SFD Promotion Initiative

Hanoi
Vietnam

Final Report

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

Date of production: 21/02/2016

Last update: 09/03/2016

SFD Promotion Initiative

SFD Report Hanoi, Vietnam, 2016

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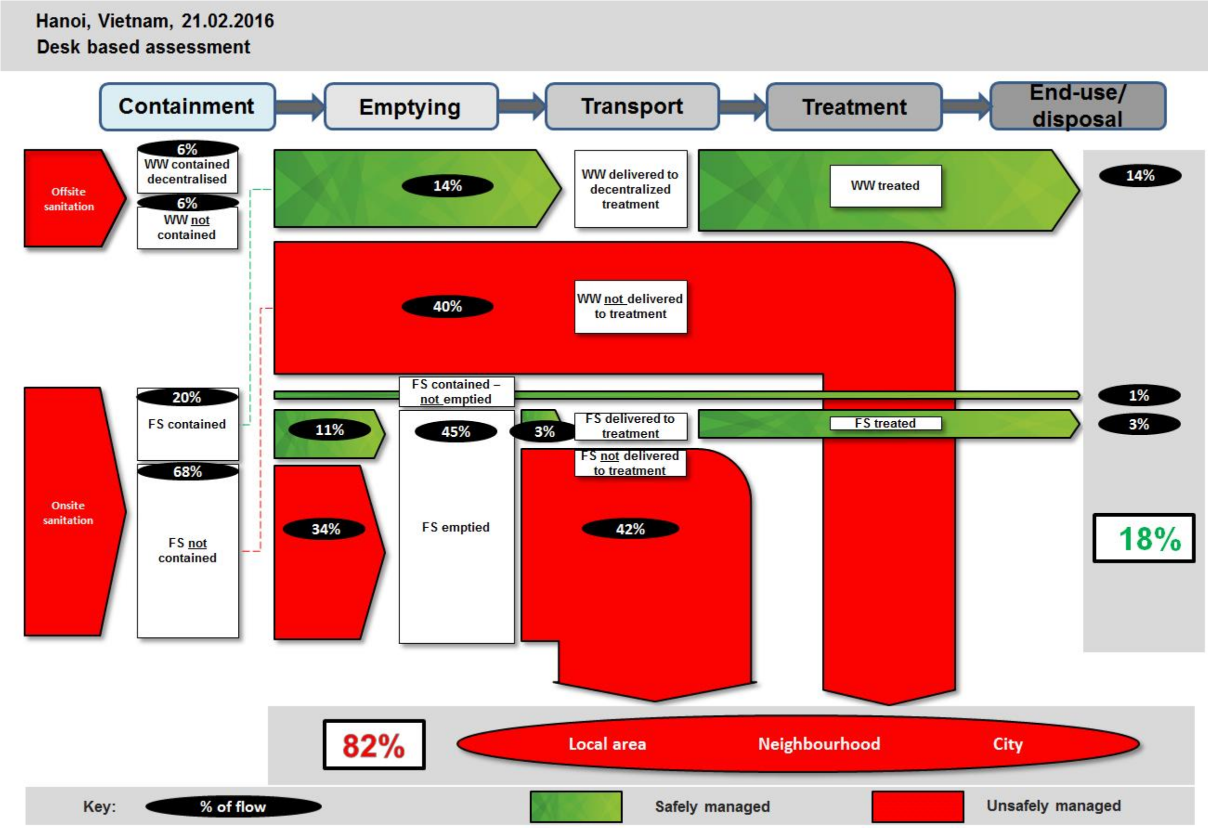
1. The Diagram



2. Diagram information

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

Collaborating partners:

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Status:

Final SFD. Not yet reviewed by external committee.

Date of production:

21/02/2016

3. General city information

Hanoi, the capital of Vietnam, is located in the Northern part of the country in the Red river delta. For the SFD project, the 12 urban districts of Hanoi were selected for inclusion, as the other districts have a rural character and different public and environmental health concerns. The urban districts (from now on referred to as Hanoi) cover an area of 304 km² with an estimated population of 3,147,000 inhabitants (44% of the population in 9% of the area of Hanoi Province) (HSO 2011; GSO 2015).

Half of the districts have population densities above 20,000 inhabitants per km² while the other half below 10,000 inhabitants per km² (HSO 2011). This illustrates the variation between dense urban districts in the centre of the city and districts where peri-urban characteristics prevail. The average household size is 4.5 people per household (Nguyen *et al.* 2011; Cornel *et al.* 2012). Large influxes of daily commuters and tourists are expected in the city, however due to lack of data it was not included in the calculations.

Hanoi has a flat topography and lies at around 7 m above sea level in a region of subtropical monsoon climate (Cornel *et al.* 2012). The warm rainy season lasts from May to October with over 80% of the average annual rainfall of 1,689 mm, leading to frequent flooding (Fischer *et al.* 2011). Most surface water bodies in Hanoi (e.g. the three main rivers: To Lich, Kim Nguu and Nhue river) are highly polluted with wastewater and faecal sludge (Nguyen *et al.* 2011; Nguyen 2016)

4. Service delivery context

Vietnam has a comprehensive legal framework of laws, decrees, decisions and other legal documents on the wastewater sector, while faecal sludge management has not yet received the necessary attention. However, with the recent Decree 80/2014 on the Drainage and Treatment of Wastewater (GOV 2014), accompanied by the new Circular 04/2015 (MOC 2015), the need for adequate faecal sludge management has now been acknowledged. The national Laws on Water Resources and on Environmental Projection emphasize the prevention of pollution of water resources and call for compensation from “any organization, family household or individual” (NAV 2014) causing environmental pollution, based on the “polluter pays principle" (NAV 2012).

As of the Decree 80/2014 (GOV 2014) and earlier ones, every household in the service area of a sewer network is obliged to connect to the sewerage system. In addition, the Vietnam Building Code required the instalment of septic tanks for every household in such areas (MOC 2008), resulting in onsite sanitation technologies being connected to the drainage network (Cornel *et al.* 2012; Nguyen *et al.* 2011).

Periodic emptying of septic tanks (by specialized vehicles) will for the first time be required by law in the Decree 80/2014 (GOV 2014). This policy is specified in the Circular 04/2015 (MOC 2015), which also requires documentation and monitoring of collected and treated faecal sludge by the relevant stakeholders. The National Strategy of Integrated Solid Waste Management (PM 2009) sets out targets for faecal sludge collection and treatment for the years 2015, 2020 and 2025 to 30%, 50% and 100% respectively. Currently, most of the faecal sludge collection and transport service providers in Hanoi are private unregulated businesses, with only one existing faecal sludge treatment facility.

Targets on wastewater treatment are specified in the Master Plan of Socio-economic Development of Hanoi (PM 2011) to 80% of wastewater treated by 2020. Reuse of treated effluent from wastewater and faecal sludge treatment is encouraged (MOC 2015). Therefore, it can be concluded that policies on excreta management exist and Hanoi will make significant progress in the wastewater sector (Nguyen 2016), however, the targets are ambitious. It is also anticipated that with acknowledgement of the need of proper faecal sludge management, Hanoi’s overall excreta management situation will improve in the future.

5. Service outcomes

For Hanoi it is estimated that 82% of the excreta is not managed safely, thus only 18% of the excreta is considered safely managed.

Although the result from the SFD decision support tool leads to a low groundwater contamination risk estimate for Hanoi, the authors wish to point out that surface water contamination is severe and groundwater recharge occurs to a large extent from highly polluted river water. The groundwater used for drinking purposes from low lying aquifers may not be in risk for faecal contamination, however, the groundwater near to the surface is likely highly contaminated.

As previously mentioned, the majority of households have septic tanks that are connected to the drainage network – an estimated 84%. Based on the calculation tool, 68% are considered to not contain faecal sludge as they are not connected to sewers but other types of drainage channels, open drains and canals not leading to wastewater treatment plants (WWTPs). The remaining inhabitants are either using flush toilets connected to the (partly combined, partly separate) sewer network or other combined drainage channels, canals and rivers (12%). Another 4% of the population employ onsite sanitation systems that contain faecal sludge, such as pit latrines and single or double vault latrines that are either used with or without urine diversion. Open defecation is estimated to be almost non-existent. (Harada *et al.* 2008; Nguyen *et al.* 2011; Chowdhry and Kone 2012). Of the 40% of the excreta that is not delivered to treatment 34% is from septic tank effluent and 6% from offsite sanitation technologies.

Emptying of septic tanks is challenging as in most cases these are constructed beneath houses without access, which requires that a hole is made from inside the house through the kitchen floor to provide access. At least 40 private emptying service providers with around 112 trucks serve Hanoi, in addition to Hanoi’s Urban Environment Company (URENCO), which owns three to four vacuum trucks and empties public toilets in the inner districts. The privately owned service providers are legally registered businesses, however, they dispose of the vast majority of collected faecal sludge directly into the urban environment due to a lack of disposal and treatment facilities. This illegal disposal is represented as 42% - faecal sludge emptied but not delivered to treatment.

It is assumed that all septic tank systems employ emptying because all households have access to emptying services and septic tanks are emptied when emergency problems occur. The average desludging period is reported to be around 6 years (Nguyen *et al.* 2011). This together with the previous assumption leads to an overall estimate of 45% faecal sludge emptied.

Only faecal sludge emptied by URENCO is delivered to the one existing faecal sludge treatment facility (Nguyen *et al.* 2011). This results in an estimate of 7% of the emptied faecal sludge being treated, which means only 3% of excreta from this population is treated. The safely managed excreta under 1% faecal sludge contained not emptied is from pit latrines.

Several WWTPs have been constructed in recent years and are estimated to serve 14% of Hanoi's population. Some treatment plants experience operational difficulties, which is partly explained by combined and incomplete drainage networks that convey diluted wastewater with a low carbon to nitrogen ratio to biological treatment processes. For this SFD, wastewater and faecal sludge that is delivered to treatment is considered effectively treated (JICA 2010; WB 2013).

The effectiveness of primary treatment in septic tanks is highly limited due to improper management, resulting in septic tank effluent with the same characteristics as influent in many cases (Harada *et al.* 2008). Therefore, regular desludging of septic tanks is necessary to prevent contamination of the environment through septic tank effluent discharged in open channels and rivers. However, regular emptying will only have the positive intended impact if faecal sludge treatment sites are constructed and inadequate discharge is eliminated.

6. Overview of stakeholders

On the national level, several ministries are dealing with excreta management, while the Ministry of Construction is the line ministry for oversight of urban water supply, sanitation and drainage. Other important ministries include the Ministry of Natural Resources and Environment and the Ministry of Health (Kuyama and Pham 2013). However, "the responsibility for urban infrastructure (planning, implementation, operation and maintenance) rests with subnational governments" (ADB 2015).

The Hanoi People's Committee (HPC) is the legal owner of wastewater infrastructure, but delegates the operation and management to the Hanoi Sewerage and Drainage Company. Departments related to each of the ministries exist under the HPC, such as the Department of Construction, which includes a Hanoi Sewerage & Drainage Project Management Board (JICA 2010). District and Commune People's Committees are required by law to organize the discharge of wastewater in their areas (NAV 2012).

The Hanoi branch of the public corporation URENCO is responsible for solid waste collection and disposal, including faecal sludge from public toilets (Nguyen 2016). In addition to URENCO, private emptying and transport companies exist in the city (WB 2013). Although policy encourages private sector participation, lacking incentives limit the actual creation of public-private partnerships (UN-ESCAP *et al.* 2015).

The Japan International Cooperation Agency is highly involved in projects for enhancement of Hanoi's wastewater infrastructure (JICA 2010; Nguyen 2016). The Institute of Environmental Science and Engineering of the Hanoi University of Civil Engineering has significantly contributed with research and policy recommendations to the sector (Schoebitz et al. 2014).

7. Credibility of data

The literature used for this SFD report was high quality secondary data – mainly articles and reports from credible international authors and organisations – and through analyses of national legislative documents by the government of Vietnam. The information from literature was enhanced by two key informant interviews which improved validation and added up to date information to the secondary data. At the same time, the experts confirmed the existing data gaps and resulting assumptions that had to be made. The design capacity and population served is known only for some of the WWTPs while up to date information on the current operating parameters is not available. Therefore, assumptions had to be made regarding percentage of wastewater treated. In this regard, also the ratio of actual sewers versus covered drainage pipes is unknown. In addition, data on faecal sludge emptying and treatment is limited. Some assumptions also were made in regard to containment, such as that all onsite sanitation systems are properly constructed.

8. Process of SFD development

The SFD report was created in several stages. First, a draft SFD was created from available English and German secondary data. The two key informant interviews were then conducted with experts in the field (academia), including their comments on the draft SFD. Their comments were incorporated in the second draft, which was then reviewed by the cooperative partner.

A lack of data on wastewater treatment and faecal sludge collection and treatment limits the certainty of some values. Therefore, another SFD was created based on a second scenario, which is displayed in Appendix 7.4 of the SFD Report. Furthermore, the lack of knowledge on percentages of the different wastewater transport systems (actual sewers versus covered drainage channels versus open channels, canals, rivers) led to a deviation from the standard methodology: The wastewater and septic tank effluent that is estimated to be transported to WWTPs is displayed as wastewater transported through the sewer system, while the remaining wastewater is displayed as being transported through open channels. As the percentage of actuals sewers is very low and the SFD calculation tool does not consider the option of covered drainage channels, this representation is considered adequate.

9. List of data sources

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Table of Content

List of tables

List of figures

Abbreviations

ADB	Asian Development Bank
CPC	Commune People’s Committee
DOC	Department of Construction
DOF	Department of Finance
DPC	District People’s Committee
DPI	Department of Planning and Investment
HPC	Hanoi People's Committee
HSDC	Hanoi Sewerage and Drainage Company
HUCE	Hanoi University of Civil Engineering
IESE	Institute of Environmental Science and Engineering of HUCE
JICA	Japan International Cooperation Agency
MOC	Ministry of Construction
MOF	Ministry of Finance
MOH	Ministry of Health
MONRE	Ministry of Natural Resources and Environment
MOST	Ministry of Science and Technology
SFD	Shit Flow Diagram
URENCO	Urban Environmental Company
WWTP	Wastewater Treatment Plant

1 City context

Hanoi (or Ha Noi / Hà Nội) is the capital of Vietnam, located in the Northern part of the country in the Red river delta. As of 2014, the province of Hanoi (with an area of 3,324.5 km²) had a population of 7,087,700 inhabitants (GSO 2015). Before the expansion of the city boundaries in 2008, the city of Hanoi consisted of nine urban districts, called Historic Hanoi. Nowadays, Hanoi can be distinguished between the following (see Table 1):

Table 1: Distinctions of the districts in Hanoi

Name	Description (Schoebitz et al. 2014)	Area [km²]	Population
Historic Hanoi	Includes the 9 districts that constituted Hanoi before 2008	180 (HSO 2011)	2,332, 200 (HSO 2011)
Urban Hanoi	Historic Hanoi and Ha Dong, Bac Tu Liem and Nam Tu Liem (altogether 12 districts) – in this report referred to as Hanoi	304 (HSO 2011) (9% of Hanoi Province)	**3,146,939**[1] 3,048,100 (HSO 2011) (44.4% of the province)
Hanoi Province	Also called Greater Hanoi, includes urban, peri-urban and rural districts	3,325 (GSO 2015) 3,329 (HSO 2011)	7,087,700 (GSO 2015) 6,870,200 (HSO 2011)

Urban Hanoi was selected for the boundary of this Shit Flow Diagram (SFD) report, which is tracking excreta flows in Hanoi, as the rural areas of Greater Hanoi have much different characteristics and public health concerns. Furthermore, it is reported that 44.4% of the population of Hanoi Province lives in the 12 urban districts, which represent 9% of the area (HSO 2011). Therefore, in this report the reference to Hanoi refers to Urban Hanoi, unless specifically stated otherwise. Refer to Figure 1 for a map and Appendix 7.1 for a list of districts and wards of Hanoi. Using new population statistics from GSO (2015) it is estimated that 3,147,000 inhabitants currently live in Hanoi.

Hanoi has a flat topography and lies at around 7 m above sea level in a region of subtropical monsoon climate (Cornel et al. 2012). The warm rainy season lasts from May to September/October with over 80% of the average annual rainfall of 1,689 mm, leading to frequent floods (Fischer et al. 2011; WB 2015). The Red (Hong) river and Duong river are the main rivers in Hanoi (Fischer et al. 2011). Other rivers are Ca Lo and Cau, some of which are connected to canals (Anh et al. 2004). “Nearly 7.5% of the total geographical area and 44.3% of the agricultural land of urban Hanoi is lakes” (Anh et al. 2004). During heavy rainfalls the combined sewer system (CSS), which is old and over-capacity, and natural water bodies overflow (WB 2009). As the numerous rivers and lakes in the city receive wastewater and

[1] Calculated as 44.4% of 7,087,700 inhabitants using the information from HSO (2011) with the recent value from GSO (2015). However, it is assumed that due to rapid urbanization the value may be higher than calculated.

faecal sludge, inundation and urban agriculture pose significant health risks to Hanoi's inhabitants.

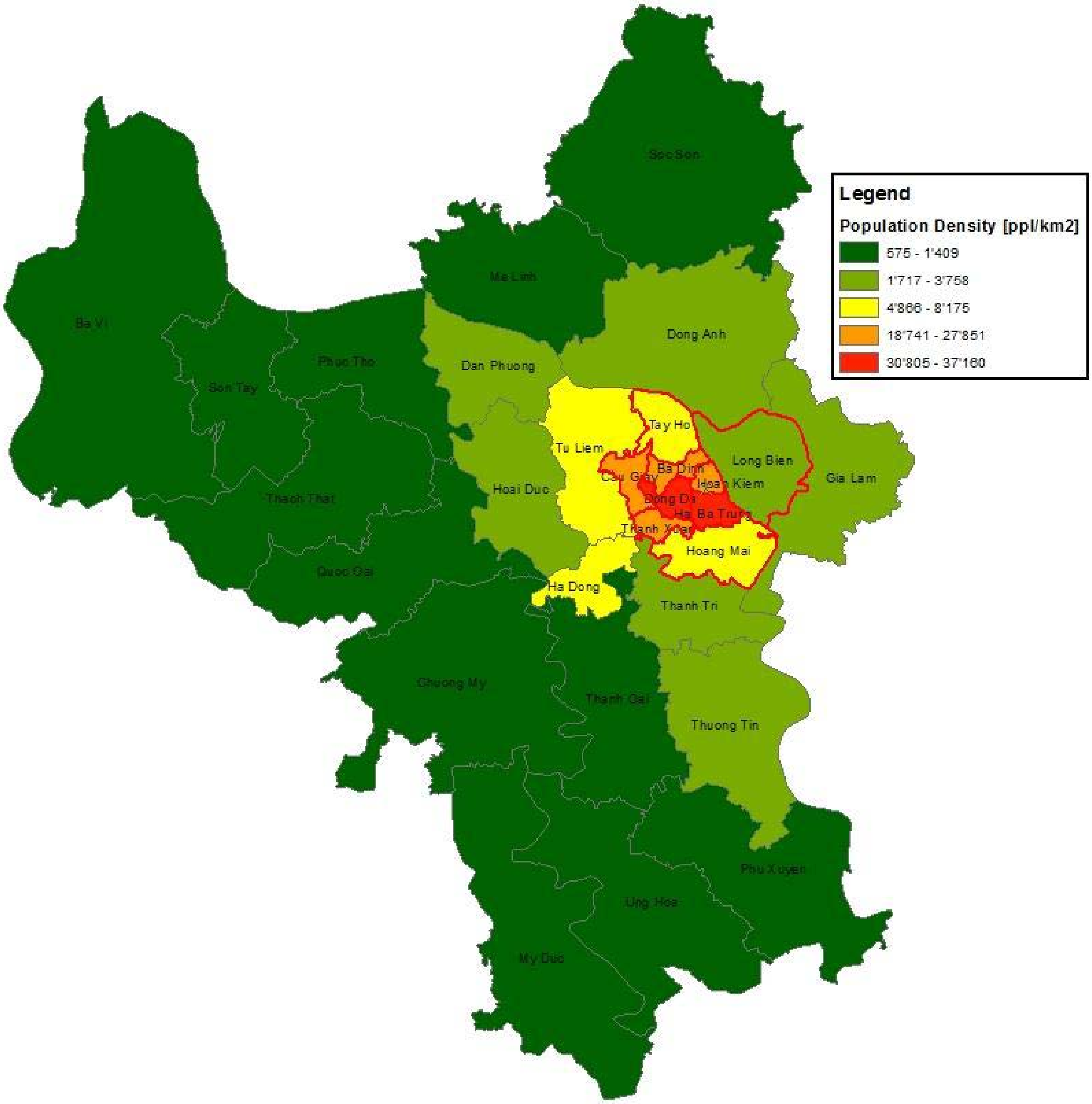

Figure 1: Map of Hanoi Districts (Schoebitz et al. 2014) . Note: The districts with red boundary are part of Historic Hanoi, while Ha Dong and Tu Liem (now subdivided into Bac Liem and Nam Liem) together with Historic Hanoi form Urban Hanoi (in this report referred to as Hanoi).

Population densities in some central districts of Hanoi are greater than 30,000 inhabitants per km^2 (see Figure 1). Half of the districts have population densities above 20,000 inhabitants per km² while the other half below 10,000 inhabitants per km² (HSO 2011). This illustrates the variation between dense urban districts and districts where peri-urban characteristics with small patches of farming land may prevail. The average household is 4.5 people per household (Nguyen et al. 2011; Cornel et al. 2012). As Hanoi is rapidly growing, the situation in the city changes very fast and numbers reported in the literature are quickly out-dated (Nguyen 2016).

2 Service delivery context description/analysis

2.1 Policy

In Vietnam, the legal and regulatory framework consists of laws, national strategies, decrees, circulars, directives, decisions, programs and plans (UN-ESCAP et al. 2015). For an overview on the most relevant legal documents in regard to excreta management in Hanoi and Vietnam, refer to Appendix 7.8.1, and for a hierarchy of legal documents in Vietnam Appendix 7.8.2. It has been acknowledged that Vietnam's water and wastewater laws and policies are progressive and that the city of Hanoi is making great efforts to improve the situation in the wastewater sector (Nguyen 2016).

The highest legislative documents just below the constitution are laws. Concerning excreta management, the Law on Water Resources (No. 17/2012/QH13) emphasizes the prevention of the pollution of water resources and calls for mechanisms to "encourage organizations and individuals to invest in researching and applying technologies to (…) treat wastewater up to standards and technical regulations for re-use" (NAV 2012). Based on the "polluter pays principle" entities that have a license to discharge wastewater are obliged to pay compensation if their illegal discharge causes damage to organisations or individuals (NAV 2012). The Law on Environmental Protection (No. 55/2014/QH13) requires the proper collection and treatment of wastewater and prohibits for example, the discharge of "hazardous wastewater" into water bodies (NAV 2014).

The most relevant or important national legislation related to excreta management is likely the Decree 80/2014/ND-CP on the Drainage and Treatment of Wastewater (GOV 2014), which replaced Decree 88/2007/ND-CP on Urban and Industrial-Parkwater Drainage (GOV 2007), and regulates drainage and sewerage in urban areas. As the change in the title indicates, the new decree shifts importance more towards proper treatment than the previous decree. It makes the government responsible for the "financing of capital investment" in the wastewater sector and requires cities to prepare wastewater plans. According to Nguyen (2016) a Hanoi wastewater and solid waste plan was developed a few years ago. For the city's development in general, a Hanoi Master Plan was prepared, which sets general city development targets to achieve by 2030 and a vision towards 2050, including 100% treated domestic wastewater before discharging into water bodies (IESE, TUD 2010).

Circulars provide further guidance on decrees, such as the Circular 04/2015/TT-BXD is (MOC 2015) providing guidance on a number of articles of the Decree No. 80/2014/ND-CP or Circular 09/2009/TT-BXD (MOC 2009) defined details on the implementation of the previous Decree 88/2007/ND-CP.

Decisions add performance targets to the decrees, as the Prime Minister's Decision 1930/2009/QD-TTg (Approval of Orientation for Drainage Development in Viet Nam Urban and Industrial Zones toward 2025 and Vision toward 2050) "provides further detailed quantitative targets for 2025 and a vision for 2050 on domestic sanitation" (ADB 2015). It sets the target for coverage of wastewater collection and treatment to 70% of the urban population by 2025 and "emphasizes polluter pays principle and moving toward cost recovery for drainage" (ADB 2015).

The Prime Minister's Decision No. 1081/QD-TTg of July 6, 2011, approves "the master plan on the socio-economic development of Hanoi city through 2020, with orientations toward 2030" (PM 2011) and lays out as one development objective to treat "over 80% of wastewater by 2020". The Socio-economic Development Plan (SEDP) 2011–2015 "places considerable emphasis on better performance by the government in reducing the environmental impact of municipal and industrial waste discharge" (ADB 2015).

Specific policies on containment are mentioned in Article 30 of the Decree 80/2014 (GOV 2014), requiring every household in the service area of a sewer network to connect to the sewerage system. The Vietnam Building Code (promulgated in Decision No. 04/2008/QD-BXD) stipulates that "wastewater from private and public toilets shall be treated through properly built septic tanks before being discharged into urban wastewater" (MOC 2008). The building code of 1997 had demanded the construction of septic tank for every household while Decree 88/2007 (GOV 2007) later allowed households to directly connect to newly constructed sewer networks (Cornel et al. 2012). The wastewater volume priced with the wastewater service charges is set equal to the volume of fresh water consumed (as by the water bill), or if no water is used from the common water supply system, the water consumed is set equal to the calculated average of water consumed per capita in the administrative division. If a household is not connected to the public sewer network, no discharge but an environmental protection fee has to be paid (GOV 2014). "The owners of the wastewater system (usually the provincial government) instruct water and wastewater companies to propose wastewater tariffs. The provincial Department of Finance assesses these proposals in coordination with the Department of Construction. The Provincial People's Committee makes the final decision on the level of the tariffs" (ADB 2015). In the end, the costs of the wastewater infrastructure manager (SADCO) have to be covered by Provincial People's Committee if the income from wastewater fees is not enough to cover them (ADB 2015; GOV 2014).

Periodic emptying of septic tanks is for the first time demanded by law in the new Decree 80/2014. It calls for the creation of a faecal sludge management regulation and specifies the management of sludge in Article 25 (GOV 2014). In Article 3 of the most recent circular (No. 04/2015) (MOC 2015) more detailed requirements for collection and transport of septic tank sludge are described, including the requirement for the use of vehicles that are in accordance with the law on traffic and environmental protection and regular monitoring and documentation by emptying, transport and treatment service providers. Appendices 7.8.3 and 7.8.4 show these two articles of the Decree and the Circular, as they are understood as an important step towards the highly needed increased attention towards proper faecal sludge management. Specific targets for collection and treatment of faecal sludge from septic tanks were set out in the National Strategy of Integrated Solid Waste Management approved by the Prime Minister's Decision 2149/QD-TTg. For cities such as Hanoi, the collection and treatment target "in an environmentally manner" was set to 30% for 2015, to 50% for 2020 and 100% for 2025. The strategy pointed out the need for "building regulations on management of sludge from septic tank" and issuance of "technical guidelines on recycling construction waste, collecting and treating mud of septic tank" (PM 2009). Still, "acceptable operating practices for household desludging and in particular for the final disposal of the sludge need to be defined and monitored" (ADB 2015).

The Decision No. 1081/QD-TTg on the Master Plan of socio-economic development of Hanoi lays out as one development objective to treat over 80% of wastewater by 2020 (PM 2011). In contrast to the former Decree, the Decree 80/2014 distinguishes “different standards for effluent discharges depending on the nature of the wastewater, where it is being discharged, and whether treatment is by a decentralized treatment plant” (ADB 2015). The related standards still have to be defined. This comes hand in hand with decentralized treatment solutions being acknowledged as a solution in Article 23 of the Decree (GOV 2014). The Decree 80/2014 “introduced decentralized approaches to wastewater collection and treatment, the reuse of rainwater and treated effluent, and an emphasis on including sludge management in scheme design” (ADB 2015).

The need for faecal sludge management is recognized in the new Decree 80/2014 (GOV 2014) which is an important step towards proper sludge emptying and treatment. Furthermore, the Decree recognizes wastewater as a resource and encourages reuse of treated effluent from wastewater treatment plants (WWTPs) in Article 24 (ADB 2015; GOV 2014).

Overall it can be concluded that with the Decree 80/2014 important steps are set out for proper wastewater and faecal sludge management in Vietnam. It is the first time that faecal sludge management is acknowledged in Vietnamese law and this growing awareness has the potential to bring forward essential and rapid changes if adopted on city levels. Until now “no city in Vietnam has yet developed a clear strategy for faecal sludge management” (UN-ESCAP et al. 2015).

2.2 Institutional roles

National, provincial, public and private stakeholders with responsibilities or interests in excreta management in Hanoi are presented in the following section. An overview of identified stakeholders is presented in Appendix 7.3. In general, the management structure has been changed to a more decentralized nature – “the responsibility for urban infrastructure (planning, implementation, operation and maintenance) rests with subnational governments” (ADB 2015).

National ministries with functions related to excreta management are presented in Table 2. For example, the Ministry of Construction (MOC) is the line ministry of urban water supply, sanitation and drainage while the Ministry of Natural Resources and Environment (MONRE) is responsible for water pollution control and the Ministry of Health (MOH) is responsible for control of drinking water and sanitation quality (Kuyama, Pham 2013). The Decree 80/2014, for example, assigns the task of the issuance of “technical standards applied to wastewater discharged into urban drainage system” to the MOC.

Table 2: Ministries with functions related to excreta management in Vietnam (Kuyama, Pham 2013).

Ministry	Function
Ministry of Construction (MoC)	Line Ministry of urban water supply, sanitation and drainage
Ministry of Natural Resources and Environment (MoNRE)	Manages water sources, water use, pollution and hydrology
Ministry of Health (MoH)	Controls drinking water and sanitation quality
Ministry of Science and Technology (MoST)	Manages standardisation and technology in water and sanitation
Ministry of Planning and Investment (MPI)	Allocates state budget. Approves investment projects (all projects need approval)
Ministry of Finance (MoF)	Distributes state funds to sectors and projects, sets annual sector goals and regulates accounting
Local Provincial People's Committee	Manages local water supply and sanitation

The province Greater Hanoi is governed by the provincial government body Hanoi People's Committee (HPC). The next government body is a district people committee (DPC) for each district, and a communal people's committee (CPC) in each of the communes of Hanoi (Schoebitz et al. 2014) . As an "executive arm", HPC is in charge of executing the Constitution, laws, decrees and other government resolutions. According to Decree 80/2014 HPC is the owner of the drainage system but can delegate the management of the system DPCs or CPCs (ADB 2015; GOV 2014). In Hanoi, the management of the wastewater infrastructure assets is delegated to the Hanoi Sewerage and Drainage One-Member State Company Limited (HSDC) (JICA 2010). DPCs and CPCs are required by law to organize the registration of discharge of wastewater in their areas (NAV 2012). Figure 2 presents an overview on national and city level stakeholders with their respective responsibilities in the wastewater and faecal sludge sector.

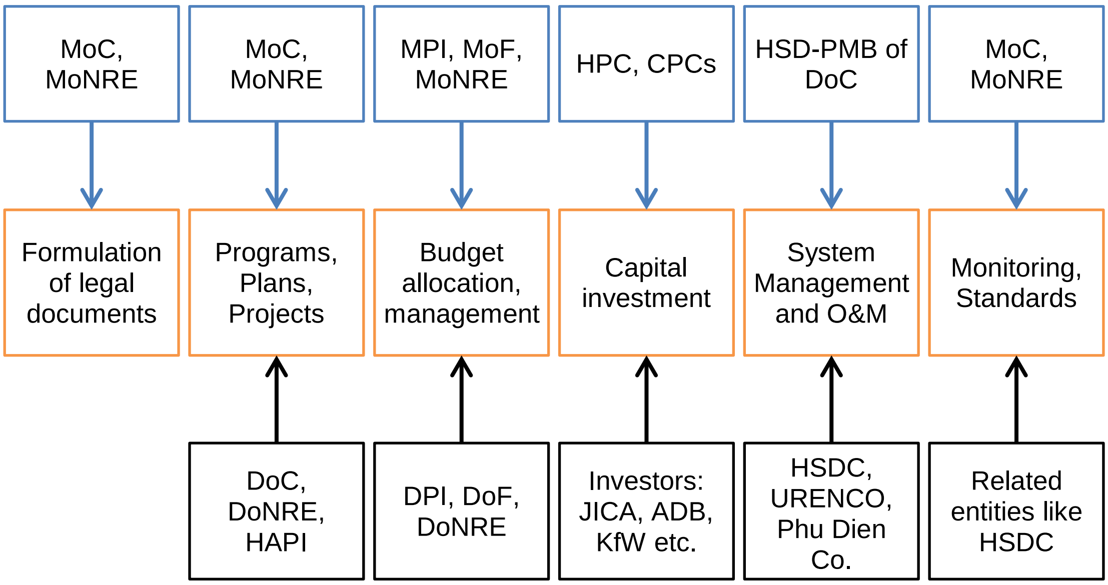

Figure 2: Institutional framework of the wastewater sector in Hanoi, Vietnam. Adopted from WB (2013b).

Departments related to each ministry exist under the HPC, such as the Department of Construction (DoC) which includes a Hanoi Sewerage & Drainage Project Management Board (HSD-PMB) which “is in charge of the sewerage and drainage project management until the beginning of the operation and management of the facilities” (JICA 2010). The HSDC is managing the sewerage and drainage facilities after the construction (JICA 2010).

Other relevant departments include the Department of Planning and Investment (DPI) and the Department of Finance (DoF) which are requested to “assess the plan for local drainage development” while the DoC shall be the leading agency and cooperate with relevant agencies to develop a drainage plan (GOV 2014).

International organisations and donors such as the Japan International Cooperation Agency (JICA), the Asian Development Bank (ADB), the German development bank Kreditanstalt für Wiederaufbau (KfW) and the World Bank (WB) support the sector with funding and capacity building activities. Academic institutions have supported the development of “national standards and policies on septic tanks, and have partnered with projects funded by international organizations” (AECOM, Eawag/Sandec 2010). These include amongst others the Institute of Environmental Science and Engineering (IESE) of the Hanoi University of Civil Engineering. Other stakeholders in the sector include Hanoi’s Environmental Protection Agency, the Environmental Police and the Vietnam Water Supply and Sewerage Association (VWSA) (Nguyen et al. 2011).

Although public-private partnerships are desired, no significant private finance has been attracted. Apart from the contracted out sewage system management by HPC to the public-private company HSDC involvement by private companies is limited (ADB 2015; UN-ESCAP et al. 2015). Private companies do exist that empty septic tanks, but the sector is informal and unregulated. Overall, most stakeholders in the excreta management sector are public, like HSDC which is managing most of the city’s wastewater treatment plants. Only one of the WWTPs (the Yen So WWTP) is managed by a private company – the Phu Dien Construction Investment and Trading Joint Stock Company (Phu Dien Co.) (JICA 2010).

Under the oversight/control of the Department of Natural Resources and Environment (DoNRE), the Hanoi branch of the public corporation Urban Environment Company (URENCO) is responsible for solid waste collection and disposal, including faecal sludge. In addition to URENCO, also private emptying and transport companies exist in the city. However, URENCO manages the only faecal sludge treatment site at Cau Dzien Composting Plant (WB 2013b).

It is not yet clear whether the decentralization and corporation process of wastewater and sanitation services led to effective water and sewerage companies. The sector is “gradually being corporatized and equitized. With such fundamental institutional changes, it is unknown whether these agencies are capable of effectively fulfilling their devolved role, and whether effective regulatory instruments are in place to hold them accountable to deliver the services assigned to them.” (ADB 2015) Both the MONRE and its provincial arms, the DONREs, “are relatively new organizations that have limited institutional experience and financial resources to implement the pollution control policies in full” (MONRE, UNEP 2008).

2.3 Service provision

Policy encourages private sector participation, yet incentives are lacking that would encourage this sector to participate in the wastewater business (UN-ESCAP et al. 2015). The Decree 04/2009/ND-CP and Decree 59/2007/ND-CP “support provision for private sector participant in the sanitation” while Circular 230/2009/TT-BTC by the MoF “creates favorable tax conditions for enterprises dealing with environmental protection activities” (ADB 2015). “Private sector involvement in building and managing decentralized wastewater treatment plants (DEWATS) should be the next step.” (UN-ESCAP et al. 2015)

“Government policy favours private investment but with government retaining ownership of assets and having significant control over operations via tariff controls and the operational funding of sanitation companies, the environment is not yet conducive for a significant increase in private sector participation” (WB 2014).

Septic tanks are often pre-fabricated and typically installed under the house. Therefore, in the majority of cases a hole has to be made through the kitchen floor and flooring to access and empty them (see Appendix 7.9 for some pictures on the emptying process). The floor then has to be repaired, and this further discourages households from having their septic tanks emptied and the work of emptying service providers less favoured.

The public utility URENCO is to collecting faecal sludge from septic tanks in the urban core of Hanoi. However, it does not have the capacities to serve all areas of Hanoi, which is why unregulated, private emptying service providers serve the majority of the city. These service providers are legally registered businesses. However, there is no existing legal discharge or treatment location for them (apart from the Cau Dien composting site which cannot cover the resulting quantities of emptied faecal sludge). This problem results in illegal discharge of faecal sludge to open drains and rivers as no other options exist (Nguyen et al. 2011).

In Decision No. 38/2007/QD-TTg wastewater companies are encouraged to “operate on modern business principles, as a transition toward full privatization” (ADB 2015). The Decree 19/2015/NC-CP promises to deliver incentives and assistance to environmental protection projects such as treatment plants of “concentrated domestic wastewater with design capacity from 2,500 m^3 of wastewater per day for urban areas of grade IV or more” (GOV 2015). The Decree 80/2014 (GOV 2014) calls for proper faecal sludge management which is hoped to increase needed measures to support emptying service providers with faecal sludge disposal and treatment sites.

Limited cost recovery, administrative challenges and “lack of effective regulation on service levels and tariffs” are obstacles for participation of the private sector. One of the very few projects with private sector participation in Vietnam is the “build and transfer project in Hanoi” which has included “an element of private sector participation” (UN-ESCAP et al. 2015). The Decree 15/2015/ND-CP on Public Private Partnership Investment Form was designed to increase transparency of private sector investment (ADB 2015).

According to the Law on Water Resources (NAV 2012) organizations and individuals have to obtain licenses to be allowed to discharge wastewater, unless the quantities are very low[2] – which may incentivize small-scale solutions.

2.4 Service standards

The Law on Water Resources calls for the "identification of water quality surveillance systems and systems for supervision of the discharge of wastewater into water sources" and demands "operating establishments (to) adopt measures to treat, control and strictly supervise the quality of their wastewater and wastes before discharging them into the soil or water sources" (NAV 2012). Furthermore, the law declares the responsibilities for the monitoring of (a) inter-provincial and transnational, (b) intraprovincial and (c) exploited, used or discharged water and wastewater to (a) MoNRE, (b) PPCs and (c) organizations and individuals, respectively (NAV 2012). However, there are many decrees that hand over the responsibility for water quality monitoring to multiple different agencies[3]. This absence of clear mandates and insufficient coordination creates confusion and hampers concrete actions (MONRE, UNEP 2008). The Decree 80/2014 calls for periodic checks of the quality of WW at WWTPs and the sewer network. Yet, "periodic" is not further defined (GOV 2014). Furthermore, consumers have little access to data generated by wastewater service providers like the HSDC. However, recently a water sector database website[4] has been established which provides information about the performance of urban water supply utilities. If this method is extended to service providers in the wastewater sector, monitoring will be improved. For now, "for urban sanitation there is no monitoring framework either for household facilities or citywide wastewater collection and treatment, though new arrangements are proposed under U3SAP" (WB 2014). Punishment and penalties on illegal, environment polluting activities are criticized as not strict enough combined with lack of enforcement. "While the Criminal Code provides for environmental criminal sanctions, no environmental crime has ever been brought and tried in the courts." (AECEN 2005)

As mentioned in chapter 2.1, according to the Vietnamese Building Code for every house in urban areas, the instalment of a septic tank is mandatory (MOC 2008) – which is why most houses in Hanoi are using septic tanks as a containment system (see Chapter 3.2.1). As mentioned before, the Decree 88/2007 allows houses to get connected to a newly constructed sewer network without an onsite wastewater treatment (GOV 2007). The National Design Standard of Vietnam for Wastewater Systems "sets the technical specifications and standards for the size and design of septic tanks" and the septic tank design, installation and operation and maintenance guidelines are published in a manual issued by the MOH. The Decision 08/2005 by the MOH describes in short hygiene standards for various types of latrines (MOH 2005). The MOC is "drafting the Design Code for the septic tank design and construction" (Nguyen et al. 2011; WB 2013b; Schoebitz et al. 2014).

[2] However, this description is not quantified. Exact wording in the law is as follows: "Organizations and individuals that discharge small volumes of WW containing no hazardous substances are not required to apply for a license" (NAV 2012)

[3] In Hanoi these agencies are the MoH, Ministry of Heavy Industries, MoC, Ministry of Water Resources, MoST; as well as the Hydrometeorological Service and the Hanoi Service for Science Technology and Environment (MONRE, UNEP 2008).

[4] The Vietam Urban Water Supply benchmarking website can be accessed at http://www.vnwd.vn or http://www.vnw.gov.vn/

UN-ESCAP et al. (2015) point out that "no city in Viet Nam has yet (…) regulated the design and construction of septic tanks for the household sanitation". This shows that numerous containment standards are available, however, cities do not have the enforcement capacities to ensure compliance to these regulations (Nguyen 2011; AECOM, Eawag/Sandec 2010).

It is known that many private emptying service providers discharge the collected faecal sludge illegally into rivers or open drains. The environment police have observed this behaviour and are imposing fines (AECOM, Eawag/Sandec 2010). As mentioned earlier, this illegal discharge practice is not done to save costs but because no other option is available. If the private emptying service providers would not offer their service, households would have no possibility of getting their septic tanks desludged. Nevertheless, with the current situation the problem is shifted from the emptying to the treatment/disposal step and it is of urgent need that legal discharge, or better treatment plants for faecal sludge are created.

The Circular No. 04/2015 (MOC 2015) demands for regular reporting to local state management agencies by (septic tank) emptying and transport service providers, documenting for example the source of faecal sludge (public facility, household etc.), quantity of faecal sludge and others (Article 3). This circular is the newest legal document related to excreta management that has been passed recently. With effective monitoring the circular will be able to positively push forward the sector. Alongside, definitions of "acceptable operating practices for household desludging" will need to be defined and monitored in order to lead to improvements for the city (ADB 2015).

Compulsory effluent standards are formulated in technical regulations such as the National Technical Regulation on Water Quality for Irrigation (QCVN 39: 2011/BTNMT), the National technical regulations on industrial wastewater (QCVN 40: 2011/BTNMT) and the National Technical Regulation of Domestic Wastewater (QCVN 14:2008/BTNMT). The effluent standards for wastewater "specify water quality parameters in terms of Class A and Class B depending on whether treated wastewater is discharged to water bodies with a function of drinking water supply (Class A) or not (Class B)." → TCVN5945-2005, B and QCVN40-2011, A or B (WB 2013b). The standards for effluent discharge have been criticized as too stringent and inflexible while frequent revisions have contributed to uncertainty among local authorities on the implementation (WB 2013b). The high standards make it difficult for low cost treatment systems to enter into the market, and a lack of reliable sampling and analysis facilities for monitoring of wastewater/effluent samples is a hindrance to the effective monitoring of the required water quality parameters. It is recommended that intermediate standards with gradual increase of more demanding standards are introduced which would allow a phased introduction of treatment and monitoring systems that would gradually improve with available funds and skills (ADB 2015; UN-ESCAP et al. 2015). As mentioned before, the Decree 80/2014 now differentiates between different types of standards to be applied depending on type of wastewater and receiving body and adapted to "small scale simple treatment technologies", however, specific standards are yet to be formulated and passed (ADB 2015). "Technical guidelines for decentralized sanitation solutions are now being compiled by the MoC and MoH" (Anh n.d.).

Circular No. 04/2015 (MOC, 2015) describes sludge treatment technologies, while these technologies refer to sludge from wastewater transport and treatment systems. About the treatment of faecal sludge from septic tanks the circular notes that the "treatment of septic tank sludge must meet regulations on environment", which needs to be specified in the future. In addition, the characteristics of faecal sludge received at a treatment site and the treatment outcomes (such as ashes, slag and other) shall be monitored regularly by the treatment system operators to ensure meeting of standards. Overall, it can be noted that the city is making intensive progress in the wastewater sector (Nguyen, 2016). It is expected that with the new decree enhanced regulations, standards and guidelines for definition of acceptable methods will be formulated. But attention should be paid that measures to support proper emptying and treatment of faecal sludge are integrated, as well.

The Law on Water Resources stipulates that "organizations and individuals that discharge wastewater into water sources must have licenses granted by competent state agencies" & "licensing of discharge of wastewater into water sources must be based on standards and technical regulations on wastewater quality, the function of water sources and their capacity to receive wastewater" (NAV 2012), which is done with the effluent standards as described above.

As mentioned earlier, in Decree 80/2014 (GOV 2014) wastewater and faecal sludge is recognized as a resource, and it is encouraged to reuse treated effluent from WWTPs (Article 24) and to recover energy and nutrients from faecal sludge (Article 25). Circular No. 04/2015 (MOC 2015) recently defined criteria for re-use of treated sludge and wastewater, while the owners of drainage works (HPC) are required to regularly monitor the treated wastewater (with "regular" not being specified). The circular postulates for example that the groundwater level (including seasonal fluctuations) should be evaluated in the areas where reuse is intended in order to avoid pollution of groundwater (MOC 2015).

3 Service Outcomes

Two versions of a possible SFD matrix are illustrated in Appendix 7.4, of which scenario A is presented in the Executive Summary and described in the following. Details on scenario B of the SFD matrix can be found in Appendix 7.7.

3.1 Risk of groundwater contamination

The SFD calculation tool differentiates between sanitation systems lying in areas of low or high groundwater contamination risk in order to determine safe or unsafe management of excreta. For the determination of the level of risk, different factors are assessed which are described as follows and presented as an overview in Appendix 7.5 with the outcomes of the SFD decision support tool.

Two main aquifers of quaternary sediments contain most of the groundwater under Hanoi: a Pleistocene (the lower) and a Holocene (the upper) aquifer (Nguyen et al. 2013; Dan, Dzung 2002). Clay and sand dominate the upper, up to 10m thick, part of the Holocene aquifer. Below, this aquifer is composed of “various sands, at times mixed with gravel” (Dan, Dzung 2002).

Overall, the predominant soil types in Hanoi are a combination of fine sand, silt and clay (Berg et al. 2008; Jusseret et al. 2009; Dan, Dzung 2002; Nguyen 2016) (see Figure 3), with mostly less permeable soil types in Hanoi (WB 2013b). Groundwater levels change throughout the year (mainly due to the impact of seasonal rainfall which acts as aquifer recharge) and are decreasing rapidly due to high groundwater usage which has already led to land subsidence (Nguyen 2016). The groundwater table is reported to be ten to 30 meters (see Figure 4) by Fischer et al. (2011). However, Nguyen (2016) points out that the reported deep groundwater levels are representing the aquifers from where groundwater is abstracted for the city’s water supply while further groundwater can be found already at 0.5 to 1 meter depths. Assessing the vulnerability of the aquifer with the method of the SFD decision support tool, the vulnerability of the aquifer for groundwater contamination would be considered relatively low according to Fischer et al. (2011), and significant according to Nguyen (2016). However, either decision does not have significant impact on the groundwater contamination risk in the decision support tool, which is described in the next paragraphs.

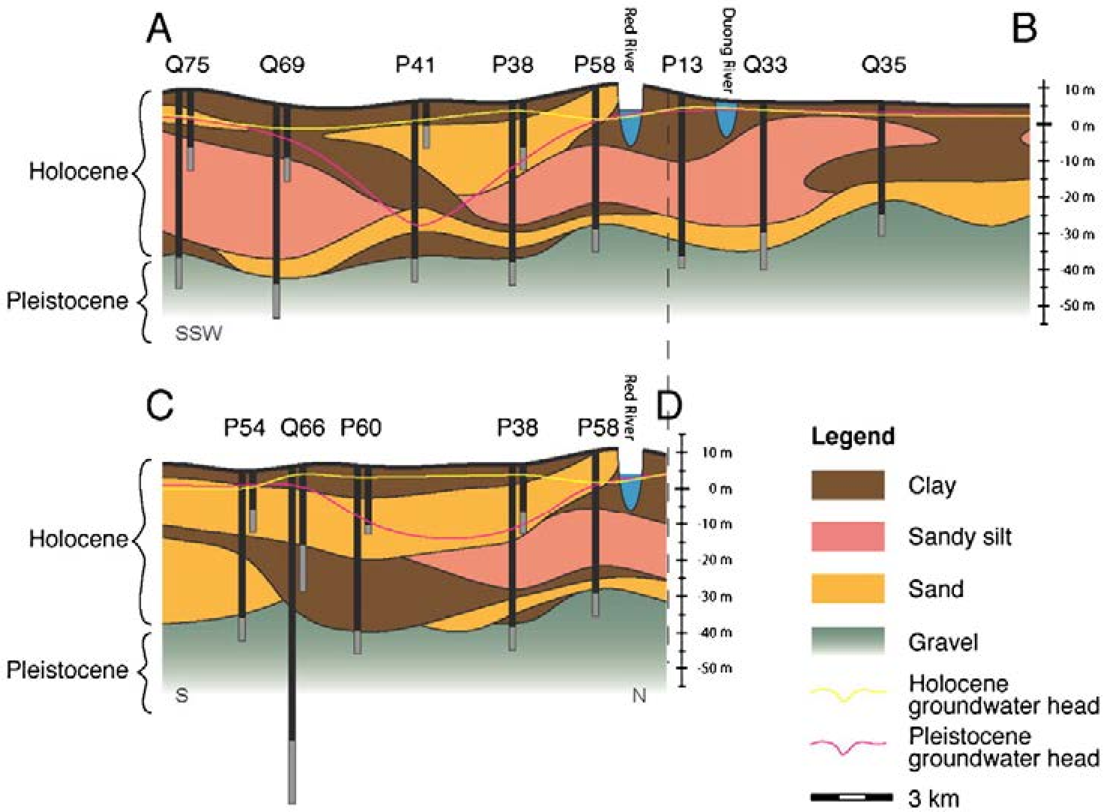

Figure 3: Sedimentary cross sections illustrating the simplified sediment architecture below the city of Hanoi (A-B) and the southern suburbs (C-D) (Berg et al. 2008).

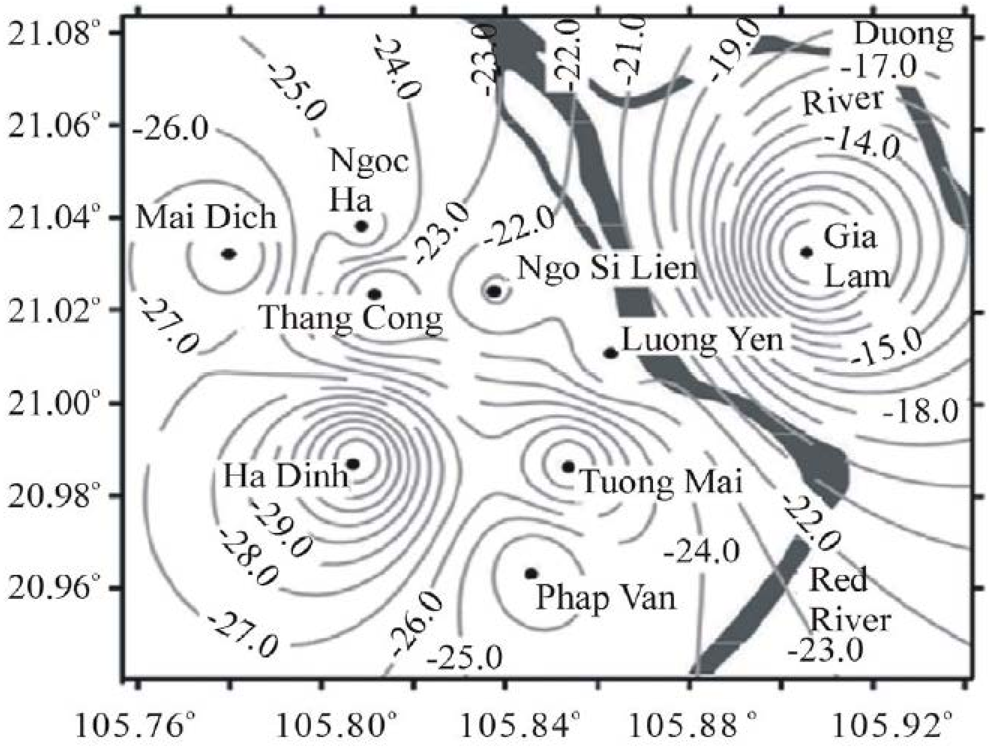

Figure 4: Groundwater levels in some districts of Hanoi in 2005 (Fischer et al. 2011).

According to data from the Hanoi Water Supply Company reported in Nguyen et al. (2011), 80% of the residents in Hanoi are connected to the central water supply network and use tap water for drinking purposes. Anh (2014) reports that the “water supply network covers about 95% of total urban population of Hanoi and the population in non-water supplied areas use underground water from private drill-wells”. Thus, the number of groundwater sources (wells) for drinking water is low. Hence it is likely that less than 25% of sanitation facilities are located less than 10 meters from groundwater sources. As the city is generally situated on flat terrain (Cornel et al. 2012), the percentage of sanitation facilities located uphill of groundwater sources is estimated to be insignificant (much lower than 25%). For these reasons groundwater contamination risk from lateral separation of sanitation facilities and groundwater sources is considered low.

As mentioned above, most of Hanoi’s residents use tap water for drinking purposes that is abstracted from groundwater sources. The groundwater is treated before being distributed through the city’s water network (Nguyen et al. 2011). Due to increasing shortages of the groundwater supply, recently new treatment plants have been built that treat surface water. The percentage of residents using a direct groundwater source is reported to be 18% (Nguyen et al. 2011).

According to the SFD decision support tool with the above information it is determined that the groundwater contamination risk in Hanoi is low (see Appendix 7.5). However, surface water contamination is severe and groundwater recharge occurs to a large extent from highly polluted river water. Furthermore, even though groundwater contamination risk is determined as low, faecal contamination of groundwater in Hanoi has been observed (Dan, Dzung 2002). To conclude, the groundwater contamination risk for this SFD is low according to the SFD decision support tool. However, the authors of this report wish to point out that groundwater contamination risk is nevertheless significant due to large amounts of faecal sludge and wastewater contaminating water bodies and being disposed in the open environment, which in turn leads to surface and groundwater contamination.

3.2 The SFD Matrix: Technologies and methods used in Hanoi

The following chapters present the technologies and methods used for different sanitation systems throughout the sanitation service chain in Hanoi. While describing the technologies and methods, the estimations and calculations for the creation of the SFD are also presented (SFD matrix is depicted in Appendix 7.4). Due to lack of data, especially for estimations on wastewater treatment (see chapter 3.2.3), two possible scenarios (and thus two possible SFDs) were created for comparison. In the following text, Scenario A is explained (which is the one depicted in the executive summary), while Scenario B is mentioned at the end of chapter 3.2.3. Both possible outcomes for the SFD matrix are illustrated in Appendix 7.4.

3.2.1 Containment

The majority of households in Hanoi have an onsite sanitation system with septic tanks being the predominant means of containment systems in urban areas of Vietnam. As described earlier, the Vietnamese Building Code of 1997 required black water to be treated by a septic tank in urban areas before being discharged to the drainage system. This resulted in most households having constructed or installed a septic tank. The septic tanks are reported to be mostly box-type and cylinder-type (Schoebitz et al. 2014) with 3 chambers, which complies with the hygiene standards on latrines by the MOH (2005). Most of the septic tanks are connected to the drainage network, with which the effluent of the tanks is collected (Nguyen et al. 2011; Harada et al. 2008; Chowdhry, Kone 2012). Recently, in newly built urban areas of Hanoi an increasing number of houses are directly connected to the drainage network (without installation of a septic tank). Thus, the percentage of households with septic tanks are reported to have decreased to 84% (Nguyen 2016).

Septic tank effluent and wastewater from flush toilets are transported in a sewerage and drainage system that is mainly composed of decentralized combined sewers (the minority) and open as well as closed decentralized combined drainage channels (the majority). That means that rainwater and wastewater is collected in the same channels/pipes. The main parts of Hanoi's sewerage and drainage system was constructed between 1905 and 1945 and covers around 1,000 ha in the central part of Historic Hanoi (Ngo 2009). In recent years, rehabilitation and expansion of the sewer system has been carried out in the context of international projects of JICA or ADB (JICA 2010; ADB 2009). New drainage networks in the city are constructed as separate sewer systems, which serve an estimated 5% of Hanoi's population who use flush toilets directly connected to separate sewers as an offsite sanitation system. However, most of Hanoi's wastewater is collected through drainage channels that are not considered actual sewer pipes (Nguyen 2016).

Apart from household latrines, excreta are also collected in one of the many public toilets that have been built in Hanoi. More than 1,400 septic tanks for more than 190 public toilet buildings exist in Hanoi. Schoebitz et al. (2014) also report that 190 public toilets exist in four urban districts of Hanoi (Hoan Kiem, Dong Da, Ba Dinh and Hai Ba Trung) which are managed by URENCO, with overall 230 fixed and 85 mobile public toilets. Although it is not known how many are mainly used by local residents it can be assumed that the public toilets in the Hoan Kiem district are mainly used by tourists. A high number of tourists also influence the generation of significant amounts of faecal sludge at restaurants and hotels. As Hanoi is a city with a high influx of tourists per year this influencing factor could be included if more information was available. (According to the Vietnam National Administration of Tourism, 3 million international and 15.5 million domestic tourists visited Hanoi in 2014 ((VNAT 2014)). If every tourist was in Hanoi for one day each, it would mean more than 50,000 population equivalents per day additional excreta generated in the city, especially in the historic centre of Hanoi.)

In the following sections, the estimations made for the SFD containment systems are explained. Table 3 provides an overview of coverage by containment type reported in literature that was identified as reliable and suitable to represent the districts covered in this SFD report. The values presented in the table (Harada et al. 2008; Nguyen et al. 2011; Chowdhry, Kone 2012) were compared to other information provided in literature (e.g. Montangero et al. 2007; Cornel et al. 2012; WB 2013a) and discussed with experts during key informant interviews (Harada 2016; Nguyen 2016). The quantitative values were assessed qualitatively on feasibility and current validity (therefore the estimations for the SFD are more a qualitative combination than an average). The numbers in Table 3 were updated with estimations from the Hanoi-based expert Nguyen (2016) to make the final estimation for input to the SFD calculation tool. These values are displayed in Table 4 and Appendix 7.6 which is depicting with different variables the percentage of the population using a specific type of sanitation technology/method along the whole sanitation service chain.

Table 3: Percentage of households using a certain type of containment technology in Hanoi as reported by household surveys

Source / Containment Type	Adopted from Harada et al. (2008, 2010) after discussion with Harada (2016)	Nguyen et al. (2011)	Chowdhry, Kone (2012)
	750 households in Historic Hanoi	300 households in Urban Hanoi	400 households in Hanoi
Flush to “sewer”	2.5%	6%	5%
Flush to open channel	2.7%	-	-
Flush to water body	0.7%	-	-
Septic tank to “sewer”	87.5%	88%	83%
Septic tank to open drain	1.4%	-	-
Septic tank to other	1.6%	1%	2%
Pit latrine	0.4%	3%	3%
(1 or 2) vault (urine diversion or not) latrine	2.6%	2%	-
Other onsite sanitation	0.3%	-	8%
No toilet / OD	0.3%	0.0%	-

Due to lack of data, assumptions had to be made, which are described in the following text. It is assumed that septic tanks from public toilets and apartment buildings are connected to the drainage/sewerage system because these are controlled more strictly by the authorities than single unit households This assumption also has an insignificant influence on the final matrix.

The containment type “sewer” is written here in quotation marks, as the definition “sewer” in literature about Hanoi is not the same as the SFD definition in the SFD document “definition of terms”[5]. Harada (2016) and Nguyen (2016) confirm that “sewers” in Hanoi are typically drainage channels (which can include “actual sewers” as well as other types of drainage channels and underground channels / covered / not covered). Therefore, it is concluded that the high percentage of sewer connections (from flush toilets or septic tanks) reported through survey results are partly connections to other types of channels. Nguyen (2016) estimates that the majority of septic tanks are connected to a drainage system leading to the environment. The ratio between “actual sewer pipes”, covered or open drainage channels, or other canals and water bodies receiving effluent from septic tanks and wastewater from flush

[5] Definition of “sewer” according to SFD definition of terms: “An underground pipe that transports Blackwater, Greywater and, in some cases, Stormwater (Combined Sewer) from individual households and other users to Treatment Plants, using gravity or pumps when necessary. The Treatment Plant and sewer network can either be Centralised or Decentralised.”

toilets is unknown. Furthermore, the SFD calculation tool does not provide an option to choose “covered drainage channels” as a containment type.

Other onsite sanitation systems in addition to septic tanks are pit latrines and single or double vault latrines (used with or without urine diversion) (Harada et al. 2010; Harada 2016). The usage of septic tanks with soak pits is considered insignificantly low (Nguyen 2016). Literature does not describe the structure of the pit and the vault latrines. However, key informant interviews revealed that single or double vault latrines are generally built above ground as fully lined tanks, whereas the pit latrines are not lined at the bottom. Both containment systems are rather used in the areas of Hanoi that display peri-urban features where fields are fertilized by farmers with excreta taken from these containment systems (Harada 2016; Nguyen 2016). In the SFD calculation tool they are included in the variable F10 (onsite sanitation, contained excreta) and estimated to be used by 4% of Hanoi’s population. They are considered to safely contain excreta if they are properly constructed and/or lying in low groundwater contamination risk areas. Therefore, the safe management estimation would change if the groundwater contamination risk decision was changed from low to significant in the city.

Applying the assumptions to the reported values leads to the following output for the SFD diagram (see Table 4 and Appendix 7.6), which will be further explained below.

Table 4: Conclusions made for the SFD on estimations on percentage of Hanoi’s population using certain containment systems

Type of containment system	Percentage
Flush toilet to combined sewerage system leading to WWTPs	1%
Flush toilet to separate sewerage system leading to WWTPs	5%
Flush toilet to those parts of the combined drainage system or rivers not leading to WWTPs (i.e. covered and open drainage channels, canals, rivers)	6%
Septic tanks to those parts of the drainage network leading to WWTPs (including sewers, and some other parts of the drainage network)	16%
Septic tanks to those parts of the drainage network not leading to WWTPs (including covered and open drainage channels, canals, rivers)	68%
Lined pit with semi-permeable walls and open bottom, no outlet or overflow	2%
Fully lined tank (sealed), no outlet or overflow	2%

The assessment leads to the output of 12% offsite sanitation (the variable W1 in the SFD matrix shown in Appendix 7.4 includes flush toilets to the separate or combined sewers, covered drainage channels, open drains, canals and rivers) and 88% onsite sanitation systems (the variable F1 includes septic tanks connected to “sewers”, open drains or other and pit latrines and other). It is safe to assume that open defecation basically does not exist in Hanoi; e.g. Harada et al. (2008) report 0.3% and WB (2013a) as well as Nguyen et al. (2011) 0%. Thus, open defecation is not shown in the SFD matrix.

Based on literature it could be estimated that around 5% of Hanoi's population uses offsite sanitation (compare Scenario B of the SFD matrix in Appendix 7.4). However, Nguyen (2016) pointed out that in recent years an increasing number of households were directly connected to the sewerage system without a septic tank (especially in newly built urban areas) and estimates that 12% of Hanoi's population uses flush toilets directly connected to the drainage network (see Table 4). In newly built urban areas a separate sewerage system has been constructed as was recommended by various stakeholders such as the ADB (2015). Only sewers that were adequately constructed are considered to be a system that properly contains wastewater. Thus it is estimated that excreta from 6% of Hanoi's population are collected in an offsite containment system that contains wastewater (variable W3) while the other 6% are not collected in offsite containment systems which do not contain wastewater (variable W15), such as covered and open drainage channels, canals or rivers (Nguyen 2016).

The value on septic tanks existing in the city (84%) is split up according to septic tanks to drainage channels and sewers that lead to WWTPs and septic tanks to other channels (include covered drainage channels, open channels and rivers). As explained previously, no distinction is made between covered drainage channels, open channels or rivers because the SFD calculation tool does not provide an option "covered drainage channels" and the percentage of occurrence is not known for these different types of transport systems. In addition, the SFD calculation tool does not consider the possibility of wastewater from open channels or rivers that ends up at decentralized wastewater treatment sites, which is the case in Hanoi. Therefore, this ratio depends on the assumptions made on treatment, which are explained in chapter 3.2.3. It is estimated that 16% of Hanoi's containment systems are septic tanks connected to those parts of the drainage network which are connected to the WWTPs (included in F2), while the remaining represent F10 (68%). It is assumed that all septic tanks are properly constructed. If information is obtained on percentage of septic tanks not functioning as septic tanks due to design or construction faults, being affected by leakage or other, these would lead to an increase of the value F10 (faecal sludge not contained (onsite)).

The variable F2 in the SFD calculation tool represents onsite sanitation systems that are considered to safely contain faecal sludge (estimated to be used by 20%). The number includes the pit latrines and fully lined tanks in Hanoi because the groundwater contamination risk is considered low and it is assumed that there is not outlet or overflow of these systems. Additionally, the variable includes septic tanks connected to sewers or drainage channels leading to WWTPs. This does not correctly represent the situation as the SFD methodology only considers septic tanks connected to actual sewers a safe containment system. However, in Hanoi, the minority of drainage channels are actual sewers.

3.2.2 Emptying & Transport

Until very recently, all parts of the sewer network in Hanoi were defined as a combined sewer system (CSS), where rainwater and wastewater are collected and transported through the same pipes/channels. This fact, in combination with the pre-treatment of faecal sludge by settling in septic tanks and other possible factors such as low flow-velocities and further settling in the sewers due to low slope, result in the wastewater that reaches treatment facilities having very low concentrations of BOD. Therefore, ADB (2015) recommended that in the future the installation of separate sewer systems should be the aim of urban authorities, which was implemented in recent sewer expansion projects in newly built urban areas. The sewerage/drainage network lying in the districts of Historic Hanoi is under the supervision of HSDC, while the other parts are managed by CPCs (Nguyen 2011; Cornel et al. 2012). It has been acknowledged that the sewer collection networks need “rehabilitation to prevent infiltration of groundwater; better design, with a proper slope to carry water during dry and wet weather conditions” (UN-ESCAP et al. 2015). This possibility of infiltration of groundwater to the drainage system is another indicator for groundwater contamination risk (by exfiltration from the system to the ground). The focus of wastewater expenditure has to shift from the mere construction of treatment facilities to the extension and upgrading of appropriate collection and transport systems (UN-ESCAP et al. 2015; Nguyen 2016). “The ratio of sewer length per capita in Hanoi city is about 0.3 m/person” (Nguyen 2011).

To highlight the deviation from the standard methodology, it should be noted that the variables W4b and W11c do not only represent wastewater in sewers and open channels respectively, but rather represent the wastewater and septic tank effluent being delivered or not delivered to WWTPs. This leads to the result that some covered drainage channels are counted as open channels, which is considered an appropriate representation as the safe management is not valid for these types of channels anyways. In addition, some of the open channels may be counted in the variable W4b, although they are not considered safely managed, but is considered as the best option to represent the wastewater flowing to decentralized WWTPs in Hanoi.

As mentioned earlier, the septic tanks are typically installed directly underneath the houses, which means that to empty or access the septic tanks a hole needs to be made from inside the house through the kitchen floor. This makes emptying of faecal sludge challenging (Schoebitz et al. 2014). The result is that most households wait many years before they call a service provider to empty their septic tank, until emergency problems such as clogging and backing up of the system gives no other option but to empty the tanks. In most cases transport of the emptied faecal sludge is carried out by trucks, however in some cases the streets are not wide enough with the result that hand carts are used as an intermediate transport system (Cornel et al. 2012).

Household surveys have reported different results for percentage of septic tanks that have never been desludged. Harada et al. (2008) and Fink (2001) report that nearly 90% or 80% respectively of Hanoi’s septic tanks have never been desludged, while the survey from Nguyen et al. (2011) reveals 62% of the septic tanks in Hanoi as never having been emptied. Of those that are emptied on a more or less regular basis, the average reported desludging period is 6-8 years (Harada et al. (2008) and AECOM, Eawag/Sandec (2010)) or 6.2 years (Nguyen et al. 2011). It is assumed that a trend can be seen to more and more septic tanks having been desludged at least once in their lifetime because over the years more households are forced to empty tanks due to system backup if they had not emptied them before[6]. William, Overbo (2015) report that “many households empty their septic tanks every several years, others wait decades before they let the septic tank be desludged”[7].

If one assumes an emptying frequency of 6 years, 17% of the septic tanks in the city would be emptied each year ((84%/6)/84). With the estimation of 587,429 households with septic tanks in Hanoi that would result in 93,989 septic tanks being emptied per year. This means 257 septic tanks would have to be emptied per day (plus public toilets). Nguyen et al. (2011) report that 112 private trucks existed in the city who serve an average of 2.7 households per day. The above calculation would require each of the 112 trucks to serve 2.3 households per day which resembles the survey results from Nguyen et al. (2011). As the authors report that private emptying service providers have a profitable business it is quite likely that more private service providers have started to operate since 2011.

The SFD asks for an estimation on “proportion of population using this system with emptying”; the matrix is not showcasing the situation for a specific year. Therefore, it is assumed that all residents of Hanoi use the system with emptying at least at one point of the system’s lifetime. This estimation is based on the fact that all households have access to emptying services (high number of emptying service providers with the capacity to serve the households in Hanoi) and the statement that the septic tanks receive emptying when problems occur (Nguyen 2016). Another estimation is represented in Scenario B of the SFD matrix. All of the pit latrines and lined tanks (single and double vault latrines) in the city are assumed to be emptied on a regular basis because the excreta is in demand for use as fertilizer (see chapter 3.2.4). Therefore, for the onsite sanitation systems it is estimated that all are used with emptying, resulting in the value of 45% faecal sludge emptied (F3). This is split up into the streams F3a (faecal sludge contained emptied) being 11% and F3b (faecal sludge not contained emptied) being 34%.

Although it is assumed that all onsite sanitation systems in Hanoi employ emptying, in many cases desludging is practiced only after many years. This infrequent emptying of septic tanks leads to pollution of the environment and health risk to the city’s inhabitants (also see chapter 3.2.3). If faecal sludge is not emptied from septic tanks, the performance of reduction of total solids, COD and other parameters is not achieved as designed and is not predictable. This risk is partly in the wastewater streams W4b and W11c which include untreated effluent from septic tanks. Currently, septic tank effluent does not meet the standards and poses significant environmental and human health risk (Nguyen et al. 2011; Harada et al. 2008). Nguyen et al. (2007) point out that the septic tanks in Vietnam have low treatment efficiencies and do not perform as well as intended. This is a result of inadequate design, improper construction and/or inefficient maintenance (e.g. irregular desludging). Harada et al. (2008) calculated that “72.8% of Chemical Oxygen Demand loads and 25.8% of Suspended Solids loads from septic tanks could be eliminated by shortening the non-desludging period

[6] The older the septic tanks get, the more likely it is that they have been desludged at one point. As the septic tanks have been built in the 90s (?), if one has emptying periods of 5-over 20 years, soon most tanks should have been emptied.
[7] Some households use a powder as an emptying method that shall digest the sludge (Fink 2001), however additives have been shown to not effectively reduce the amount of sludge in containment, and should not be considered treatment options (Foxon, Still 2012).

from seven years, the median value in urban Hanoi, to one year". As a portion of the excreta flows out of septic tanks with the effluent through sewers or open drains or directly into rivers, the pollution load of the variables W4b and W11c is largely influenced by the septic tanks' performance.

3.2.3 Treatment

In Hanoi, the majority of excreta receive only some primary treatment at the household level in poorly maintained septic tanks. The SFD does not consider this onsite sanitation technology as full treatment, as it is only primary treatment (some settling and long-term anaerobic digestion), with faecal sludge remaining onsite that still needs to be managed. As stated above, the majority of septic tanks in Hanoi are inadequately maintained and thus treatment effectiveness is low (ADB 2015; Harada et al. 2008). Properly maintained septic tanks can remove 30 to 50% of the Biological Oxygen Demand, 40 to 60% of Total Suspended Solids (UNEP 2004) and 1-log of E. coli (Tilley et al. 2014). However, if not desludged every 2-5 years (Tilley et al. 2014), the effluent concentrations can be same as the inflow, or even increase (Harada et al. 2008; Harada 2012). Nam et al. (2006) report that almost all septic tank effluent parameters analysed were higher than the Vietnamese standard, and illustrates the need for education campaigns on proper operation and maintenance of septic tanks. Otherwise, "the septic tanks are just converting the pollutants from solid phase to dissolved phase, which escape with the septic tank effluent due to insufficient retention time" (Nam et al. 2006). Therefore, effective secondary treatment of the septic tanks' effluent at wastewater treatment plants, as well as treatment of the faecal sludge taken out from the tanks is required. The existing treatment sites in Hanoi are described in the following text.

Wastewater treatment

Based on literature (WB 2013b; Schoebitz et al. 2014), there are four WWTPs operating in Hanoi which are treating a fraction of the total generated wastewater. However, since the most recent literature, two more WWTPs have started operation (Nguyen 2016). The available information on these six treatment plants is presented in Table 5, and some further detail in appendix 7.10.1.

Table 5: Operating WWTPs in Hanoi (WB 2013b; Nguyen 2016).

WWTP name	Start-up year	Number of people designed to serve	Capacity in m^3/d (design)	Capacity in m^3/d (in operation)	Treatment process / technology
Kim Lien	2005	(not reported)	3,700	3,700	A2O (AS)
Truc Bach	2005	15,700	2,500	2,500	A2O (AS)
North Thang Long	2009	150,000	42,000	7,000	A2O with nitrification
Yen So	2012	(not reported)	200,000	120,000	SBR
Bay Mau	After 2012	N/A	N/A	14,000	N/A
Ho Tay	After 2012	N/A	N/A	13,000	N/A

The first two WWTPs in Hanoi (Kim Lien and Truc Bach) were built for demonstration purposes (which is why they have a low treatment capacity) and in spite of operational difficulties, the effluent meets discharge standards. These two WWTPs "treat sewage of low concentration, due to the prevalence of combined sewer systems, groundwater infiltration into sewers, some pretreatment of sewage in household septic tanks, and long detention times in oversized collector mains" (ADB 2015). The influent for the Yen So WWTP is not from sewers, but polluted river water from the Kim Nguu and Set rivers. The Yen So WWTP is indirectly treating wastewater, as rivers are the main receiving bodies of urban untreated wastewater (WB 2013b). Therefore, it is difficult to estimate how much domestic wastewater this WWTP is currently treating. Furthermore, the SFD calculation tool does not have options to clearly show the exact situation in Hanoi, as it is a reasonably unique situation where river water is being treated at treatment plants, as opposed to raw wastewater being delivered by a sewer. The source of wastewater in surface water bodies is septic tank effluent which flows through open drains without treatment, and faecal sludge dumped by collection and transport trucks (Nguyen et al. 2011). According to literature, the North Thang Long WWTP treats primarily industrial wastewater, not household wastewater, and thus one could exclude it during the SFD calculations[8]. However, for scenario A of the SFD it is assumed that all WWTPs treat domestic wastewater with the working capacities mentioned in Table 5. A quite different approach was used for Scenario B (see Appendix 7.7). On the two newest WWTPs Bay Mau and Ho Tay, no data was yet available in literature. Nguyen (2016) provided the information about the wastewater treatment capacities at these treatment plants.

Combining this knowledge, it is assumed that a total of 160,200 m³ of domestic wastewater is treated in Hanoi per day. From the information that the total water consumption in Hanoi is 900,000 m³/day and wastewater is estimated as 80% of the water consumption (Nguyen 2016), the percentage of wastewater treated equals 22% (160,200/(0.8*900,000)). This 22% is not equal to the percentage of population served by wastewater treatment plants (as represented in the SFD in the upper right by 14% - variable W5b) because the SFD is tracking excreta, not wastewater, and some excreta remains in the septic tanks as sludge / is emptied during the desludging process.

Nguyen (2016) and Harada (2016) made a qualitative estimate that 20-25% of the wastewater generated in Hanoi is treated. Also Schoebitz et al. (2014) report values from HSDC which depict that 20% of the 650,000 m³/day of wastewater are treated. Other sources though estimate a wastewater treatment capacity of 10% for Hanoi (ADB 2015; WB 2013b). The above estimations for wastewater delivered to treatment are understood as one possible scenario for wastewater treatment in Hanoi. As this matter is based on many assumptions and uncertainties a second scenario is created, based on estimations of people served per WWTP. These estimations are used to create a second version of the SFD, which is depicted in Appendix 7.4, Scenario B, and described in Appendix 7.7.

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[8] Further information on North Than Long WWTP: It has a low operation capacity because the sewer lines that were to lead to the WWTP were never constructed (local funds that were to be used were never made available) (WB 2013b). For successful operation of WWTPs in planning/procurement phase it is important that the connecting sewer network is constructed and the influent meets the design criteria (Schoebitz et al. 2014).

Having estimated the percentage of wastewater treated at the WWTPs, next it is calculated back how much septic tank effluent receives treatment at the treatment plants, and thus how many septic tanks are connected to the parts of the drainage/sewerage network that lead to treatment sites. It is assumed that 50% of the septic tanks' content is faecal sludge, while the rest is leaving the tanks as effluent (which is likely much higher due to the infrequent desludging practices, however due to lack of data, the estimate with the least possible error is chosen). Having estimated that 22% of the wastewater is treated at the WWTPs, and 6% is from flush toilets connected to the sewerage network, the percentage of septic tanks connected to the drainage network that leads to treatment is the remaining 16%.

From reports (JICA 2010; WB 2013b) it is apparent that the effluent concentrations from the WWTPs generally meet the standards (TCVN5945-2005, B and QCVN40-2011, A or B) (also see Appendix 7.10.3) and thus it is estimated that all wastewater delivered to WWTPs (W4b) is treated effectively (→ W5b = W4b). However, experts are concerned about the limited treatment performance of some WWTPs in the city (Harada 2016), and literature reports operational difficulties especially at the Yen So WWTP, where the low BOD influent values create an imbalance in the carbon to nitrogen ratio (WB 2013b). In general, the influent often has very low COD and BOD concentrations. Thus, if in the future wastewater with increasing pollution load arrives at the treatment plants, it is not known how the treatment performance will be affected.

Faecal Sludge Treatment

There is only one existing faecal sludge treatment plant in Hanoi: the Cau Dien co-composting plant in Tu Liem district, which is under the management of URENCO. Apart from faecal sludge from public toilets, this treatment plant also receives organic market waste from four inner districts of Hanoi. The faecal sludge is thickened in a settling tank (for process flow diagram of the Cau Dien composting plant refer to Appendix 7.11). The products (either solid and liquid parts) of the settling process are disposed at the landfill (the solid fraction), sent to a stabilization pond (liquid fraction) or added to the organic waste during the aerobic processes (liquid fraction) (Schoebitz et al. 2014) . As only faecal sludge trucks operated by URENCO are allowed to discharge at the composting plant, and no other legal discharge location exists in Hanoi, private emptying service providers have no other option but to discharge "directly into the urban environment, in open channels, lakes and rivers" (Schoebitz et al. (2014) citing Nguyen et al. (2011)). ("Small quantities of untreated faecal sludge are sold to farmers for direct application as a soil amendment and for use in fish ponds" ((Schoebitz et al. 2014)); but as no numbers exist and the values are estimated to be insignificant to show up as percentage in the SFD, they are not evaluated further.)

Two faecal sludge treatment options were constructed at the Cau Dien composting plant: co-composting with organic waste and anaerobic digestion/settling, however co-composting is not operational and anaerobic digestion has limited efficiency. According to literature, the composting plant receives and treats 10 – 30m³ faecal sludge per day (mostly from public toilets serviced by URENCO) while it is estimated that 500 m³ of faecal sludge are generated per day in Hanoi[9], which would mean that only 2 – 6% of the generated faecal sludge is

[9] Sludge generation volumes are very difficult to estimate and vary greatly depending throughout literature and depending on the assumptions made (Schoebitz et al.).

treated (WB 2013b). Hence, for all the faecal sludge collected in Hanoi, only that emptied by URENCO is delivered to treatment. URENCO has three vacuum trucks. 120 more vacuum trucks are in operation by numerous private emptying service providers. Through previous estimation in chapter 3.2.2 it was estimated that 257 septic tanks are emptied per day. According to Nguyen et al. (2011) the average volume of a septic tank in Hanoi is 2.6 m^3, which would result in an emptying volume of 668.2 m^3 (257*2.6 m^3). According to Nguyen (2016) the present treatment capacity of the Cau Dien composting plant is 50 m^3/day, which is used by URENCO to collect faecal sludge from public toilets. Using this information it is estimated that 7% (50/(668+50)) of faecal sludge is treated in Hanoi, resulting in an overall percentage of 3%. Another possible scenario is presented in Appendix 7.7.4. These estimations for faecal sludge treatment are applied to the faecal sludge from septic tanks. For the emptied sludge from pit latrines and lined tanks it is estimated that they are not delivered to treatment, but all reused near the source of production (see chapter 3.2.4).

The result of all the estimates together is that 82% of the populations' excreta is not managed safely and 18% is managed safely. The result that 82% of excreta in Hanoi is not being safely managed is due to on large part the inadequately maintained septic tanks, which discharge contaminated effluent that requires further treatment. On the other hand, the problem of the large amount of wastewater in open channels (parts of the 40% - W11) cannot be solved by just building treatment plants (like the Yen So treatment plant) if adequate sewer connections to households are not constructed at the same time. Apart from this pollution load from wastewater and septic tank effluent, it is an urgent need to construct faecal sludge treatment sites for legal discharge by private emptying service providers, and treatment with safe enduse or disposal.

3.2.4 End-use and disposal

The effluent from the Kiem Lien and Truc Bach WWTPs are discharged into the Lu River and the Truc Bach lake respectively (Schoebitz et al. 2014) . The sludge that is generated during the wastewater treatment process at the WWTPs is disposed of at landfills.

At the Cau Dien composting plant every month around 60 to 70 tons of compost from organic waste and faecal sludge are produced and sold. However “due to high variations of the input quality”, no consistent quality of the compost can be guaranteed and thus the amount and price of the fertilizer is low (Schoebitz et al. 2014) . The faecal sludge collected by private emptying service providers is disposed (illegally) into open drains and rivers (WB 2013b).

Informal wastewater re-use is common in the peri-urban areas of Greater Hanoi by applying excreta or wastewater directly on the field or using river water, which receives untreated wastewater. However, this re-use procedure is not formalized or supervised by any official organization or management scheme and poses significant health risks to both urban farmers and consumers of these vegetables (Lam et al. 2015, Schoebitz et al. 2014). Excreta are taken from single or double vault latrines or pit latrines to use as fertilizer for rice fields (seldom for fish ponds). In double vault latrines one chamber is used for a few months until usage is switched to the second chamber. If urine is separated it is collected in containers and used as liquid fertilizer (Harada 2016; Nguyen 2016). In the case of a double vault urine diversion toilet, the excreta reuse may likely be considered safe if the drying and composting process is practiced effectively. However, in the SFD diagram those systems are presented as onsite sanitation systems being emptied but not delivered to treatment sites (unsafe management), although some of it may be viewed as safe excreta management. In any case, the acceptance of excreta and wastewater reuse by the population is valued as a positive influencing factor that may facilitate larger scale reuse projects (backed up by findings from Anh (2014)).

3.2.5 Uncertainty of data

Important information was obtained during key informant interviews that influenced the outcome of the SFD diagram. For example, some terms such as “sewer” in literature is defined differently in Hanoi than in the SFD methodology. However, the ratio of actual sewerage pipes versus open channels, covered drainage pipes and other canals, or rivers transporting wastewater and faecal sludge is still unknown.

Furthermore, the amount of wastewater delivered to and treated at WWTPs is based on many assumptions. Design capacities of treatment plants are described in literature, but recent values on population served could not be obtained. In addition, knowledge of newly constructed WWTPs is due to expert knowledge of Hanoi and was not available in literature, and the population served was also not available.

In addition, the number and frequency of onsite sanitation systems emptied and the amount of generated versus treated faecal sludge could not be verified with actual recent numbers.

4 Stakeholder Engagement

4.1 Key Informant Interviews

Two key informants were identified and interviewed during the research for this desk-based SFD report. Both are collaborators and research partners of Eawag/Sandec.

The first key informant interview was carried out with Viet-Anh Nguyen (Nguyen 2016), the director of the Institute of Environmental Science and Engineering (IESE), Hanoi University of Civil Engineering (HUCE) and head of the Water Supply & Sanitation Division of the Department of Environmental Engineering, HUCE. This expert knowledge was key for making reasonable estimates and understanding the most recent developments in the sector.

The second key informant was Hidenori Harada (Harada 2016), who conducts research in Hanoi and is co-author of journal articles on containment systems and septic tank management in Hanoi. The interview was used to clarify details of published results and further validate information necessary for the creation of the SFD. The interview confirmed the existing data gaps and challenges existing in the quantification of actual sewers versus drainage channels and people served by wastewater treatment plants.

Additionally, the report relies on the long-term experience of researchers from Eawag/Sandec working in Hanoi.

It can be concluded that literature alone is not sufficient to give an up to date picture of the situation in the city. Key informant interviews with stakeholders that have been working in the city for many years are of utmost importance if the SFD report is created with a desk-based (instead of a field-based) study.

5 Acknowledgements

Special thanks are extended to Viet-Anh Nguyen and Hidenori Harada, the two key experts for informant interviews who shared their knowledge on excreta management in Hanoi. Their expert opinions were valuable in correctly illustrating the current sanitation situation in Hanoi, and identifying current challenges and data gaps.

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7 Appendix

7.1 Districts and wards of Urban Hanoi

The 12 urban districts according to http://english.hanoi.gov.vn/administrativebodies and its wards (as of January 2014) according to (Schoebitz et al. 2014) :

1. Ba Dinh (North Centre) – 14 wards

Cống Vị · Điện Biên · Đội Cấn · Giảng Võ · Kim Mã · Liễu Giai · Ngọc Hà · Ngọc Khánh · Nguyễn Trung Trực · Phúc Xá · Quán Thánh · Thành Công · Trúc Bạch · Vĩnh Phúc

2. Hoan Kiem (Centre) – 18 wards

Chương Dương Độ · Cửa Đông · Cửa Nam · Đồng Xuân · Hàng Bạc · Hàng Bài · Hàng Bồ · Hàng Bông · Hàng Buồm · Hàng Đào · Hàng Gai · Hàng Mã · Hàng Trống · Lý Thái Tổ ·Phan Chu Trinh · Phúc Tân · Trần Hưng Đạo · Tràng Tiền

3. Tay Ho (North) – 8 wards

Bưởi · Thụy Khuê · Yên Phụ · Tứ Liên · Nhật Tân · Quảng An · Xuân La · Phú Thượng

4. Long Bien (North East) – 14 wards

Bồ Đề · Cự Khối · Đức Giang · Gia Thụy · Giang Biên · Long Biên · Ngọc Lâm · Ngọc Thụy · Phúc Đồng · Phúc Lợi · Sài Đồng · Thạch Bàn · Thượng Thanh · Việt Hưng

5. Cau Giay (North West) – 8 wards

Bưởi · Thụy Khuê · Yên Phụ · Tứ Liên · Nhật Tân · Quảng An · Xuân La · Phú Thượng

6. Dong Da (Centre) – 21 wards

Cát Linh · Hàng Bột · Khâm Thiên · Khương Thượng · Kim Liên · Láng Hạ · Láng Thượng · Nam Đồng · Ngã Tư Sở · Ô Chợ Dừa · Phương Liên · Phương Mai · Quang Trung ·Quốc Tử Giám · Thịnh Quang · Thổ Quan · Trung Liệt · Trung Phụng · Trung Tự · Văn Chương · Văn Miếu

7. Hai Ba Trung (Centre) – 20 wards

Bạch Đằng · Bách Khoa · Bạch Mai · Bùi Thị Xuân · Cầu Dền · Đống Mác · Đồng Nhân · Đồng Tâm · Lê Đại Hành · Minh Khai Ngô Thì Nhậm · Nguyễn Du · Phạm Đình Hổ · Phố Huế · Quỳnh Lôi · Quỳnh Mai · Thanh Lương · Thanh Nhàn · Trương Định · Vĩnh Tuy

8. Hoang Mai (South East) – 14 wards

Đại Kim · Định Công · Giáp Bát · Hoang Liet · Hoàng Văn Thụ · Lĩnh Nam · Mai Động · Tân Mai · Thanh Trì · Thịnh Liệt · Trần Phú · Tương Mai · Yên Sở · Vĩnh Hưng

9. Thanh Xuan (South) – 11 wards

Hạ Đình · Khương Đình · Khương Mai · Khương Trung · Kim Giang · Nhân Chính · Phương Liệt · Thanh Xuân Bắc · Thanh Xuân Nam · Thanh Xuân Trung · Thượng Đình

10. Ha Dong (South West)- 17 wards

Quang Trung; Nguyễn Trãi; Hà Cầu; Vạn Phúc; Phúc La; Yết Kiêu; Mộ Lao; Văn Quán; La Khê; Phú La; Kiến Hưng; Yên Nghĩa; Phú Lương; Phú Lãm; Dương Nội; Biên Giang; Đồng Mai

11. South (=Bac) Tu Liem (North West) – 13 wards

Cổ Nhuế 1, Cổ Nhuế 2, Đông Ngạc, Đức Thắng, Liên Mạc, Minh Khai, Phú Diễn, Phúc Diễn, Tây Tựu, Thượng Cát, Thụy Phương, Xuân Đỉnh, Xuân Tảo

12. North (=Nam) Tu Liem (North West) – 10 wards

Cầu Diễn, Đại Mỗ, Mễ Trì, Mỹ Đình 1, Mỹ Đình 2, Phú Đô, Phương Canh, Tây Mỗ, Trung Văn, Xuân Phương

The last three districts were not part of Historic Hanoi. Greater Hanoi includes 17 more districts and one provincial town (see Figure 5, Appendix 7.2).

7.2 Map of the Districts in Hanoi Province

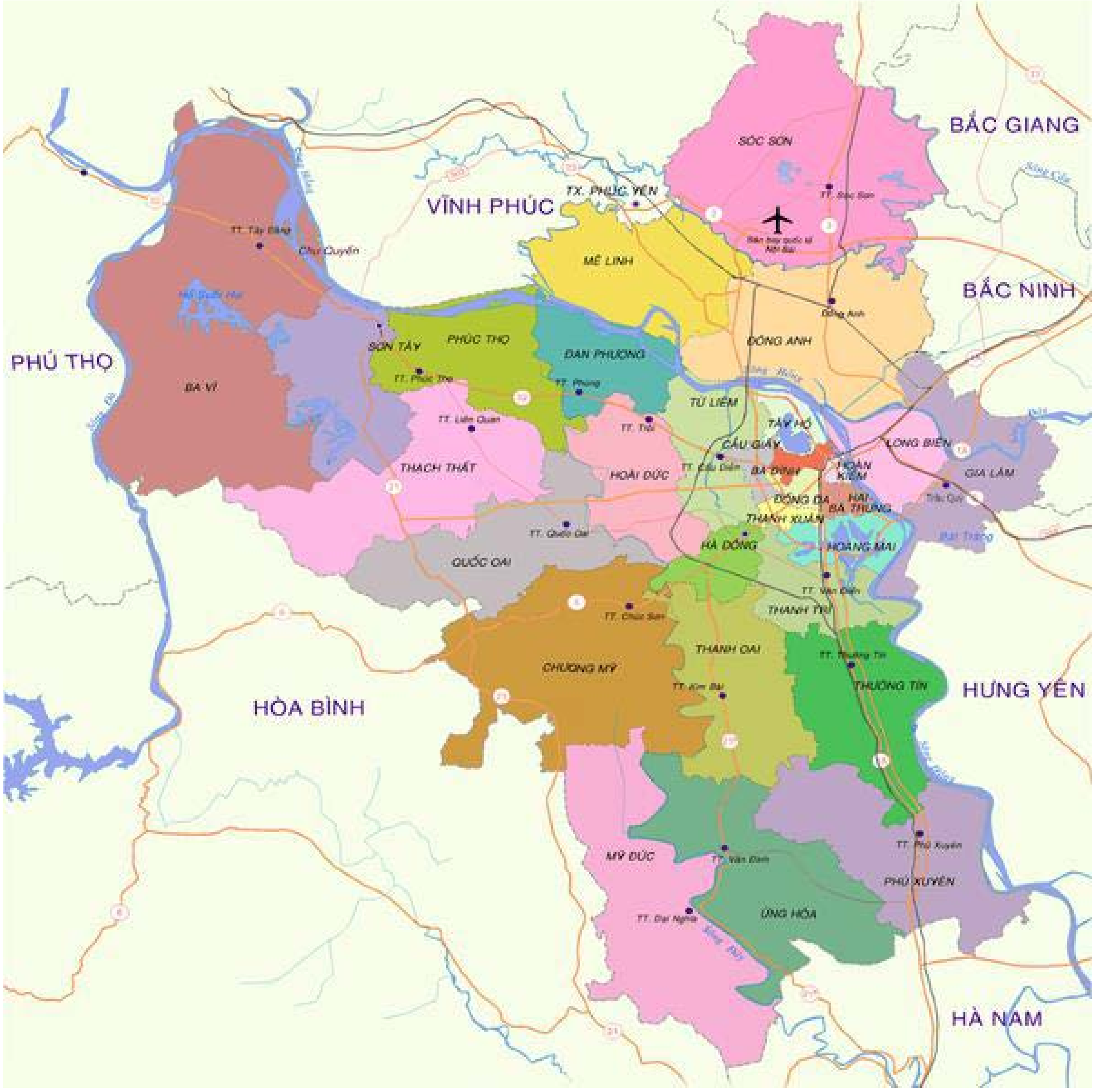


Figure 5: Map of the districts of Hanoi Provinceas of 2013[10] (Anh 2014).

[10] In December 2013, Tu Liem was split into Bac Liem and Nam Liem. http://en.nhandan.com.vn/society/item/2186002-hanoi-has-two-new-districts-bac-tu-liem-nam-tu-liem.html

7.3 Stakeholder identification (Tab 2: Stakeholder Tracking Tool)

	Stakeholder Group*	**Name of organisation**
Stakeholder 1	1	Hanoi People's Committee (HPC), DPCs & CPCs
Stakeholder 2	1	Department of Natural Resources and Environment (DoNRE)
Stakeholder 3	1	Department of Construction (DoC)
Stakeholder 4	6, 9	Hanoi Urban Environment Company (URENCO)
Stakeholder 5	6	Unknown private emptying service providers
Stakeholder 6	7	Hanoi Sewerage and Drainage One-Member State Company Limited (HSDC)
Stakeholder 7	7	Phu Dien Construction and Trading Joint Stock Company
Stakeholder 8	2, 4	Ministry of Natural Resources and Environment (MONRE)
Stakeholder 9	2, 3	Ministry of Construction (MOC)
Stakeholder 10	4	Ministry of Health (MOH)
Stakeholder 11	4	Ministry of Finance (MOF)
Stakeholder 12	10	Institute of Environmental Science and Engineering (IESE), Hanoi University of Civil Engineering (HUCE)
Stakeholder 13	10	Japan International Cooperation Agency (JICA)
Stakeholder 14	10	Asian Development Bank (ADB)
Stakeholder	10	World Bank (WB)
	10	(IDA)
Stakeholder 15	10	German Development Cooperation Agency (GIZ)
Stakeholder 16	10	Vietnam Water Supply and Sewerage Association (VWSA)

* The stakeholder group number describes the following (according to the SFD stakeholder tracking tool):

1 City council / Municipal authority / Utility;

2 Ministry in charge of urban sanitation and sewerage;

3 Ministry in charge of urban solid waste;

4 Ministries in charge of urban planning, environmental protection/ health, finance and economic development, agriculture;

5 Service provider for construction of onsite sanitation technologies;

6 Service provider for emptying and transport of faecal sludge;

7 Service provider for operation and maintenance of treatment infrastructure;

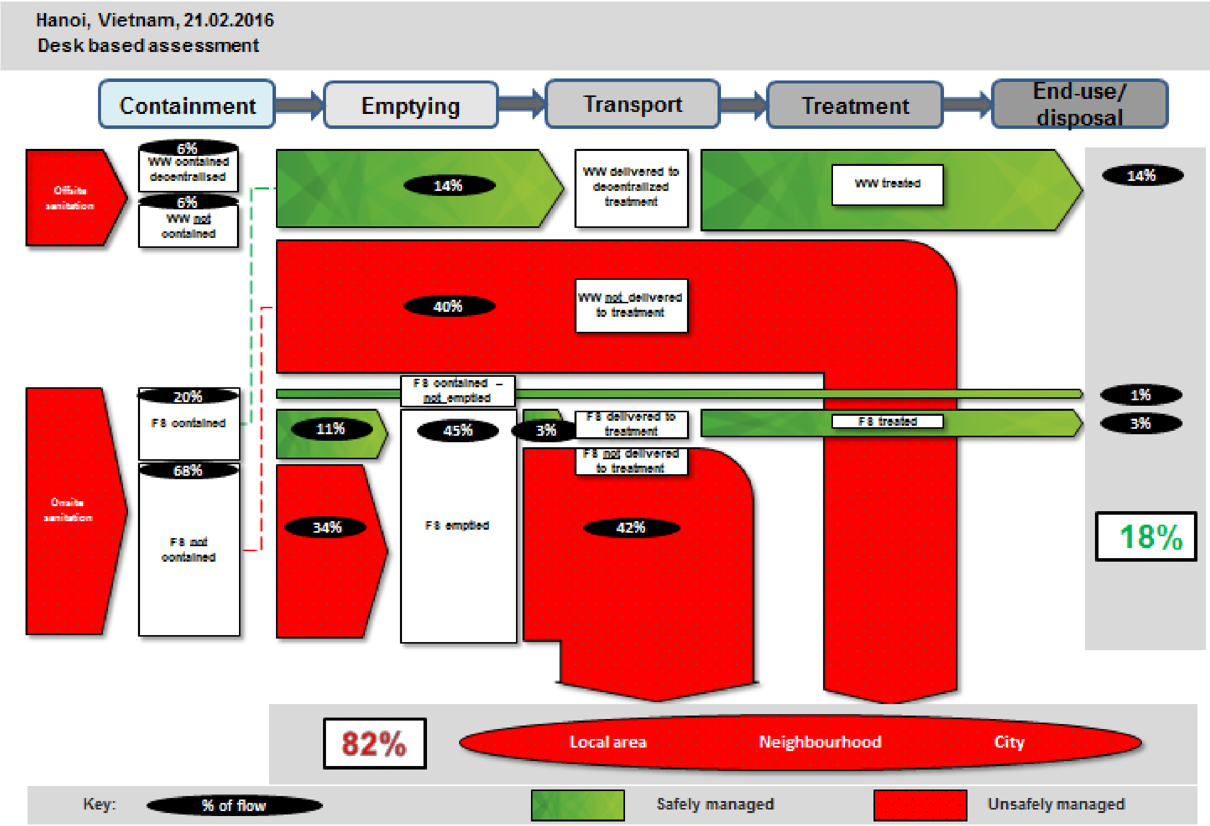
8 Market participants practising end-use of faecal sludge end products;

9 Service provider for disposal of faecal sludge (sanitary landfill management);

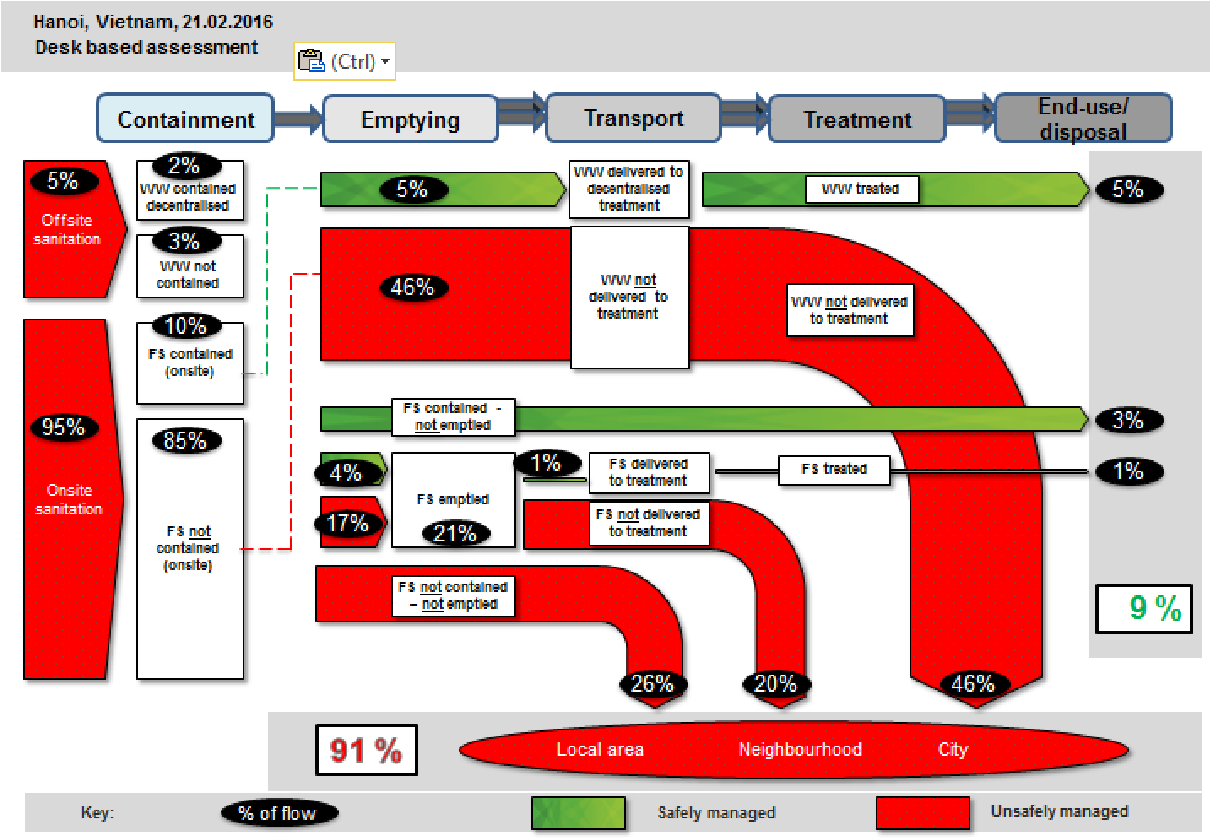
10 External agencies associated with FSM services: e.g. NGOs, academic institutions, donors, private investors, consultants

7.4 SFD matrix

Scenario A:



Scenario B:



Other possible scenarios could be created based on different assumptions on septic tanks being emptied. The variable defined as "wastewater not contained, not delivered to centralized treatment plants" does not describe the situation in Hanoi correctly. It should be described as "wastewater not contained, not delivered to decentralized treatment plants". However, this variable exists in the SFD calculation tool only for wastewater from sewers and not from open channels, therefore this variable had to be chosen.

7.5 Assessment of groundwater contamination risk

1) Vulnerability of the Aquifer		
A) What is the rock type in the unsaturated zone?	fine sand, silt and clay (Berg et al. 2008; Jusseret et al. 2009; WB 2013b)	Question 1: Outcome Low Risk
B) What is the depth to the groundwater table?	> 10m (Fischer et al. 2011)	
2) Lateral separation		
A) What is the percentage of sanitation facilities that are located <10m from groundwater sources?	Less than 25% (Expert estimate based on the knowledge that the number of wells are relatively low as most residents are connected to the public water supply network)	Question 2: Outcome Low Risk
B) What is the percentage of sanitation facilities, if any, that are located uphill of groundwater sources?	Less than 25% (Expert estimate based on the knowledge that the city has a flat terrain)	
3) Water supply		
Percentage of drinking water produced from groundwater sources	More than 25% / Between 1 and 25% (Nguyen et al. 2011; Anh et al. 2013; Nguyen 2016)	
4) Water production		
Water production technology	Protected boreholes, protected dug wells or protected spring where adequate sanitary measures are in place	

Depending on the understanding of “Question 3: Percentage of drinking water produced from groundwater sources” the percentage would be “more than 25%” (option 1) or “between 1 and 25%” (option 2). Output 1 is chosen from the fact that the drinking water supplied to Hanoi’s residents (through the central water supply system) is produced from groundwater sources. However, the groundwater used is treated before distribution and comes from the deep aquifers (e.g. 90 meters deep abstracted with deep wells) (Nguyen 2016). Thus, one could also chose option 2 when setting more emphasis on the fact that very few residents use direct groundwater for drinking or cooking purposes (Anh et al. 2013; Harada 2016).

7.6 Sanitation Containment Systems of Scenario A (Tab 1: SFD Calculation Tool)

Questions	Where does the user interface discharge to? (i.e. what type of container, if any?). If none apply, then select 'not applicable' and go to list B.	Where the user interface and/or container is abandoned, failed, damaged, collapsed, not working or open defecation is practised, select which option applies?	What is the containment (or user interface if no containment) connected to? (i.e. where does the outlet or overflow discharge to?)	Containment and Emptying Outcome	Tab 1 ref
System 1	No onsite container, user interface discharges directly to destination given in question C	Not applicable- question A applies	to decentralised combined sewer	Contained, emptying not applicable	T1A1C3
System 2	No onsite container, user interface discharges directly to destination given in question C	Not applicable- question A applies	to open drain or storm sewer	Not contained, emptying not applicable	T1A1C6
System 3	Septic tank	Not applicable- question A applies	to decentralised combined sewer	Contained, emptying possible	T1A2C3
System 4	Septic tank	Not applicable- question A applies	to open drain or storm sewer	Not contained, emptying possible	T1A2C6
System 5	Lined pit with semi-permeable walls and open bottom	Not applicable- question A applies	no outlet or overflow	Contained, emptying possible	T1A5C10
System 6	Fully lined tank (sealed)	Not applicable- question A applies	no outlet or overflow	Contained, emptying possible	T1A3C10
System 7	No onsite container, user interface discharges directly to destination given in question C	Not applicable- question A applies	to decentralised foul/separate sewer	Contained, emptying not applicable	T1A1C4

7.7 Details on Scenario B of the SFD

The scenario B of the SFD (which is described in the following) was created mainly based on the information received from literature with some additional information from the key informant interviews. Through detailed discussion with the Hanoi-based expert (and co-author) Viet-Anh Nguyen (2016) some values were later changed again to create scenario A (as literature e.g. was not recent enough to include the newly built urban areas where separate sewers were constructed, or the most recently build WWTPs). However, as the scenario A includes a few assumptions that could not be cross-verified through literature, this version B is understood as another plausible representation of the excreta management situation in Hanoi. The differing aspects of scenario B are illustrated in the following chapters and summarized below:

- Containment: newly built urban areas with separate sewers not included
- Emptying: different estimation for emptying of septic tanks
- Treatment: calculations based on estimations of people served instead of wastewater volumes

7.7.1 Sanitation Containment Systems of Scenario B (Tab 1: SFD Calculation Tool)

Questions	Where does the user interface discharge to? (i.e. what type of container, if any?).	Where the user interface and/or container is abandoned, failed, damaged, collapsed, not working or open defecation is practised, which option applies?	What is the containment (or user interface if no containment) connected to? (i.e. where does the outlet or overflow discharge to?)	Containment and Emptying Outcome	Tab 1 ref	%
System 1	No onsite container, user interface discharges directly to destination given in question C	Not applicable- question A applies	to decentralised combined sewer	Contained, emptying not applicable	T1A1C3	2%
System 2	No onsite container, user interface discharges directly to destination given in question C	Not applicable- question A applies	to open drain or storm sewer	Not contained, emptying not applicable	T1A1C6	3%
System 3	Septic tank	Not applicable- question A applies	to decentralised combined sewer	Contained, emptying possible	T1A2C3	6%
System 4	Septic tank	Not applicable- question A applies	to open drain or storm sewer	Not contained, emptying possible	T1A2C6	85%
System 5	Lined pit with semi-permeable walls and open bottom	Not applicable- question A applies	no outlet or overflow	Contained, emptying possible	T1A5C10	2%

System 6	Fully lined tank (sealed)	Not applicable-question A applies	no outlet or overflow	Contained, emptying possible	T1A3C10	2%

7.7.2 *Calculations for estimations on emptying for Scenario B*

The estimations on containment systems for scenario B exclude the information about the newly built urban areas as no hard facts could be obtained on this in literature. Table 6 summarizes the information presented in Appendix 7.7.1 (overview from SFD calculation tool) to describe the containment system in the context of Hanoi. The values presented in Table 3 (mainly Harada et al. 2008; Nguyen et al. 2011; Chowdhry, Kone 2012) were compared to other information provided in literature (e.g. Montangero et al. 2007; Cornel et al. 2012; WB 2013a) and discussed with experts during key informant interviews (Harada 2016; Nguyen 2016). The quantitative values were assessed qualitatively on feasibility and current validity (therefore the estimations for the SFD are rather a qualitative combination than an average).

Table 6: Conclusions made for the SFD on estimations on percentage of Hanoi's population using certain containment systems.

Type of containment system	**Percentage**
Flush toilet to those parts of the drainage system leading to WWTPs (including sewers, and some other parts of the drainage network)	2%
Flush toilet to those parts of the drainage system or rivers not leading to WWTPs (including covered and open drainage channels, canals, rivers)	3%
Septic tanks to those parts of the drainage network leading to WWTPs (including sewers, and some other parts of the drainage network)	6%
Septic tanks to those parts of the drainage network not leading to WWTPs (including covered and open drainage channels, canals, rivers)	85%
Lined pit with semi-permeable walls and open bottom, no outlet or overflow	2%
Fully lined tank (sealed), no outlet or overflow	2%

The assessment leads to the output of 5% offsite sanitation (the variable W1 in the SFD matrix shown in Appendix 7.4 includes flush toilets to "sewers", covered drainage channels, open drains, canals and rivers) and 95% onsite sanitation systems (the variable F1 includes septic tanks connected to "sewers", open drains or other and pit latrines and other).

It is assumed that the number of septic tanks in the city is increasing while the number of pit latrines and single or double vault latrine (with urine diversion or not) is decreasing. This assumption is based on the trend that had been observed in literature (Nam et al. 2006) and the fact that flush toilets are preferred and septic tanks are considered as the adequate option by law (Nguyen 2016). This leads to the estimation that the total number of septic tanks in the city is currently 91%.

7.7.3 Calculations for estimations on emptying for Scenario B

The last value reported by Nguyen et al. (2011) on percentage of septic tanks having been desludged (see Table 7) is rounded up to 40% (60% not emptied) and used as the estimate for percentage of septic tanks emptied in the city. It is assumed that the lower numbers reported by Fink (2001) and Harada et al. (2008) are influenced by the fact that a respondent may not have known that his/her septic tank had been desludged at one point if they have not lived on the premises for a significant period of time. This results in the estimate of 21% of emptied onsite sanitation systems (F3) – 4% from onsite sanitation systems where faecal sludge is contained and 17% from systems where faecal sludge is not contained.

Table 7: Reported numbers for septic tanks (STs) having been desludged/emptied.

	Fink (2001)	Harada et al. (2008)	Nguyen et al. (2011)	
	41 households in Hanoi	750 households in Historic Hanoi	300 households in urban & peri-urban Hanoi	Estimation for SFD
STs emptied	20%	10%	38%	40%
STs not emptied	80%	90%	62%	60%

7.7.4 Calculations for estimations on treatment for Scenario B

Wastewater treatment

Different to scenario A, in the following calculations only three WWTPs (as reported by WB (2013b)) are assumed to treat wastewater in Hanoi. The scenario is created without the information about the two newly built WWTPs (which would increase the estimation of wastewater treated by a few percentage points) and excluding the North Thang Long WWTP (because according to literature it treats industrial wastewater, not domestic wastewater).

For the SFD diagram the number of people served by WWTPs needs to be estimated. Due to the difficulty of estimating this scenario, it is not possible to make an exact calculation of the percentage of wastewater treated or people served by WWTPs. WB (2013b) reported the Truc Bach WWTP is serving 15,700 people. It is assumed that the number of people served by Kim Lien WWTP can be based on the ratio of number of people served per m^3 capacity at a similar WWTP. As the Kim Lien was built for the same purpose (demonstration) as the Truc Bach WWTP and has the same treatment technology (A2O) as well as a capacity more similar to the Truc Bach WWTP than the North Thang Long WWTP the calculation is based on the values known for the Truc Bach WWTP (see Table 8: A). Thus, both WWTPs together would serve 38,936 (15,700+23,236) people, which would be 1.2% of the 3,146,939 inhabitants of Hanoi.

Table 8: Calculation of the number of people served at Kim Lien and Yen So WWTP

A: Calculation for Kim Lien WWTP based on values from Truc Bach WWTP	B: Calculation for Yen So WWTP (necessary assumptions explained below)
(15,700 people / 2,500 m³ capacity) * 3,700 m³ capacity = (6.28 people/m³ capacity) * 3,700 m³ capacity = 23,236 people	(15,700 people / 2,500 m³ capacity) * 200,000 m³ capacity * (10 m³ domestic wastewater / 100 m³ river water) = (6.28 people/m³ capacity) * 20,000 m³ domestic wastewater = 125,600 people

Assuming the Yen So WWTP is operating at full capacity of 200,000 m³/day, the calculation of the number of people served is undertaken with a similar method (see Table 8: B). However, this calculation relies on multiple assumptions. One challenge is the estimation of the volume of domestic wastewater treated at this WWTP, as it receives polluted river water and not wastewater from households through sewers. It is assumed that the ratio of domestic wastewater in river water is one to ten (which would depend on season). The second assumption made is that the Yen So WWTP cannot serve more than 150,000 (the number of people the North Thang Long WWTP was designed for, which has one fifth of the design capacity of the Yen So WWTP). Using the same number of people served per m³ of capacity as for the Truc Bach WWTP (third assumption) one can calculate the number of people served by the Yen So WWTP as 125,600 people.

Therefore, for all three WWTPs combined, it is estimated that wastewater from 164,536 people is treated (see Table 9), which would be 5% (W5b) of the more than 3 million citizens of Hanoi. For the entire country of Vietnam different estimations are reported in the literature, some report 4% of sewage being treated in Vietnam (AECOM, Eawag/Sandec 2010), whereas others estimate that around 10% of urban wastewater in Vietnam is treated (ADB 2015; WB 2013b). 10% is similar to the above calculated estimate, because if 5% of Hanoi's population is served by the three WWTPs, that is equal to 11% of the wastewater of the sewerage and drainage network being delivered to treatment. Sensitivity analysis results showed that with different assumptions the maximum deviation was only ±2%. Thus, the above stated value is understood as a reasonable estimate. However, this calculation of people served is based on many assumptions and to be precise would need much greater further analyses in the future.

Table 9: Estimation of people served at WWTPs

	Estimation of people served	
Truc Bach WWTP	15,700	
Kim Lien WWTP	23,236	
Yen So WWTP	125,600	
TOTAL	164,536	= 5% of Hanoi's population

Having estimated the percentage of the population being served by the WWTPs, it is next calculated back how much septic tank effluent receives treatment at the treatment plants, and thus how many septic tanks are connected to the parts of the drainage/sewerage network that lead to treatment sites. It is assumed that 50% of the septic tanks' contents are leaving the tanks as effluent (which is likely much higher due to the infrequent desludging practices, however due to lack of data, the estimate with the least possible error is chosen). Having estimated that 91% of the population uses septic tanks, and 2% flush toilets are connected to the sewerage network, the percentage of septic tanks connected to the drainage network that leads to treatment is calculated as follows:

$$\% \, STs = \frac{5\% \text{ (population served by WWTPs)} - \; 2\% \text{ (WW from offsite sanitation)}}{50\% \text{ (effluent assumption)} \; * \; 91\% \text{ (percentage for all existing STs)}} = 6.6\%$$

To prevent total numbers that do not add up to 100% due to rounding errors in the SFD calculation tool, the number is rounded down to 6% and used for the estimations on containment systems.

Faecal sludge treatment

Based on the fact that the three URENCO's vacuum trucks are larger than those of private emptying service providers and the assumption that URENCO has more stable daily business activity (Nguyen et al. 2011; Nguyen 2016) it is assumed that one URENCO truck empties twice as many systems as one of a private emptier. This would result in 5% (3*2/120) of collected faecal sludge being treated, with the remainder being dumped untreated directly into the urban environment. This estimate is similar to the national estimate by WB (2013) of 4%, and AECOM, Eawag/Sandec (2010) also estimate that less than 4% of septage is treated in Vietnam. For faecal sludge treatment it is assumed that all faecal sludge emptied by URENCO is delivered to treatment and treated effectively, which is estimated to be the case for less than 1% of the population (F5) – calculated from 5% of the faecal sludge emptied.

7.8 More information on policies

7.8.1 Most relevant legislative documents

Below, the most relevant legislative documents related to excreta management in (Hanoi,) Vietnam, are listed:

Laws:

- Law on Water Resources (No: 17/2012/QH13) (NAV 2012)
- Law on Environmental Protection (No. 55/2014/QH13) (NAV 2014)

Decrees:

- **Decree 80/2014/ND-CP** on the Drainage and Treatment of Wastewater (GOV 2014)
  - replaces Decree 88/2007/ND-CP
- Decree 19/2015/NC-CP detailing the implementation of a number of articles of the Law on Environmental Protection

National strategies:

- Unified Sanitation Sector Strategy and Action Plan (U3SAP) – adopted in 2011

Circulars:

- **Circular 04/2015/TT-BXD** providing guidance on a number of articles of the government's Decree No. 80/2014/ND-CP (MOC 2015)
  - replaces the Circular No. 09/2009/TTBXD

Decisions:

- **Decision No. 1081/QD-TTg** of July 6, 2011, approving the master plan on socio-economic development of Hanoi city through 2020, with orientations toward 2030 (PM 2011)

Standards:

- National standard QCVN 39: 2011/BTNMT - National technical regulation on water quality for irrigation
- National standard QCVN 40: 2011/BTNMT - National technical regulations on industrial wastewater
- QCVN 14 2008_BTNMT_national technical regulation on domestic wastewater

7.8.2 Hierarchy of legal documents in Vietnam

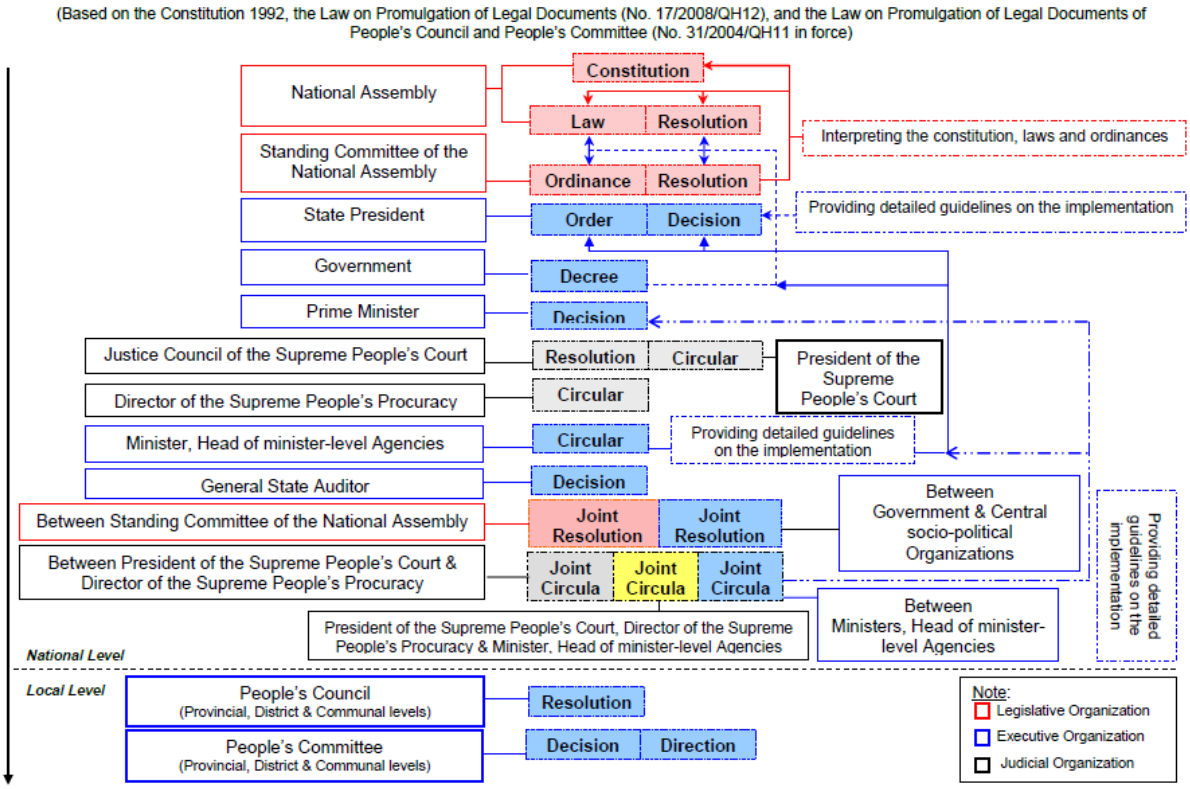


Figure 6: Hierarchy of legal documents in Vietnam (Nguyen 2009)

7.8.3 Excerpt from the Decree No. 80/2014/ND-CP on the Drainage and Treatment of Wastewater sludge (GOV 2014)

Article 25. Management of waste

1. Waste sludge must be classified in order to manage and select suitable technologies that reduce the costs of transportation and treatment, facilitate the management and operation of the burial sites.

2. Waste sludge is classified as follows:

a) According to origin: waste sludge generated from drainage systems (sewer network and wastewater treatment plants) and waste sludge generated in septic tanks;

b) According to pollution standard of each waste sludge;

c) According to hazardous standard of waste sludge generated in wastewater treatment process and according to other relevant regulations.

3. Criteria for the selection of technology of waste sludge treatment:

a) Centralized, decentralized or on-site treatment;

b) The volume of waste sludge generated;

c) The characteristics of waste sludge;

d) The stability of the technology;

dd) The requirements for environmental protection; economic and technical efficiency;

e) The requirements for operation and maintenance;

g) Preference of technologies which is environmentally friendly, energy saving and used for recycling waste sludge and heat recovery.

4. Collection, carry and treatment of waste sludge in drainage systems:

a) Waste sludge shall be collected, stored and carried to the planned treatment points or the locations approved by competent agencies for treatment in order to ensure the environmental hygiene; untreated waste sludge are prohibited to discharge into the environment. If a waste sludge contains hazardous elements, it must be managed according to the regulations on managing hazardous wastes;

b) The treatment and reuse of waste sludge must comply with the regulations on management and use of waste sludge promulgated by competent State agencies and other regulations on environmental protection;

c) When investing in constructing wastewater treatment plant, a suitable solution for collecting and treating waste sludge must be decided.

5. Pump, carry and treatment of waste sludge in septic tanks:

a) Waste sludge generated from households, offices, manufacture factories must be pumped out periodically;

b) The pump and carry waste sludge in septic tanks must be carried out by specialized equipment in order to meet the requirements for technique and environmental protection;

a) Waste sludge in septic tanks shall be collected, stored and carried to the locations approved by competent agencies for treatment. Waste sludge in septic tank is prohibited to directly discharge into drainage system and the environment;

d) Treating and recycling waste sludge must comply with the regulations on environmental protection;

dd) The cost of pump, carry and treatment of waste sludge in septic tanks shall be paid by households, offices and manufacture factories in compliance with the clauses in the contracts signed with the service providers.

6. The Ministry of Construction shall provide guidance on calculating and managing the costs of collection, carry and treatment of waste sludge in drainage systems and septic tanks

7.8.4 Excerpt from the Circular No. 04/2015/TT-BXD (MOC 2015)

Article 3. Managing septic tank sludge

1. Requirements for collection and transport of septic tank sludge;

Facilities, equipment, vehicles that are used for collection and transport of septic tank sludge must be vehicles specialized and eligible for operation according to the law on traffic and environmental protection.

2. Responsibilities of the units providing services of collection and transport of septic tank sludge;

a) Document client management as follows:

Name of householder/unit/number of persons;

Address;

Service supply contract;

Size and volume of septic tank;

Regular septic tank suction schedule;

Other information if necessary;

b) Septic tank sludge must be transported to a centralized treatment zone under the planning or permitted by competent agencies; encouragement shall be given to the treatment of septic tank sludge at centralized wastewater treatment plants on the basis of the plant's capacity of reception and treatment, environmental conditions and budget;

c) Expenses for suction, transport and treatment of septic tank sludge paid by householders, administrative agencies, and production, trading and service facilities under the contract signed with service providers;

d) Establish work diary, document management of collection and transport of septic tank sludge and make regular reports to local state management agencies, take responsibility for such problems as dispersion and leakage of sludge that result in environmental pollution;

Documentation of management of collection and transport of septic tank sludge include the following subject matters:

General information about collection and transport service providers;

Number of shipments of sludge sucked in a day/month/quarter;

Quantity of septic tank sludge to be sucked, collected and transported;

Types of septic tanks (from public sanitation facilities, households and agencies...) are subject to suction and collection of sludge. Reasons for suction are to cancel their operation for the construction of new works or to move them to new places...);

Positions for discharge of sludge (treatment station or a dumping ground as planned...);

Cost for transport and collection;

Other information if necessary;

dd) Septic tank sludge is transported by specialized vehicles that meet the following technical safety requirements:

Mechanically and chemically sustainable while operation;

No leakage, dispersion of sludge and odor to the environment;

Measures to tackle problems while operation;

3. Responsibilities of the septic tank sludge treatment units:

a) Receive and process sludge from owners of sources, collection and transport service providers under the contract signed between the two parties;

b) Regularly monitor and document quantity of sludge received for treatment; Subject matters of the documentation include:

General information about septic tank sludge treatment units;

Quantity/volume/number of shipments of sludge received;

Amount of biological/chemical preparations (if any);

Daily records of operation of treatment technology line (including treatment of problems...);

Amount of solid matter after treatment;

c) Treatment of septic tank sludge must meet regulations on environment; types of exhaust, wastewater, sludge, ashes, and slag must be analyzed, monitored, assessed to ensure satisfaction of the standards;

7.9 Pictures illustrating the emptying process of septic tanks in households

	
Cracking open of the floor to access a septic tank underneath. Photo: Lars Schoebitz	The pipe through which the faecal sludge is sucked from the tank to the truck. Photo: Lars Schoebitz
	
Fixing of the floor tiles after septic tank emptying. Photo: Lars Schoebitz	Repaired floor. Photo: Lars Schoebitz.

7.10 Information on WWTPs in Hanoi

7.10.1 Existing and planned WWTPs

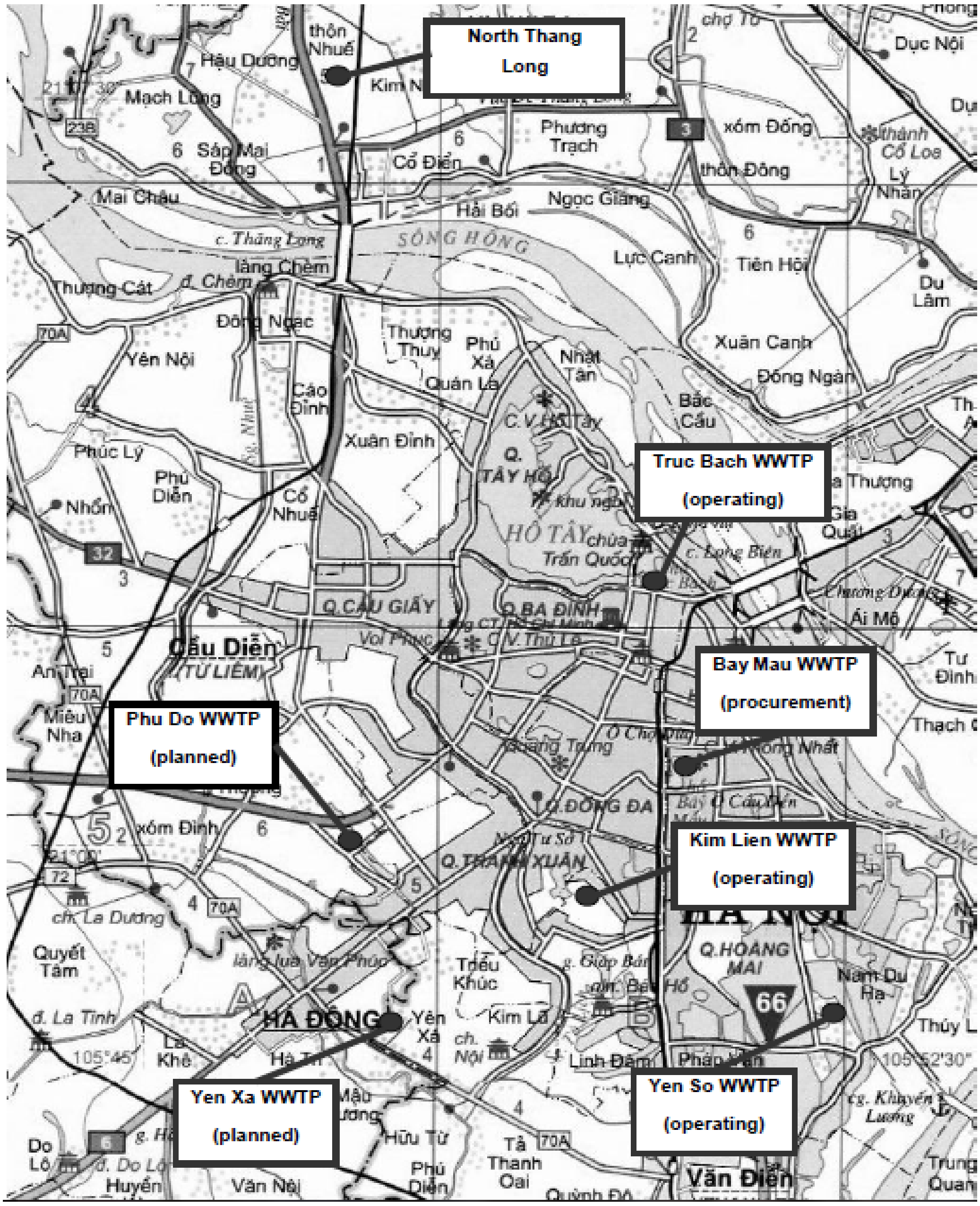


Figure 7: Existing and planned WWTPs (Schoebitz et al. 2014) .

http://en.baomoi.com/Info/Hanoi-enlarges-wastewater-treatment-plant/6/539645.epi

→ Ho Tay WWTP (at west lake – near Tay Ho district) in construction phase

7.10.2 Treatment process block diagrams of the WWTPs

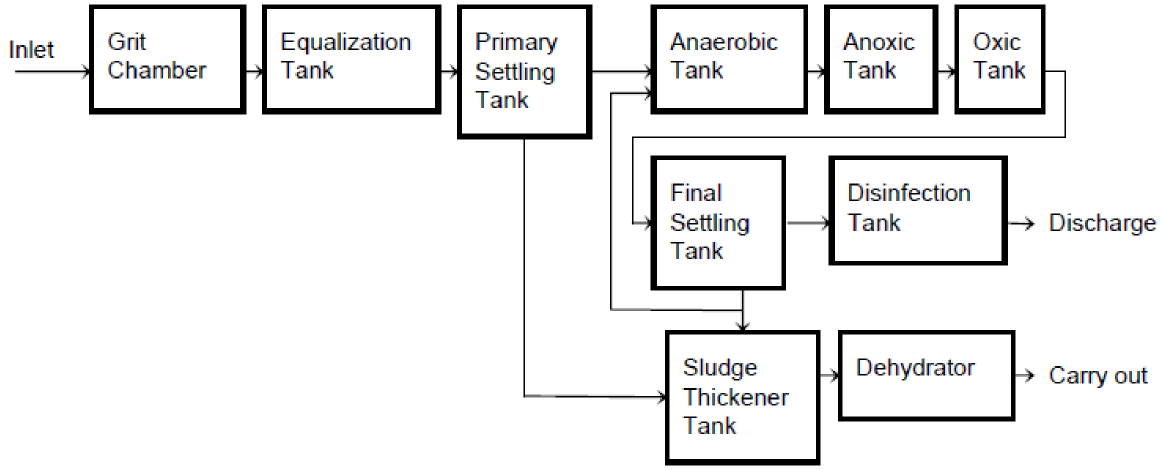


Figure 8: Treatment process block diagram of the Kim Lien and Truc Bach WWTPs (JICA 2010).

7.10.3 Influent and effluent values of WWTPs

	Influent					Effluent				
	COD	BOD	SS	T-N	T-P	COD	BOD	SS	T-N	T-P
Authorized Regulation Value						48	30	60	18	3.6
Design Criteria	225	150	180	40	5.0	35	20	20	15	1.0
HSDC data average	189	94	86	44	6.2	22	11	6	16	1.4
JICA team data average	202	NA	73	41	6.1	35	NA	9	16	2.0

Figure 9: Influent and effluent values of Kim Lien WWTP in mg/L (JICA 2010)

The effluent from the Kim Lien WWTP is discharged into Lu River.

	Influent					Discharged water				
	COD	BOD	S S	T-N	T-P	COD	BOD	S S	T-N	T-P
Water quality standards						48	30	60	18	3.6
Design criteria	225	150	180	40	5	35	20	20	15	1.0
HSDC average	191	94	91	39	5.6	24	12	5	15	0.9
JICA team average (Investigation results)	181		61	40	5.4	24		2	14	1.9

Figure 10: Influent and effluent values of Truc Bach WWTP in mg/L (JICA 2010).

The effluent from the Truc Bach WWTP is discharged into Truc Bach Lake.

WWTPs	City	Treatment process	Sewage system	BOD (mg/L)		COD (mg/L)		TSS (mg/L)		NH_4-N (mgN/L)		T-N (mg/L)		T-P (mg/L)		Coli-form (MPN/ 100mL)	Applicable Effluent Standard
				Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Eff.	
Kim Lien	Hanoi	A2O (AS)	CSS	115	9	145	18	85	5	18	-	40	17	6.5	1.7	0	TCVN5945-2005, B
Truc Bach		A2O (AS)	CSS	135	8	155	15	85	5	-	-	34	16	6.5	1	0	TCVN5945-2005, B
Bac Thang Long		A2O (AS)	CSS	85	12	135	16	65	8	-	-	38	12	5.4	0.85	100	QCVN40-2011, A
Yen So		SBR (AS)	CSS	45	6	132	24	51	10	28	0.5	34	8	7.2	6.5	-	QCVN40-2011, B

Figure 11: Influent and effluent values of Hanoi's WWTPs (WB 2013b).

“Effluent standards in Vietnam specify water quality parameters in terms of Class A and Class B depending on whether treated wastewater is discharged to water bodies with a function of drinking water supply (Class A) or not (Class B).” (WB 2013b)

7.10.4 Pictures of WWTPs in Hanoi

Picture of Truc Bach WWTP (Nguyen 2015)

Picture of Kim Lien WWTP (Nguyen 2015)

Picture of Bac (North) San Lo WWTP (Nguyen 2015)

Picture of Yen So WWTP (Nguyen 2015)

7.11 Process flow of the Cau Dien composting plant

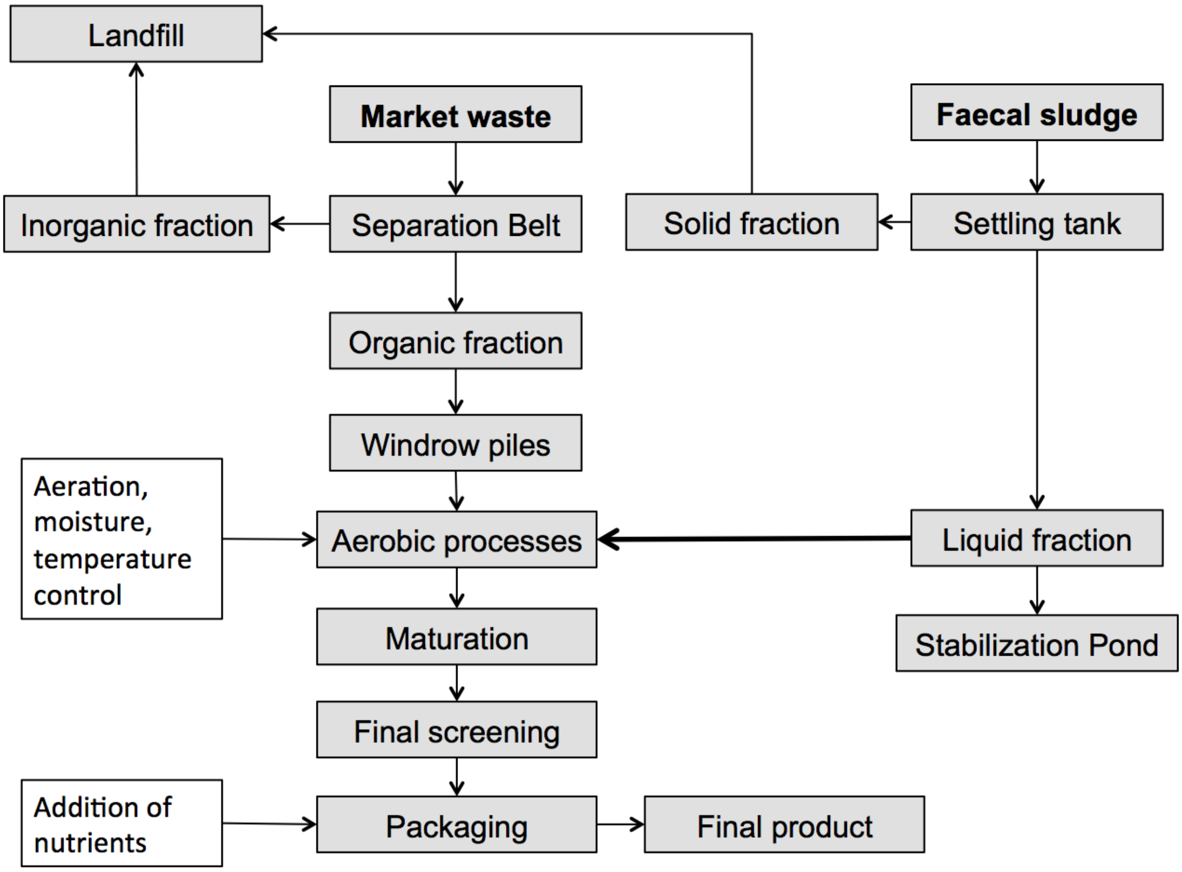


Figure 12: Process flow of the Cau Dien composting plant (Schoebitz et al. 2014) .