## 1.5 Improving efficiency of waste collection and transport

Waste collection cost is strongly influenced by choices in equipment and by time inefficiencies, like the idle time of this truck waiting for ages to be loaded with waste. In this module, we'll be covering the factors of inefficiency in waste collection and transport, with some suggestions on how to improve on cost efficiency. So hopefully after this module, you will be able to identify the reasons for inefficiencies in waste collection, for instance in your own city, and be able to provide some suggestions on how to improve on efficiency in collection. One aspect is the placement of the containers or points of collection and the routing in a neighbourhood. Let's take a look at this example of a neighbourhood. If you would want to collect all these yellow bins, you would have to follow a route that for instance takes you this way, which would imply that sometimes, you have to cover the same stretch of road twice. So how could you improve the routing and placement of bins? For instance, you could place your bins at strategic locations and set them together to decrease the time of stop and go for your truck, as shown here in this example. However, you must check if the bins are not too far away from the houses, as else, the residents will not bring their waste to the bins. A distance of 200 meters is a good reference as maximum distance. So now, if you circle the area from the bins with a radius of 200 metres, you can see what area these bins can approximately cover. And then, if you do this for all the bin locations, you can see that the whole area is well-covered. So now, with these new bin locations, you can improve the routing. Try to avoid turns that cross traffic. So if you drive on the left side, that means: Avoid right-hand turns! A second factor to increase efficiency is to decrease loading time. These three examples show inefficient loading. For example: waiting for the people to bring their waste   
or manual loading of the waste or finally a very high loading height, which decreases the efficiency. The examples below show some measures to decrease the loading time. For instance with automatic lifting of the containers, the lifting of a hook container or by kerbside collection, using bags and a very low loading height. A note on containers or collection point: What you see here is a collection point with a hook container with side openings for easier access. What you also see is a ramp that allows smaller vehicles to easier discharge into the container. But you also see the problem: The container is located at the wrong position. It should actually be here on the side of the ramp - else, the ramp cannot be used. This example shows that technology is not enough. Although this is an appropriate technology, it is not used correctly. The truck driver has not placed the container at the right location. So it is important to always include the human factor. Another factor is transport distance. This is the distance from when your truck is full after collection to the point where you need to deliver the waste,   
be this a disposal site or treatment facility. When the transport distance increases beyond 20 kilometres, then most often it is advisable to consider a transfer station. Here, the waste is transferred from a smaller vehicle to a larger one. Transporting a larger load with a larger vehicle is more cost-efficient. Here are some examples of transfer stations: Above using a large truck - in fact some cities might even use train waggons or barges. The example below from India shows a transfer station where the load from the smaller trucks is unloaded into a storage bunker, and then from there transferred to larger trucks with a truck excavator grapple. Once the waste arrives at the disposal point, it will depend on how fast the truck can be unloaded. A very inefficient example is shown here, where the waste is manually unloaded; in contrast this example with a hydraulic tipping and unloading of the truck body. Another aspect I would like to highlight is the choice of the vehicle used for waste collection. There is a wide variety of vehicles available on the market. Whatever your choice, I would strongly recommend to check the local market. Choosing a vehicle that is common in your region often also means that it can be serviced more easily. Other criteria that should influence your choice of vehicles are on one hand of course the dimensions - width depends on street conditions, body volume and payload. These two factors will depend on waste amounts and the route lengths and the number of trips per day that the vehicle should make. Then there is also the number of crew that is needed to operate the vehicle, which impacts on the operational cost of the vehicle through the salaries needed for the crew. Finally, there's also the cost of the vehicle and the cost of its operation such as fuel consumption, maintenance cost etc. All these factors will reflect on the costs per ton of waste collected. This table shows a comparison of different vehicle types, starting off with the density of 350 kilograms per cubic meter. You can see that the compactor increases the density, but on the other hand, it has less body volume because a part of the volume is taken up by the machinery. So now, if you multiply body volume by density, what you get is 1200 in this case, 6300 for the open body truck and 5850 for the compactor truck. So you see that the compactor truck under these circumstances of density can actually transport less than an open body truck. If you then compare other factors in terms of performance, you can then calculate the cost per day of the vehicle, compare this with the waste per day you can collect, which then gives you a cost per kilogram or ton of waste collected. Another aspect of increasing efficiency is to reduce the downtime of vehicles. That means the time that the vehicle is out of service, broken and waiting to be repaired. Relying on locally well-represented brands increases the chances that spare parts can be easily obtained - and that there are skilled mechanics familiar with these brands. A further aspect is to establish a well-functioning and well-organized mechanic workshop that conducts preventive inspections and maintenance to avoid the truck even breaking down. Also, it is important to simplify procurement rules and regulations so that when spare parts are needed, they can quickly be organized and the truck quickly fixed. Another element to increase efficiency is especially increasing fuel efficiency - and that involves training of the drivers. Here are some core tips for fuel efficient driving. They can reduce fuel consumption by over 20 percent. Also, training of staff can increase efficiency - on one hand in terms of risks and safety to avoid accidents, but also to speed up the collection process. One aspect is also the communication with the waste generators. It is important to reduce delays when collecting the waste. Monitoring and supervision is important to always strive for further improvements. Feedback from the crew and drivers on how things could be improved should be really integrated, and observations might also help in streamlining the collection process. Measuring performance of vehicle and staff is important for various reasons; on one hand to identify bottlenecks, but also to plan for preventive maintenance. GPS trackers and electronic on-board recorders are innovative devices that can help with monitoring. A weigh bridge at the disposal site will help identify the amount of waste collection. Remember: Monitoring is crucial, as data availability is a step towards improving management. Finally, some last words on communication: Ensuring open communication channels with the beneficiaries, the residents, is important to get their feedback and their suggestions as well as their complaints, and be able to inform them about new developments. Ensuring communication with the collection team from a central location is also crucial to know if delays are expected or finding ways to solve problems rapidly. GPS trackers can visualise to a central location where the truck is at the moment, giving management an overview of the vehicle fleet. So in summary, in this module, we have looked at different factors that influence efficiency in waste collection: optimization of collection points and routing, decreasing the loading time, longer distance, use transfer stations, decrease vehicle emptying times, choose vehicles appropriately, monitor and supervise performance, train and educate staff, and communicate and cooperate, especially with the waste generators. As mentioned, I would like to recommend these two excellent books on waste collection in developing countries. They are available for download in the list of key readings, but also on the Internet and they give much more details on all the aspects I have discussed here. Thanks for watching.

## 1.5 Improving efficiency of waste collection and transport

Waste collection cost is strongly influenced by choices in equipment and by time inefficiencies, like the idle time of this truck waiting for ages to be loaded with waste. In this module, we'll be covering the factors of inefficiency in waste collection and transport, with some suggestions on how to improve on cost efficiency. So hopefully after this module, you will be able to identify the reasons for inefficiencies in waste collection, for instance in your own city, and be able to provide some suggestions on how to improve on efficiency in collection. One aspect is the placement of the containers or points of collection and the routing in a neighbourhood. Let's take a look at this example of a neighbourhood. If you would want to collect all these yellow bins, you would have to follow a route that for instance takes you this way, which would imply that sometimes, you have to cover the same stretch of road twice. So how could you improve the routing and placement of bins? For instance, you could place your bins at strategic locations and set them together to decrease the time of stop and go for your truck, as shown here in this example. However, you must check if the bins are not too far away from the houses, as else, the residents will not bring their waste to the bins. A distance of 200 meters is a good reference as maximum distance. So now, if you circle the area from the bins with a radius of 200 metres, you can see what area these bins can approximately cover. And then, if you do this for all the bin locations, you can see that the whole area is well-covered. So now, with these new bin locations, you can improve the routing. Try to avoid turns that cross traffic. So if you drive on the left side, that means: Avoid right-hand turns! A second factor to increase efficiency is to decrease loading time. These three examples show inefficient loading. For example: waiting for the people to bring their waste   
or manual loading of the waste or finally a very high loading height, which decreases the efficiency. The examples below show some measures to decrease the loading time. For instance with automatic lifting of the containers, the lifting of a hook container or by kerbside collection, using bags and a very low loading height. A note on containers or collection point: What you see here is a collection point with a hook container with side openings for easier access. What you also see is a ramp that allows smaller vehicles to easier discharge into the container. But you also see the problem: The container is located at the wrong position. It should actually be here on the side of the ramp - else, the ramp cannot be used. This example shows that technology is not enough. Although this is an appropriate technology, it is not used correctly. The truck driver has not placed the container at the right location. So it is important to always include the human factor. Another factor is transport distance. This is the distance from when your truck is full after collection to the point where you need to deliver the waste,   
be this a disposal site or treatment facility. When the transport distance increases beyond 20 kilometres, then most often it is advisable to consider a transfer station. Here, the waste is transferred from a smaller vehicle to a larger one. Transporting a larger load with a larger vehicle is more cost-efficient. Here are some examples of transfer stations: Above using a large truck - in fact some cities might even use train waggons or barges. The example below from India shows a transfer station where the load from the smaller trucks is unloaded into a storage bunker, and then from there transferred to larger trucks with a truck excavator grapple. Once the waste arrives at the disposal point, it will depend on how fast the truck can be unloaded. A very inefficient example is shown here, where the waste is manually unloaded; in contrast this example with a hydraulic tipping and unloading of the truck body. Another aspect I would like to highlight is the choice of the vehicle used for waste collection. There is a wide variety of vehicles available on the market. Whatever your choice, I would strongly recommend to check the local market. Choosing a vehicle that is common in your region often also means that it can be serviced more easily. Other criteria that should influence your choice of vehicles are on one hand of course the dimensions - width depends on street conditions, body volume and payload. These two factors will depend on waste amounts and the route lengths and the number of trips per day that the vehicle should make. Then there is also the number of crew that is needed to operate the vehicle, which impacts on the operational cost of the vehicle through the salaries needed for the crew. Finally, there's also the cost of the vehicle and the cost of its operation such as fuel consumption, maintenance cost etc. All these factors will reflect on the costs per ton of waste collected. This table shows a comparison of different vehicle types, starting off with the density of 350 kilograms per cubic meter. You can see that the compactor increases the density, but on the other hand, it has less body volume because a part of the volume is taken up by the machinery. So now, if you multiply body volume by density, what you get is 1200 in this case, 6300 for the open body truck and 5850 for the compactor truck. So you see that the compactor truck under these circumstances of density can actually transport less than an open body truck. If you then compare other factors in terms of performance, you can then calculate the cost per day of the vehicle, compare this with the waste per day you can collect, which then gives you a cost per kilogram or ton of waste collected. Another aspect of increasing efficiency is to reduce the downtime of vehicles. That means the time that the vehicle is out of service, broken and waiting to be repaired. Relying on locally well-represented brands increases the chances that spare parts can be easily obtained - and that there are skilled mechanics familiar with these brands. A further aspect is to establish a well-functioning and well-organized mechanic workshop that conducts preventive inspections and maintenance to avoid the truck even breaking down. Also, it is important to simplify procurement rules and regulations so that when spare parts are needed, they can quickly be organized and the truck quickly fixed. Another element to increase efficiency is especially increasing fuel efficiency - and that involves training of the drivers. Here are some core tips for fuel efficient driving. They can reduce fuel consumption by over 20 percent. Also, training of staff can increase efficiency - on one hand in terms of risks and safety to avoid accidents, but also to speed up the collection process. One aspect is also the communication with the waste generators. It is important to reduce delays when collecting the waste. Monitoring and supervision is important to always strive for further improvements. Feedback from the crew and drivers on how things could be improved should be really integrated, and observations might also help in streamlining the collection process. Measuring performance of vehicle and staff is important for various reasons; on one hand to identify bottlenecks, but also to plan for preventive maintenance. GPS trackers and electronic on-board recorders are innovative devices that can help with monitoring. A weigh bridge at the disposal site will help identify the amount of waste collection. Remember: Monitoring is crucial, as data availability is a step towards improving management. Finally, some last words on communication: Ensuring open communication channels with the beneficiaries, the residents, is important to get their feedback and their suggestions as well as their complaints, and be able to inform them about new developments. Ensuring communication with the collection team from a central location is also crucial to know if delays are expected or finding ways to solve problems rapidly. GPS trackers can visualise to a central location where the truck is at the moment, giving management an overview of the vehicle fleet. So in summary, in this module, we have looked at different factors that influence efficiency in waste collection: optimization of collection points and routing, decreasing the loading time, longer distance, use transfer stations, decrease vehicle emptying times, choose vehicles appropriately, monitor and supervise performance, train and educate staff, and communicate and cooperate, especially with the waste generators. As mentioned, I would like to recommend these two excellent books on waste collection in developing countries. They are available for download in the list of key readings, but also on the Internet and they give much more details on all the aspects I have discussed here. Thanks for watching.

## 5.2 Shit Flow Diagrams

Hello, and welcome to the MOOC module Shit Flow Diagrams: A tool to illustrate and communicate sanitation service delivery. My name is Lars, I'm an environmental engineer and I'm working in the department of sanitation, water and solid waste flow development. <i>Shit flow diagrams are often referred to as SFDs, <i>and in 2015 a team of organizations came together <i>to develop a consistent approach for the production of SDFs, <i>and the description of sanitation service delivery. <i>I hope you are excited to learn about the SFD, excreta management, <i>and the overall link to sanitation systems <i>and fecal sludge management. At the end of this module, you'll be able to describe what an SFD could be used for, explain the different pathways excreta can take in the environment, and provide examples of safely managed and unsafely managed excreta. To start, let's answer the question of what the SFD can be used for. The SFD is an assessment of sanitation service delivery, which is helpful for understanding the current situation. The SFD is a communication tool, which presents complex information in a simple illustration. And the SFD is an advocacy tool. It can be used to demonstrate the need for improved sanitation service delivery. Now, let's discuss what the SFD can convey. The SFD conveys percentages of excreta transported through sewers or emptied from containment, but it's not a detailed planning tool. It also shows how much is delivered to treatment, but it's not a quantification tool with accurate volumes. Lastly, it shows percentages of excreta treated or not treated, but doesn't assess treatment performance. <i>Let me just briefly introduce you to the research behind the SFD. <i>Discussions about SFDs are only possible <i>if results are based on a consistent approach. <i>On this slide, you can see an example. <i>This SFD is based on the methodology and tools <i>which are available on the website. <i>Green and red arrows illustrate safely and unsafely managed excreta <i>along the sanitation service chain. <i>The SFD method provides guidance to derive these percentages, <i>but also defines terminology. <i>During the following minutes, I'll guide you through a city <i>to explain this terminology in more detail. <i>Here you can see an example city. <i>Excreta is managed with off-site and on-site sanitation. <i>The SFD starts out by separating those two sanitation options. <i>This pictures shows a typical wastewater treatment plant. <i>Ideally, wastewater is delivered to treatment. <i>If not delivered, or not treated, <i>we refer to it as "excreta unsafely managed," <i>as shown here in red. <i>But if the wastewater is treated, <i>then we refer to it as "excreta safely managed," <i>as shown here in green. <i>Here you can see a pit latrine, which is an on-site sanitation technology <i>used by the majority of the population in low-income countries. <i>Fecal sludge accumulates in these technologies, <i>and once the containment fills up, the sludge needs to be removed. <i>In this example, a manual emptying-service provider <i>collects fecal sludge in barrels, <i>which are then transferred to a pickup truck. <i>On the SFD, this is described as "fecal sludge emptied." <i>The terms "fecal sludge contained" and "fecal sludge not contained" <i>will be explained in a later scene. <i>Ideally, fecal sludge is then delivered to treatment, <i>the next step of the sanitation service chain. <i>If delivered, the arrow on the SFD is green. <i>In this example, you can see a septic tank, <i>another common on-site sanitation technology, <i>which is connected to flush or pour-flush toilets. <i>If the groundwater and soil conditions allow, <i>the effluent infiltrates through a soak pit <i>into the ground for natural treatment. <i>Solids settle at the bottom of the tank, <i>and fecal sludge has to be removed on a regular basis. <i>If not removed, tanks can overflow, <i>and this can result in groundwater pollution. <i>Instead of using barrels, septic tanks are usually emptied by vacuum trucks. <i>If delivered to treatment, the arrow on the SFD is green. <i>Here you can see a typical fecal sludge treatment plant. <i>Liquids and solids are separated in settling tanks. <i>The solids are then transferred to drying beds, <i>while the liquid part is often treated in ponds. <i>If treatment is effective, fecal sludge is described as "treated" on the SFD, <i>and therefore safely managed. The next scenes will provide you with more examples of unsafely managed excreta, which is a common situation in many places. <i>Where sanitation facilities don't exist, <i>open defecation is practiced, <i>which directly contaminates the environment, <i>and is considered unsafely managed. <i>The next examples show situations where fecal sludge is emptied, <i>but then not delivered to treatment, as described on the SFD. <i>Where sanitation facilities exist, <i>but vacuum trucks cannot access the facility, <i>dumping of fecal sludge directly into the environment is common. <i>Fecal sludge is directly flushed out into nearby drains <i>by removing bricks from the containment, or by installing pumps. <i>Informal emptying practices also often lead <i>to dumping of fecal sludge into the nearby environment. <i>On the SFD, both scenarios are referred to <i>as "fecal sludge emptied, but then not delivered to treatment," <i>and therefore unsafely managed. Let us now look in more detail into the definition of "fecal sludge contained" and "not contained." <i>To do this, we need to look at the water table and soil conditions. <i>The animation provides you with an example <i>of a septic tank and a pit latrine that infiltrate into the ground. <i>In this first scenario, the water table is low, <i>and therefore the risk of groundwater pollution. <i>The result is fecal sludge contained, as you can see on the SFD as green. <i>Another scenario is that the water table is high, <i>and in this case, infiltrate from the septic tank and pit latrine <i>drains into the groundwater. <i>This situation causes a significant risk of groundwater pollution. <i>The result is "fecal sludge not contained," <i>which you can see on the SFD as red. <i>In places where there's enough space, <i>a common practice is to cover a full pit with soil, <i>and then build a new one. <i>If groundwater pollution is not an issue because of good soil conditions, <i>and low water table, this practice could be considered as safely managed. <i>While it can provide a solution in rural settings, <i>this should not be promoted in urban settings. You have now learned about scenarios where fecal sludge is not safely managed due to a number of reasons. But I hope you're not surprised if I tell you that even fecal sludge emptied and collected by vacuum trucks often is not delivered to treatment. <i>There are many possible reasons for this. <i>Firstly, treatment plants for fecal sludge <i>may simply not yet exist. <i>Fecal sludge is dumped into the environment, <i>and on the SFD considered as "not delivered to treatment," <i>and therefore unsafely managed. <i>Another common scenario is that treatment may exist, <i>but is located far outside of the city. <i>In overcrowded cities where traffic jams are the reality, <i>fecal sludge gets dumped into the environment, <i>which again is referred to as "unsafely managed" on the SFDs. <i>But even where treatment exists and is reachable, <i>high fees for discharge may discourage service providers <i>to actually deliver sludge to treatment. <i>The last situation shows trucks that deliver fecal sludge <i>to a wastewater treatment plant. <i>This typically results in failure of treatment processes. <i>The SFD illustrates this as "fecal sludge or wastewater not treated," <i>and therefore unsafely managed. <i>Let's zoom out of our city again. <i>You have now learned about the SFD terminology, <i>and what unsafely and safely managed excreta means. I hope you enjoyed this animation. So now, before we finish this module, I would like to show you one more example of a real SFD. <i>Here you can see the SFD for Dar es Salaam in Tanzania. <i>On the left-hand side, you can see <i>that 9% of the population uses off-site sanitation. <i>90% of the population use on-site sanitation, <i>and 1% practices open defecation. <i>In total, we found that 43% of excreta are safely managed, <i>and 57% are unsafely managed. <i>Of the 57% that is unsafely managed, <i>the majority results from fecal sludge that is not contained and not emptied. <i>This is the scenario we have shown you in the animation, <i>where the water table is high <i>and excreta infiltrates into the groundwater. <i>Additionally, more than half of the emptied fecal sludge <i>is actually not delivered to treatment, <i>and directly dumped into the environment. <i>This contributes another 18% to unsafely managed excreta. <i>Of the 43% safely managed excreta, <i>a major contribution is fecal sludge contained and not emptied. <i>SFDs represent the current situation. <i>At the time this one was made, <i>many pit latrines were built quite recently, <i>and simply not yet full. <i>Once these pit latrines need to get emptied, <i>treatment infrastructure needs to be available <i>so that emptying service providers <i>have an appropriate location for discharge. <i>If not, the percentage of unsafely managed excreta <i>would increase significantly. The SFD promotion initiative has developed a methodology, tools, and templates for worldwide production of SFDs, using the terminology presented here. To learn more about SFDs, please visit the project website, where all those materials can be downloaded. Is there an SFD for your city? If not, maybe you can start producing one, and use it to raise awareness about the gaps in sanitation service delivery. Thanks for listening to me today. We really hope you enjoyed this module.