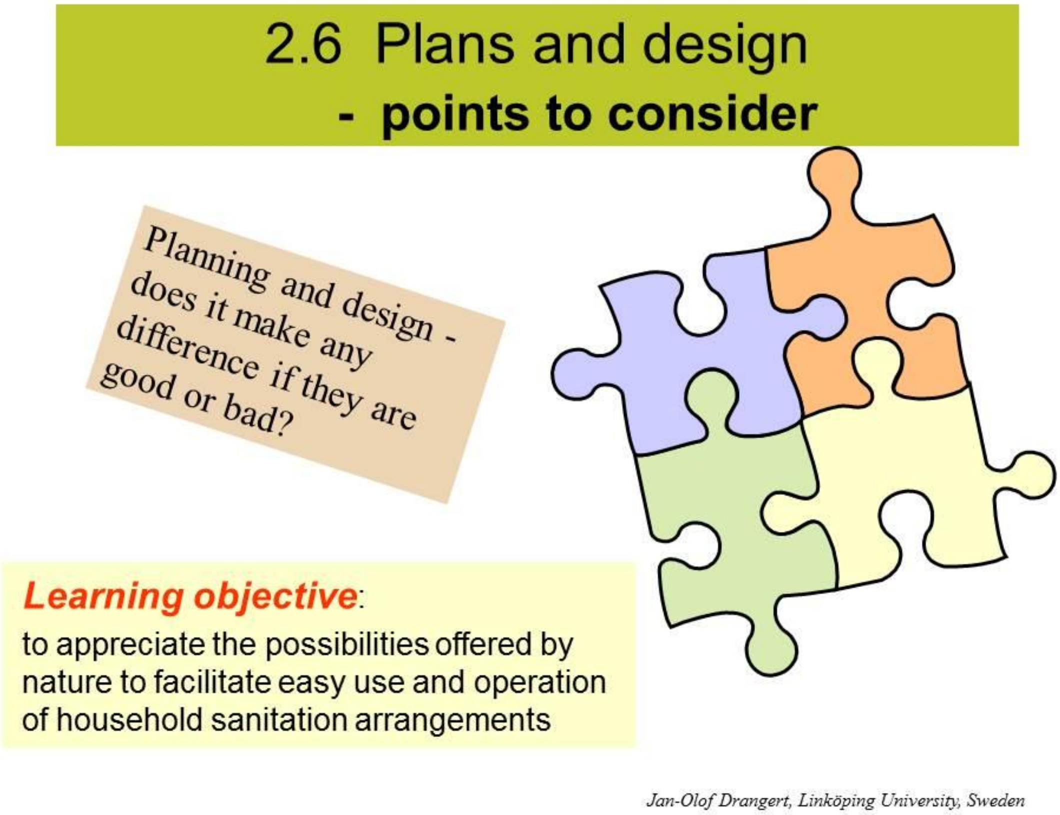


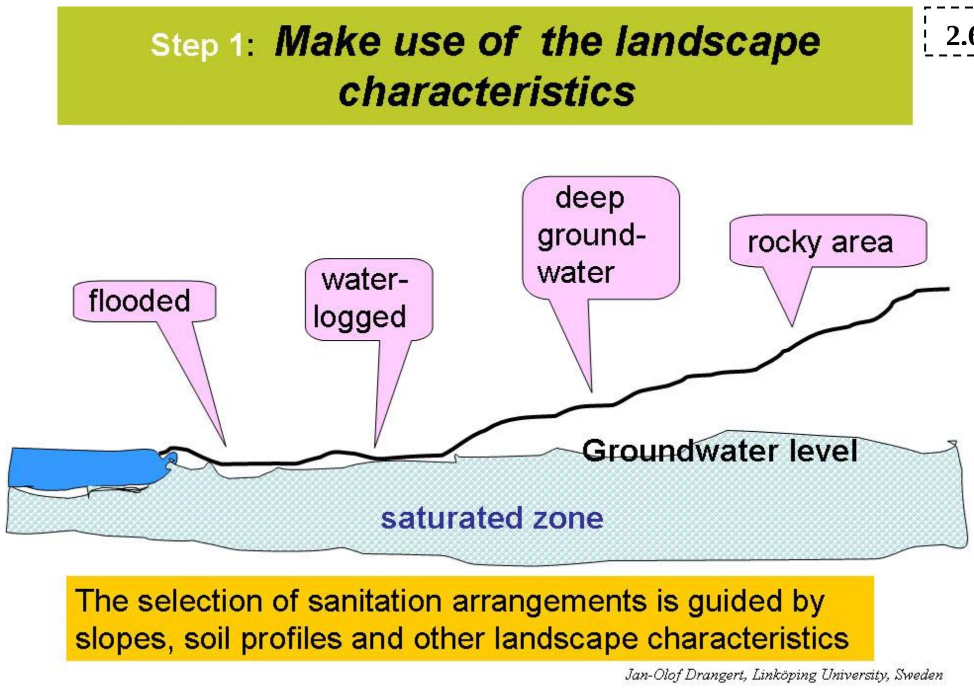
This module provides guidance for development practitioners on how best to utilise natural physical conditions for the benefit of users and to secure easy use and operation of the sanitation arrangements. The next module focuses on design and technical installations to facilitate use and to enhance health and sustainability management.

The introduction of a new technology or installation often requires modifications in the practices of those who use them. Designers run the risk of forgetting about the normal wisdom required to make the unit user-friendly. A common problem is that if a urine-diverting toilet is built with a vault above ground, the toilet itself may have to be elevated and the designer often forgets that having to climb steps to reach the cubicle will make use more cumbersome for many user groups – for as long as the toilet exists. Another example is that latrine pits are usually placed far away from the house because of foul odours, and therefore projects often also place odourless toilets at an awkward distance from the home. A third example is greywater pipes leaving the house at a level that does not allow gravity flow of the water to the garden.

In this module we put forward design criteria that should apply to any sanitation installation, be it a toilet or a greywater treatment system. The criteria deal with easy access and require no extra effort to use or operate the unit. We may also allow the technical historian Thomas Hughes to remind us about the difficulties of introducing new technical systems. Hughes writes (1983)

"*In sum, it is difficult to change the direction of large electric power systems – and perhaps of large sociotechnical systems in general – but such systems are not autonomous. Those who seek to control and direct them must acknowledge the fact that systems are evolving cultural artifacts rather than isolated technologies. As cultural artifacts, they reflect the past as well as the present. Attempting to reform technology without systematically taking into account the shaping context and the intricacies of internal dynamics may well be futile. If only the technical components of a system are changed, they may snap back to their earlier shape like charged particles in a strong electromagnetic field. The field also must be attended to; values may need to be changed, institutions reformed, or legislation recast*." (p. 465)

2.6 - 2



Physical environments vary considerably and there is no single sanitation arrangement suited to all situations. Sanitation arrangements include the handling and reuse of treated solid waste, urine and faeces, and wastewater. Sustainable sanitation arrangements have to be designed to suit the water sources and physical conditions of the landscapes in which they are constructed.

In areas with seasonal or occasional ***flooding*** most sanitation arrangements will break down temporarily. Dug latrines and twin pits overflow and so do sewers and this may cause diarrhoea and in the worst cases – an epidemic. The immediate solution may be to have the toilet on high ground such as a railway bank or on the roof top. Any general long-term solution must, above all, prevent faeces from spreading into the environment.

In ***waterlogged*** areas the groundwater level is very shallow and it becomes difficult to dispose of any kind of wastewater or to dig a pit. There is a high risk of contaminating the groundwater, which is particularly problematic where it is being used for the household water supply. Also, the groundwater may intrude into the sewer pipe and add to the volume of wastewater, thereby making the treatment less efficient and more expensive. Drainage and latrine pits may also fill up prematurely and spread excreta on the ground. Therefore, the solution is – again – to keep excreta away from water. It is not nature that causes the human suffering but poor design of the toilets that allow overflow to take place.

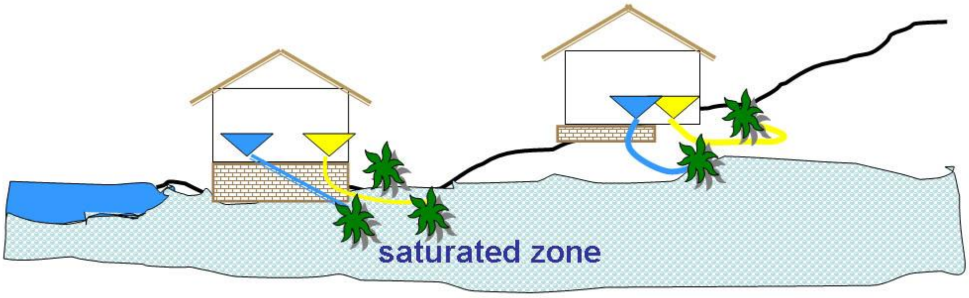
In places with ***deep groundwater*** levels and/or less permeable soil, the risk of contaminating the groundwater is small. Most infiltration arrangements can safely be installed in such areas. However, in clayey soils infiltration of wastewater, ablution water, and urine is very slow and may create puddles. Here, one may need to rely more on evaporation to dispose of liquids.

Rocky ground makes any kind of digging tedious and expensive. The difficulty of laying pipes on rocky ground means that individual solutions are needed for each house rather than lying pipes in long trenches. The kind of rock determines if it can hold water or not. Fissures may cause rapid infiltration of wastewater to the groundwater. Leaking pipes and pits can also become serious sources of groundwater contamination. This calls for above-ground sanitation arrangements, in particular where groundwater is used by households.

In conclusion, the physical conditions that nature provides have to be considered and we should not ignore them and think that they can be overcome by our technological skills. If we do not pollute the ground and surface water we can avoid long-term costs for water treatment.

Step 2: *Take advantage of sloping ground and raised house foundations (fluids)*

2.6 - 3



Make use of gravity to discharge fluids

Jan-Olof Drangert, Linköping University, Sweden

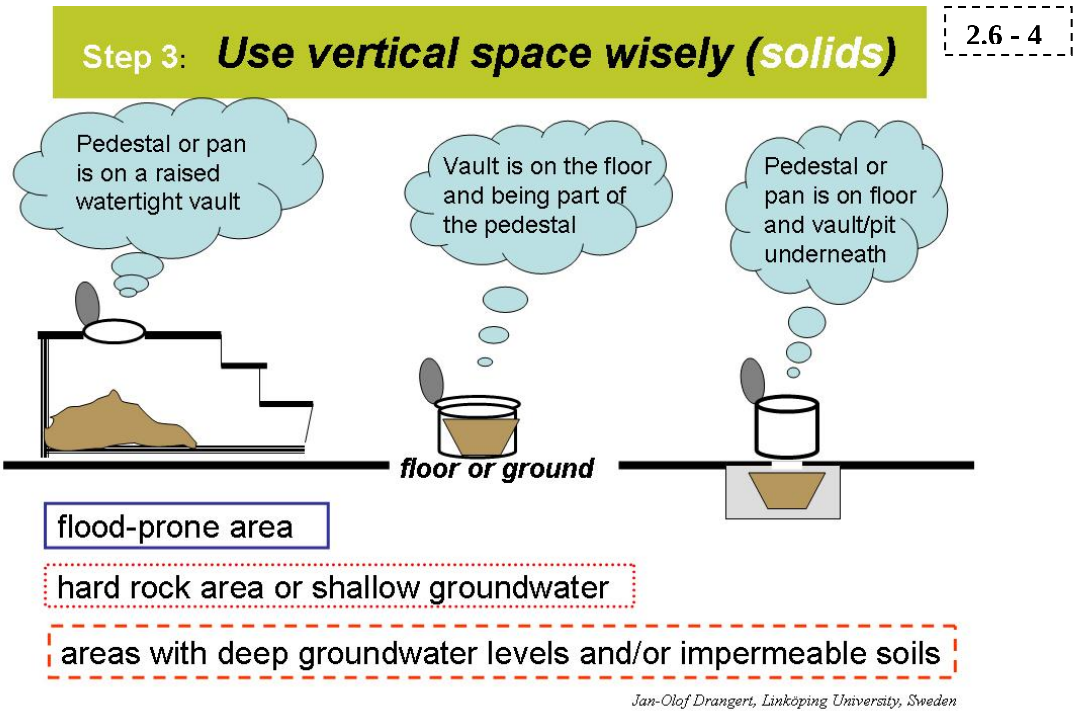
The three fluids; urine, greywater and ablution water should leave the house by gravity to minimise energy usage and health risks. The house foundations may be raised to prevent inundation, but also to make it possible to use gravity to move fluids (see picture). If this is done, large volumes of wastewater can be discharged through a pipe with much less work than it would take to carry the valuable contents in buckets. Therefore, the kitchen, bathroom and toilet should be positioned so that all fluids can flow out of the house to the highest point of the surrounding area to where it is needed.

Also, if the greywater is treated in a septic tank or reed bed it is beneficial to let the inflow be at the highest point so that the outgoing effluent can move by gravity to any infiltration area.

If the ground is sloping (right house), the kitchen and shower should if possible still be placed in the corner of the house closest to the highest ground so that gravity can transport fluids to the garden. The toilet room, on the other hand, can be placed anywhere if an appropriate toilet design is selected (see next slide).

If the urine has to be stored before it is applied as a fertiliser, a urine tank may be located on the ground near the house or it may be dug into the ground and emptied with a simple hand pump (see Module 4.2).

The ablution water can safely be directed separately to a soil filter with plants, or be mixed with other wastewater and treated and percolated into the ground.



We now show how the toilet can be designed to fit the physical conditions presented in the first slide by making use of available vertical space. We deal primarily with urine-diverting toilets and partly with twin-pit toilets, because WCs and vacuum toilets are less dependent on gravity and dug latrines are in the yard. We disregard the toilet superstructure, which is for privacy, and focus on the substructure or inside part of the toilet unit.

In ***flood-prone areas*** the pedestal or squatting pan must be on top of a watertight vault for excreta or just faecal matter and paper (to the left). When the floodwater rises it cannot enter the vault and its contents are unaffected. In this case a urine-diverting toilet is ideal, since the entire structure is indoors and secured from flooding in the same way as the house itself. The urine tank, if there is one, is airtight and does not let flood water in. Even if some water enters, it does no harm. If the house is elevated (flood-proof) the vault can be on the ground and yet there is no need for steps to climb the toilet.

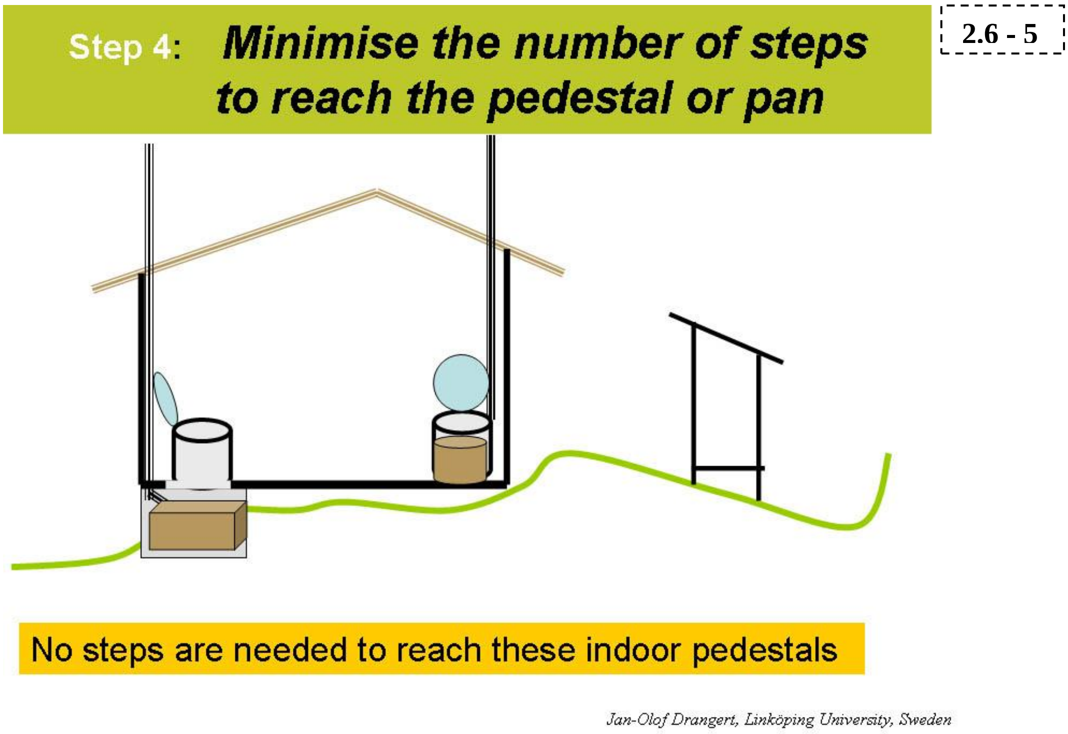
The pit latrine, twin-pit and WC are not suitable for flood-prone areas since they will overflow.

Where digging is prevented by ***rocky ground or shallow groundwater*** it is possible to use the same solution as for flood-prone areas. However, a urine-diverting toilet with a bin for faecal matter inside the pedestal is also a suitable option indoors (slide 2.1-11). There are no steps to climb. The dry faecal matter can be removed from outside the house (by the family or a contractor) and brought to a composting station where it is converted to a soil conditioner.

In this case the twin-pit system could be built on a mound to avoid the rock or to stay above the shallow groundwater. A pit latrine is not an option here, nor is the WC because of the difficulty to dig for the sewer.

In areas with ***deep groundwater and/or impermeable soil*** the two previous options do well, as do some additional ones. There is no danger of overflow or groundwater pollution, so the vault can be under the floor or in the ground if it is easy to reach by a door on the outside.

The simplest in-the-yard arrangement is a shallow pit, arbour loo, which is covered with soil when full and a tree planted on top to utilize the nutritious content. If enough water is available a pour-flush twin pit toilet can be installed from which liquid infiltrates to the soil. Ablution water should in all cases be treated in a sand-bed before being let out subsurface to plants or trees.



The toilet substructure should be selected so as to avoid having to use stairs to reach the pan or pedestal – whenever possible. The previous picture showed it is primarily in flood-prone areas that stairs have to be used, in cases where the house itself is not elevated. Another competing requirement is that the substructure should be easy to open and empty. The house owner has to strike a balance between these two requirements while ensuring that gravity can be used to transport the urine and wastewater. Remember that climbing stairs is done several times a day by every user, while the emptying is done once a week or less often. The picture shows that the pedestal toilet can be placed in any corner of the house with no need for stairs, and the vaults are still easy to empty. The urine container may be placed anywhere. The toilet to the left could also be a squatting pan with no steps. However, siting of a squatting pan to the right would require some 3–4 steps to be reached and is not in an optimal location. Urine and water for hand washing is easier to discharge over the plot by gravity in the right-hand option since it is on high ground.

The pour-flush twin-pit toilet is also most appropriately sited in the right-hand corner since this will enable the overflow from the pits to be distributed by gravity over a larger area.

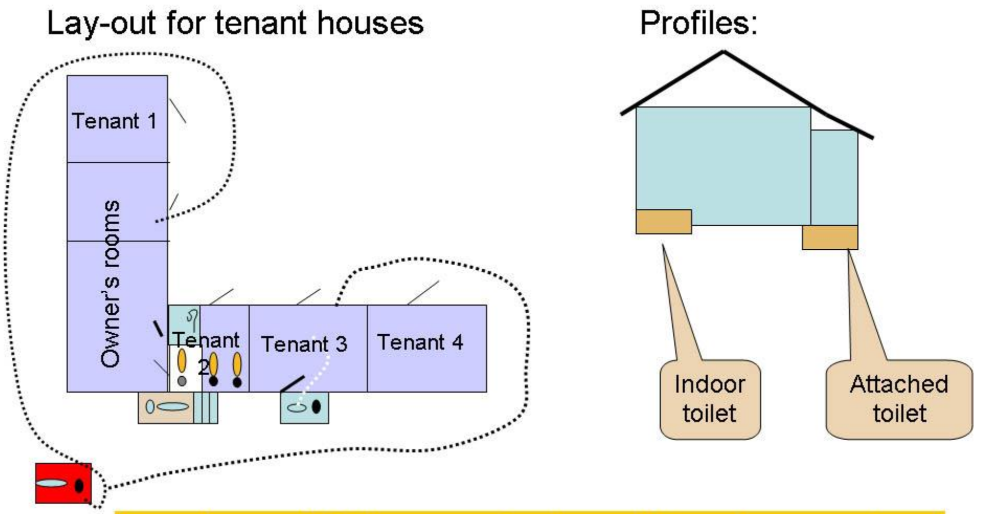
The choice between the two positions shown in the picture may be influenced by a desire on the part of the resident to hide the vault and its contents. But in both cases there are toilets with a flap beneath the seat which closes when you rise and thus hides the inside contents (slide 2.7- 7).

The bins may be emptied every week when they are still lightweight, and this also prevents flies from breeding (they need two weeks to hatch). More details about the options for bins are discussed in Module 5.5.

A neighbour’s latrine in the yard is also included in the picture, but is not recommended due to less comfort as highlighted in the next slide.

2.6 - 6

Step 5: *Minimise the distance to the toilet*



Locations of toilet rooms in a tenant housing complex

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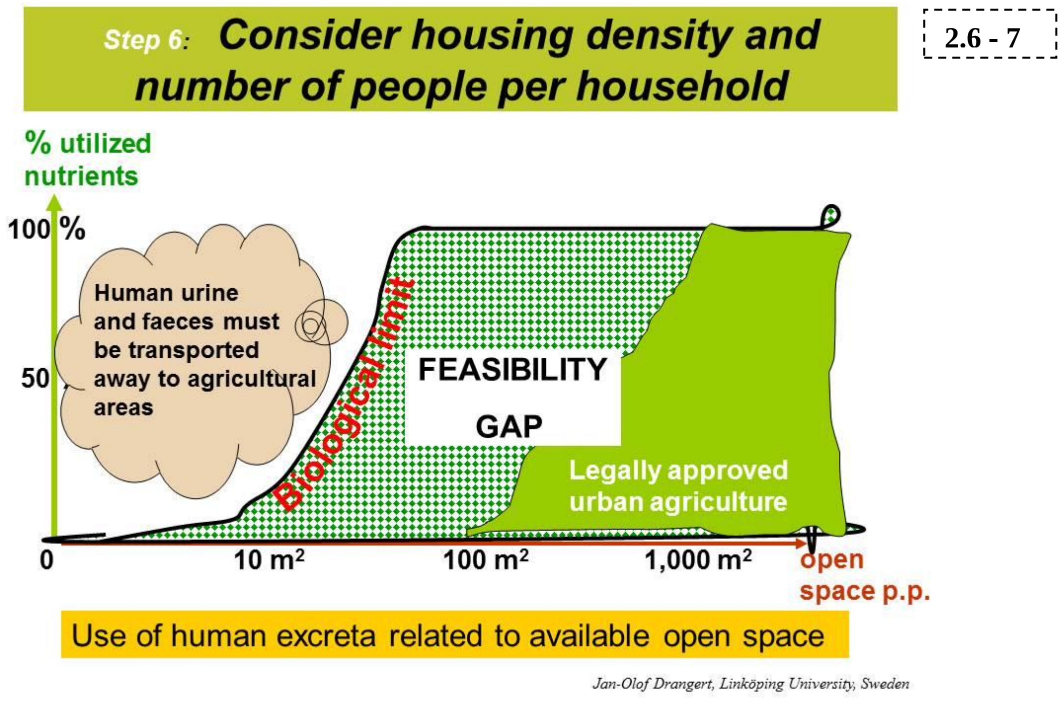
The most common site for a dug latrine is behind the house (red latrine in picture). The walking distance is long and unpleasant if it is raining or you are in a hurry. The position makes it very cumbersome to use for children with diarrhoea. Also, the hand washing facility is not likely to operate properly. The common argument for locating the toilet in an inconvenient place is that the toilet smells. So, if the toilet does not smell, it can be built indoors.

The toilet room can be placed in several positions – inside the house as in the case of a WC, or if indoor space is limited it can be attached to the house with the entrance inside the house (right). Sometimes one may find the toilet attached to the home, but without taking advantage of direct access from the house. This is likely if the builder’s perception is that any toilet smells. However, an odour-free urine-diverting toilet or a pour-flush twin pit is appropriate to locate indoors. A door is opened in the wall of the house to get direct access to the attached toilet room. This is more convenient and makes it easy to clean the toilet, help infants and the elderly, and make sure the hand-washing facility is functioning.

The ideal for the tenant housing shown in the picture is to have one toilet for each family with direct access. Available space and economy may allow the owner to sacrifice only one room and the rent from that room. On the other hand, the owner can probably charge higher rents for the remaining rooms, since the standard has been improved. The vacated room can be converted to two toilets, one for the tenants and a toilet and shower room for the owner’s household. If dry toilets are installed, there is no need for water for flushing but only for hand washing. A simple hand-washing facility can be added inside or outside the toilet room. Residents who are washers will also benefit from such a dry toilet, since they do not need to bring water along when visiting the toilet. All these improvements are fairly easy to make – including in existing houses. They are likely to improve kids’ health and everybody’s comfort and security (slide 2.4-13).



The possibilities for gainfully disposing of urine, hygienised faecal matter and greywater locally depend on the amount of open space available for cultivation. The picture shows what proportion of a person's excreta that can be used gainfully in a garden or elsewhere. Note that the axis with open space per person is logarithmic.

First of all, there is a biological limit for reuse. If there is just a square meter or so of land available, only a negligible portion of the nutrients can be used in plant production on that spot. The area can be extended by making a "growing wall" with pots on the wall, or pots with plants on the roof, or a "growing tower" (see Module 4.8). Most urine and faecal matter from such a congested area need to be transferred off-site to a farm where the nutrients can be recycled.

However, if there is, say 100 m^2 or more per person, most nutrients can be gainfully used and fertilise several crop yields per year (right graph). In such low-density areas where conditions are similar to those found in rural areas, the city council should allow "urban" agriculture.

In areas with a population density between, say, 10–100 m^2 of open space per person, it is biologically possible to carry out agricultural activities, but many cities prohibit any food production within the city limits. This '**feasibility gap**' between what is allowed and what is biologically possible can provide food for people, not least vegetables, and also take care of the human-derived nutrients in a sustainable way.

The fact is that such production is already vital for many cities (UNDP, 1996). Surveys show that some 50% of the food in Dar es Salaam, Moscow, Jakarta and other cities is produced within the city borders. Such cultivation not only helps to achieve food security, but also helps reduce carbon emissions by minimising transport of food.

Urine alone would be useful to recycle in dense settlements, since it contains most of the nutrients in human excreta (see Module 4.2). Urine makes up 90% of the volume of excreta and the remaining small volume of faecal matter and paper is easy to transport away. A urine equation tells us that "an adult person eats 250 kg of cereals per year, which has been grown on less than 250 m^2 and fertilised to perhaps fifty per cent by the person's urine." (Drangert, 1998). If an intensive urban production gives two or three yields per year, the urine from one person can be productively used by plants on a much smaller area.

2.6 - 8

Reuse on-site is a household task, while transport and use of urine and faecal material off-site can be managed in a number of ways. It may be partly or entirely organised by an entrepreneur with links to farmers. The municipal council provides guidance, allocates land for a treatment unit, and monitors the activities. In rare cases it involves itself directly in such activities.

The pictures show examples of collection of faecal bins in Kimberley (left) and co-composting together with horse manure and straw (right). The system came about in a newly built area with dry urine-diverting toilets in all houses. A worker at the building site saw a business opportunity to collect the dry faecal matter from the households and compost them on a nearby site. He offered his services for a small weekly fee that almost all the 114 households found reasonable. His income for a day’s work per week earned him more than his previous salary for a full week’s work. Importantly, the housing association agreed to collect the fees when they collected the rent from each participating household. The entrepreneur was relieved of the burden of having to ask customers for money every time, and instead he could collect the fee once a month at the office. At the same time the association ensures that the entrepreneur collects the bin contents and returns the bins properly washed.

The composted material is taken back by the residents to fertilise their gardens. This puts no burden on the council or the wastewater treatment plant. This was also the objective of the whole housing project; the council did not want to receive any wastewater from these households since the existing treatment plant was overloaded (Drangert , Duncker, et al., 2006).

Step 8: Consider the changing local culture

2.6 - 9

Residents: Enough space is necessary for reuse in situ, but is not sufficient. Reuse also presupposes an interest to do so. Many societies do not practise urban agriculture, but when given the opportunity residents to a large extent accept the idea of gardening. A strong reason is that sanitised urine and treated dry faecal material are used, not fresh excreta.

Professionals: Well-maintained urine-diverting toilets are odour-less and can be installed indoors. However, professionals often believe that toilets in poor housing areas have to be in the yard. Repeatedly it has been shown that residents prefer an indoor toilet, once they are aware of the odour-less option.

Some benefits of indoor toilets are that they offer better privacy and security, are easy to clean and maintain, and they are convenient for the sick and disabled. From a health point of view the indoor toilet increases the likelihood of hand-washing after defecation.

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If the users are not interested or do not accept a sanitation arrangement, it will not be taken care of. However, cultural views are rarely cut in stone, but tend to adjust to new realities. When farmers move to town, a number of rural imperatives are modified or done away with. Men and women start using the same toilet – even young men and their mothers in law. Strong norms such as the number of children per family lose their power and numbers are reduced, sometimes drastically. Therefore, projects which try to introduce new technologies or behaviours should be culturally sensitive without assuming that all prevailing traditions and attitudes are rigid.

Increases in the prices of food and fertilisers may gradually change people’s understanding and attitudes about alternative fertilisers as well as about urban agriculture. During the “World” Wars in Europe most urban areas were heavily cultivated. Food security was a strong incentive.

Knowingly or not, professionals tend to promote sanitation systems that they view as beneficial to their careers and status. This human instinct can lead to vast improvements in sanitary arrangements. However, the instinct can also prevent improvements, in particular in situations where there is no public intervention to change values, reform institutions or recast legislation as Thomas Hughes alluded to in 1983 (slide 2.6-1). The case of urine-diverting toilets shows that professionals tend to talk and think about fresh faecal matter rather than composted or dry faecal matter. Therefore, they tend to promote odourless urine-diverting toilets to be sited in the yard away from the home. They may also entertain the view that poor residents should not have an indoor toilet similar to the indoor WC. If such toilets work well, the power of the argument for installing WC, water supply and a sewerage would weaken.

There is certainly room for all kinds of effective technologies in a world where more than two billion people lack proper sanitation. There is no risk of professionals becoming unemployed. But if professionals continue to promote WCs indoors and latrine pits in the yard, billions of people will end up with an inferior arrangement which leaves residents with poor health and discomfort.

When professional pride takes precedence, we are likely to be offered hope for future improvement rather than immediate remedies. Mankind has progressed beyond just hiding excreta in a pit (which is a good thing) and now we can improve hygiene and health by providing hand-washing facilities to most residents. This cannot take place with a toilet in the yard. Professionals should be ethically bound to promote indoor toilets for this reason.

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