SFD Report

Mavoko
Kenya

Final Report

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SFD Report Mavoko, Kenya, 2018

Produced by:

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This Executive Summary and SFD Report are available from:

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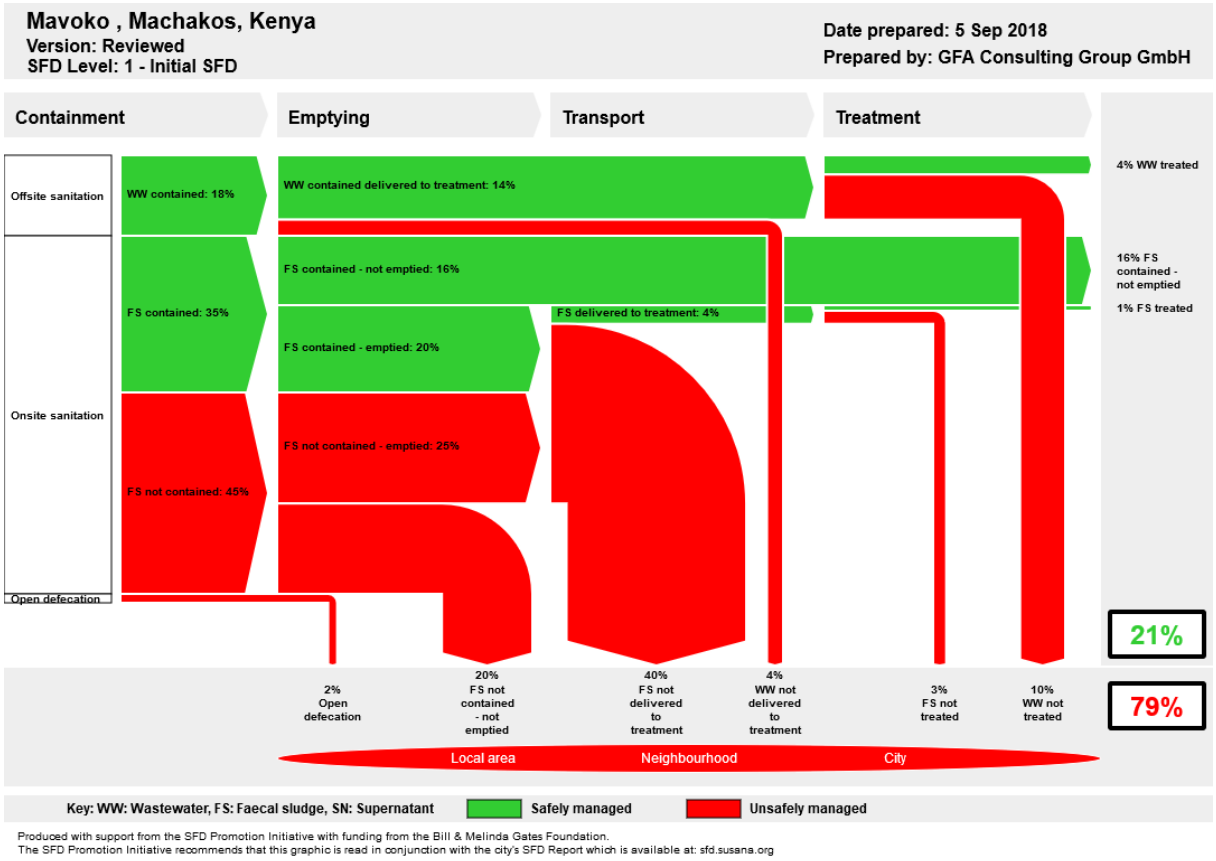
1. The SFD Graphic



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The SFD Promotion Initiative recommends that this graphic is read in conjunction with the city's SFD Report which is available at: sfd.susana.org

2. Diagram information

SFD Level:

This is an Initial level SFD report.

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I would like to thank Mr. Rodney Senga from the Water Sector Trust Fund for his input as well as engagement of relevant stakeholders in Mavoko.

Collaborating partners:

Water Sector Trust Fund (WSTF).

Status:

This is a final SFD report

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3. General city information

Mavoko Town is one of the eight sub-counties of Machakos County in Kenya, which is located around 30km southeast of Nairobi. The whole area of Mavoko covers 963 km^2 including large rural parts. This SFD focuses on the service area of the local Water Service Provider (WSP) named Mavoko Water and Sewerage Company (MAVWASCO). The WSP serves the urban agglomerations of Mavoko, which are organized in four wards, namely Athi River, Kinanie, Muthwani and Syokimau/Mlolongo. Athi River is the most densely populated urban agglomeration and Mavoko has also been known as Athi River town. Due to the close location to Nairobi, its land availability and good transport connections along Mombasa Road, Mavoko is a quickly industrializing and growing area (UN-Habitat 2006). The population in the MAVWASCO service area is estimated to be 244,259 inhabitants and is predicted to double up to 593,182 residents by 2030.

The housing structure is mixed. In 2010, over 30 low-income areas were identified near the industrial areas of Athi River. In addition, the number of middle- and high-income housing compounds is quickly growing especially in Syokimau/Mlolongo.

The climate in the area is semi-arid. There are two rainy seasons per year, one shorter from October to December and a longer one from March to May (Muriithi, 2016). The annual precipitation varies between 300mm and 800mm, while there have been severe draughts in the last years. Despite the upcoming urbanization, parts of Mavoko still rely on agriculture (Mutua, 2017b), in Kinanie Ward.

4. Service outcomes

Mavoko heavily relies on onsite sanitation services. It is estimated that only 18% of the population is served by two main/trunk sewer lines. The main parts of the sewer infrastructure as well as the only treatment plants/ponds located in Mavoko are not owned by the local utility MAVWASCO but by the Export Processing Zones Authority (EPZA). The treatment works are overwhelmed and only roughly 30% of the effluents reaching the ponds get safely treated (Mutua et al. 2017).

The majority of the population (over 70%) relies on onsite sanitation. Septic/holding tanks are mainly used in the upcoming housing developments especially in Syokimau. Residents of this ward, comprising 20% of the population of Mavoko, state that when their tanks are full, these are directly channelled into an open water body (Mutua 2017a).

It is estimated that about 16% of faecal sludge (FS) remains contained onsite, as it is not emptied from pit latrines nor septic/holding tanks. This is because many containers are never fully emptied due to the high costs. Of the FS emptied by vacuum or manual emptying services, only 5% reach the treatment plant. According to a household survey, over 60% of the latrine and septic tanks users state the waste gets pumped "onto the surface ground" (Mutua et al 2017a). Hence, it assumed the FS is not safely managed.

In the less dense areas, simple pit latrines are the main sanitation options. Of a total share of 41% of latrines, only 3% are ventilation improved latrines (VIPs) and 7% pour flush toilets. According to the household survey (Mutua 2017a), about half of the interviewees indicated that their latrine would not need to be emptied or they would not know how it would be emptied. Hence, it is assumed that mostly illegal manual pit emptying services are practiced which dispose the FS in the environment.

For the transforming yet rural areas of Mavoko, it is assumed that 19% of the pits are abandoned when full, of which 12% are adequately covered with soil and 7% not.

Due to recurrent drought, groundwater is increasingly used for drinking water purposes and new boreholes have been drilled by the local water utility MAVWASCO as well as the county government. The groundwater tables in the Nairobi Basin Area, where Mavoko is located, are generally deeper than 100m due to the volcanic rock layer that covers the area. Hence, the groundwater pollution risk is assumed as rather low.

5. Service delivery context

Article 43 (b) of the 2010 Constitution of Kenya "declares sanitation as a basic human right and guarantees every person to reasonable standards of sanitation" as well as "a clean and healthy environment". The Vision 2030 of Kenya highlights that in 2030 the government aspires to ensure universal access to safe sanitation.

Through the 2010 Constitution (Chapter 11) and the County Government Act (2012) Kenya required the devolution of the Government, meaning the decentralization of Governmental power. Since then, the 47 newly formed County Governments are responsible to implement aspects of health and sanitation. In Machakos County, the main legal framework is the Water and Sanitation Act of 2014 which was published by the Machakos County Gazette Supplement. It is important to note that the Act includes, "the provision of on-site sanitation services including latrines, septic tanks and conservancies[1] including the associated exhauster services" in its definition of the sanitation sector. Nevertheless, manual emptying services remain illegal by county by-laws (KII 1, 2018).

Through the 2016 Kenyan Environmental Sanitation and Hygiene Policy (KESHIP) by the (previous) Ministry of Health, onsite sanitation and faecal sludge management have been declared as issues of special need and urgency.

In Mavoko Town, the water and sewerage infrastructure is partly owned by the local utility MAVWASCO and partly by the Export Processing Zones Authority (EPZA). Disparities between the responsibilities of the institutions have lead to complications such as water shortages in the past. Beyond that, Mavoko's vacuum trucks were partly not able to discharge to the EPZA treatment ponds and had to take up longer distances towards Machakos or Nairobi treatment facilities (KII 1, 2018).

6. Overview of stakeholders

Until 2017, sanitation fell under the mandate of the previous Ministry of Public Health and Sanitation. Yet after the general elections in

[1] Conservancies refer to water storage facilities including conservation of wetlands and forests, and water saving technology for ground aquifer recharging (Article 47).

2018, the Kenyan urban water and sanitation sector is headed by the Ministry of Water and Sanitation (formerly Ministry of Water and Irrigation) which is responsible for the formulation of relevant policies. The Ministry of Health (MoH) is coordinating rural sanitation and hygiene promotion (Ministry of Water & Irrigation Online).

According to the responsibilities of the devolved Government, the County is in charge of implementing sanitation works in Machakos. The County Water and Sanitation Act of 2014 mandates the County Water and Sanitation Board with the provision of adequate services and the development and maintenance of infrastructure. The County Executive Committee Member for Water, Irrigation and Sanitation is mandated to develop county policies, and cross-sectoral development plans. In addition, it coordinates the water institutions in the county. So far, there is no County Level Policy on Water and Sanitation. An overview of the key stakeholders in Machakos County is shown in Tab. 1.

Tab. 1: Overview of Key Stakeholder in 2018

Key Stakeholders	Institutions / Organizations /
Public Institutions	(National) Ministry of Water and Sanitation (National) Ministry of Health Water Sector Trust Fund (WASREB) County Water and Sanitation Board County Executive Committee for Water, Irrigation and Sanitation The Municipal County of Mavoko Mavoko Water and Sewerage Company (MAVWASCO) Export Processing Zones Authority (EPZA)
Private Sector	Private Emptier (manual and vacuum trucks) Enterprises selling and operating bio-digester/ bio-boxes
Development Partners, Donors	KFW, GIZ, USAID
NGOs	WSUP

7. Process of SFD development

For this desk-based study there were mainly two reports on the service outcomes in Mavoko available. This is, on the one hand, a 2014 Water and Sanitation Status Report for the Athi River Service Board on the satellite towns of Nairobi. There is also a research study published by Muia Mutua and Agwata (2017) at the Centre for Advanced Studies in Environmental Law and Policy at the University of Nairobi. This study collected primary data from expert interviews and observations as well as households. 385 household samples were taken in 2015 to 2016 from four wards representing the area of the town.

These reports were enriched with other data and reports from MAVWASCO and the World Bank. Moreover, relevant stakeholders were engaged, however with moderate success. Two private companies selling and operating onsite treatment solutions (bio-box) were approached via phone and email.

Through the help of the Water Sector Trust Fund (WSTF), the Technical Manager of MAVWASCO as well as the County Environment Officer were approached. They both were provided with a SFD Draft and the assumptions being made for their validation, yet did not give feedback to the data provided. Instead, a WSTF representative complemented the understanding process of the service delivery in Mavoko.

8. Credibility of data

The credibility of both reports (AWSB 2014, Mutua 2017a) is considered very high as one is an extend consultancy report approved by the Athi Water Service Board and the other one is published in an international research journal.

Mutua and Agwata have also published another paper on sanitation, this time with S. Anyango on the effectiveness of policies and legal framework and instruments for sanitation management in Mavoko. In this research process, the municipality and service providers were included as stakeholders as well. This increases the credibility by including other perspectives other than the users.

9. List of data sources

- Athi Water Service Board 2014. “Water and Sanitation Status Report” for the Nairobi Satellite Towns Water and Sanitation Development Programme. Consulting Service by Gauff Ingenieure and GFA Consulting Group GmbH.
- Republic of Kenya 2010. The Constitution of Kenya, the National Council of Law Reporting. Nairobi.
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- Muia Mutua, J.K.; Agwata J.F.; Anyango, S. 2017b. “Effectiveness of sanitation policy instruments in Mavoko Municipality of Machakos County, Kenya”. In Cogent Environmental (3).
- UN-Habitat 2006: Mavoko Urban Sector Profile. Nairobi.

SFD City Mavoko, Kenya, 2018

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Abbreviations

AWSB	Athi Water Service Board
CADP	Count Annual Development Plan
CIDP	County Integrated Development Plan
EMCA	Environment Management and Coordination Act
EZPA	Export Processing Zone Authority
FS	Faecal Sludge
GoK	Government of Kenya
KES	Kenyan Shilling
KESHSF	Environmental Sanitation and Hygiene Strategic Framework
KESHP	Kenyan Environmental Sanitation and Hygiene Policy
MoERN	Ministry of Environment and Naturals Resources (MoERN)
MoH	Ministry of Health
MAVWASCO	Mavoko Water and Sewerage Company
NCWSC	Nairobi City County
NCC	Nairobi City Water and Sewerage Company
SFD	Shit Flow Diagram
WASH	Water, Sanitation and Hygiene
WASREB	Water Service Regulatory Board
WARIS	Water Regulation Information System
WRA	Water Resources Authority
WSS	Water and Sanitation Services
WSB	Water Service Board
WSTF	Water Sector Trust Fund

1 City context

The Kenyan town of Mavoko is located in the metropolitan area of Nairobi, around 30km southeast of the centre of Nairobi and considered as a suburb to it, though belonging to Machakos County. Mavoko is not a town in itself but is one of the eight sub-counties/ constituencies of Machakos County (CADP, 2017) that covers an area of 963 km^2 and comprises four wards, namely Athi River, Kinanie, Muthwani and Syokimau/Mlolongo (Mutua et.al 2017a). Mavoko is often referred to as Athi River town, its original name, named after the river that passes through it.

This SFD only looks at the service area of the local water utility Mavoko Water and Sewerage Company (MAVWASCO) instead of the whole geographical area of Mavoko town. This is because the sub-county area includes large rural parts (which can be seen in Figure1 and Figure 2) and the MAVWASCO service area focuses on the urban agglomerations. Therefore, data is mainly available for these parts as well.

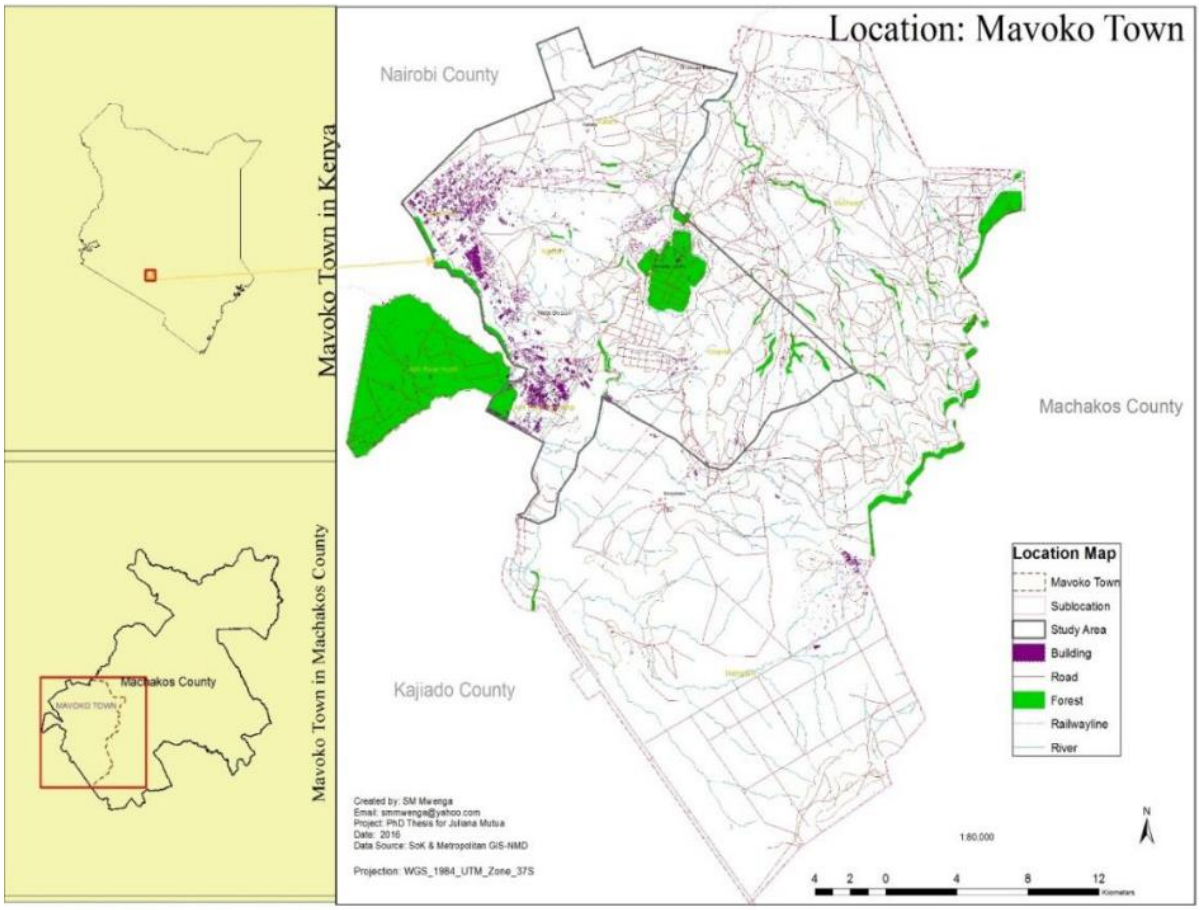

Figure 1: MAVWASCO service area within Mavoko Town (Mutua, 2017a)

The service area of MAVWASCO covers three urban centres namely Athi River, parts of Kitengela Town and Mlolongo/Syokimau. Syokimau is an estate located in the south-eastern outskirts of Nairobi, along Mombasa Road. It can be considered a suburb of Nairobi in which medium- to high-cost housings, i.e. housing estates with similar design, on a common parcel of land and constructed by a common developer, are popular (Mutua et al 2017b).

According to the national census of 2009, approximately 160,000 people lived in Mavoko and 152,000 in the service area of MAVWASCO. The same census predicted a population growth rate of 10% until 2010, 9% until 2017, 7% until 2020, 5% until 2030 and 4% until 2035. Hence, the population of 2017 is estimated to be 244,259 and predicted to grow to up to 593,182 residents until 2030 (Mutua, 2017).

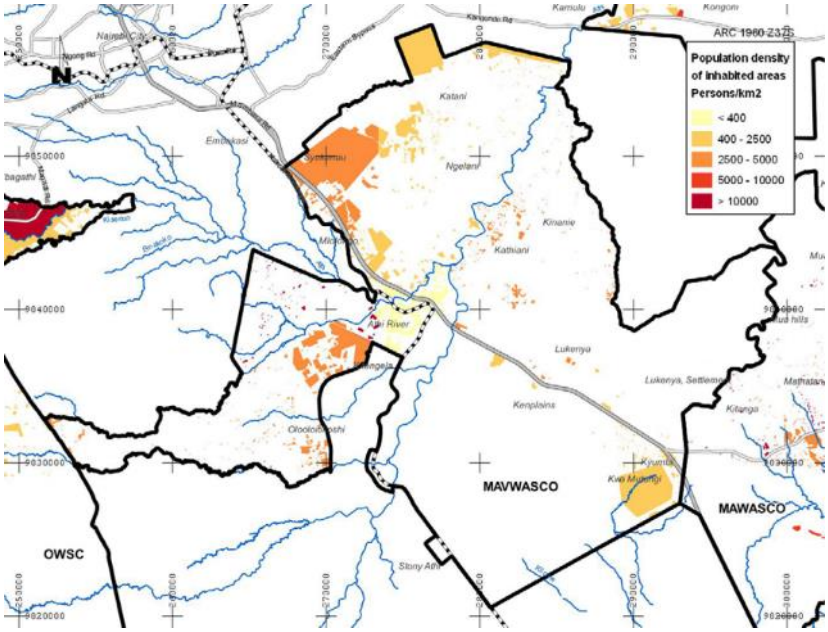

Figure 2: Population Density in the service area of MAVWASCO (AWSB, 2014)

Coming from a heritage of agriculture, Mavoko is quickly transforming from a ranching to industrial and commercial area, which are the main sources of employment (AWSB 2014/Francis 2010). In 2014 already, there were approximately 150 light and heavy industries including four cement factories, an Export Processing Zone (not served by MAVWASCO). The quick transformation of Mavoko is driven by the available land in proximity to Nairobi and its strategic location along the main traffic roads connecting Tanzania with Mombasa at the coast. Correspondingly, the population structure is mixed and includes, but is not limited to, impoverished slum dwellers, pastoral and agricultural communities, a commuting working class and a growing wealthy upper middle class, mainly gravitating from nearby Nairobi, as well as manufacturing companies.

The climate in Mavoko is semi-arid and due to its proximity to the equator, it does not experience great seasonal varieties yet two main rainy seasons: October to December months (short rains) and March to May (long rains). The annual precipitation varies between 300mm and 800mm (Muriithi, 2016). The area however is highly susceptible to climate change and has experienced severe droughts in the last years. Moreover, rainfall, climate and soil conditions naturally vary in the area due to a large plateau, which is southeast sloping. Whereas the western parts of Nairobi steeply rise up to 2400m above sea level, Mavoko is located in the mostly flat Athi River plains levelling at about 1500-1700m above sea level. Due to this gradient, the south-eastern parts of Nairobi, where the National Park is located, and the surrounding parts of Mavoko, experience flooding and flash-floods when raining (Daily Nation, 2013).

2 Service Outcomes

2.1 Overview

This section presents the range of infrastructure, technologies, methods and services designed to support the management of wastewater and faecal sludge through the sanitation service chain in Mavoko.

List A: Where does the toilet discharge to? (i.e. what type of containment technology, if any?)	List B: What is the containment technology connected to? (i.e. where does the outlet or overflow discharge to, if anything?)									
	to centralised combined sewer	to centralised foul/separate sewer	to decentralised combined sewer	to decentralised foul/separate sewer	to soakpit	to open drain or storm sewer	to water body	to open ground	to 'don't know where'	no outlet or overflow
No onsite container. Toilet discharges directly to destination given in List B	T1A1C1				Significant risk of GW pollution Low risk of GW pollution					Not Applicable
Septic tank					T2A2C5 T1A2C5					
Fully lined tank (sealed)					Significant risk of GW pollution Low risk of GW pollution		T1A3C7			T1A3C10
Lined tank with impermeable walls and open bottom	Significant risk of GW pollution Low risk of GW pollution	Significant risk of GW pollution Low risk of GW pollution	Significant risk of GW pollution Low risk of GW pollution	Significant risk of GW pollution Low risk of GW pollution	Significant risk of GW pollution Low risk of GW pollution				T1A4C9	Significant risk of GW pollution Low risk of GW pollution
Lined pit with semi-permeable walls and open bottom	Not Applicable									T2A5C10 T1A5C10
Unlined pit										T2A6C10 T1A6C10
Pit (all types), never emptied but abandoned when full and covered with soil										Significant risk of GW pollution T1B7C10
Pit (all types), never emptied, abandoned when full but NOT adequately covered with soil										T1B8C10
User interface failed, damaged, collapsed or flooded								T1B9 C1 TO C10		
Containment (septic tank or tank or pit latrine) failed, damaged, collapsed or flooded								T1B10 C7 TO C9		
No toilet. Open defecation	Not Applicable								T1B11 C7 TO C9	Not Applicable

Figure 3: SFD Selection Grid

For this desk-based study, there were mainly two reports on the service outcomes in Mavoko available. The first one is a 2014 Water and Sanitation Status Report for the Athi River Service Board on the satellite towns of Nairobi. This study was conducted by two German consultancies, Gauff Ingenieure and the GFA Consulting Group GmbH. The second report is a research study published in 2017 by Juliana Kamanthe Muia Mutua and Jones Agwata from the Centre for Advanced Studies in Environmental Law and Policy, University of Nairobi. This study collected primary data from expert interviews and observations as well as households. It was found, that 385 household samples were taken in 2015 to 2016 from the four wards representing the area of the town. The credibility of both reports is considered very high and hence used as the main source for this initial SFD. In 2017, K.M. Muia Mutua and J. Agwata have also published another paper on sanitation, this time with Stephen Anyango on the effectiveness of policies and legal framework and instruments for sanitation management in Mavoko. In this research process, the municipality and service providers were stakeholders as well.

2.2 SFD Matrix

Mavoko , Machakos, Kenya, 5 Sep 2018. SFD Level: 1 - Initial SFD
Population: 244259
Proportion of tanks: septic tanks: 100%, fully lined tanks: 100%, lined, open bottom tanks: 100%

System label	Pop	W4a	W5a	F3	F4	F5
System description	Proportion of population using this type of system	Proportion of wastewater in sewer system, which is delivered to centralised treatment plants	Proportion of wastewater delivered to centralised treatment plants, which is treated	Proportion of this type of system from which faecal sludge is emptied	Proportion of faecal sludge emptied, which is delivered to treatment plants	Proportion of faecal sludge delivered to treatment plants, which is treated
T1A1C1 User interface discharges directly to a centralised combined sewer	18.0	80.0	30.0			
T2A2C5 Septic tank connected to soak pit, where there is a 'significant risk' of groundwater pollution	2.0			80.0	30.0	30.0
T1A2C5 Septic tank connected to soak pit	3.0			80.0	30.0	30.0
T1A3C7 Fully lined tank (sealed) connected to a water body	20.0			90.0	0.0	0.0
T1A3C10 Fully lined tank (sealed), no outlet or overflow	11.0			90.0	30.0	30.0
T1A4C9 Lined tank with impermeable walls and open bottom, connected to 'don't know where'	2.0			80.0	0.0	0.0
T2A5C10 Lined pit with semi-permeable walls and open bottom, no outlet or overflow, where there is a 'significant risk' of	3.0			0.0	0.0	0.0
T1A5C10 Lined pit with semi-permeable walls and open bottom, no outlet or overflow	3.0			80.0	0.0	0.0
T2A6C10 Unlined pit, no outlet or overflow, where there is a 'significant risk' of groundwater pollution	3.0			80.0	0.0	0.0
T1A6C10 Unlined pit, no outlet or overflow	6.0			80.0	0.0	0.0
T1B7C10 Pit (all types), never emptied but abandoned when full and covered with soil, no outlet or overflow	12.0					
T1B8C10 Pit (all types), never emptied, abandoned when full but NOT adequately covered with soil, no outlet or overflow	7.0					
T1B9 C1 TO C10 User interface, septic tank damaged, collapsed or flooded, connected to sewer, soak pit, open drain or storm sewer, water body, open	4.0					
T1B10 C7 TO C9 Containment (septic tanks, fully lined tanks, partially lined tanks and pits, and unlined pits) failed, damaged, collapsed or flooded - connected to water	4.0			30.0	0.0	0.0
T1B11 C7 TO C9 Open defecation	2.0					

Figure 4: SFD Matrix

2.3 Offsite Sanitation

2.3.1 Sewerage coverage

In the County of Machakos there are only two sewer lines located in Machakos and in Mavoko, precisely in Athi River and its surrounding (Figure 5). The existing network in Mavoko is partly up to 60 years old and it comprises a total of 31.07 km of sewer network and covers less than 1% of the 963 km^2 area of Mavoko town (Mutua et al. 2017b).

Two authorities provide sewerage services in Mavoko: Mavoko Water & Sewerage Company (MAVWASCO) and the Export Processing Zone Authority (EPZA). The main trunk sewer system, network, connections and treatment are currently owned and operated by EPZA. MAVWASCO, on the other hand, owns and operates very limited sewer networks, which then discharge to the EPZA trunk sewers. These are located in Athi River, Mlolongo and the small stripe of land west of Mombasa Road. The sewage is channelled to the EPZA Treatment Plant, located northeast of Athi River (AWSB, 2014).

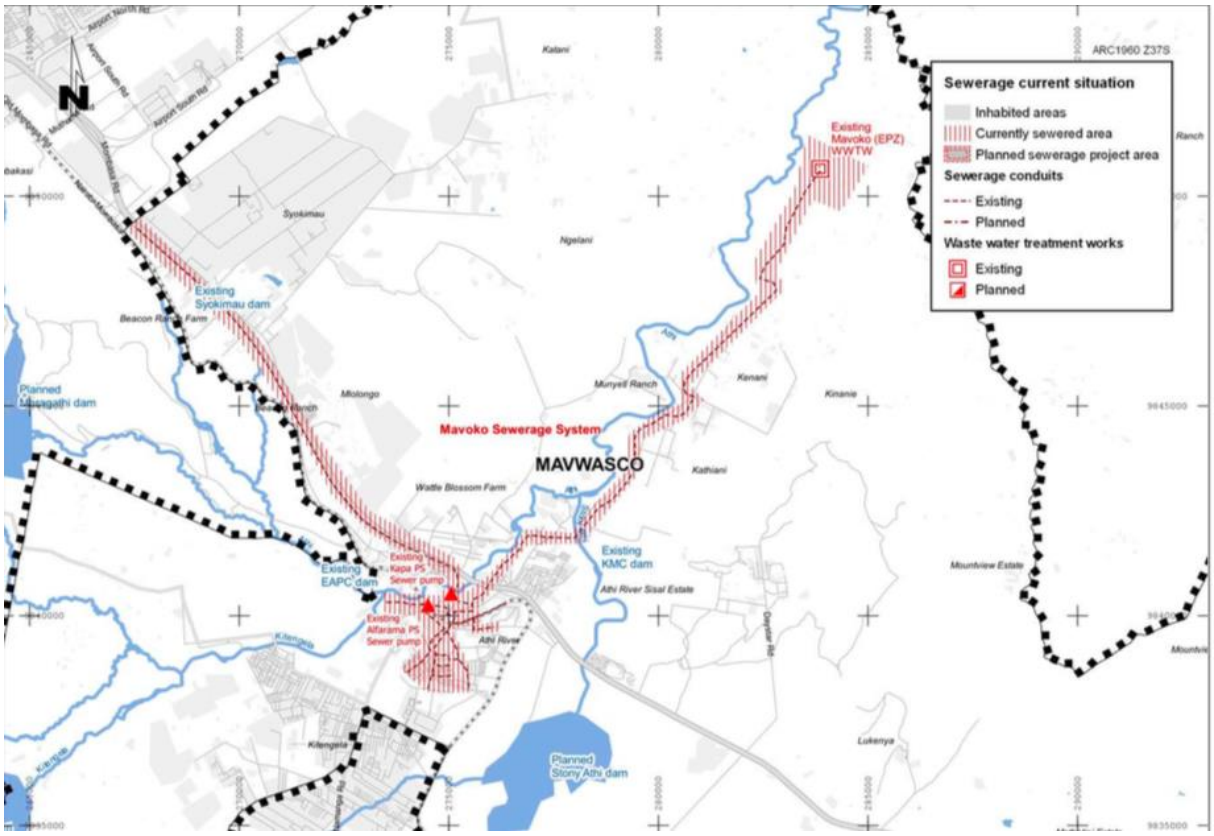

Figure 5: Existing sewer lines in Mavoko (AWSB, 2014)

In Athi River, the most densely populated urban agglomeration of Mavoko, the coverage is still less than 40% and approximately 36,5% of the population is served by the conventional sewer line. Katani and Syokimau areas had less than 14% of the population connected to the conventional sewer (Mutua et al. 2017a). In addition, it has been reported that some industries and estate developers in the area had to construct sewers and connect these to the trunk sewers (AWSB 2016, 13-15). An overall estimation indicates that the sewerage system covers about 15% of the existing housing and commercial space of Mavoko (AWSB 2014, 13-15).

Of the two reports available, one estimates that 16% (ATWSB, 2014) of the population is being served by sewers, while the other one estimates 23% (Mutua, 2017a). Considering the population growth of Mavoko, especially in areas that are not served by sewers, yet also acknowledging efforts by MAVWASCO to increase the network, an 18% overall trunk sewer connection is taken as an average of these both numbers. Due to the age of construction (1997) and the common practice of trunk/conventional sewers, it is assumed that the trunk sewer is a combined sewer with storm water. It is reported that in times of water shortage, the residents in Athi River connected to the sewer do not flush, yet use their facility as a pour flush toilet.

2.3.2 The sewer network segments

As mentioned above, large parts of the sewage network are owned by EPZA and not the local water utility MAVWASCO. The EPZA network was constructed during the development of the site in 1997, referring to Athi River, Mlolongo and west of Mombasa Road, which is mostly an industrial area. From Athi River there is a 19,6km long concrete trunk sewer that runs to the EPZA treatment works. The network works a lot with gravity yet there are two pumping stations in Athi River which pump the sewage into the main trunk sewer lines (see figure 5). Athi River Townships are served with sewer network of 25km, which was built in the 1950s.

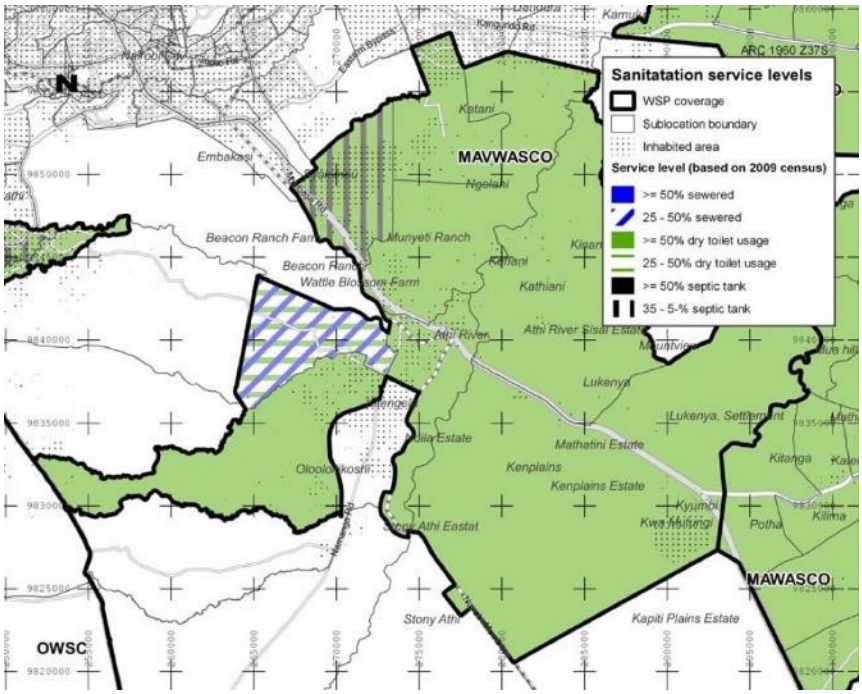

Figure 6: Sanitation Service Levels in Mavoko (AWSB, 2014)

There is also a small share (4%) of so-called small-bore sewers, mainly known as solids-free sewers (Eawag Online Compendium) in Mavoko**.** These are used in the areas that are already connected through the regular sewer system, mostly in the affluent areas of Mlolongo (9%) Athi River (5%) and Syokimau (4%) since they either discharge into an onsite solution, such as a septic tank or into the main sewer network, in this case the trunk sewer of Athi River.

2.3.3 Offsite Treatment

The sewage treatment works of Mavoko are located about 14km to the northeast of the Athi River Town (see Figure 5). They are waste stabilization ponds operated by EPZA and include inlet works, four anaerobic ponds, three primary and secondary facultative ponds, six maturation/oxidation ponds, and 16 sludge drying beds. The design capacity of the existing

treatment plant, which was constructed in the early 1990s, is 6,480 m^3/day (AWSB, 2014). The system is overloaded and has exceeded its capacities due to increase in industries and residential developments. According to the study of Mutua et al. (2017a), the whole Metropolitan area of Nairobi is overloaded in this sense and has a deficit of 86% in sewerage treatment capacity. The existing sewerage treatment capacity stands at 192,000 m^3 against a required capacity of 1,407,000m^3. This is therefore taken as a reference for Mavoko. A study by Mutua et al. (2017c) indicates that overflowing sewers (32%), broken pipes (28%), overflowing toilets (7%) and blocked drains (5%) are major issues appearing around the sewer network. Taking into account the age of the sewer network as well as these issues, mainly during rainy season, a leakage of 20% is estimated. Thus, for this SFD, it is assumed that 80% of the wastewater delivered in the sewer system is delivered to a treatment plant and that only 30% is being managed safely Mutua et al. (2017b). Observations at the EPZA WWTP of Mavoko, also known as Kinanie Oxidation Ponds, showed no signs of life in the water of the oxidation pond before discharging into Athi River, yet instead a thick pink residue of industrial waste in the final ponds (Mutua 2017c).

2.4 Onsite Sanitation

2.4.1 Containment & Emptying

The main parts of the MAVWASCO service area are using onsite sanitation in the form of septic tanks, especially in the upcoming middle- and high-cost areas, and mostly simple pit latrines in low income and rural areas. Adding up from the main reports used for this SFD, it is estimated that 39% of the population have some sort of a tank as their sanitation management option. This includes actual septic tanks as well as lined holding tanks. Often (fully-) lined holding tanks are mistaken for septic tanks, yet they do not include the two-chamber settlement phase. Their liquid should discharge into a sewer or soak pit, yet the solids of both tanks need to be emptied.

Septic tanks
It is assumed that there are no septic tanks connected to a sewer network. The number of actual septic tanks connected to a soak pit is estimated in total at 5%. Since the infiltration level in volcanic & clay soil condition in the area, depends on wet or dry season it is estimated that 3% of the septic tanks connected to a soak pit have a low and 2% have a significant groundwater pollution risk. It is estimated that in both cases, the faecal sludge does not reach a treatment plant.

Holding Tanks
The share of septic tanks, or as assumed here, holding tanks is in total 39% for the whole of Mavoko. They are mainly distributed in the upcoming neighbourhoods such as in Syokimau ward: In the Sabaki housing area 83% of the population use tanks, followed by Mlolongo at 68% and Syokimau at 64% (Mutua et al. 2017a). In Katani, 43% of the population are served by this option. Users indicate they choose this sanitation option due to its environmental safety and availability. These tanks however are the most expensive option with almost 94% of users spending 12,000-15,000KES (120-150US$) per year or 1000-1250KES (10-12,5US$) per month (Mutua et al. 2017a). The total amount of these tanks in all wards is indicated as 37% (Mutua 2017a). These 37% are in this SFD divided up as follows:

It is assumed that out of those holding tanks, 11% are fully lined with no outlet and hence need to be emptied by exhausters. It is assumed that only 50% of those are emptied by licensed vacuum trucks who dispose to two designated treatment sites. It is assumed that the remaining tanks are 2% lined tanks with impermeable walls that leak into the ground and hence do not get emptied (as often). Their content does not reach a treatment plant.

According to the household survey of Mutua et al. (2017a) the residents of Katani and Syokimau stated that when their tanks fill up, the faecal sludge gets channelled into to the Sabaki stream which then leads into a wetland in the area. These two areas are populated by around 50,080 people which is 20,5% of the population in Mavoko. Hence it is marked in the SFD Matrix that 20% of fully lined tanks discharge into a water body.

Bio-digesters
In addition, there is a growing market for decentralized systems such as bio-digesters by private enterprises. These also serve the higher income-housing areas, especially larger compounds and are suggested by the National Environmental Authority (NEMA) to be the most suitable option for these new housing developments (Omwenga, 2017). A present brand is called bio-boxes and the private stakeholder selling and implementing these confirmed that Mavoko/Athi River is one of their busiest markets (KII 5, 2018). The study of Mutula et al. (2017a) which collected data in 2015-2016, found that this onsite sanitation option served less than 1% of the population in Mavoko, yet considering the growth of the market, especially in the upcoming middle-higher income areas, it is estimated that their share has increased to 2%. It is reported that not all of them are functional and hence need to be emptied (AWSB, 2014). It is assumed that only 1% of the population has functional bio digesters. In the SFD Matrix, these are included under the 11% using Lined tanks with no outlet or overflow.

Latrines
There are three types of latrines used in Mavoko; the pour flush latrines (7%), the ventilated improved latrines (VIPs) (3%) and simple latrines which are used by 24% of the population. The simple latrine is mostly spread in Kinanie, which is a low-density area, where 92% of the population use it. According to the household survey of Mutua et al. (2017a), users indicated they prefer simple latrines due to its low cost of installation and emptying (52%) as well as its overall convenience (33%). 43% of the simple latrine users pay 3000-5000KES (30-50US$) for the emptying of faecal sludge which is mainly once per year. 36% indicate that they even pay 9000-10,000KES (90-100US$), whereas 29,8% say they do not know.

It is assumed that in total 41% of the population uses some sort of a latrine as their sanitation option (see distribution ☞ section 2.6). In the less densely populated areas, it is common to cover pits when full and dig a new one. There are no numbers indicated, yet the AWSB assessment states that abandonment of full latrines is a common method, practiced especially in the rural and low-income areas of Mavoko. For this SFD it is therefore estimated that 19% of the pits are abandoned when full, out of which 12% are adequately covered with soil and 7% are not. The remaining share is distributed between those, which are emptied by manual emptying services who then discharge into the environment, or have collapsed interfaces and structures. It is estimated by the author that generally only 80% of the faecal waste is emptied

and that 20% remain inside the latrines, as many households cannot afford to have their latrines fully emptied.

Emptying
According to Mutula et al. (2017, 2017a) only septic/holding tanks and simple pit latrines are emptied. As described above, most tanks and pits do not get fully emptied due financial costs, and overall residue of 20% is assumed. Of the share that is getting emptied Mutua (2017a) described that the most common methods for emptying sludge are the use of the vacuum trucks pumping into the open grounds. 67% of emptied sludge from holding tanks was pumped into the surface ground while 64% was using vacuum trucks. The same picture is portrayed in the emptying of the simple pit latrine in which 33% pump into the surface ground while 25% use the exhauster service.
In addition, it is important to know that about half of all respondents said that they would not know about the emptying method or the costs. The reason for this can be that for holding tanks as well as latrines users, this service is included in the rent. However, stating that their latrines do not fill up, leads to the assumption that many were not willing to answer, most likely because they are hiring manual emptying services, which are illegal by the by-laws in Machakos. Another reason could be that their latrine is either new and/or is leaking to the ground and has therefore not filled up yet. Overall, the household survey depicted that septic tanks, simple latrines as well as VIPs are emptied mostly once a year, sometimes every second or third year.

2.4.2 Transport & Disposal

There are two designated discharging points for licensed vacuum and exhausting trucks in Machakos County. One is the Decentralized Treatment Facility (DTF) that was built under the Upscaling Sanitation for the Urban Poor Program (UBSUP), which is implemented by the Water Sector Trust Fund (WSTF). This DTF is located in Machakos Town in a distance of about 40km of Mavoko. Hence, emptying trucks previously also discharge in Ruai Treatment Plants (Ponds), which are located in Nairobi County yet are more accessible from Mavoko than Machakos (KII 1, 2018). However, due to the location in Nairobi County, vacuum trucks would have to pay for a double operating license.

After disparities between the water service providers in Mavoko, the trucks are now discharging at the closest location, the EPZA Waste Water Treatment Plant /Kinanie Oxidation Ponds (Mutua et al. 2017c) northeast of Mavoko. This is the same WWTP that also receives the sewerage effluents. However, there is no indication that the WWTP is designed for treating faecal sludge received from the vacuum trucks. This will consequently lead to an overload of organic matter in the treatment ponds; though only a small percentage, estimated around 5% in this SFD of sludge is at all reaching the WWTP.

The tariffs for discharging at Kinanie Ponds are not set yet. However, the general tariffs for discharging for licensed trucks in Machakos County is either a fee or 15,000 KES (15US$) per month or 1,000KES (10US$) per discharge (KII 1, 2018).

2.5 Open Defecation

It is assumed that 2% of Open Defecation remains in Mavoko. Even though projects have decreased the use of “flying toilets” (depositories bags of human waste) in areas where this practice has been especially common (Maji Insight 2015-2016) and the use of plastic bags is prohibited since 2017 in Kenya, the practice is not totally eliminated. Especially, during the rainy season, when it is quick and easy to dispose used bags in the dense low-income areas, it remains a *convenient* option for disposal.

2.6 Groundwater Pollution Risk

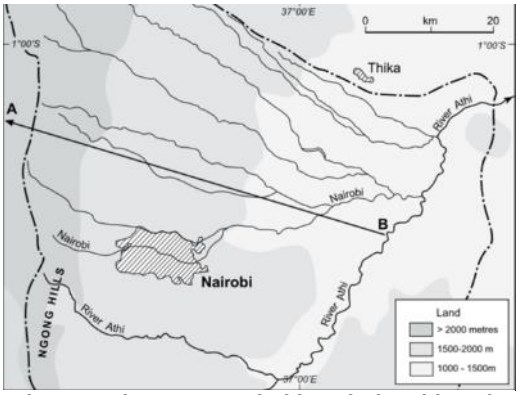

Figure 7: Figure Map Nairobi Basin (World Bank, 2005)

The groundwater basin of Mavoko is part of the larger Nairobi groundwater basin which extends from the zone of north-south rift faulting west of the city, with an elevation of about 2,400m above sea level (asl) towards the Athi river floodplain, with an elevation of 1,500m asl, east of the city centre where Mavoko is located. The soil type in the area varies depending on the location on the plateau, yet ranges from well drained shallow, dark red clay soils particularly in the plains (CADP, 2017) to deep black Vertisol, developed from volcanic activities of Mount Kenya (Muriithi, 2016). Hence, the ‘Nairobi aquifers’ occur in the multi-layered volcanic rocks that show a wide range of porosity and permeability. The groundwater flow follows the southeast sloping and the extension of this multi layered aquifer system is fairly well known from the many boreholes that have been drilled to depths of 100-350m (Worldbank, 2005).

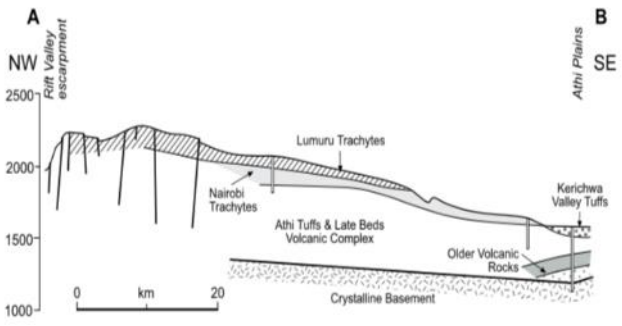

Figure 8: Nairobi Basin Geological cross-section (World Bank, 2005)

Already in 2002, it was estimated that around 25% of the overall water supply of the population of Greater Nairobi was served in this way (Muraguri, 2013). Even though stakeholders in the area, speak of a high water table, the ground water table is lowering due to the high water demand of the growing population. The World Bank (2005) also reports that the number of groundwater wells and the depth of drilling is increasing, which “may draw waters with different composition towards the screen and cause mixing of waters” (Appelo and Postma 1996). The aquifer groundwater quality from the Nairobi basin is known to be good and reaches the drinking water standards except for fluoride. However, the aquifer partly also recharges through infiltration of wastewater, water leakage and excess rainfall and it is difficult to say how much of this reaches the groundwater, especially as the volcanic Vertisols show a wide range of porosity and permeability. They are very hard when dry and very sticky when wet, almost impermeable when saturated (Muriithi, 2016).

Table 1: Estimation and Indication of Groundwater Pollution Risk (2018)

Proxy indicator for groundwater pollution risk	
Q1.A: Rock type in unsaturated zone?	Clay/ Volcanic Soil
Q1.B: Depth of groundwater table?	> 10 m
Q2.A: % of sanitation facilities that are located <10m from groundwater sources?	Less than 25%
Q2.B: % of sanitation facilities, if any, that are located uphill of groundwater source?	Greater than 25%
Q3: % of drinking water produced from groundwater sources?	Greater than 25%
Q4: Water production technology used?	Protected boreholes
Overall risk	Low

The different soil and porosity conditions in the area make it difficult to predict the vulnerability of the aquifer. Even though the depth of the boreholes, over 150m, would conclude that it is rather low it has to be considered that large amounts of unsafely managed wastewater from Nairobi are flowing downhill towards Mavoko. For this SFD the overall assumption remains a low groundwater pollution risk. Yet to not neglect the mentioned uncertainties, the SFD Matrix includes a small percent of faecal sludge/effluent from latrines and septic tanks that may discharge where there is a higher risk of groundwater pollution. This does not have a significant impact on the SFD Graphic yet is simply included in order to credit this uncertainty as seen in Table 2.

2.7 Discussion of data uncertainties and challenges

The reports used for this SFD, focus on household sanitation and neglect other sources of waste generation from schools, hospitals or hotels. The data on offsite sanitation makes it clear that a connection to the sewage network would only be possible in certain areas, along the existing limited lines. In the rural areas, which are now urbanizing, the use of simple pit latrines is dominant, which indicates that schools will also use the same sanitation management. When it comes to decentralized on-site systems in the growing middle -and income areas, two private enterprises selling and operating onsite wastewater treatment options have been approached. Through this, it could only be confirmed that Mavoko/Athi River is one of their busiest markets yet no detailed information could be collected.

As for uncertainties within the SFD Matrix, often the term septic tank is used when actually the tanks are not connected through an outlet to a soak pit or, sewer or another drain. The study of Mutua et.al (2017a) also mentioned that many households confuse a septic tank and their sewer connection, as they do not clearly know the outlet of their user interface. For this SFD, it is assumed that there are a small number of septic tanks with an outlet connected to a soak pit, but the majority of onsite tanks are fully lined (sealed) tanks (known locally as holding tanks), with no outlet or overflow. These holding tanks do not have a two-chamber system or have failed and need emptying. As for the treatment capacities of the EPZA ponds, the overall treatment deficit in the Nairobi Metropolitan area is taken as a reference point as the capacities in Mavoko might alter.

There is little information on standards of service provision in Mavoko available online. Key stakeholders relevant to Machakos County and the water utility were approached and engaged, yet their constructive feedback is still awaited. For instance, MAVWASCO reports on their company homepage that through a Public-Private Partnership, two projects have been accomplished serving two new areas, with a sewerage system. One of them is in the former rural yet urbanizing ward Kinanie connecting the area around the university. However, details on the service outreach of this project are missing and should be included in a future updated version of this SFD (the projects are mentioned in the chapter 3.4 on service provision, yet not included in the SFD Matrix). Therefore, that section should be enriched with more local and county specific details for future SFDs.

2.8 The SFD Graphic

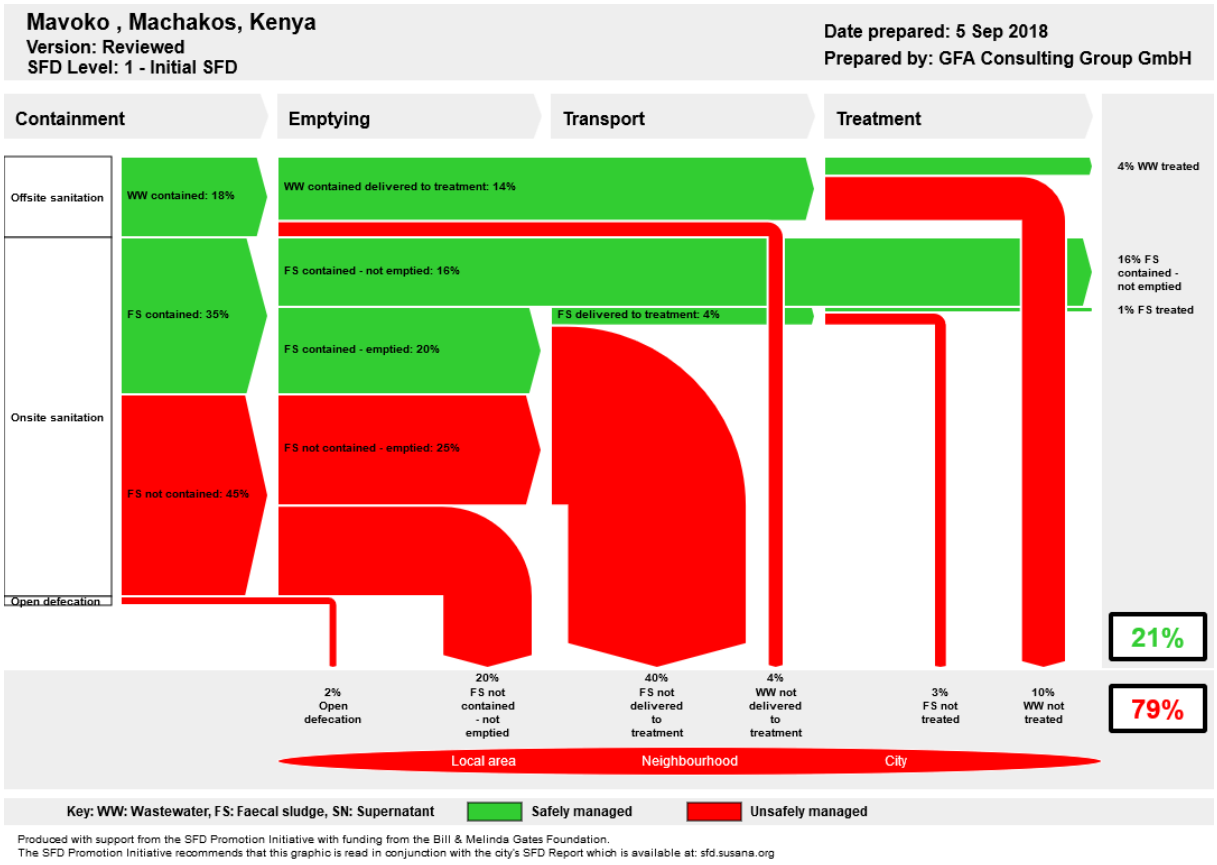

Figure 7: SFD Graphic for Mavoko

The overall result of the SFD shows that almost 80% of the excreta in Mavoko is not safely managed. For offsite sanitation the key challenges area low coverage of sewerage networks (18%), issues of overflows and blockages and challenges within the treatment works. The majority of the population (about 80%) relies on onsite sanitation of which only 17% get safely managed. About 16% of FS however is considered as safely managed as it stays contained in the container, such as lined pits or tanks and never gets emptied, or pit latrines that get covered when full. Yet of the onsite generated FS only 5% gets transported to a treatment facility by licensed vacuum trucks, of which then 1% actually gets treated. The main share of FS either gets emptied (19%) and then disposed into the environment or it is actually never contained onsite (45%) as it directly discharges into water bodies or leaks to the open ground. As

described above, around 20% of all FS in Mavoko directly gets channelled into Sabaki stream (Mutua et al. 2017a).

Overall, it is estimated that there is a relatively low risk of groundwater pollution from the sanitation technologies (Table 1). However, it is recognised that in some localised areas the risk may be greater, as described in section 2.6. Therefore, a more detailed and conservative division of all sanitation systems in relation to their groundwater pollution risk (GPR) is used to produce the SFD Graphic, as shown in Table 2.

Table 2: Theoretical distribution of sanitation facilities in relation to groundwater pollution risk

SFD Matric Code	Type of sanitation containment	Total	Low GPR	High GPR	unspecific
T1B11 C7 TO C9	Open Defecation	2%			2%
	Total Offsite Sanitation	**18**			
T1A1C1	Toilet discharges directly to a centralised combined sewer	18%	18%		
	Onsite Sanitation				
T1A2C5 / T2A2C5	Septic tank to soak pit	5%	3%	2%	
T1A3C7	Fully lined tank (sealed) connected to a water body	20%			20%
T1A3C10	Fully lined tank (sealed), no outlet or overflow	11%	11%		
T1A4C9	Lined tank with impermeable walls and open bottom, connected to 'don't know where'	2%			
	Total septic / holding tanks	**38%**	**14%**	**2%**	**20%**
T1A5C10 / T2A5C10	Lined pit with semi-permeable walls and open bottom, no outlet or overflow	6%	3%	3%	
T1A6C10 / T2A6C10	Unlined pit, no outlet or overflow	9%	6%	3%	
T1B7C10	Pit (all types), never emptied but abandoned when full and covered with soil, no outlet or overflow	12%	12%		
T1B8C10	Pit (all types), never emptied but abandoned when full but NOT covered with soil, no outlet or overflow	7%	7%		
T1B9 C1 / TO C10	Toilet failed, damaged, collapsed or flooded, connected to sewer, soak pit, open drain or storm sewer, water body, open ground or 'don't know where'	4%	4%		
T1B10 C7/ TO C9	Containment (septic tanks, fully lined tanks, partially lined tanks and pits, and unlined pits) failed, damaged, collapsed or flooded - connected to water bodies, or open ground or 'don't know where'	4%	4%		
	Total Pit latrines	**42%**	**36%**	**6%**	
	Total onsite options	**80%**	**49%**	**9%**	**20%**

3 Service delivery context

3.1 Policy, legislation and regulation

3.1.1 Policy

Article 43 (b) of the new 2010 Constitution of Kenya "declares sanitation as a basic human right and guarantees every person to reasonable standards of sanitation." Beyond that, Article 42 guarantees the right to "a clean and healthy environment" (KESHP, 2016) and by 2030 the government aspires to ensure improved accessibility to safe sanitation, including "(iv) Constructing water and sanitation facilities to support industries and a growing urban population" (NCWSC Strategic Plan, p.3). In Kenya's economic blueprint the Vision 2030, the government aspires to establish as a middle-income country to ensure improved and increased accessibility to both safe water and sanitation services beyond present levels by the year 2030. Hence, in the last ten years concerning water and sanitation the following documents are the latest outputs playing an important role for the development of the sector (Table 2):

Table 3: Overview of policies and legislation regulating the Sanitation Sector (2018)

Policy / Act	Key points
Kenyan Constitution 2010	Recognizes human rights to water and sanitation.
Kenya Vision 2030	Kenya Vision 2030, developed in 2007 and revised in 2012, aims for universal sanitation by 2030.
Water Act (2002)	Replaced by the Water Act 2016.
Water Act (2016)	Issued to reflect constitutional changes and adjusting the institutional arrangements, based on devolution reforms.
Environment Management and Coordination Act (EMCA 1999)	Provides the legal framework for environmental management and conservation and established the National Environment Management Authority (NEMA). EMCA provides regulations on water pollution prohibition, effluents to be discharged into the sewerage system, licensing for discharge of effluents, standards for waste, licenses for existing waste disposal sites and plants, etc.
Kenyan Environmental Sanitation and Hygiene Policy 2016-2030	The KESHP aims to achieve improved sanitation for all (not just eradication of open defecation) by 2030. KESHP sets the ambition to increase public investment in sanitation from 0.2% to 0.9% of the GDP by 2030. The policy promotes the adoption of onsite sanitation. It emphasizes the need for sustainable systems for collection and safe disposal of solid waste from residential and commercial areas.
National Environmental Sanitation and Hygiene Strategic Framework (KESHSF) 2016-2030	The Kenya Environmental Sanitation Strategic Framework (KESSF) 2016-2030 provides a medium-term framework for the implementation of the KESHP 2016-2030. It aims to declare 100% of Kenya ODF by 2030, and to ensure that at least 55% of urban households have access to improved sanitation facilities.
Urban Areas and Cities Act (2011)	Provides for the classification, governance, and management of urban areas and cities and the criteria of establishing urban areas. One of the criteria for classifying an area as urban, city, or a municipality is the capacity to effectively and efficiently deliver essential services including sanitation services and the capacity for functional and effective waste management and disposal. To this end every city and municipality must formulate and operate within the framework of an integrated development plan. The Urban Areas and Cities Act also provides the basis for promoting service providers, contractors, public-private partnerships, and joint ventures as well as the regulation of city, municipal, and town services.
County Government Act (2012)	Provides the basis for sanitation planning and performance management within each country's integrated development plan. The Act requires that in planning for services the county governments must provide clear input, output, and outcome performance indicators, including the percentage of households with access to basic services including water and sanitation.
Public Health Act (1986)	Makes provisions to promote public health and prevent infectious, communicable, or preventable diseases. The Act makes proscriptions on sanitation and housing and prohibits nuisance injurious to health, including unsafe housing.
Kenya Water Master Plan 2030	Highlights the effects of climate change on the water and related sectors and analyses they will impact the socio-economic and political development goals defined under the Vision 2030.

In alliance with the above-mentioned national sanitation policy and supporting strategic framework, the national Sanitation Bill is currently under process. As the draft has been developed by the Urban Sanitation Technical Working Group, which consists of governmental and public key stakeholder, especially NGOs and (social) enterprises working on urban sanitation in Kenya. Generally, this way of expert and public consolidation leads to a faster processing and the Parliament has to accept the draft in its overall terms and can only suggest minor changes.

However, after all, the third parliamentary hearing had been delayed due to the political interruption of the national elections in 2017. After this election, the Ministry of Water & Sanitation has been newly formed out of the previous Ministry for Water & Irrigation, and through this act, it has become unclear if the Sanitation Bill will be passed. In contrast, the new Ministry stated in July 2018 that, a water policy is under development, which shall guide the implementation of the Water Act of 2016. It is aimed to forward the draft for the first reading in September and pass it through parliament in December. The policy shall advise on water harvesting plans and storage capacity to meet rising demand for water (The Star Kenya, July 2018).

County Government Act: The Transition to Devolved Government Act, 2012
Part of the new Constitution of 2010 has been envisioned by a devolved government through the development of 47 Counties and County Governments. Previously Kenya was organized in regions. Section 48 of the County Government Act from 2012 determines the principle of a devolved government meaning to decentralize services to the lowest unit of the county government may determine (sub-counties, wards, etc.). Therefore, “the provision and management of water and sanitation services should be aligned to this priority” (NCC Policy on Water and Sanitation 2016, Paragraph 9.5, p.18) meaning that the County Governments and their sub-governmental organizations are in charge hereof.

3.1.2 Institutional Roles

According to Eberhard (2017), Kenya’s urban water sector and related institutions have evolved in two main phases over the last two decades. The Water sector reform 2002, led to the establishment of eight nationally-owned asset development and holding companies for water services (Water Services Boards) operating regionally, as well as at the local-level, commercially-oriented operating companies for water supply in cities and towns. The Constitutional reform of 2010, led to the establishment of 47 devolved county governments with responsibility for water supply and sanitation. The water companies are now owned by the county governments. The water services boards (WSBs) have continued to play a dominant role in investment planning and implementation, pending the establishment of water works development agencies provided for in the Water Act 2016 and an uptake of the investment role by county governments. The intention is for the water works development agencies to fund “nationally important” or strategic water services assets as well as cross-county water services infrastructure.

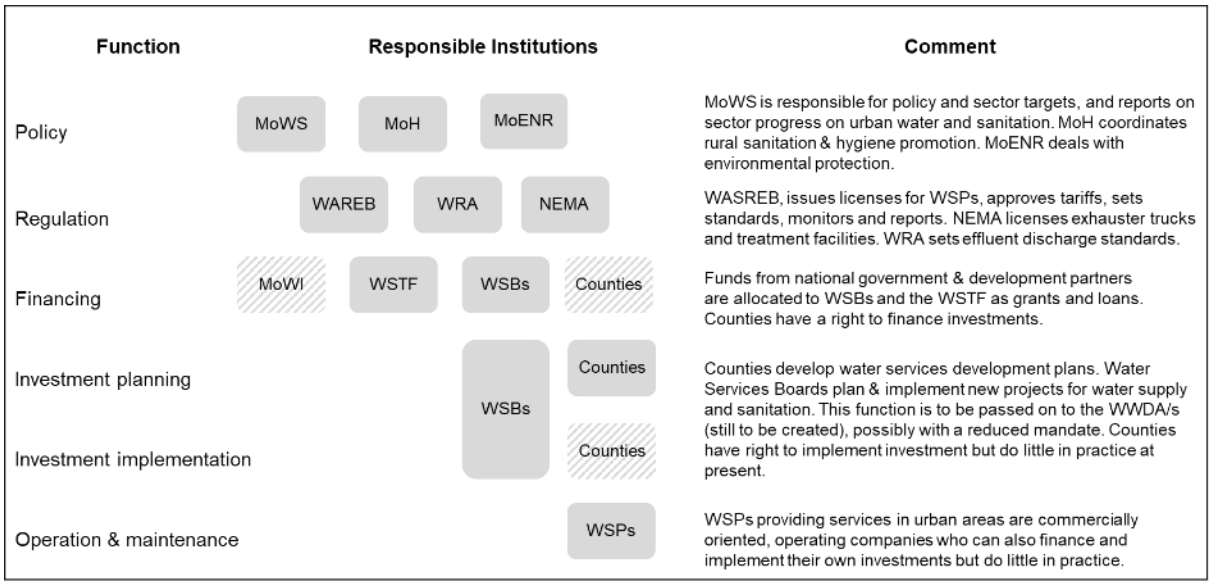

Figure 8: Institutional roles in the water & sanitation sector (adapted from Eberhard, 2017)

At the national level, the institutional set-up of the Kenyan urban water and sanitation sector is headed by the Ministry of Water and Sanitation (formerly Ministry of Water and Irrigation) which is responsible for the formulation of relevant policies. The Ministry of Health (MoH) is coordinating rural sanitation and hygiene promotion and the Ministry of Environment and Naturals Resources (MoERN) through the National Environmental Management Authority (NEMA), is responsible for environmental regulation (Mansour et al., 2017). Below the policy level, there is an institutional division between Water Resources Management and Water and Sanitation Services. On the national level, the Water Service Regulatory Board (WASREB) regulates Water and Sanitation Services and also holds the mandate to protect consumers (WASREB, 2018). The Water Resources Authority (WRA) issues permits and sets standards for effluent discharge into water bodies. NEMA is in charge of environmental protection and issues licenses to vacuum trucks and wastewater and sludge treatment facilities. The County Governments delegate their mandate for water and sanitation service provision to registered and licensed Water Service Providers (WSPs) which are responsible for providing water and sanitation services to the population in their service area.

The water users are represented by water consumer groups or water action groups. The Water Sector Trust Fund (WSTF) is the pro-poor financing institution of the Kenyan water sector with the mandate to fund the development of water and sanitation services in marginalized areas (GoK, 2016; Eberhard, 2017).

There is a lack in clarity concerning responsibilities for urban on-site sanitation. The Water Act 2016 states that the counties through established WSPs are responsible for ‘water services provision’ within a specified area through a license from WASREB. The Act further defines, ‘water services’ as “any service of or incidental to the supply or storage of water and includes the provision of sewerage services”. As per definition in the Act, sewerage services are defined as “the development and management of infrastructure for transport, storage, treatment of water originating from centralized and decentralized systems but shall not include household sanitation facilities” (GoK, 2016).

County Sanitation Legal framework and institutional roles

The main legal regulation for Water and Sanitation provision in Machakos County is the Water and Sanitation Act, 2014 (No. 1 of 2014). Hereby it is important to note that sanitation is defined as "the provision of on-site sanitation services including latrines, septic tanks and conservancies including the associated exhauster services", which is progressively acknowledging that sanitation management goes beyond offsite provision through sewage systems and needs to include emptying and transports services as part of the sanitation value chain.

Article 43 of this Act also prohibits causing pollution of the environment and human health through the discharge or disposal of polluted effluents either into the environment or the sewers. The qualities of a final effluent to be judged as (non-) polluted is to be defined by Kenya Bureau of Standards (Article 54). Manual pit emptying services are illegal through County by-laws.

Table 4: Overview of key institutions and their service roles in the sanitation sector of Machakos County (2018)

Institution	Service Role
County Water and Sanitation Board	○ Provision and management of WSS and adequate water supply through the development and maintenance. ○ In charge of the promotion of water conversation and recycling, encouraged through public private partnerships (Article 52) ○ issue licenses which enable operating in the WSS (Article 23)
County Executive Committee Member for Water, Irrigation and Sanitation	○ Develop county policies, report on service provision and formulate undertake water sectoral as well as cross-sectoral development plans and coordinate all water institutions in the county ○ Comprehensive inter-sectoral program on sewerage and sludge treatment for decentralized sanitation facilities shall be developed ○ So far, no County Policy on Water and Sanitation has been developed for Machakos County.
County Assembly	○ Legislative organ plays an oversight role on all County public institutions including the urban areas and cities.
The Ministry of Decentralized Units and County Administration, Energy and Natural Resources	○ Mandate to manage solid, liquid waste and sanitation
Export Processing Zones Authority (EPZA)	○ A State Corporation, under the Ministry of Trade and Industry ○ owns large parts of the sewerage network and the treatment ponds in Mavoko
Mavoko Water and Sewerage Company (MAVWASCO)	○ Local utility given the mandate to provide water and sewerage services to the population in the service area.

3.1.3 Service provision

Water Supply

The local water utility MAVWASCO follows the mission "to provide high quality water and sewerage services in a timely, efficient and reliable way to the satisfaction of costumers" (MAVWASCO online). Whereas the water supply in the dense areas is good, in the rural areas of Machakos the distance towards water sources can be up to 5km (CIDP). The overall water coverage in Mavoko is 67% and only 6h of water supply per day (WASREB, 2018). Non-revenue water is 41%. Hence, in terms of access, Mavoko does not fulfil the Minimum Service Level (MSL) for WSPs in Kenya (see Table 6).

A case study of MAVWASCO states that it is mostly children who are given the task to collect water from the distant water points (Maji, 2016). In the informal settlement areas, water is supplied through water kiosks. Registered local groups (MAVWASCO online) constructed and run these through a partnership with the WSTF.

Water resources
Water resources in Machakos County are under pressure from agricultural chemicals, urban and industrial waste, as well as from the use of hydroelectric power. The County has two permanent rivers namely Athi and Tana. Tana River is mainly used for hydroelectricity generation while Athi River is used for domestic and industrial uses. There are also several dams that serve as water resources and springs which are found in the hilly areas (CADP, 2017). MAVWASCO receives the bulk of their water supply, about 90,000m^3 of water per month, from the Nairobi Utility, called Nairobi City Water and Sewerage Company (NCWSC). However, due to draughts in the last years, water levels in the area have decreased which has resulted in shortages/water rationing for MAVWASCO at times.

The company also states disputes with the EPZA over the ownership of water lines as well as sewerage networks. Hence the company informs that “MAVWASCO through Tanathi water service board and the government of Kenya has secured financing in the year 2017/2018 to construct a dedicated water line for supply of fresh water from Nairobi to Athiriver” (MAVWASCO Online). To support their water sources, MAVWASCO abstracts about 7,000m^3 of water monthly from seven boreholes. Moreover, the county government of Machakos has also drilled several boreholes to ease the water shortage in Mavoko and in Machakos County in general.

Sanitation Sector Achievements
Besides the description of sanitation management in Chapter 2 of this SFD Report, there are smaller achievements in the sector, which should be mentioned here. However, as their outreach is rather small, it does not have a significant impact on the SFD Matrix or the levels of (un-)safely managed excreta.

The County Annual Development Plan (CADP Financial Year 2016/17) indicates that achievements have been made in the water sector of the county. This includes the maintenance of 207 toilets and 17 market toilets, the provision of sanitary bins to 23 toilets and construction of two new modern toilets, there is no indication given on the location or type of these toilets though. In addition, it is mentioned that drainage systems and sanitation lanes for Mavoko and Machakos Sub County have been improved. In the sector of solid waste management, collecting workers have been provided with protective clothing (gloves, gumboots, dustcoats) and through a donation, 54 litter bins could be installed. The Ministry of Trade, Economic Planning, Investment and Industrialization, reports that under the Program of Trade Development, 80 public toilets in markets have been constructed. The location and the type of toilet and waste management are not mentioned. However, the allocated budget is 80,000,000 KES (80,000 US$) (CADP, 2017).

Besides these achievements, the CADP also lists a number of programs by different ministries that include sanitation issues in their goals. However, clear strategic steps or sometimes even

a budget is missing. In the CADP, the Sub-Programme by the Department of Decentralized Units & County Administration aims to increase the number of modern toilets through a spending 6,300,000KES (6,300 US$). Hereby modern toilets are mentioned as a key indicator, yet no definition of *modern* is given nor the number of toilets that should be built (CADP, 2017).

The Ministry of Health, Environment and Emergency Services has launched a programme for the promotion of preventive services. Hereby the goal is not only to achieve 100% sanitation coverage and but also build up capacities for quality assurance and quarterly monitoring and evaluation (M&E) reports. However, there is no budget allocated to the activities.

In addition, the Ministry of Water and Irrigation, has indicated a Programme aiming for increased Water access in every ward 80% connectivity to sewer lines by 2017, allocating in total 1,925,236,160KES (1,925,236 US$). Considering the fact that there are currently only two sewer lines, serving about 18% of the population, this is a goal, which has neither been fulfilled, nor has it been realistic. Furthermore, it has neglected the fact that over 80% of the population are relying on onsite sanitation, including the growing medium- and high-cost housing units in Athi River.

3.1.4 Service standards

Water Service Providers (WSPs) agree to meet the Minimum Service Level (MSL), which result from the Right to Water in Kenya. The key aspects of the MSL are listed in Table 4.

Table 5: Minimum Service Levels in the Water & Sanitation Sector (WAREB, 2018)

Water	○ Physical access (non-discriminatory) to a water outlet in urban areas with a 30 minutes cycle and in rural within a distance of 2km round trip. ○ Sustainability of access. ○ Acceptable water quality (in the urban setting treated water). ○ Affordability (regulated but not more than 5% of household income as maximum). ○ Reliability (>12h as minimum service hours).
Sanitation	○ Physical access to an acceptable toilet (household, public, working place, recreational facilities, learning institutions). ○ Storage, collection and treatment of human and other waste. ○ Evacuation of treated effluent according to minimum standards. ○ Clean Environment free of solid, liquid and gaseous wastes.

The overall development strategy of Machakos County is documented in three main outputs: The Manifesto of the Governor (2017-2022), the County Integrated Development Plan (CIDP) and the County Annual Development Plan (CADP). As described above, the CADP lists the annual programs and projects to be implemented by the County “through identifying the sub-sector, focus area, projects and key indicators” (CADP,p.6). The CADP is further guided and developed in coherence with the County Integrated Development Plan. Both development plans, especially the CADP clearly mention water & sanitation is as a key focus area and reveal that sanitation is a cross-sectoral development issue. Hence, sanitation aspects are included in development programs such as education or functional market infrastructures.

Besides the need for improvement towards strategic clarity, there is also a gap towards including onsite sanitation and their service management in the development goals. For

instance, there is a need to formalize the tariff for mechanical vacuum trucks discharging at the EPZA treatment ponds (Discussion with the WSTF).

In terms of urban development strategies, Mavoko has been part of several spatial development programs. It falls under the Nairobi Metropolitan Services Improvement Project (NaMSIP) by the World Bank, which aims to strengthen urban services and infrastructure in the Nairobi Metropolitan Region. In addition, the low-income areas of Mavoko also have been part of several "slum upgrading" programs as they are considered of the larger Nairobi area. For instance, Mavoko has been part of the "Sustainable Neighbourhood Program" (SNP) by UN-Habitat under the Kenya Slum Upgrading Program (KENSUP), (UN-Habitat 2008). Nonetheless, there is a need for a spatial development specifically for Mavoko.

Furthermore, the County Water Act of 2014 informs on a need for a County Policy on Water and Sanitation as strategic guidance for the Water Act. So far, such a policy has not been published and there is no indication that one is under process.

3.2 Outputs

3.2.1 Monitoring and reporting access to services

The *Impact* Report by the Water Services Regulation Board (WASREB) is the main tool and for monitoring the performance of Kenya's water services sector. It compares the performances of the water utilities and services providers on county level and offers more detail on city level. There are nine key indicators, which are: "Water Coverage, Drinking Water Quality, Hours of Supply, O+M Cost Coverage, Personnel Expenditure as a % of O+M Costs, Revenue Collection Efficiency, Non-Revenue Water, Staff Productivity and Metering Ratio" (WASREB, 2018). The performance of each Kenyan utility is assessed through a web-based Water Regulation Information System (WARIS) and crosschecked with quarterly monitoring and evaluation reports from utilities.

Through comparison, the report is meant to create competition in the sector and thus creating impetus for institutions to improve their performance. Therefore, it is also a source to hold stakeholders accountable (WASREB Online) and protect the rights of consumers. As a next step, WASREB is in the process of developing new regulatory instruments to monitor the performance of utilities in low income areas. These include guidelines on pro-poor services and on kiosks management (WASREB 2018).

A self-evaluation of the Machakos County Government on their performance in the water service sector revealed a medium confidence in Monitoring and Evaluation (M&E) processes on the County as well as the capacities to carry out these M&E activities. The County appeared confident though that M&E results used to inform and improve sanitation program implementation in the county (Water and Sanitation Program 2014).

Since 2006, Community Health Workers play an important role in data collection on household in Kenya. The Kenyan Ministry of Health has strengthened their position in providing a structured reporting tool, which also collects data on WASH (Water, Sanitation and Hygiene)

access and practices (Kavoo et al. 2016). This data is then populated in the “District Health Information Database System 2” which is a free and open source health management data platform used by multiple organizations and governments worldwide (Openhealth News online). However, for Machakos County has not controlled the quality of data collected, nor has been formally evaluated in order to assess WASH practices in the county (Kavoo et al. 2016).

4 Stakeholder Engagement

The three main reports that were used for the development of the SFD grid were enriched and crosschecked with other data and reports found from institutions such as MAVWASCO or the World Bank. Moreover, relevant stakeholders were engaged, however with moderate success.

Two private companies selling and operating onsite treatment solutions (bio-box) were approached via phone and email, yet the only confirmation received was that Mavoko/Athi River is their busiest market.

Through the help of the WSTF, the Technical Manager of MAVWASCO as well as the County Environment Officer were approached. They both were provided with a SFD Draft, the assumptions being made and reacted positive towards a follow-up discussion. However, feedback towards the Draft is yet awaited. Instead, a phone conversation with a contact of the WSTF was fruitful and enriched the process understanding of the service delivery in Mavoko.

There is the chance that county standards on sanitation management are missing. The WSTF and the County Environment Officer were asked for a documentation on important county level regulations, however besides the County Water Act 2014, he only referred to national level documents.

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7 Appendix

7.1 Appendix 1: Tracking of Engagement

Table 6: Tracking of Stakeholder Engagement (2018)

Stakeholder	Group	Purpose of Engagement	Date
WSTF	Government Institution	Connection with further stakeholder in the group / KII 1	27.08.2018 03.09.2018 05.09.2018 12.09.2018
WSTF	Government Institution	Data Collection /KII 2	12.09.2018
MAVWASCO	Government Institution	KII 3	06.09.2018 07.09.2018
County Authority for Environment	Government Institution	KII 4	06.09.2018 10.09.2018 12.09.2018 14.09.2018
WSS Provider	Private Sector	Data Collection / KII 5	30.08.2018 03.09.2018
WSS Provider	Private Sector	Data Collection	29.08.2018 06.09.2018 07.09.2018
WASH Expert	Private Sector	Data Collection	29.08.2018 03.09.2018

7.2 Appendix 5: Machakos County Physiographic Characteristics

Table 7: Machakos County Physiographic Characteristics (CIDP, 2015)