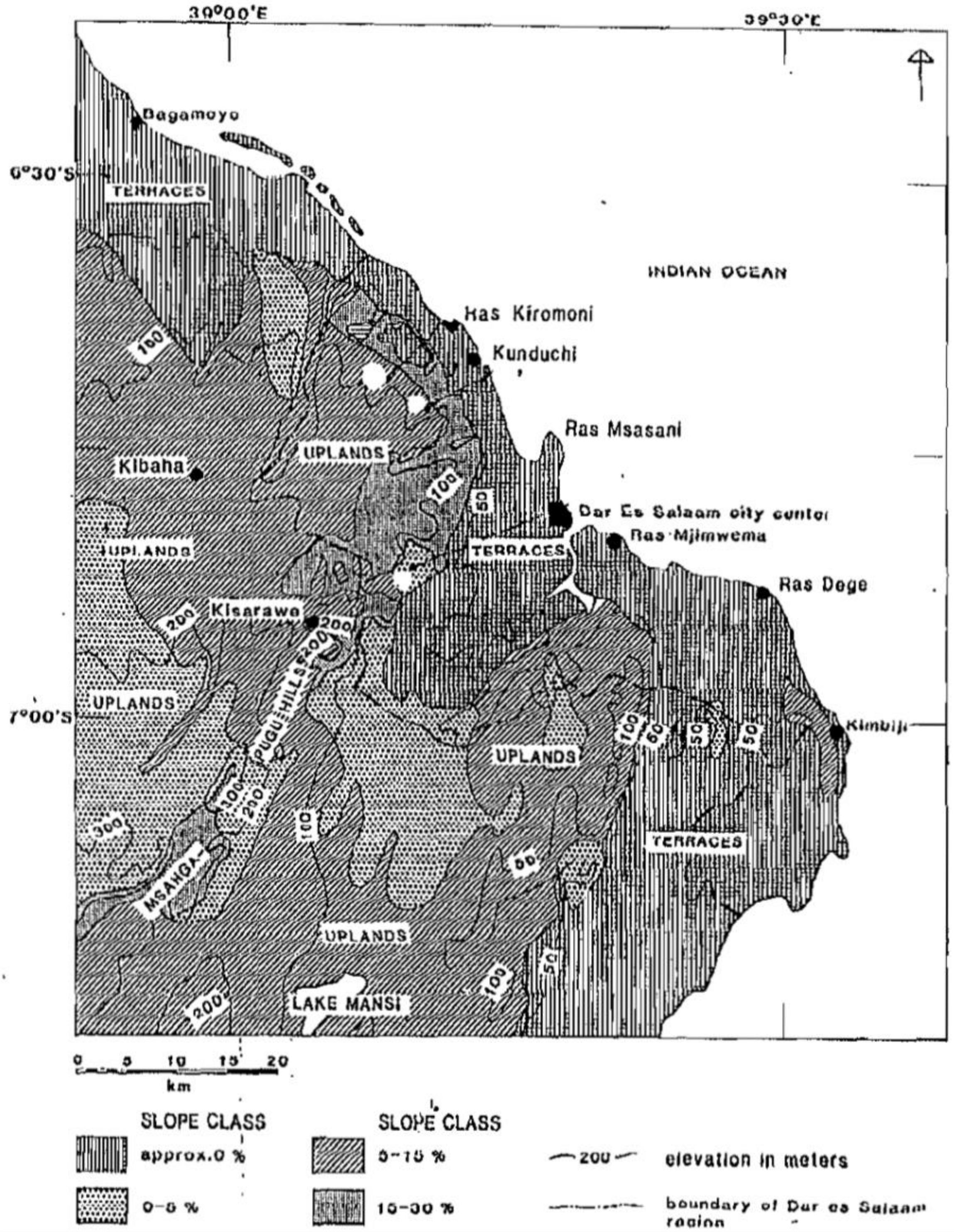


Figure 14: Geomorphological map (Msindai, 2004).

7.8 Appendix 8: Dar es Salaam Maps

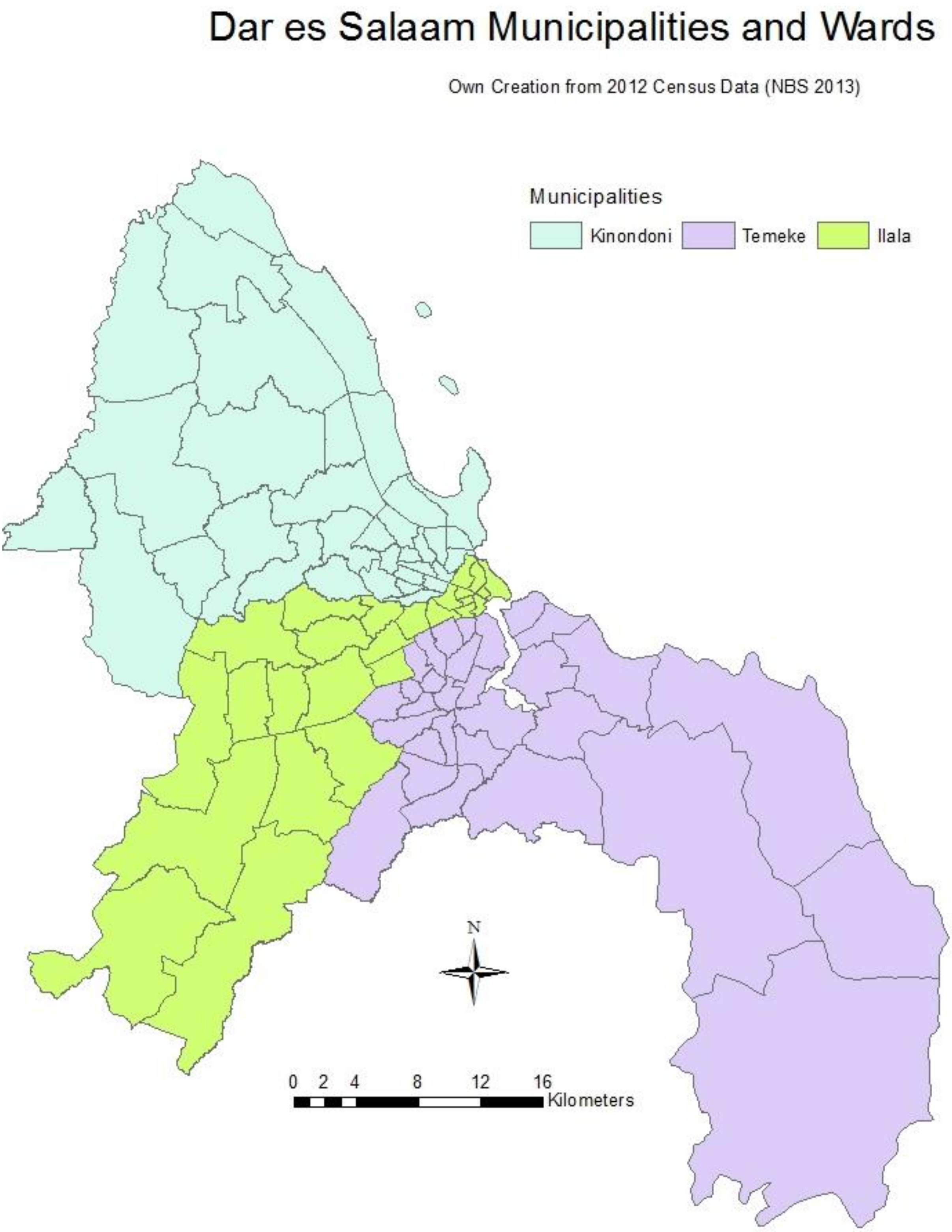


Figure 15: Dar es Salaam Municipalities and ward boundaries. Own creation from 2012 Census Data (NBS, 2013).

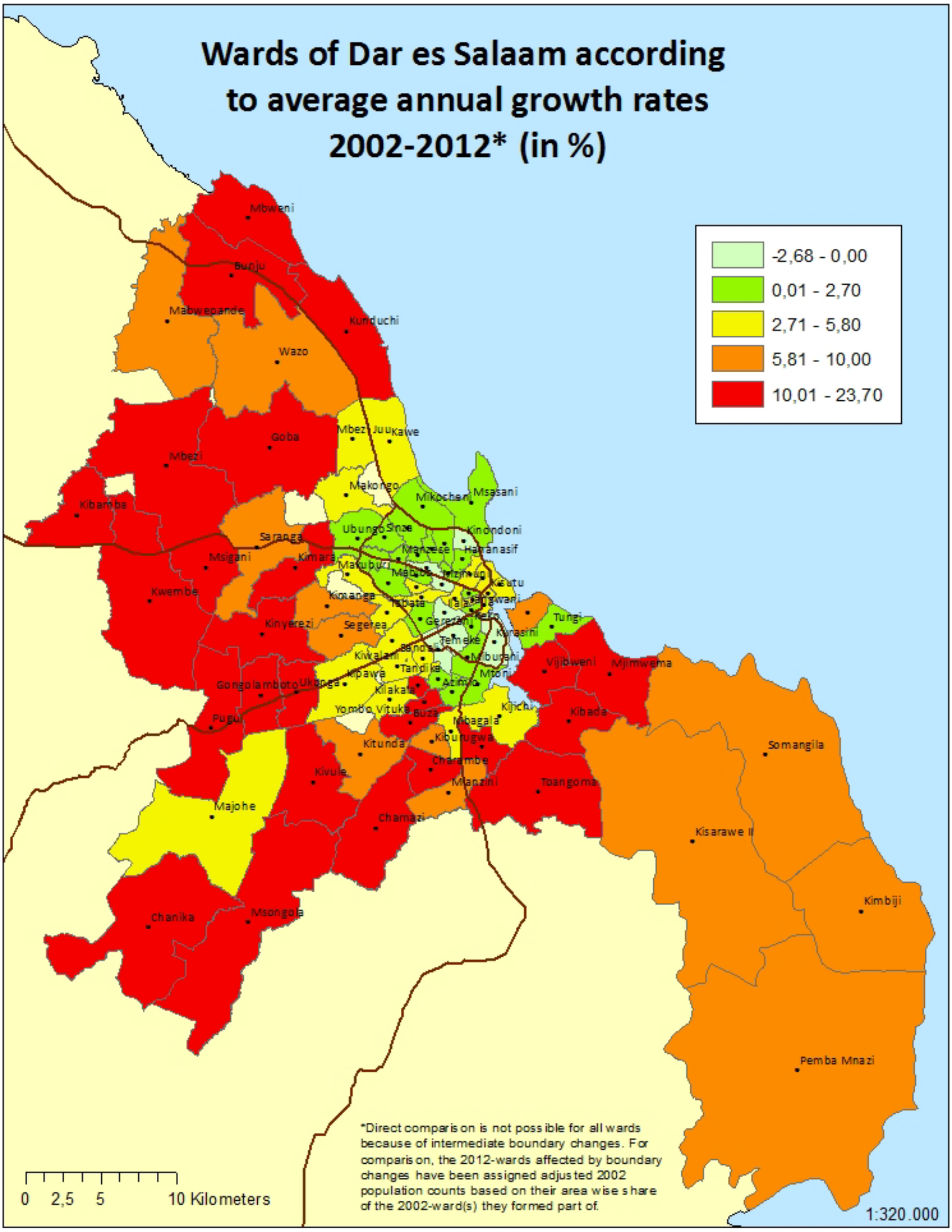


Figure 16: Wards of Dar es Salaam according to average annual growth rates (Andreasen, 2013).

7.9 Appendix 9: Sanitation Facilities reported for Dar es Salaam

Table 8: Sanitation facilities reported for Dar es Salaam.

	Definition	Variable	GW contami-nation risk	Description in Dar es Salaam context	Main sources
Offsite	User interface discharges directly to a decentralised separate sewer	T1A1C4	N/A	sewer (minus septic tank to sewer)	everyone
Offsite	WW not contained, emptying not applicable	T1A1C6 & T1A1C7	N/A	flush toilet to open drain / river (no matter whether high or low GW risk)	(EHOs FGD, 2015)
Onsite	User interface to soak pit	T1A1C5 T2A1C5	low significant	Pour flush to offset pits	(EHOs FGD, 2015)
Onsite	Lined pit with semi-permeable walls and open bottom, no overflow	T1A5C10 T2A5C10	low significant	Lined pit with semi-permeable walls and open bottom	(Mkanga and Ndezi, 2014)
Onsite	lined tank with impermeable walls and open bottom, no overflow	T1A4C10 T2A4C10	low significant	lined tank with impermeable walls and open bottom, no overflow	(NGOs FGD, 2015)
Onsite	lined tank with impermeable walls and open bottom, to open drain/water body	T1B10C6 & T1B10C7-10	N/A	pits with pipes letting FS discharge to open drain / water body	(EHOs FGD, 2015)
Onsite	Unlined pit, no overflow	T1A6C10 T2A6C10	low significant	unlined pit	(NGOs FGD, 2015)
Onsite	Pit (all types), never emptied but abandoned when full and covered with soil	T1B7C10 T2B7C10	low significant	Pit never emptied but abandoned when full and covered with soil	(EHOs FGD, 2015)
Onsite	Pit (all types), never emptied but abandoned when full & not adequately covered with soil	T1B8C10	N/A	Pit never emptied but abandoned when full & not adequately covered with soil	
Onsite	fully lined tank (sealed), no outlet or overflow	T1A3C10	significant	fully lined tank/pit (raised) in waterlogged areas	(Jenkins et al., 2014b)
Onsite	Containment failed, damaged, collapsed or flooded - no overflow	T1B1C10	significant	fully lined tank/pit (raised) in waterlogged areas, not watertight	
Onsite	fully lined tank (sealed), no outlet or overflow	T1A3C10	significant	EcoSan in high WT areas	(Mkanga and Ndezi, 2014), (NGOs FGD, 2015), (NBS, 2014), (Manual emptying & motorized transport service providers, 2015)
Onsite	septic tank to soakpit	T1A2C5 T2A2C5	Low risk Significant	septic tank to soakpit	(Mkanga and Ndezi, 2014)
Onsite	septic tank to open drain	T1A2C6	N/A	septic tank to open drain	(NGOs FGD, 2015)
Onsite	septic tank to decentralised foul/separate sewer	T1A2/3C4	N/A	septic tank to decentralised foul/separate sewer (also includes not properly partioned STs to sewer)	(NGOs FGD, 2015)

	fully lined tank (sealed) to soakpit	T1A3C5	Low risk	septic tank not properly partinioned to soak pit	(NGOs FGD, 2015)
		T2A3C5	Significant		
	containment failed, damaged, collapsed or flooded, to soakpit or open drain or sewer or other	T1B10C4-9	N/A	septic tank not watertight to soakpit, sewer or other	
	fully lined tank (sealed) to open drain, water body or other	T1A3C6/7	N/A	septic tank not properly partinioned to open drain or other (excludes to sewer)	
	Containment failed, damaged, collapsed or flooded - no overflow	T1B1C10	N/A	flooded pits	(Mkanga and Ndezi, 2014)
	User interface failed, damaged, collapsed or flooded	T1B9C1-10	N/A	user interface failed, damaged, collapsed, flooded	(Mkanga and Ndezi, 2014)
OD	Open Defecation	T1B11C7-9	N/A	OD to water body (sea), into plastic bags (thrown into environment, river), buckets	Almost everyone

Note: Every source mentions that pit sewers, pit latrines and septic tanks exist in Dar es Salaam, but many again do not differentiate on the containment technology, but rather the user interface, e.g. NBS (2014) differentiates as follows:

- open pit without slab
- pit latrine with slab (not washable)
- pit latrine with slab (washable)
- ventilated improved pit latrine
- pour flush toilet
- flush toilet with cistern
- composting toilet / ecosan toilet
- no toilet / bush / field
- other

7.10 Appendix 10: SFD Matrix Creation Methodology

Sources were identified that provided reliable estimations on the use of the different sanitation technologies. Sometimes though, only one or two sources gave a statement, which had to be used, but which was also commented on in the discussions concerning the quality of data (chapter 3.3).

7.10.1 Containment

The numbers from the different sources were combined according to the larger containment typologies existing in Dar es Salaam:

Table 9: Containment Variables for Dar es Salaam.

SFD variable	**Own variable**	**SFD description**	Dar es Salaam **Description**
W3	W3	WW contained decentralised (offsite)	decentralised sewers
W15	W15	WW not contained (offsite)	flush toilets to open drain or water body
F2 or F10	F2(e), F2(n), F10(e) or F10(n)	FS contained or not contained (onsite)	Septic Tanks
			Pit latrines
OD9	OD9	Open Defecation	Open Defecation

The main sources for the general containment decision are summarized in the table below:

Table 10: Main sources for containment decisions.

	Dawasco 2015	**NBS 2015**	**Pauschert et al 2012**	**EHOs FGD 2015**	**Mkanga & Ndezi 2014**	**Trémolet &Binder 2013**	**Interviews with MCs**
	Ewura reports FY 2014/15	*2012 National Census*	*Survey with X HHs*	*FGD with 7 ward EHOs of Kinondoni*	*Estimation based on survey and literature review*	*citing Bereziat (2009) and DAWASA (2008)*	*KIIs with EHOs of MCs*
W3 - sewer	3.50%	5.70%	4.80%	6.3%	10%	10%	max. 8.6%, depends on MC
W15 - flush to open drain etc	-	3.10%	-	8.8%	-	-	-
F2 or F10 - septic tank	-	15.20%	-	12.4%	9%	13%	20%

F2 or F10 - pit latrine	-	75.80%	-	71.4%	81%	70%	60-72%
OD9	-	0.20%	<1%	1.1%	-	7%	1.50%

DAWASCO's EWURA reports from the FY 2014/15 (DAWASCO, 2015b) state that around 18,100 domestic sewer connections exist. DAWASCO (2015b) estimates that the "average number of people served per domestic sewer connection" is ten. Thus, around 181,000 people get served by domestic sewer connections in Dar es Salaam, which is 3.5% of the total (estimated) population of 5,140,000, or 4% of the 2012 population reported in the 2012 census (NBS, 2013). As NBS (2015) and other literature suggests a higher number of the population is served by sewers, the number is adjusted to 6%, taking into account the part of the population who commute to the city centre every day for work and whose excreta is partly contained by sewers, although they might only have a pit latrine at home. The HHs connected to simplified sewers are too small to have an impact on the SFD Matrix (less than 100 HHs (CCI, 2015) – less than 0.001% of total HHs).

During interviews with DAWASCO (2015d) and DAWASA (2015a), the utility officials report that there is a sewer coverage of 10 to 15%. Some refer to area, some to population. Also, many other interviewees talk about an estimation of around 10% sewer coverage in Dar es Salaam. However, after discussions with DAWASCO officials and detailed analysis of some of their internal records, the conclusion has been drawn that the sewer coverage of 10 to 15% refers to the percentage of their customers being connected to piped water networks. The utilities estimate that 80% of clean water consumed by its customers ends up as WW, and this is the basis for their sewerage charges (DAWASCO, 2015d).

Based on interviews, survey reports and national census data (NBS, 2014, NBS, 2015), it is estimated that 1% of the population practise OD in Dar es Salaam.As official survey reports are probably an underestimation (HHs may not want to admit to practice illegal OD), more weight than usual is given to interview statements. Analysis of literature and of the interview statements led to the following quantitative estimations for the containment systems in Dar es Salaam:

Table 11: General estimations on containment in Dar es Salaam.

Own Variable	Dar es Salaam Description	Percentage
W3	decentralised sewers	6%
W15	flush toilets to open drain / water body	3%
F2(e), F2(n), F10(e) or F10(n)	Septic Tanks	15%
F2(e), F2(n), F10(e) or F10(n)	Pit latrines	75%
OD9	Open Defecation	1%
	Total containment	*100.0%*

F2(e), F2(n), F10(e) or F10(n) was created to differentiate between systems that can be emptied versus those that cannot, which leads to the following possible containment variables:

1. W3 = WW contained decentralised (offsite)
2. W15 = WW not contained (offsite)
3. OD9 = Open Defecation
4. F2(e) = FS contained, emptying possible
5. F2(n) = FS contained, emptying not applicable
6. F10(e) = FS not contained, emptying possible
7. F10(n) = FS not contained, emptying not applicable

The creation of these “own variables” was a result of the limited amount of sanitation facilities that could be created in the SFD Excel calculation tool. It is limited to ten systems, but, in Dar es Salaam, more than ten systems can be found (see appendix 7.9).

A more detailed analysis was made for the categories F2 and F10 to differentiate between F2(e), F2(n), F10(e) or F10(n) in the different situations low versus significant GW risk, and for properly versus not properly constructed/functioning facilities.

Septic Tanks

During FGDs and interviews, it was noted that more than half of the septic tanks are not properly partitioned and more than 50% are not fully watertight. As no exact number is known, it is estimated that at least 60% of the septic tanks in Dar es Salaam are not properly constructed (a combination of not being properly partitioned and not watertight). The differentiation between a septic tank and a sewer versus a soakpit or an open drain/water body was estimated during the NGOs FGD (2015). The below table depicts the resulting final estimations for septic tanks, whereas 100% is the number of septic tanks (STs) in the city.

Table 12: Estimations on the septic tank systems in Dar es Salaam.

F2(e) STs	ST to sewer properly constructed (low or significant GW risk) → contained	3.20%
F10(e) STs	ST to sewer not properly constructed (low or significant GW risk) → not contained	4.80%
F2(e) STs	ST to soakpit in low risk GW area, properly constructed → contained	15.40%
F10(e) STs	ST to soakpit in low risk GW area, not properly constructed → not contained	23.10%
F10(e) STs	ST to soakpit in high risk GW area (proper and not proper) → not contained	38.50%
F10(e) STs	ST to open drain/water body (proper and not proper, both GW risk types) → not contained	15.00%

To summarize, the septic tanks lead to the following numbers for the calculation tool:

Table 13: Summary of contained versus not contained septic tanks.

	100% Septic Tanks	Of overall containment
F2(e) STs	18.60%	2.8%
F10(e) STs	81.40%	12.2%

As the calculation tool only allows ten containment systems, the septic tanks were combined as presented above. This leads to the fact that not all systems are properly represented in the final calculation. As septic tank to soak pit is the dominant type, this system is used in the calculation tool, which excludes material flow from the septic tank to the sewer or open drain.

Pit latrines

For pit latrines the estimations were more challenging, as a lot of different systems exist in the city. Due to time constraints and the SFD project decision to limit the number of possible containment systems to ten, many systems were combined. Through literature and field-based research, the following pit latrine types were identified for Dar es Salaam:

Table 14: Types of pit latrine systems in Dar es Salaam.

1	*User interface to soak pit*	*T1A1C5*	*low*	*Pour flush to offset pits*	*F2(e) PLs*
2		*T2A1C5*	*significant*		*F10(e) PLs*
3	Lined pit with semi-permeable walls and open bottom, no overflow	T1A5C10	low	Lined pit with semi-permeable walls and open bottom	F2(e) PLs
4		T2A5C10	significant		F10(e) PLs
5	lined tank with impermeable walls and open bottom, no overflow	T1A4C10	low	lined tank with impermeable walls and open bottom, no overflow	F2(e) PLs
6		T2A4C10	significant		F10(e) PLs
7	lined tank with impermeable walls and open bottom, to open drain/water body	T1B10C6 & T1B10C7-10	N/A	pits with pipes letting FS discharge to open drain / water body	F10(e) PLs
8	Unlined pit, no overflow	T1A6C10	low	unlined pit	F2(e) PLs
9	Unlined pit, no overflow	T2A6C10	significant	unlined pit	F10(e) PLs
10	*Pit (all types), never emptied but abandoned when full and covered with soil*	*T1B7C10*	*low*	*Pit never emptied but abandoned when full and covered with soil*	*F2(n) PLs*
11		*T2B7C10*	*significant*		*F10(n) PLs*
12	*Pit (all types), never emptied but abandoned when full & not adequately covered with soil*	*T1B8C10*	*N/A*	*Pit never emptied but abandoned when full & not adequately covered with soil*	*F10(n) PLs*
13	fully lined tank (sealed), no outlet or overflow	T1A3C10	significant	fully lined tank	F2(e) PLs
14	Containment failed, damaged, collapsed or flooded - no overflow	T1B1C10	significant	fully lined tank, not watertight	F10(e) PLs

15	*fully lined tank (sealed), no outlet or overflow*	*T1A3C10*	*significant*	*EcoSan in high WT areas*	*F10(e) PLs*
16	*Containment failed, damaged, collapsed or flooded - no overflow*	*T1B1C10*	*N/A*	*flooded pits*	*F10(n) PLs*
17	*User interface failed, damaged, collapsed or flooded*	*T1B9C1-10*	*N/A*	*user interface failed, damaged, collapsed, flooded*	*F10(n) PLs*

Although abandoned pits and broken user interfaces exist in Dar es Salaam, they were not included in the calculations for the SFD matrix. If they were included, it would lead to a double counting of inhabitants. Some inhabitants reported abandoning their last containment system, but, at the moment, are using a new one for defecation. The same applies to broken user interfaces and collapsed containment systems. With a collapsed system, the user would revert to a neighbour's or a new facility. With a broken user interface, the facility might still be in use, but could be counted as one of the other options as well. The option "user interface to soak pit", or what is in Dar es Salaam called "pour flush to offset pit", is allocated to the other types of facilities. Last but not least, composting toilets, or EcoSan type sanitation facilities, are used by too few HHs in Dar es Salaam to have an impact on the final look of the SFD and, therefore, were left out of the calculations. Comparing this and the table for the septic tanks, one can observe that the variables F2(n) and F10(n) are not used any more. Of the sources that differentiate between different types of lining (NGOs FGD, 2015, EHOs FGD, 2015, Jenkins et al., 2014b), a differentiation was made between semi-permeable or impermeable walls only during the NGOs FGD. This led to the decision to combine the systems T1A5C10 and T1A4C10, as well as T2A5C10 and T2A4C10. Thus, the table used for calculations looks as follows:

Table 15: Grouping of pit latrine systems.

1	T1A5C10 & T1A4C10	(partially) lined pit with open bottom, low GW risk	F2(e) PLs	low
2	T2A5C10 & T2A4C10	(partially) lined pit with open bottom, significant GW risk	F10(e) PLs	significant
3	T1B10C6 & T1B10C7-10	lined tank with impermeable walls and open bottom, to open drain/water body (pits with pipes letting FS discharge to open drain / water body	F10(e) PLs	N/A
4	T1A6C10	Unlined pit, no overflow, low GW risk	F2(e) PLs	low
5	T2A6C10	Unlined pit, no overflow, high GW risk	F10(e) PLs	significant
6	T1A3C10	fully lined tank (sealed), no outlet or overflow (fully lined tank)	F2(e) PLs	significant
7	T1B1C10	Containment failed, damaged, collapsed or flooded - no overflow (fully lined tank not watertight)	F10(e) PLs	significant

The only estimation on the pits with pipes letting FS discharge to an open drain/water body was given during the FGD with EHOs. The figure of 24.8% pits with pipes letting FS discharge to open drain/water body as reported by EHOs is considered to be too high. Some respondents may have thought about pits where the emptying is executed with a waste pipe when answering this question. Nevertheless, it is believed that this system exists in the city, because people did mention it. Also, BTC and BORDA mentioned this system during the KIIs (BTC, 2015, BORDA, 2015). Therefore, the number is readjusted down to 15%.

Generally, it is estimated that 50% of Dar es Salaam's inhabitants use pit latrines in areas with significant groundwater contamination risks. However, unlined pits were reported to be built only in low water table areas as otherwise they would collapse. Therefore, it is estimated that 80% of the unlined pit latrines are built in areas with low GW contamination risks. Fully lined pits/tanks were reported to be built only in high water table areas because people would prefer to build semi-lined pit latrines where possible to save on construction and emptying costs. Of the fully lined pits/tanks, it is estimated that 60% are not watertight (EEPCO, 2015, NGOs FGD, 2015).

Combining the three estimations from the NGOs FGD (2015), EHOs FGD (2015) and Jenkins et al. (2014b), the following systems are differentiated for the SFD calculations:

Table 16: Estimations for the pit latrine systems.

1	PLs F2(e) 1	(partially) lined pit with open bottom, low GW risk	T1A5C10 & T1A4C10	23.45%
2	PLs F2(e) 2	Unlined pit, no overflow, in low GW risk areas	T1A6C10	22.56%
3	PLs F2(e) 3	fully lined tank (sealed), no outlet or overflow (fully lined tank)	T1A3C10	3.96%
4	PLs F10(e) 1	lined tank with impermeable walls and open bottom, to open drain/water body (pits with pipes letting FS discharge to open drain / water body	T1B10C6 & T1B10C7-10	15.00%
5	PLs F10(e) 2	(partially) lined pit with open bottom, significant GW risk & Containment failed, damaged, collapsed or flooded - no overflow (fully lined tank not watertight) & unlined pits in significant GW risk areas	T2A5C10 & T2A4C10 & T1B1C10 & T2A6C10	35.03%

Combining the estimations for the offsite and onsite sanitation facilities, the following table summarizes the obtained information:

Table 17: Estimations for the sanitation technologies in Dar es Salaam.

System Number	Own Variable	Percentage	Description
1	W3	6.0%	decentralized sewers
2	W15	3.0%	flush toilets to open drain / water body
3	F2(e) STs	2.8%	Septic Tanks which are considered contained
4	F10(e) STs	12.2%	Septic Tanks which are considered not contained
5	PLs F2(e) 1	17.6%	Pit latrines which are considered contained: (partially) lined pit with open bottom, low GW risk
6	PLs F2(e) 2	16.9%	Pit latrines which are considered contained: unlined pit, no overflow, in low GW risk areas
7	PLs F2(e) 3	3.0%	Pit latrines which are considered contained: fully

			lined tank (sealed), no outlet or overflow (fully lined tank)
8	PLs F10(e) 1	11.3%	Pit latrines which are considered not contained: fully lined tank (sealed), to open drain/water body (pits with pipes letting FS discharge to open drain / water body
9	PLs F10(e) 2	26.3%	Pit latrines which are considered not contained, including (partially) lined pit with open bottom, significant GW risk & Containment failed, damaged, collapsed or flooded - no overflow (fully lined tank not watertight) & unlined pits in significant GW risk areas
10	OD	1.0%	Open Defecation

In the calculation tool, the above table looks as follows:

Table 18: Sanitation Containment Systems of Dar es Salaam as in the SFD calculation tool.

Summary of Sanitation Containment Systems						
	Question A	Question B	Question C	Question D		
Questions	Where does the user interface discharge to? (i.e. what type of container, if any?).	Where the user interface and/or container is abandoned, failed, damaged, collapsed, not working or open defecation is practised, select which option applies?	What is the containment (or user interface if no containment) connected to? (i.e. where does the outlet or overflow discharge to?)	What is the risk of pollution of groundwater? Determine risk using 'Tab 3-Question D'.	Containment and Emptying Outcome	Tab 1 ref
Answers for system 1	No onsite container, user interface discharges directly to destination given in question C	Not applicable-question A applies	to centralised foul/separate sewer	Significant risk	Contained, emptying not applicable	T1A1C2
Answers for system 2	No onsite container, user interface discharges directly to destination given in question C	Not applicable-question A applies	to open drain or storm sewer	Low risk	Not contained, emptying not applicable	T1A1C6
Answers for system 3	Septic tank	Not applicable-question A applies	to soakpit	Low risk	Contained, emptying possible	T1A2C5
Answers for system 4	Septic tank	Not applicable-question A applies	to soakpit	Significant risk	Not contained, emptying possible	T2A2C5
Answers for system 5	Lined pit with semi-permeable walls and open bottom	Not applicable-question A applies	no outlet or overflow	Low risk	Contained, emptying possible	T1A5C10
Answers for system 6	Unlined pit	Not applicable-question A applies	no outlet or overflow	Low risk	Contained, emptying possible	T1A6C10
Answers for system 7	Fully lined tank (sealed)	Not applicable-question A applies	no outlet or overflow	Significant risk	Contained, emptying possible	T1A3C10
Answers for system 8	Fully lined tank (sealed)	Not applicable-question A applies	to open drain or storm sewer	Low risk	Not contained, emptying possible	T1A3C6
Answers for system 9	Lined pit with semi-permeable walls and open bottom	Not applicable-question A applies	no outlet or overflow	Significant risk	Not contained, emptying possible	T2A5C10
Answers for system 10	Not applicable-question B applies	Open defecation	to open ground	Low risk	Not contained, emptying not applicable	T1B11 C7 TO C9

Table 19: Estimations on the sanitation containment systems as in the SFD calculation tool.

T1A1C2	User interface discharges directly to a centralised foul/separate sewer	Reference L1	6%
T1A1C6	User interface discharges directly to open drain or storm sewer	Reference L4	3%
T1A2C5	Septic tank connected to soak pit	Reference L7	3%
T2A2C5	Septic tank connected to soak pit, where there is a 'significant risk' of groundwater pollution	Reference S2	12%
T1A3C6	Fully lined tank (sealed) connected to an open drain or storm sewer	Reference L8	11%
T1A3C10	Fully lined tank (sealed), no outlet or overflow	Reference L10	3%
T1A5C10	Lined pit with semi-permeable walls and open bottom, no outlet or overflow	Reference L11	18%
T2A5C10	Lined pit with semi-permeable walls and open bottom, no outlet or overflow, where there is a 'significant risk' of groundwater pollution	Reference S4	26%
T1A6C10	Unlined pit, no outlet or overflow	Reference L11	17%
T1B11 C7 TO C9	Open defecation	Reference L20	1%

As mentioned before, some systems were combined because the calculation tool only allows answers for a maximum of 10 systems. Thus, the descriptions in the above table are meant to be representative for more than one system. This makes the SFD less representative and accurate than it could be. For example, for system 3 “septic tank to soakpit in low GW pollution risk”, septic tanks to open drains and sewers are included. However, this is not shown in the matrix. The description “to soakpit” is chosen for the calculation tool because it is the dominating septic tank system. The definition “fully lined tank (sealed) connected to an open drain or storm sewer” does not accurately describe the containment system “pit to open drain or water body” that exists in Dar es Salaam. However, the SFD methodology does not provide an accurate description; therefore, the decision was made to include it in this typology. The proportion of each fully lined tank (sealed) which is FS (not effluent, supernatant or infiltrate) is set to 100% so that FS flows are not transferred from the onsite sanitation emptying stream F3b or F15 to the offsite sanitation stream W11c. A further issue is that there are pits that connect to open drains, and others to rivers. Thus, due to this combination, the difference is not displayed.

In the SFD matrix, the following containment variables are displayed:

Table 20: Containment variables with percentages.

Variable	Percentage	Description
W3	6.0%	WW contained decentralised (offsite)
W15	3.0%	WW not contained (offsite)
F2	40.3%	FS contained (onsite)
F10	49.7%	FS not contained (onsite)
OD9	1.0%	Open Defecation

7.10.2 Emptying & Transport

Based on the variables F2(e), F2(n), F10(e) or F10(n), a further breakdown for the emptying analysis was created:

Table 21: Emptying variables with description.

Variable	Explanation	Dar es Salaam context
W4b	WW contained delivered to decentralized treatment plants	going to WSPs
W11b	WW contained not delivered to decentralized treatment plants	sea outfall, leakage/overflow
W11c	WW not contained and not delivered to treatment	WW flowing directly to open drains or rivers
F8	FS contained not emptied	=*F2(n)* + F2(e) not emptied
F3a	FS contained, emptied	=F2(e) emptied
F3b	FS not contained, emptied	=F10(e) emptied
F15	FS not contained, not emptied	=*F10(n)*+F10(e) not emptied
OD9	OD9	OD

As mentioned during the containment analysis, abandoned pits and failed user interfaces are not considered in the containment calculations. Thus, F2(n) and F10(n) are zero. Abandonment of systems is in surveys often counted as an emptying method, as new pits are constructed. However, in these calculations, abandonment of pits is counted as “never emptied” and goes into the streams F8 (FS contained, not emptied) or F15 (FS not contained, not emptied).

Table 22: Emptying variables with main sources.

Variable	Explanation	Main source
W4b	going to WSPs → fraction of W3	AAW et al 2008, referred to by DAWASCO 2015
W11b	sea outfall, leakage/overflow → fraction of W3	AAW et al 2008, referred to by DAWASCO 2015
W11c	WW flowing directly to open drains or rivers	See containment = W 15
F(2e+10e) not emptied	includes: never emptied pits + tanks	surveys: percentage never emptied
F(2e+10e) emptied	includes: frogmen, vacuum trucks, flooding out	surveys, EHO FGD

Emptying of offsite sanitation systems

For the variables W4b, W11b and W11c, the estimations are simple. W11c equals W15 from the containment estimations (WW from flush toilets directly disposed in open drains or water bodies). The amount of WW delivered to treatment versus WW disposed through the sea outfall (fractions of W3) is estimated from the data in the Strategic Sanitation Plan by AAW et al. (2008). When DAWASCO officials were questioned about the amount of WW disposed at the different ponds versus the sea outfall, they referred to this report. Average inflow estimations are presented in this report; however, it remains unclear how these estimations were calculated, and the report is seven years old. Average inflow estimations show that at least 26% of the total WW is disposed through the sea outfall directly into the Indian Ocean without any treatment. Trémolet and Binder (2013) report that from interviews with DAWASA officials, they estimate that 70% of all WW is disposed through the sea outfall. However, as no further background information on this estimation is given, the estimation for W11c is based on the inflow estimations from AAW et al. (2008) and set at 30%: This includes the fact that frequent blockages and overflows occur in the city [on average 6 sewer blockages per day (leading to WW overflow) during the FY 2013/14 (EWURA, 2014b)]. Therefore, the emptying and transport situation looks as follows:

Table 23: Estimations on emptying and transport.

Variable	Explanation	Percentage
W4b	going to WSPs	4.2%
W11b	sea outfall, leakage/overflow	1.8%
W11c	WW flowing through open drains / rivers	3.0%
F(2e+10e) not emptied	includes: never emptied pits + tanks	Yet to be estimated
F(2e+10e) emptied	includes: frogmen, vacuum tanks, flooding out etc	Yet to be estimated
OD	Open Defecation	1.0%

Emptying of onsite sanitation systems

The challenge of estimating the frequency of use of the different onsite sanitation emptying methods is that only “F(2e+10e) not emptied” and “F(2e+10e) emptied” are known, but not the individual contributions from the different systems. Excreta in the stream “F(2+10e) not emptied” includes the FS of systems which have never been emptied, or never been emptied in the last ten years. Jenkins et al. (2014b) state that 64% of the survey respondents (in informal settlements) reported that they never emptied their systems. Comparing this value to statements by Mkanga and Ndezi (2014), the EHOs FGD (2015) and an unpublished survey by BORDA (BORDA, 2015), it is estimated that 50% of the onsite sanitation systems are not emptied.

Furthermore, it is assumed that all FS emptied by vacuum trucks or the gulper technology is delivered to treatment sites and all other methods lead to FS being dumped in open drains, water bodies or other parts of the city’s environment. Taking this as a basis, the different sources report the following:

Table 24: Estimations from different sources on transport of FS.

	EHOs FGD 2015	Trémolet & Binder 2013	BORDA 2014 unpublished survey	Mwalwega 2010	Jenkins et al 2014	Mkanga&Ndezi 2014
	FGD with 7 ward EHOs of Kinondoni	citing Bereziat (2009) and DAWASA (2008)	middle income wards Mzimuni and Mlalakua in Kinondoni	study with 379 HHs (95 per ward) in squatter areas in 4 wards in Temeke	662 residential properties across 35 unplanned, low-income sub-wards	survey with 1180 people in informal settlements of 6 wards over all 3 MCs
FS delivered to treatment	45.0%	44.5%	86%	27.8%	18.0%	36.2%
FS not delivered to treatment	55.0%	55.5%	14%	72.2%	83.0%	63.8%

The above table is summarized and compared as follows:

Table 25: Summary and comparison of information from Table 24.

	informal settlements (Mwalwega, Jenkins et al, Mkanga & Ndezi)	middle/high income (BORDA)	whole Dar es Salaam from sources (EHOs, Trémolet & Binder)	whole Dar es Salaam calculated from informal * 0.7 + middle * 0.3
FS delivered to treatment	27%	86%	45%	45%
FS not delivered to treatment	73%	14%	55%	55%

The calculation for all of Dar es Salaam is based on the information that at least 70% of Dar es Salaam's inhabitants live in informal settlements. As expected, it can be observed that in the unplanned areas the predominant emptying methods used do not deliver FS to treatment plants, whereas in middle/high-income areas, onsite sanitation facilities are emptied mainly by vacuum trucks. For all of Dar es Salaam, the sources agree that 45% of FS emptying is executed by vacuum trucks which deliver the FS to the treatment site. The remaining 55% of FS is emptied by frogmen, waste drain pipes or other emptying methods which lead to FS being dumped in the environment.

Unlined pit latrines cannot be emptied by vacuum trucks as the pressure from the vacuum pump together with the unstable soil conditions often leads to the collapse of the pits. Furthermore, it is known that emptying is especially practiced in high WT areas because there the systems are regularly flooded during the rainy season. As unlined pits are rarely built in high WT areas, this confirms what was mentioned before (NGOs FGD, 2015, EHOs FGD, 2015, Manual emptying & motorized transport service providers, 2015). Trémolet and Binder (2013) estimate as well, that less than one third of the pit latrines, but more than two thirds of the septic tanks, are emptied by vacuum trucks and that vacuum truck drivers report that three fourths of the emptied systems are septic tanks. Therefore, it is estimated that 80% of the septic tanks that are emptied, are emptied by vacuum trucks. Thus, the remaining percentage of "emptied by vacuum truck" is the (partially) lined pit latrines.

The below table displays the estimations made for the emptying and transport of FS from onsite sanitation technologies (based on interviews):

Table 26: Estimations on emptying of onsite sanitation technologies

		Comment on emptying	% of all containment	ESTIMATION: How many emptied?	CALCULATION: Of the OSS systems, how many are emptied?	ESTIMATION: How much delivered to treatment?	CALCULATION: Of the OSS systems, how much is delivered to treatment?
T1A2C5	Septic tank connected to soak pit	STs emptied less often than PLs, but with trucks	2.8%	70.0%	2.18%	80.0%	2.0%
T2A2C5	Septic tank connected to soak pit, where there is a 'significant risk' of groundwater pollution	STs emptied less often than PLs, but with trucks	12.2%	75.0%	10.17%	80.0%	9.2%
T1A3C6	Fully lined tank (sealed) connected to an open drain or storm sewer	emptying method is the pipe to open drain/water body	11.3%	100.0%	12.56%	0.0%	0.0%
T1A3C10	Fully lined tank (sealed), no outlet or overflow	emptied regularly	3.0%	50.0%	1.67%	55.0%	0.8%
T1A5C10	Lined pit with semi-permeable walls and open bottom, no outlet or overflow	probably less emptied than T2A5C10, cos FS drains away	17.6%	15.0%	2.93%	55.0%	1.5%
T2A5C10	Lined pit with semi-permeable walls and open bottom, no outlet or overflow, where there is a 'significant risk' of groundwater pollution	often emptied, partially delivered to treatment sites	26.3%	65.0%	18.99%	55.0%	9.5%
T1A6C10	Unlined pit, no outlet or overflow	probably rarely emptied, cos FS drains away	16.9%	10.0%	1.88%	0.0%	0.0%
				Total emptying should be 50%:	50.4%	should be 45% of all emptied (22.7%)	22.9%

7.10.3 Treatment

Nine WSPs exist in Dar es Salaam to treat WW. Two of them (Vingunguti and Kurasini) also receive FS from emptying and transport service providers. For five of the ponds, influent and effluent parameters analysed by DAWASCO were obtained during field research (DAWASCO, 2007, DAWASCO, 2010a, DAWASCO, 2010b, DAWASCO, 2014b). The analysis shows that total solids content, BOD and COD are partially reduced to up to more than 50%. However, most of the values still do not reach the permissible limits set by the TBS (2005). Therefore, the amount of WW and FS treated is estimated at a maximum of 50%, although it can be assumed that the FS treatment efficiency is lower because the ponds were not designed for FS treatment. This can also be observed from the parameters at Vingunguti and Kurasini, the parameters of which are generally higher than at the other ponds.

As a significant amount of WW is not delivered to treatment plants, but is directly disposed through the sea outfall, the overall number of treated WW (W5b) is 2.1%.

The small DEWATS at the HH and institutional level could not be assessed concerning their functionality. However, the material flow from these systems is negligible in the sense that the volumes are too small to have an effect on the overall appearance of the SFD. The DEWATS managed by the UMAWA in Kigamboni is estimated to be principally functioning (Manual emptying & motorized transport service providers, 2015, BORDA, 2015).

Some of the TBS (2005) standards set, are:

Table 27: TBS (2005) effluent standards.

Parameter	TBS Permissible Limit
pH	6.5-8.5
Color (tcu)	300
Total solids (mg/l)	100
BOD (mg/l)	30
COD (mg/l)	60

7.11 Appendix 11: Sewer network, Waste Stabilization Ponds etc.

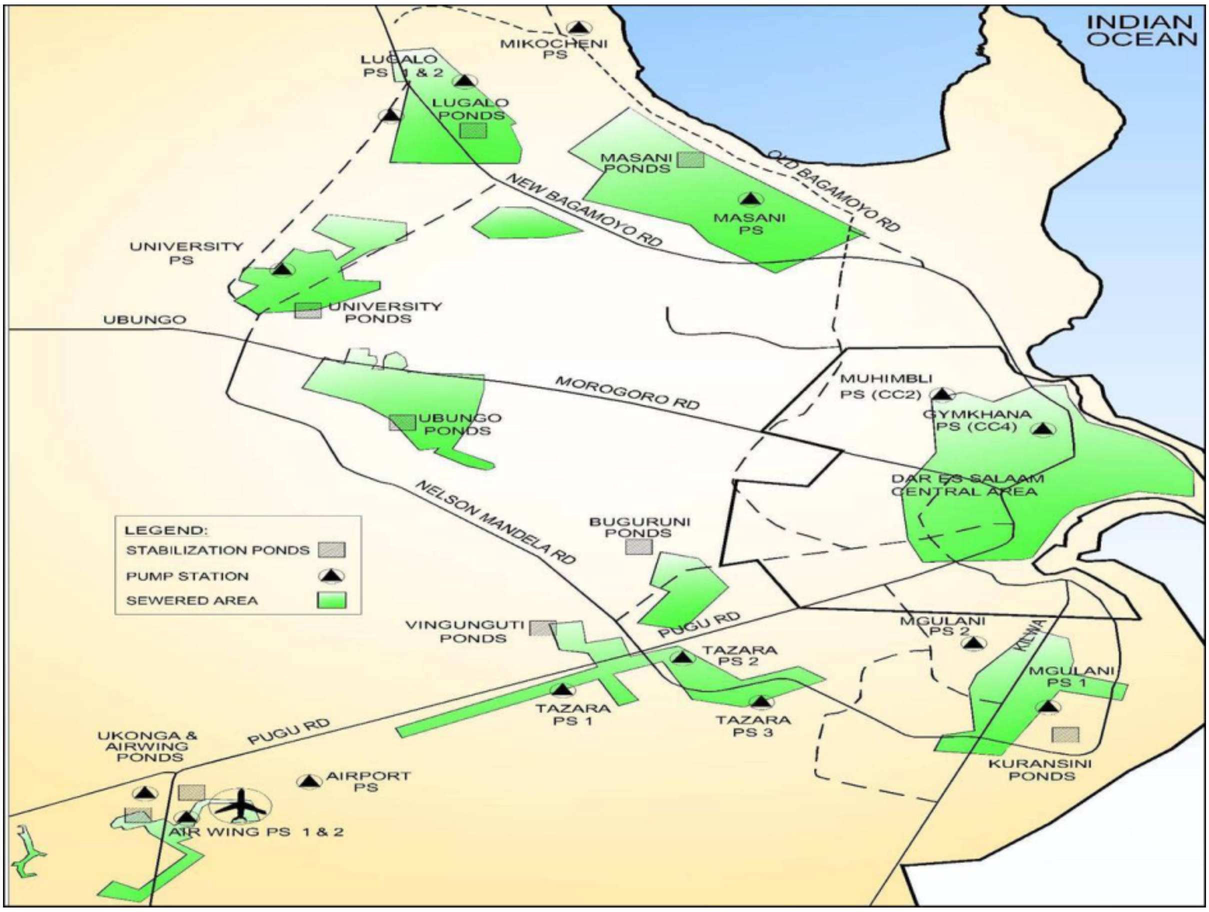


Figure 17: Sewer network, WSPs and pumping stations in Dar es Salaam (Mkumba, 2013).

7.12 Appendix 12: Further Information from DAWASCO

7.12.1 Procedure for FS Disposal at DAWASCO's WSPs

For a FS emptying and transport service provider to be allowed to dispose FS at DAWASCO's WSP, they have to be registered atDAWASCO. There, the truck driver has to sign the vacuum truck rules, see the copy below:

26th October 2013

REF: Rules of disposing wastewater from vacuum trucks at the ponds

Refer to the heading above.

It have been identified that most of the drivers for wastewater vacuum tracks do not follow the procedures for disposing wastewater at dawasco ponds.

So punishment will be taken to those that won't obey to our regulations that they are told to our pond supervisors

The following regulations should be followed

1. All the cars will be served by a system of queuing.
2. All the pipes for sucking wastewater should not have leakages so that to avoid spillages to the environment.
3. All the trucks should dispose wastewater to appropriate place constructed for this purpose.
4. The service time at the pond is between 12:00am to 12:00pm *[translator's comment: 6am – 6pm English time]*
5. The payment mode is pre-paid and all the trips made should be recorded by the dawasco officer at the site.

Whoever won't obey to our rules and regulations will cause the trucks being restricted from our ponds and removed from our registry, and hence the truck owner will lose the service of Dawasco.

We are thankful for your cooperation to make this sector sustainable.

Mathias Mulagwanda

On behalf of the chief executive officer

Name of driver: Signature of Driver

Figure 18: Rules for disposing FS from vacuum trucks at the ponds (obtained during KII with DAWASCO (2015d), translated by Nuhu Moto).

7.13 Appendix 13: Working Groups under the S&H MoU

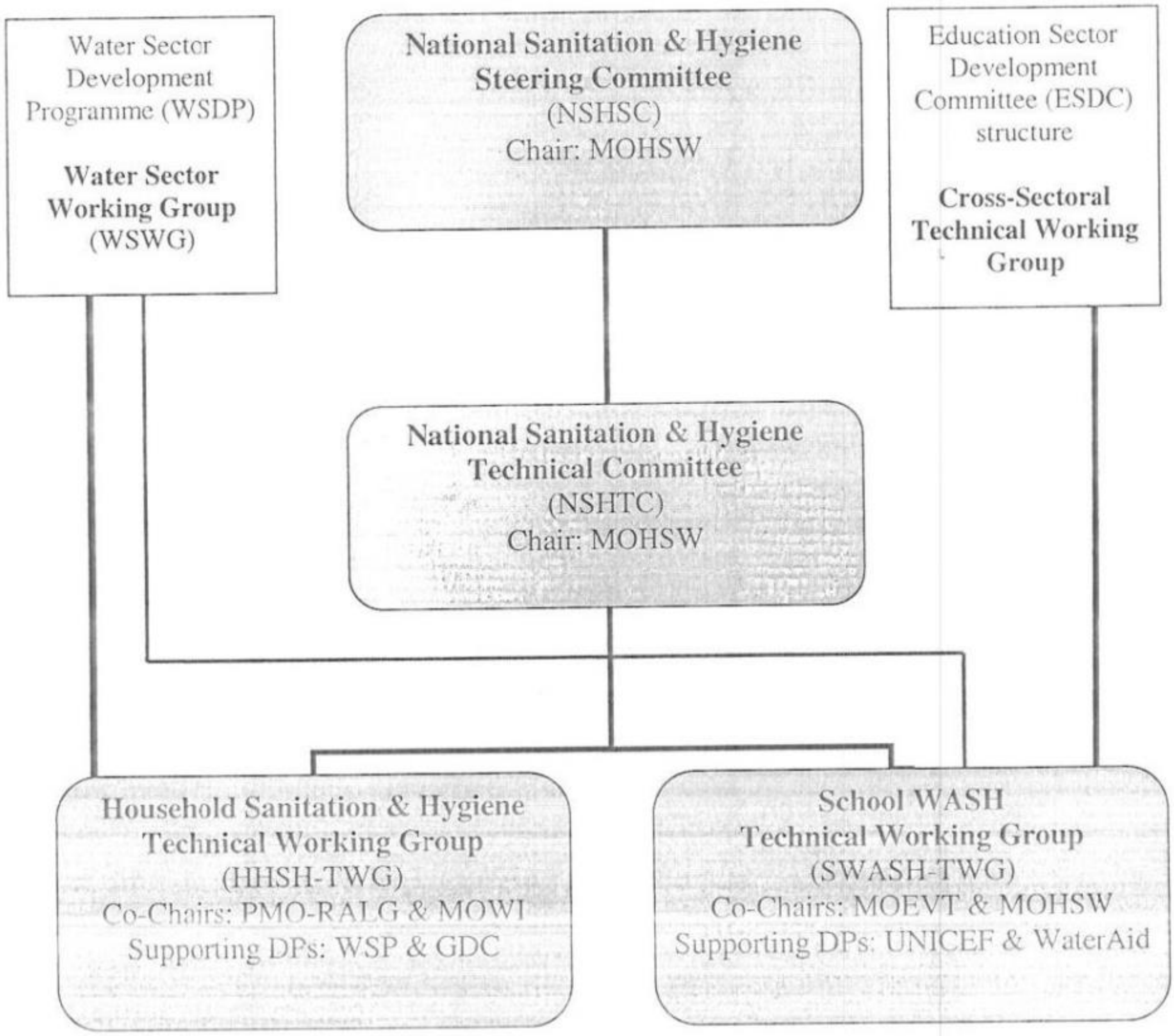


Figure 19: Working groups established under the Memorandum of Understanding (S&H MoU, 2009).

7.14 Appendix 14: Stakeholders organization charts

7.14.1 MoHSW organization chart

Available at:

http://www.moh.go.tz/index.php/about-us/organizational-structure (accessed 28th July 2015)

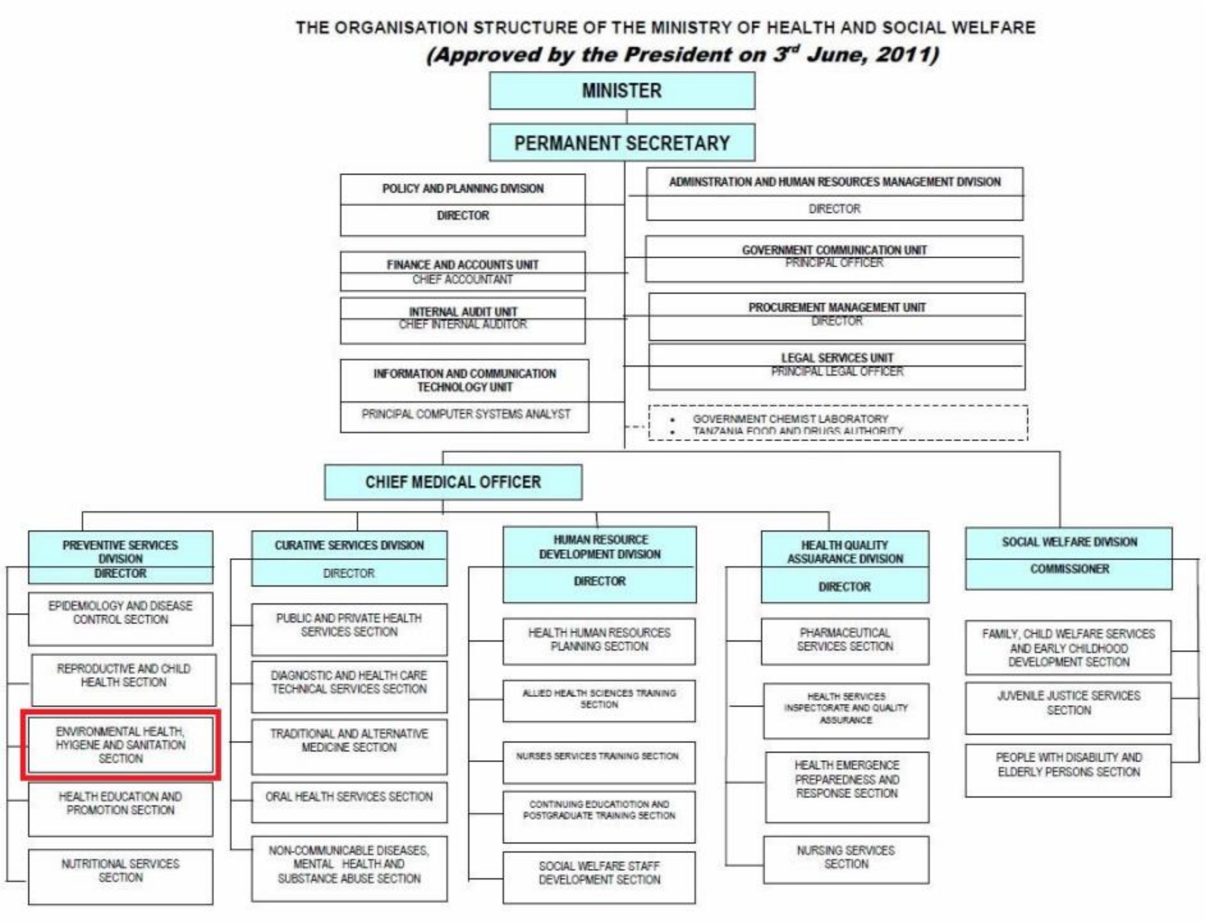


Figure 20: Organizational Chart of the MoHSW.

Marked in red: The sub-directorate for environmental health, hygiene and sanitation

7.14.2 DAWASCO organization chart

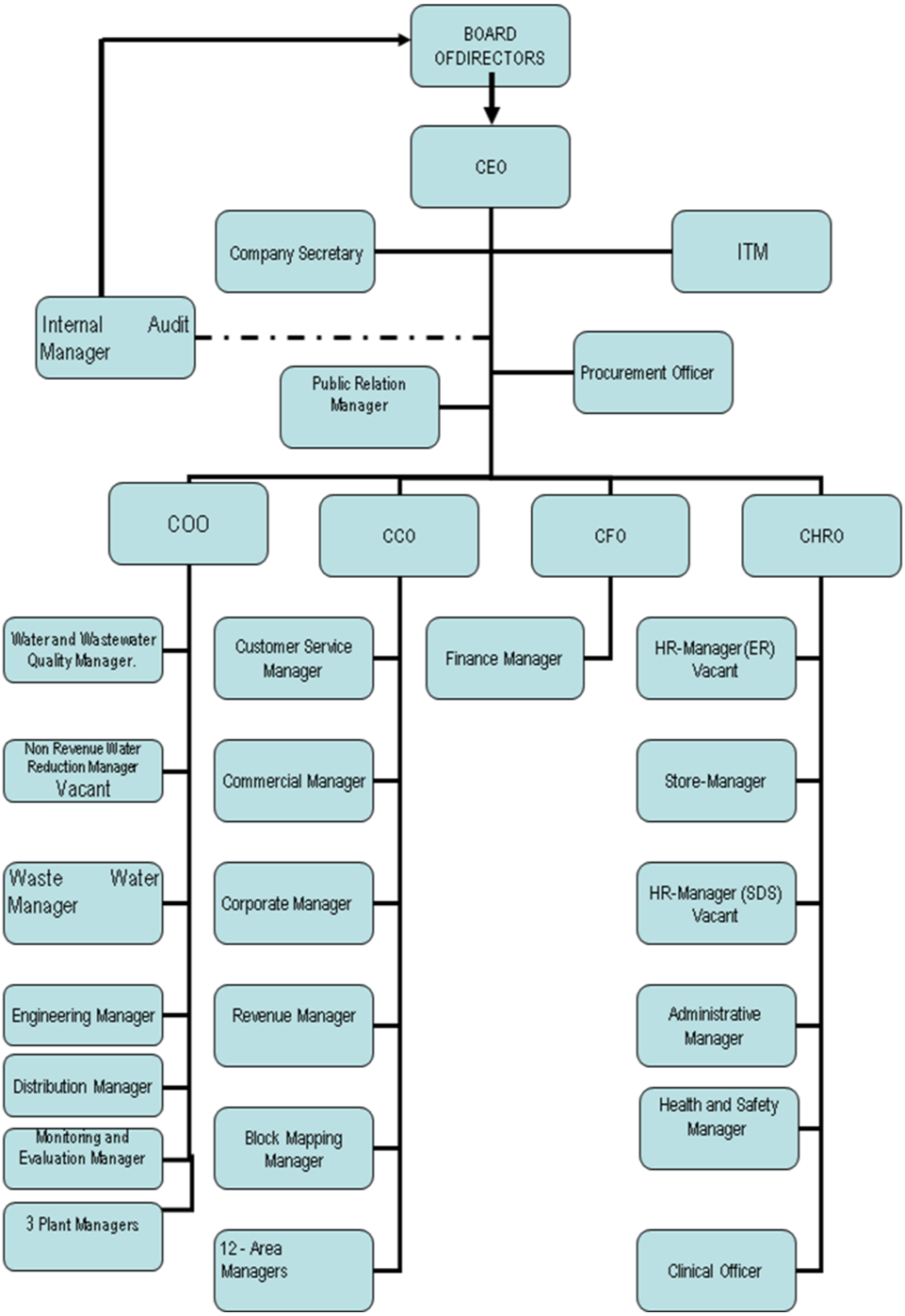


Figure 21: DAWASCO Organizational Chart (DAWASCO, 2013b).

CEO: signed our introduction letter

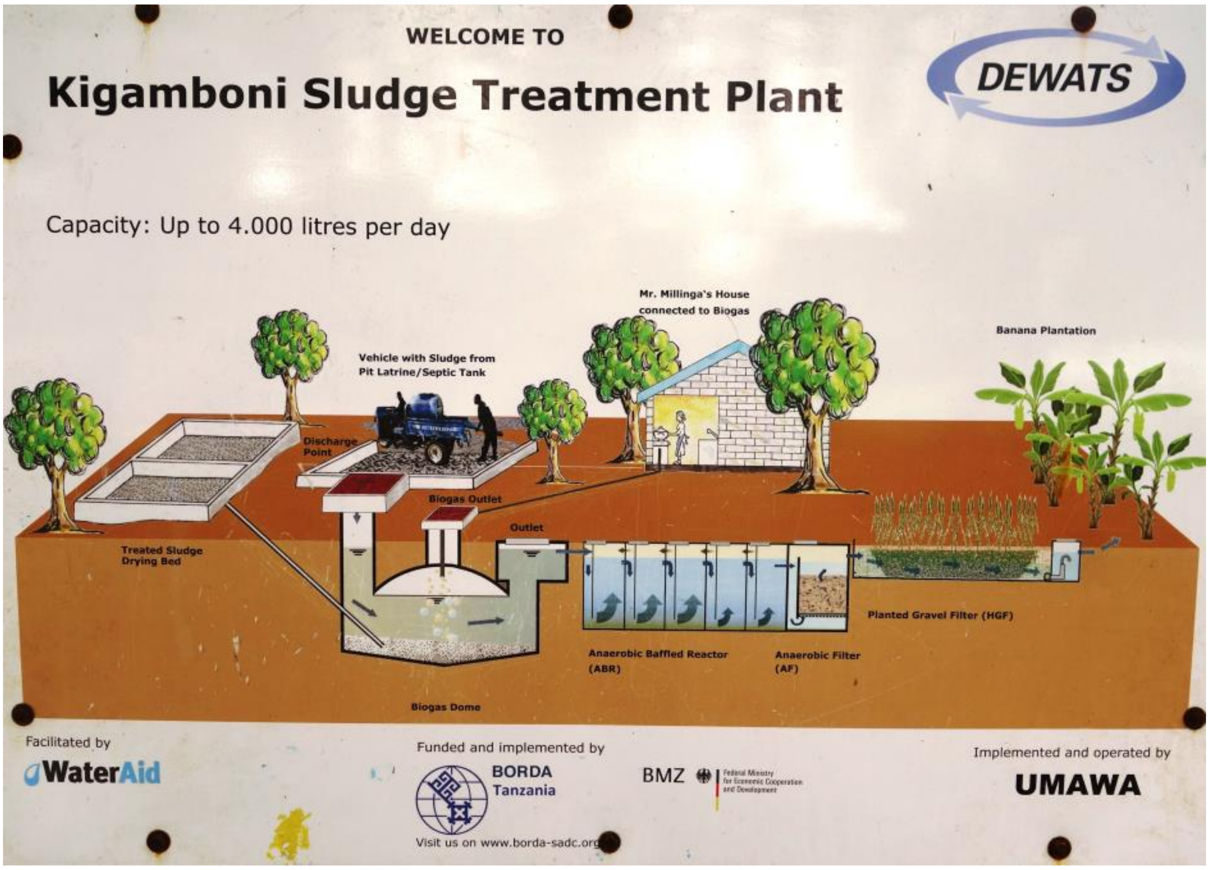
We met:

- COO, CCO

- Water and WW Quality Section
- Waste Water Manager
- M&E Manager
- 1 Worker for the Plant Manager
- Commercial Manager
- Revenue Manager

7.15 Appendix 15: Selected pictures taken during observation

7.15.1 Field Trip to Kigamboni DEWATS & pit emptying service by UMAWA



Poster displaying design of the DEWATS. Photo credit: Imanol Zabaleta

Anaerobic baffled reactor. Photo credit: Imanol Zabaleta

Dried sludge. Photo credit: Imanol Zabaleta

Biogas used for cooking. Photo credit: Imanol Zabaleta

Solid waste removal from pit latrine before FS emptying. Photo credit: Imanol Zabaleta

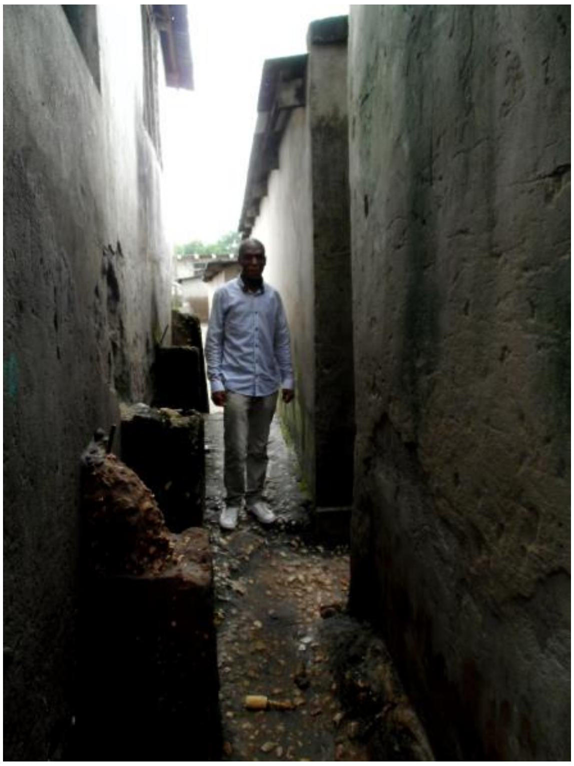
FS emptying with the gulper technology. Photo credit: Moritz Gold

FS transfer to storage tank for transport. Photo credit: Moritz Gold

7.15.2 Tandale poor informal settlement area

Open Drain

Stagnant Water



Path inaccessible to vacuum trucks

Solid Waste in River and Latrine

7.15.3 Buguruni WSP

First pond

V-Notch showing low inflow

Information on Buguruni WSP:

- Three ponds in series
- On one side settlements, on the other side few buildings, industrial area
- Fenced, but open at very few points
- Seemed the WSP with the least solid waste and the lowest influent volume (of the four observed WSPs Buguruni, Mabibo, Vingunguti & UDar es Salaam)

7.15.4 Mabibo WSP

First pond

Information on Mabibo WSP:

- Fenced, but many people and animals walk along the ponds
- Guided by a security person
- Surrounded by settlements, but people have not encroached as near as at the Vingunguti WSP.

7.15.5 University WSP

Information on University WSP:

- High grass around the ponds
- No settlements nearby
- Not been desludged since construction

7.15.6 Vingunguti WSP

WSP overview. Photo credit: Moritz Gold

WW inflow to the pond. Photo credit: Moritz Gold

FS disposal by vacuum trucks. Photo credit: Moritz Gold

Solid waste problem. Photo credit: Moritz Gold.

Woman gardening on dried sludge next to WSPs. Photo credit: Imanol Zabaleta

Information on Vingunguti WSP:

- One of the two ponds where emptying and transport service providers are allowed to dispose FS.
- Settlements have encroached close up.
- High solid waste pollution.
- Looks like the one least functioning of the four WSPs visited.