SFD Promotion Initiative

Gwalior
India

Final Report

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sustainable sanitation alliance

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On behalf of Federal Ministry for Economic Cooperation and Development

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wsp water and sanitation program

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Sandec Sanitation, Water and Solid Waste for Development

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SFD Report Gwalior, India, 2016

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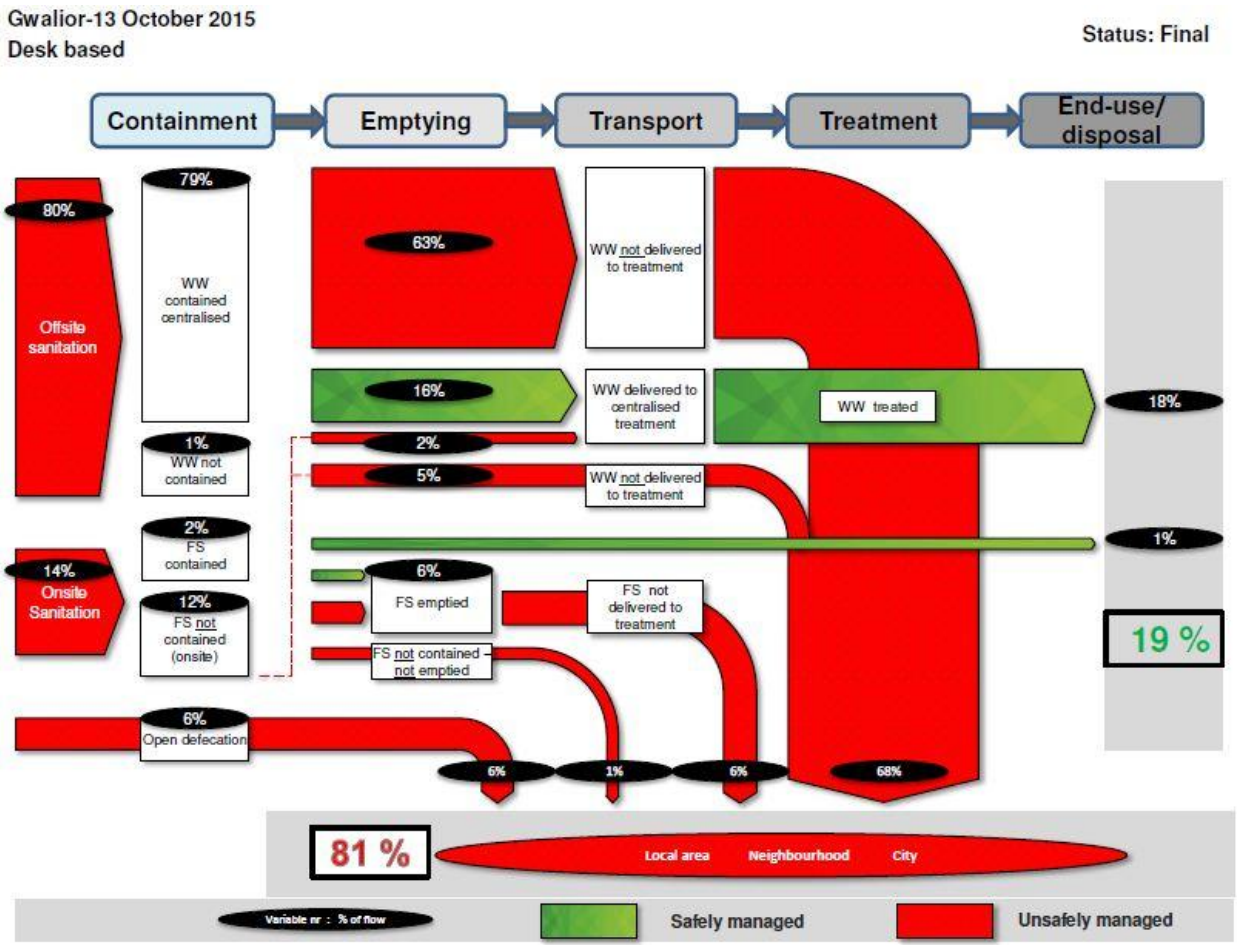
1. The Diagram



2. Diagram information

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3. General city information

Gwalior is a historical city in the Indian state of Madhya Pradesh. It is also the district headquarters. It is surrounded by industrial and commercial zones of neighbouring districts. It is one of the largest cities of Central India and is often referred to as the tourist capital of Madhya Pradesh (UD&ED, 2010).

The population of city as per the 2011 Census is 1,053,505. The density of city is 6,292 persons per sq.km which is very high when compared to state average of 319 persons per sq.km. Total slum population is 52,429 which is 17% of the total population (Census of India, 2011).

Municipal boundary has been chosen for the current study. It comprises of an area of 46.61 sq.km (GMC, 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 (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) Acts. 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 covering around 80% of the population. Rest of the city is dependent on septic tanks that are generally not adhering to design prescribed by Bureau of Indian Standards (BIS). The effluent from the septic tank flows into open drains.

Emptying: Presently, GMC has four vacuum tankers, which are used to empty septage on demand (UD&ED, 2010). There is no information on private emptiers. There are no instances of manual emptying reported.

Transport: GMC emptiers transport septage by truck mounted vacuum tankers to sanitary landfill site located at Chandoha Khurd Village, 12 km away from the city (GMC, 2015a). Sewage is conveyed to a Sewage Treatment Plant (STP) and river channels (UD&ED, 2010).

Treatment: There is one Sewage Treatment Plant (STP) based on Waste Stabilization Ponds (WSPs) technology with the capacity of 50 MLD to treat the sewage, only 17-20 MLD reaches to the STP. There are no treatment facilities for septage (UD&ED, 2010).

End-use/Disposal: The emptied septage is disposed in sanitary landfill site. Untreated and treated sewage is disposed into river channels, which is further used by farmers depending upon the requirement of farms (UD&ED, 2010).

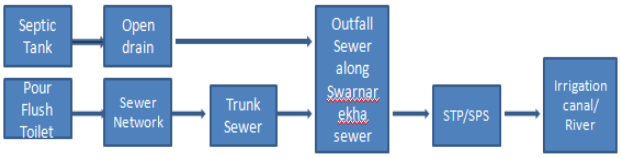

Figure 1: Schematic sketch of wastewater collection, conveyance and disposal system (UD&ED, 2010)

Figure 2: Outfall sewer along Swarnarekha River (Source: Shantanu/CSE, 2015)

According to Census of India, 2011, 80% of city is dependent on offsite systems, population connected to sewer is 79% and user interface directly discharging in open drain or open ground is 1%.

It is estimated that only 16% of wastewater (WW) reaches the STP and rest is delivered to irrigation canal without treatment. Though the city is widely covered with sewerage network, but due to limited treatment at STP, the discharge is shown unsafe in SFD. The public

toilets are assumed to be connected to sewerage network and hence are incorporated in off-site sanitation systems. 2% of WW is tapped from open drains to treat at STP in Morar.

Figure 3: Indiscriminate discharge of wastewater into irrigation channel without treatment (Source: Shantanu/CSE, 2015)

14% of the city is dependent on onsite sanitation systems (OSS), out of which 12% is dependent on septic tanks and around 2% on pits. Septic tank is not contained as it is connected to open drain but pit is contained as ground water table is more than 10 mbgl. A significant population (6% of the city) still practices open defecation.

It is difficult to determine the volume of effluent and septage generated from septic tanks, hence to reduce the maximum error; it's assumed to be 50% each. Therefore, around 6% of faecal sludge (FS), that is effluent, goes into open drain and rest is emptied from tanks whenever full. Some FS is always left in the tanks and is estimated to be 1%. Whereas FS from pits is considered contained and is calculated as 2% which includes infiltration of water as well.

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 the 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 Gwalior:

Key Stakeholders	Institutions / Organizations
Public Institutions	Gwalior Municipal Corporation (GMC), Public Health and Engineering Department (PHED) State Pollution Control Board (SPCB)

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

PHED is responsible for planning and designing of sewerage system. GMC is responsible for implementation, operation and maintenance of sewerage network.

GMC is responsible for septage management. They are providing services within the city. GMC/SPCB is responsible for performance monitoring of STPs.

7. Credibility of data

Two key sources of data are used; Census of India, 2011 and draft CSP, 2010. The data is crosschecked and updated by Key Informant Interviews (KIIs). Only 1 KII was conducted with GMC during visit to the city.

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

Some of the issues and challenges are listed below:

- Data insufficiency and non availability: No data available on how many septic tanks are connected to open drains and how many are connected to soak pits. No data on systems prevalent in commercial establishments, institutions etc. available
- Accuracy: Discrepancy observed between Census data and actual ground situation
- Data available at different time lines
- Limited data available on reuse (formal / informal).

Assumptions followed for preparing SFDs:

- Data provided by Census, 2011 is correct
- Septic tanks and sewer connections on ground are as per septic tanks and sewer connections defined in Census.
- Volume of waste water generated is 80 % of water supplied
- 90% of the people get their tanks emptied when full

8. Process of SFD development

http://gwaliormunicipalcorporation.org

Data is collected through secondary sources, and then the 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 that defined in the project is established. .

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

In spite having good sewerage network within the city only 19% of wastewater is safely managed in the city and rest 81%, which also includes 6% of city defecating in open, is shown unsafe in SFD.

Limitations of SFD:
It's dependent on secondary data 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.

Excreta is safely managed or not is dependent on the containment of the system, and not on whether the waste is safely handled or not.

9. List of data sources

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

- Published reports and books:
  - Census of India 2011, House listing and Housing data, Government of India
  - CSP of Gwalior, Urban Development and Environment Department, Govt. of Madhya Pradesh, 2010
- KIIs with representatives from
  - Government agencies: GMC
- Websites/web links:

Gwalior, India, 2015

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Abbreviations

BIS	Bureau of Indian Standards
BMGF	Bill and Melinda Gates Foundation
BOD	Biological Oxygen Demand
^{0}C	Celsius
CPHEEO	Central Public Health and Environmental Engineering Organisation
CSP	City Sanitation Plan
CSE	Centre for Science and Environment
E	East
GoI	Government of India
GoMP	Government of Madhya Pradesh
GMC	Gwalior
INR	Indian Rupee
IS	Indian Standards
Km	Kilometer
mi	Miles
mm	Millimeter
mbgl	Metre below ground level
MoUD	Ministry of Urban Development
MPMA	Madhya Pradesh Municipality Act
MPPCB	Madhya Pradesh Pollution Control Board
N	North
NUSP	National Urban Sanitation Policy
OD	Open Defecation
OSS	On-site Sanitation Systems
O & M	Operation and Maintenance
PHED	Pubic Health and Engineering Department
SFD	Shit Flow Diagram
Sq.km	Square Kilometer
SMP	Septage Management sub-Plan
SLB	Service level Benchmark
SPS	Sewage Pumping Station
STP	Sewage Treatment Plant
SWM	Solid Waste Management
TDS	Total Dissolved Solids
UD & ED	Urban Development and Environment Department
ULB's	Urban Local Bodies
USAID	United States Agency for International Development
USD	United States Dollar
WSS	Water Supply and Sewerage
WW	Waste Water

1 City context

Gwalior is a historical and major city in the Indian state of Madhya Pradesh, India. It is 319 kilometers (198 mi) south of Delhi, the capital of India (UD&ED, 2010). The population of the city, as per the Census of India, 2011 is 10,53, 505. The Municipal corporation area is about 46.61 sq.km. The gross population density of the city is 6,292 persons per sq. km. Population of slum is 52,429 which is 17% of the total population. Municipal boundary has been chosen for the current study. Gwalior Municipal Corporation is divided into 60 wards (UD&ED, 2010). The population growth rate of the city is given in the following table.

Table 1: Decadal population growth rate of Gwalior city

Year	Population	Decadal Growth (%)
1961	300,590	24.43
1971	406,140	35.11
1981	539,020	32.72
1991	690,765	28.15
2001	827,026	19.73
2011	1,053,505	27.38

(Source:Census of India,2011)

Gwalior is located at 26.22 N 78.18 E. It has an average elevation of 197 metres (646 feet) (GMC, 2015). It is located in a rock basin corresponding to Vindhyan hills in the west & Bijawar hills in the south–east. Swarnarekha river and Morar river passes through the city (UD&ED, 2010).

The climate of Gwalior is, with mean temperature ranging between 40^0C before the monsoon and 10^0C during the winter. The highest recorded temperature was 53^oC and the lowest was -1^oC. The rainy season lasts from the second week of June to September, the winter from November to February and summer from March to mid June. The month of October records the transition from rainy to the winter season. The average annual rainfall is around 762 mm, which occurs during July and August (UD&ED, 2010).

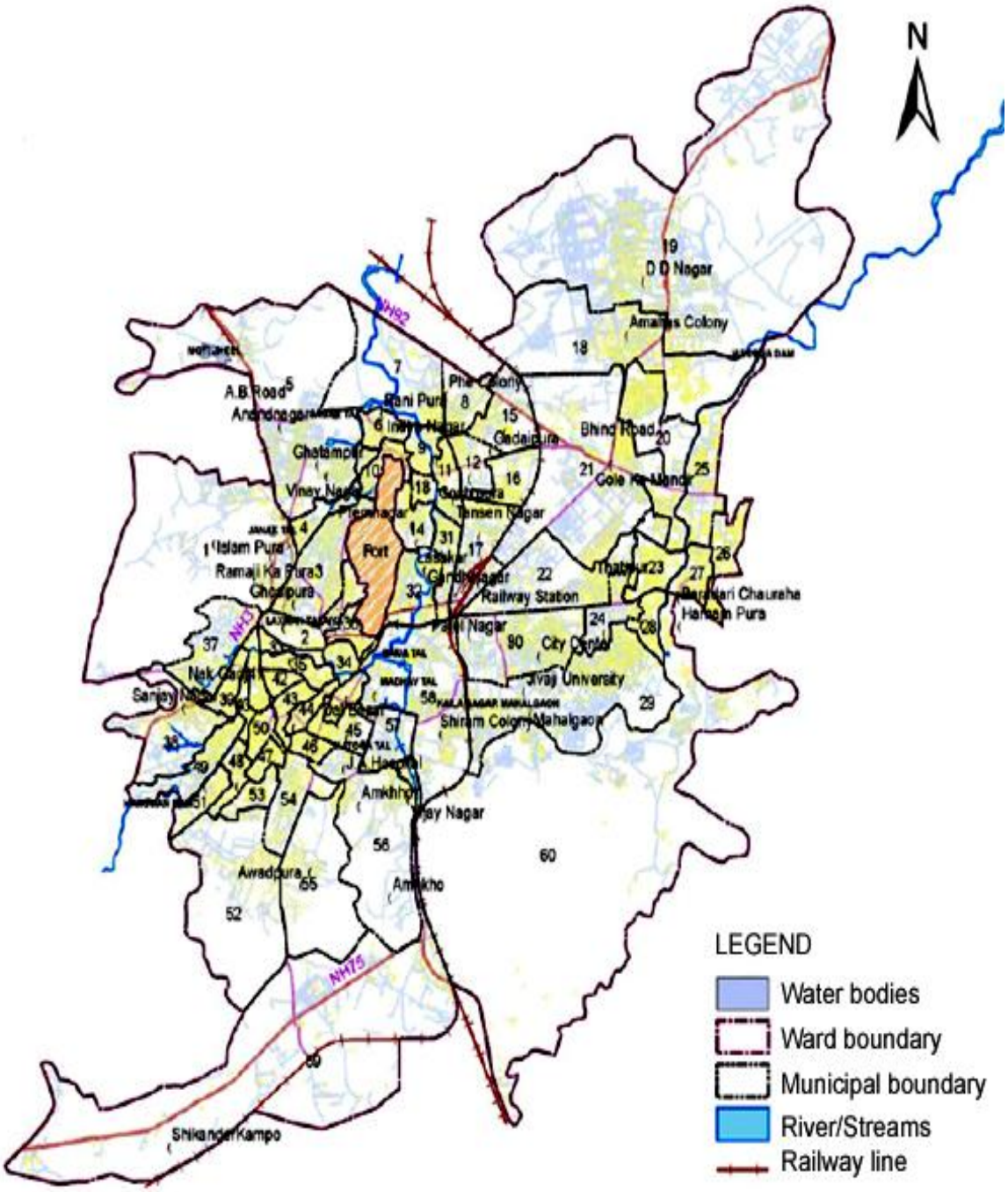

Figure 1: Base map of Gwalior city

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 behavior 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 on-site 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 that, have finalized their CSPs, and those plans are also not implemented. This remains a major drawback in the implementation of NUSP.

The advisory note on septage management in urban India, issued by MoUD in 2013, recommends supplementing CSPs with a Septage Management Sub-Plan (SMP) be prepared and implemented by cities. Septage refers here broadly 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 the Central Public Health and Environmental Engineering Organization (CPHEEO) guidelines, Bureau of Indian Standard (BIS) standards, and other resources that users of this advisory may refer for details 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 to (ULB'S) to plan and implement septage management plans.

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 in regard to disposing wastes into the environment. ULBs/ utilities also have to comply with discharge norms for effluent released from sewage treatment plants 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 the 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 and 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 the Constitution of India, water and sanitation are state subjects. Statutory powers are conferred to the state for making laws on water and sanitation.

As part of NUSP implementation, the Government of Madhya Pradesh has initiated the Integrated Urban Sanitation Programme (IUSP) for the state. The programme focus is to develop citywide sanitation plans and implement them by integrating all aspects of sanitation in an effective way.

The Madhya Pradesh Municipalities Act, 1961 (MPMA) provides ULBs with powers (by notification) to ensure safe sanitation provisions in each building or land parcel within the city and also has some penal provisions for non-compliance. The ULB is empowered to raise revenue through taxes on property, water supply, tax on private latrines, tax on drainage provision and a cess on all buildings to pay for public facilities and city cleaning arrangements.

The Urban Development Department, GoMP has issued specific policy directives related to involvement of various stakeholders in urban sanitation, including ward committees, Mohalla Samitis (Madhya Pradesh Mohalla Samiti Niyam 2008 dated 13 October 2008), Safai Kamgars (Instruction No. 1849/2008/183 dated October 3, 2008) and ragpickers (Ardha Shasakiya Patrak, PMU191 dated May 24, 2010) (GMC,2010).

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).

The existing institutional environment in Gwalior is multi-layered with varying roles and responsibilities that involve many agencies and projects. Both formal and non-formal institutions/actors exist to provide services related to sanitation and water supply. The functioning of these institutions is shaped by many factors including the political

commitments (local, state and national level), international commitments, administrative capacities, market capacities, need/interest of the local community, existing laws, availability of financial/technical/ infrastructure resources which sometimes brings strength and induces weakness as well (UD&ED, 2010).

Management and delivery of urban basic services in Madhya Pradesh is governed by various institutions. The following are the institutions responsible for policy making, service provision and regulation of urban services. The following table provides roles and responsibilities of various institutions

Table 2: Roles and responsibilities

Institution	Roles and responsibilities
Urban Development and Environment Department (UD&ED)	It is responsible for policy formulation, preparation of municipal laws, monitoring and evaluation of programmes, supervision of municipal administration, coordination with related state government departments, liaison with the central government and external funding agencies etc.
MPPCB	Regulatory measures for domestic and industrial, licensing for environmental check etc. Monitor the compliance of the standards regarding ground water, ambient air, leachate quality and the compost quality including incineration standards as specified under Schedule II, III & IV of 'The Water (Prevention and Control of Pollution) Act 1974.
PHED	The PHED is responsible for planning, designing, construction, operation and maintenance of sanitation schemes including their transportation and distribution.
Gwalior Development Authority	Preparation and implementation of area development plans and projects for ensuring scientific land use pattern. Working as coordinating agency between various government departments and other agencies involved in development activities. Land acquisition and development for various purposes in suitable locations based on an assessment of future needs, control of land subdivision and reconstruction of plots wherever necessary. Determining the phasing development.
GMC	The GMC is responsible for planning/design, implementation, operation and maintenance and regulation of water supply in the city. GMC is also responsible for implementation and operation and maintenance of sanitation schemes along with PHED. GMC is responsible for surface drain and solid waste management of the city.

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 subsidize operating costs (Planning Commission, 2002a).

In the absence of a separate utility, 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).

GMC is responsible for solid waste management (SWM), sanitation, tax recovery, slum development work, maintenance of parks and plantations, issue of licenses, traffic and junction improvement, capital work and maintenance of roads, *nullahs* etc, maintenance of hospitals, schools, GMC office buildings, market complexes, etc owned by GMC. The engineering section carries out capital work for roads, junction improvement, open drains (including O&M), maintenance of parks and plantations, community and public toilets, street lights, provision of water through stand posts, capital works for SWM services provided by the health section, etc (UD&ED, 2010).

Two major agencies PHED and GMC carry out all the capital works of the water supply and sewerage. The PHED and GMC are under the administrative control of Urban Development and Environment Department of the Govt. of Madhya Pradesh. Multiple agencies are responsible for delivering various facilities leading to lack of coordination accountability and transparency (UD&ED, 2010).

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.
    III. Set out guidelines on how to operationalize this framework in a phased manner. The 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 -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. 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.

4. Manual on Sewerage and Sewage Treatment, Second Edition, 2013: This manual has been developed by Central Public Health and Environmental Engineering Organisation (CPHEEO). It provides detailed design and guidelines for various technologies of wastewater management.

3 Service outcomes

Service outcome analysis is based on secondary sources. Two key sources of data are used; Census of India, 2011 and City Sanitation Plan (CSP), 2011 of Gwalior. The data is crosschecked and updated by Key Informant Interviews (KIIs). Data on containment is available in Census of India, 2011. 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 Wastewater (WW) through sanitation service chain in Gwalior. 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	76.3%
2	Septic tank	Septic tank connected to open drain or storm sewer	T1A2C6	12.5%
3	Other systems	User interface discharges directly to open ground	T1A1C8	0.6%
4	Pit latrine with slab	Lined pit with semi-permeable walls and open bottom, no outlet or overflow, significant risk	T1A5C10	1.4%
5	Pit latrine without slab	Unlined pit no outlet or overflow, significant risk	T1A6C10	0.2%
6	Night soil disposed into open drain	User interface discharges directly to open drain or storm drain	T1A1C6	0.2%
7	Service latrine	User interface discharges directly to ‘don’t know where’	T1A1C9	0.3%
8	Public latrine	Septic tank connected to open drain or storm sewer	T1A1C2	2.6%
9	Open defecation	Open defecation	T1B11C7 TO C9	5.9%

3.1.1 Sanitation facilities

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

Community/public toilets:

The city has about 169 community toilets (GMC, 2010). The data from the primary survey conducted during preparation of the City Sanitation Plan (CSP) reveals that out of 169 community toilets, about 148 (87%) toilets have the provision of toilets seats and are in use at present and the remaining (13%) community toilets are either encroached or dismantled. Out of the total seats available for women, men and children, only about 77%, 78% and 87% respectively are functional currently (UD&ED, 2010).

Institutions and commercial areas play an important role in the sanitation landscape of the city in terms of ensuring universal cleanliness and maintenance of services for individuals, groups and public at large who visit these institutions for work and study. Gwalior is a vibrant city with flourishing institutional base with the presence of many educational institutes, hotels, markets, industries, hospitals, etc. There are several educational institutions which include 459 schools (GMC, 2010), 19 colleges and 3 universities (GMC, 2015, GMC, 2015a). There are 25 hospitals/clinics, 14 market places, 53, 309 no. of shops, 20 cinema halls, 25720 private office, 3 malls and 316 factories, 4103 hotels and restaurants are in the city (UD&ED, 2010) (UD&ED, 2010).

Due to lack of data on existing sanitation facilities, the excreta generated from institutions, industrial areas, restaurants and hotels have not taken into consideration for the production of SFD. Whereas excreta generated from individual toilets of household and public toilets is under consideration for this study.

3.1.2 Containment

More than half of the city is covered by sewerage system. The sewer connection is provided free of cost by GMC (GMC, 2015a). The city sprawl is dependent on septic tanks. The effluent from the septic tank flows into open drains along the road network. Some households are also connected to the pits. It is observed during a visit to the city that, size, location, and design of on-site systems are majorly dependent on the space available. The IS code 2470-2 (1985) for septic tank design prescribed by the Bureau of Indian Standards is not followed. Due to space constraints in congested areas, households get discouraged to construct septic tanks.

3.1.3 Emptying

Septage from septic tanks and pit latrines is emptied by the GMC using suction machines. Septic tanks are generally emptied once in 3-5 years and/or based on the request from individual households. A resident has to register in sanitation wing of GMC in advance to avail the desludging service. The sustainable mechanism to provide emptying service is yet to be developed. Charges levied for service provision are INR 500 (7.52 USD) (GMC, 2015a). There is no information available on private emptiers business running in the city. Emptying work is done mechanically. GMC has four suction pumps, which are used to remove the faecal sludge on demand (GMC, 2010).

The vacuum tankers in general are operated by 2-3 persons; one driver, one operator and one helper if required. There is no provision or usage of gloves, boots, masks or any other safety gear. Only 14% of the city's population is dependent on onsite sanitation systems (OSS), and the municipal corporation prefers an underground sewerage system (GMC, 2015a).

3.1.4 Transportation

The city is divided into two drainage zones, viz. (i) Lashkar-Gwalior and (2) Morar. The Lashkar-Gwalior zone is situated on the western part of the city whereas the Morar zone is located on the eastern part of the city.

In Lashkar–Gwalior zone, the wastewater generated from the household connected to sewer is conveyed to the sewage pumping station (SPS). The waste water generated from the household dependent on septic tank, the over flow from septic tanks along with grey water is intercepted at strategic locations in Laskar-Gwalior Zone. A main trunk sewer line has been laid beneath the Swarnarekha river channel (as shown in figure 2) and conveyed up to the SPS located near PHE colony (UD&ED, 2010).

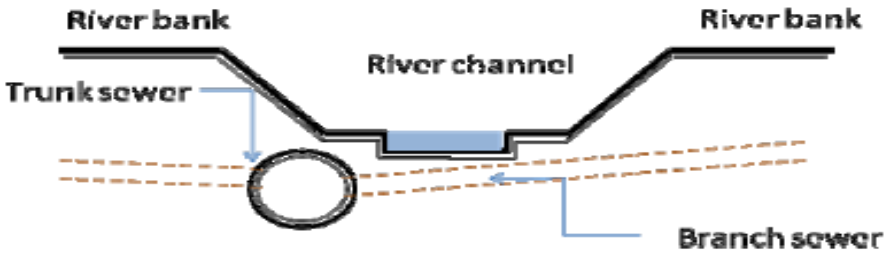

Figure 2: Schematic section of Swarnarekha river

In Morar zone, wastewater generated from the households connected to sewer is transported to the 50 MLD Morar STP. Only 17-20 MLD waste water is delivered to STP. The effluent from the septic tank along with grey water flows through the Morar river channel. The river is not channelized as done in case of Swarnarekha river. Interception of open drains is still in planning phase in this zone (UD&ED, 2010).

Septage is generally transported through vacuum tankers. GMC emptiers carry septage in vacuum tankers and travel approximately 10-12 km in the outskirts of the city and discharge the septage onto sanitary landfill located at Chandoha Khurd village (GMC, 2015a).

Figure 3: Swarnarekha river channel (Source: Shantanu/CSE, 2015)

3.1.5 Treatment and disposal

A 50 MLD Waste Stabilization Pond (WSP) technology based Sewage Treatment Plant (STP) is located in Morar. The STP at Lashkar zone currently functions only as a pumping station, except for separating out solid component of the sewage through screening. From Morar STP 17-20 MLD of treated wastewater is discharged into the Morar river which is further used in irrigation. The inlet BOD of the wastewater is around 150-180mg/l and the effluent BOD of the treated wastewater is around 30-40 mg/l. In case of Lashkar- Gwalior zone the wastewater is directly used for irrigation. Septage is disposed into solid waste landfill or on barren land (GMC, 2015a).

Figure 4: Sewage is discharged into irrigation channel without treatment (Source: Shantanu/CSE, 2015)

3.2 SFD matrix

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

3.2.1 SFD matrix explanation

According to Census of India, 2011, 80% of city is dependent on offsite systems, population connected to sewer line is 79% and user interface directly discharging in open drain or open ground is 1%, it is estimated that only 16% of wastewater (WW) reaches the STP and rest is delivered to irrigation canal without treatment. Though the city is widely covered with sewage network, but due to limited treatment at STP, the discharge is shown unsafe in SFD. The public toilets are connected to sewerage network and hence are incorporated in off-site sanitation systems. 2% of WW is tapped from open drains to treat at STP in Morar.

14% of the city is dependent on onsite sanitation systems (OSS), out of which 12% is dependent on septic tanks and around 2% on pits. Septic tanks are not contained as they are connected to open drains but pits are contained as ground water table is more than 10 mbgl. A significant population (6% of the city) still practices open defecation.

It is difficult to determine the percentage of effluent and septage generated from tanks, hence to reduce the maximum error; it's assumed to be 50% each. Therefore, around 6% of FS is effluent, that goes into open drain and rest is emptied from tanks whenever full. Some FS is always left in the tanks and is estimated to be 1%. Whereas FS from pits is considered contained and is calculated as 2% that includes infiltration of water as well. 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 delivered to treatment plant
W5a	WW treated at centralized treatment plant
F10	FS not contained (onsite)
F2	FS contained (onsite)
F3	FS emptied
F3a	FS contained- emptied
F3b	FS not contained- emptied
F8	FS contained- not emptied
F15	FS not contained- not emptied
F11	FS not delivered to treatment
OD9	Open Defecation

Assuming Census figures are correct; W2 was estimated to be around 79%, which includes WW from public toilets as well. Around 16% of WW reaches STP hence W4a is estimated to be 16% and W11a as 63%. W15 is rounded off as 1%, as it includes WW discharged in open drains i.e. 0.2%, WW discharged on open ground (defined as other systems in Census) i.e. 0.6% and WW from service latrines i.e. 0.3%. 6% of FS, that is effluent from septic tanks, is also discharged into open drains. WW tapped from open drain and delivered to treatment plant is estimated to be 2%, therefore W4c=2%. Rest of the WW which is not contained and not delivered to treatment plant comes out to be 5%, hence W11c=5%. Total WW not delivered to treatment plant, i.e.W11 comes out to be 68% (W11=W11a+W11c). WW treated at Morar STP is estimated to be 18% (16% through sewerage network and 2% tapped from open drains) hence W5a becomes 18%.

F10 is estimated to be around 12%, which constitutes population dependent on septic tanks and F2 is estimated to be around 2% which constitutes of 1.4 % population dependent on lined pits with semi-permeable walls & open bottom and 0.2% are dependent on unlined pits. Since there is no clear demarcation in volume of solid FS generated and effluent/infiltration generated from an onsite system, it is assumed to be 50% each. It is also assumed that 90% of population (dependent on onsite systems) gets their system emptied when full. Therefore out of 12% septic tank dependent population, FS of 5% population gets emptied, therefore F3b=5%. Similarly for lined pits and unlined pits FS emptied taken together (i.e. F3a), comes out to be 1% approximately, making total FS emptied (i.e. F3) equal to 6%. Whereas FS contained but not emptied, i.e. F8 comes out to be 1%. The emptied FS is discharged untreated in environment therefore F11 comes out to be 6%. Since there's some sludge always left in the tanks and pits, F15 is estimated to be 1%. 6% of population practice open defecation and hence OD9 is computed to be 6%.

It can be concluded that excreta of only 19% population is managed safely in Gwalior city and 81% of excreta is discharged in environment untreated. Table 5 summarizes the percentages of the population using each sanitation technology and method along the service chain.

3.2.2 Risk of groundwater contamination

The groundwater level in Gwalior city is reported to be 3.38-7.92 mbgl (CGWB, 2013). In Gwalior, about 80% of the population is dependent on piped water connection. The rest of the households depend on ground water sources. It has been reported that no treatment exists for the ground water extracted from bore-well and hand pumps. Water quality sampling and analysis exercise was taken up by GMC. High TDS level and presence of fecal-coli form in the case of hand-pump has been reported (UD&ED, 2010).

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

System type	Containment	Emptying	Transport	Treatment	End-use/ disposal
Offsite	T1A1C2 (Reference L1): 79% of the population is connected to centralised sewer, hence W2 is 79%. T1A1C6 (Reference L4): 0.2 % of the population is discharging their excreta directly to open drain. T1A1C8 & T1A1C9 (Reference L5): 0.6 % of the population is discharging their excreta directly to open ground and 0.3% discharging-don't know where. Total WW not contained (offsite), i.e.W15, adds up to 1%.	Not applicable.	WW of 16% of the population served by centralised sewers, reaches treatment facilities, hence W4a is 16%. It is estimated that rest of the 63% would be discharged to open drain, hence W11a=12%. WW not contained, delivered to centralised treatment plant, i.e. W4c is estimated to be2%. WW not contained not delivered to centralised treatment plants, i.e. W11c, is 5% which includes effluent from OSS. Total WW not delivered to treatment plant, i.e. W11, is 68%.	WW treated at treatment plant is 18%, hence W5a comes out to be 18%. It also includes 2% of WW which is tapped from open drains.	WW is disposed in irrigation canal and used for irrigation occasionally.
Onsite	14% of population is dependent on onsite sanitation systems, hence F10, FS not contained is 12% and F2, FS contained is 2% T1A2C6 (Reference L8): 12% of population is dependent on septic tanks connected to open drain T1A5C10 (Reference L11):1.4% of population is dependent on lined pit with semi permeable walls and open bottom T1A6C10 (Reference L11):0.2% of population is dependent on unlined pit	It is assumed that 90% of population gets their onsite system emptied. Since there is no clear differentiation between % of septage and effluent, it is assumed to be 50% each. FS not contained-emptied, i.e. F3b comes out to be 5% and FS contained-emptied, i.e. F3a is 1%. FS contained- not emptied, i.e. F8, becomes 1 % and FS not contained-not emptied, i.e. F15 becomes 1%.	No FS is transported to treatment plant therefore FS not delivered to treatment plant, i.e.F11, is 6%.	No treatment facility exists hence no FS is treated, therefore FS treated, i.e. F5, is 0%.	All the FS emptied ends up in local area without any treatment.
Open Defecation	6% of population practice open defecation and hence OD9 is computed to be 6%.				

4 Stakeholder engagement

4.1 Key informant interviews

The relevant departments were contacted through e-mail, letter, call and fax prior to visit to the city. The purpose of the SFD study and depth of data required was conveyed through an introductory letter to respective departments. Only 1 KII was conducted with the Municipal Corporation from stakeholders of government functionaries (see appendix 7.2). The GoMP operate through its UD & ED.

The city was visited because few documents were available on websites. This 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. All the key stakeholders engaged in sanitation services could not be interviewed in person during visit to the city.

5 Acknowledgement

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7 Appendix

7.1 Stakeholder identification

Table 6: Stakeholder identification

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

7.2 Tracking of engagement (Tab 3: Stakeholder tracking tool)

Table 7: Tracking of stakeholder engagement

Name of the organisation	Name of contact person	Position	Date of engagement	Purpose of engagement
Gwalior Municipal Corporation	Mr Ajay Gupta	Commissioner	4/5/2015	Introducing SFD
Gwalior Municipal Corporation	Mr Shishir Shrivastava	Project Engineer	5/5/2015	KII

7.3 SFD matrix

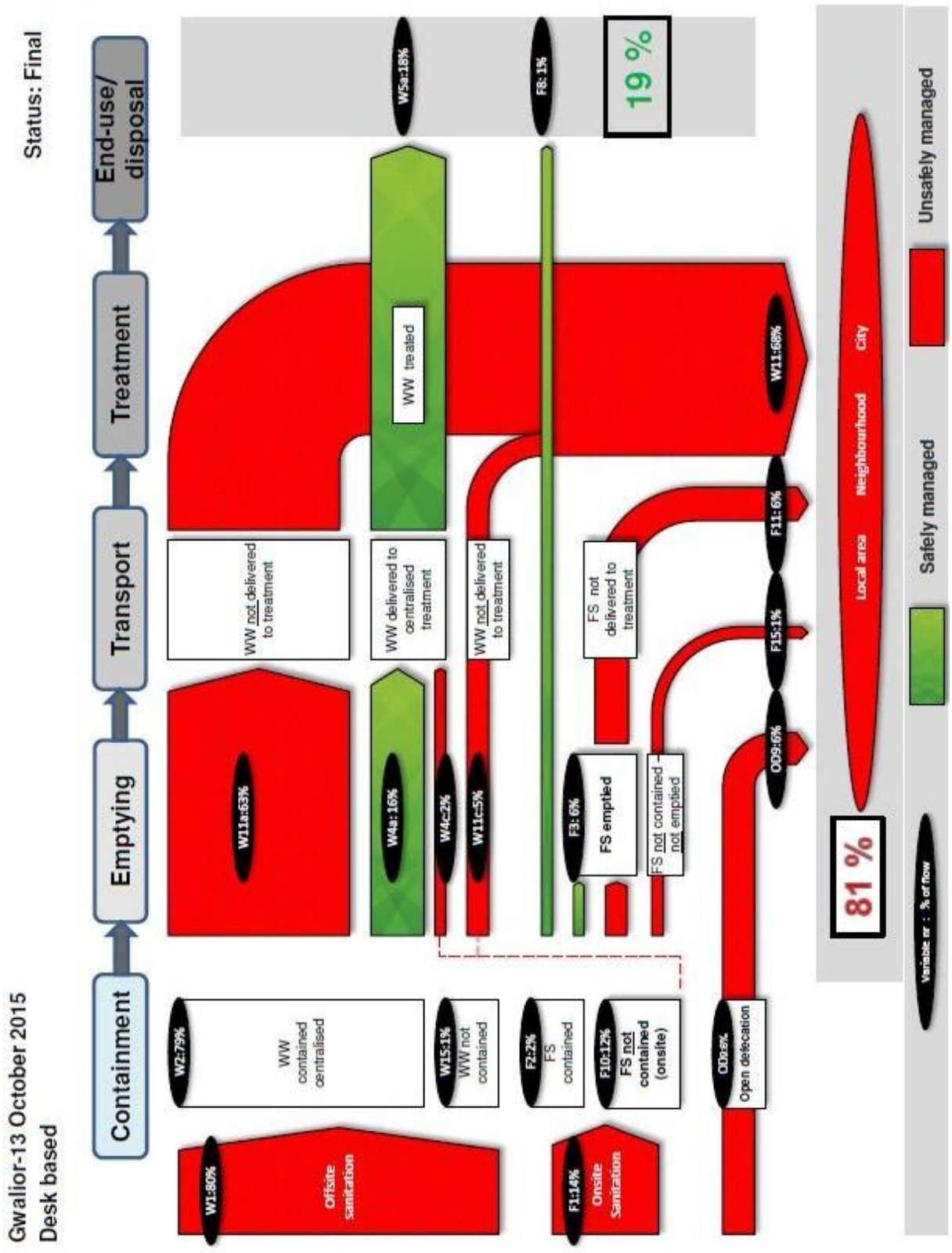

Figure 5: SFD matrix

7.4 Organogram of Gwalior Municipal Corporation

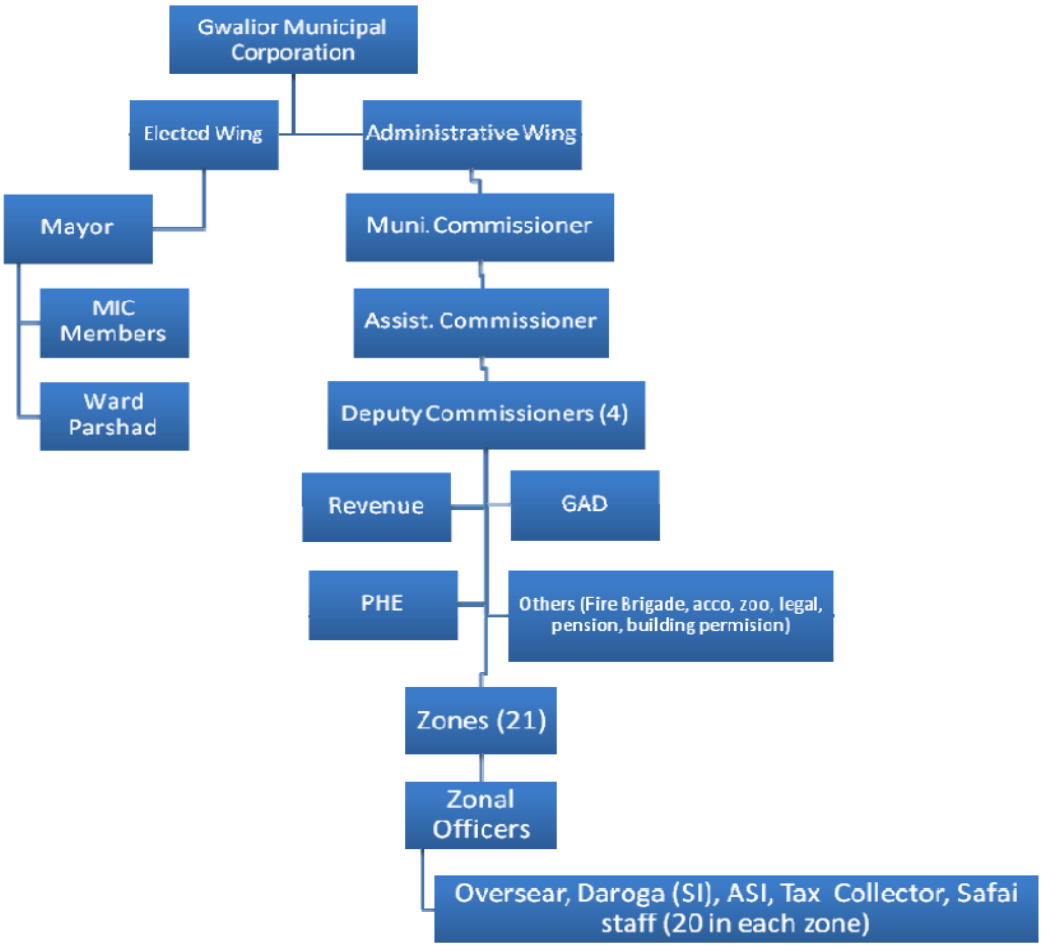

Figure 6: Organogram of Gwalior Municipal Corporation