



SFD Promotion Initiative

Bikaner India

Final Report

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SFD Report Bikaner, India, 2016

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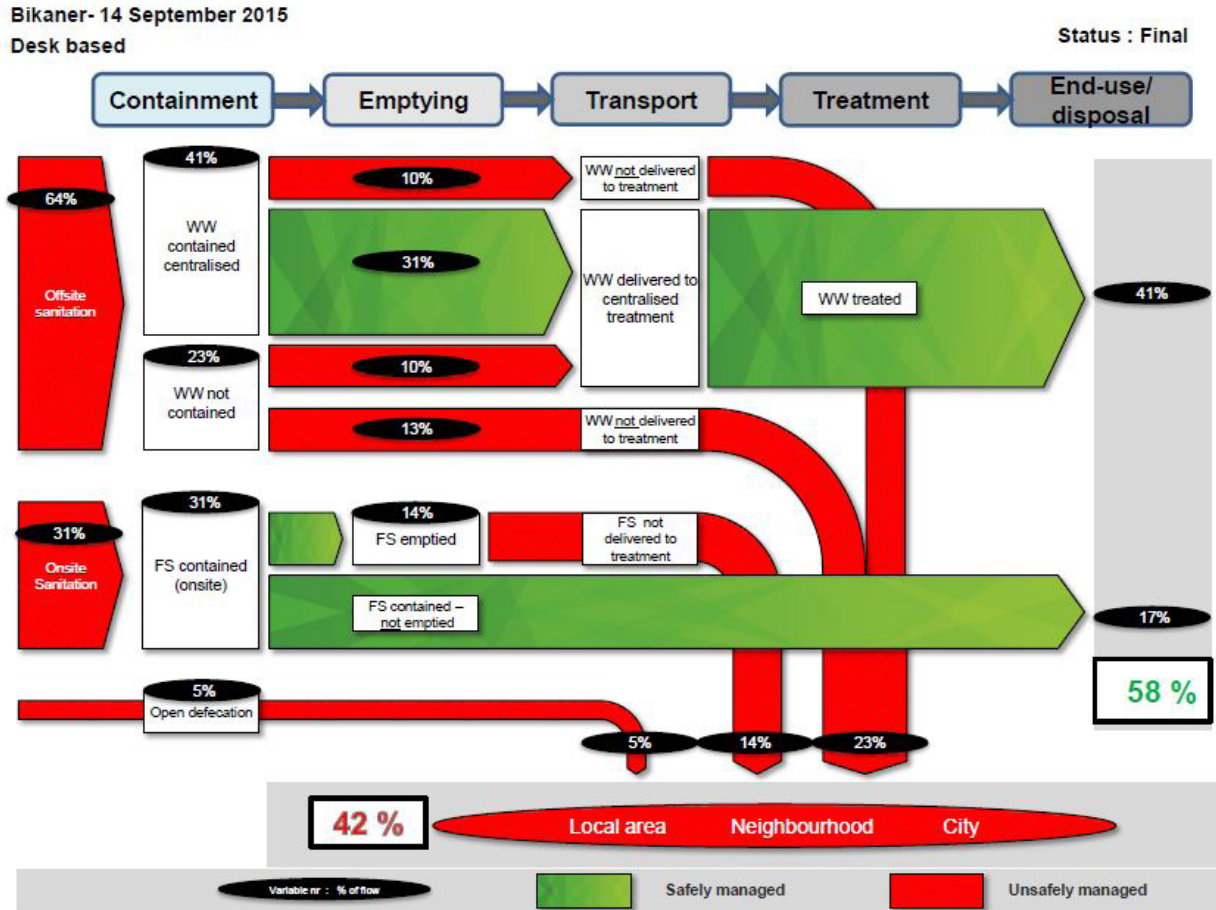
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1. The Diagram



2. Diagram information

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3. General city information

Bikaner city lies in the northwest region of Rajasthan state in northern India. The city is the administrative headquarters of Bikaner district. It was formerly the capital of the princely state of Bikaner. Situated in the middle of the Thar desert, it has hot desert climate with very little rainfall and extreme temperatures. In summers temperature can exceed 45 °C, and during the winters it may dip below freezing temperature (CII, 2015).

The population of city as per the Census 2011 is 644,406. The density of city is 4,157 persons per sq.km which is very high when compared to state average of 201 persons per sq.km. Total slum population is 121,855 representing 18.9% of the total population (Census of India, 2011).

Municipal boundary has been chosen for the current study. It comprises of an area of 155 sq.km (BMC, 2015).

4. Service delivery context

In 2008, the Ministry of Urban Development (MoUD) issued the National Urban Sanitation Policy (NUSP). The policy aims to: raise awareness, promote behaviour change; achieve open defecation free cities; develop citywide sanitation plans; and provide 100% safe confinement, transport, treatment and disposal of human excreta and liquid wastes. The NUSP mandates states to develop state urban sanitation strategies and work with cities to develop City Sanitation Plans (CSPs). Furthermore, it explicitly states that cities and states must issue policies and technical solutions that address onsite sanitation, including the safe confinement of faecal sludge (FS) (USAID, 2010).

The objectives of NUSP are to be realized through CSPs and state sanitation strategies. As of now there are very few cities which have finalized their CSPs, and those plans are also not implemented. This remains a major drawback in implementation of NUSP.

The advisory note on septage management in urban India, issued by MoUD in 2013, recommends supplementing CSPs with Septage Management Sub-Plan (SMP). Still septage management in India is not prominent due to lack of knowledge, consideration of septage management as an interim solution, lack of sufficient funding and many other socio-political issues.

There are no specific legal provisions relating to septage management, but there are a number of provisions relating to sanitation services and environmental regulations, which majorly stems from, The Environment (Protection) Act, 1986 and the Water (Prevention and Control of Pollution) Act. Municipal acts and regulations usually refer to management of solid and liquid wastes but may not provide detailed rules for septage management (MoUD, 2013).

5. Service outcomes

Overview on technologies and methods used for different sanitation systems through the sanitation service chain is as follows:

Containment: There is sewerage network in some part of the city. Significant number of households do not have onsite sanitation system; the user interface discharges directly to open drains. Peri-urban areas, within municipal boundary, are dependent on lined pits which are locally known as “Kuii”. The pits are constructed circular in shape with diameter of 1.5 to 1.8m, and a depth varying from 4.5 to 15m. These pits are properly covered at the top and are



Figure 1: WC to open drains (Source: Shantanu & Rahul/CSE, 2015)

well maintained. These popular pits are referred as septic tanks in Census 2011.

Emptying: Bikaner Municipal Corporation doesn't provide septage emptying service. The city is dependent on one private emptier with one vacuum tanker of 5,500 litres capacity. The emptying fee is INR 1500/- (22 USD) per trip. Emptying frequency is 20 to 30 years. On an average a private vacuum tanker empties 30 pits per month which also includes services in rural areas, outside municipal boundary. There are no instances of manual emptying reported (S R Garu 2015, pers. comm., 12 March).

Transport: Private emptier transport septage by truck mounted vacuum tanker. Sewage is conveyed to Sewage Treatment Plants (STP) through three Sewage Pumping Stations (SPS) along with trapped open drains, generally open drains are lined.

Treatment: There are three STPs based on Waste Stabilization Pond (WSP) technology with total capacity of 38 MLD. There are no treatment facilities for septage.

End-use/Disposal: The emptied septage is discharged onto barren land at outskirts of the city (S R Garu 2015, pers. comm., 12 March). The treated sewage is used for cultivating vegetables at Vallabh garden. The treated sewage from 12 MLD STP is discharged onto land (BMC, 2015a). There are no separate treatment facilities for septage.



Figure 2: Treated wastewater disposal point at Vallabh Garden (Source: Shantanu & Rahul/CSE, 2015)

According to Census, 64% of city is dependent on offsite systems, population connected to sewer line is 41% and user interface directly discharging in open drain is 23%. 10% of waste water is lost in transmission via sewer lines and 13% is lost in transportation via open drains. Around 41% waste water is treated at STP which also includes 10% of waste water tapped from open drains.

Rest of the 31% of the city is dependent on onsite sanitation systems (OSS), out of which 23% is dependent on septic tanks and 8% on pits. The public latrines are connected to septic tanks and hence are incorporated in onsite systems. Lined pits with semi-permeable membrane and open bottom are quite common in Bikaner, but in Census these are referred as septic tanks. Since the ground water table is very low, these pits are considered contained.

There is no clear differentiation between volume of FS infiltrated and septage emptied from the pits, hence it's assumed to be 50% each. But since 90% people are getting their pits emptied, around 14% of FS is emptied and 17% of FS is left in the pits, which includes infiltration of water as well. 5% of population practices open defecation.

6. Overview of stakeholders

The 74th Constitutional Amendment Act of 1992 reformed the sector by transferring responsibility for domestic, industrial, and commercial water supply and sewerage (WSS) from state agencies, such as Departments of Public Health Engineering and State Water Boards, to Urban Local Bodies (ULBs). This transfer has resulted in a variety of implementation models, as well as lack of clarity in allocation of roles and responsibilities between state and local agencies, which sometimes result in large gaps in implementation (USAID, 2010).

The following stakeholders are responsible for sanitation service delivery in Bikaner:

Key Stakeholders	Institutions / Organizations
Public Institutions	Public Health Engineering Department (PHED), Bikaner Municipal Corporation (BMC), Urban Improvement Trust (UIT) Rajasthan Pollution Control Board (RPCB)
Private Sector	Private emptier

Table 1: Key stakeholders (Source: compiled by CSE, 2015)

PHED and UIT are responsible for planning, designing and construction of sewerage system. Operation and maintenance comes under Bikaner Municipal Corporation (BMC) but presently the functions have not been transferred to BMC and PHED is maintaining the STPs. The city corporation has no regulation on septage management in Bikaner.

One private emptier is responsible for septage management, providing services within the city and some rural areas nearby. PHED and RPCB are responsible for monitoring and evaluation of STPs.

7. Credibility of data

One key source of data is used; Census of India, 2011. The data is crosschecked and updated by key informant interviews. Five KIIs have been conducted with different stakeholders.

Data on containment is available in Census. Data on emptying and transport is collected by KIIs and field visit. However most of the data is qualitative.

Some of the issues and challenges are listed below:

- o Data insufficiency and non-availability



- o Accuracy: Discrepancy observed between Census data and actual ground situation- No proper septic tanks found, lined pit with open bottom prevalent all over the city
- o Data available at different time lines
- o Limited data available on reuse (formal / informal)

Assumptions followed for preparing SFDs:

- o Data provided by Census, 2011 is correct
- o Sewer connections on ground are as defined in Census, 2011
- o Volume of waste water generated is 80 % of water supplied
- o 90% of people dependent on OSS get their systems emptied, when full

8. Process of SFD development

Data is collected through secondary sources, and then city is visited to conduct KIIs with relevant stakeholders, to fill in the gaps in data and to crosscheck the data collected.

To start with, a relationship between sanitation technologies defined in Census of India and the ones defined in project is established.

The data is fed into the calculation tool to calculate the excreta flow in terms of percentage of population.

Overall 58% of excreta is safely managed in the city and rest of the 42%, which also includes 5% of city defecating in open, is shown unsafe in SFD.

Limitations of SFD:

It's dependent on secondary data and KIIs and true picture of the city may differ.

The data available is at different timelines, for example data on containment is from Census 2011, and data on emptying and transportation is collected through KIIs conducted in 2015.

Whether excreta is safely managed or not is dependent on whether the system is contained or not, and not on whether waste is safely handled.

9. List of data sources

Below is the list of data sources used for the development of SFD.

- o Published reports and books:
 - Census of India 2011, House listing and Housing data, Government of India
 - Service levels in water and sanitation sector, MOUD, 2012.
 - Excreta Matters- volume 2, Centre for Science and Environment, 2012
- o KIIs with representatives from
 - Government agencies: BMC, PHED
 - Service providers:
 - Private emptiers
- o Websites/web links:
 - <http://bikanermc.org/>

Bikaner, India, 2015

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Abbreviations

BIS	Bureau of Indian Standard
BMC	Bikaner Municipal Corporation
CAA	Constitutional Amendment Act
CII	Confederation of Indian Industry
CGWB	Central Ground Water Board
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organization
CSE	Centre for Science and Environment
CSP	City Sanitation Plan
FS	Faecal Sludge
GoR	Government of Rajasthan
KII	Key Informant Interview
LPCD	Litres Per Capita per Day
MoUD	Ministry of Urban Development
MSL	Mean Sea Level
NIUA	National Institute of Urban Affairs
PHED	Public Health and Engineering Department
RSPB	Rajasthan State Pollution Control Board
SFD	Shit Flow Diagram
SLB	Service Level Benchmarks
SMP	Septage Management Plan
SPS	Sewage Pumping Station
STP	Sewage Treatment Plant
SWM	Solid Waste Management
UIT	Urban Improvement Trust
USAID	United States Agency for International Department
WW	Waste Water



1 City context

Bikaner lies in the northwest region of Rajasthan state. The city is the administrative headquarters of Bikaner district. It was formerly the capital of the princely state of Bikaner. The strategic location of Bikaner on the ancient caravan routes made Bikaner a major trade center; these routes linked central Asia and north Asia with Gujarat seaports (CII, 2015).

The population of city as per the Census 2011 is 644,406. The area of Municipal Corporation is about 155 sq.km. The density of city is 4157 persons per sq.km which is very high when compared to state average of 201 persons per sq.km. Total slum population is 121,855 representing 18.9% of the total population. The population growth rate of the city is given in the following table.

Table 1: Population growth rate

Census year	Population	Growth rate (%)
1971	2,08,900	-
1981	2,80,400	34.2
1991	4,16,300	48.5
2001	5,29,690	27.2
2011	6,44,406	21.7

The city is located at 28°1'N and 73°19' E. The magnificent forts and palaces, made of reddish-pink sandstone, bear testimony to its rich historical and architectural legacy. The city is Asia's biggest wool market and a leading carpet yarn manufacturing centre in the world. Bikaner is still calm and less crowded tourist destination (CII, 2015).

The city is well connected to some of major Indian cities via railways and roadways. It is 320 km and 445 km distance from Jaipur and New Delhi respectively. The city has direct rail connections to Delhi, Kolkata, Chennai, Mumbai, Kanpur, Guwahati and other cities (CII, 2015).

The city is situated in the middle of the Thar desert and has a hot desert climate. It has high temperatures during summer. The maximum temperature rises to around 48° C in summer and minimum dips to 4° C in winters. It receives very nominal rainfall throughout the year. The scarcity of water has affected the vegetation of the area. The soil type of the area is majorly alkaline (CII, 2015).

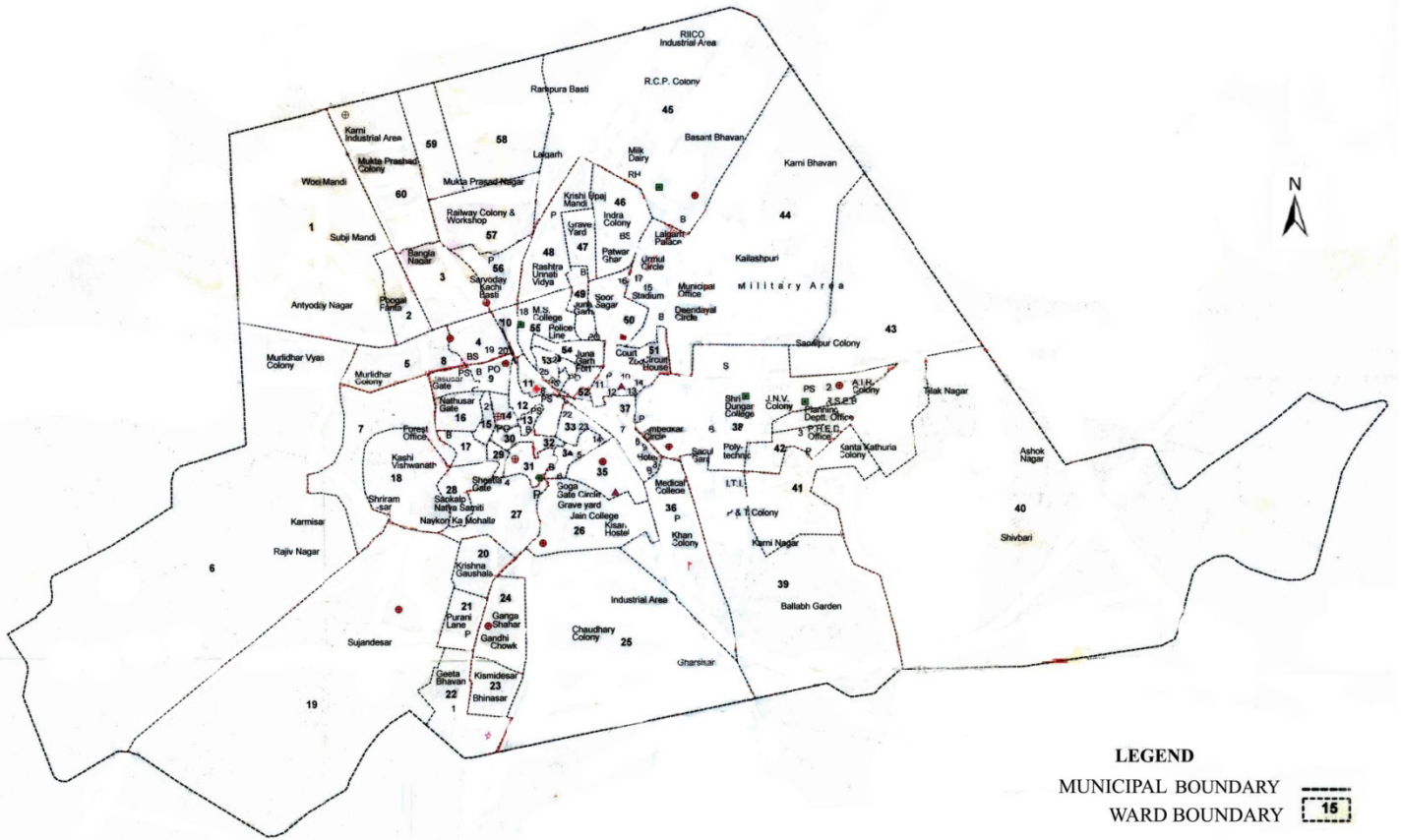


Figure 1 Ward map of Bikaner



2 Service delivery context description/analysis

2.1 Policy, legislation and regulation

2.1.1 Policies, legislations and regulations at national Level

In 2008, the Ministry of Urban Development (MoUD) issued the National Urban Sanitation Policy (NUSP). The policy aims to: raise awareness, promote behaviour change; achieve open defecation free cities; develop citywide sanitation plans; and provide 100% safe confinement, transport, treatment and disposal of human excreta and liquid wastes. The NUSP mandates states to develop state urban sanitation strategies and work with cities to develop City Sanitation Plans (CSPs). NUSP specifically highlights the importance of safe and hygienic facilities with proper disposal and treatment of sludge from on-site installations (septic tanks, pit latrines, etc.) and proper operation and maintenance (O&M) of all sanitary facilities. Furthermore, it explicitly states that cities and states must issue policies and technical solutions that address onsite sanitation, including the safe confinement of faecal sludge (FS) (USAID, 2010). The objectives of NUSP are to be realized through CSPs and state sanitation strategies. As of now there are very few cities, which have finalized their CSPs, and those plans are also not implemented. This remains a major drawback in implementation of NUSP.

The advisory note on septage management in urban India, issued by MoUD in 2013, recommends supplementing CSPs with Septage Management Sub-Plan (SMP) as a part of the CSP, being prepared and implemented by cities. Septage here broadly refers to not only fecal sludge removed from septic tanks but also that removed from pit latrines and similar on-site toilets. This advisory provides references to Central Public Health and Environmental Engineering Organisation (CPHEEO) guidelines, Bureau of Indian Standard (BIS) standards, and other resources that users of this advisory may refer to, while preparing their SMP (MoUD, 2013). It clearly discusses on techno- managerial and socio- economic aspects of septage management in India and provides guidelines for Urban Local Bodies (ULBs) to plan and implement SMP.

There are no specific legal provisions relating to septage management, but there are a number of provisions relating to sanitation services and environmental regulations, which majorly stems from, The Environment (Protection) Act, 1986 and the Water (Prevention and Control of Pollution) Act, 1974. It also applies to households and cities with regard to disposing wastes into the environment. ULBs/ utilities also have to comply with discharge norms for effluent released from sewage treatment plants (STPs) and to pay water cess under the Water Cess Act, 1977. The ULB is responsible for ensuring the safe handling and disposal of septage generated within its boundaries, for complying with the Water Act for meeting all state permit requirements and regulations (CSE, 2010). Municipal acts and regulations usually refer to management of solid and liquid wastes but may not provide detailed rules for septage management (MoUD, 2013).

The Prohibition of Employment as Manual Scavengers and their Rehabilitation Act is enacted in 2013. This act prohibits employment of manual scavengers, installation of insanitary latrines. It has laid strong emphasis on rehabilitation of manual scavengers. This act has become instrumental in eradicating manual scavenging from India.

2.1.2 Policies, legislations and regulations at state level and ULB level

According to Constitution of India, water and sanitation is a state subject. Statutory powers are conferred to the state for making laws on water and sanitation.

The Rajasthan State Sewerage and Wastewater Policy, 2015 aims to improve public health through the creation of sustainable sanitation methods that serve all people living in the state of Rajasthan, especially



poorer segments of the population. Priorities include the creation of City Sanitation Plans (CSPs) in each urban area and improving onsite and offsite sanitation, as well as wastewater reuse. Establishing an efficient, effective, affordable and accountable system for managing urban sewage and septage is one of the core principles of the policy. In addition, it provides details on septage collection, treatment and disposal.

Rajasthan Municipalities Act, 2009 - This act has the provision to consolidate and amend the law relating to municipalities. As per this act, all the privies, cesspools within the municipality are under the control of the municipality. Removal of night soil is listed as one of the municipal functions.

2.1.3 Institutional roles

The MoUD is the nodal ministry for policy formulation and guidance for the urban water supply and sewerage sector. The ministry's responsibilities include broad policy formulation, institutional and legal frameworks, setting standards and norms, monitoring, promotion of new strategies, coordination and support to State Programmes through institutional expertise and finance. The ministry is also responsible for managing international sources of finance. The Central Public Health and Environmental Engineering Organisation (CPHEEO), created in 1953, is the technical wing of the MoUD, which advises the ministry in all technical matters and collaborates with the State Agencies about water supply and sanitation activities. CPHEEO plays a critical role in externally funded and special programmes. CPHEEO also plays a central role in setting design standards and norm setting for urban water supply and sanitation (Planning Commission, 2002).

The 74th Constitutional Amendment Act of 1992 reformed the sector by transferring responsibility for domestic, industrial, and commercial water supply and sewerage (WSS) from state agencies, such as Departments of Public Health Engineering and State Water Boards, to Urban Local Bodies (ULBs). This transfer has resulted in a variety of implementation models, as well as lack of clarity in allocation of roles and responsibilities between state and local agencies, which sometimes leave large gaps in implementation (USAID, 2010).

Management and delivery of urban basic services in Rajasthan is governed by various institutions. The following table provides details of the institutions responsible for policy making, service provision and regulation of urban services.

Table 2: Institutional roles and responsibilities

Institution	Roles and responsibilities
The Department of Local Self Government (DLSG)	This department controls all the municipalities. It also performs monitoring and co-ordination function at the state level for all the 188 municipal bodies of the state.
Public Health and Engineering Department (PHED)	Responsible for: water supply and treatment; setting water tariffs; construction of STPs and sewerage system operations and maintenance of sewer system and STPs.
Bikaner Municipal Corporation (BMC)	Responsible to establish By-Laws; for septage management, operation and maintenance of sewer system and STPs.
Rajasthan Pollution Control Board (RPCB)	Responsible for the monitoring and enforcement of environmental acts and rules enacted by the national and state governments. It plays an important regulatory role for environmental protection, which is closely tied to sanitation and wastewater management.
Urban Improvement Trust (UIT)	The main functions assigned to UITs include formulation of various schemes for development of the city, matters related to preparation of master plan, land acquisition and disposal, preparation of land layout, formation of open areas, provision of infrastructure facilities and sanitary arrangements, construction of buildings, streets and other public amenities such as water supply, street lighting, drainage, etc.

Several institutions are involved in management of sanitation activities with varying roles. While most of the state level institutions are responsible for policy setting, oversight and monitoring, PHED, UIT, BMC are responsible for actual implementation. Their roles are often overlapping. The Municipal Acts place most of the responsibilities in the area of sanitation to BMC.

2.1.4 Service provision

Institutional arrangements for water supply and sanitation in Indian cities vary greatly. Typically, a state-level agency is in charge of planning and investment, while the local government (Urban Local Bodies) is in charge of operation and maintenance (NIUA, 2005). Some of the larger cities have developed municipal water and sanitation utilities that are legally and financially separated from the local government. However, these utilities remain weak in terms of financial capacity. In spite of decentralization, ULBs remain dependent on capital subsidies from state governments. Tariffs are also set by state governments, which often even subsidize operating costs (Planning Commission, 2002a).

Furthermore, when no separate utility exists, there is no separation of accounts for different activities within a municipality. Some states and cities have non-typical institutional arrangements. For example, in Rajasthan the sector is more centralized and the state government is also in charge of operation and maintenance, while in Mumbai the sector is more decentralized and local government is also in charge of planning and investment (NIUA, 2005).



2.1.5 Service standards

1. Service Level Benchmarks (SLB), 2008: Issued by the Ministry of Urban Development in 2008, which seeks to (i) identify a minimum set of standard performance parameters for the water and sanitation sector that are commonly understood and used by all stakeholders across the country; (ii) define a common minimum framework for monitoring and reporting on these indicators and (iii) set out guidelines on how to operationalize this framework in a phased manner. SLB refers to improving service through better provision and delivery. It evaluates the performance of ULBs in providing urban services.
2. General Standards for Discharge of Environmental Pollutants Part-A: Effluents-The Environment (Protection) Rules, 1986 (Schedule VI): Issued by Central Pollution Control Board (CPCB), a statutory organisation constituted in September, 1974 under the Water (Prevention and Control of Pollution) Act, 1974.
3. Manual on Sewerage and Sewage Treatment, Second Edition, 2013: This manual has been developed by Central Public Health and Environmental Engineering Organization (CPHEEO). It provides detailed design and guidelines for various technologies of wastewater management.
4. Code of Practice for Installation of Septic Tanks, 1985: Issued by Bureau of Indian Standards. It is a national standards setting body of India. The code specifies standards and design consideration for installation of septic tanks.

3 Service outcomes

Service outcome analysis is based on secondary sources. One key source of data is used; Census of India, 2011. The data is crosschecked and updated by key informant interviews (KIIs). Data on containment is available in Census. Data on emptying and transport is collected by KIIs. However most of the data is qualitative.

3.1 Overview

This section presents the range of sanitation technologies/infrastructure, methods and services designed to support the management of FS and/or Waste Water (WW) through sanitation service chain in Bikaner. The details on quantitative estimations are presented in table below and following sections:

Table 3: Sanitation technologies and contribution of excreta in terms of percentage of population

S. No.	Sanitation technologies and systems as defined by:		SFD reference variable	Percentage of population
	Census of India	SFD promotion Initiative		
1	Piped sewer system	User interface discharges directly to centralized separate sewer	T1A1C2	40.9%
2	Septic tank	Lined pit with semi-permeable walls and open bottom, no outlet or overflow, general situation	T1A5C10	26.6%
3	Other systems	User interface discharges directly to open ground	T1A1C8	6.4%
4	Pit latrine with slab	Lined pit with semi-permeable walls and open bottom, no outlet or overflow, general situation	T1A5C10	3.3%
5	Pit latrine without slab	Unlined pit no outlet or overflow, general situation	T1A6C10	0.4%
6	Night soil disposed into open drain	User interface discharges directly to open drain or storm drain	T1A1C6	16.5%
7	Service latrine	User interface discharges directly to 'don't know where'	T1A1C9	0.3%
8	Public latrine	Lined pit with semi-permeable walls and open bottom, no outlet or overflow, general situation	T1A5C10	0.4%
9	Open defecation	Open defecation	T1B11C7 TO C9	5.1%



3.1.1 Sanitation facilities

This section presents existing sanitation facilities in slums, institutions and commercial establishments.

Public/ Community toilets: As per Census of India, 2011, 94 % of the city's population has individual toilets. The dependency on public toilets is very less. There are two community and five public toilets (BMC, 2015).

Institutional, Industrial and Commercial areas: There are 155 schools, 5 universities, 21 colleges, 15 hospitals in the city (BMC, 2015). Rani bazaar is an industrial area located in centre of the city. It holds around 190 production units. This is provided with water supply and sewerage by PHED. The markets in the city are covered by sewerage system (GoR, 2016).

Due to the lack of data on excreta generated from institutions, industrial areas, restaurants and hotels. These establishments have not been taken into consideration for production of SFD.

3.1.2 Containment

The existing sewerage network covers less than half of the population. A significant population of the city doesn't have any type of containment, i.e. the night soil is disposed directly to open drains. 90% of the open drains are lined (BMC, 2015). The rest of the city is dependent on septic tanks which are generally not adhering to design prescribed by the Bureau of Indian Standards (BIS). In fact, the septic tank is commonly called as *Kuii* (BMC, 2015a). *Kuii* is a pit with diameter of 1.5m to 1.8m and depth of 4.5m to 15m. It is a lined pit with semi-permeable walls and open bottom with no outlet or overflow. It is covered with a slab. The pit gets filled in 20 to 30 years. This kind of containment is prevalent in peri-urban area (S R Garu 2015, pers. comm., 12 March).

3.1.3 Emptying

BMC doesn't provide septage emptying service. The city is dependent on only one private emptier with one vacuum tanker of 5,500 litres capacity. The emptying fee is INR 1500/- (22 USD) per trip. Emptying frequency is 20 to 30 years. On an average, private vacuum tanker empties 30 pits per month which also include trips outside the city. Earlier the private emptier used plastic tanks of 1000 litres capacity mounted on a mini truck with a generator set for suction to empty the pits. The emptier doesn't use protective measures like use of gloves, boots or masks or any other safety gear (S R Garu 2015, pers. comm., 12 March).

3.1.4 Transportation

The truck mounted vacuum tanker is fabricated by a metallurgy workshop in Haryana (S R Garu 2015, pers. comm., 12 March). After emptying septage from the *Kuii*, it is transported to outskirts of the city. The city is surrounded by desert. The sewage generated from the households is conveyed through two sewage pumping stations (SPS) located at public park and Sudharsan Nagar. Households connected directly to open drains; the sewage is intercepted at SPS located in Gangasehar and conveyed to STP (BMC, 2015a).

3.1.5 Treatment and disposal

There are three Sewage Treatment Plants (STPs) based on Waste Stabilization Pond (WSP) technology. The total capacity of the 3 STPs is 38 MLD. A 20 MLD sewage treatment plant is located at Vallabh garden, 12 MLD STP at Gangasehar and 6 MLD STP at Pugol road, which is not fully functional. The inlet BOD of 20 MLD STP is around 300 mg/l and the outlet BOD is 80 mg/l. The treated sewage is used for cultivating



vegetables at vallabh garden. The treated sewage from 12 MLD STP is discharged onto land (BMC, 2015a). There are no separate treatment facilities for septage. Private emptier discharges septage onto barren land in the outskirts of the city (S R Garu 2015, pers. comm., 12 March)

3.2 SFD matrix

The final SFD for the Bikaner is presented in appendix 7.3.

3.2.1 SFD matrix explanation

According to Census of India 2011, 64% of the city is dependent on offsite systems, population connected to sewerage network is 41% and user interface directly discharging in open drain or open ground is 23%, it is estimated that 10% of waste water is lost in transmission via sewer lines and 13% is lost in transportation via open drains. Around 41% waste water is treated at STP which also includes 10% of waste water tapped from open drains. Around 31% of the city is dependent on onsite sanitation systems (OSS), out of which 27% is dependent on septic tanks and 4% on pits. Assuming public latrine is connected to septic tank, it is incorporated in onsite system. Lined pits with semi-permeable membrane and open bottom are quite common in Bikaner, but in Census these are referred as septic tanks. Since the ground water table is very low, these pits are considered contained.

There is no clear differentiation between the volume of infiltrate and septage generated from these pits, hence to reduce the maximum error; it's assumed to be 50% each. As 90% people get their pits emptied, when full, it is estimated that around 14% of FS is emptied. FS (including infiltrate) left in pits is estimated to be 17%. 5% of the population still practices open defecation. Definition and estimation of different variables (used to make SFD) are explained below.

Table 4: Description of variables used in SFD

Variable	Description
W2	WW contained centralized (offsite)
W15	WW not contained (offsite)
W11	WW not delivered to treatment
W11a	WW not delivered to centralized treatment plant
W11c	WW not contained not delivered to treatment plant
W4a	WW delivered to centralized treatment plant
W4c	WW not contained but delivered to treatment plant
W5a	WW treated at centralized treatment plant
F2	FS contained (onsite)
F3	FS emptied
F3a	FS contained- emptied
F8	FS contained- not emptied
F11	FS not delivered to treatment
OD9	Open Defecation

Assuming Census figures are correct; W2 was estimated to be around 41%. It is assumed that 31% of WW would reach STP through sewer line hence W4a is estimated to be 31% and W11a as 10%. W15 is rounded



off as 23%, as it includes WW discharged into open drains i.e. 16.5%, WW discharged on open ground (defined as other systems in the Census) i.e. 6.4% and WW from service latrines i.e. 0.3%. 10% of WW from open drain is tapped and is reaching STP; hence W4c becomes 10% and W11c 13%. Since 100% WW reaching STP is treated, W5a becomes 41% (31%+10%). Total WW not delivered to the treatment plant, i.e. W11 comes out to be 23% (W11=W11a+W11c).

F2 is estimated to be around 31% and constitutes of 30.3% population dependent on lined pits with semi-permeable walls and open bottom (26.6% household septic tanks, 0.4% public toilet septic tanks and 3.3% pit latrine with slab) and 0.4% are dependent on unlined pits. Since there is no clear demarcation in the quantity of solid FS generated and infiltration generated from an onsite system, it is assumed to be 50% each. It is also assumed that 90% of the population (dependent on onsite systems) gets their system emptied when full. Therefore, out of 31% OSS dependent population, FS of 14% population is emptied; hence F3 is equal to 14%. Whereas FS contained but not emptied, i.e. F8 comes out to be 17%. F8 includes infiltrate as well. The emptied FS is discharged untreated in the environment; therefore F11 comes out to be 14%. 5% of population practice open defecation and hence OD9 is computed to be 5%.

It can be concluded that excreta of 58% population is managed safely in Bikaner city and 42% of excreta is discharged in environment untreated. Table 5 summarizes the percentage of the population using each sanitation technology and method along the service chain.

Table 5: Percentage of the population using each system technology and method

System Type	Containment	Emptying	Transport	Treatment	End-use/ disposal
Offsite	<p>T1A1C2 (Reference L1): 41% of the population is connected to centralised sewer, hence W2 is 41%.</p> <p>T1A1C6 (Reference L4): 16.5 % of the population is discharging their excreta directly to open drain.</p> <p>T1A1C8 & T1A1C9 (Reference L5): 6.4 % of the population is discharging their excreta directly to open ground and 0.3% discharging-don't know where.</p> <p>Total WW not contained (offsite), i.e.W15, adds up to 23%.</p>	Not applicable.	<p>WW of 31%of the population served by centralised sewers, reaches treatment facilities, hence W4a is 31%. It is assumed that 10% would be lost due to leakage, hence W11a=10%</p> <p>WW not contained, delivered to centralised treatment plant, i.e. W4c is 10%.</p> <p>Therefore WW not contained not delivered to centralised treatment plants, i.e. W11c, is 13%</p> <p>Total WW not delivered to treatment plant, i.e. W11, is 23%.</p>	<p>41% of the population has their WW treated, and therefore W5a is 41%.</p> <p>This also includes 10% of WW treated after tapping from open drains.</p>	<p>Treated WW is disposed into lake land and also used for irrigation sometimes.</p> <p>Total WW disposed untreated in local area comes out to be 23%</p>
Onsite	<p>31% of population is dependent on onsite sanitation systems, hence F2, FS contained is 31%</p> <p>T1A5C10 (Reference L11):30.3% of population is dependent on lined pit with semi permeable walls and open bottom</p> <p>T1A6C10 (Reference L11):0.4% of population is dependent on unlined pit</p>	<p>Since most of the population is getting their systems emptied, it is assumed 90% of population has their onsite technology emptied.</p> <p>Since there is no clear differentiation between % of septage and infiltrate, it is assumed to be 50% each. FS contained-emptied, i.e. F3a/F3 is 14%. FS contained- not emptied, i.e. F8, becomes 17 %</p>	<p>No FS is transported to treatment plant therefore FS not delivered to treatment plant, i.e.F11, is 14%.</p>	<p>No treatment facility exists hence no FS is treated, therefore FS treated, i.e. F5, is 0%.</p>	<p>All the FS emptied ends up in local area without any treatment.</p>
Open Defecation	5% of population practice open defecation and hence OD9 is computed to be 5%.				

3.2.2 Risk of groundwater contamination

According to 2011 data, the depth to water level of aquifers in Bikaner ranges from 8.54 to 111.70 mbgl during the pre monsoon season and 7.64 to 116.40 mbgl during the post monsoon season (CGWB, 2013). Data on faecal coliform contamination is not available.



4 Stakeholder engagement

4.1 Key informant interviews

The relevant departments were contacted through e-mail, letter, call and fax prior to a visit to the city. The purpose of the SFD study and depth of data required was conveyed through an introductory letter to respective departments. Overall, 5 KIIs were conducted with different stakeholders like government functionaries, private emptier, (see appendix 7.2). The Government of Rajasthan operates through its Department of local self-Government.

The city was visited as few documents were available on internet. The visit helped in collecting data, including unpublished reports. The KIIs and data collected helped in understanding the existing situation and upcoming development plans in the sanitation sector. Due to the limitation of desk-based study all the key stakeholders engaged in sanitation services could not be interviewed in person.



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7 Appendix

7.1 Stakeholder identification

Table 6: Stakeholder identification

No.	Stakeholder group	In Bikaner context
1	City council / Municipal authority / Utility	Bikaner Municipal Corporation
2	Ministry in charge of urban sanitation and sewerage	Department of Local Self Government, GoR
3	Ministry in charge of urban solid waste	Department of Local Self Government ,GoR
4	Ministries in charge of urban planning finance and economic development.	Department of Local Self Government, GoR
	Ministries in charge of environmental protection/	Environment Department, GoR
	Ministries in charge of health	Department of Medical Health and Family Welfare Department, GoR
5	Service provider for construction of onsite sanitation technologies	Local masons
6	Service provider for emptying and transport of faecal sludge	Private emptiers
7	Service provider for operation and maintenance of treatment infrastructure	Bikaner Municipal Corporation
8	Market participants practising end-use of faecal sludge end products	Farmers
9	Service provider for disposal of faecal sludge (sanitary landfill management)	N/A
10	External agencies associated with FSM services: e.g. NGOs, academic institutions, donors,	Private emptiers



7.2 Tracking of engagement

Table 7: Tracking of engagement

Name of the organisation	Name of the contact person	Designation	Date of engagement	Purpose of engagement
Bikaner Municipal Corporation	Mr Virender Kumar Verma	Commissioner	11/3/2015	Permission to collect data and information from officials.
Bikaner Municipal Corporation	Mr Ramesh Meena	Executive Engineer	11/3/2015	KII
Bikaner Municipal Corporation	Mr Anil Acharya	Health Officer	11/3/2015	KII
Bikaner Municipal Corporation	Mr Deepak Kansal	STPs- In charge	12/3/2015	KII and data collection
Public Health and Engineering Department	Mr Arun Sethyia	Assistant Engineer	12/3/2015	KII and data collection
N.A	S. R. Garu	Private emptier	12/3/2015	KII

7.3 SFD matrix

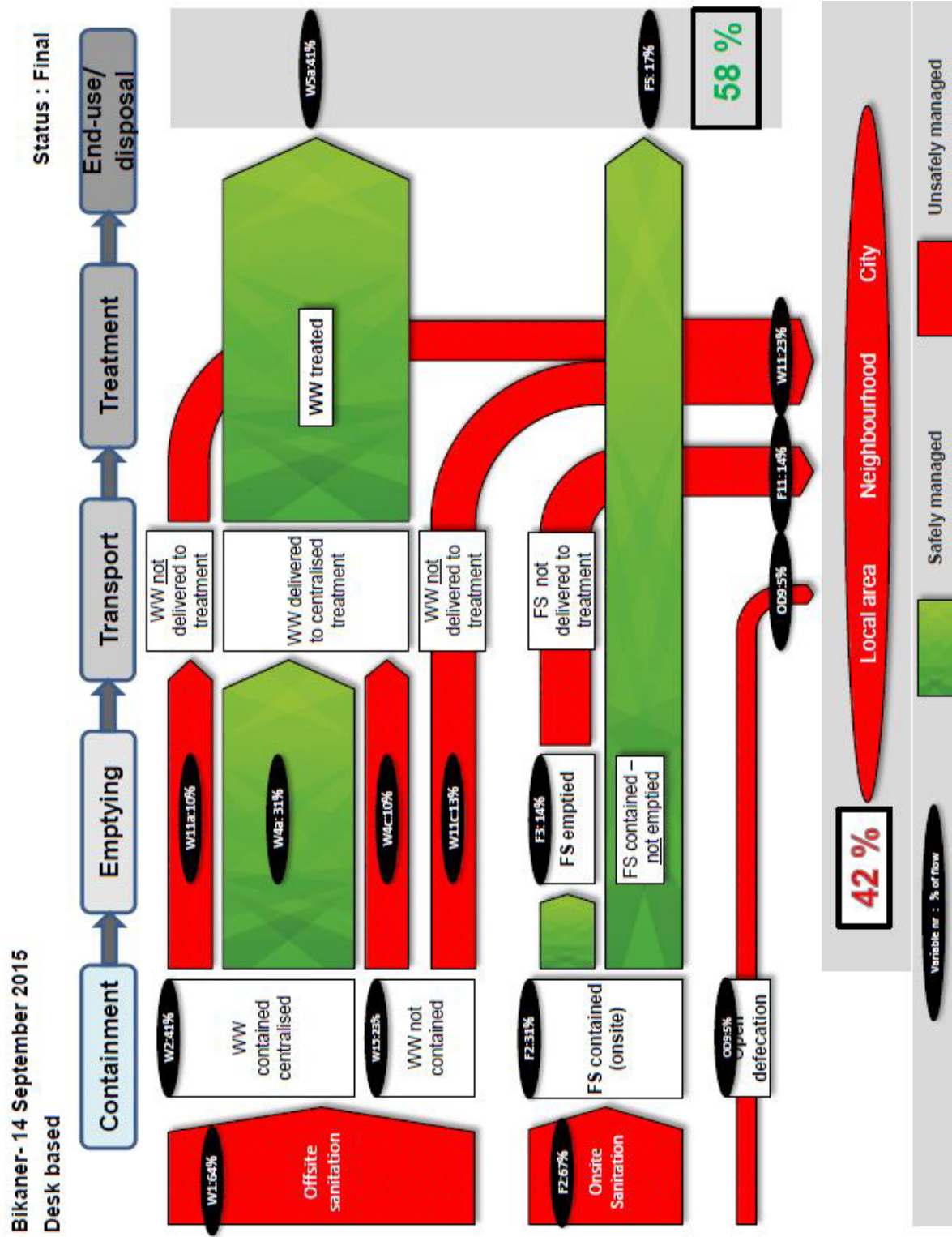


Figure 2: SFD matrix

7.4 Selected pictures taken during visit



Figure 3: Night soil disposed into open drain (Source: Shantanu & Rahul/CSE, 2015)



Figure 4: Kuii (lined pit with open bottom) (Source: Rahul/CSE, 2015)



Figure 5: Open drain(Source: Rahul/CSE, 2015)



Figure 6: Open drain interception at Gangasehar (Source: Shantanu /CSE, 2015)



Figure 7: Generator based suction pump (Source: Rahul/CSE, 2015)



Figure 8: Waste Stabilization Pond in Vallabh garden (Source: Shantanu/CSE, 2015)



Figure 9: Land disposal of treated sewage at Vallabh garden area (Source: Shantanu/CSE, 2015)



Figure 10: Cultivation of vegetables at Vallabh garden (Source: Rahul/CSE, 2015)

7.5 SFD graphic

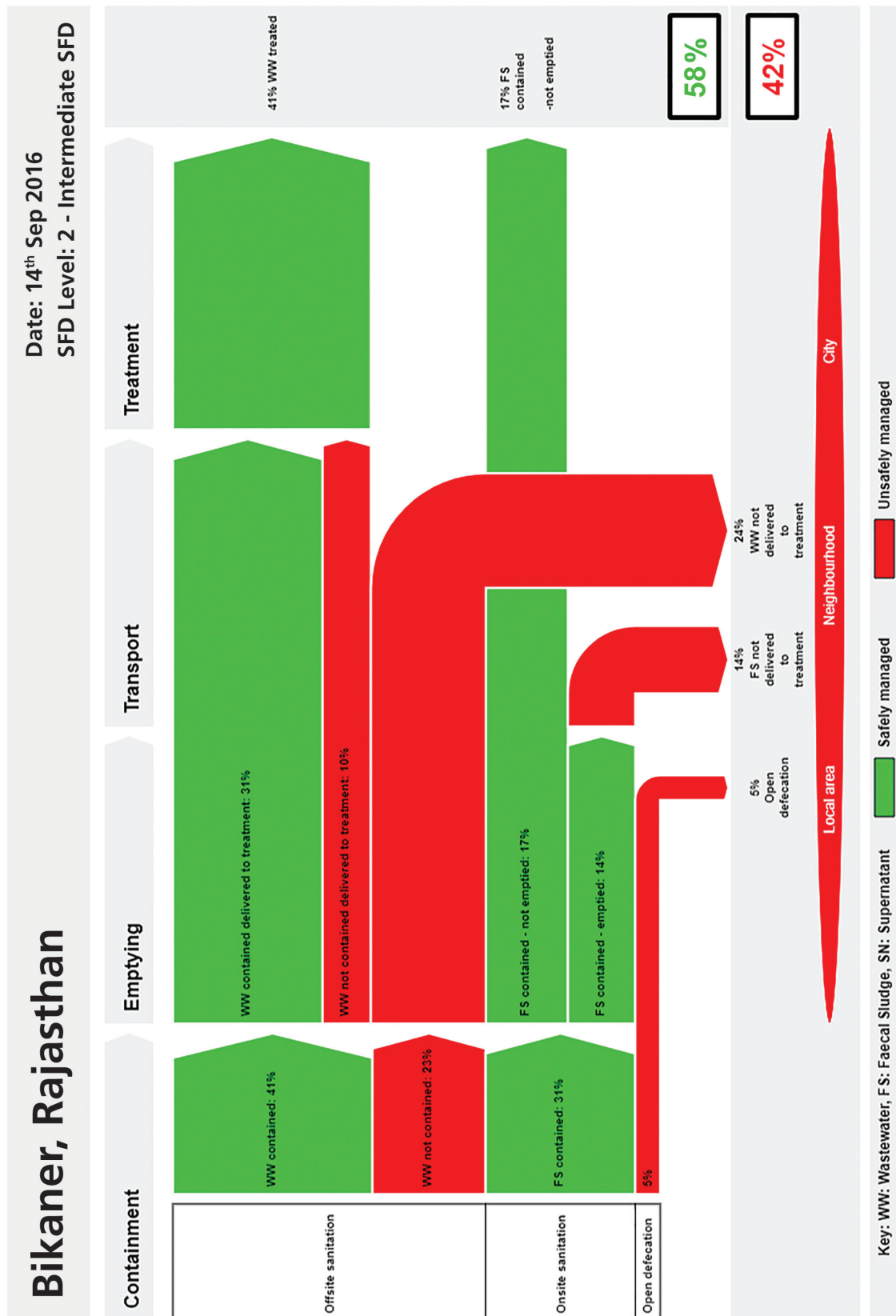


Figure 11: SFD graphic generated using graphic generator



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