Worked example: SSP IN NEWTOWN

SANITATION SAFETY PLANNING

Step-by-step risk management for safely managed sanitation systems

World Health Organization

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Introduction

This worked example gives a hypothetical case of sanitation safety planning (SSP) in a small municipality called Newtown in an imaginary country called the Republic of Sanitola. The Republic of Sanitola is located in the tropical climate zone and is a middle-income country. Newtown is a town on the outskirts of a large metropolitan city and has a population of approximately 50 000 people. The population in Newtown has increased considerably during the past 10 years, and the rapid population growth has posed challenges for the town's infrastructure. Water supply is from a surface water source located far upstream of the town. Seasonally heavy rains occur in the area. However, the beginning of the wet season is becoming less predictable. Further, regional climate models predict that average rainfall will decrease during the dry season and increase during the wet season over the next 30 years.

The two main types of sanitation system in Newtown are:

- **sanitation system 1** – cistern flush toilet with sewerage and off-site wastewater treatment; and
- **sanitation system 2** – cistern or pour flush toilets with soak pits or septic tanks and effluent infiltration, and off-site faecal sludge disposal.

According to a recent health survey, the burden of sanitation-related diseases in the town is high compared with other areas in the region. Against this background, Newtown's Municipal Council initiated the SSP process in response to a request from national and city authorities.

The example of Newtown is used to illustrate the SSP modules and show how to report the findings. As every SSP process is developed to suit its own circumstances, the details and conclusions for Newtown are only illustrative.

MODULE 1. Prepare for sanitation safety planning

Step 1.1. Define the SSP area and lead organization

SSP area

As the SSP process is initiated by the local authority, the SSP area is determined by the **territorial division covered by the Newtown municipality.** In this case, the two existing sanitation systems (systems 1 and 2) and all sanitation steps within the sanitation service chain (i.e. toilet, containment–storage/treatment, conveyance, treatment, and end use or disposal) are considered.

Lead organization

The **Newtown Sanitation Department (NSD)** is the SSP lead organization. The NSD is the local authority with responsibility for sanitation service provision.

Step 1.2. Assemble the SSP team

SSP team leader

The **Head of Planning of the NSD** was appointed as the SSP team leader. This person has many years of experience in developing sanitation investment projects, and has resources, knowledge and management skills to lead project implementation. The Municipal Council hired an SSP expert to support the SSP team leader and train the SSP team.

SSP core team

The team leader formed a **core team** within the NSD to drive the SSP process. The core team includes a senior engineer who oversees system 1, a senior engineer who monitors system 2, and an Environmental Health Officer who coordinates environmental health programmes in Newtown.

Stakeholder analysis and steering committee for large or complex SSPs

Because of the size and complexity of the sanitation systems in Newtown, the SSP core team decided to conduct a stakeholder analysis to ensure that all relevant stakeholders were engaged. With facilitation by the SSP consultant, the four members gathered in a brainstorming session to identify and analyse stakeholders representing the entire sanitation service chain for each system type using tool 1.2. Results are presented in Table 1.1.

Table 1.1. Stakeholder analysis

Sanitation step	Stakeholder	Role of stakeholder	Motivating factors	Constraining factors	Importance	Influence/power	Participation required
Entire sanitation chain	NSD	Direct control and oversight of implementation of national guidelines and standards at each step of the chain.	SSP will help them to identify the right sanitation interventions.	Too much effort and insufficient resources.	High	High	Empowerment
Entire sanitation chain	RHD	Influence – coordinate with NSD to ensure that sanitation systems do not pose public health risks.	Providing safe sanitation services is a requirement for healthy communities.	Sanitation has never been a priority; they might have little knowledge about their role in the sanitation sector.	Low	Low	Collaboration
Entire sanitation chain	Epidemiologist, Sanitola School of Public Health	Interest in sanitation systems. The public health sector has had little involvement in sanitation.	They have been developing studies on waterborne diseases.	Do not know the key actors in the sanitation sector.	High	Low	Consultation
Entire sanitation chain	Expert on climate change, DEA	Some interest – oversee climate change trends, and propose mitigation and adaptation plans.	There are opportunities to obtain national funds for climate-resilient infrastructure.	Not familiar with the sanitation infrastructure in Newtown.	Low	Low	Collaboration
Entire sanitation chain	Local council	Direct control – promulgate new local by-laws and regulations. Support from the legislative branch of the local government is key to SSP.	They contribute to improving the environment and public health, leading to improved reputation and better chance of re-election.	Lack of experience and interest in sanitation.	High	High	Collaboration
Entire sanitation chain	Water system operator	Affected – water quality and operations of the water plant are affected by discharges from sanitation systems.	Lately, changes have been implemented in the water treatment plant due to increasing pollution.	Do not work with the NSD.	Low	Low	Consultation
Entire sanitation chain	Mayor	Influence – as the leader of the municipal government, ultimately responsible for providing municipal services to the population.	SSP could represent an opportunity to offer sanitation services and improve the environmental quality of Newtown, leading to improved reputation and better chance of re-election.	Sanitation has never been a priority; would prefer government funds to be allocated to other sectors.	Low	High	Collaboration
Entire sanitation chain	Department of Sanitation, Faculty of Civil Engineering, Sanitola National University	Interested in sanitation systems – has been collaborating in an SFD project with the SFD Alliance.	SSP could represent an opportunity to collaborate in a platform of actors and learn about new ways of providing sanitation.	Faculties might be concerned about the lack of resources to carry out pilot tests and research activities.	Low	Low	Collaboration
Entire sanitation chain	Association of water and waste service workers	Influence – representatives of formal and informal sanitation workers advocating for fair working conditions and pay.	Workers along the chain will be responsible for implementing proposed system improvements and monitoring, and can evaluate the practicality and safety for workers in the system.	Limited representation of informal and workers who are not members of the associatuion.	High	Medium	Collaboration
System 1: Sewered system (flush toilet with sewerage and off-site wastewater treatment)							
Toilet	Commercial Unit, NSD	Direct control – register and charge households connecting to the sewer system.	Many houses do not connect to the sewer system, so they are interested to know how to improve.	The unit is relatively new and does not have a proper register of connected households.	High	Low	Information

Sanitation step	Stakeholder	Role of stakeholder	Motivating factors	Constraining factors	Importance	Influence/power	Participation required
Toilet, conveyance	Private vendors of toilets and plumbing supplies	Some influence – determine what toilets and plumbing supplies are available on the local market.	Businesses want to stock items meeting national and local standards, and benefit from sales associated with SSP improvement.	Products sold by businesses must be affordable and attractive to local customers.	High	High	Information
Conveyance	Engineering Section, NSD	Direct control – operate and maintain the sewer system.	They expect to obtain funds to repair the sewer system.	Resources and staff are lacking.	High	High	Empowerment
Treatment	Operations Managers, WWTP	Direct control – operate and maintain the WWTP.	They work in challenging conditions given the current state of the plant.	Resources and staff are lacking.	High	High	Empowerment
End use/disposal	WWTP effluent monitoring official, DEA	Direct control – enforce norms and standards of effluents from WWTPs for disposal and safe use.	The DEA's section on WWTP effluent monitoring is required to develop norms and standards for sanitation.	Resources and capacities to monitor effluent quality are lacking.	High	High	Collaboration
End use	Regional Department for Agriculture and Rural Development	Direct control – develop official guidelines and quality standards for agricultural products, and conduct training and projects with farmers.	Use of wastewater for agricultural purposes has been increasing, but users do not have much experience.	Resources and staff are lacking.	High	Low	Collaboration
End use	Farmers Cooperative	Direct control – farmers use wastewater both directly and indirectly.	Farmers are already using wastewater and recognize its nutrient value. However, odour and illness are concerns.	They do not interact with authorities. In general, farmers are not supported in this region.	High	Low	Consultation
System 2: On-site system (flush toilets with septic tanks and effluent infiltration, and off-site faecal sludge disposal)							
Toilet, containment–storage/treatment	Homeowners Association	Direct control – in charge of maintaining their own on-site systems and should cover the costs of refurbishment and upgrading.	They would be interested in increasing property values.	They are concerned about the costs of repairing and refurbishing their on-site system.	Low	Low	Consultation
Toilet, containment–storage/treatment	Newtown Housing Department	Direct control – regulate the construction, inspection and monitoring of pits and septic tanks.	They do not have a complete register of houses with on-site systems. They would be interested in having a digital tool.	They have low resources and capacities.	High	High	Empowerment
Toilet, containment–storage/treatment	Local Building Association	Direct control – members are constructing houses with pit toilets and septic tanks. As an association, they offer training.	They might be interested in new businesses to upgrade existing on-site systems.	They are concerned about being overregulated.	Low	High	Consultation
Toilet, containment–storage/treatment	RHD	Some influence – raise awareness of households about operation and monitoring of on-site systems.	SSP could guide the RHD in conducting effective behaviour change campaigns on sanitation among the target population.	Sanitation has never been their priority; they might have little knowledge about their role in the sanitation sector.	High	Low	Empowerment
Toilet, containment–storage/treatment	Private vendors of toilets and on-site containment and treatment systems	Some influence – determine what toilets and plumbing supplies are available on the local market.	Businesses want to stock items meeting national and local standards, and benefit from sales associated with SSP improvement.	Products sold by businesses must be affordable and attractive to local customers.	High	High	Consultation
Conveyance	Vacuum tanker operators – private and public providers	Direct control – empty pits and tanks.	They are motivated by legalization and recognition.	They might suffer the most, as their practices have remained unnoticed and unregulated. They might be concerned about fees, regulations, surveillance and unexpected costs.	Low	High	Empowerment

Sanitation step	Stakeholder	Role of stakeholder	Motivating factors	Constraining factors	Importance	Influence/power	Participation required
Conveyance	Homeowners Association	Affected – pay for the service of emptying on-site systems.	They want to improve living environments.	They are concerned about possible increases in rent fees or desludging fees.	Low	Low	Consultation
Conveyance	City Service "Traffic law enforcement and licences"	Some influence – the government agency that gives licences for transport of sludge.	They work without a clear regulatory framework. They would like to have clear guidelines on how to deal with sludge emptiers.	They are afraid that the fees collected from these trucks might be transferred to the NSD.	High	Low	Empowerment
Treatment	Operations Managers, WWTP	Affected – receive some of the faecal sludge collected by vacuum tankers.	They would prefer not to receive faecal sludge because of the nuisance and because it affects the quality of the system.	Until now, they have received only a small proportion of the faecal sludge. They are afraid that SSP will make them responsible for all the faecal sludge produced.	High	High	Empowerment
Disposal	Environmental Protection, DEA	Direct – have a surveillance team that monitors illegal waste discharges to the environment. However, they have not focused on vacuum tankers.	SSP supports their overall aim of providing leadership in environmental protection.	This project could represent new tasks that have not been included in strategic planning.	High	High	Empowerment

SSP steering committee

Following the results of the stakeholder analysis, the SSP core team decided to invite the following people to form the SSP steering committee:

- Mayor. The SSP team invited the Mayor as Chair of the steering committee so that he is aware and somewhat engaged, and understands the rationale for investment in proposed improvements. He will appoint a member of his team to keep him informed.
- Member of the Municipal Council. Engagement and commitment of Newtown Municipal Council could ensure key regulation control measures.
- Head of the NSD.
- Head of the Regional Health Department (RHD).
- Head of the Newtown Housing Department (NHD).
- Head of the Department of Environmental Affairs.
- Head of the Regional Department for Agriculture and Rural Development (RDARD). It took much effort to get the RDARD on the steering committee, but this was worthwhile.

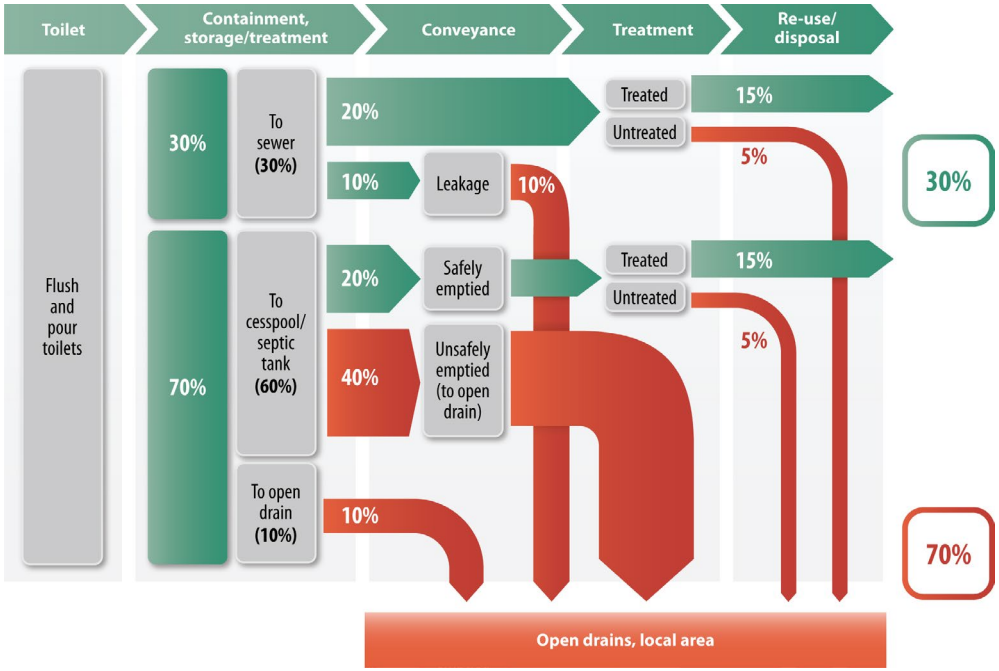
The SSP expert suggested keeping the steering committee small.

Step 1.3. Establish SSP priorities

It was not feasible to develop SSP for all sanitation systems in Newtown because of limited resources. The SSP expert collaborated with the Faculty of Civil Engineering of the Sanitola National University to develop an **excreta flow diagram** (SFD) and suggested using the results from the SFD as a starting point for the discussion.

The SSP core team hosted a **kick-off meeting** with members of the SSP steering committee. The main objective of the meeting was to decide which sanitation systems were to be prioritized by SSP and which target systems are likely to pose the greatest health risks. A member of the Faculty of Civil Engineering presented the SFD in Fig. 1.1.

Fig. 1.1. Excreta flow diagram (SFD)



Members of the steering committee noticed that the situation with on-site sanitation was especially critical. The team debated whether to include centralized treatment systems in the SSP. One committee member pointed out that only 30% of the population was connected to the relatively new sewer system and suggested first concentrating on the 70% of the population relying on pit toilets and septic tanks. The SSP team decided to prioritize system 2 (flush toilets with septic tanks and effluent infiltration, and off-site faecal sludge disposal).

The SSP team leader presented key results from the stakeholder analysis and asked the steering committee to propose additional members for an extended SSP team.

Roles of individuals on extended SSP team

Table 1.2 shows the members of the extended SSP team, who will be consulted and invited to key SSP meetings. Tool 1.1 was used to record their roles in the SSP team.

Table 1.2. Extended SSP team

Representatives	Main role in SSP team
Head of Planning, NSD[a]	Team leader
RHD officera	Provides information about ongoing public health activities related to sanitation. Selects control measures, especially for behaviour change.
Epidemiologist, Sanitola School of Public Health	Provides epidemiological data and expert input during the risk assessment.
Expert on climate change, DEA	Provides information about expected climate change and climate variability scenarios, and links SSP to ongoing emergency preparedness plans.
Water system operator	Allows consideration of implications for local water supply systems.
Operations Manager, WWTP[a]	Provides information about the faecal sludge transported and treated in the WWTP.
WWTP effluent monitoring official, DEA	Supplies information about the performance of the WWTP. Will lead the development of standards and norms for disposal and safe end use of the liquid and solid fractions of the treated faecal sludge.
Farmers Cooperative	Oversees hazard management of in-farm practices and produce handling to farm gate.
Regional Department for Agriculture and Rural Development	Will support the implementation of control measures for end use of wastewater and faecal sludge.
Newtown Housing Departmenta	Provides information about coverage and status of on-site sanitation systems. Supports team leader with consolidation of data for system 2.
Municipal Environmental Health Practitioner, RHD	Provides information about the status of on-site containment systems (toilets, soak pits and septic tanks).
Homeowners Association	Provides information to carry out risk assessment at the containment and conveyance steps. Selects and implements feasible control measures.
Local Building Association	Provides information about technical options and decides feasible control measures at the containment–storage/treatment step.
Sanitation workers associations (e.g. vacuum tanker operators)	Provides information to carry out risk assessment at the conveyance step. Selects and implements feasible control measures.
City Service "Traffic law enforcement and licences"	Provides information to carry out risk assessment. Selects and implements feasible control measures, specially to control risks at the conveyance step.
Environmental Protection, DEA	Provides information to carry out risk assessment at the disposal step. Selects and implements feasible control measures, specially to stop illegal dumping of faecal sludge.

DEA: Department of Environmental Affairs; NSD: Newtown Sanitation Department; RHD: Regional Health Department; SSP: sanitation safety planning; WWTP: wastewater treatment plant.
[a] Members of the SSP core team.

Management and financial considerations

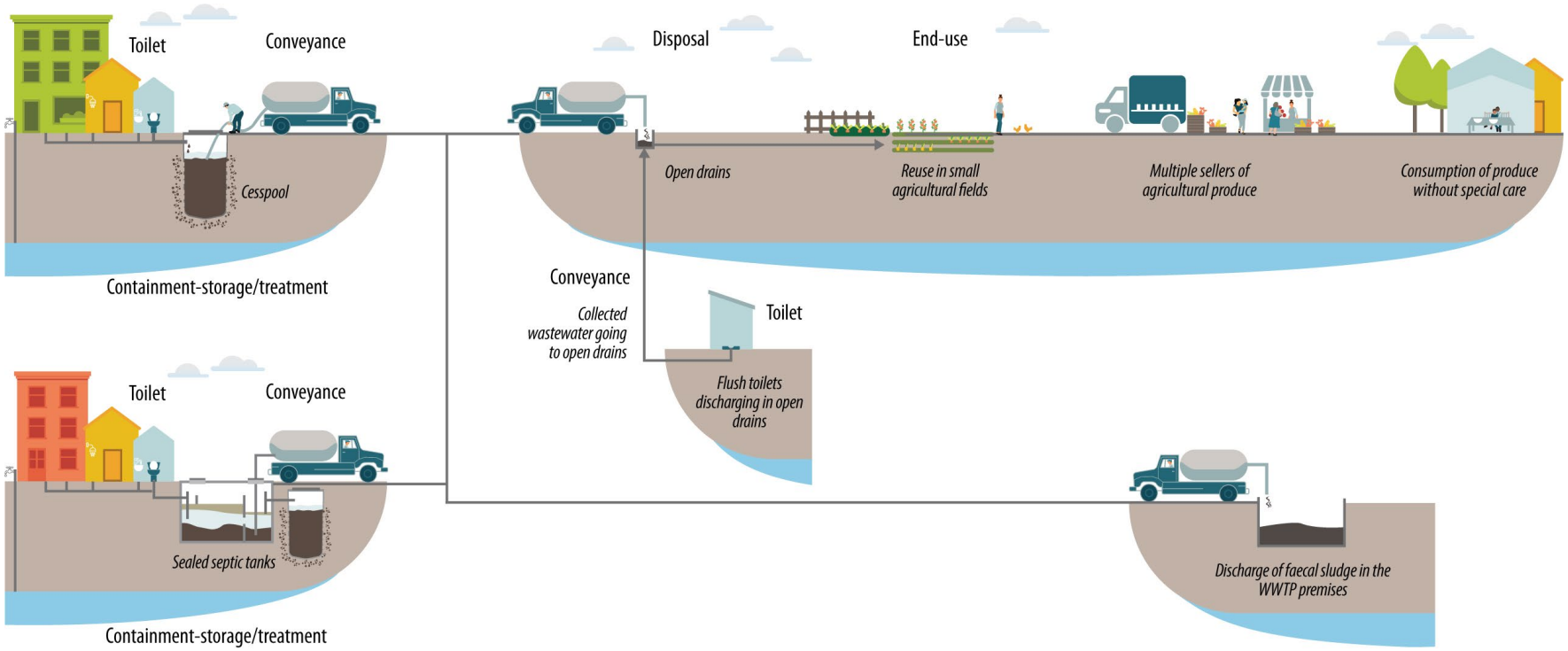
During the kick-off meeting, the members of the steering committee appointed representatives of their organizations, and committed their time as in-kind contributions. The Mayor and the Municipal Council members agreed on including funds for implementation of the SSP measures within the next year's budget. They requested a complete SSP, with a proposed budget, within 4 months.

MODULE 2. Describe the sanitation system

Step 2.1. Map the system

Thanks to previous work by the Faculty of Engineering on the development of Newtown's SFD, much of the information needed had already been gathered. The SSP team leader organized a 1-day workshop with members of the extended SSP team to map and describe the system. In the invitation letter, the SSP team leader asked each member of the team to come to the meeting with information that could inform this exercise. It was decided to use a **free-flowing sketch** to understand the on-site system. This is shown in Fig. 2.1.

Fig. 2.1. Free-flowing sketch of the on-site sanitation system



The sewered sanitation system was not considered as part of this SSP. However, the Operations Manager of the wastewater treatment plant (WWTP) insisted on considering the discharge of faecal sludge in the WWTP, as this practice had negative consequences for the functioning of the plant. The team noticed that many small farmers were using water from open drains to grow some agricultural products. Therefore, the RHD officer insisted on including the end-use step up to the point of consumption.

Once the system was agreed on by the participants, the formal process flow diagram was prepared (Fig. 2.2).

Fig. 2.2. Process flow diagram

The map produced by the team was accompanied by the following description.

P1: Toilet and containment–storage/treatment with soak pits and septic tanks

About 60% of the population (approximately 6000 households) used cistern or pour flush toilets draining into septic tanks or soak pits. Representatives of the Local Building Association mentioned that they usually installed soak pits, and that the septic tanks they had installed in the past often cracked a few years after installation and did not function well. The SSP core team conducted a household survey and confirmed that most of these systems were full or showed signs of damage, causing the main septic tank chamber to leak. Many home dwellers did not maintain their tanks and sometimes did not even know where it was located.

P2: Disposal of liquid fraction by infiltration

The liquids in soak pits drain directly into the soil, while the solids accumulate in the bottom. In septic systems, the sealed baffled tank collects faecal sludge, and the liquid effluent infiltrates to the soil in an adjacent leach field or soak pit.
Some households rely on shallow wells for drinking-water due to intermittent piped water supply, especially during the dry season. The epidemiologist at the Sanitola School of Public Health said that results from a recent study confirmed high concentrations of *Escherichia coli* in drinking-water samples from the shallow wells. The study also highlighted a high prevalence of diarrhoea among young children in the area, especially during the dry season.

T1: Conveyance by vacuum trucks

Obtaining information on faecal sludge emptying practices in Newtown was challenging. The WWTP Operation Manager had data about vacuum trucks discharging in his premises. He counted a total of three formal vacuum tankers regularly discharging at the WWTP. The core SSP team conducted a survey to map all operators in Newtown, starting by asking householders who they contacted to empty their pit or septic tank. Ten service providers were found to be active in the town; most (seven) operated informally. All used mechanical vacuum trucks. Householders emptied their pit or septic tank every 3–5 years on average, ranging from 12 months to 10 years.

P3: Transfer of faecal sludge to the WWTP

Three vacuum tankers transfer faecal sludge to the WWTP, where it is co-treated with wastewater from sewers. The Operation Manager of the WWTP mentioned that the increasing amount of faecal sludge being discharged at the WWTP negatively affected the performance of the waste stabilization ponds. Given the limited capacity of the WWTP to treat faecal sludge, vacuum truck operators sometimes had to be turned away.

P4: Disposal of faecal sludge in open drains

Although some faecal sludge reaches the WWTP, a large amount is illegally dumped into drains and flows directly into waterways. At least seven informal service providers are known to dispose of faecal sludge in open drains.

P5: Flush toilets discharging in open drains

It is estimated that 10% of the population (around 1000 households) is not connected to the sewer system, despite connection being technically possible. The internal plumbing systems of these households collect blackwater and greywater, and direct the wastewater to open drains. The household survey showed that many households were not aware of the possibility of connecting to the sewer system, and others did not want to pay for a connection. The senior engineer of the NHD mentioned that the NHD does not have the capacity to monitor the connections, and hires external engineers to approve new constructions. They rely on the Commercial Unit of the NSD to keep a register of users.

T2: Open drains

Open drains are designed to collect stormwater and direct it to natural streams. In Newtown, open drains are contaminated by domestic wastewater from toilets discharging to the drains, illegal disposal of faecal sludge, road runoff, and animal waste from livestock grazing in and around open drains. There is no industry of significance that produces industrial wastewater. The hospital and other healthcare facilities have reasonable waste management practices that are separate from Newtown's sewage system. Solid waste is regularly thrown into the drains, which often causes blockages and leads to overflowing and flooding of the channels during storm events. Concentrations and flow rates vary widely over time; however, storm events are becoming noticeably more intense each year. Workers from Newtown's engineering department maintain and repair the open drain systems but have limited resources.

P6: Use of wastewater in agriculture

Some local farmers grow crops using the water from open drains. When the team visited the site and spoke with local people, they found that the channels are deliberately diverted to farms for this purpose. During the dry season, this is sometimes the only source of water.

The officer from the RDARD provided information on local agricultural practices. Irrigation is typically via open furrows or manual application (e.g. scoops and other labour-intensive systems such as watering cans). The crops grown include vegetables eaten uncooked, such as onions, carrots, lettuces and capsicums. It is estimated that about 30 small farming lots exist around Newtown. The produce is consumed by the farmers and their families or sold to the local community. Farmers' children often help with fieldwork after school.

Focus group interviews showed that the farmers and their children do not perceive any risks associated with using the water. Medical records for the farmers and their families were examined, and discussion with the farmers (as part of the validation process) revealed that:

- diarrhoeal diseases are common, especially after rains;
- intestinal worm infections are highly prevalent among farmers and their families; and
- mosquito-related diseases such as malaria and skin diseases are occasionally reported.

According to the epidemiologist from the Sanitola School of Public Health, previous studies found that communities living around farming areas often complained about bad smells and mosquitoes, and reported that soil-transmitted helminth infections were common among children.

P7: Consumption of agricultural products

Consumers in the town do not take any special care in preparing their foods. Observations indicate that, at best, foods are given a very cursory clean regardless of whether the food is eaten raw (e.g. lettuce, tomatoes, onions, carrots) or cooked.

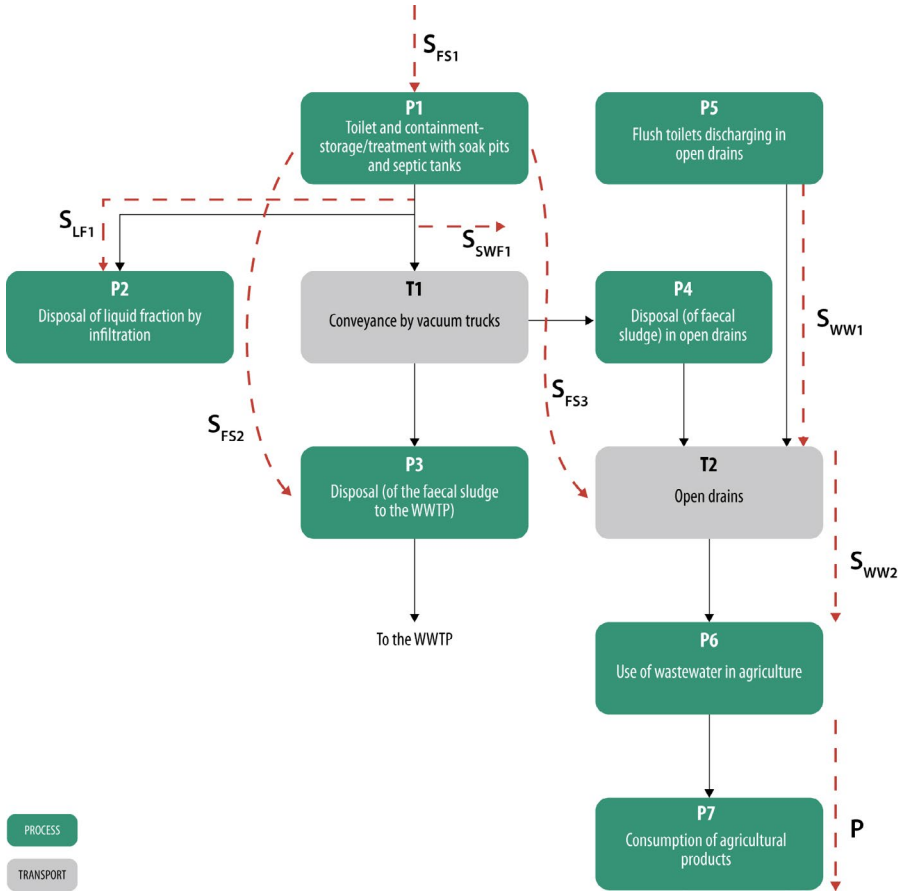
The RHD officer reported that foodborne disease outbreaks are frequent in the area. A recent survey confirmed the presence of *Salmonella* species in about 30% of samples from vegetable products.

Based on the information obtained, the SSP team mapped the path of different waste flows through the sanitation system, from the point of generation (i.e. toilets) to final use or disposal (Fig. 2.3).

The description of each system flow is as follows:

- S_{FS1} = faecal sludge collected in soak pits and septic tanks
- S_{LF1} = liquid fraction that percolates from soak pits and septic tanks
- S_{SWF1} = solid waste fraction screened out during emptying of soak pits and septic tanks
- S_{FS2} = faecal sludge emptied into vacuum trucks and transported to the WWTP
- S_{FS3} = faecal sludge emptied into vacuum trucks and discharged in open drains
- S_{WW1} = wastewater transported from households directly to open drains
- S_{WW2} = wastewater transported in open drains
- P = produce reaching the market.

Fig. 2.3. Process flow diagram showing the path of system flows (S)



Step 2.2. Characterize system flows

Based on the information available, the team used tool 2.1 to characterize the system flows and to collect key quantitative information, and information on the microbiological, physical and chemical hazards.

Table 2.1. Characterization of system flows

Sanitation step	Description of the system flow	Key information	Expected variations	Type of potential hazard
P1: Toilet and containment–storage/ treatment with soak pits and septic tanks	S_{FS1} = faecal sludge collected in soak pits and septic tanks Faecal sludge – solids and water that are collected in underground tanks	About 7000 m^3 collected. BOD could reach 600 mg/L.	The sludge could contain anal cleansing materials, menstrual hygiene products, sharp objects and other foreign material. It may also contain chemicals present in greywater.	Biological Physical Chemical
P2: Disposal of liquid fraction by infiltration	S_{LF1} = liquid fraction that percolates from soak pits and septic tanks Liquid fraction resulting from infiltration of wastewater from soak pits and unsealed/broken septic tanks	Concentrations of nitrates and nitrites are estimated to be high in groundwater (>50 mg/L for nitrates).	Percolation increases with rainfall. There could be some traces of chemicals in greywater.	Biological Chemical
T1: Conveyance by vacuum trucks	S_{SWF1} = solid waste fraction screened out during emptying of soak pits and septic tanks Solid waste is screened out while pumping out the faecal sludge. Operators throw the solid waste into the nearest waste dump.	About 2 kg of solid waste is screened out each time.	With heavy rainfall, solid waste ends up in the open drains.	Biological Physical
P3: Transfer of the faecal sludge to the WWTP	S_{FS2} = faecal sludge emptied into vacuum trucks and transported to the WWTP	About 20 m^3 of faecal sludge is emptied every day.	No expected variations.	Biological
P4: Disposal of faecal sludge in open drains	S_{FS3} = faecal sludge emptied into vacuum trucks and discharged in open drains	About 40 m^3 of faecal sludge is emptied every day.	Heavy rainfall leads to heavy dilution in open drains.	Biological
P5: Flush toilets discharging in open drains	S_{WW1} = wastewater transported from households directly to open drains	About 1000 m^3 of wastewater. BOD could reach 600 mg/L.	No expected variations.	Biological Chemical
T2: Open drains	S_{WW2} = wastewater transported in open drains Stormwater – surface water including urban runoff mixed with wastewater	There are no data about stormwater. Diluted BOD could reach 300 mg/L.	No expected variations. The wastewater will contain a wide range of dilute constituents, including nutrients, metals, pathogens, organic material (oxygen-demanding substances), hydrocarbons, animal wastes and solid waste.	Biological Chemical Physical
P6: Use of wastewater in agriculture	S_{WW2} = wastewater transported in open drains Stormwater – surface water including urban runoff mixed with wastewater	It is not known how much water is used by farmers.		Biological Chemical Physical
P7: Consumption of agricultural products	P = produce reaching the market	There are no data about quantities.	In dry seasons, more products are expected to be grown using wastewater.	Biological

BOD: biochemical oxygen demand; WWTP: wastewater treatment plant.

Step 2.3. Identify exposure groups

As a next step, the SSP team identified the exposure groups (Fig. 2.4) and used tool 2.2 to identify who they are, how many are there, where they are and how exposure occurs.

Fig. 2.4. Process flow diagram showing exposure groups

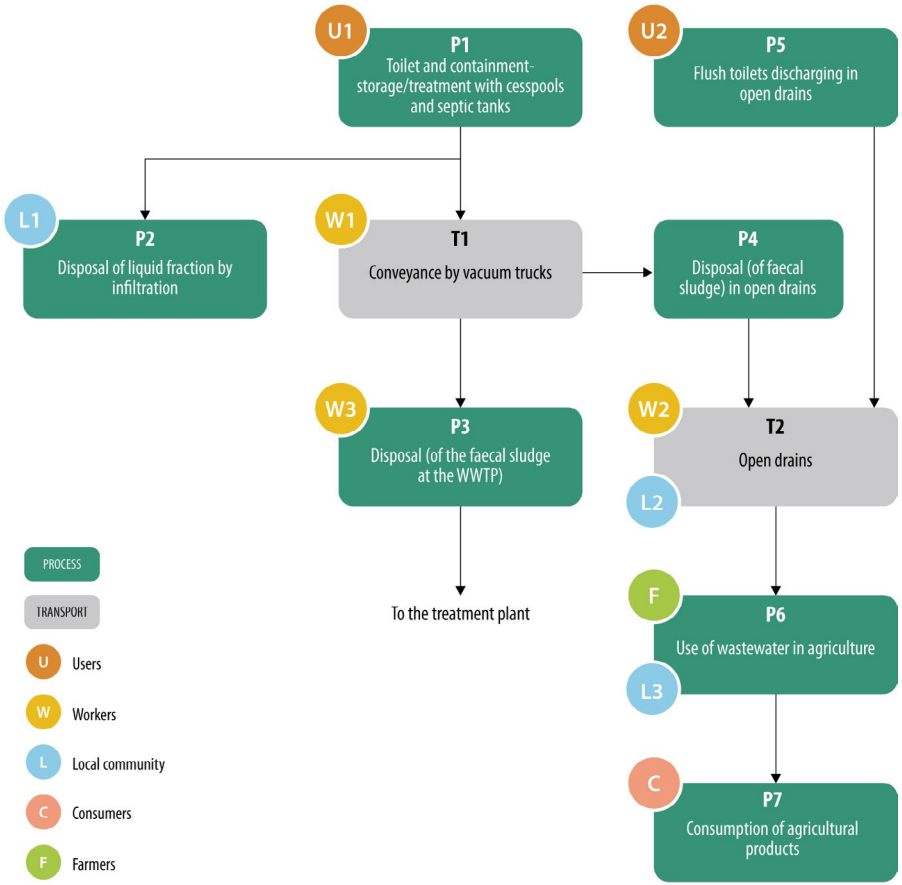


Table 2.2. Characterization of exposure groups

Sanitation step	Exposure group ID	Who are the exposure groups?	How many are there?	What are they doing there?	What are they exposed to?	How often are they exposed?
P1: Toilet and containment–storage/treatment with soak pits and septic tanks	U1	Users of flush toilets connected to septic tanks and soak pits in their properties	6000 households (around 30 000 people). About 40% are children.	Septic tanks and soak pits are usually outside the house, in the backyard. Children play and adults perform different activities in the vicinity of the tank.	They could have contact with wastewater during overflows. They are exposed to microbial pathogens.	Overflow could happen every 3 years, but is more frequent during heavy rains.
P2: Disposal of liquid fraction by infiltration	L1	Families living in areas where septic tank effluent and soak pits infiltrate to the groundwater	4000 households (about 20 000 people). About 40% are children.	They usually have shallow wells because the water supply is not reliable.	High concentrations of *E. coli* in water samples from shallow wells	It could be daily when the water supply is low. However, this situation is worst during dry periods.
P5: Flush toilets discharging in open drains	U2	Users connecting their wastewater pipes to open drains	1000 households (about 5000 people)	They live in houses not connected to the sewer systems.	There could be a backflow to their houses when the water levels in open drains are too high.	This is very rare.
T1: Conveyance by vacuum trucks	W1	Private vacuum truck operators	About 20 operators (10 trucks, working in groups of 2)	They open the underground tanks, insert the hose and empt the soak pits. They also handle the solid waste extracted.	They are in direct contact with faecal sludge, which contains microbial pathogens.	Every day
P3: Transfer of the faecal sludge to the WWTP	W3	WWTP operators who receive faecal sludge	3 operators (working in shifts of 2 people)	They usually do not come into contact with the sludge (i.e. only administrative work).	They are not in direct contact with faecal sludge.	Not applicable
P4: Disposal of faecal sludge in open drains	L2	All citizens of Newtown	50 000 people	They walk and live beside the open drains, which were designed for stormwater. Children play near the drains.	Mosquitoes breeding, pathogens from the wastewater and sharp objects in the solid waste. They are also exposed to blockages and inundation during heavy rainfall.	Every day; the problem increases during heavy rains.
T2: Open drains	W2	Open drain workers	6 operators (working in shifts of 2 people)	They are in charge of removing the solid waste from the drains and cleaning blockages.	Pathogens in the wastewater. During the dry season, they are exposed to aerosols and sharp objects.	They clean the open drains twice a month.
P6: Use of wastewater in agriculture	F	Farmers using the open drain wastewater to irrigate their land	30 families (about 150 people)	They are in direct contact with the water.	Pathogens, including helminths, and mosquitoes	Every day, but specially during the dry season.
	L3	Community living around the farming plots	150 families (about 750 people)	They live around the farms.	Occasional bad smells and mosquitoes. Children play in the area, and hookworms are very common.	Every day, but specially during the dry season.
P7: Consumption of agricultural products	C	Consumers of farm products	200 families. It is thought that only families living around the farms buy the products.	They eat the products without much care.	Pathogens	Every day, but specially during the dry season.

WWTP: wastewater treatment plant.

Step 2.4. Gather supporting information

Guidance note 2.4 was used to collate supporting information. Important sources of data included the information compiled for the SFD, municipal town planning data and future growth projections, health reports and records, historical weather records and flooding history, national and regional climate change projections, and mapping. The SSP team extracted relevant information from each of these documents and summarized the major issues in Table 2.3.

Table 2.3. Supporting information

Information sources	Summary of key observations
Standards and regulations	
Sanitola National Effluents Standard 2010	BOD and SS limits. *E. coli* limits of 1000/100 mL are given. Does not include limits for helminth egg concentrations. Enforcement is limited.
Sanitola Biosolid Standards and Regulations 1998	Use of WWTP sludge in agriculture is prohibited in Sanitola because of concerns about heavy metals.
Information related to system management and performance	
2020 Regional Health Department "Epidemiological study on the prevalence of helminthic infections in school-aged children"	A total of 300 school-aged children (9–14 years) were enrolled in a cross-sectional study carried out at the 10 major schools of Newtown in 2019. Hookworm and *Ascaris lumbricoides* were the most common helminth infections, with a prevalence of 21.9% and 18.4%, respectively. *Trichuris trichiura* infection was detected in 1.5% of the children. No *Schistosoma* eggs were found in any of the stool and urine samples. Outbreaks of *Cryptosporidium* have occurred in low-lying areas following flooding.
Demographics and land-use patterns	Limited space is available in Newtown. Populations from rural areas are migrating to the town in search of employment opportunities. Many move to informal settlements at the periphery of the town or in low-lying flood-prone areas where sanitation conditions are poor.
Changes relating to weather or other seasonal conditions	During the cooler months (December–February), use of wastewater by farmers is low. Reduced rainfall during the dry season causes occasional water restrictions, resulting in some households using shallow groundwater wells and an increased demand for wastewater use by farmers. Demand for pit emptying also increases during heavy rainfall events, but flooding makes access to some areas difficult. Sewers overflow during severe rain events as a result of high flow and blockages caused by solid waste.

BOD: biochemical oxygen demand; SS: suspended slids; WWTP: wastewater treatment plant.

Step 2.4. Gather supporting information

The SSP team verified the system description through field investigations while conducting steps 2.1–2.4 to ensure that the information was complete and accurate. The SSP team identified hazards present in each system flow. As part of the verification process, the RHD officer and the epidemiologist from the Sanitola School of Public Health reviewed local health statistics to understand potential health concerns. They also conducted some focus group discussions to summarize the most important health hazards (Table 2.4).

Table 2.4. Key information gathered during the verification step

Hazards	Key information
Biological	Different viruses, bacteria and protozoa are present in the solid and liquid waste fractions. Diarrhoea prevalence is high among young children, especially during the dry season. Foodborne disease outbreaks are frequent. Helminth infections are common among the local population (prevalence of soil-transmitted helminths in school-aged children: 18–22%), with hookworm and *Ascaris lumbricoides* being the predominant species. Malaria (*Plasmodium vivax*) is the most important vector-related disease, with occasional cases being recorded at health facilities.
Chemical	Data from the national environmental monitoring programme show that concentrations of toxic chemicals such as heavy metals are below national and international reference values in Newtown's surface waters. This reflects the absence of industry in the catchment area.
Physical	Work-related injuries during maintenance of repairs of drains blocked by solid waste.

MODULE 3. Identify hazardous events, and assess existing control measures and exposure risks

Step 3.1. Identify hazards and hazardous events

Once the SSP core team had collected and validated the system description, they gathered the members of the extended SSP team in a workshop to evaluate health risks. Results of steps 3.1–3.4 are presented in Table 3.2.

Step 3.2. Identify and assess existing control measures

Table 3.1 gives examples of some of the control measures in Newtown's SSP.

Table 3.1. Control measures

Sanitation step	Type of control measure	Example control measures currently in place in Newtown SSP, with comments
P1: Toilet and containment–storage/ treatment with soak pits and septic tanks	Technical control measure	Some of the soak pits have been constructed to maintain a safe distance from community wells. Septic tanks are in good condition.
T2: Open drain	Management and operational control measure	Personal protective equipment (e.g. boots and gloves) is provided to formal workers, although is not consistently used.
P6: Use of wastewater in agriculture	Management and operational control measure	Some farmers occasionally wear boots.
P7: Consumption of agricultural products	Behaviour change	Some crops from the main farming area are cooked before being eaten. Hygiene campaigns promote washing of produce before consuming, which is practised by some households.

Step 3.3. Assess and prioritize the exposure risk

A semi-quantitative risk assessment was conducted using the matrix and definitions in tools 3.5 and 3.6. The risk assessment (Table 3.2) presents all hazards, hazardous events, existing control measures and the risk evaluation.

The risk assessment was carried out under current climatic conditions. To consider the climate change and climate variability expected over the next 30 years, two "most likely" scenarios were also evaluated:

- drought conditions, with decreased average rainfall during the dry season; and
- more intense precipitation and flooding during the wet season.

Table 3.2. Newtown's risk assessment table

COMPONENT	HAZARD IDENTIFICATION				EXISTING CONTROLS		RISK ASSESSMENT						COMMENTS JUSTIFYING RISK ASSESSMENT (Under current conditions, climate change scenarios, or effectiveness of the control)
							Under current conditions (L = likelihood; S = severity; R = risk (H = high; M = medium; VH = very high)				Under the most likely climate change scenarios (+ means increased risk, – means decreased risk, = means the same risk)		
Sanitation step	Hazardous event	Hazard	Exposure group	Number of people at risk	Description	Validation	L	S	Score (LxS)	R	Drought	More intense precipitation	
P1 Toilet and containment–storage/ treatment with soak pits and septic tanks	Ingestion after contact with excreta in nonfunctional toilets	All microbial pathogens	**U1**	30 000	Flush toilets and water supply	Visual and survey	4	2	8	M	+	-	Currently, households do not have a continuous water supply. This worsens in dry conditions, and there also is not enough water to flush toilets.
P2 Disposal of liquid fraction by infiltration	Ingestion of contaminated groundwater due to infiltration from soak pits and septic tanks into shallow groundwater	Faecal pathogens	**L1**	20 000	In some cases, safe distance from wells has been considered.	Field visits	5	4	20	H	+	+	High prevalence of diarrhoea is reported among among young children, especially during the dry season. Likelihood of groundwater use is expected to increase during drought periods. Severity will increase with more and prolonged flooding due to climate change. Consideration should be given to vulnerable communities that may have a reduced ability to find alternative water sources.
		Nitrates and nitrates	**L1** (children less than 5 years old)	8000	Awareness-raising campaigns among mothers	Interviews with mothers	5	8	40	VH	+	+	
P1 Toilet and containment–storage/ treatment with soak pits and septic tanks	Ingestion after contact with wastewater from overflowing on-site systems due to damage or blockage	All microbial pathogens	**U1**	30 000	Septic tanks and soak pits present problems.	Interviews and field visits	4	4	16	H	-	+	Likelihood and severity will increase with heavy rainfall and flooding.
			L2	50 000			3	4	12	M	-	+	The localized problem of septic tank damage becomes a community problem with flooding, affecting others in the vicinity.
P5 Flush toilets discharging in open drains	Ingestion after contact with excreta in nonfunctional toilets	All microbial pathogens	**U2**	5000	Flush toilets and water supply	Visual survey	4	2	8	M	+	-	Currently, households do not have a continuous water supply. This worsens in dry conditions, and there is also not enough water to flush toilets.
P5 Flush toilets discharging in open drains	Ingestion after contact with wastewater from overflowing on-site systems due to damage or blockage	All microbial pathogens	**U2**	5000	None	Interviews	4	4	16	H	–	+	Likelihood and severity will increase with heavy rainfall and flooding.

COMPONENT	HAZARD IDENTIFICATION				EXISTING CONTROLS		RISK ASSESSMENT						COMMENTS JUSTIFYING RISK ASSESSMENT (Under current conditions, climate change scenarios, or effectiveness of the control)
							Under current conditions (L = likelihood; S = severity; R = risk (H = high; M = medium; VH = very high))				Under the most likely climate change scenarios (+ means increased risk, – means decreased risk, = means the same risk)		
Sanitation step	Hazardous event	Hazard	Exposure group	Number of people at risk	Description	Validation	L	S	Score (LxS)	R	Drought	More intense precipitation	
T1 Conveyance by vacuum trucks	Ingestion after contact with raw sewage during vacuum tanker operation	All microbial pathogens	**W1**	60	Nil	NA	3	4	12	M	=	+	Handwashing and washing of equipment after emptying activities is not widely practised. In flooding conditions, the likelihood will increase.
T1 Conveyance by vacuum trucks	Ingestion after contact with faecal sludge while entering or falling into soak pits or septic tanks	All microbial pathogens	**W1**	20	Nil	NA	2	4	8	M	=	+	Stability of tanks can be affected by flooding.
	Injury to the body, possible asphyxiation, caused by entering or falling into soak pits or septic tanks	Injury to the body, including asphyxiation	**W1**	20	Nil	NA	2	8	16	H	=	+	
T1 Conveyance by vacuum trucks	Ingestion after contact with faecal sludge caused by spillage during emptying and transport	All microbial pathogens	**U1**	30 000	Procedures to deal with spillage	Interviews	3	4	12	M	=	+	During heavy rains, likelihood of spillage increases.
P4 Disposal of faecal sludge in open drains	Ingestion after contact with faecal sludge discharged without treatment to open drains	All microbial pathogens	**L2**	50 000	Nil	NA	5	8	40	VH	=	+	Risk increases during heavy rains.
T2 Open drains	Ingestion after contact with raw sewage in open drains during maintenance activities	All microbial pathogens	**W2**	6	Boots worn, no gloves	Visual and survey	5	4	20	H	=	=	Gloves were not observed in use during site visits.
T2 Open drains	Dermal contact with raw sewage in open drains during maintenance activities	Hookworm	**W2**	6	Boots worn, no gloves	Visual and survey	3	2	6	M	=	=	Hookworm infection among adults may be less severe.
T2 Open drains	Inhalation of particles with pathogens during maintenance activities	Pathogens in aerosols	**W3**	6	Face masks	Observation	5	2	10	M	+	=	Face masks are seldom worn, especially during dry periods.

COMPONENT	HAZARD IDENTIFICATION				EXISTING CONTROLS		RISK ASSESSMENT						COMMENTS JUSTIFYING RISK ASSESSMENT (Under current conditions, climate change scenarios, or effectiveness of the control)
							Under current conditions L = likelihood; S = severity; R = risk (H = high; M = medium; VH = very high)				Under the most likely climate change scenarios + means increased risk, – means decreased risk, = means the same risk)		
Sanitation step	Hazardous event	Hazard	Exposure group	Number of people at risk	Description	Validation	L	S	Score (LxS)	R	Drought	More intense precipitation	
T2 Open drains	Ingestion after contact with wastewater while entering or falling into drains during maintenance	All microbial pathogens	**W2**	6	Working in pairs	Observation and worker training report	2	4	8	M	=	+	Increased likelihood with more frequent and prolonged flood events due to climate change.
T2 Open drains	Injury to the body, possible drowning, caused by entering or falling into drains	Injury to the body, including drowning			Working in pairs		1	8	8	M	=	+	Increased likelihood with more frequent and prolonged flood events due to climate change.
T2 Open drains	Ingestion after contact with raw sewage in open drains	All microbial pathogens	**L2**	50 000	Nil	NA	4	4	16	H	+	+	In drought conditions, there is an increase in the concentration of pathogens in drains. During flooding, there is increased runoff, increasing the amount of waste in the environment.
T2 Open drains	Dermal contact with raw sewage in open drains	Hookworm	**L2**	50 000	Nil	NA	4	4	16	H	=	+	Some children were observed to play in the drains. Hookworm infection can impair nutritional status of children and cause anaemia. Severity of disease varies, depending on number of worms harboured by an individual. Consequently, the moderate severity category was selected. The likelihood will increase with frequent and severe rainfall events.
T2 Open drains	Injury caused by falling into open drains	Injury to the body	**L2**	50 000	Nil	NA	1	8	8	M	=	+	Increased likelihood with more frequent and prolonged flood events due to climate change.
T2 Open drains	Enhanced transmission of malaria caused by mosquito (vector) breeding in stagnant water	Vector-related diseases	**L2**	50 000	Nil	NA	4	4	16	H	–	+	*Plasmodium vivax* malaria (the only endemic *Plasmodium* species in Sanitola) does not result in fatal illness. Increased likelihood with prolonged flooding due to climate change.
P6 Use of wastewater in agriculture	Ingestion after contact with raw sewage from open drains during farming activities	All microbial pathogens	**F**	150	Nil	NA	5	8	40	VH	+	=	Farmers are in direct contact with untreated sewage. Increased likelihood with water shortages in drier climate scenarios. Increased severity with high pathogen concentrations in low-flow rivers.

COMPONENT	HAZARD IDENTIFICATION				EXISTING CONTROLS		RISK ASSESSMENT						COMMENTS JUSTIFYING RISK ASSESSMENT (Under current conditions, climate change scenarios, or effectiveness of the control)
							Under current conditions (L = likelihood; S = severity; R = risk (H = high; M = medium; VH = very high)				Under the most likely climate change scenarios (+ means increased risk, – means decreased risk, = means the same risk)		
Sanitation step	Hazardous event	Hazard	Exposure group	Number of people at risk	Description	Validation	L	S	Score (LxS)	R	Drought	More intense precipitation	
P6 Use of wastewater in agriculture	Dermal contact with raw sewage in open drains during farming activities	Hookworm	**F**	150	Farmers wearing footwear were not observed.	Field visits	4	4	16	H	+	+	Farmers and children are in direct contact with untreated sewage. Hookworm infection can impair nutritional status of children and cause anaemia. Severity of disease varies, depending on number of worms harboured by an individual. Consequently, the moderate severity category was selected.
P6 Use of wastewater in agriculture	Dermal contact with wastewater in areas near farming plots	Hookworm	**L3**	750	Nil	NA	4	4	16	H	+	+	Children were observed to play in the fields. Hookworm infection can impair nutritional status of children and cause anaemia. Severity of disease varies, depending on number of worms harboured by an individual. Consequently, the moderate severity category was selected.
P6 Use of wastewater in agriculture	Enhanced transmission of malaria caused by mosquito (vector) breeding in stagnant water	Vector-related diseases	**L3**	750	Nil	NA	4	4	16	H	–	+	*Plasmodium vivax* malaria (the only endemic *Plasmodium* species in Sanitola) does not result in fatal illness. Increased likelihood with prolonged flooding due to climate change.
P7 Consumption of agricultural products	Consumption of contaminated produce grown with raw sewage in open drains	All microbial pathogens	**C**	1000	Post-harvest washing is not rigorous.	Observations	5	4	20	H	+	=	Some crops are eaten uncooked. Post-harvest washing is carried out, but not rigorously. With water scarcity, this practice is diminished.

NA: not applicable.

Note: This table is illustrative only of the hypothetical Newtown SSP. The steps and linked hazard identification and scoring may not be representative of other systems.

Once the extended SSP team had conducted the health risk analysis, the SSP team leader invited the steering committee to a high-level meeting to decide which hazardous events to prioritize. Based on the evidence, the hazardous events in Table 3.3 were prioritized by members of the steering committee.

Table 3.3. Newtown's prioritized hazardous events with very high risk

Sanitation step	Hazardous event	Exposure group	Number of people at risk	Risk	Projection of changes in risks with climate change scenarios	Priority given
P2 Disposal of liquid fraction by infiltration	Ingestion of contaminated groundwater due to leakage from soak pits and septic tanks into shallow groundwater	L1 (children less than 5 years old)	8000	Very high	Increases during drought and heavy rains	Very high
P4 Disposal of faecal sludge in open drains	Ingestion after contact with faecal sludge discharged without treatment to open drains	L2	50 000	Very high	Increases with flooding	Very high
P6 Use of wastewater in agriculture	Ingestion after contact with raw sewage from open drains during farming activities	F	150	Very high	Increases during drought	Very high

The steering committee realized that it would be possible to address some hazardous events with high risk concurrently (Table 3.4).

Table 3.4. Newtown's prioritized hazardous events with high risk

Sanitation step	Hazardous event	Exposure group	Number of people at risk	Risk	Projection of changes in risks with climate change scenarios	Priority given
P2 Disposal of liquid fraction by infiltration	Ingestion of contaminated groundwater due to leakage from soak pits and septic tanks into shallow groundwater	L1	20 000	High	Increases during drought and heavy rains	High
T1 Conveyance by vacuum trucks	Injury to the body, possible asphyxiation, caused by entering or falling into soak pits or septic tanks	W1	60	High	Stability of the tanks can be affected by flooding	High
T2 Open drains	Ingestion after contact with raw sewage in open drains during maintenance activities	W2	6	High	Remains high	High
T2 Open drains	Ingestion after contact with raw sewage in open drains	L2	50 000	High	Increases in both scenarios	High
T2 Open drains	Enhanced transmission of malaria caused by mosquito (vector) breeding in stagnant water	L2	50 000	High	Increases in heavy rains	High
P6 Use of wastewater in agriculture	Dermal contact with raw sewage (hookworm) in open drains during farming activities	F	150	High	Increases in both scenarios	High
P6 Use of wastewater in agriculture	Dermal contact with wastewater (hookworm) in areas near farming plots	L3	750	High	Increases in both scenarios	High
P6 Use of wastewater in agriculture	Enhanced transmission of malaria caused by mosquito (vector) breeding in stagnant water	L3	750	High	Increases in heavy rains	High
P7 Consumption of agricultural products	Consumption of contaminated produce grown with raw sewage in open drains	C	1000	High	Increases in drought	High

MODULE 4. Develop and implement an incremental improvement plan

After the meeting of the steering committee, three SSP task forces were set up. Each included stakeholders involved in each of the sanitation steps where hazardous events were prioritized. The three SSP task forces were as follows.

P2: Disposal of liquid fraction by infiltration. Members of SSP task force 1:

- NHD
- water system operator
- Municipal Environmental Health Practitioner of RHD
- Local Building Association
- RHD officer.

This team was in charge of preparing an incremental improvement plant to mitigate the risks posed by:

- ingestion of contaminated groundwater due to leakage from soak pits and septic tanks into shallow groundwater.

P4: Disposal of faecal sludge in open drains. Members of SSP task force 2:

- vacuum tanker operators
- City Service "Traffic law enforcement and licences"
- Environmental Protection, Department of Environmental Affairs
- Operations Manager, WWTP
- Engineering Section, Open Drains and Sewer System, NSD.

This team was in charge of preparing an incremental improvement plant to mitigate the risks posed by:

- ingestion after contact with faecal sludge discharged without treatment to open drains;
- injury to the body, possible asphyxiation, caused by entering or falling into soak pits or septic tanks;
- ingestion after contact with raw sewage in open drains; and
- enhanced transmission of malaria caused by mosquito (vector) breeding in stagnant water.

P6: Use of wastewater in agriculture. Members of SSP task force 3:

- Farmers Cooperative
- RDARD
- RHD officer
- epidemiologist, Sanitola School of Public Health.

This team was in charge of preparing an incremental improvement plan to mitigate the risks posed by:

- ingestion after contact with raw sewage from open drains during farming activities;
- dermal contact with raw sewage (hookworm) in open drains during farming activities;
- dermal contact with wastewater (hookworm) in areas near farming plots;
- enhanced transmission of malaria caused by mosquito (vector) breeding in stagnant water; and
- consumption of contaminated produce grown with raw sewage in open drains.

The SSP task forces gathered in meetings to analyse all possible new control measures that address these risks at the most effective places in the system.

Step 4.1. Consider options to control identified risks

In this step, members of the SSP task forces considered a variety of ways to control risks, including technology upgrades, changes in management and operation, behaviour change measures, and policy and regulatory measures, covering all steps of the sanitation chain (Table 4.1).

Table 4.1. Improvement options at step P2: Disposal of liquid fraction by infiltration

Step of the sanitation service chain: P2: Disposal of liquid fraction by infiltration **Description of hazardous event:** Ingestion of microbiologically contaminated groundwater due to infiltration from soak pits and septic tanks into shallow groundwater **Exposure group:** About 8000 children less than 5 years old; in total, 20 000 people consuming contaminated water					
IMPROVEMENT OPTIONS					
Option	**Effectiveness**	**Level of resources**	**Effectiveness under climate change scenarios**	**Comments/discussion**	**Priority for improvement plan**
Awareness-raising campaign targeting caregivers to treat and safely store drinking-water	Medium	Low	Effective	A team of environmental health practitioners is already working with communities and a maternal health programme in Newtown.	Immediate
Improved water supply	High	High	In dry seasons, water sources are insufficient.	A water safety plan has been developed in Newtown. One of the priorities is to increase coverage of vulnerable areas. WSP team is planning extension of piped water service to vulnerable areas.	Medium term
Technical norms and standards for construction of on-site systems	Medium	Medium	Effective	The NHD agreed to develop norms and standards in collaboration with the health authority.	Immediate
New regulation on types of on-site sanitation systems	Medium	Low	Effective	The Municipal Council agreed to write, pass and enforce a by-law requiring households to meet the new technical norms.	Short term
Training of construction companies about new regulations, norms and standards	Medium	Medium	Effective	The Local Building Association committed resources to train its members as soon as the norms and standards are ready.	Medium term
Building a database of on-site sanitation infrastructure	Medium	Medium	Effective	The NHD mentioned that they had limited capacity and resources.	Medium term
Guidelines on periodic inspection of on-site systems	Medium	High	Effective	The NHD mentioned that they could start with new housing projects.	Medium term
Programme to encourage refurbishment of unsealed containment tanks	High	Medium	Effective	The Municipal Council agreed to develop and implement a subsidy and incentive scheme for households to repair or replace damaged pits and tanks to meet the new regulation.	Medium term

NHD: Newtown Housing Department.

Table 4.2 shows the control measures analysed by task force 2 to control the practices of vacuum emptiers.

Table 4.2. Improvement options at step P4: Disposal of faecal sludge in open drains

Step of the sanitation service chain: P4: Disposal of faecal sludge in open drains **Description of hazardous event:** Ingestion after contact with faecal sludge discharged without treatment to open drains **Exposure group:** 50 000 people (all citizens of Newtown) **Description of the hazardous event:** Injury to the body, possible asphyxiation, caused by entering or falling into soak pits or septic tanks. **Exposure group:** 60 people (vacuum trucks operators)					
IMPROVEMENT OPTIONS					
Option	**Effectiveness**	**Level of resources**	**Effectiveness under climate change scenarios**	**Comments/discussion**	**Priority for improvement plan**
Issuing a municipal decree/by-law for faecal sludge management	High	Low	Effective	The Municipal Council agreed to write and pass a by-law. This will only be effective with proper enforcement.	Immediate
Licensing of emptying service providers	High	Medium	Effective	There were discussions about who should take responsibility. City Service "Traffic law enforcement and licences" and Environmental Protection, DEA, decided to work together to ensure that all formal and informal emptying service providers are licensed.	Short term
Upgrading equipment and providing training on standard operating procedures among informal service providers	High	Medium	Effective	The Municipal Council agreed to support a scheme to support informal service providers through provision of safer equipment and training.	Short term
Issuing a DEA regulation to bring all faecal sludge to the WWTP	High	Low	Detrimental	There were discussions about this issue. The WWTP Operations Manager strongly opposed this option, but no other immediate solution was possible.	Immediate
Supporting an association of vacuum truck operators	Medium	Low	NA	The SSP team leader initiated discussions with vacuum truck operators relating to creation of an association.	Immediate
Training vacuum truck operators about health and safety	High	Medium	NA	The DEA and the RHD agreed to collaborate on this.	Short term
Monitoring and controlling vacuum truck operators (e.g. through GPS systems)	High	High	Effective	The DEA would like to develop this in the long term.	Long term
Strengthening enforcement authorities	High	Medium	Effective	City Service "Traffic law enforcement and licences" agreed to provide training on the traffic policy and to identify irregular practices.	Medium term
Constructing a faecal sludge treatment plant (dewatering, drying and composting)	High	High	Effective	All participants agreed that a faecal sludge treatment plant should be constructed.	Long term

DEA: Department of Environmental Affairs; NA: not applicable; RHD: Regional Health Department; WWTP: wastewater treatment plant.

This team also analysed the hazardous events occurring in open drains (Table 4.3).

Table 4.3. Improvement options at step T2: Open drains

Step of the sanitation service chain: T2: Open drains
Description of hazardous event: Ingestion after contact with raw sewage in open drains during maintenance activities
Exposure group: 6 people (open drain workers)
Description of the hazardous event:
– Ingestion after contact with raw sewage in open drains
– Enhanced transmission of malaria caused by mosquito (vector) breeding in stagnant water
Exposure group: 50 000 people (all citizens of Newtown)

IMPROVEMENT OPTIONS					
Option	**Effectiveness**	**Level of resources**	**Effectiveness under climate change scenarios**	**Comments/discussion**	**Priority for improvement plan**
Issuing a municipal decree/by-law to oblige connection to the sewer system	High	Low	Effective	The Municipal Council agreed to write and pass a by-law.	Immediate
Programme to encourage the population to connect to the sewer system	High	Medium	Effective	The SSP team leader contacted the Head of the NSD to bring the Commercial Unit on board.	Medium term
Pest control during rainy season	High	Medium	Effective	The RHD officer mentioned that funds have to be sought for this.	Medium term
Removal of solid waste from drains before flood periods to lower flood depth and duration	High	Low	Effective	The SSP team leader contacted the Head of the NSD to bring the Engineering Section, NSD (in charge of the sewer system), on board.	Short term
Workers wearing protecting clothing	Medium	Low	Effective	The Head of the NSD indicated that new personal protective equipment would be received next month.	Short term
Training of workers on health and safety	Medium	Low	Effective	The Head of the Engineering Section, NSD, indicated that a new training programme would soon be in place.	Short term

NSD: Newtown Sanitation Department; RHD: Regional Health Department.

SSP task force 3 analysed the hazardous events associated with wastewater use (Table 4.4).

Table 4.4. Improvement options at step P6: Use of wastewater in agriculture to protect farmers

Step of the sanitation service chain: P6: Use of wastewater in agriculture
Description of the hazardous event:
– Ingestion after contact with raw sewage from open drains during farming activities
– Dermal contact with raw sewage (hookworm) in open drains during farming activities
Exposure group: 150 people (farmers and their families)

IMPROVEMENT OPTIONS					
Option	**Effectiveness**	**Level of resources**	**Effectiveness under climate change scenarios**	**Comments/discussion**	**Priority for improvement plan**
On-farm short-retention-time anaerobic ponds to reduce numbers of helminth eggs and, to some extent, other pathogen loads	Medium	High	Ineffective	Representatives of the Farmers Cooperative were not happy about losing part of their plots to ponds.	Long term
Drip irrigation	High	High	Effective	RDARD committed resources as there are only 30 families.	Medium term
Farmers wearing protective clothing	Low	Medium	Ineffective	For example, boots/shoes, gloves. Needs highly motivated famers; high risk of noncompliance by farmers.	Short term
Farmers' improved handwashing and hygiene	High	High	Effective	For example, improved access to good handwashing and washing/bathing facilities for farmers. Moderately expensive option but does offer high protection to farmers.	Long term
New irrigation channel with treated water or fresh water	High	High	Moderate	A clean source of water is the aim in the long term. The RDARD mentioned that it is not possible in the short term.	Not further considered

RDARD: Regional Department for Agriculture and Rural Development.

Task force 3 also analysed options to control health risks to communities living near farms (Table 4.5).

Table 4.5. Improvement options at step P6: Use of wastewater in agriculture to protect community

Step of the sanitation service chain: P6: Use of wastewater in agriculture **Description of the hazardous event:** – Dermal contact with wastewater (hookworm) in areas near farming plots – Enhanced transmission of malaria caused by mosquito (vector) breeding in stagnant water **Exposure group:** 750 people (people living near the farms)					
IMPROVEMENT OPTIONS					
Option	**Effectiveness**	**Level of resources**	**Effectiveness under climate change scenarios**	**Comments/discussion**	**Priority for improvement plan**
Pest control during rainy season	High	Medium	Effective	The RHD officer mentioned that funds have to be sought for this.	Medium
Fencing of agricultural plots	High	High	Effective	Representatives of the Farmers Cooperative said that this was too expensive.	Not further considered
Deworming programme for whole population	Low	Medium	Effective	The RHD officer mentioned that this was possible soon.	Short term
Awareness-raising programme to inform the population about the risk posed by nearby farms	Medium	Low	Medium	A team of environmental health practitioners ia already working with communities in Newtown.	Immediate
Awareness-raising programme for shoe wearing among whole population	High	Low	Effective	A team of environmental health practitioners is already working with communities in Newtown.	Immediate

RHD: Regional Health Department.

Finally, task force 3 analysed the options to control the risks associated with consumption of products (Table 4.6).

Table 4.6. Improvement options at step P7: Consumption of agricultural products

Step of the sanitation service chain: P7: Consumption of agricultural products **Description of the hazardous event:** Consumption of contaminated produce grown with raw sewage in open drains **Exposure group:** 1000 people					
IMPROVEMENT OPTIONS					
Option	**Effectiveness**	**Level of resources**	**Effectiveness under climate change scenarios**	**Comments/discussion**	**Priority for improvement plan**
Crop restriction	High	Medium	High	Representatives of the Farmers Cooperative were not happy about restricting crops. The RDARD offered its support to identify high-value products.	Medium
Pathogen die-off before consumption (e.g. cessation of irrigation before harvest)	High	Low	High	The RDARD will conduct a programme to train farmers.	Short term
Monitoring safety of products	Medium	High	High	The RHD officer indicated that these analyses were too expensive and could not be done on a regular basis.	Not further considered
Education programmes to ensure consistent good practice in food preparation	Medium	Low	HIgh	A team of environmental health practitioners is already working with communities in Newtown.	Immediate

RDARD: Regional Department for Agriculture and Rural Development; RHD: Regional Health Department.

Step 4.2. Develop an incremental improvement plan

Once all the options were analysed, the SSP team leader gathered the members of the steering committee to jointly decide the time frame for implementation. The decision-makers were very interested in "quick-wins" – that is, control measures that did not required major funds or time. Table 4.7 shows the incremental improvement plan for the next 3 years.

Table 4.7. Incremental improvement plan for 3 years

Improvement measure	Cost	Source of funds	Lead organization	Year 1												Year 2				Year 3			
				1	2	3	4	5	6	7	8	9	10	11	12	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
P2: Disposal of liquid fraction by infiltration																							
Awareness-raising campaign targeting caregivers to encourage safer water management practices	100	RHD	Environmental Protection, DEA																				
Technical norms and standards for construction of on-site systems	1000	NHD	NHD																				
New regulation about types of on-site sanitation systems	50	MC	MC																				
Training of construction companies about new regulations, norms and standards	1000	LBA	LBA																				
Guidelines on periodic inspection of on-site systems	1000	NHD	NHD																				
Programme to encourage refurbishment of unsealed containment tanks	10 000	Annual budget	MC and NHD																				
P4: Disposal of faecal sludge in open drains																							
Issuing a municipal decree/ by-law for faecal sludge management	100	MC	MC and NSD																				
Issuing a DEA regulation to bring all faecal sludge to the WWTP	100	DEA	Environmental Protection, DEA																				
Creation of an association of vacuum truck operators	1000	NSD	NSD																				

Improvement measure	Cost	Source of funds	Lead organization	Year 1												Year 2				Year 3			
				1	2	3	4	5	6	7	8	9	10	11	12	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
P4: Disposal of faecal sludge in open drains																							
Licensing of emptying service providers	1000	DEA	City Service "Traffic law enforcement and licences" and DEA																				
Training of vacuum truck operators about health and safety	1000	RHD	DEA and RHD																				
Strengthening enforcement authorities	1000	City Service "Traffic law enforcement and licences"	City Service "Traffic law enforcement and licences"																				
Construction of a faecal sludge treatment plant (dewatering, drying and composting)	50 000	NSD	NSD																				
T2: Open drains																							
Issuing a municipal decree/by-law to oblige connection to sewer system	100	RHD	Environmental Protection, DEA																				
Workers wearing protective clothing	(Already acquired)	NSD	NSD																				
Training of workers on health and safety	100	NSD	Engineering Section, NSD																				
Removal of solid waste from drains before flood periods to lower flood depth and duration	150	NSD	Engineering Section, NSD																				
Programme to encourage the population to connect to the sewer system	1000	NSD	Commercial Unit, NSD																				
Pest control during rainy season	1000	Annual budget	RHD																				
P6: Use of wastewater in agriculture to protect farmers																							
Farmers wearing protective clothing	1000	RDARD	RDARD																				
Drip irrigation	25 000	RDARD	RDARD																				
Farmers' improved handwashing and hygiene	10 000	NSD	NSD																				

Improvement measure	Cost	Source of funds	Lead organization	Year 1												Year 2				Year 3			
				1	2	3	4	5	6	7	8	9	10	11	12	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
P6: Use of wastewater in agriculture to protect farmers																							
On-farm short-retention-time anaerobic ponds to reduce numbers of helminth eggs and, to some extent, other pathogen loads	45 000	RDARD	RDARD																				
P6: Use of wastewater in agriculture to protect community																							
Awareness-raising programme to inform the population about the risk posed by nearby farms	100	RHD	Environmental Protection, DEA																				
Incorporation of messages on shoe wearing within health and hygiene behaviour change campaigns	100	RHD	Environmental Protection, DEA																				
Deworming programme for whole population	1000	RHD	RHD																				
Pest control during rainy season	(Considered above)		RHD																				
P7: Consumption of agricultural products																							
Education programmes to promote safe food-handling practices	100	RHD	Environmental Protection, DEA																				
Training on crop restriction and pathogen die-off before consumption (e.g. cessation of irrigation before harvest)	1000	RDARD	RDARD																				

DEA: Department of Environmental Affairs; LBA: Local Building Association; MC: Municipal Council; NHD: Newtown Housing Department; NSD: Newtown Sanitation Department; RDARD: Regional Department for Agriculture and Rural Development; RHD: Regional Health Department; WWTP: wastewater treatment plant.

Step 4.3. Implement the improvement plan

SSP implementation was challenging, and building upon the initial commitments and motivation of all stakeholders required continuous follow-up. The SSP team leader organized meetings with the SSP task forces on a regular basis to review progress and discuss challenges. The team leader also made sure to keep the members of the steering committee informed throughout.

MODULE 5. Monitor control measures and verify performance

Step 5.1. Define and implement operational monitoring

Once the SSP improvement plan was ready, the SSP team leader invited all lead organizations to a workshop to develop a monitoring and verification plan. Tool 5.1 helped to decide which control measures to monitor to ensure that each is operating as intended (Table 5.1).

Table 5.1. Operational monitoring overview

Sanitation step	Control measures for a detailed operational monitoring plan
P2: Disposal of liquid fraction by infiltration	• Awareness-raising campaign targeting caregivers on safe water management practices • Training of construction companies about new regulations, norms and standards • Programme to encourage refurbishment of unsealed containment tanks
P4: Disposal of faecal sludge in open drains	• Licensing of emptying service providers • Training of vacuum truck operators about health and safety
T2: Open drains	• Workers wearing protective clothing, and training of workers on health and safety • Removal of solid waste from drains before flood periods to lower flood depth and duration
P6: Use of wastewater in agriculture	• Farmers wearing protective clothing • Drip irrigation • On-farm short-retention-time anaerobic ponds to reduce numbers of helminth eggs and, to some extent, other pathogen loads • Awareness-raising programme to inform the population about the risk posed by nearby farms • Awareness-raising programme for shoe wearing among the whole population • Education programmes to ensure consistent good practice in food preparation • Training on crop-restriction and pathogen die-off before consumption

Tables 5.2–5.5 show a few operational monitoring plans for control measures at each step.

Table 5.2. Operational monitoring plan for P2: Disposal of liquid fraction by infiltration

Operational monitoring plan for: Awareness-raising campaign among caregivers to promote safe drinking-water management practices				
Operational limits	**Operational monitoring of the control measure**		**Corrective action when the operational limit is exceeded**	
<50 every week	**What is monitored?**	Number of activities conducted and estimated population reached, by each activity	**What action is to be taken?**	Discuss with the team the reasons for the low coverage and adapt the strategy.
	How is it monitored?	Review of detailed activity records and rapid survey		
	Where is it monitored?	In a weekly meeting	**Who takes the action?**	Environmental Health Department Supervisor
	Who monitors it?	Environmental Health Department Supervisor	**When is it taken?**	Every Monday
	When is it monitored?	Every Monday	**Who needs to be informed of the action?**	Head of Environmental Health Department

Table 5.3. Operational monitoring plan for P4: Disposal of faecal sludge in open drains

Operational monitoring plan for: Training of vacuum truck operators about health and safety				
Operational limits	**Operational monitoring of the control measure**		**Corrective action when the operational limit is exceeded**	
100% (Workers are required to use personal protective equipment [PPE] at all times)	**What is monitored?**	Frequency of PPE use by workers	**What action is to be taken?**	Policy involves a fee to be paid to City Service "Traffic law enforcement and licences".
	How is it monitored?	Surprise visits to the field and observation		
	Where is it monitored?	At the household and roads	**Who takes the action?**	Traffic policy officer
	Who monitors it?	Traffic policy officer	**When is it taken?**	Every time
	When is it monitored?	Constantly	**Who needs to be informed of the action?**	Regional Health Department

Table 5.4. Operational monitoring plan for T2: Open drains

Operational monitoring plan for: Removal of solid waste from drains before flood periods to lower flood depth and duration				
Operational limits	**Operational monitoring of the control measure**		**Corrective action when the operational limit is exceeded**	
No solid waste is to be seen in the channels	**What is monitored?**	Presence of solid waste in selected areas	**What action is to be taken?**	Gather the team of sanitation workers and discuss why it is not done. If needed, appoint extra staff.
	How is it monitored?	Visits and observation		
	Where is it monitored?	At 20 random points that are known to be very dirty	**Who takes the action?**	Supervisor of the NSD
	Who monitors it?	Supervisor of the NSD	**When is it taken?**	Immediately after observing solid waste
	When is it monitored?	The week before heavy rains, typically October	**Who needs to be informed of the action?**	Head of the NSD

NSD: Newtown Sanitation Department.

Table 5.5. Operational monitoring plan for P6: Use of wastewater in agriculture

Operational monitoring plan for: Drip irrigation Training on crop-restriction and pathogen die-off before consumption				
Operational limits	**Operational monitoring of the control measure**		**Corrective action when the operational limit is exceeded**	
The farmer knows how to use the drip irrigation system, is restricting the crops and applies pre-harvest irrigation control (e.g. cessation of irrigation before harvest)	**What is monitored?**	Farm practices	**What action is to be taken?**	Retrain the farmer on the spot.
	How is it monitored?	Interviews with farmers and observation		
	Where is it monitored?	At the farm	**Who takes the action?**	Supervisor of the RDARD
	Who monitors it?	Supervisor of the RDARD	**When is it taken?**	During the field visit
	When is it monitored?	Every 2 months after the training	**Who needs to be informed of the action?**	Head of the programme of the RDARD

RDARD: Regional Department for Agriculture and Rural Development.

Step 5.2. Verify system performance

In setting the system verification plan, the team was mindful of the practical limitations of the RHD in testing. However, the SSP team recognized that it was important that stakeholders obtain data on the effectiveness of the SSP interventions. Conducting microbial testing on a regular basis was deemed impractical, but the Sanitola School of Public Health suggested that testing be conducted annually. Table 5.6 shows the SSP verification plan for Newtown.

Table 5.6. Operational verification plan

Sanitation step	**Verification**				
	What	**Limit**	**When**	**Who**	**Method**
P2: Disposal of liquid fraction by infiltration	*E. coli* testing in drinking-water	No detectible *E. coli*/100 mL	Annual	Epidemiologist, Sanitola School of Public Health	Sampling and testing
P4: Disposal of faecal sludge in open drains	Amount of faecal sludge transported to the WWTP	>50 m3/day	Every week	WWTP Operations Manager	Survey
T2: Open drains	Number of new connections to the sewer system	>500/year	Annual	Head, Commercial Unit, NSD	Annual reports
T2: Open drains	Number of overflows per year	<3 overflows	Annual	Engineering Section, NSD	Annual reports
P6: Use of wastewater in agriculture	Farmer health status: % of farmers and family member with helminth infections	<10%	Annual	Regional Health Department	Annual survey
P6: Use of wastewater in agriculture	Microbial concentration of pathogens at harvest	No worm eggs or *E. coli*/gram in vegetables	Annual	Epidemiologist, Sanitola School of Public Health	Sampling and testing

NSD: Newtown Sanitation Department; WWTP: wastewater treatment plant.

Step 5.3. Audit the system

It was decided to review auditing requirements in 2 years after some experience had been gained in implementing the SSP.

MODULE 6. Develop supporting programmes and review plans

Step 6.1. Identify and implement supporting programmes

The SSP team decided to start two supporting programmes:

- **Programme to empower private truck operators.** The SSP team leader decided to collaborate with the Entrepreneurship Faculty of the National University of Sanitolia, to support formalization of informal private sanitation service providers (e.g. truck operator businesses, sanitation workers in charge of cleaning drains). The programme covered training in basic finances and business, as well as assistance in obtaining equipment and capital in banks.
- **Research programmes.** The WWTP Operations Manager expressed a need to understand the characteristics of faecal sludge in order to plan the faecal sludge treatment plant that will be constructed in year 3. Therefore, the SSP team leader engaged the Sanitation Department of the Civil Engineering Faculty in a research project to characterize the faecal sludge, and propose treatment and safe end-use options.

Step 6.2. Periodically review and update the SSP outputs

The SSP team decided to revise the SSP in 12 months with the members of the steering committee.

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