# SFD Promotion Initiative

# Patna
# India

## Final Report

This SFD Report was created through field-based research by Population Services International (PSI)

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SFD Report Patna, India, 2018

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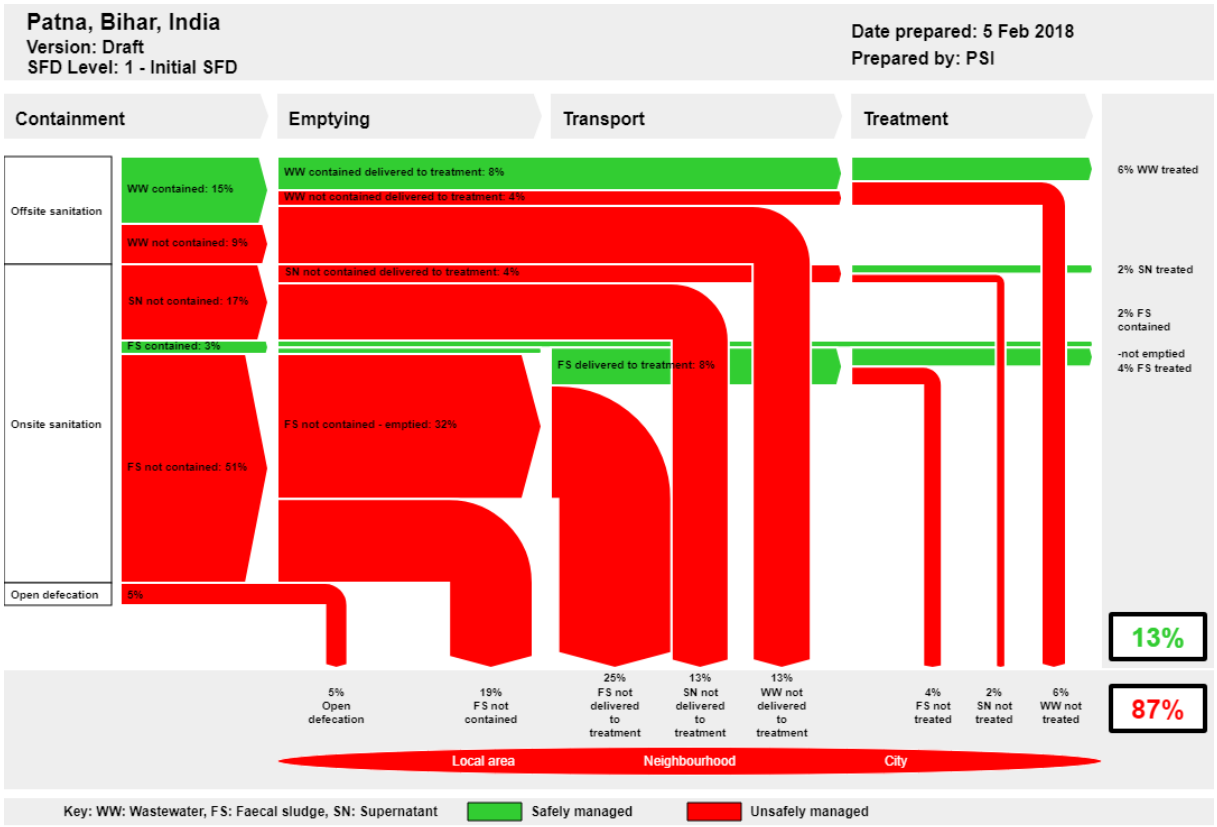
## 1. The Diagram




The SFD Promotion Initiative recommends preparation of a report on the city context, the analysis carried out and data sources used to produce this graphic.
Full details on how to create an SFD Report are available at: sfd.susana.org

## 2. Diagram information

### Desk or field based:

This is a field-based SFD.

### Produced by:

This SFD is prepared by Population Services International (PSI).

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## 3. General city information

Patna, the state capital of Bihar, is situated on the southern bank of Ganga River. The city is surrounded by two other rivers on two other sides: Sone River and Pun-Pun River.

Patna is the second largest city in eastern India after Kolkata. For the preparation of the SFD, the territory of Patna Municipal Corporation (PMC) is selected.

The city of Patna is divided into four circles under control of executive officers, with 72 wards, administered by PCM. The names of the four circles are New Capital Circle, Bankipur Circle, Kankarbagh Circle and Saidpur Circle (KII-PMC, 2016).

The total population of the city is 1.68 million with decadal growth rate of 22% and annual growth rate of 2.1%, as per the 2011 census. The population density of the PMC area is 15,640 persons per square kilometre. The total area under PMC is 109.21 km$^2$, which is 23 km in length and 18 km wide (PMC, 2016).

Patna has road and train connectivity to other districts, so a lot of people commute to other parts of Bihar through Patna. Many people also come to Patna for education and availing advanced medical services. The diurnal population of Patna is 0.3 million per day (PMC, 2016).

PMC area is distributed as follows: 48% is residential, 17% is vacant/agricultural and 10% is public and semi-public area.

## 4. Service delivery context

The Ministry of Urban Development (MoUD) formulated the National Urban Sanitation Policy (NUSP) in 2009. Recognizing sanitation as state subject, this policy provides an overall framework for all towns and cities for becoming totally sanitized. NUSP program was facilitated by PMC under the Supported Program for Urban Reformation (SPUR), sponsored by the Department for International Development (DFID).

The key components of the policy include: (1) generating awareness and policy change towards sanitation, (2) achieving open defecation free cities, (3) developing city sanitation plans and (4) achieving sanitary and safe disposal of 100% human excreta.

The Atal Mission for Rejuvenation Urban Transformation (AMRUT) mission was formulated in 2015 for 500 cities of India, including Patna and conceding funds from central and state government. AMRUT has five mandates: 1) water supply, 2) sewerage facilities and septage management, 3) storm water drain to reduce flooding, 4) pedestrian, 5) creating green spaces and parks.

The National Ganga Basin Rejuvenation Program (NGBRP) was launched in June 2014 for cities and *gram panchayats* (a village council) from the Ganga River basin. The key mandate of the program is ensuring sustainable municipal sewage management where the central government allocated funds for successful implementation of this program. This program is a subsequent program of the Ganga Action Plan launched in 1985.

The 74$^{th}$ Constitutional Amendment Act of 1992 reformed the sector by transferring responsibility of domestic and commercial Water Supply and Sewerage (WSS) from state agencies to Urban Local Bodies (ULBs). The expectations arising from the 74$^{th}$ amendment have not been fully met. Of the 18 functions to be devolved to the ULBs, the Twelfth Schedule of the Bihar Municipal Act 2007 has mandated 16 functions. In this regard, water, sewerage and solid waste management have been transferred to ULBs.

Planning for water supply and sanitation in PMC is carried out by the Bihar Rajya Jal Parishad (BRJP) based on mandates developed by the Urban Development and Housing Department (UD&HD). Operation and management of water pumping stations and sewer treatment plants are also maintained by BRJP. While the tariff and revenue collection is regulated by PMC, the Bihar Pollution Control Board (BPCB) regulates the pollution control in PMC area.

There are four Sewerage Treatment Plants (STPs) in the city, maintained and operated by BRJP. The total capacity of all the STPs is 109 Million Litres per Day (MLD). Individual treatment capacities are 45 MLD, 35 MLD, 25 MLD and 4 MLD. However, all STPs do not operate at their full capacity. Only 21% of the Households (HHs) in the city are connected through a sewer network. The remaining HHs are dependent on on-site sanitation systems.

There is no regulation for construction of septic tanks in city. The majorly of the Faecal Sludge (FS) from septic tanks is emptied by private emptiers and discharged into open drains connected to rivers.

Population Services International (PSI), an international NGO, has taken initiative of establishing decentralized FS treatment plants in Patna. PSI is also engaged with private emptiers for safe collection and discharge of FS.

## 5. Service outcomes

The Census of India from 2011 was the first census to include a section on HH sanitation facilities (Census, 2011). The census focused on the containment technologies present in HHs. Connections to the central sewer system were also included.

- Containment. As per census, 92.3% of HHs in Patna have toilet facilities with 21.5% of the toilets connected to the sewer system, 65.5% of the toilets connected to septic tanks and 2.8% with pit latrines and other systems. Moreover, 2.4% of the HHs are dependent on public toilets and 5% practice open defecation.
- Emptying. PMC has a total of 8 vacuum tankers with jetting and suction pump assembled with a truck/tractor. The capacity of the vacuum tankers is 1,000 or 3,000 litres. Emptying of the pits is carried out based on HHs a requisition. An amount of INR 1,000 (USD 15) is charged for each service. In general, septic tanks are emptied by private emptiers with emptying fees ranging from INR 1,500 to 1,800 (USD 18-23) per service.
- Transportation. For off-site sanitation systems, the user interface is connected to the sewer network and wastewater (WW) is transported to the STPs. For on-site containment systems, FS collected is generally discharged into open drains, sewer manholes or canals connected to the rivers.

- Treatment. Treatment of WW carried through sewers is carried out by Activated Sludge Process (ASP) technology. The total volume of WW transported to STP for treatment is not known.
- End-use/Disposal. Treated WW has a Biological Oxygen Demand (BOD) of 80-100 mg/l whereas the Chemical Oxygen Demand (COD) is around 250mg/l. Treated WW is disposed-off to Pun-Pun and Ganga Rivers.

**Figure 1: Treated WW from a STP to Pun-Pun River (Credit: Rabhesh & Abhishek)**

In terms of supply of safe drinking water, almost 40% of HHS are dependent on treated source of drinking water (Census, 2011), 45% of HHs draw water from hand pumps or deep bore-wells of depth between 40 to 100 feet. The remaining 15% is dependent on another untreated source of water (EIA Saidpur, 2015). PMC also pumps water through deep tube-well for drinking water supply to households. Hence, there is a possibility that contaminated water is consumed by people of Patna.

## 6. Overview of stakeholders

The Indian constitution classifies questions concerning the water and sanitation sector as state subjects. Both state-level and municipality-level agencies such as ULBs share responsibilities for the water and sanitation sector. Several private sector organizations and development partners are also involved.

Sulabh International, a non-profit organization, plays a crucial role in providing public toilets in the city at areas with high mobility such as railway stations, bus stands or auto stands. Key stakeholders interviewed to produce the SFD of Patna are outlined in Table 1.

**Table 1: Sanitation Sector Stakeholder**

| Key Stakeholders | Institutions/Organizations |
|---|---|
| Public Institutions | PMC, BRJP |
| Private Sector | Private pit emptier |
| Non-Government Organization | PSI |

Table 2 shows the PMC departments or agencies responsible for sanitation service delivery, divided in 4 sectors.

**Table 2: Institutional framework for sanitation sector in Patna**

| Service | Responsible Agencies |
|---|---|
| Planning | BRJP, PMC |
| Implementation | BRJP, PMC |
| Operation and maintenance (O&M) | BRJP, PMC |
| Tariff Setting | PMC |

## 7. Credibility of data

Data concerning the containment facilities in Patna was drawn from the Census of India 2011. Data concerning the further steps of the sanitation chain such as emptying, transport, treatment and end-use/disposal were collected from official reports, secondary literature review and the outcomes of Key Informant Interviews (KIIs) that were conducted during a visit to the PMC and BRJP headquarters in December 2016. These data are accounted as mostly qualitative. No focus group discussions were conducted.

Assumptions:

- ✓ Census 2011 data was regarded as correct.
- ✓ Data gap is found in total WW transported to the STPs. Considering the leakage in sewer networks, WW transported to STPs is taken as 50%.
- ✓ Data gap was found on the proportion of FS discharged in sewer/open drains and open ground. It was assumed of 50%.

## 8. Process of SFD development

This SFD is based on data derived from outcomes of the census of India from 2011. Wherever possible, census data were cross-checked with data from secondary sources such as the City Sanitation Plan (CSP), its review, several organizations and the city development plan.

The SFD calculation tool was then used to calculate the percentage of safely and unsafely managed WW and FS.

Limitations of SFD:

SFD is developed based on the risk of groundwater contamination which was difficult to validate.

## 9. List of data sources

-BRJP, 2016. "lab Technician Interview". (27 Dec 2016).

-Census, 2011. “Census of India”. Patna: GoI.

-EIA Saidpur, 2015. "Revised EIA Report of Design Construction, Operation and, maintenance of STP & Sewer Network at Saidpur, Patna: s.n."

-KII-PMC, 2016. "Interview with Additional Municipal Commissioner" (27 Dec 2016).

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-PMC, P. M. C.,2016. Wikipedia.

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# Abbreviations

| | |
|---|---|
| ASP | Activated Sludge Process |
| AMRUT | Atal Mission for Rejuvenation and Urban Transformation |
| BIS | Bureau of Indian Standard |
| BOD | Biological Oxygen Demand |
| BPCB | Bihar Pollution Control Board |
| BRJP | Bihar Rajya Jal Parishad |
| BUIDCO | Bihar Urban Infrastructure Development Corporation |
| COD | Chemical Oxygen Demand |
| CPHEEO | Central Public Health Engineering and Environment Organization |
| CSP | City Sanitation Plan |
| CRSP | Central Rural Sanitation Program |
| DFID | Department for International Development |
| EPA | Environmental Protection Act |
| FS | Faecal Sludge |
| FSM | Faecal Sludge Management |
| HH | Household |
| INR | Indian Rupee |
| JNNURM | Jawaharlal Nehru National Urban Rejuvenation Mission |
| KII | Key Informant Interview |
| MoUD | Ministry of Urban Development |
| MLD | Million Liter Day |
| NBA | Nirmal Bharat Abhiyan |
| NUSP | National Urban Sanitation Program |
| NGBRP | National Ganga Basin Rejuvenation Program |
| O&M | Operation and Management |
| PMC | Patna Municipal Corporation |
| PSI | Population Services International |
| SFD | Shit Flow Diagram |
| SMP | Septage Management Sub-Plan |
| STP | Sewerage Treatment Plant |
| SBM | Swacch Bharat Mission |
| SN | Supernatant |
| SPUR | Supported Program for Urban Reformation |
| TSC | Total Sanitation Campaign |
| TSS | Total Suspended Solid |
| UD & HD | Urban Development and Housing Development |
| ULB | Urban Local Body |
| USD | United States Dollar |
| WSS | Water Supply and Sewerage |
| WW | Wastewater |

# 1 City context

Patna, state capital of Bihar, is one of the oldest inhabited and civilized places in the world (Wikipedia, 2016). It is located between the Ganga River in the North, the Pun-Pun River in the South and the Sone River in the west (Wikipedia, 2017).

The city is approximately 25 km long and 9 to 10 km wide, being the second highest populated city in eastern region after Kolkata (EIA Saidpur, 2015). The city is divided into four circles under control of executive officers, with 72 wards, administered by Patna Municipal Corporation (PMC). Names of the four circles are New Capital Circle, Bankipur Circle, Kankarbagh Circle and Saidpur Circle. Total area under PMC is 109.21 $km^2$ which is 23 km in length and 10 km wide (PMC, 2016). Figure 1 shows the administrative map of Patna (PMC, 2016).


**Figure 1: Administrative map of Patna**

The total population of the city is 1.68 million with decadal growth rate of 22% and annual growth rate of 2.1%, as per 2011 census. The population density of the PMC area is 15,640 persons per $km^2$ (Census, 2011). Diurnal population of the city is very high since it is an educational, health and trade hub in the state. The diurnal population in the year 2006 was 0.2 million per day (CEPT University, 2006). The current diurnal population is around 0.4-0.5 million (KII-PMC, 2016). Decadal population growth rate of Patna is outlined in Table 1 (Census, 2011).

**Table 1: Population and decadal population growth rate of Patna**

| Year | Population | Decadal growth rate (%) |
|---|---|---|
| 1951 | 283,000 | -- |
| 1961 | 365,000 | 29 |
| 1971 | 473,000 | 30 |
| 1981 | 776,371 | 64 |
| 1991 | 917,243 | 18 |
| 2001 | 1,366,444 | 49 |
| 2011 | 1,683,200 | 24 |

The city has an elevation of 53m above sea level. A characteristic feature of the geography of Patna is at the confluence of rivers. Ganga River flows a total of 445km of its total length of 2,525km through the entire state. It has a narrow strip of high land of about 8km in width along the southern bank of the Ganga River, having very fertile soil and alluvial fertile plains in the remaining portions (Wikipedia, 2016).

Patna has a humid subtropical climate with an extremely hot summer from late March to early June, monsoon season from late June to late September and chilly winter nights and foggy or sunny days from November to February (Wikipedia, 2016).

# 2 Service delivery context

The need for sanitation for all was first addressed through the Central Rural Sanitation Policy (CRSP) in 1986 (Department of drinking water supply, 2007). This flagship program was followed by many other central and state programs like the Total Sanitation Campaign (TSC), the Nirmal Bharat Abhiyan (NBA) and the Swacch Bharat Mission (SBM).

## *2.1 Policy, legislation and regulations*

### *2.1.1 Policy legislation and regulation at national level*

In 2008, the Ministry of Urban Development (MoUD) issued the National Urban Sanitation Policy (NUSP). The policy aims to: (1) raise awareness, (2) promote behaviour change, (3) achieve open defecation free cities, (4) develop citywide sanitation plans and (5) provide 100% safe containment, 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 systems (septic tanks, pit latrines, etc.) and proper Operation and Maintenance (O&M) of all sanitary facilities and elimination of manual scavenging. Furthermore, it explicitly states that cities and states must issue policies and technical solutions that address on-site sanitation, including the safe containment of Faecal Sludge (FS). The objectives of NUSP are implemented through CSPs and state sanitation strategies (MoUD, 2008). As of now, there are very few cities which have completed their CSPs, meaning that those plans are also not implemented yet. 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 the Septage Management Sub-Plan (SMP) as a part of the CSP, and being prepared and implemented by cities. Septage here broadly refers not only to FS removed from septic tanks but also FS removed from pit latrines and similar on-site toilets. This advisory note also provides references to the Central Public Health and Environmental Engineering Organization (CPHEEO) guidelines, the Bureau of Indian Standard (BIS) standards, and other resources that users of this advisory may refer to while preparing their SMP. 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 (MoUD, 2013).

The Water (Prevention and Control of Pollution) Act, 1974 and the Environmental (Protection) Act (EPA), 1986 together empower the government to take all such measures as it deems necessary or expedient for protecting and improving the quality of the environment and preventing, controlling and abating environmental pollution. However, most of the states of India have not used the provisions of the EPA to introduce specific rules for managing FS (GoI, 1986).

Under the Water Act and the EPA, the central government supports programs/schemes for wastewater (WW) management to limit environmental pollution. Launched in 2005, The Jawaharlal Nehru National Urban Renewal Mission (JNNURM) encouraged investments in centralized sewerage systems. Faecal Sludge Management (FSM) and on-site sanitation improvements, were, in general, not covered (GoI and MoUD, 2006).

The Swachh Bharat Mission (SBM), launched in 2014, supports the goals expressed in the NUSP financially, focusing on the needs of the urban poor. The Atal Mission for Rejuvenation and Urban Transformation (AMRUT), launched in 2015, considers FSM as one of its mission components and concedes financial support for the urban poor (GoI and MoUD, 2015).

### *2.1.2 Policy, legislation and regulation at state and ULB level*

According to the 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 expectations arising from the 74$^{th}$ amendment have not been fully met. Of the 18 functions to be devolved to the ULBs, the Twelfth Schedule of the Bihar Municipal Act 2007 has mandated 16 functions. While water, sewerage and solid waste management have been transferred to ULBs, inadequate capacities at local government level have hindered effective service delivery (CEPT University, 2006)

As part of NUSP implementation, the government of Bihar initiated the Support Programme for Urban Reforms (SPUR), funded by the Department for International Development (DFID). The program focus was to develop citywide sanitation plans and implement them by integrating all aspects of sanitation in an effective way (GoB, 2010).

### *2.1.3 Institutional roles*

The Urban Development and Housing Department (UD&HD) of Bihar is the nodal department for policy formulation and guidance for the urban Water Supply and the Sewerage (WSS)

sector. The UD&HD allocates resources to ULBs through various centrally-sponsored schemes, providing finance support through national financial institutions. It also supports various external assistance programs for housing and urban development in the state, establishing coordination between various departments of the state such as BRJP and PMC, among others, to develop water and sanitation facilities in the state.

The CPHEEO, created in 1953, is the technical wing of the MoUD, advising the ministry on all technical matters and collaborating with the state agencies in water supply and sanitation activities. CPHEEO plays a critical role in externally-funded and special programmes and in setting design standards and norms for urban water supply and sanitation (CPHEEO, 2006)

The 74$^{th}$ Constitutional Amendment Act of 1992 reformed the sector by transferring responsibility for domestic, industrial, and commercial WSS from state agencies, such as the public health engineering department and the state water boards, to ULBs. This reform mandated the transfer of WSS management and solid waste management as a core area of the PMC act, 2007. This resulted in a variety of implementation models, as well as a lack of clarity in the allocation of roles and responsibilities between state and local agencies, leaving large gaps in implementation (PMC, 2016). Sanitation service delivery and the O&M in Bihar is governed by various institutions. Table 2 provides details of the institutions responsible for policy making, service provision and regulation of urban services.

**Table 2: Institutional roles and responsibilities**

| Department | Roles and Responsibility |
|---|---|
| Urban Development and Housing Department (UD&HD) | The Urban Development Department allocates resources to ULBs through various central and state sponsored schemes, provides finances through national financial institutions and supports various external assistance programs for housing and urban development in the state as a whole |
| Patna Municipal Corporation (PMC) | Established in 1952, is local urban governing body. Patna Municipal Corporation has nine distinct departments which cover all the aspect of city related to development, maintenance and sanitation. It also deals with the revenue collection, legal case and financial aspects. Nine departments constitute the PMC: engineering department, revenue department, urban planning department, water supply, education department, health and sanitation department, finance and accounts department, legal department and estate department. |
| Bihar Rajya Jal Parishad (BRJP) | A nodal agency constituted in 1979 for operation and management of water supply and WW management. |
| Bihar Urban Infrastructure Development Corporation (BUIDCO) | Started in 2009 under the government of Bihar, it has th mandate of executing and accelerating urban development projects e.g. water supply, sewer networks, storm water drainage project, urban street light, market developments, solid waste management etc. |

### *2.1.4 Service provision*

Institutional arrangements for water supply, sanitation and sewerage management vary in different cities. State level government department is responsible for planning and fund allocation of WSS management while ULBs manage O&M. Table 3 shows the planning, O&M, tariff and regulation of various facilities in Patna by different departmental institutions (KII-PMC, 2016).

**Table 3: Institutional framework for water and sanitation**

| State department | Planning | Implementation | Operation and Management | Tariff | Regulation |
|---|---|---|---|---|---|
| Water Supply | UD&HD | BRJP | ULB & BRJP | ULBs | BPCB |
| FSM | UD&HD | BRJP | ULB & BRJP | ULBs | BPCB |
| On-site Sanitation | Nil | Nil | Nil | Nil | Nil |

Taxes levied for water and sanitation by ULBs are minimal and are collected in the form of holding tax. Holding tax include water tax (2%), sanitation tax (2.5%), education tax (1.5%), health tax (1%) and other taxes (KII-PMC, 2016).

### *2.1.5 Service standards*

Though the central government has prescribed service level benchmarks for urban areas, there are no standards being executed/followed for service delivery, health, water, waste water management and solid waste management at state level (GoB, 2010).

# 3 Service Outcome

The analysis of service outcomes is based on data gathered from desk- and field-based studies. Census 2011 data were used to produce the Shit Flow Diagram (SFD) of Patna. Census data were validated through field based research by conducting various Key Informant Interviews (KIIs). Data on sewer network and treatment of WW were collected by visiting the office of BRJP and visits to the Sewerage Treatment Plants (STPs). Data on on-site containment were taken from the census, whereas transportation, treatment and disposal of FS/WW were collected by meetings with relevant people from the sanitation sector in the city. The objective of developing a SFD for Patna is to present a clear picture of the sanitation situation in the city.

## *3.1 Overview*

This section provides an overview of the range of containment systems and sanitation infrastructure in the city. Almost 92% of the households have individual toilets in their households (HHs). Only 3 % of the population is dependent on community toilets, maintained by ULBs. The remaining 5% practice open defecation (Census, 2011).

### *3.2 Off-site technologies*

One-fifth (21.7%) of the population is connected to sewer lines. WW flows to the STPs through the sewer network (MD-BRJP, 2016).

There are separate sewerage systems, including a storm drain in the city (MD-BRJP, 2016). Open drains act as sewers during the dry weather whereas, in the monsoon, the same drains has a dual purpose, acting both as sewers and drains, thus making the situation worse for the local public. The situation is further aggravated as all the solid waste is also being disposed-off into these public drains (Figure 2). Due to the dumping of solid waste in the drains, the solid waste does not only obstruct the flow but also causes septic condition resulting in foul odours and fly nuisance making the surrounding highly unhygienic (EIA Saidpur, 2015).

**Figure 2: Solid waste in storm drain**

### *3.3 On-site technologies*

There are two types of on-site sanitation technologies according to the 2001 census: septic tanks and pit latrines. There is a lack of data available on FS generated from institutions, railway stations, restaurants and hotels. Hence, FS generated from these facilities has not been considered to produce the SFD.

#### *3.3.1 Septic tanks*

65% of the HHs use septic tanks (Census, 2011). Septic tanks have 2 or 3 chambers, correctly built with proper outlet for the flow of the effluent. Effluents from septic tanks were observed flowing into storm drains and into open lands.

There is a lack of information on the percentage of septic tanks connected to drains or open lands.

### *3.3.2 Pit latrines*

Four percent of the toilets are either unlined pits or lined pits with semi-permeable walls and open/closed bottom (Census, 2011). Generally, these pits are manually emptied by private emptiers (KII-PMC, 2016). Emptied FS is discharged into nearby open drains or open grounds.

### *3.3.3 Open defecation*

Five percent of the population practice open defecation.

Combining the previous assumptions, Figure 3 shows the selection grid of the containment technologies for Patna.

| 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 | | T1A1C2 | | | Significant risk of GW pollution<br>Low risk of GW pollution | T1A1C6 | | T1A1C8 | | Not Applicable |
| Septic tank | | | | | Significant risk of GW pollution<br>Low risk of GW pollution | T1A2C6 | | T1A2C8 | | |
| Fully lined tank (sealed) | | | | | Significant risk of GW pollution<br>Low risk of GW pollution | | | | | |
| Lined tank with impermeable walls and open bottom | Significant risk of GW pollution<br>Low risk of GW pollution | Significant risk of GW pollution<br>Low risk of GW pollution | Significant risk of GW pollution<br>Low risk of GW pollution | Significant risk of GW pollution<br>Low risk of GW pollution | Significant risk of GW pollution<br>Low risk of GW pollution | | | | | Significant risk of GW pollution<br>Low risk of GW pollution |
| Lined pit with semi-permeable walls and open bottom | Not Applicable | | | | | | | | | Significant risk of GW pollution<br>T1A5C10 |
| Unlined pit | | | | | | | | | | Significant risk of GW pollution<br>T1A6C10 |
| Pit (all types), never emptied but abandoned when full and covered with soil | | | | | | | | | | Significant risk of GW pollution<br>Low risk of GW pollution |
| Pit (all types), never emptied, abandoned when full but NOT adequately covered with soil | | | | | | | | | | |
| User interface failed, damaged, collapsed or flooded | | | | | | | | | | |
| Containment (septic tank or tank or pit latrine) failed, damaged, collapsed or flooded | | | | | | | | | | |
| No toilet. Open defecation | Not Applicable | | | | | | | | T1B11 C7 TO C9 | Not Applicable |

**Figure 3: SFD Selection Grid for Patna**

## *3.4 Emptying*

Emptying of septic tanks is generally carried out by private emptiers. An amount of INR 1,200-1,500 (USD 18-23) is charged for each emptying.

Patna Municipal Corporation has two vacuum tankers in each municipal circle with jetting and suction machine assembled with a truck/tractor (Figure 4). Between two or three tanks are emptied on demand per day (KII-PMC, 2016). Emptying of septic tanks is generally carried out early morning or at night. PMC charges INR 1,000 (USD 15) for emptying a septic tank (KII-PMC, 2016).


**Figure 4: Government tanker belonging to PMC**

Despite the manual scavenging act 2013, manual scavengers operate in PMC (IPE, 2010).

### *3.5 Transportation*

There is no provision of dumping FS at STPs (KII-PMC, 2016). Hence, all FS collected from septic tanks is discharged into open ground, open drains or sewer manholes in the sewer network (MD-BRJP, 2016).

FS from septic tanks is emptied by private emptiers and transported to open spaces in outskirts of the city. It is also transported and discharged into open drains connected to the Pun-Pun or Ganga River. The quantity of the FS transported to STPs through manholes and open drains is not known. Therefore, it is assumed that 50% of the FS collected from onsite sanitation systems is transported to STPs for treatment through open drains and sewer manholes.

### *3.6 Treatment and disposal*

There are four STPs operating in the city, all based on Activated Sludge Process (ASP) technology. The total capacity of the four STPs is 109 Million Litres per Day (MLD). A 45 MLD sewage treatment plant is located at Saidpur, a 35 MLD STP is located at Beur, a 25 MLD STP is running at Pahari, and a 4 MLD is operating at Karmalichak. The treated WW is discharged into Pun-Pun River from three STPs and to Ganga River from one STP. The Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Total Suspended Solids (TSS) values of treated WW at Beur STP are outlined in Table 4 (Hareram-BRJP, 2016).

**Table 4: Treated WW quality at Beur STP**

| Parameter | Value |
|---|---|
| BOD | 40-100 mg/l |
| COD | 200 mg/l |
| TSS | 100 |

Table 5 shows the STPs with the total capacity and current capacity in use in Patna (MD-BRJP, 2016).

**Table 5: STPs design capacity and current volume of WW being treated**

| Location of STPs | Capacity (MLD) | Current capacity in use for treatment (MLD) |
|---|---|---|
| Saidpur | 45 | 33 |
| Beur | 35 | 20 |
| Pahari | 25 | 16 |
| Karmali Chak | 4 | 2 |
| **Total** | **109** | **71** |

In addition to the STPs, there are 34 pumping stations maintained by BRJP. Pumping stations pump WW from storm drain and sewer networks to STP for treatment (EIA Saidpur, 2015).

There are no separate treatment facilities available for septage emptied from on-site sanitation systems. Government vacuum tankers also discharge collected FS into sewer manholes or open drains. Private emptiers also discharge FS into manholes connected to pumping stations or into barren land and drains connected to rivers in the outskirts of the city. Henceforth, there is ambiguity in the percentage of FS collected from septic tanks that reaches the STP for treatment. For the SFD development, it is considered that 50% of WW reaching the STP from HHs connected to the sewer network is treated. It is also assumed that 50% of the FS transported to STPs through open drains or manholes is treated.

Considering all the assumptions made, Table 6 shows the proportion of each type of system that is emptied and/or delivered to treatment and is treated.

**Table 6: Final estimations for the SFD matrix calculation of containment systems**

Patna, Bihar, India, 5 Feb 2018. SFD Level: 1 - Initial SFD
Population: 1680000
Proportion of tanks: septic tanks: 50%, fully lined tanks: 50%, lined, open bottom tanks: 50%

| System label | Pop | W4a | W5a | W4c | W5c | F3 | F4 | F5 | S4e | S5e |
|---|---|---|---|---|---|---|---|---|---|---|
| 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 wastewater in open sewer or storm drain system, which is delivered to treatment plants | Proportion of wastewater delivered to 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 | Proportion of supernatant in open drain or storm sewer system, which is delivered to treatment plants | Proportion of supernatant in open drain or storm sewer system that is delivered to treatment plants, which is treated |
| T1A1C2 User interface discharges directly to a centralised foul/separate sewer | 15.0 | 50.0 | 50.0 | | | | | | | |
| T1A1C6 User interface discharges directly to open drain or storm sewer | 7.0 | | | 50.0 | 50.0 | | | | | |
| T1A1C8 User interface discharges directly to open ground | 2.0 | | | | | | | | | |
| T1A2C6 Septic tank connected to open drain or storm sewer | 34.0 | | | | | 95.0 | 25.0 | 50.0 | 25.0 | 50.0 |
| T1A2C8 Septic tank connected to open ground | 34.0 | | | | | 95.0 | 25.0 | 50.0 | | |
| T1A5C10 Lined pit with semi-permeable walls and open bottom, no outlet or overflow | 2.0 | | | | | 95.0 | 25.0 | 50.0 | | |
| T1A6C10 Unlined pit, no outlet or overflow | 1.0 | | | | | 95.0 | 25.0 | 50.0 | | |
| T1B11 C7 TO C9 Open defecation | 5.0 | | | | | | | | | |

# 4 SFD Matrix

## *4.1 SFD for Patna*

Figure 5 shows the SFD for Patna. A detailed explanation of all assumptions used to estimate the percentages of excreta flows are described in sections 4.2 and 4.3.

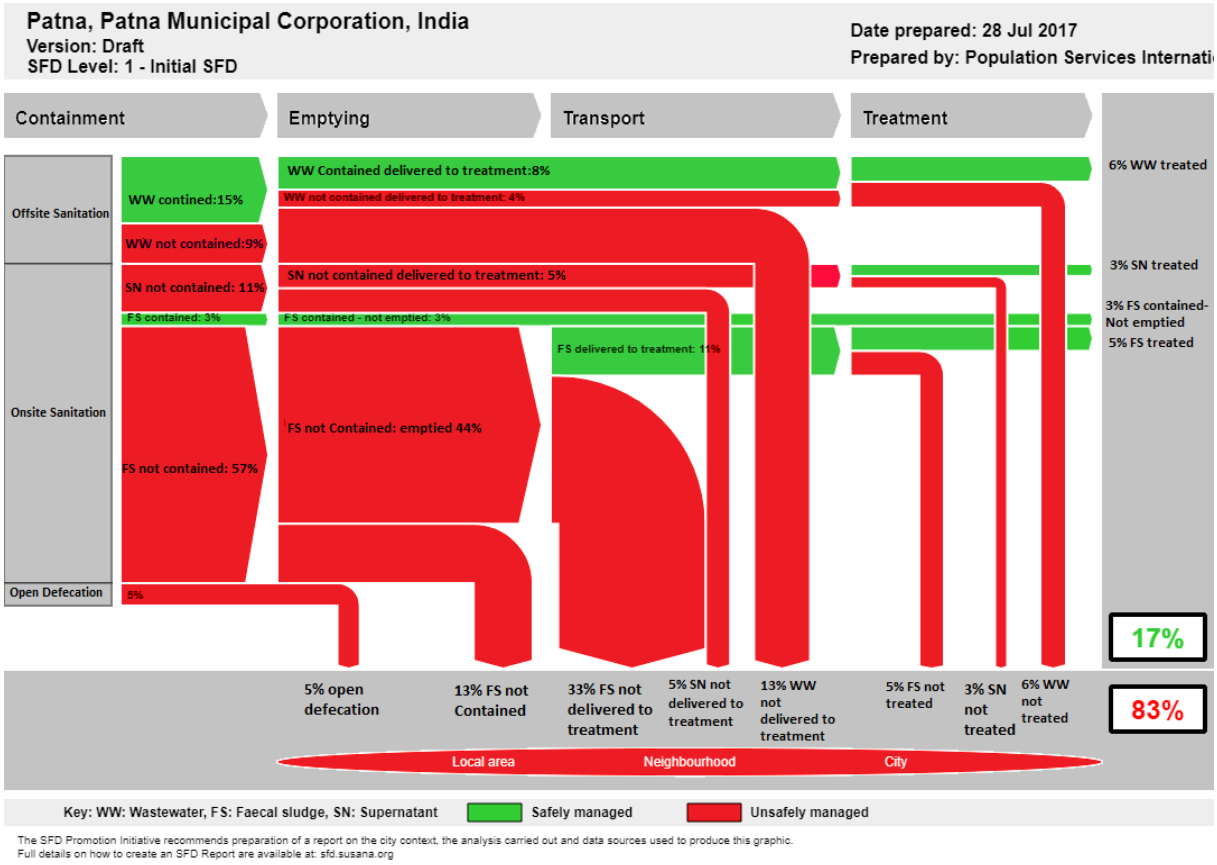


**Figure 5: SFD of Patna**

## *4.2 Off-site sanitation systems*

According to the census of India 2011, 25% of the population in Patna is dependent on off-site systems, wherein population dependent on sewer network is 21.7%. User interface directly discharging in open drain is 1.8% and discharging onto open ground is 1%.

Sewer networks connected to the HHs are broken at several points, leading to leakages of WW as seen in Figure 6 (MD-BRJP, 2016). There are several intercepts between sewer lines and open drains (Hareram-BRJP, 2016) At some places, the WW carried in sewer networks flows into open drains and the other way around.

**Figure 6: Raw sewage in collection tank with solid waste shows leakage in sewer network**

The percentage of WW discharged into open drains and sewer network is not known. Therefore, it is assumed that 70% of the WW generated from HHs connected to piped sewer system (15%) is discharged into the sewer network and 30% to open drains (7%). Additionally, WW from 2% of the HHs is discharged directly to open ground.

It is also assumed that only 50% of the WW discharged into the sewer network goes for treatment to STPs. From all the WW discharged into open drains, only 50% is transported to the STPs, 50% of which is treated.

### *4.3 On-site sanitation systems*

68% of the population is dependent on on-site sanitation systems. This includes 2.8% of the population dependent on community toilets, maintained by PMC (KII-PMC, 2016). Effluents of septic tanks are either discharged into open or storm drains or into open ground. Percentage of Supernatant (SN) discharged into open drains or open ground is not known. Hence, it is assumed that 50% of the SN is discharged into open drains and 50% goes into open ground (Kumar, 2016)

Emptying of on-site sanitation systems is managed by private players. Vacuum tankers from the government provide services to very few HHs. Since there is no data available on the percentage of the septic tanks emptied in the city, it is assumed that 95% of the septic tanks are emptied. It is also assumed that the 5% remaining are abandoned or not being emptied regularly.

Collected FS is transported and discharged either into drains or open lands after emptying by vacuum tankers (Figure 7). It is assumed that 50% of FS reach the STPs for treatment through drains (private tanker operators or government tanker operators discharge FS into manholes) and 50% is discharged into open ground (Kumar, 2016). It is also assumed that only 50% of the FS transported through open drains is treated at the STPs. Similarly, 50% of the FS discharged into open ground is treated.

**Figure 7: Private tanker operator discharging FS into open drains**

Almost 2% of the HHs use lined pits with semi-permeable walls or unlined pit types of containment systems. It is assumed that 95% of the FS generated is emptied, 25% is transported and 50% is treated at the STPs.

One percent of the population uses unlined pits. Out of that 1%, it is assumed that 95% of the FS generated is discharged into open drains, 25% of the FS is transported to the STPs and 50% of the transported FS is treated. Open defecation is practiced by 5% of the population.

As a summary, Table 7 outlines all sanitation systems and the WW/FS fate through the sanitation chain as well as all the assumptions made to draw the SFD for the city.

**Table 7: Summary of sanitation systems and the WW/FS fate through the sanitation chain, including all assumptions made**

| | Sanitation technologies and systems as defined by: | | SFD Reference variable | Percentage of population | % emptied | % going for treatment | % treated | Assumption |
|---|---|---|---|---|---|---|---|---|
| | Census 2011 | SFD promotion initiative | | | | | | |
| Offsite | Piped sewer system | User interface discharges directly to centralized separate foul/sewer system | T1A1C2 | 15% | - | 50% | 50% | Considering leakages in piped sewer system, it is assumed that only 70% is transported to STP for treatment |
| | Piped sewer system + No onsite container, night soil discharged to open drain | To open drain | T1A1C6 | 7% | - | 50% | 50% | Remaining 30% of sewage discharged into open drain, including 1% of night soil disposed in open drain |
| | Other system-No onsite containment | User interface discharged directly to open ground | T1A1C8 | 2% | - | 50% | 50% | Discharges to pond or open land |
| Onsite | Septic tank | Storm Drain | T1A2C6 | 34% | 95% | 25% | 50% | It is assumed that 50% of the SN goes to storm drain and 50% to open ground. Around 95% is emptied. 50% of the FS collected is discharged in storm drain and 50% is discharged on open ground |
| | Septic Tank | Open ground | T1A2C8 | 34% | 95% | 25% | 50% | |
| | Pit Latrine with slab | Lined pit with semi-permeable walls and open bottom, no outlet or overflow, general situation | T1A5C10 | 2% | 95% | 25% | 50% | Due to lack of information, it is assumed that almost 95% of this type of toilet is emptied. 25% FS is transported. 50% of the transported is treated |
| | Pit Latrine without slab | Unlined pit no outlet or overflow, general situation | T1A6C10 | 1% | 95% | 25% | 50% | |
| | Open Defecation | Open defecation | T1B11C7 to C9 | 5% | - | - | - | |

# 5 Risk of groundwater contamination

There are many factors that increase the risk of groundwater contamination. Large part of the excreta waste is unsafely managed, discharged to open ground or rivers. In a study conducted by CPHEEO to test the ground water contamination, a significant number of bacterial contamination was found, suggesting possible groundwater contamination (CPHEEO, 2006). Almost 36% of the population is dependent on either hand pumps or bore wells (Census, 2011). Remaining 48% of the population consumes tapped water from treated source. BRJP pumps water from Ganga River for piped water supply for HHs (MD-BRJP, 2016).

Since no accurate data were available and ground water is drawn from more than 100 feet depth for drinking purposes, ground water risk is considered as low-risk for SFD development.

# 6 Uncertainty of the data

This report is produced based on desk- as well as field-based data collection. For considering the type of containment system/technology, census 2011 data has been considered. However, field visits for data collection were also performed to collect and understand the actual treatment capacity of STPs, effluents discharged in drains and the place of discharging the FS by tanker operators after emptying. Moreover, some data were validated from relevant departments through desk research.

Current data on the percentage of sewage transported and treated was not found. Hence, it was assumed that only 50% of the total sewage generated from the HHs connected to the sewer network reaches the STPs. Moreover, due to leakages and inefficiency of the STP, it is assumed that only 50% of the of the sewage is treated.

Current data on number of septic tanks connected to sewer network is also lacking. Also, percentage of septic tanks emptied and not emptied was not found. It was assumed that 95% of the septic tanks are getting emptied by either private or government tanker operator(s). Also, it was assumed that 50% of the FS extracted from septic tanks is transported to STPs through open drains or manholes.

# 7 Key Informant Interviews

Key informant interviews (KIIs) were conducted in accordance with the methodology to verify the information retrieved from various reports. The aim of the interviews were the validation and the actualization of data derived from the reports. The interviews were conducted face-to-face with Mr. Shirshat Kapil Ashok (MD- BRJP and Acting Municipal commissioner), Mr. Vinay Kumar Mandal (Additional Municipal Commissioner-sanitation) and Mr. Arvind Kumar (Chief Engineer, BRJP- Patna Municipal Corporation).

# 8 Acknowledgements

This SFD is dedicated to the citizens of Patna. Its production would not have been possible without the support of Mr. Shirshat Kapil Ashok (MD - BRJP and Acting Municipal commissioner), Mr. Arvind Kumar (Chief Engineer- BRJP), Mr. Arvind (Supply Chain Manager, PSI), Mr. Surojeet Chandan (FSM Manager, PSI) and, especially, Mr. Sanjay Singh (Associate Director- PSI).

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# 10 Appendix

## *10.1 Appendix 1: Stakeholder identification*

| Name of person | Name of Organization | Position |
|---|---|---|
| Mr. Kapil Ashok Shirsat | BRJP (Bihar Rajya Jal Parishad and Patna Municipal Corporation) | MD, BRJP<br>Acting Municipal Commissioner-PMC |
| Mr. Arvind Kumar | BRJP (Bihar Rajya Jal Parishad and Patna Municipal Corporation) | Chief Engineer- BRJP |
| Mr. Vinay Kumar Mandal | Patna Municipal Corporation | Additional Municipal Commissioner-Sanitation |
| Mr. Hareram | BRJP, STP- Beur | Chemist/Lab Technician |
| Mr. Sonu Kumar Yadav | Private Tanker Operator | Private Tanker Operator |

### *10.2 Appendix 2: Tracking of engagement*

| Name | Date of Engagement | Summary of outcome |
|---|---|---|
| Mr. Kapil Ashok Shirsat | 19 Dec 2016 | The SFD approach was presented, followed by a discussion about the general sanitation situation in the city. An overview on STP and drainage system was provided. Various sites were suggested to visit to gather more information and understanding. |
| Mr. Hareram | 20 Dec 2016 | Beur STP was visited, overview of Beur STP functionality, MLDs of WW reaching through drainage network, functionality of other STPs of Patna was discussed. |
| Mr. Arvind Kumar | 21 Dec 2016 | Overview of sanitation scenario of Patna was discussed. Discussion on water supply and drainage system was also discussed. |
| Mr. Hareram | 22 Dec 2016 | Functionality of Beur STP was understood well. STP capacity, technology, % of WW treated at STP, level of purity of treated water and disposal of treated water was discussed and captured. |
| Mr. Vinay kumar Mandal | 27 Dec 2016 | Overview of sanitation system in PMC area was discussed. Census data was validated. Facilities and charges for pit emptying was asked. What happens to collected FS was also discussed. Additionally, water and sanitation charges from HH was asked. |
| Mr. Sonu Kumar yadav | 27 Dec 2016 | General understanding about FSand disposal was understood. Where they dispose, how much they charge, basic challenges in disposal of collected FS was understood. |