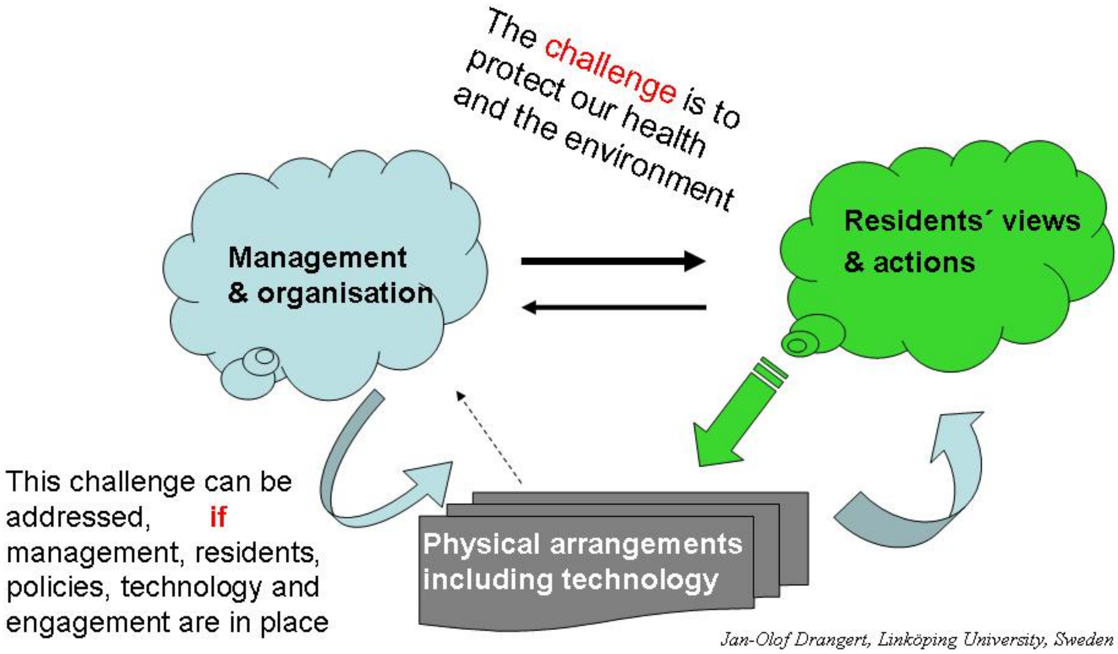
Ch 1. Sustainable sanitation - a review



Sanitation is about ensuring safe conditions for human beings and their communities. The aim is to protect our health and the environment. People themselves play a crucial role in improving sanitation conditions, while health professionals and environmentalists can give guidance about what to do. However, are health professionals yet up to the task? Dr. Jamie Bartram at WHO wrote recently:

> "In developing countries, some 2.6 billion people invest a significant proportion of their household time or money in simply securing drinking-water or somewhere private to defecate. In the European Union, planners are preoccupied with the cost of serving the public´s preference for bathing in sewage-free seas – as enshrined in the Bathing Water Directive, its most popular legislation.
>
> Intervention studies report reductions in diarrhoeal disease incidence averaging 25-37 %, and – using the criteria of the Commission on Macroeconomics and Health – these interventions are cost effective or very cost effective in developing countries. Even the findings value only health outcomes – analysing all impacts indicates a benefit that can be valued at 3 to 34 dollars per dollar invested.
>
> … Yet water is fundamental to both unfinished business; diarrhoea, re-emerging cholera, malaria control, Guinea worm eradication and drowning prevention - and to the new health agenda. This agenda includes non-communicable conditions such as fluorosis, arsenicosis, hydration-related effects and exposure to modern pollutants. …
> A public health perspective in water management provides opportunities to both improved population health and reduced costs.
>
> … The slow progress in extending basic services leaves a billion people waiting in line for services to reach them. But empowering households to take charge of water quality can dramatically reduce diarrhoeal disease. Since the establishment of the WHO network for safe household water in 2003 there has been a tangible shift from seeing this empowerment as a dangerous competing approach to a complementary response.

Is the health system adequately prepared to exploit these opportunities? Often not. The need for surveillance of water-related disease is recognized … but surveillance systems are often ineffective. … Similarly, health impact assessment - which considers health impact in local decision-making - is rarely required. Tools to address costs and impacts of policy and technical alternatives are only now in development.

Water is critically important for health. Yet it is typically low on the health agenda and the health system is often ill-equipped to engage effectively. It is time to re-engage. " (Bartram, 2008)

Sanitation is implicit in the above account. But, sanitation is too important to be appended only to water, and it deserves attention in its own right. Careful reading of the Millennium Development Goals shows that improved sanitation is promoted, but mostly indirectly as a by-product of other measures. In this chapter we give an overview of sanitary conditions in the world and the role sanitation can play for human wellbeing and for the environment.

In Chapter 3 we provide a full account of hygiene issues with a focus on microorganisms and risk management.

In the quote from Bartram above, he only hints at the emerging chemical society when writing "… exposure to modern pollutants." These pollutants are discussed in this chapter but more fully in Module 4.5 – 4.7 in connection with treatment of wastewater containing medicinal residues, persistent organic compounds, heavy metals, antibiotics and other pollutants.

Chapter 1 provides updated information on sustainable sanitation as evidenced today:

Module 1.1 deals with 'Sanitary conditions in the world'

Module 1.2 deals with 'Resources-from waste to reuse and sustainability'

Module 1.3 deals with 'Physical resource flows'

Module 1.4 deals with 'Demographic change'

1.1 Sanitary Conditions in the world

How do we perceive sanitary conditions?
What functions must a sustainable system fulfil?

***Learning objective*:**

To become familiar with various sanitary conditions in the world, functions of sanitation, and to foster a critical understanding of statistics and other data.

Jan-Olof Drangert, Linköping University, Sweden

Sanitary conditions vary over time and between places. For a long period of time, sanitation was about protecting humans from disease and death. This was a time when a hundred or two hundred infants out of a thousand live born died before the age of one. In the last half century infant mortality figures have dropped dramatically and are now mostly in the range of a handful to 60 deaths out of 1000 live born (UNICEF, 2008). Many different improvements have contributed to this positive development, not least improved sanitation behaviours.

Sustainable sanitation has gained importance in the last half-century, inspired by the fall in infant mortality and morbidity. Another reason is that population growth and growth of consumption per capita put pressure on natural resources to produce the products as well as on a degrading environment by poor disposal of the used goods. A study of human footprints on nature showed that the 29 largest cities of the European part of the Baltic Sea watershed appropriate - for their resource consumption and waste assimilation - an area of forest, agricultural, marine, and wetland ecosystems that is at least 565 – 1130 times larger than the area of the cities themselves (Folke et al., 1997). The largest area was required for waste assimilation. Can the situation be improved with recycling and reuse of used resources?

When silk and porcelain was transported on the Silk Road from China to Rome in return for glass two thousand years ago, the environmental impact was negligible. The amounts were small and the means of transport required only human and animal energy which would have been used anyway. When China today is the manufacturing powerhouse of the world and providing lots of goods to billions of people the impact is sizeable. Emissions from transports alone contribute substantially to global warming. This is one reason why today information appears about the environmental impact of several products. This is an important information tool to make individuals conscious of their own impact on the global environment.

Sanitation must not be reduced to an issue of toilets. In this introductory chapter on sustainable sanitation we present the width of sanitation issues, comprising clean environment incl. water and wastewater treatment, solid waste management, grey water and excreta/sludge disposal, storm water handling, and personal and household hygiene. Some pictures will illustrate these points.

1.1 - 3

Data on sanitation conditions in the world are indicative rather than exact, since countries define adequate sanitation slightly differently and data is not updated regularly. WHO and UNICEF (2010) recommend some definitions, but each country can adopt their own standards. Their Joint Monitoring Programme estimates that 2.5 billion people lack adequate sanitation by 2015.

The global statistics tell that about 2 of every 10 people in the developing world were without access to safe water in year 2000; 5 of 10 lived without adequate sanitation; and 9 of 10 lived without their wastewater being treated in any way (IMF and World Bank, 2003). The combined effects of unsafe water and poor personal and environmental sanitation are considered to be the most important risk factor for diseases and death (Murray and Lopez, 1996). Yet, more human and financial resources are directed towards other sectors than to sanitation. This is why sanitation is viewed as “the silent crises”.

Municipal and city councils as well as international organisations focus on installation of piped water supplies and to a lesser extent on sewers and wastewater treatment plants. The reported data to the Millennium Development Goals (MDG) global statistics on water and sanitation take for granted that if piped systems are in place, the community has solved the silent sanitation crises. Yet, it is well known that technical systems can fail for shorter or longer periods of time. Therefore, we endorse function-based definitions in this material. For instance, a function-based definition of water quality is that it is safe to drink all the time, instead of taking for granted that a piped water supply always provides safe drinking water. Safe water may contain microorganisms, even pathogens, but not in quantities that cause illness with a certain probability.

Malnutrition lowers the body´s self-defence towards all kind of diseases. Since sanitation deals with organic material, good fertilisers can be produced to increase food production. Thus, sustainable sanitation can reduce malnutrition. A proper sanitation policy can play a strategic role to improve health as indicated by Bartram (slide 1.1-1).

In the following slides some data are given about technical infrastructure and backlogs that the MDG tries to address.

Proportion of households in major cities connected to piped water and sewers

1.1 - 4

	House or yard connection for water (%)	Connected to a sewer (%)
Africa	43	18
Asia	77	45
Latin America & Caribbean	77	35
Oceania	73	15
Europe	96	82
North America	100	96

Source: *Stockholm Water Front*, No. 4 December 2007

The coverage of piped water in major cities in 2007 was fairly high, while coverage of sewerage was much lower, except for North America and Europe. In smaller towns the difference is likely to be even greater. The data reflects the emphasis on water supply over the previous decades, and the modest interest in sewerage. This is particularly evident from data on wastewater treatment plants as shown in the next slide.

There is a general view among experts that proper sanitation poses special challenges to achieve in urban areas, as described by Barbara Evans, Leeds University:

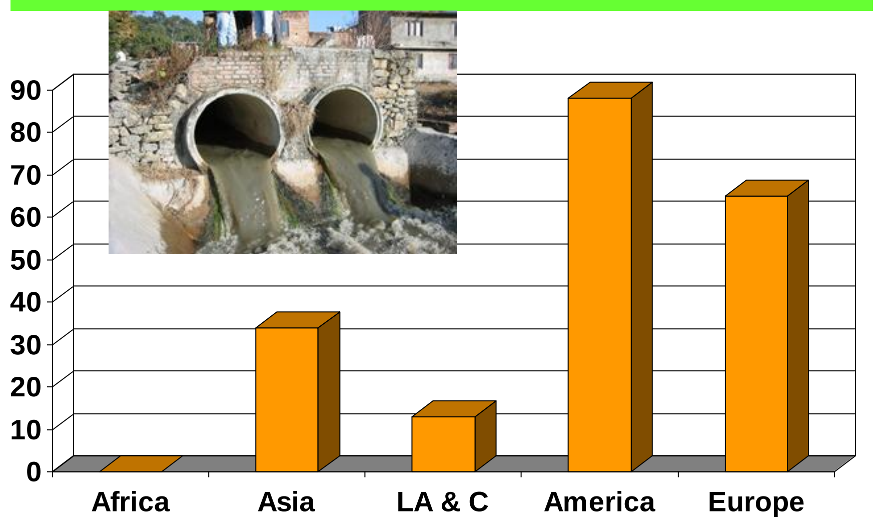
> Providing urban sanitation services, as compared to rural sanitation or other urban services poses special challenges. One central challenge is that services to the household have to be embedded within a workable, sustainable and effective urban system, which in many areas does not exist. A city's infrastructure or lack thereof, impacts its ability to install functional sanitation systems, especially in slums. This connection goes both ways, as wastes generated in the slums – such as excreta, greywater, stormwater runoff. – negatively impact the city as a whole. Regrettably, cities generally have a poor track record of positive engagement with underserved and marginalised communities. Self-help in communities that lack adequate sanitation only works over long periods of time if integrated with the holistic planning and functions of the city. (Stockholm Water Front, No 4. December 2007)

This is true when thinking along conventional municipal-wide solutions, since the rapidly growing towns are next to unmanageable (See Module 1.4). The prospect of improved sanitary conditions, in particularly in informal areas, is brighter if the authorities accept a wider range of solutions that communities and households can organise and implement. In Module 2.1 five inspiring local examples are presented.

Countries and cities with a low percentage figure for sewers have an advantage from the point of view that they can select an appropriate treatment method without inflicting sunk cost for previous investments. Examples are to take care of wastewater on individual plots or to lay low-cost condominium sewers as in Brazil (Melo, 2005). 18% coverage for sewers in Africa means that 82% can install sustainable on-site solutions at a much lower investment and running costs than centralised piped systems.

Wastewater - collected and treated by effective treatment plants (median percentage)

1.1 - 5



Source: UNDP & UNICEF 2003 (Fig. 3.13)

Equally important as provision of infrastructure, is the issue of where the sewer pipes end up. The diagram shows that only a small fraction of the urban wastewater is being effectively treated, again with the exception of North America and to some extent Europe. However, more detailed information would be necessary in order to let the statistics guide strategies. In the end, it is only possible to draw up a strategic plan for a known community. For instance, greywater (no toilet water) from a single household that uses few chemicals needs very little treatment and can safely be poured on the ground. Source-control can thus give a better result than sophisticated treatment of wastewater loaded with chemicals from households and industries. A common experience of effective treatment plants with too small capacity to treat all water, in particular during heavy rainfall, shows that they may discharge substantial volumes of organic matter and other substances directly to the receiving water (slide 1.3-17). For instance, the sewers in London overflow into the Thames about 60 times per year, and pollute the river. Half of London's water mains are thought to be more than 100 years old and a third could be over 150 years old – and leaking to the groundwater (Deloitte, 2011). These issues are addressed in the Modules 4.5 – 4.7 dealing with greywater.

As in the case of sewers, countries with a low coverage of plants to treat wastewater can have an advantage in that they can select an effective and efficient system without inflicting sunk costs of previous investments. They still have the option of treating at the source or at the end of pipe. They may also plan for treating not only today's wastewater but also the anticipated future constituents of wastewater.

Treatment plants produce sludge and the more effective the treatment is, the more contaminated sludge is produced! If sludge did not contain contaminants from a mix of industrial and household chemicals, it could be turned into a good fertiliser. However, most sludge from treatment plants has to be treated before use or contained. In the following chapters we will discuss affordable methods to treat wastewater to a quality level which makes it possible to use sludge with little risk of accumulation of contaminants in the soil. A decent treatment before use would cost only 0.3-0.5 USD per cubic meter (IMF and World Bank, 2003).

1.1 - 6

Stormwater, solid and organic waste

Stormwater drainage as a conduit for solid waste

Animals scavenging organic material and clogged storm water drains

Jan-Olof Drangert, Linköping University, Sweden

Storm water drainage is an important part of sanitation, and how it functions can often serve as a litmus test for other components of a city´s sanitation system. Poor solid waste collection compels residents to use drains to get rid of waste, which may result in clogged drains and inundation of low-lying settlements (pictures above). Also cities with functioning waste collection and sewerage frequently face problems caused by occasional large downpour of rain. This is particularly common where there are combined sewers. Large enough combined sewers are too costly, however. It is next to impossible to divert all rainwater and a partial solution is to collect and use or recharge rainwater on site. New housing complexes in Berlin are required to make on-site arrangements to infiltrate the rainwater. However, it is more common that cities remove existing pond and tank systems to build roads and buildings and thereby block natural routes for stormwater. The result is recurrent flooding of parts of the city.

Another common cause of flooding, which is beyond the city’s jurisdiction, is found upstream where water-containing forests have been cleared and the river straightened out and even walled (Mississippi, the Rhine, Ganges and other rivers). Storm water can flush whole cities and where there are sewers, these are washed out and the content may spread disease. Even wastewater treatment plants can be flushed out, and wastewater and sludge end up in rivers and lakes. Such disasters are often called natural, but they are actually made possible by human activity. Another way of obscuring the cause-effect is to say that such events only occur with long intervals, and the longer this period is it seems that the likelihood of remediation goes down.

The amount of solid waste is steadily increasing with improved living standard. The only solution to growing mountains of disposed solid waste is to sorting in fractions what can be recycled, reused or incinerated while hazardous waste is stored. The solid waste aspect is only dealt with in connection with organic matter in this sourcebook. Suffice it to mention that there is an established waste handling hierarchy (EU Waste Directive) that is not very different from what applies to wastewater as we interpret it in slide 1.3 - 8:
1. Reduce waste volume and harmful content in products,
2. Recycle items that are possible to use again,
3. Treat and use the material to make new products,
4. Incinerate what is left in order to generate energy, and
5. Hazardous products are stored or put safely on a landfill.

1.1 - 7

Pathogens thrive in specific environments and, for example, bacteria thrive where there is substrate to feed on. Improved sanitation is about creating barriers and harsh conditions for the pathogens. For instance, the pictures above show a narrow alley that was paved with cement. The man hole indicates that a sewer line is collecting the wastewater from the adjacent houses. The alley became easy to sweep and mosquitoes have no wet debris where to breed. Stormwater runs off easily to irrigate fields which also become infiltration sites. Greywater is no longer disposed in the alley.

The exercise is to discuss the reductions of pathogen exposure to human beings. For example, if used water is just disposed outside the housing area, mosquitoes will still breed and enter nearby houses. Kids are likely to play there and they may attract helminths and disease-causing vectors. Half-measures may therefore not improve people´s health as expected.

The second part of the exercise is to suggest further improvements of the sanitation conditions in this alley and beyond. Just like members of the community need to think through the entire flow system and pay attention to how the flow ends. One way is to think in terms of a waste handling hierarchy (see previous slide) for getting rid of disease-causing matter in a safe manner.

There are a lot of technical solutions available. A challenge lies with organising the process to upgrade the urban environment (Module 2.3) and to select a sustainable arrangement (Module 2.5).

The kids in the pictures are exposed to very different levels of health risks. One important aspect of sanitation is about keeping humans and pathogens apart as far as possible.

There are numerous options for defecation arrangements. The choice may be guided by local tradition, religion, economic conditions, taste, modernity or self-image or a combination. A commonplace communal pour-flush toilet (top-left) often functions poorly and the content may be emptied in a nearby drain. This is not very different from open defecation and resembles ”delayed open defecation”. Better is, for instance, to bury the excreta in the soil or in a shallow pit such as an arbor loo (see Module 5.4). The challenges facing public toilets are discussed in detail in Module 5.2. Common sense tells that the chance to keep the toilet clean and functional increases if it is a private one in the home. In addition, toilets that keep urine and faecal matter separate (top-right) are hygienic – and productive if urine and treated faecal matter is used to fertilise a garden.

Chapter 3 presents a wide range of measures that reduce health-risks, not the least for the most vulnerable groups in society. One important function of any defecation arrangement is to keep excreta away from the water cycle, and divert products to soil as rapidly as possible. As can be seen from the two lower pictures, nutrients from faeces do NOT belong to water but to soil, food production, and to make our environment green.

The cost issue is important for any aspiring household. In many cities there is no choice but the existing flush toilet, and the household cannot influence what happens to the black water after flushing. On plots with no existing building, on the other hand, any arrangement can be considered. The selection process should build on what functions are to be fulfilled (see table below). A selection procedure is presented in slide 2.5-11.

One way to receive relevant information about costs could be to check on a typical existing arrangement (slide 2.1- 3). The case of a private house in Kathmandu, Nepal, shows that the extra investment for in situ water and toilet arrangements was repaid in six years by not being obliged to pay water bills. In two centuries the value of the whole house would be earned from paying no bills. In addition, the household is ensured 24 hour water supply and does not contribute to the city’s stormwater or wastewater problems.

Table: Sanitation Cost Ladder for Conventional and ecological Sanitation Methods

Conventional Sanitation (sourced from UN Millennium Project, 2005; original source UNEP 2004:9			**Sustainable Sanitation** (various sources)	
	Method	Estimated cost per person (USD) incl. operation and maintenance		Method
Mainly urban	Tertiary wastewater treatment	800	340 (1190 per household (hh)) China Dong Sheng EdoSanRes Programme	Urine-diverting high standard porcelain dry toilet (indoors); piped urine system, dry faecal collection and composting, decentralised piped grey water treated using septic tank, and aeration treatment local collection and transportation costs included
	Sewer connection and secondary treatment	450	330 (1500 per hh) Sarawak (Mamit et al, 2005)	Conventional indoor toilet with sealed conservancy tank, black water collection by truck; local biogas digester; decentralised piped greywater treated using septic tank and vertical biofilm filter technique
	Connection to conventional sewer (without treatment)	300	150 (675 per hh)	Indoor dry single-vault urine-diverting pedestal toilet; decentralised piped greywater treatment using constructed wetland: local transportation included
Mainly peri-urban	Sewer connection with local labour (without treatment)	175	88 (400 per hh) South Africa 25 (110 per hh) Mexico, El Salvador, India, South Africa, Zimbabwe (Morgan 2005)	Dry single or double-vault urine-diverting squatting pan or pedestal toilet with permanent upper housing structure: greywater treatment and disposal on site: local recycling
	Septic tank latrine	160	12 (55 per hh) Nanning, China 8 (35 per hh) West Africa Klutse &Ahlgren 2005	Dry single or double-vault urine-diverting squatting pan or pedestal toilet with permanent upper housing structure: greywater treatment using on site infiltration pit; transportation assumes as local labour
Mainly rural	Pour-flush latrine	70		
	Ventilated improved pit latrine	65	8 (40 per hh) Zimbabwe, Mozambique. (Morgan 2005)	Soil composting pit with cement slag and simple upper housing structure (Aborloo or Fossa Alterna); greywater treatment and disposal onsite; local recycling
	Simple pit latrine	45		
	Improve traditional practice	10	3 (10 per hh) (estimated)	Soil composting shallow open pit; soil added after each use

Source: (SEI, 2005)

1.1 - 9

Diseases related to excreta and wastewater

Disease:	Mortality (death/year)	Burden of disease*	Comments
Diarrhoea	1 800 000	62 000 000	99.8% of deaths occur in dev. countries; 90% are children
Typhoid	600 000	no data	Estimate: 16 million cases/year
Ascariasis	3 000	1 800 000	Estimate: 1.45 billion infections, of which 350 million suffer adverse health effects
Hookworm disease	3 000	60 000	Estimate: 1.3 billion infections of which 150 million suffer adverse health effects
Schisto-somiasis	15 000	1 700 000	Found in 74 countries, 200 million estimated infected, 20 mi with severe consequences
Hepatitis A	no data	no data	Estimate: 1.4 million cases/yr. Source: WHO, 2006

* DALYs/year estimates the time lost due to disability or death from a disease compared with long life free of that disease (See Ch 3).

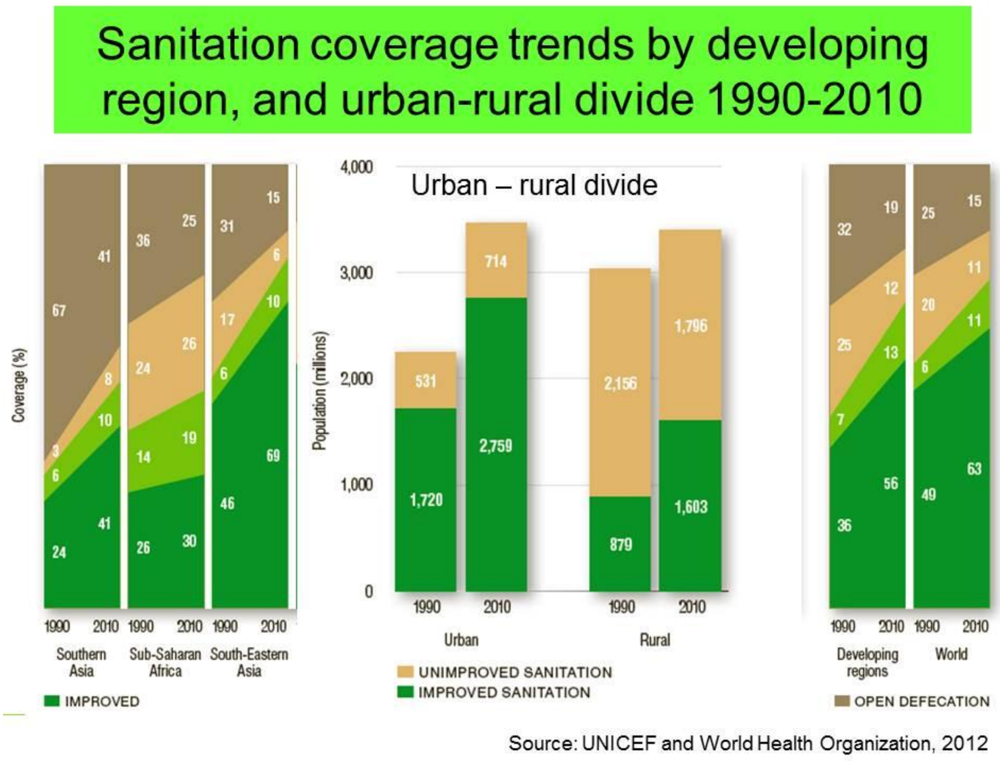
Excreta and wastewater contain high concentrations of pathogens, and excreta-related infections are common in many countries. The failure to properly treat and manage wastewater and excreta worldwide is directly responsible for adverse health and environmental effects. Human excreta have been implicated in the transmission of many infectious diseases, including cholera, typhoid, viral hepatitis, polio, schistosomiasis and a variety of helminth infections. Most of these excreta-related illnesses occur in children living in poor environments. Overall, WHO estimates that diarrhoea alone is responsible for 3.2 % of all deaths and 4.2 % of DALYs worldwide (Module 3.1). In addition, 16 million people contract typhoid and over *one* billion people suffer from intestinal helminth infections (Table).

Diarrhoea or gastrointestinal diseases are often used as a proxy for all excreta-related infections. The average person in the USA suffers from 0.79 episodes of acute gastroenteritis (diarrhoea, vomiting or both) per year. Worldwide, adults suffer the same magnitude of gastroenteritis. However, children especially those living in high-risk situations generally have a much higher rate and one study found the rate to be 3.2 episodes per child per year (WHO, 2006).

Generally a well-nourished child stands a much better chance to have a mild effect of an infection compared to a mal-nourished child. Several studies show that children who are living in poor sanitary conditions are infected with one infection after the other. They hardly recover from one before they attract the next, and in severe cases this may lead to stunning (Mata, 1978).

The table above compiled by WHO (2006) gives some rough data on the magnitude of some common diseases. The diseases affect billions of people and causes death for millions.

1.1 - 10



The diagram shows the improvements in sanitation arrangements in the world between 1990 and 2010. The proportion of people with so called improved arrangements have increased by one-third, while the number of people without improved toilets also has gone up. The definition of improved and unimproved sanitation used for the data is as follows (Unicef & WHO, 2012):

Improved sanitation:	**Unimproved sanitation:**
Flush or pour-flush to: - Piped sewer system - Septic tank - Pit latrine	Flush- or pour flush to elsewhere (htat is not to piped sewer system, septic tank or pit latrine)
Ventilated improved pit (VIP) latrine	Shared or public facility of any type
Pit latrine with slab	Pit latrine without slab, or open pit
Composting toilet	Bucket toilet
	Hanging toilet or hanging latrine
	No facilities, bush or fields (open defecation)

The above definition seems to take into account accessibility to some degree and health issues (in toilet rooms as well as in the environment). The improved arrangements are fairly safe (e.g. a slab is easy to keep clean) and the excreta is contained or treated to some extent before release to the environment. The potential contamination of groundwater through seepage from pits is viewed as acceptable. The unimproved arrangements include those that pose a threat to the environment, or where excreta are not contained, or those that are difficult to keep clean (e.g. being used by more than one household, toilets may not be hygienic and fully separate human waste from contact with users, and may not be available at night, or used by children).

The definition does not consider nutrient reuse aspects (Module 5.1), and only indirectly the aspect of easy access to hand-washing (slide 5.3-4).

The fact that rural population remains almost stagnant at about 3 billion people is reflected in the table as increased coverage of improved facilities, most clearly for water, but also for sanitation. Regions with low sanitation coverage today will need to make a substantial effort to reach the MDGoals, such as rural Southern Asia, Sub-Saharan Africa and East Asia.

The slide shows that 15 per cent of the world population still practise open defecation, defined as defecation in fields, forests, bushes, bodies of water or other open spaces. This represents 1.1 billion people of which 626 million live in India. Though the proportion of people practising open defecation is decreasing, the absolute number has remained at over one billion for several years, due to population growth.

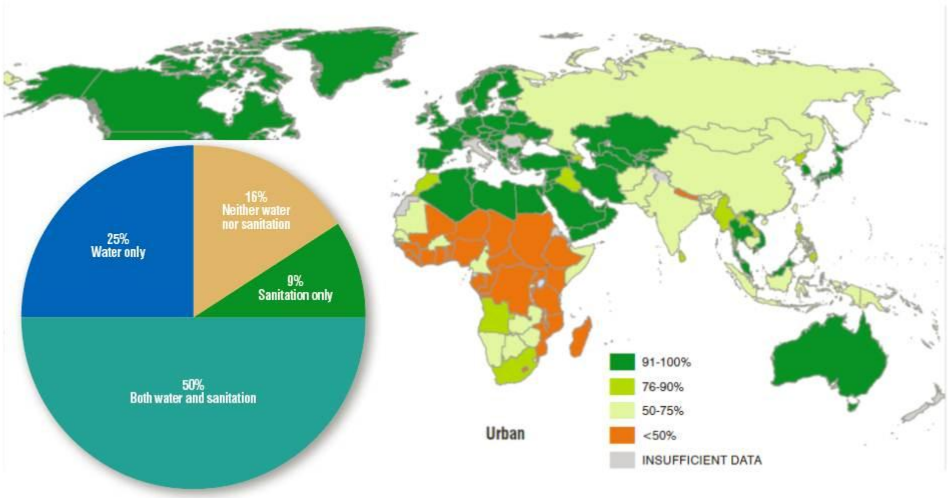
The figures on open defecation need to be commented on. Open defecation is a disputed issue about which local and professional views often differ. If 'open defecation' is instead defined as defecating in the open and leaving the excreta exposed like dogs do, but different from cat behaviour, a range of defecation practices do not qualify as open defecation (Drangert & Bahadar, 2011). Women going out in the dark to a designated place are not seen defecating, and they do cover the faecal matter. A man defecating behind his robe is not seen defecating, although any passer-by understands what is taking place. If he covers the faecal matter it is not counted as open defecation. The next level of being seen is when someone defecates behind a straw or mud wall; no one can see what is going on but anyone understands that the person goes to that place for urination or defecation. If there is only a cat hole in there, then this situation is little different from attending an ordinary toilet room. If there is a pour-flush toilet in there, the discharge goes to a pit or to a sewer or an open drain or to the street. The latter two cases represent a kind of delayed open defecation where the sewage is left in the open.

According to this definition, very little open defecation takes place among adults. However, children are seen defecating indiscriminately, and their faeces are likely to be collected only when found inside the compound. A widespread perception is that children's faeces are harmless. Therefore, they may not be considered to be in the wrong place if they are found in public places. Non-farming sections of communities have little experience-based reference to nutrient loops, so they may adopt more restrictive views on what is a right place and what is orderly. The fact is that child faeces contain equally or more pathogens than adult faeces which makes open defecation among children a serious health concern.

There is a marked difference in attitudes to the role of water: professionals say that adding excreta contaminates water, while farmers may claim that adding water to excreta will change the colour, smell and appearance of the excreta and thus make it less risky. This perception can be used to justify the use of wastewater for irrigation (and fertilisation) without upsetting social order. It is similar to the tradition of farmers encouraging defecation in their fields and to applying partly composted human excreta in agricultural fields. This practice is in line with the concept of waste being in the right place (reused) according to their tacit understanding of a nutrient loop. The same goes for the widely accepted practice of peeing near to fruit trees. Often, peeing on the ground is perceived as orderly since urine disappears almost immediately.

Improved urban sanitation coverage 2010

1.1 - 11



Proportion of the population in 59 developing countries using both improved drinking water sources and improved sanitation (per cent)

Source: UNICEF and World Health Organization, 2012

2.5 billion people were estimated to lack improved sanitation in 2010 (Unicef & WHO, 2012). Of these, 1.8 billion live in rural areas and 0.7 billion in urban areas (up 183 million since 1990). Already at this stage data has to be interpreted carefully since the definition of urban and rural differs between countries. Urban sprawl in the last decade has made 830 million people live in urban slums 2010, up from 770 million in 2000 (UN-Habitat 2008). This would mean that less than half of the slum dwellers had access to so called improved sanitation. Proportions of slum dwellers are declining, but numbers are growing. As we near 2015 the 'running target' of slum dwellers targeted for Millennium Development Goals (MDG) will increase considerably if the UN population estimate holds of more than 6 billion urban dwellers (up from 3 billion) by 2050.

Shared sanitation is defined as sanitation facilities of an otherwise acceptable type that are shared between two or more households, including public toilets. Globally, the number of people using shared sanitation is growing and the number of users has increased by 425 million since 1990 – an increase from 6 per cent to 11 per cent in 20 years. For instance, hundred thousand Sulabh community toilets have been built in India, but they are not counted as improved toilets in the JMP statistics. Shared sanitation is predominantly an urban phenomenon, and over 60 per cent of people using this type of facility live in urban areas. In many countries, particularly in crowded urban areas, shared sanitation is the only viable option for those wishing to avoid open defecation; in rural areas, families often keep costs down by sharing latrines between one or more households with family ties (Unicef & WHO, 2012).

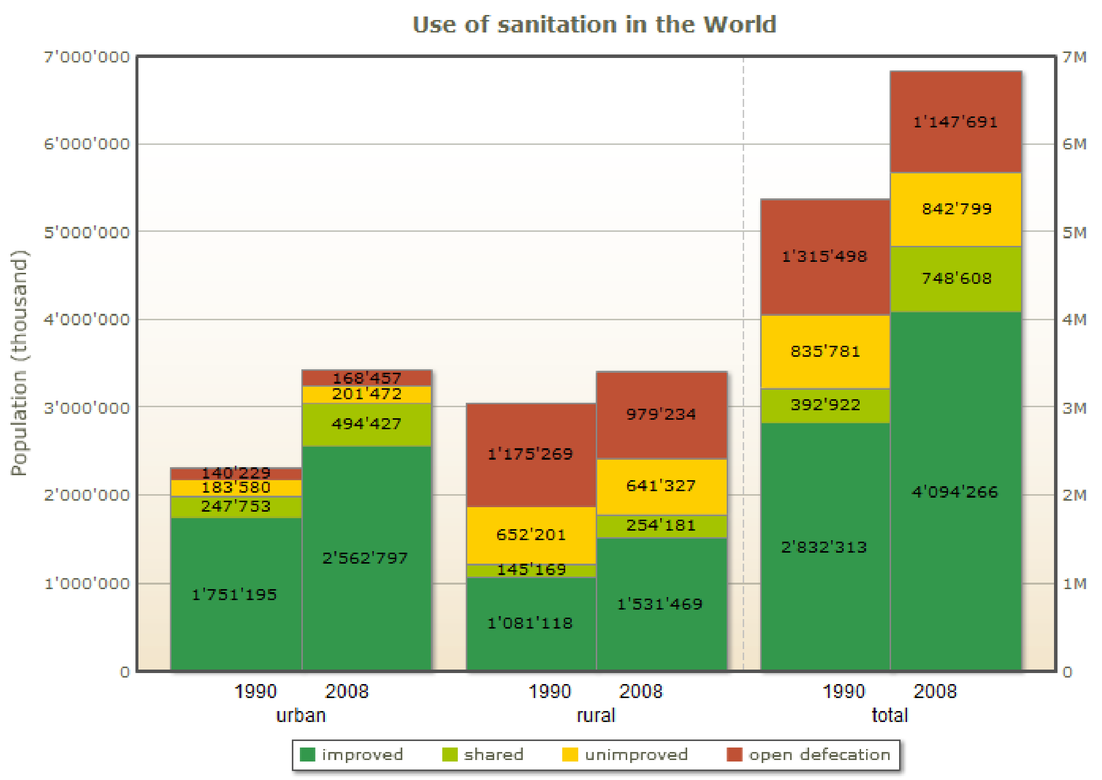
The capacity to attain the MDGs could be more favourable in urban areas than in rural areas, since the proportion of the population of working age is much higher. It may or may not be easier to construct infrastructure here than in rural areas, however, due to factors such as corruption, inefficiencies and simply lack of space for locally organised *own-key* arrangements (see Module 1.4). Several examples of decentralised urban arrangements are presented in Module 2.1.

The World Water Development Report (2006) stated that, while we are globally on track to meet the 2015 drinking-water target, we will miss the sanitation target by over half a billion people if current trends continue. WHO (2006) stated at the World Water Forum:

"*In sub-Saharan Africa, where coverage of both drinking water and sanitation is lowest in the world, there is a looming threat that both targets will be missed. And in South Asia, governments are challenged to provide access, to sanitation in particular, to the largest group of people in absolute numbers. The conclusions are clear: we need more and more effective action, so that efforts to achieve the targets can be intensified and trends effectively adjusted. At all levels, available resources need to be used more efficiently. This applies as much to the efficient use of human resources as to the use of water resources themselves*". Such strong statements are important, but words will not be enough.

The statement takes the stand that GOVERNMENTS are challenged to provide. This view is itself challenged by many stakeholders, for instance the comment made by Jamie Bartram about household inputs (slide 1.1). The reality is that water infrastructure in urban areas is paid by residents as connection fees and through water bills, while governments have taken the necessary loans for the investments. Governments are in charge of the framework for sector development, but not for providing all necessary financial and other resources. Unfortunately, utilities and financing institutions are almost exclusively planning new infrastructural developments as blue-prints of existing conventional centralised solutions. The time is ripe for rethinking how to make the urban water cycle sustainable by considering also decentralised systems (Module 2.1). This message is clearly challenging for professionals, and the issue will be discussed throughout this sourcebook.

The Joint Monitoring Programme (2010) provides data on the number of water and sanitation arrangements there are of various kinds. The table can be read as a list of backlogs of MDGs.



What sanitation is about

1.1 - 12

Traditional interpretation:

- Personal and household hygiene
- Clean environment incl. water
- Solid waste management
- Greywater disposal and treatment
- Safe excreta disposal
- Stormwater handling

Additional perspectives:

- Acceptance, affordable, convenience and pride
- Environmentally sustainable arrangements incl. chemical risks and resource conservation

Jan-Olof Drangert, Linköping University, Sweden

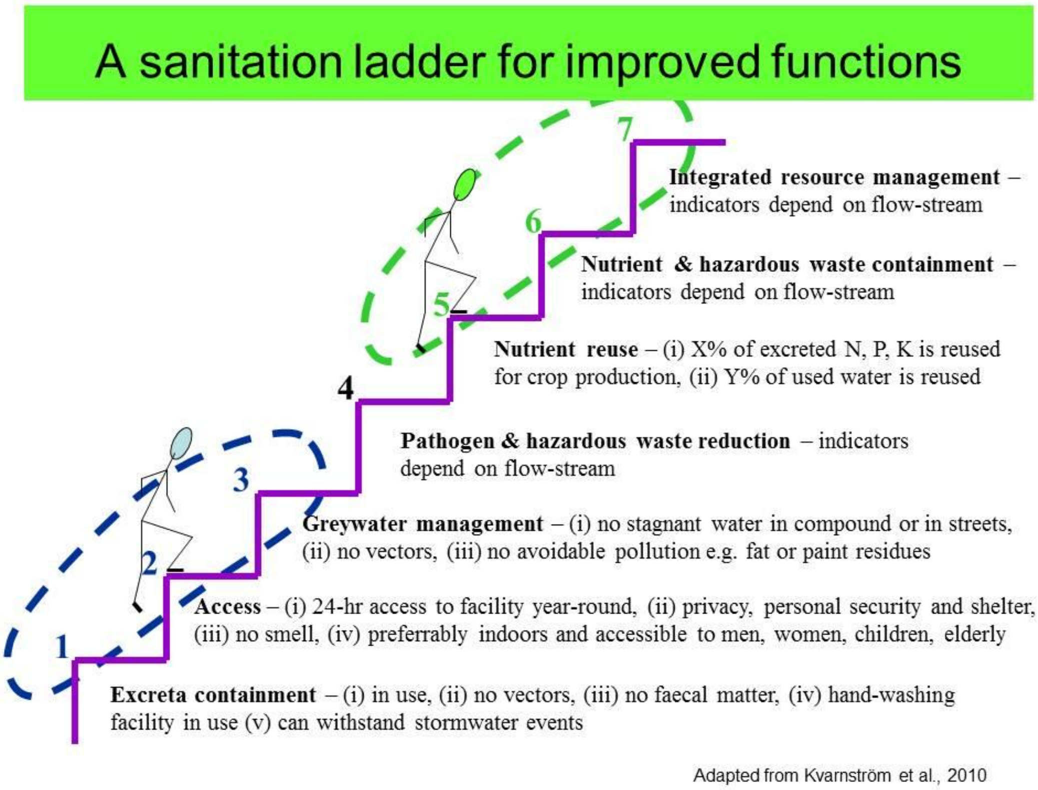
Sanitation measures include attaining clean water, managing solid waste, safely disposing grey water and excreta, handle stormwater, and practise personal and household hygiene. Some pictures of the above points are shown in the slides 1.1-6–8.

Two new requirements have been added; the arrangement must be acceptable to residents and represent an environmentally sustainable solution. In the next picture we will discuss what sustainable sanitation includes, but one point should be mentioned already here. Material flows through the sanitation system must contribute to sustainability. This demanding requirement joins sanitation to other sectors in society, foremost the agriculture sector. This is not a new situation, but has been forgotten for a century.

A fundamental change has taken place over the last century. Few consumer products were available before industrialisation and landfills were small. Most products were biodegradable, such as wooden equipment and building materials. Soap made of vegetable oils was used for all kind of cleaning. Household wastewater could thus be used for irrigation purpose without any treatment. Industrialisation brought in new non-degradable products which were discharged in the sink or toilet. The wastewater could be quite contaminated and as more chemical products entered the market since 1940s, the quality of the wastewater from households has degraded (Module 4.5). In order to meet these new challenges, authorities have to engage in activities such as source control to reduce waste volumes and hazardous content, reuse, recycling, incineration and proper landfill.

Today, major challenges are environmental in nature. The receiving water bodies cannot accumulate the loads of nutrients and pollutants, and finding space for new landfills is problematic. Solutions require revised policies, management and technical arrangements to be ’sustainable’. Fortunately, not only goods and air-borne pollution are transported between countries and continents, but also information and knowledge about ways to solve environmental problems.

1.1 - 13



We may define a sanitation ladder or hierarchy which orders improved functions related to human health and the environment (blue for health and green for environmental in picture). People can climb the ladder by moving to a new dwelling or by improving the one they inhabit.

Typically ladders are based on technology arrangements, but in this sourcebook the focus is on how arrangements function in real life and therefore a function-based ladder is advocated. It is certainly more demanding to assess functions than counting the numbers of various technical installations, but the information is vastly more useful. The following account is a slightly revised version of a ladder by Kvarnström et al. (2010) by adding aspects of hazardous waste. The ladder is intended to be universally applicable and technology neutral. Each step includes all functions of the previous step(s).

1. The first function is to **contain faecal matter** since it poses the greatest health risk: This function comprises well-known containment of excreta (e.g. no-open defecation, faeces out of reach for children, toiletwater out of reach for humans and groundwater) and barriers to pathogen spread (e.g. no flies or rodents, washing hands, no fingers in the mouth, covering food items). The containment must function also during heavy rains and regularly occurring flooding.

2. The second function comprises **easy access to the facility:** It should be available 24 hours a day, easy to reach from the house/flat preferably indoors and with no stairs to reach and with a hand washing basin nearby, and provide personal safety and privacy. If so, the facility is also user-friendly to less able persons. Users should also encounter a clean and odour-less toilet room in order to be encouraged to use it with care.

3. The third function concerns **greywater management** (the toiletwater is dealt with under the first step): Greywater should be disposed of so that no stagnant water is formed (mosquito breeding) and no pollution of groundwater or surface water occurs.

4. The fourth function is to **reduce pathogens and hazardous waste to levels which are safe:** Allow long enough storage time for urine and faecal matter to make them safe. Avoid using products containing hazardous waste and use biodegradable products whenever possible. Decrease levels of pathogens, organic matter and hazardous/toxic waste in sludge, toiletwater, and greywater below risk limits.

5. The fifth function concerns **reuse of nutrients:** Treated faecal matter, urine and/or safe sludge are to be used productively to increase food and energy production.

6. The sixth function deals with **containment of hazardous waste and nutrients:** Any treatment removes only partially nutrients and hazardous/toxic waste from the water, and they will be found in the sludge (or emitted as gases). Controlling that nutrient and hazardous waste levels released to the environment are below background levels in nature.

7. The seventh function is about **integrated resource management:** The resource flows to and from communities are managed in a coordinated manner in order to minimise waste volumes. The sanitation sector should be re-connected to the agricultural, manufacturing and energy sectors. The hierarchy for a sustainable end-of-flow is (Slide 1.3 – 8):

(a) Reduce waste volume and harmful content of products,

(b) Reuse items that are possible to use again,

(c) Treat and/or recycle the material to make new products,

(d) Generate energy of what is left through incineration or biogas production, and

(e) Hazardous products are destructed, stored or put safely on a landfill.

Thinking in terms of functions provides an incentive to include activities that each stakeholder can perform. Oftentimes a particular outcome can be achieved in more than one way.
Heavy metals can be removed from wastewater by filtering through a carbon filter, but it can also be achieved by a conscious choice of consumer products not containing these heavy metals. The integrated resource management embraces the chain from making products to use and further to treatment and disposal. The issue of selecting technical solutions should be raised only after the analysis of desired functions has been done.

1.1 - 14

The Bruntland Commission's outline of sustainability set the stage for more detailed criteria of sustainability. There is general agreement about long time line and dealing with components such as ecology, economy, social, resource saving and, to a lesser extent, reuse. In the case of sanitation we include (picture) care about human health and the environment, and being appropriate in a wide sense. These criteria are analysed and used throughout the sourcebook.

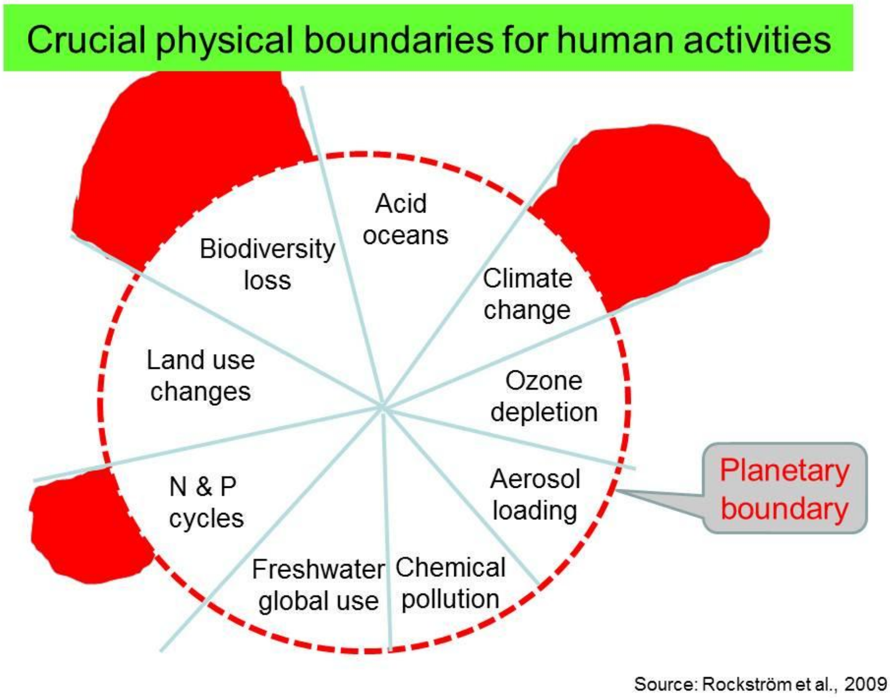
Recirculation of plant nutrients from human waste to agriculture was very common in the period prior to late industrialisation in Europe and other countries. In connection with the dramatic growth of large conglomerates of workers and industries the nutrient flow changed direction and were flushed away through sewers (slide 1.3-13). This caused stress in agriculture since at that time there were hardly any alternative fertilisers.

Cities in those days comprised everything from pigsty, urban food production, and local use of human excreta to multi-storey buildings with piped water supply and sewerage. Worries that agriculture was being deprived of plant nutrients by introducing flush toilets is often represented by a quote from *Les Miserables* written by the French author Victor Hugo:

> Science, after having long groped about, now knows that the most fecundating and the most efficacious of fertilisers is human manure. The Chinese, let us confess it to our shame, knew it before us. Not a Chinese peasant -- it is Eckberg who says this -- goes to town without bringing back with him, at the two extremities of his bamboo pole, two full buckets of what we designate as filth. Thanks to human dung, the earth in China is still as young as in the days of Abraham. Chinese wheat yields a hundredfold of the seed. There is no guano comparable in fertility with the detritus of a capital. A great city is the mightiest of dung-makers. Certain success would attend the experiment of employing the city to manure the plain. If our gold is manure, our manure, on the other hand, is gold (Hugo, 1862).

Today, we anticipate a looming scarcity of nutrients, in particular phosphorus, potassium and sulphur, during this century which will affect our possibility to feed the growing world population (Module 5.1). Again, recycling of human excreta will be part of the solution that the sanitation sector can provide.

1.1 - 15



The concept of sustainability has now advanced beyond a vision into what is required to transform the world in the present era of change. The sanitation sector will play a strategic role in improving global sustainability as evidenced in this resource book.

Planetary boundaries are real (Rockström et al., 2009). They define the safe operating space for humanity with respect to the Earth system and are associated with the planet´s biophysical subsystems and processes. Today, most of the thresholds can be given by a value for one or more control variables, such as carbon dioxide concentration in the atmosphere (350 parts per million by volume). Two of the identified 9 boundaries have no threshold values yet (see slide). Three planetary boundaries have already been transgressed; the rate of biodiversity loss, climate change and the human interference with the nitrogen cycle. The variables and their boundary values are indicated below together with the present values and pre-industrial values.

Climate change (measured as CO_2 concentration < 350 ppm and radiative forcing < 1 watt per sq. m) is kept at bay if the temperature increase is below 2^oC above the pre-industrial level. Today, the CO_2 concentration is already 387 ppm, while the pre-industrial level was a mere 280 ppm. The radiative forcing is now 1.5 watts/m^2 and is estimated to have been zero around the year 1800.

Rate of biodiversity loss (as number of extinct species < 10 per million and year) has accelerated massively caused by e.g. land-use change. Current loss is estimated at >100 per year and fossil records indicate a pre-industrial loss rate of <1.

Nitrogen cycle change (as amount of N_2 removed from the atmosphere for human use < 35 million tons per year) is now at 120 million tonnes of reactive nitrogen mainly for production of fertilizers. Runoff of N and P from soils to water bodies cause pollution. The pre-industrial level of N_2 removal was zero.

Phosphorus cycle release to oceans (as millions of tonnes of P < 11 per year) is presently some 9 million tonnes, while the oceans released some P to soil and atmosphere before 1800.

Stratospheric ozone depletion (as concentration of ozone in the atmosphere < 276 Dobson units) is now 283 units, while it is estimated to have been 290 units in pre-industrial period.

Ocean acidification (as saturation level of aragonite in surface seawater < 2.75 units) has now reached 2.90 while the pre-industrial level was 3.44.

Global freshwater use (for human use < 4,000 km^2 per year) is now 2,600 km^2 per year and rapidly increasing while it was very small, 417 km^2, in pre-industrial period with almost only rain fed agriculture.

Changes in land use (as % of global land cover converted to cropland < 15 %) is now at 11.7%, while very small areas were converted to cropland before industrialization when the total world population was still below one billion people.

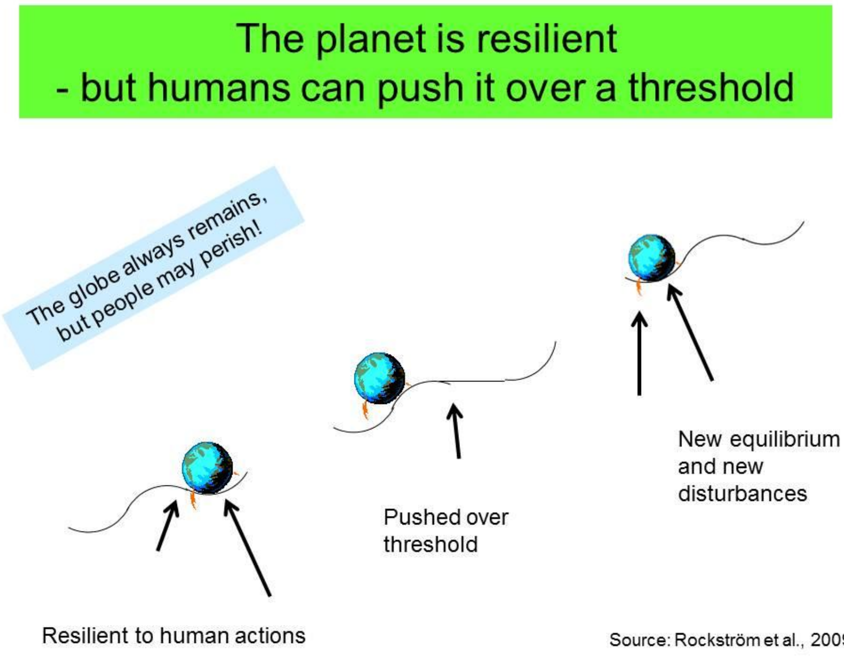
Atmospheric aerosol loading (variable and value to be determined) deals with the overall particulate concentration in the atmosphere such as dimming effects.

Chemical pollution (variables and values to be determined) deals with all more or less hazardous compounds that are being manufactured or unearthed for human use (persistent organic pollutants, endocrine disrupters, heavy metals and nuclear waste, etc.). The chemical society emerged after the Second World War and has accelerated since then.

An interesting and important observation is that the sanitation sector as defined in this source book will play a crucial role in preventing from coming close to most of the mentioned planetary boundaries. For instance, recycling nitrogen and phosphorus from the food chain back to agriculture would reduce the need for removing N_2 from the atmosphere and phosphate rock from the ground.

Although the planetary boundaries are described in terms of individual quantities and separate processes, the boundaries are tightly coupled. If one boundary is transgressed, then other boundaries are also under serious risk. For instance, significant land-use changes in the Amazon could influence water resources as far away as Tibet.

1.1 - 16



Recently (2011), a group of prominent researchers and Nobel Laureates discussed the leading themes of global sustainability under three headings; reconnecting people to ecosystems, from hunter-gatherer to planetary stewards, and tipping towards sustainability. The group recognizes the new situation at hand with unprecedented challenges of solving interrelated issues such as poverty, inequality, food security, and environmental degradation, and concludes on a rather optimistic note that the capacity and ingenuity to deal with these challenges exist – and **given that** we channel our creativity in a way that reconnects human development with the biosphere (the global ecological system) and continue to develop within planetary boundaries (Symposium on Global sustainability, 2011).

The first theme on **reconnecting people to ecosystems** outlined the gradual divorce between people and ecosystems from early Industrialization (1800). Five key messages are provided:

1a) In spite of immense technological development and progress, our economies and societies still fundamentally depend on ecosystems to provide us with a hospitable climate, clean water, food, fibres and numerous other goods and services;

1b) It is time to fully realise that our societies and economies are integral parts of the biosphere, and to start accounting for and governing natural capital. Poverty alleviation and future human development cannot take place without such a wider recognition of nature´s contribution to human livelihoods, health, security and culture;

1c) The issue at stake extends beyond climate changes to a whole spectrum of global environmental changes that interplay with interdependent and rapidly globalizing human societies. Science has a great responsibility in this respect to provide better understanding of the multiple challenges facing humanity and to explore solutions for sustainable development in an increasingly unpredictable world;

1d) Resilience thinking is an important part of the solution, as it strives at building flexibility and adaptive capacity rather than attempting to achieve stable optimal production and short-term economic gains;

1e) It is time for a new social contract for global sustainability rooted in a shift of perception - from people and nature seen as separate parts to interdependent social – ecological system. This provides exciting opportunities for societal development in collaboration with the biosphere; a global sustainability agenda for humanity.

The second theme concerns **the human-dominated planet** where our responsibility expands to cover all parts of our planet. Oceans are here viewed as a forgotten aspect of the functioning of the Earth as a whole. The key messages are:

2a) The human imprint of the planet´s environment is now so vast that the current geological period should be labelled the ’Anthropocen’ – the Age of Man;

2b) Human pressure has reached a scale where the possibility of abrupt or irreversible global change – challenging our own well-being – can no longer be excluded;

2c) The challenges of the 21st century – resource constrains, financial instability, inequalities, environmental degradation – are a clear signal ’business-as-usual’ cannot continue;

2d) We are the first generation with the knowledge of how our activities influence the Earth as a system, and thus the first generation with the power and the responsibility to change our relationship with the planet;

2e) Effective global stewardship can be built around the ’planetary boundaries’ concept, which aims to create a scientifically defined safe operating space within which humanity can continue to evolve and develop.

The third theme of **tipping towards sustainability** regards the social-ecological innovations for planetary opportunities. The 5 key messages are:

3a) An immense number of sustainability initiatives are emerging (transition towns, clean energy, agroecological farming, ecosystem-based fisheries management, etc.) Such initiatives need to be upscaled through e.g. innovation funds, seed money, structural adjustment funds and other incentives in order to have a global impact. Social media and associated advances in information and communication technologies can play a role in this process;

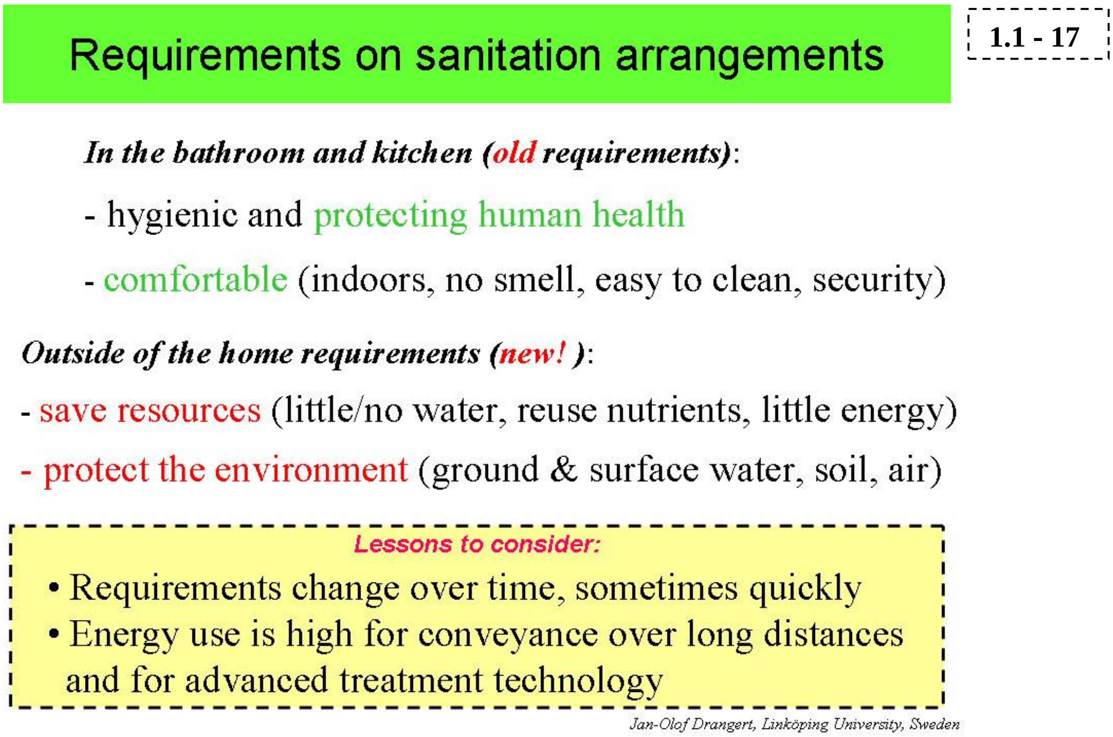
3b) On-going large-scale transformations in e.g. information technology, biotechnology and energy systems have the potential to significantly improve our lives in a sustainable way, but only if we incorporate knowledge of social-ecological systems and planetary boundaries in risk assessments and development strategies;

3c) Most current economic and technological solutions are ecologically illiterate and too linear and single problem-orientated. What is needed is financial and political support for safe-fail experiments in communities around the world, using diverse technologies, organisations and ideas, for instance in ’Policy Laboratories’ or ’Change Labs’;

3d) Policy makers around the world need to adopt a new system thinking that pays much more attention to the negative side-effects of quick fixes and recognizes the numerous possibilities in investing in sustainable use of ecosystems and their services;

3e) We need a new type of social-ecological innovations and technologies that work more directly for social justice, poverty alleviation, environmental sustainability and democracy, while including the creativity and ingenuity of users, workers, consumers, citizens, activists, farmers and small businesses alike (excerpt from Symposium on Global sustainability, 2011).

Ecosystem services and the resilience of the planet have served our activities rather well up to now, but we have reached a stage where we push the planet out of its present equilibrium. Next slide will discuss how that might happen, and here we end with a matter of fact: The planet will remain after such a shock, and it is the human community that will suffer – to the extent that it may perish.



Requirements on sanitation arrangements change over time, because of changes in lifestyle and material wealth. They may also change in response to changes in environmental impacts and awareness, as witnessed by the issue of climate change and planetary boundaries (1.1 – 14&15). Our perceptions about what is beneficial may also be influenced or manipulated by ads and business interests.

Urban residents tend to take good care of private bathrooms, and invest in affordable arrangements. But, they also tend to put a blind eye to environmental problems away from the home as long as these are perceived as having no solution.

Introducing an improved sanitation arrangement contributes to a healthier environment in the cities where they are installed, but often they do the opposite for those living downstream. The reason is that reduction of pathogenic organisms and chemicals is often insufficient. Conventional treatment plants were developed to remove large particles, biodegradable organic substances and nutrients in order to protect receiving waters from eutrophication. Only recently is the removal of the chemical content in wastewater in focus (Module 4.5). Today´s treatment plants are not designed to remove all pathogens and chemical compounds. For instance, residues of medical products are not trapped in the treatment. Therefore, even if functioning properly, the discharge from conventional wastewater treatment plants is still not safe, failing to meet the quality requirements of bathing water, if the dilution with cleaner lake water is not large enough.

Conventional sanitation systems often fail the new requirement of saving resources since reuse of compounds is minimal and energy use is high for conveyance over long distances and for sophisticated treatment of wastewater. In Sweden, for instance, many hamlets were connected to urban utilities and water had to be pumped tens of kilometres, and the wastewater was pumped back the same distance to a centralised wastewater treatment plant situated on the outskirt of towns. The energy cost for pumping is prohibitive today and cannot be expected to go down in the future. The calculations done when building these infrastructures in the 1960s and -70s did not take the energy use and cost seriously because cheap energy was available (slide 2.3-11).

1.1 - 18

Saving water at your home

Activity	Method practiced	Qty lit	Method to be adopted	Qty lit
Brushing	Running tap for 5 min	45	Tumbler or Glass	0.5
Hand washing	Running tap for 2 min	18	Half filled with wash basin	2.0
Shaving	Running tap for 2 min	18	Shaving mug	0.25
Shower	Letting shower run	90	Wet down, tap off, soap up, rinse off	20
Flushing toilet	Using old fashion cistern	>13	Dual system short flush	4.5
Watering plant	Running hose for 5 min	120	Water can	5
Washing Car	Running hose for 10 min	400	Bucket	18

Jan-Olof Drangert, Linköping University, Sweden

The sustainability requirement of saving resources is a practical and doable one. It helps to bring back responsibility to the users, who will become partners in sustainable development.

The slide shows some examples of the potential of saving or wasting water in the home. The figures are not precise, but depending on the rate of water flushing through the pipe. A drop per second will add up to half a litre in one hour, while a hose may provide 2.5 m^3 in one hour. Keeping this difference in mind, we can have a closer look at the figures in the diagram.

People commonly brush their teeth twice daily. If they are considerate with the rate of water flush they may use 3 litres per minute. Two 2-minute brushes a day require 12 litres as compared to the 90 litres used by wasteful person. It they instead use a cup or glass they will save 11- 89 litres every day. This will add up to 330 – 2,600 litres per month. With a real water cost of 3 USD per cubic meter the saving in cash is 1- 7.5 USD per person monthly.

The same kind of calculations can be done for the other water-using activities. The changes in use are facilitated further by installing a one-grip handle faucet which will keep the temperature when switching on and off. Also, inserting a mesh at the tip of the tap (will add air to the water) will retain the feeling of unchanged rate of flushing water, despite the fact that actual volume is reduced by half.

The demand management component (see slide 2.2-5) of having a progressive tariff to stimulate users to use less water could be quite effective, given that the users are well informed about the tariff system. It requires that each flat has a water meter, and the fee collection is done properly. The saving is always done at the last litre of total water use, and therefore the higher cost per litre is gained for each litre saved. The first litres used could have a very low cost level in order to assist poor users to afford a minimum of required water, while the following cost steps could be quite steep in order to send a monetary signal to normal earning citizens to stop wasting – or even better – start saving water.

Demand management is a tool to reduce wastage of water, not a way to reduce comfort and joy of the user.

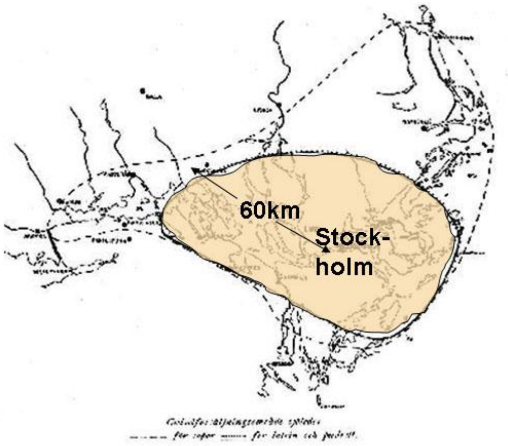
Reuse or disposal in the history of sanitation

1.1 - 19

The ”silent highway” man rowing on river Thames

Illustration: www.CartoonStock.com.

Land area making use of organic waste from the city of Stockholm 1910



Karl Tingsten, 1911

Countries adopted different policies in the sanitation sector. In mid-19th century, the UK went for disposing sewage into rivers. An editorial cartoonist in London lamented the rise in sewage carried into the river Thames – killing off fish, risking public health and causing the “Great Stink” that was so bad that it forced the House of Commons to abandon the parliament building for a period. The ‘silent highway’ man (left picture) rows his boat among rats and debris. Despite this disastrous consequence of this policy, it did not change. It took a century before most of the wastewater was partly treated before emptied in river Thames.

In other countries the policy was similar but protests were rampant. In Paris, the issue pertaining to the new flush toilets focussed on the loss of valuable nutrients (our manure is gold) to the rivers and lakes. In the second half of the 19th Century the debate was fierce between farmers and other citizens as shown by the quote from Victor Hugo in the slide 1.1-14.

In Stockholm, Sweden where industrialisation came later, flush toilets were introduced only gradually and human excreta were returned to agricultural use up to the 1920s. The map (right) shows the agricultural area that was fertilised with sanitised excreta (inner brown circle) and composted material from organic waste (dotted circle). The view of reuse in those days foreshadows the modern concepts such as ‘carrying capacity’ and ‘ecological foot prints’.

In the European Union, more than a century later, planners are still preoccupied with the cost of serving the public´s preference for bathing in sewage-free seas – as enshrined in the Bathing Water Directive. The Londoners were lucky in the sense that the ebb and flood reached up to London and made the river carrying the polluted water out into the English Channel once every day. At the same time this hydrological regime and accompanying perceptions have delayed sustainable sanitation solutions.

Many countries still suffer from the legacy of these British perceptions of sanitary solutions. Their experiences became a precursor of what happens in many big cities today. Poor handling of wastewater causes health risks both directly and indirectly through pollution of groundwater from leaking pipes. The groundwater under all towns is contaminated by leaking sewers and therefore well water drawn in poor areas often contains chemicals and pathogens which would require pre-treatment (slide 4.5-6).

Epidemics rather than endemics have shaped our views

1.1 - 20

Example 1

After John Snow discovered (1854) that cholera can be transmitted by contaminated well water, sanitary engineers focussed their interest on organic matter in water as an indicator of faecal contamination. Many rivers with high organic loads were wrongly labelled as hazardous since the origin of the organic matter was not from faeces but from humus! (Hamlin, 1990)

Example 2

Sanitary inspectors in Linköping (small town in Sweden) described the sanitary conditions in the workers´ living quarters as deplorable with stagnant storm water and awful smell, and causing ill health (1870s). However, infant mortality in such areas did not differ from that in richer areas with piped water and sewers. Lack of sanitary precaution by all classes was the reason, and not until the general hygiene improved did the death toll figures come down! (Nilsson 1994; Esrey, 1990)

Evidence-based experiences often guide our actions, be they tacit or scientifically derived. A look back in history can provide us with some useful insights of the relationship between our perceptions and scientific statements.

Chris Hamlin (1990) brought up interesting facets of what John Snow and others thought about the cholera spread around the Broad Street well in London in the 1850s (14,000 people were killed by cholera in the epidemic of 1849). It was during this period that the modern concept of disease specificity and the corresponding emphasis on a single exciting cause of each disease were coming to be applied to the kinds of diseases bad water was thought to cause. Hence, where Chadwick and the early sanitarians had assumed that each outbreak of disease was a version of a common filth disease and had felt little obligation to restrict the number of operating causes in any particular case, sanitarians in the 1860s and 1870s were beginning to look for single causes and tending to regard multi-factorial explanations as the lumping together of an important, exiting cause with a collection of less important predisposing causes. More significant than the change in ideas of how disease spread was the change in the concept of what a disease was. This was long before the German chemist Koch could identify microorganisms in 1893.

Hans Nilsson (1994) compared infant mortality data in a small town in Sweden for the period before the introduction of piped water and sewers in 1875 with data for the following years. He found that there was a reduction of some 25% in infant mortality! But are we certain that the improvement came about due to the new infrastructure? Nilsson also collected data for working-class suburbs with very poor sanitary conditions and no such services (and occupied only after 1875). He found that infant mortality here was as low (or high) as in the piped part of the town. The water in the pipe came from the same river where the workers draw their water. The explanation for this unexpected result with similar rates of infant mortality is that all classes practised the same poor hygiene in relation to babies.

This finding is supported by Steven Esrey´s study (1990) in which he compared results from various studies of the impact of provision of water on users´ health. He found that very few studies could prove a health benefit from improved water supply only and also that many of the studies had serious flaws. His conclusion was that improved sanitation conditions enhance public health more than improved drinking water quality.

Continued

1.1 - 21

Example 3

Water issues have been in focus to the detriment of appreciating good sanitation. Cairncross (1989) and others have reached the conclusion that water quantity is more important to good health than water quality for many diseases. Enough water to clean the hands and body, wash clothes, clean the house, etc. is more important than improved drinking water quality at the margin.

Lesson to consider:

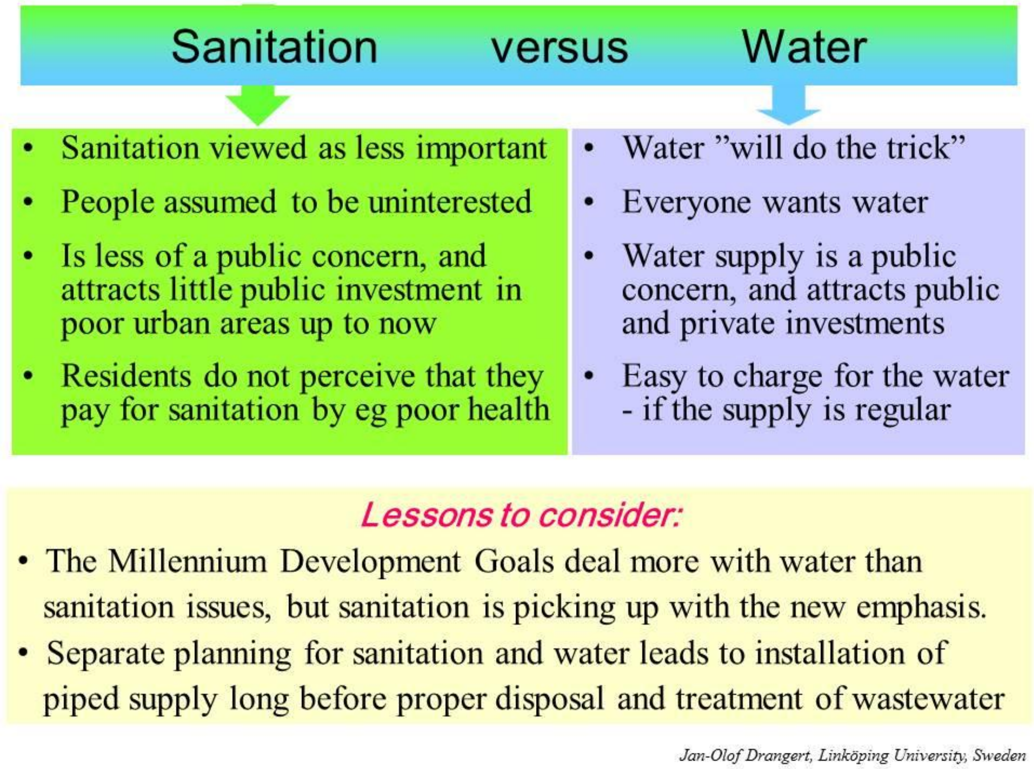
We need to measure the right parameters to be able to draw useful conclusions.

Jan-Olof Drangert, Linköping University, Sweden

Chadwick preached organising public service to achieve complete urban drainage and plenty of water to flush all wastes from cities to sewage farms. In his sanitary report of 1842 the final word on water was that "the formation of all habits of cleanliness is obstructed by defective supplies of water" (Hamlin, 1990). Hamlin also interprets this formative period for understanding the relationship between water, sanitation and causes of disease as much as a means to improve water quality and human health as a struggle between proponents of public and private ownership of the systems. There is also a competition between proponents of chemical and biological causes of disease.

These three examples show that data can give valuable information about sanitation conditions. However, there is a need to interpret the data carefully in order to let them guide our strategies and policies. In short, we need to measure the right parameters to be able to draw useful conclusions in order to make relevant policy decisions. This challenge will be discussed more in detail in Module 2.4 where we deal with selection of sanitation arrangements and in Module 3.1 where hygiene aspects are scrutinized.

1.1 - 22



Sanitation and water issues are partly similar, partly radically different.

Viruses survive much longer in cold water than in warmer water. Bacteria in water die off due to lack of feed and due to cannibalism. In contrast, bacteria multiply rapidly on substrates like left-over food. This is one of the reasons why ingestion of infectious doses is more likely to come from food than from water. But, not all pathogens need high numbers to cause disease.

Authorities and donors have put much more resources into water supply than sanitation as a response to assumed difference in popular demand. Water supply is a public concern and conforms nicely to making political promises. Yet, much of the water supplied in periurban areas is actually provided by individual well owners or private entrepreneurs. Residents are prepared to pay for water if it is supplied on a regular basis.

Sanitation options other than sewerage and flush toilets tend to be viewed a private concern rather than a public one. Sanitation seems less rewarding for politicians, and comparatively small efforts were made previously. But the situation is improving with the implementation of MDGs. The mental separation of water supply and wastewater handling has resulted in that residents do not perceive that they pay for disposed wastewater or management of stormwater.

Rarely do decision-makers take into account that 'more water in' results in 'more water out' from households. A possible reason is the high cost of sewerage and contradictory perception that it is free of charge. Professionals and consultants seem to support this non-coordinated approach of water first, leading to higher total investment costs. They know that ensuing wastewater problems will feature high on the development agenda and will have to be dealt with sooner or later. They are certain to secure contracts for sewerage in due time. The problematic result of this piecemeal approach is that no sustainable intermediate solution is looked for. Instead haphazard arrangements evolve which tend to cause environmental problems for single households as well as causing groundwater pollution, drainage problems and pollution of rivers and lakes.

The piecemeal approach excludes a holistic integrated view of the water flow through society, and will not encourage a recovery strategy. Rethinking in this respect is evolving slowly, and is focussing on local small scale arrangements that are sustainable. Hopefully, these may be allowed to gradually replace the conventional city wide sewerage.

References

Bartram, J. 2008. Flowing away: water and health opportunities. *Bulletin of the World Health Organization*. Volume 86, Number 1, January 2008.

Brundtland Commission 1987. *Our Common Future*. World Commission on Environment and Development (WCED). United Nation Environmental Programme. Nairobi.

Cairncross, S. 1989. Water Supply and Sanitation: an Agenda for Research. *Journal of Tropical Medicine and Hygiene*, 92, pp.301-314.

Deloitte, 2011. *Water tight 2012. The top issues in the global water sector*. Deloitte Global Services Limited. http://www.deloitte.com

Drangert, J-O. and Bahadar, N. 2011. A cultural-spatial analysis of excreting, recirculation of human excreta and health – the case of NWFP in Pakistan. *Health & Place*. 17(2011); 57-66.

Esrey, S.A. et al. 1990. Health Benefits from Improvements in Water Supply and Sanitation: Survey and Analysis of the Literature on Selected Diseases. Arlington. *WASH Technical Report* No. 66.

Folke, C., Jansson, Å., Larsson, J., and R. Constanza 1997. Ecosystem Appropriation by Cities. *Ambio* Vol. 26 No. 3, May 1997.

Hamlin, C. 1990. A *Science of Impurity. Water Analysis in the Nineteenth Century Britain*. Berkeley, University of California Press.

Hugo, V. 1862. *Les Miserables*, ch.323, A. Lacroix, Verboeckhoven & Co.

IMF and World Bank, 2003. *Progress report and critical steps in scaling up: Education for all, Health, HIV/AIDS, Water and Sanitation*. Development Committee (Joint Ministerial Committee of the Boards of Governors of the Bank and the Fund on the Transfers of real resources to Developing Countries). Washington D.C.

Kvarnström, E., McConville, J., Bracken, P., Johansson, M., and Fogde, M. 2010. The sanitation ladder – Need for a revamp? *Journal of Water, Sanitation and Hygiene for Development*, 1(1), 3-12.

Mata, L.J. 1978. *The children of Santa Maria Caqué*. Guatemala. MIT Press, Cambridge.

Melo JC. The Experience of Condominial Water and Sewerage Systems in Brazil. Water and Sanitation Program, Lima; 2005. Available from: http://www.wsp.org/wsp/sites/wsp.org/files/publications/BrasilFinal2.pdf

Murray, C.J.L. and A.D. Lopes (eds.) 1996. *Global burden of disease. A comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020.* Harvard University Press.

Nilsson, H. 1994. Mot bättre hälsa. Dödlighet och hälsoarbete i Linköping 1860-1894. (Diss.) *Linköping Studies in Arts and Science* No. 105. Linköping university, Sweden.

Rockström, J., et al., 2009. A safe operating space for humanity. Identifying and quantifying planetary boundaries that must not be transgressed could help prevent human activities from causing unacceptable environmental change. *Nature*, Vol 461/ 24 September, 2009.

Rockström, J., et al. 2009. Planetary boundaries: exploring the safe operating space for humanity. Ecology and Society, Vol 14. Issue 2: Article 32. http://www.ecologyandsociety.org

SEI, 2005. *Sustainable Pathways to Attain the Millennium Development Goals* (For the UN World Summit, September 2005). Stockholm Environment Institute.

Stockholm Water Front. 2007. Urban sanitation- Politics in a dirty world. *Stockholm Water Front* No 4, December 2007.

Symposium on Global sustainability, 2011. *Transforming the World in an Era of Global Change*. Executive summary of scientific background reports to the 3rd Nobel Laureate Symposium on Global Sustainability. Jointly organized by Stockholm Resilience Centre at Stockholm University, the Royal Swedish Academy of Sciences, the Stockholm Environment Institute, The Beijer Institute of Ecological Economics and the Potsdam Institute for Climate Impact Research.

Tingsten, K. 1911. *Stockholms renhållningsväsende från äldsta tid till våra dagar*. Nordstedts & Söner. Stockholm.

UN-Habitat 2003. *Slums of the World: The face of urban poverty in the new millennium? Monitoring the Millennium Development Goal, Target 11 – World-wide slum dweller estimation*. Working Paper, United Nations Human Settlement Programme (UN-Habitat), Nairobi.

UN-Habitat 2008. *State of the World´s cities 2010/11. Bridging the urban divide*. United Nations Human Settlement Programme (UN-Habitat), Earthscan. London Washington DC.

UNICEF, 2008. *The state of the world´s children 2009*. United Nations Children´s Fund. New York.

Unicef & WHO, 2012. *Progress on drinking water and sanitation: 2012 Update*. Geneva, Switzerland. WHO Press. At http://www.wssinfo.org/

WHO and UNICEF, 2004. *Meeting the MDG drinking water and sanitation target: the urban and rural challenge of the decade*. WHO Press. World Health Organisation, Geneva. http:/www.who.int/water_sanitation_health/monitoring/jmpfinal.pdf

WHO and UNICEF, 2010. Meeting the MDG drinking water and sanitation target: the urban and rural challenge of the decade. WHO Press. World Health Organisation, Geneva. http:/www.who.int/water_sanitation_health/monitoring/jmpfinal.pdf

WHO 2006. Cluster of Sustainable Development and Healthy Environments. Statement delivered at the *World Water Forum, 2006* by Susanne Weber-Mosdorf, Assistant Director-General, WHO.

World Water Development Report. 2006. The World Bank. Oxford University Press.