SUSTAINABLE SANITATION IN CITIES

A FRAMEWORK FOR ACTION

Christoph Lüthi, Arne Panesar, Thorsten Schütze, Anna Norström,
Jennifer McConville, Jonathan Parkinson, Darren Saywell, Rahul Ingle

sustainable sanitation alliance

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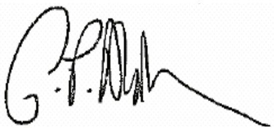
Foreword

Sanitation is usually a forgotten problem in the low-income areas of our fast growing cities, where close to 5,000 children under 5 years old are dying every day because of lack of access to basic sanitation. As the World becomes progressively more urban, most of civilisation, who currently reside in small towns and large villages, will see their living environment change. The pace of urbanisation will impact many areas of their life, their living environment and their access to basic services. The challenges to provide basic sanitation services will play an essential part of the planning and management of these settlements. Without proper approaches, we risk more unplanned slums and the potential threat that the small urban settlements of today will become the haphazard and unplanned mega-cities of tomorrow. Planning sanitation for cities needs to give due attention to the diverse needs of all city residents, rich and poor, old and young. Integrated approaches must be developed where on-site systems and off-site systems work together. The International Year of Sanitation went a long way to raise the level of awareness and to provide a set of key messages, that all could follow in meeting the challenge. However this was a global call to action, which needs practical and realistic interventaions.

Much of the developed world relies on piped, centralised sewerage systems, serving mainly the high income residents. These systems have their limitations including that: they need too much energy for transport and treatment of wastewater and; they waste precious elements in wastewater like phosphorus – a limited resource, badly needed as fertiliser. One issue is certain, without sustainable reuse of excreta, we are wasting a valuable resource. As we consider options for urban areas of all sizes, reuse of nutrients must be part of the plan. For urban areas, the challenge will be providing effective sanitary arrangements linked to sustainable collection and transport and treatment of the excreta to the point of re-use. In some smaller urban centres, closer to the rural hinterland, this will be more easily accomplished than in the mega cities. So-called "ecological approaches" to sanitation must be the main solution in a sustainable urban future.

This book "Sustainable Sanitation in Cities" prepared by partners of the Sustainable Sanitation Alliance (SuSanA) network is a real eye-opener. It takes a look at some of the methods that have worked well in the past, to guide us in solving the problems of the future. By addressing sanitation as a key element of the urban metabolism, and by linking sanitation with urban planning and neighbouring sectors like solid waste management or waste recycling, it allows for a holistic approach. It is only through this comprehensive view that new solutions come to light and there are many opportunities. In the cities of tomorrow, we will need to focus more on recycling energy. A good example being biogas generation from wastewater and sludges. Water will also become an increasingly scarce commodity. Greywater (from showers and sinks) can be treated in urban constructed wetlands or used to water and fertilise urban green spaces. Such examples of productive sanitation systems will form an integral part of infrastructure in sustainable cities.

“Sustainable Sanitation in Cities” is a call for action, as we battle against the challenges of an urbanising world, we have to start today to adapt and develop innovative solutions and approaches. This book provides guidance on concepts and sustainable solutions which are tried and tested. I hope this book will kick start a new approach to urban sanitation founded on sound ecological principles. It provides an inclusive approach and helps us to advance up the learning curve faster. Most importantly it reminds us that neglecting ecological approaches to sanitation is a missed opportunity, which will greatly improve the lives of future generations.



Dr Graham Alabaster
Chief of Section I
Water Sanitation & Infrastructure Branch
UN-Habitat

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Content

1 Introduction

Context

The world is facing increasing pressures on both ecological and human environments. Climate change, rapid urbanisation, and economic crises create changing conditions which mean that the world can not continue with business as usual. With the depletion of non-renewable resources we will continue to see rising prices for transport, energy and fertilisers. This will be accompanied in many countries by water stress and growing insecurities in food supplies. These increasing pressures will demand that we reduce long-term dependency on non-renewable resources through the adoption of innovative and adaptive systems promote recycling and reuse.

Sanitation will increasingly play a critical role in adapting to energy and resource constraints and supporting the development of reuse oriented urban settlements. Up until the mid 19th Century, the integration of sanitation systems with food production was a common practice in many parts of the World. Agricultural societies were well aware of the fertilising value of excreta and adopted various systems to return the nutrients back to the soil. But, from the mid 19th century a dramatic change took place during the "sanitation revolution"; beginning initially in Great Britain. Public health at all levels of society was in danger and child mortality was extremely high in many European cities. This was not only seen as an abomination by social reformers, but was also having an economic impact on burgeoning industries. The need to protect the health, and therefore the productivity of the workforce was one of the arguments used during the Industrial Revolution for large scale investments in sewerage.

These systems were highly effective at reducing the incidence of diarrhoea and other diseases related to poor sanitation and, as a result, sewerage has set a precedence for sanitation throughout the World. But sewerage generates a massive wastewater disposal problem which can only be mitigated with very significant investments for wastewater treatment. Even with the use of highly advanced and complex treatment and the application of sludge to land, the replenishment of agriculture soils with nutrients is lost as most of the nutrients are discharged with the treated effluent.

Rationale

Today we are on the brink of another "sanitation revolution", in which we must broaden our horizons about the way we manage excreta in order to keep our cities running and to feed the World's population.

In addition to maintaining a sanitary environment to live, sustainable sanitation systems will need to promote water, nutrient and energy reuse, as the shortage of finite resources becomes more apparent and the prices for water, fertiliser and energy continue to rise.

Within this context of a paradigm shift in sanitation, the need for this book arose from discussions within the Sustainable Sanitation Alliance (SuSanA) working group on "Sanitation in Cities". The members of the working group envisage a need for sanitation systems to be integrated parts of the urban environment and therefore the planning and design of urban infrastructure needs to be undertaken in an integrated manner.

The Sustainable Sanitation Alliance (SuSanA)

The SuSanA network was initiated prior to the International Year of Sanitation in 2007 in an attempt to promote concepts of sustainability for the sanitation sector. It is a loose network of over 120 organisations working together to promote sustainable sanitation solutions in different urban and rural contexts through knowledge sharing and joint publications. There are 12 thematic groups working on a variety of issues from knowledge and capacity building to food security and productive sanitation. This book was produced by the working group "Sustainable Sanitation for Cities" in an effort to develop strategies on how cities can adopt an appropriate planning, implementation, and management process that leads towards more integrated and sustainable sanitation solutions. For more information about the alliance see the SuSanA website (www.susana.org).

The paradigm shift outlined in this book encourages the development of sanitation systems which:

- are based on the principles of a closed loop recycling economy and the 3 Rs (reduce, reuse, recycle);
- are resource efficient and reduce long-term dependency on energy and transport costs;
- open up new options and opportunities for local job creation; and
- are based on the multiple use of urban space and integration of sanitation and reuse systems in urban design.

These principles are understood as guiding principles on how to move towards more sustainable pathways. A large part of this book translates and exemplifies these principles for challenging informal environments - especially for unserved communities living on marginal land in urban and peri-urban informal settlements. Sanitation is a cross-cutting issue and there is a huge potential, and indeed a necessity, to integrate sanitation and water resource management agendas. There are also inherently strong linkages with other sectors including agriculture and urban management, as well as the health and energy sectors.

Vision

It is our firm belief that sanitation in cities of the future will be integrated with other types of infrastructure and management systems in a completely different manner than it is today. This entails a radical change for energy and food production, the transport of goods, and the management of waste streams.

The implementation of sustainable sanitation can be regarded as crucial for achieving the Millennium Development Goals (MDGs). But it requires a radical rethink of urban planning, moving beyond the strictures of zoning to more open and flexible planning formats that envisage cities as habitats. Green urbanism features new modes of waste management, regional economies and social organisation, which utilise decentralised technologies to reduce demands for energy, water and nutrients. This book features some successful examples of where this type of system is already happening at different neighbourhood levels.

The publication is intended to serve as an eye-opener with regards to the role of sanitation within the context of sustainable urban development. Within this context, our vision for the future of sustainable sanitation includes:

- Wastewater from households and industry will be collected separately to enable easier reuse.
- Wastewater will only be treated to the appropriate level for the intended reuse option or the save discharge for the augmentation of surface or groundwater bodies.
- Sanitation systems will produce reusable products such as renewable energy, fertiliser and water.
- Decentralised wastewater management and treatment systems such as constructed wetlands and lagoons will contribute to the quality of the urban living environment and to better micro-climates in cities.
- The reuse of products from sanitation systems will be integrated in the planning, design and operation of green cities.

This vision for sustainable sanitation is long term and incremental in nature. However, as we are currently witnessing in the energy sector, global shifts in framework conditions can trigger rapid change towards more sustainable systems that were previously considered unrealistic.

Scope

This publication addresses the topic of sustainable sanitation systems in cities within the context of both developed and developing countries.

The focus is on the urban environment taking into consideration the significant variations in population density, level of economic development and extent of existing investments that have already been made.

The book introduces innovative technologies that are not yet main-stream, but have the potential to provide significant benefits in cities where there is at present low coverage and inadequate sanitation facilities. In situations where there has been little investment in the sanitation infrastructure, it provides an opportunity to introduce new technologies that serve the immediate needs, whilst also satisfying long-term objectives related to sustainable urban development and resource management.

A large part of this book is therefore dedicated to innovative approaches and implementations of sanitation solutions. It focuses on sanitation in the urban environment, but underlines the relevance of addressing the rural-urban interface and the importance of avoiding negative downstream consequences. Furthermore it showcases good practice from around the world, both North and South, and features pathways for moving towards more sustainable sanitation. The publication is in line with the Bellagio Principles for environmental sanitation adopted by sector experts in the year 2000. The four Bellagio Principles place human dignity and demand responsiveness, good governance and effective participation, integrated waste management processes and the maxim that waste should be managed as close as possible to its source and diluted as little as possible, at the centre of sustainable sanitation efforts (WSSCC, 2005).

This book aims to take a practical viewpoint and focuses on technologies that have already been successfully implemented. These are illustrated via the case studies at the end of this book and numerous examples throughout this book (see Figure 1.1). Although there are strong interlinkages with other infrastructure (for example stormwater and solid waste management) the focus of this book is specifically on the management of excreta and liquid waste, which are originating from households.

In addition, the book does not address the financial and economic analysis of sustainable sanitation in any depth. This is because there are still very few examples that can provide reliable and comparable data, even though financing and cost recovery issues are taking increasing prominence in the sector.

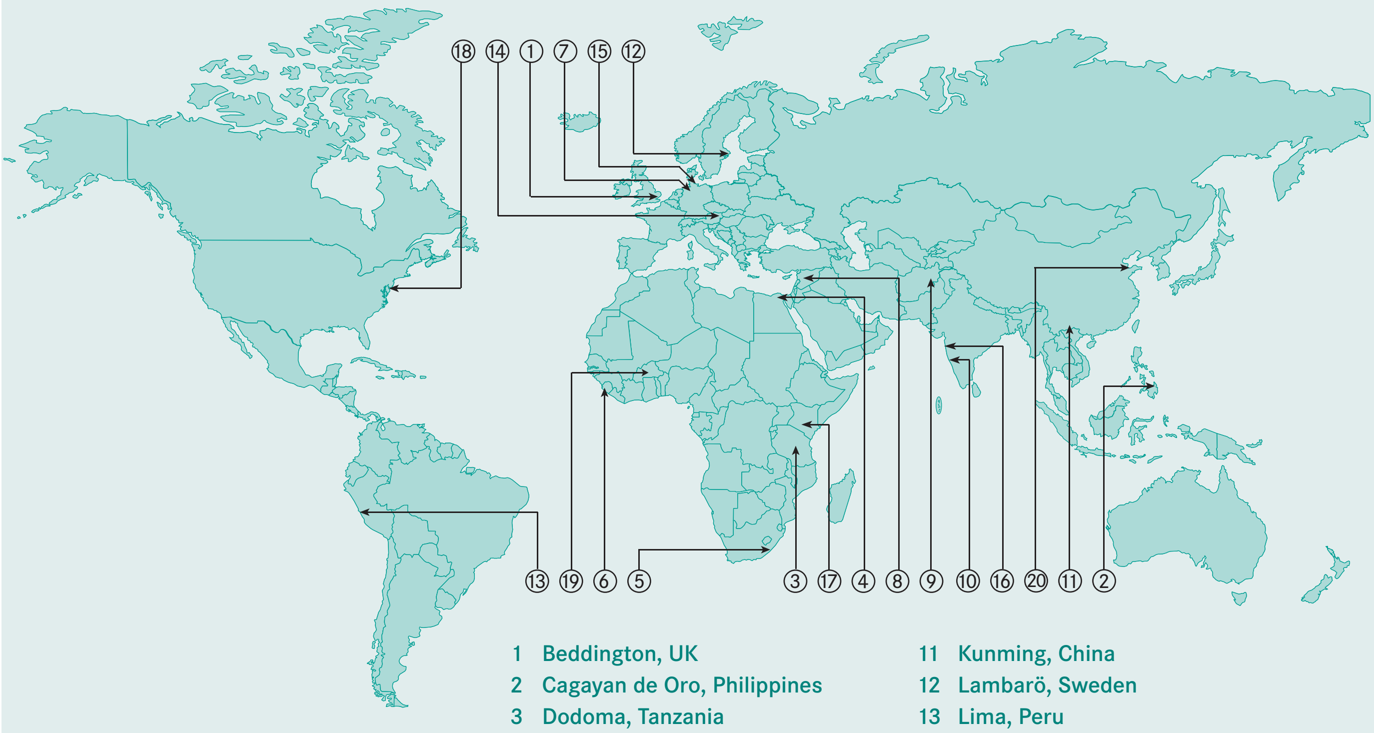
The main reasons for this are 1. the lack of a sufficient number of innovative, decentralised systems from which to draw information, and 2. the widespread use of external support in form of hardware subsidies applied by local governments or donors.

Therefore, there is still considerable research required to assess all cost factors, including costs of management arrangements of the various systems and solutions presented in the book. Two initiatives are currently dealing with a better understanding of the economics of sustainable sanitation: the IRC "WASHCost" project (www.irc.nl) and the SuSanA working group on Economics & Finance (www.susana.org/lang-en/working-groups/wg02).

Target Audience

This book is intended for professionals, decision makers, planners and sanitation engineers who are responsible for city planning and management and urban infrastructure provision. The authors aim to address the sanitation crisis in a way that helps to bridge the existing gap between two communities of practice: urban planners and sanitation engineers. Bridging this gap is considered essential if an increased sustainability of urban sanitation systems, as a key contribution to the overall sustainability of cities, is to be achieved. To do so, an integrated trans-disciplinary approach is required, therefore the book promotes a dialogue between both communities. It should also be useful to

Fig. 1.1 **Overview of case studies and projects mentioned in this book**



1 Beddington, UK
2 Cagayan de Oro, Philippines
3 Dodoma, Tanzania
4 El Mofty El Kobra, Egypt
5 eThekwini, South Africa
6 Freetown, Sierra Leone
7 Hamburg, Germany
8 Haran Al Awamied, Syria
9 Kabul, Afghanistan
10 Kolhapur, India
11 Kunming, China
12 Lambarö, Sweden
13 Lima, Peru
14 Linz, Austria
15 Lübeck, Germany
16 Mumbai, India
17 Nairobi, Kenya
18 New York City, USA
19 Ouagadougou, Burkina Faso
20 Tianjin Eco-city, China

academia, especially scholars of sustainable development, engineering science and urban planning.

Structure

Chapter 2 describes the situation with regards to urban sanitation in cities throughout the world. The chapter gives an overview of current sanitation coverage and types of urban sanitation that serve communities of different socio-economic status. These range from the rudimentary and poorly maintained toilets that serve the majority of the urban poor living in low income settlements to the fully sewered standards of rich cities. It also provides an overview of the health, economic and environmental impacts of poor sanitation coverage.

Chapter 3 introduces a historical perspective on sanitation in cities underlining that the history of urban sanitation did not begin in the 19th Century. Important lessons can be learned for the future by examining how we arrived at the current standard for urban sanitation. It analyses the main drivers for centralised systems, as these drivers may change drastically as we enter a resource-scarce century.

Chapter 4 links the discourse on sustainability in cities to the topic of sanitation. It is the discourse around sustainability that has helped us to understand today what the big challenges of tomorrow will be. This chapter relates the topic of the book to the discourse around eco-cities and a more sustainable future. It underlines that we need guiding visions to decide on our future, and discusses how sustainability criteria can be used to develop, control and monitor long-term progress.

Chapter 5 provides a set of practical actions for local application. An analysis of the physical and environmental factors combined with an assessment of the social groups, institutional structures within these domains and the respective incentives for being involved in sanitation improvements forms the basis for the identifying opportunities for intervention. The chapter concludes with a set of typical urban environments - from low-density suburbs to poor informal settlements - and proposed opportunities for targeted intervention in each of these typified uban areas.

Chapter 6 deals with the planning of sustainable sanitation for urban and peri-urban areas and its importance for achieving more sustainable forms of urban development. The first section addresses shortcomings of past approaches to sanitation planning as a way of highlighting areas that need more attention during the planning process. Then, new trends in planning are introduced, followed by a discussion of recent innovations in planning tools. In particular this chapter highlights the need for communication between stakeholders, the use of sustainability criteria to guide planning decisions, and the need to remain flexible and creative in the search for locally adapted solutions.

Chapter 7 makes the case for a systems approach to sanitation, underlining the importance of considering the entire treatment and management chain, and not just providing toilets. The different effects of matter fluxes and the resulting products and wastes together with logistical and management aspects must be considered as integral parts of sanitation systems. Different sanitation system configurations are then presented, ranging from dry, source-separating systems in Germany to simplified sewers in Brazil.

Chapter 8 describes entry points for action on the ground focussing on putting plans into practice, underlining key issues of implementation relating to social mobilisation, sanitation promotion and the creation of enabling environments. It is elaborated on some of the key challenges and reasons why projects can fail and then present 10 successful case studies from around the globe that have managed to implement sustainable sanitation solutions in varying urban and peri-urban contexts in both "rich" and "poor" cities.

Chapter 9 provides further sources of information and a list of interesting websites on sustainable sanitation and green urbanism.

2 State of Urban Sanitation

Anna Norström
Christoph Lüthi
Jennifer McConville

This chapter describes the situation with regards to urban sanitation throughout the world. It focuses on current levels of coverage of sanitation facilities, the quality of these facilities and the resultant impacts on health and environmental pollution. When aspiring towards more sustainable sanitation systems presented in subsequent chapters, it is important to keep this current situation in mind taking into consideration the fact that there are many other challenges other than those related to sustainable management of resources. Especially the almost one billion urban poor living in unplanned and un-serviced informal settlements represent one of the most significant service delivery challenges related to poverty alleviation and sustainable development.

2.1 Entering the Urban Millennium

In 2008, for the first time in history, over half of the world's population were recorded to be living in urban areas. This equates to approximately 3.3 billion people, but by 2015 the urban population is expected to reach 60% (UN-Habitat, 2005) and will continue to grow to an estimated 4.9 billion by 2030 (UNFPA, 2007). As illustrated in Figure 2.1, the majority of this growth is expected to occur in low and middle-income countries and it is predicted that 95% of the urban population growth will take place in the developing world over the next two decades, and 80% of the world's urban population will be located there by 2030 (UNFPA, 2007).

Fig. 2.1: **Urban and rural population trends, highlighting the increasing urban growth in less developed countries** *(Source: UNDESA 2007)*

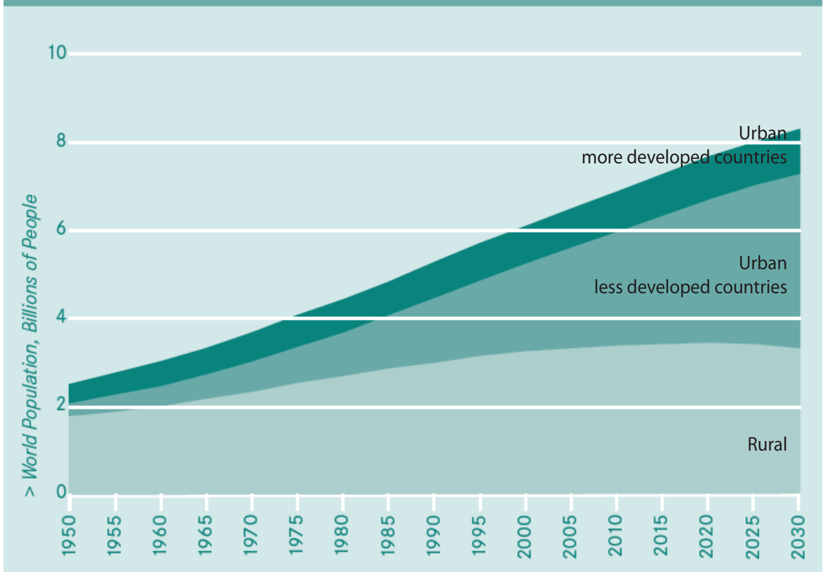


Figure 2.1. Urban and rural population trends, highlighting the increasing urban growth in less developed countries. Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2006 Revision and World Urbanisation Prospects: The 2007 Revision, http://esa.un.org/unup (accessed 2009-04-21).

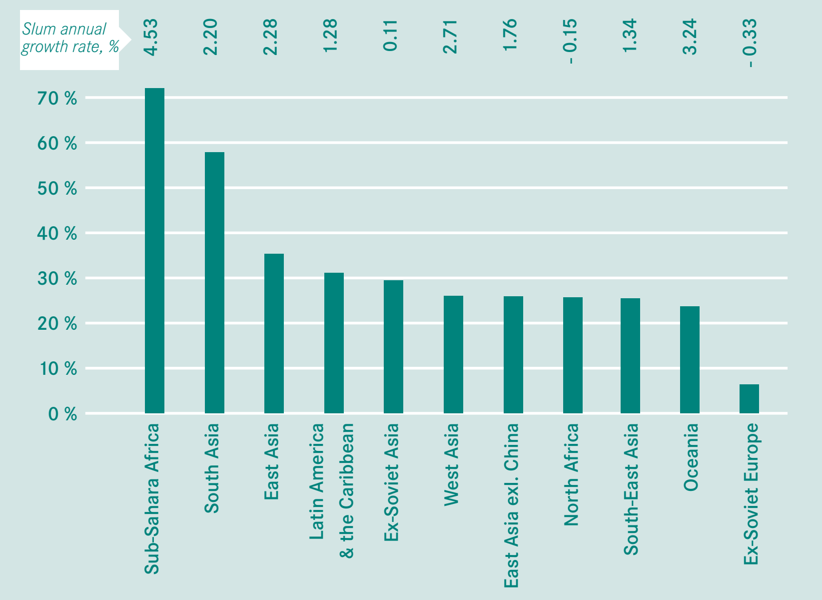
There are a growing number of "megacities". These are urban agglomerations with populations over 10 million. In 1950, New York was the only megacity in the world; today there are over 25 (UNDESA, 2007). However, the majority of the urban growth is in fact in smaller (less than 0.5 million inhabitants) and medium (1 to 5 million inhabitants) urban centres. In 1950 there were 83 cities with populations of more than 1 million, but by 2007 that number had grown to 468 (Brinkhoff, 2009). In 2006, three-quarters of the urban population already lived in these smaller cities and this percentage is expected to continue growing.

2.1.1 Slums and urban poverty

Although cities provide the focal points for major socio-economic transformations that drive national economies, they are also centres of poverty with large populations living in informal settlements and slum areas. Empirical results show that the poor urbanize faster than the population as a whole (Ravaillon et al., 2007). However, the urbanisation of poverty must be understood in the context in which it occurs. The accelerated economic growth in China and India in the past two decades, while leading to rising income inequality (especially in urban areas), have lifted over half a billion people out of $1-a-day poverty between 1981 and 2004. In Sub-Saharan Africa though, the urbanisation process has not been associated with falling poverty and in many countries rural and urban poverty prevalence is almost the same (UN Habitat, 2008).

According to UN-Habitat, almost one billion people (one in six people) were living in informal settlements in 2005 (see Figure 2.2). This is expected to increase to 1.4 billion by 2020, with the biggest growth taking place in Africa and South Asia (UN-Habitat, 2008). Informality

Fig. 2.2: **Urban population living in slums by region (% of total), 2005**
(Source: The Economist, 2007).



is complex, for example, all informal settlements are not slums and all inhabitants of informal settlements are not poor. However, a common factor is that they tend to be underserviced.

Although there are exceptions, existing governance structures are also often reluctant to legalize informal settlements and continue to treat them as non-existent. This leads to a consistent policy of under-estimating the scale and depth of urban poverty by using a flawed statistics that are often based on outdated projections.

The lack of formality of these settlements means that they are often not entitled to be connected to municipal infrastructure and services. In addition, official structures may lack the capacity to extend services to informal areas. Thus, a main feature of urban population growth is the fact that it is composed, to a large extent by poor people living in the unplanned and un-served informal settlements, many of which become slums.

2.1.2 Complexities of service provision

A key determinant on demands for urban services is the population growth rate. Although in many cities, the population is increasing rapidly, especially in the larger megacities, this is not always the case in smaller market towns which may be increasing as well as decreasing in size due to rural – urban migrations. Cities can be characterised by their level of economic development compared with the level of sunk investments in urban sewerage, as show below in Table 2.1.

Conditions in the urban context are significantly different from the rural environment, leading to substantive and particular implications for implementation and management of urban services. For example, socio-cultural complexities tend to be greater than in urban areas due to the diversity of ethnicity and religious affiliation, the general lack of community homogeneity, transient and unstable populations, and a higher degree of renters rather than owners. Although reference is often made to the "urban poor" as a homogenous group, in reality there are significant differences and conflicts of interest among and between them. In addition, high population densities have implications on the complexity of technical issues. Consequently, devising common intervention strategies for transient urban communities is especially challenging.

Depending on the political structure of the city, the division of responsibilities relating to sanitation can be an institutional headache. Responsibilities for sanitation service provision are often fragmented and accountability for environmental, health and water resource impacts related to poor sanitation are housed in different departments and ministries. This fragmentation makes coordinated action difficult and can even lead to conflict between stakeholders for resources and areas of influence. "Poor" urban governance further complicates issues. The

Table 2.1 **Economic development and level of sunk investments.** *(Source: Authors)*		
	with sunk investments	without sunk investments
'Poor' cities	Central areas of many south Asian cities, African capital cities (although only a few have working networks).	All the rest
'Rich' cities	New development zones in China, Japan, Korea, etc. New towns in Europe and other OECD country cities.	Shanghai, Shenzen, Mumbai, other fast growing metro areas.

need to provide services in exchange for votes often takes precedence over more rational planning processes. For example, politicians looking to gain votes in a certain neighbourhood are more likely to promise delivery of service provision. In this way, certain neighbourhoods may receive extra services while some that count less in the political power struggle or have supported a part other than the government will receive none.

In addition to demands for investment in other urban services such as transportation, energy and water, local authorities are faced with myriad problems related to sanitation provision. The reasons for slow progress in the sanitation sector, both in developed and developing areas, are manifold and explain why performance, both at policy and implementation levels, have been so weak and sanitation continues to be neglected by municipal, national and international decision-makers. Perhaps it is because of the taboo nature of the topic that gives it lower prestige and makes politicians shy away from seriously putting sanitation on the table. Even when sanitation systems are implemented they are often done with minimal effort to adapt the design to local conditions or improve its efficiency. Thus, the systems appear adequate on paper, but have significant deficiencies in practice.

Figure 2.3 Image of Kibera, Nairobi - illustration of "urban complexity" (Source: David Crosweller).

The main shortcomings for both policy and implementation are given below:

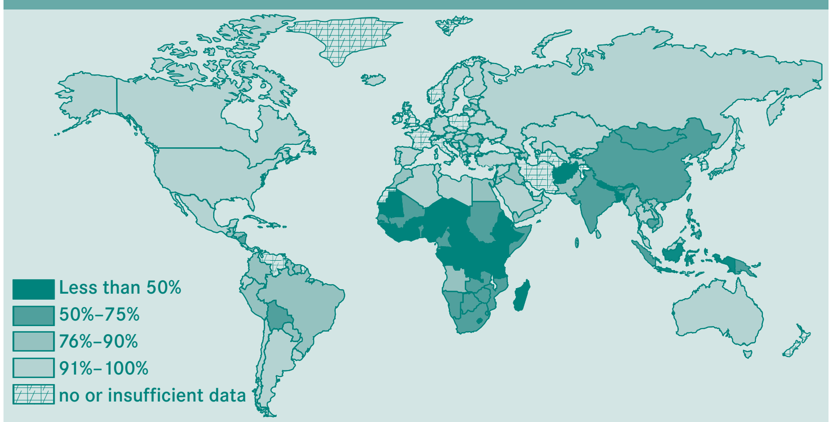
- Weak institutional and poor policy frameworks,
- Lack of political will due to low prestige of the sector,
- Inadequate and poorly utilised resources,
- Inappropriate approaches and national standards & regulations,
- Neglect of consumer preferences.

2.2 Urban Sanitation

Many cities continue to experience population growth that far exceeds the ability and resources of local authorities to extend coverage of infrastructure or provide adequate levels of sanitation services. As a result, there is considerable diversity in the levels of service provision within different parts of cities. These range from areas with high incomes and high water consumption, which are connected to sewerage systems, to pour flush toilets connected to cesspools or open drains, to no provision at all. Most middle and upper income groups live in urban areas. This ensures that average incomes and the proportion of people with services is higher in urban areas. However, this does not mean that the poorest of the urban population, most of them living in unplanned informal settlements, have better basic services than their poorer rural counterparts. In addition, proximity does not necessarily mean access to improved services and many governmental authorities are reluctant to accept the extent to which their citizens lack access to water, sanitation, habitable dwellings and secure land tenure.

The majority of the urban population living in low income settlements use some form of on-site sanitation but many of these facilities are rudimentary and poorly maintained. These systems are considered to be inadequate from a public health perspective. Excreta flows out from cesspools into the streets, is dropped indiscriminately through open defecation, or tossed over the wall as "flying-toilets" (as in the case of Kibera as described in Box 2.1) or a bucket of wash water. It is these conditions and the corresponding degradation of living conditions,

Fig. 2.4: **Sanitation coverage in urban areas in percent, 2006.**
(Source: UN-JMP report, 2008)



health and economic opportunities that lead to the inclusion of sanitation as one of the United Nations Millennium Development Goals (MDGs: target 10 of Goal 7 seeks to halve the percentage of people living without adequate sanitation by 2015). But, target 10 of Goal 7 only? seeks to halve the percentage of people living without adequate sanitation by 2015. Those living in more affluent conditions are more likely to have an in-house flush toilet connected to a septic tank or sewer. But many of these systems are also poorly maintained which, as described below, can cause public health concerns, on local level as well as in downstream areas. The provision of sanitation services to urban communities is a challenge that urgently needs to be addressed. Although sanitation coverage is significantly higher in urban areas than rural areas, 40% of the developing region's urban population still lacked adequate sanitation in 2008 (UN-JMP, 2008). In situations not unlike those found in historical accounts (see Chapter 3), inhabitants in many urban areas suffer from ill health, lost income, inconvenience and indignity due to the lack of access to a proper toilet.

The United Nation's International Year of Sanitation 2008 highlighted the enormous increase in the number and use of improved sanitation facilities in accordance with the MDG target on basic sanitation. According to recent estimates, around 400,000 people will have to be provided with adequate sanitation daily, during the period 2001

Box 2.1: The size of the slum challenge in Kibera

Kibera on the outskirts of Nairobi has the reputation of being the largest slum in Africa, with a population density of around 250,000 people per km^2. This informal settlement on the edge of Nairobi is estimated to house between 600,000 to 1 million people, more than a quarter of the capital city's population. Tight quarters and a lack of toilet facilities mean that many residents resort to the use of "flying toilets", i.e. plastic bags that are used for defecating and then thrown into ditches and roadsides. These plastic bags clog the drainage ways and pile up in empty spaces and on roof tops where they often break and spill their contents back into the environment. The result is huge volumes of human excreta being released directly into the public or shared spaces of the Kibera inhabitants. Depending on their diet each resident will excrete around 1.5 litres of urine and 250 g of faeces daily (Jönsson et al., 2004). Even if one uses the conservative estimate of the population in Kibera (600,000) this means that 900 m^3 of urine and 150 tonnes of faeces are dumped in Kibera every day. That is more than 330,000 m^3, or the equivalent of 131 Olympic-sized swimming pools, of human waste that are dumped in Nairobi's environment every year.

and 2015, to meet the sanitation target of the MDGs. But, these global statistics hide large discrepancies between the “haves” and “have-nots”, regarding regional variations as well as within individual cities.

Types of urban sanitation system

Conventional sewerage systems require vast investments and tend to be expensive to operate and maintain. They are also dependent on a well resourced institutional set-up, with an advanced regulatory and enforcement framework and well trained staff to function properly. Many utilities in lower income countries are not able to meet these criteria and are extra challenged to meet the complex demands for service provision in burgeoning cities typified with rapidly expanding unplanned settlements.

The level of sewerage coverage ranges enormously in different cities in different parts of the world. In northern Europe and North America, it is not unusual for every household to have in-house flush toilets connected to a sewer. However, in global terms, they are by far the minority. A typical example of the opposite is from Freetown, Sierra Leone, where there is a total of four kilometres of sewerage which only partially serves the business district in the centre of a city of more than 1 million inhabitants.

For these reasons, the vast majority of households will remain served by some form of on-site sanitation for the foreseeable future. These on-site systems may be proper septic tanks , but generally rudimentary and poorly constructed pit latrines or cesspits are used / can be found.

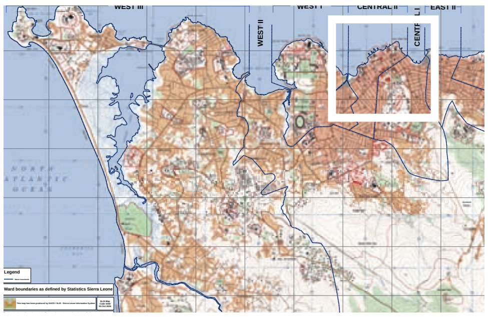


Figure 2.5: Sewerage coverage in Freetown, Sierra Leone (Atkins, 2008)
(The continous black lines indicate installed sewer line.)

This picture is seen in most cities throughout the world.

However, there are a number of low-cost sewerage technologies that are viable in urban areas. These are known as condominial sewerage, small-bore or low-cost sewerage systems. These may be connected either to the conventional sewerage system or to a decentralised wastewater treatment system (DEWATS) such as these ones promoted by BORDA in Asia and parts of Africa.

Another option for poor communities living in dense urban settlements, where there is no room for the installation of household latrines, may include access to communal latrines. However, these need maintenance and a reliable water source. Unfortunately there are many examples of communal latrines which are in poor condition On much promising approach to attract users is the combined development of communal latrines with bathing and washing facilities. An example is shown in Figure 2.6.

Figure 2.6: Communal latrines with bathing and washing facilities in an informal settlement of Nairobi, Kenya (Source: Sandec)

2.3 Impacts of Poor Sanitation

Although urbanisation offers economic opportunities, increasing human density also corresponds to increasing quantities of waste. Excessive waste accumulation leads to environmental degradation, water pollution and a multitude of related health and livelihood impacts. The growth of cities and its implications for resource consumption and climate change is already showing to be the single largest influence on global development in this century. Since the majority of urban growth will continue to occur in the cities of the developing world, what happens there will have impacts for the rest of the world.

In fact, the size of the urban waste problem is huge and growing. Given that an average human produces about 1.5 litres of excreta per day, a city of one million discharges 1500 cubic meters of waste daily. This does not include the volumes of greywater (more than 20 times as much) and solid waste that accumulate in streets, drains and waterways. For the majority of households served with various forms of on-site sanitation, which need emptying once every year or so (sometimes more, sometime less), there is rarely any form of treatment provided. Faecal sludges is discharged illicitly by both registered and unregistered truck drivers into open drains, sewers or land on the outskirts of cities.

2.3.1 Health impacts

Inadequate sanitation, water supplies and poor hygiene are critical determinants for diarrhoeal diseases and infectious diseases transmitted by the faecal-oral route. Poor maintenance, combined with overuse, frequently results in latrines that are degrading and a source of disease transmission. Poor sanitation also limits the impact of drinking water quality improvements.

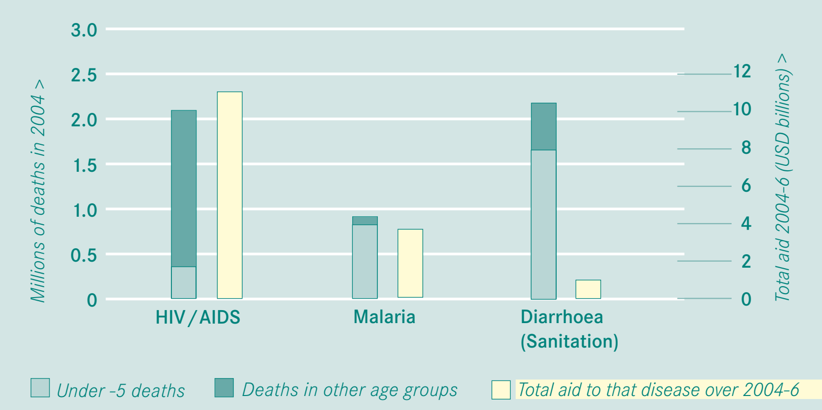
Acute epidemics of cholera may grab the headlines but it is the impacts of repeated gastro-intestinal infections that causes prolonged bouts of diarrhoea that are of greater concern. Around 4,000 people, mostly children, die every day as a result of diarrhoeal diseases (WaterAid, 2009). This accounts for more than 40% of the total number of deaths related to unsafe water, inadequate sanitation facilities and poor hygiene behaviour (ibid). In fact, diarrhoea remains the second leading cause of death among children under five globally; killing more children than AIDS, malaria and measles combined. Geographically, Africa and South Asia account for over half the cases of childhood diarrhoea. The total disease-attributable to diarrhoea in all age groups equates to 73 million disability-adjusted life years (DALYs). Taking into account the additional health burden associated with malnutrition caused by diarrhoea (approximately 20 million DALYs, this is equivalent to the burden associated with Acute Respiratory Infections (95 million DALYs). In addition, other "neglected" tropical water, sanitation and hygiene related diseases such as trachoma, schistosomiasis and chronic infestations by intestinal parasites (nematode worms), affect over one billion people globally and constitute a further health burden on 19 million DALYs .

Repeated diarrhoea exacerbates malnutrition which stunt children's growth and although intestinal worms are unlikely to cause mortality directly, they are responsible for substantial disability. Up to two thirds of all schoolchildren in some African countries are infected with parasitic worms. Malnutrition has been estimated as an underlying cause between 35% and 53% of child deaths globally. Over half of this malnutrition-associated mortality is associated to complications due to diarrhoea and nematode infections caused by poor sanitation.

Women are affected disproportionately by lack of access to clean water and basic sanitation and are at higher risk of exposure to water and sanitation-related diseases. Around 1.3 billion women and girls in developing countries live without access to private, safe and sanitary toilets. Women without toilets can spend a considerable time each day queuing for public toilets or seeking secluded spots to defecate, during which time they put themselves at risk from rape or other violence (UN-Water, 2006). In addition, poor menstrual hygiene can lead to increased health problems such as infections and infertility. Women may also suffer from other illnesses resulting from poor sanitation such as urine retention due to lack of access to latrines.

Studies have shown that investments in sustainable sanitation in developing regions brings a return in the range of US$5 to US$46 (depending on the intervention) for every US$1 invested (Hutton et al., 2007). But although sanitation related disease causes more deaths than either HIV/AIDS or malaria, projects for the provision of sanitation received significantly less funding (Figure 2.7).

Fig. 2.7: **Neglect of sanitation in global health financing** *(Source: WaterAid, 2009).*



2.3.2 Pollution of water resources

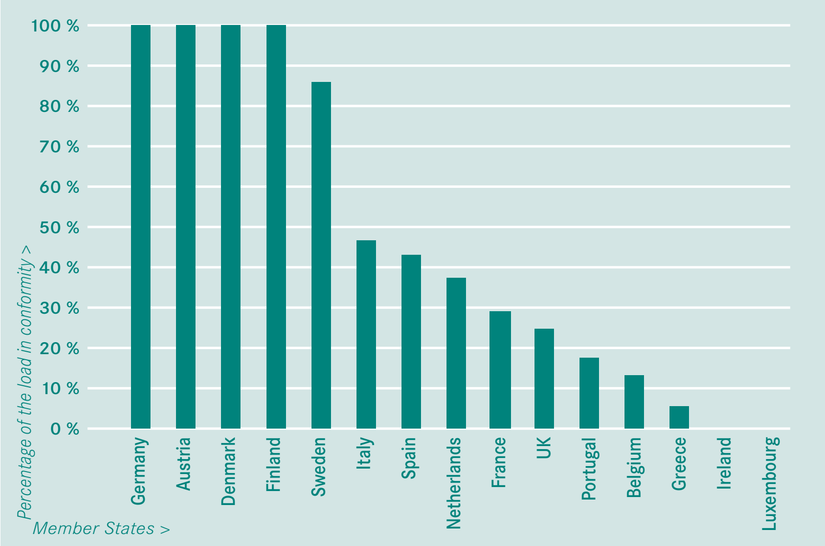
Improved and hygienic sanitation facilities aim to solve problems related to contamination of the household and local environment. However, also such installations are often the source of pollution, due to poor treatment of the effluent and residues.

Eutrophication is the enrichment of freshwater and marine systems with nutrients, particularly nitrogen and phosphorus. In freshwater systems, phosphorus is normally limited, so when excessive amounts are released from agricultural runoff and municipal sewage sources it causes serious water quality problems. Algal blooms result and alter aquatic eco-systems eliminating species of fish and vegetation by clouding the surface of the water and decreasing oxygen levels in deeper waters and sediment. Eutrophication has been a serious environmental concern in much of the developed world for the past 30 years, and is now a global concern.

A major reason for the degradation of natural watercourses relates to the poor management of excreta and treatment. None of the aforementioned sanitation systems have been successful on a global scale at controlling the discharge of organic waste into the environment. It is estimated that more than 90% of sewage in the developing world is discharged directly into rivers, lakes, and coastal waters without treatment of any kind.

Proper disposal of human waste remains a challenge even in the "developed" countries of Europe and North America. Wastewater treatment in all parts of Europe has improved significantly since the 1980. However there remain many inefficiencies and treatment levels vary greatly between regions. According to the EU Commissions' 2007 report on wastewater treatment, only 61% big cities in Europe (population greater than 150,000) complied with the treatment requirements of the Urban Waste Water Treatment (UWWT) Directive.

Fig. 2.8: **Percentage of the load in 'big' European cities (>150 000 p.e) having required treatment level in 2003** *(Source: UWWTT, 2007)*



In fact, 17 of these cities had no treatment at all in 2003, including Milan, Cork, Barcelona and Brighton (UWWT, 2007). Only four out of 15 EU countries fully treated the wastewater from their "big" cities to the required treatment levels (Figure 2.8). For example, in 2001, the Italian government was taken to court for dumping the waste from the 2.7 million residents of Milan untreated into a tributary of the river Po. The situation in south-eastern European countries (for example Turkey, Bulgaria, Romania) is worse and only approximately 40% of the population is connected to wastewater treatment facilities. The situation is however improving, partly due to better reporting to the commission, and partly due to real improvements in the treatments, so that some of the cities now conform to the EU directives and others plan to complete work soon.

2.3.3 Economic impacts

Illnesses related to poor sanitation have a direct impact on household finances in terms of the financial outlay to pay for medicines and primary healthcare as well as the loss of working days due to sickness. In addition, the ill-health of one-member of the family has repercussions on the others.

Chronic infections have long-term impact in terms of future educational performance. Diseases consume nutrients and calories and lead to listlessness and trouble concentrating in the classroom. Girls are also reluctant to attend schools, and parents are disinclined to send them, if there are no safe, private toilets for them to use.

Malnutrition and poor state of health, amplified by for example diarrhoea and helminth infections, is particularly a problem for those who depend on their physical strength to earn a livelihood. Thus, a greater share of the socio-economic burden falls on poor communities, whose members rely upon income from labour. This increases inequalities in society. In the longer term, illnesses drain household savings, lower learning ability, reducing productivity and impacting upon development objectives. Ill-health is the single most common trigger for the downward slide into poverty.

Contamination of the natural aquatic resources also has major economic implications, both directly in terms of the cost of having to treat water more extensively after abstraction and indirectly in terms of the impact of the polluted waters on tourism.

2.4 Sustainability Issues – The Impending Nutrient Crisis

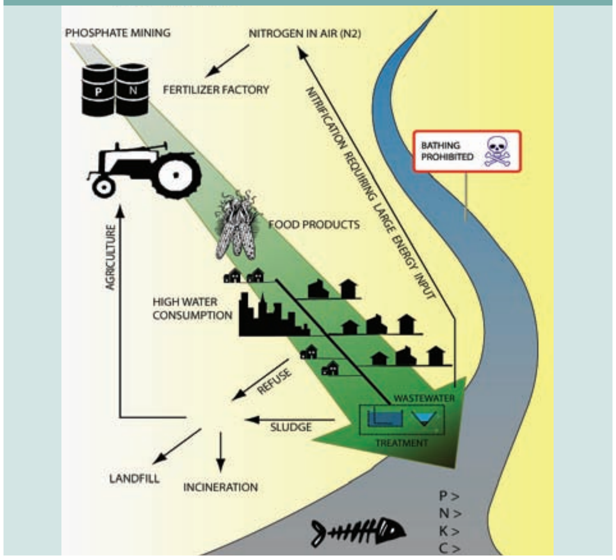
Disposal of faeces and urine remains a problem in spite of its content of valuable nutrients and organics with soil-enriching properties (Lundin et al., 1997). A consequence of food producing areas being far from the point of consumption, combined with subsidised fertiliser-consuming agricultural practices, is that much of the intrinsic value of organic wastes containing nutrients is lost.

In the combined wastewater system, large volumes of water are mixed with relatively small amounts of waste and the potential for resource reuse tends to be lost due to excessive dilution. In addition, the mixing of waste streams results in the contamination of valuable components of wastewater with more persistent pollutants, which also makes recovery of resources more problematic (Figure 2.9).

The depletion of limited available mineral phosphorus rock resources is increasingly recognised to be an impending crisis. Modern agricultural farming practices depend upon the continual application of synthetic fertiliser to support crop production. The decreasing availability of natural phosphorus deposits in the soil combined with the accumulation of phosphorus in the natural environment have led to increasing concerns about the sustainability of current agricultural practices and a focus of attention on strategies to mitigate associated environmental problems.

Phosphorus is a nutrient essential to all living organisms, and thus, it is essential in food production for humans. However, although it is the eleventh most abundant element on Earth, phosphorus never occurs in its pure form and is always bonded with other elements forming compounds, such as phosphate rock. More importantly, much of the phosphorus in soil is not available to plants, thus requiring nutrient additions to produce crops. As a result of increasing food demands, this non-renewable resource is being mined at an increasing rate to produce artificial fertilisers, which use approximately 80% of phosphates used globally (Cordell, 2009). A change in sanitation practices could have a positive impact on this situation. For example, the widespread practise of using wastewater for irrigation is one way to recycle phosphorus, however, due to health issues this practice should follow certain standards (for example www.fao.org).

Fig. 2.9 Resource flows in conventional urban wastewater systems
(Sandec 2005, adapted from Lange and Otterpohl, 2002)



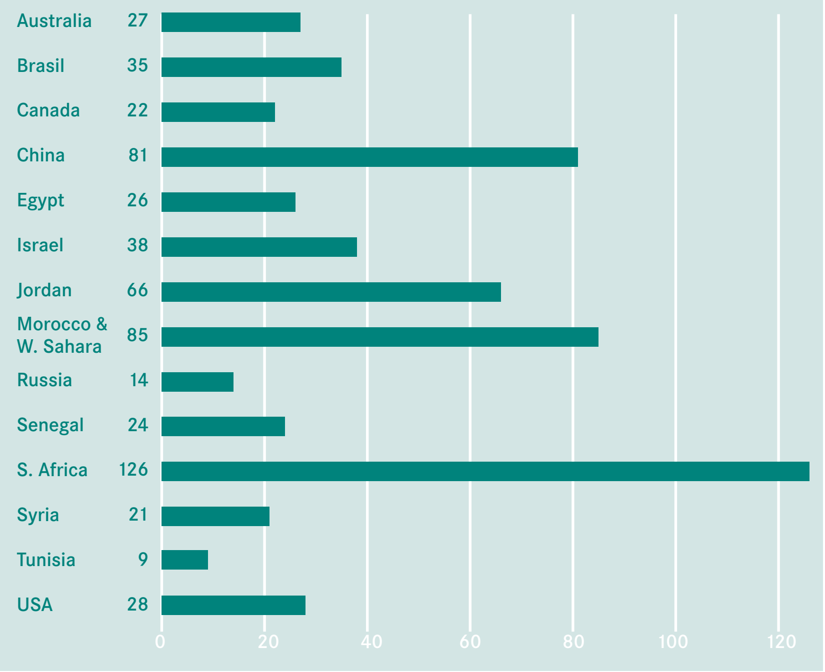
Box 2.2 How long will Phosphorus resources last ?

More than 30 countries mine phosphate rock for commercial purposes, with the top 12 countries supplying 93% of all phosphorus. China, Morocco and the United States alone currently produce almost two-thirds of global phosphate. In addition, China's reserves are estimated to account for 37% of the world total and Morocco's reserves for 32%. Due to the finite nature of phosphorus resources, Morocco and Western Sahara have been engaged in a border conflict since 1975 as a result of the reserves in the contested territory.

Estimates on the remaining amount of phosphorus vary, as do projections about how long it will take to deplete the irreplaceable resource entirely. Figures range from 60-130 years (Steen, 1998) and 60-90 years (Tiessen, 2008), at current market prices with diverse assumptions about the rate of production and demand. However all sources agree that continued phosphorus production will decline in quality and increase in cost. The relatively inexpensive phosphorus we use today will likely cease to exist within 50 years (see Figure 2.10). It is imperative that we begin to recycle phosphorus and re-turn it to the soil to decrease the need for mined phosphorus as artificial fertiliser. Within a half century, the severity of this crisis will likely result in increasing food prices, food short-ages and geopolitical rifts.

Between 1950 and 2000, about 1 billion metric tonnes of phosphorus has been mined (Gumbo et al., 2002). During this period, about 800 million metric tonnes of fertiliser phosphorus were applied to the Earth's croplands. This has increased the standing stock in the upper 10 centimetres of soil in the world's croplands to roughly 1,300 million metric tonnes, an increase of 30%. Close to a quarter of the mined phosphate (250 Mt) since 1950 has found its way into the aquatic environment (oceans and fresh water lakes) or was buried in sanitary landfills or sinks. For 1990, the amount of phosphate discharged into oceans was double the amount of phosphate applied as fertiliser (Tiessen, 2008).

Fig. 2.10: **Phosphate rock – years of extraction remaining based on current reserves from 2006 using a 2% yearly increase** *(Source: USGS)*



3 Looking Back to Move Forward

Thorsten Schütze
Patrick Bracken
Jonathan Parkinson

Since the mid nineteenth Century, urban sanitation in industrialized countries has been characterised by flush toilets connected to sewers that carry excreta away from areas of inhabitation. This system has become such an established standard that both the reasoning behind its development and its suitability and sustainability in the twentyfrist century has long gone unquestioned. However the history of urban sanitation did not begin in the nineteenth century and important orientations can be gleaned for the future by examining how the current paradigm for urban sanitation was developed.

3.1 Traditional Societies Practicing Excreta Reuse

Prior to the advent of agriculture roughly twelve thousand years ago, communities were dependent on hunting and gathering as a means of meeting their food requirements. The taming of livestock and cultivation of crops enabled larger human populations to settle in fixed locations for longer periods than had been previously possible. However, as a result, communities were faced for the first time with the problem of excreta disposal.

Many traditional agricultural societies approached this problem in a pragmatic way, recognising the value of human waste for soil fertility and practising the collection and reuse of excreta. This enabled them to live in communities in which nutrients and organic matter contained in excreta were returned to the soil. Historical descriptions about these practices are sparse, but it is known that excreta reuse was practiced widely in Asia (for example in Japan and in Korea as described in Box 3.1) but also in Central and South America. However, the most renowned example of the organised collection and use of human excreta to support food production is that of China (Brown, 2003). The Chinese were aware of the benefits of using excreta in crop production more then 2500 years ago, enabling them to sustain more people at a higher density than any other system of agriculture.

Aquaculture using excreta has also been traditionally practised in many parts of South-East Asia as a means of producing fish and aquatic plants for human consumption (Edwards, 1992). The most basic approach toward this has been the use of overhung latrines installed directly over fish ponds into which the excreta drops directly into the water. Fish such as tilapia may be cultured in caged enclosures and freshwater plants (macrophytes) such as water spinach and water mimosa also grow in faecally contaminated surface waters. These products can be used as a secondary stage feed stock for the production of larger, high-value fish and crustaceans or as an input for land-based animal husbandry systems (Mara and Cairncross, 1989).

Excreta reuse was also popular in ancient Arab cultures where the collection and use of excreta was also incorporated into agricultural systems. These practices continued for many centuries. In the twelfth and thirteenth century, Ibn al-Awam, an Arab living in southern Spain wrote about techniques for the composting of human excreta. He also noted the benefits for plant health and that the application of compost could cure diseases of plants and trees.

In the urban centres of Yemen such as in Sana'a, elaborate sanitation systems were developed in which the separate collection of excreta was installed in multi-storey buildings. Faeces were collected in chambers at ground floors, which were connected to toilets in the upper storeys via vertical drop shafts. But, after drying, the faeces were used as fuel for cooking rather than for agriculture. Urine did not enter the same shaft. Instead it drained horizontally from the toilets along a channel through the outside walls, where the liquid quickly evaporated.

Box 3.1 Traditional excreta reuse in Korea

In Korean traditional societies, it was well known that urine and faeces could enhance land fertility. The high value of composted excreta for food production is reflected in the old Korean proverb: *"You can always give away a bowl of rice, but never a bag of compost"*. It was also known that faeces had to be handled in a safe way as they could cause illness. As a consequence, the application of fresh, uncomposted faeces was only allowed in early spring or in autumn after the harvest.

Until the beginning of the twentieth century, a graded pricing system existed for the marketing of different types of faeces collected from households and transported to agricultural areas outside the cities. (Schütze, 2005). Various kinds of toilets were used in cities as well as in rural areas to collect excreta for reuse, with the type of toilet depending on the conditions of each location:

- *Pot-toilets* were mainly used in urban areas. Due to the limited space the excreta, mixed with ash, was collected regularly and carried out of the city to designated sites where it was composted.
- *Pig-toilets* were used mainly in rural areas. Human faeces were consumed directly after defecation by animals (particularly pigs).
- *Ash-toilets* were used in areas with relatively low building density and near agricultural land. The faeces were stored and composted on-site.
- *Temple toilets* were used in temples. They are *dehydration toilets*, whose working principle is based on the collection and drying of faeces on-site. (Lee, 2000)

The value of human excreta for soil fertility was also well known in traditional societies of the Americas. In Mexico and Peru for instance, both the great Aztec and Inca cultures collected human excreta for agricultural use. The Incas in particular had a high regard for excreta as a fertiliser and stored them as a dry powder until the next planting, when it was applied to the ground together with the maize seeds. (Bracken et al., 2006). In Central Amazonia the ancient cultures collected urine and faeces separately. Through processing charcoal, organic waste and faeces in a special way, they produced a so-called "terra preta" (black soil), which allowed the sustainable fertilization of forest gardens for agricultural production as well as the conservation and enhancement of soil fertility in the hot and humid climate of the tropics (Pieplow, 2008).

In addition to agricultural production, there have been various other practices carried out by traditional societies which involved excreta reuse. For example, the Celts had many uses for urine including for personal hygiene and for ritual, but of particular practical importance was its use for dyeing and washing clothes. In India, ancient Sanskrit texts outlined the medicinal use of urine through "shivambu" (auto-urine therapy), which was practiced throughout India and Asia, and still has a popular following today (in natural medicine and traditional healing). Like the Celts, the Romans were well aware of the cleaning power of urine and also used it for washing clothing, developing in some towns and cities the logistics to collect larger volumes of urine (Bracken et al., 2006).

In ancient Roman and Greek cultures, the use of excreta in agriculture was widely practiced. Texts exist from both ancient Roman and Greek authors praising the virtues of its use in agriculture. The Romans also practiced the greywater reuse as huge volumes were used as a result of the Roman bath culture. Daily per capita water consumption has been estimated to be up to 600 litres for the upper classes, whereas slaves and soldiers may have used around 200 litres (Guhl, 2003). As the reuse of excreta for agriculture was the rule in Roman times, the wastewater from most settlements consisted mainly of greywater. This water was often led outside of the settlement and used to irrigate agricultural areas.

3.2 Dry Sanitation in the Twentieth Century

As shown in Figures 3.5 and 3.6 and described in Box 3.2, these traditional forms of sanitation and excreta reuse have continued in various parts of the world for centuries and were still common practice at the advent of the Industrial Revolution. Even as the world became increasingly more urbanised, the nutrients in excreta from urban sanitation systems were still used in many societies as a resource to maintain soil fertility, despite rising population densities.

Figure 3.1 Traditional pot-toilet in Korea.
The excreta was defecated in pots, which functioned as a toilet and were emptied regularly. The excreta was composted in open swales before they were applied on fields (Oh, 2010).

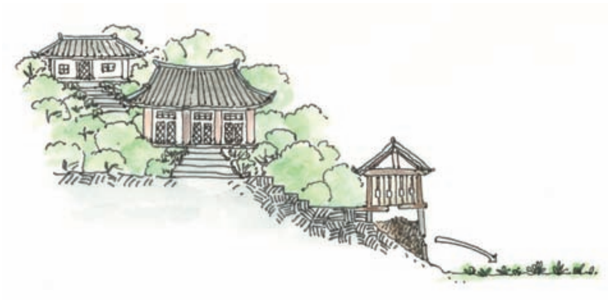


Figure 3.2 Temple-toilet next to houses and agricultural areas. The faeces was defecated in well-ventilated compost chambers. Composted faeces was removed from the bottom and used directly for the fertilization of fields (Oh, 2010).

Figure 3.3 Traditional manual transport of excreta in Korea.
Left: urine is transported in an earthen container. A stick is used for supporting the lifting and safe walking. Right: faeces are transported in pots which are fixed on a horizontal carry-stick (Oh, 2010).

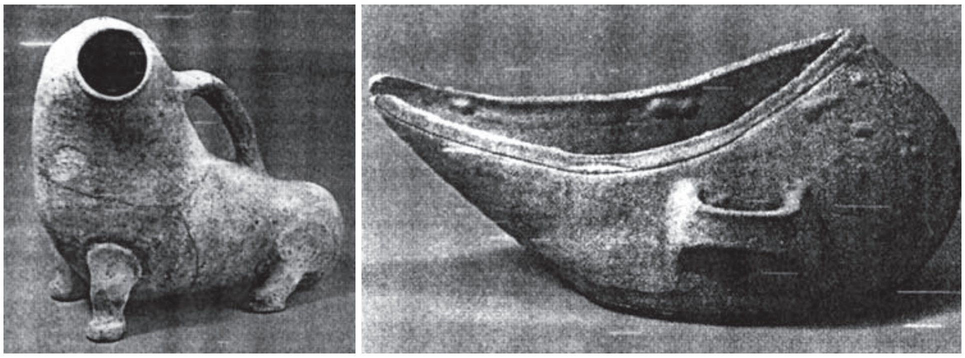


Figure 3.4 Historical chamber pots from Korea, for men (left) and women (right) (Lee, 2000).

Figure 3.5 Pig-toilet on the island of Jeju, South Korea. The opening in the stone wall is the outlet from the latrine through which the faeces passes for the pigs to consume (Schütze, 2005).

Figure 3.6 Vault toilet in Kabul, Afghanistan. The "vault" latrine incorporates urine-diversion and collects faeces in an enclosed receptacle prior to collection. The vault is emptied from the street by farmers who take the nightsoil by donkey- or hand-cart out of the city for use in agriculture (Parkinson, 2009).

In Japan a highly organised use of excreta in agriculture was practiced. Public toilets were constructed specifically with the aim to collect excreta for reuse. Urine was also regarded as a useful fertiliser and was collected separately for direct use (Matsui, 1997). The faeces were applied at rates of up to 4 tonnes per hectare on fields in areas that were considerably more urbanised than that of China. In 1911, King (in Brown, 2003) reported seeing night soil transported out of Yokohama and Tokyo "*carried on the shoulders of men and on the backs of animals, but most commonly on strong carts drawn by men bearing six to ten tightly covered wooden containers holding forty, sixty or more pounds each*". Statistics from the Japanese Bureau of Agriculture for the year 1908 show that almost 24 million tons of excreta had been used on around 13.5 million hectares of arable land.

The practice of using the nutrients in excreta and wastewater for agriculture continued in China into the middle of the nineteenth century, and the marketing of fertiliser derived from excreta and organic waste was a thriving business (Brown, 2003). Contractors first had to pay for a license before collecting the excreta and selling it on to farmers. Larger towns were often zoned, so that those living nearer the fields paid less for their collection than those living in the centre. According to Scott (1952), "*the annual market price of the excreta output of the entire population was estimated at "between 50 and 80 million pounds sterling at 1924 market prices*."

As a result of the agricultural benefits, excreta reuse is seen to have widespread economic benefits and, up until recent times, has employed a considerable number of people. Sanitation and waste management in European cities was carried out by an informal army of self-employed private sector workers. In most cities, the night-soil men were part of an informal but complex logistics chain to remove excreta from within cities and to transport it to nearby agricultural land. The value of urine and faeces as a fertiliser was clearly recognised with well-developed systems in place to enable the collection of excreta from cities and its transportation to fields. In most cases, these systems were generally not formally organised from a central authority perspective.

In Belgium, the sale of human excreta and animal dung was also a booming business. By the sixteenth century, up to 60% of farmers expenditure was on fertiliser (in the form of excreta and dung). Near the city of Antwerp, farm rents soared, but farmers were able to cope with the increasing costs of land thanks to the high agricultural production, which was supported by the reuse of excreta. The excreta from Dutch towns were transported for intermediate storage by barge to great stores of manure on the river Schelde between the cities of St. Amand and Baasrode, before they were sold and applied on agricultural land (Brown, 2003). Farmers were eager to get hold of the fertilisers to increase production and, as a result, the overall urban environment also benefited.

In Paris, in 1850, urban agriculture was practised on 15% of the city area and Paris exported vegetables, compost and fertiliser derived from pits to the surrounding regions (Illich, 1987; Lange, 2002). The agricultural utilisation of excreta from these pits, tubs or vaults was generally financed by building owners or city councils and was performed by the municipalities themselves or by private businesses or associations (Mels et al., 2005). As far as the supply was covering the demand, the utilisation of the excreta was no problem. The excreta were carried to collection points where the farmers picked them up, carried them to their fields and applied them. However, in bigger cities where huge amounts of excreta were available, it became less feasible to utilise the excreta in the direct neighbourhood of the cities. As a result, methods were sought to reduce the quantity of waste to enable transport to agricultural areas further afield. One approach that was practiced in several cities in Germany and the Netherlands in the period from 1870 until 1915 involved the production of a fertiliser powder with the so-called "Liernur system", consisting of dried excreta called "*poudrette*" (Mels et al., 2005). The production process was based on the dehydration of human excreta by heat. The end product was brown powder, which was packed and sold in bags of 75kg. An amount of 1 m^3 excreta and peat powder was required for the production of 125kg *poudrette*, with a water content of 12 percent. However, the process required an immense energy input for drying the excreta, making it economically less attractive as other forms of sanitation prevailed.

In order to increase the regularity of collection of faeces in short intervals and thus to reduce odour problems, a "tub" system was introduced in some cities. Tubs or barrels were either placed under single toilets or under vertical pipes to collect excreta from multi-storey buildings. These were then collected weekly and carried out of the city where the contents were either used directly for fertiliser or processed to produce compost. However, even though the collection pipes were mechanically ventilated and systems were introduced to close the toilet after use, the stench of these systems was overbearing. Therefore, it became increasingly common for the excreta to be covered with peat dust, dried topsoil, ash or sawdust to absorb urine and the ammonium, which was the main cause of bad odours. The addition of a powder, consisting of burnt lime and charcoal (in a ratio of 100:15) contributed to further reductions in smell.

These systems, today known as "soil" or "litter" toilets, were relatively widespread in Europe and different models were designed to be equipped with mechanical systems to automatically drop ash or other dry matter on the excreta after each use. The English pastor Moule developed the most famous litter toilet around 1860. The toilet was equipped with an "automat", which covered the excreta with a mixture of sifted soil and coal ash (in ratio of 2:1).

Soil-toilets with separate urine diversion were developed in the second half of the nineteenth century in order to improve performance and comfort (for instance to avoid bad odour). The urine was drained from a specially designed toilet seat through a pipe to a filter basket, which was filled for example with peat powder. The surplus was discharged into ditches and used for fertiliser production. The faeces were dried in a shelter, grinded and mixed with 15 percent urine, before they were dried again and sold as fertiliser (Stadtentwässerung Zürich, 1987).

3.3 The Demise of Excreta Reuse and the Rise of Sewerage

Although reuse has been sustainably practiced for centuries, the following factors have contributed to the demise of traditional practices of excreta reuse in the past century.

1) Growth of urban settlements and increasing distance from agricultural fields

As urban settlements continued to grow and become increasingly denser (see Table 3.1), the logistical challenge of removing the excreta from densely populated city centres to increasingly distant agricultural areas proved to be uneconomical. The traditional buckets and hand carts proved incapable of dealing with the volumes of excreta generated in urban centres and the system began to break down. A description of how the system ceased to function in the capital of Afghanistan is provided in Box 3.2.

Table 3.1: **Samples of 19th Century urban population densities with a modern comparison** *(Brown, 2003)*

In 1894	Population Density (cap per km²)
New York (10th Ward)	130 900
Prague (Josefstadt)	121 350
Paris (Bourse)	108 550
London (Bethnal Green)	91 325
2007	
Mumbai*	29 650

**In 2007 Mumbai was the world's most densely populated city.*
(source: http://www.citymayors.com/statistics/largest-cities-density-125.html)

2) Increasing water consumption and use of flush toilet

The development and widespread implementation of piped domestic water supplies since the nineteenth century, combined with the development of flush toilets created a new type of waste that was not conducive for collection by the traditional systems. One of the primary reasons for the demand for flush toilets was the fact that it could be installed within the home, thus satisfying the need for convenience and privacy, with far fewer problems related to smell.

3) Production of synthetic fertilisers

The nutrient demand of farmland was met for all three major nutrients (N, P and K) using affordable chemical fertilisers, making any efforts to recover and reuse the nutrients and organic material from human excreta uneconomical. Professor Justus van Liebig became the "father of the chemical fertiliser industry" when he discovered that nitrogen is an essential plant nutrient and in his formulation of the "law of the minimum" (1850) he described the effect of individual nutrients on crops (Mårald, 2000).

4) Political intervention

In some societies, most widely known in India, the practice of nightsoil collection by the lowest caste of society was seen to be degrading and inhumane. Even though Indian law prohibited the use of urine and faeces already in the 1960s, when chemical fertiliser production began,and the practice of the so-called "sweeping" was officially banned in 1994, it is well known that the practice is still in operation today. In addition, the real health risks associated with excreta reuse have been used as a reason to make reuse unacceptable from a societal perspective. The traditional practice of excreta reuse in aquaculture which is still found in some Asian countries, such as Thailand, China, and Vietnam, is increasingly being made illegal by government policies.

A combination of the above factors has contributed to the demise of traditional "dry" sanitation and other forms of excreta reuse practices. But the lack of any viable alternative, combined with the dramatic increase of population-densities in European cities, sanitation and waste management became an increasingly serious environmental problem. By the end of the nineteenth century population densities in major cities around the world had reached alarming proportions (see Table 3.2) and sanitary conditions in major European cities degraded dramatically as the urbanites choked on their own waste.

The combination of population densities and atrocious sanitary conditions had devastating effects on public health. The impact was then, as it is today, particularly harshly felt by children under five. In British cities in the mid nineteenth century half of all children born would not live to see their fifth birthday (Brown, 2003). In most European urban areas, toilets and centralised collection systems were rare and the existing systems were eventually not able to cope with the quantities of excreta and organic waste produced. In many growing cities, excreta from humans and animals as well as other waste from households and businesses were regularly discharged directly on to the streets.

Box 3.2 The collapse of excreta reuse in Kabul, Afghanistan

Up until 1992, the collection and transport of excreta for reuse was undertaken by a combination of independent collectors and trucks managed by the municipality. But between 1992 and 1994, no organised collection was carried out because of war. As a result, the transport of the nightsoil by the informal sector became increasingly difficult. A survey carried out in 1999 by ICRC counted more than 800 of these independent collectors operating in the city with wheelbarrows, carts or trucks. However, due to the increase in the urban population over the previous two decades, the traditional night soil collection system broke down. In recent years, the number of night-soil collectors who used to regularly empty the private latrines in Kabul has been to small to keep up with the expanding population. The greater availability of cheap chemical fertiliser on the market has also reduced demand for excreta for reuse in agriculture. As a result, many latrines are emptied far too infrequently, especially within overcrowded residential areas. The nightsoil collectors prefer to serve the areas that are closest to the areas of agriculture. They also prefer areas where latrines have been improved because the urine is separated. Furthermore, the nightsoil is easier to handle and exempt of plastics and other types of rubbish. In addition, the demand for fertiliser is concentrated during the growing season between March and September. Hence, during the rest of the year, the system collapses.

Table 3.2: **Child mortality rates in British cities in the 19th Century** *(Brown, 2003)* **with a modern comparison** *(WHO, 2009).*

Proportion (%) of children dying before the age of five (average for a 16 year period)

19th Century, Brithish cities	
Birmingham	48%
Glasgow	43%
Hull	50%
Leeds	48%
Liverpool	53%
Manchester	51%
London	41%
England	26%
2008	
Sierra Leone*	26,2%
Afghanistan	25,7%

** In 2008 Sierra Leone had the world's worst under five mortality rate*

Governments attempted to legislate and improve urban sanitation based upon existing practices. But this proved difficult to implement and had little impact. Physicians and hygienists were caught in a losing battle against faecal-oral diseases. The sewage systems, which were introduced on the European continent from the 1840s onwards, were thus a solution to an enormous public health crisis. Water flushed systems provided the opportunity to dramatically transform the situation at the time, with sewage being flushed away from homes and the hearts of cities into nearby rivers and thus shifting the pollution to downstream areas.

The introduction of piped domestic water supplies to cities in the nineteenth century made these water flushed sewerage systems possible. With time, the installation of the centralised water supplies was eventually combined with the construction of mixed sewer systems. Thus, it was the political decisions in Europe triggered by a public health crisis starting in the UK, to invest in waterborne sanitation that set the precedence for the modern trend toward sewered sanitation.

However, the first and biggest cholera epidemic which hit the German city of Hamburg and killed ten-thousands of people in the year 1892 was spread by the newly installed centralised system. Sewage contaminated with cholera pathogens was centrally discharged into the river "Elbe". During floods, the contaminated river water reached the drinking water withdrawal area further upstream. The river water was abstracted and centrally supplied without previous treatment. All areas which were connected to the drinking water supply network were affected by the epidemic, while areas without were not. The discharge of sewage further downstream was regarded as too costly and wastewater treatment processes were introduced only decades later. (Umweltbehörde Hamburg, 1992)

Even at the time of the introduction of centralised sewer systems in the 1840s there was a critical and ongoing discussion of the benefits and risks of water borne sanitation systems. In order to improve the abysmal sanitary state of cities it was initially considered acceptable to discharge raw sewage to surface water bodies, spending large sums of money to install vast sewerage networks throughout cities to do so. In 1860, as flush toilets began to come to the fore as the answer to the sanitation woes of densely populated European cities, professor Justus von Liebig warned that *"the introduction of water flush closets into most parts of England results in the annual loss of the materials capable of producing food for three and a half million people"*. In 1866 he wrote to the Frankfurt-based physician Georg Varrentrapp that he believed that waterborne sewer systems were the safest way to transport excreta out of the cities to achieve health and public cleanliness. However, he added that it would also be crucial that sewage should not be discharged into rivers but used for irrigation and fertilization of agricultural land. He was convinced that the marketing of sewage for agricultural purpose would be a significant source of income for cities (Hapke, 1997). In response to this, attempts such as the "Liernur-system" (as described in Box 3.3 below) were made to develop systems which enable the reuse of black water.

Box 3.3 Vacuum sewered sanitation systems in Europe

At the end of the nineteenth century Charles Liernur from Haarlem in the Netherlands (1828 – 1893) developed a pneumatic system for the collection of waste from flush toilets that enabled the reuse of blackwater in agriculture. The approach was to collect faeces without inconveniencing the residents and to transport them as efficiently as possible for reuse to agricultural areas (van Zon, 1986). Liernur's system was based on the separate collection of domestic sewage (rainwater and greywater) and blackwater from toilets. The blackwater was drained through an airtight cast-iron pipe system and stored intermediate in underground tanks. An underground pumping station created a vacuum in the drainage system which allowed the operation of the connected toilets with a relatively low volume of water (Lange, 2002).

The intermediate storage tanks for blackwater were emptied every night by a mobile vacuum pump, powered by a steam engine. The content was pumped in three tank wagons and transported out of the city. The evacuation of blackwater from 400 – 500 residents or 60 – 80 buildings took only ten minutes. The system consisting of one pump and three tank wagons was sufficient for the evacuation of wastewater of 12,000 – 15,000 persons per night. The Liernur system worked well on a small scale for more than 25 years in the Dutch cities of Leiden (1870 – 1915 for 1200 people), Dordrecht (1872 – 1887 for 800 people), and Amsterdam (1872 – 1912 for 1,700 people) as well as in Luxemburg, Prague (for 10,000 soldiers) and St. Petersburg (for 22,000 people). The selling of the residues as fertiliser made the system economically feasible. In Amsterdam, the service itself was profitable for a long period (1897 – 1915) and was commissioned to a local fabricant (Mels et al., 2005). However, inevitable the system failed to compete with modern forms of urban sewerage and eventually ceased to operate.

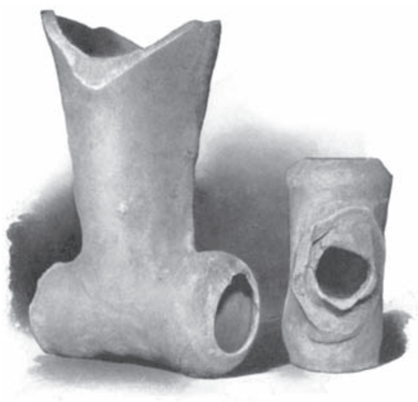


Figure 3.7 Knee and T joints made of baked clay about 4000 BC in Babylonia. (United States Cast Iron Pipe & Foundry Co., 1914)

As described above, many societies have utilised various forms of dry sanitation over the centuries. However, although it is often assumed that water flushed systems were developed relatively recently for use in industrialised societies, there are in fact a considerable number of examples of ancient societies that have adopted water-based systems for urban sewage. Even though these systems were generally used for the discharge of stormwater and greywater, there is also evidence that some systems were used for excreta disposal (see Table 3.3) as well. This suggests that water-flushed sanitation systems have been attractive also in some ancient civilisations because they facilitate the removal of waste without too much effort required from its users.

Figure 3.8 Ruins of a public latrine from the Roman era in Ephesos, Turkey, dated 1st century AD. (Harding, 1998)

Table 3.3: Evidence of sewerage systems in ancient civilisation *(Schladweiler, 2010)*

Date	Location	Archeological evidence
3200 BC	Orkney Islands, Scotland	Excavations show early drainage systems. First lavatory-like plumbing systems were fitted into recesses in the walls of homes -- with drained outlets. Certain liquid wastes drained to area(s) either under or outside of buildings/homes.
4000 - 2500 BC	Eshnunna/Babylonia - Mesopotamian Empire (Iraq)	Babylonia had stormwater drains in the streets constructed of sun-baked bricks or cut stone. Babylonia is also documented as one of the first places to mold clay into pipes using a potter's wheel. T's and angle joints were produced and then baked to make pipes (see Figure 3.8).
3000 – 2000 BC	Indus Civilisation - City of Mohenjo-daro (Mound of the Dead) (Pakistan)	Water was used for flushing and homes had bathrooms on the street sides connected to sewers. Some homes had bathrooms on the second-floor with terra-cotta piping and vents. Solids traps were located along sewer lines and also along street drains (sewers) and wooden "bar screens" were installed at the ends of the drains prior to discharge.
3000 - 100 BC	Aegean Civilisation - Isle of Crete (Minoans)	Many of the drains from 2000 BC are still in service today on Crete. Drainage systems of terra-cotta pipe (clay pipe with bell & spigot joints, sealed with cement) and open-topped channeled drainage systems built of stone conveyed storm water primarily, but also human wastes. Some of the sewers were large enough for people to walk through.
2000 - 500 BC	Egypt	More affluent households had toilets which used beds of sand to catch and contain the faeces while urine would drain through. Servants cleaned the sand regularly.
300 BC - 500 AD	Greece	Sewers in Athens drained storm water and human wastes to a collection basin outside of town. From the basin, the storm water and wastes were conveyed through brick-lined conduits to fields to irrigate (and fertilize) fruit orchards and field crops.
200 BCE - Early CE	China	The contents of a royal tomb of the Western Han Dynasty shows the presence of an antique latrine, complete with facilities for running water, a stone seat, and a comfortable armrest.
800 BC - 300 AD	Rome	The Roman Cloaca Maxima, built by Tarquinius Priscus (616 – 578 BC), was originally a system of channels draining rainwater from Rome, but later became the main sewer carrying wastewater and storm water out of the city, and discharging it downstream into the Tiber.

4 Sustainability in the Urban Context

Arne Panesar
Thorsten Schütze
Jonathan Parkinson

The main objective of a sanitation system is to protect and promote human health by providing a clean environment and breaking the cycle of disease. In order to be sustainable a sanitation system has to be not only economically viable, socially acceptable, and technically and institutionally appropriate, it should also protect the environment and the natural resources. Existing sanitation practices however are often too expensive, a frequent source of pollution and a threat to human health. This chapter puts the focus on how hygienically safe sanitation systems can contribute to a sustainable urban metabolism – for example by providing resources like irrigation water, biogas or nutrients for other processes – and thereby increase sustainability in the urban context. An analysis of the principles of sustainability derived during the 1980s helps us to understand the challenges of the future and relates them to the reality and potential of today's sanitation systems. This chapter relates the topic "urban sanitation" to the current discourses of "sustainable development", "urban metabolism" and "eco-cities".

4.1 Introducing Concepts of Sustainability Development

With more than half of the world's growing population now living in cities it is becoming increasingly crucial to understand the impact of our cities on the earth. Urban environments today consume the largest part of the world's resources and we need to put the urban metabolism on a more sustainable trajectory.

Although much of the excessive and disproportionate resource consumption is associated with higher income countries, it has also become an imperative to sustainably manage development in lower income countries. In recognition of the growing pressures from population, pollution and depleting resources the concept of sustainability is increasingly influencing development policies around the globe.

The importance of development that focuses on positive contributions to the local ecology, economy and society is increasingly recognised and gaining support amongst professionals, especially those involved in the design, planning, development and management of urban areas.

Although economic pressures are often viewed as threats to sustainability (Braden, 1998), according to Lijklema (1993), a positive synergy between economic growth and environmental quality can occur. Braden (1998) states that an economic approach to the management of resources requires balancing competing objectives and economics can provide a framework for weighing those objectives. Several authors (Wackernagel and Rees, 1996; Wackernagel, 2006; Sturm et al., 1999) underline that reducing the "ecological footprint" of a production process - for instance through reducing energy and material consumption - can increase ecological sustainability of the process and competitiveness of the producer simultaneously.

As a result of these concerns and insights, the agreements made at the Earth Summit in Rio in 1992, subsequently laid down in Agenda 21 (United Nations, 1992) have implications for all aspects of development and resource management. The United Nations Conference on Environment and Development defined the goal of sustainable development as promoting economic growth whilst concurrently maintaining the essential integrity of the Earth's ecosystem.

4.1.1 Definitions of sustainable development

The most widely known and accepted definition of sustainable development is found in the Brundtland report (Brundtland Commission, 1987), which states that sustainable development "meets the needs and aspirations of the present generation without compromising the ability of future generations to meet their own needs". This definition is open to interpretation and there have been other attempts to define its meaning, many of which are similar to the original definition in the Brundtland report. For example, the "World Conservation Strategy Report" states that sustainable development "should improve the quality of life whilst living within the carrying capacity of supporting ecosystems" (IUCN et al., 1991). According to the UK committee of the United Nations Environment and Development, "a sustainable community lives in harmony with the local environment, and does not cause damage to remote environments or other communities, both now and in the future" (UNED-UK, 1994). An alternative definition by Schultz and Hornbogen (1995) states that "sustainable development requires the consideration of the interaction of a planned system with nature and society under both present and long-term future conditions". Jacobs (1996) defined sustainability as the "goal of living within environmental means that should not pass the costs of present activities onto future generations".

It seems apparent from these definitions that, fundamentally, the broader objectives of sustainable development point in the same direction, but the goal of ultimate sustainability may be an idealised and potentially unattainable state. Brooks (1980) concluded that terms such as "sustainable development" and "sustainable growth" are likely to remain ambiguous, with no consensus of agreement on absolute definitions.

4.1.2 Objectives of sustainable development

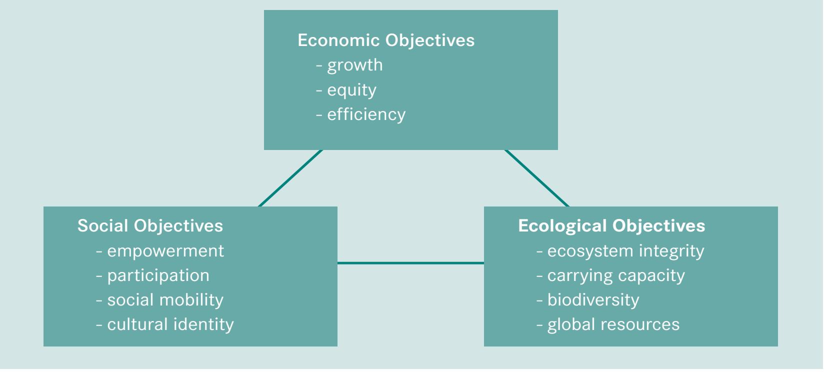
The translation of sustainability concepts becomes difficult in operational terms (Henze et al., 1997) and the concept itself does not give any guidance how the objectives of sustainable development can be implemented in the real world.

Clearly, sustainable development is an outcome of political processes and it is directly relevant to all forms of human activity. Consequently, social and economic systems cannot be isolated from the environmental systems, when analysing for example the sustainability of urban processes. The Commission of the European Communities concluded that sustainable development is a much broader concept than environmental protection (CEC, 1994) and the linkages between environmental quality and human health are widely recognised (UNED-UK, 1994).

The objectives of sustainable development as agreed by the United Nations impose greater emphasis on the need to utilise resources more efficiently in all aspects of human activity. The objectives of sustainable development must be considered on a global scale. The flows of residual wastes are recognised to be intrinsically related to the consumption of resources which may originate from locations far from the point of usage. Therefore, the use of resources is inherently linked to socio-economic development of human societies and the unsustainable use of resources results in the production of wastes and the pollution of the natural environment around the globe.

Consequently, reducing the production of wastes is fundamental to sustainable strategies for the protection of natural resources and one of the key themes of sustainable development is the efficient use of resources and limiting the use of non-renewable resources (Hellström and Kärrman, 1997). Thus, as illustrated in Figure 4.1, sustainable development is an overarching concept of which man, nature, and technology are inseparable parts, and economic and social dimensions should be integrated within the ecological dimension of for example urban systems (Stanner and Bourdeau, 1995). Within this framework,

Fig. 4.1: **Objectives of sustainable development**
(Serageldin and Steer, 1994)



the water sector should assist societies in providing solutions that contribute to a development into a more sustainable direction (Varis and Somlyódy, 1997).

4.1.3 Sustainable resource management

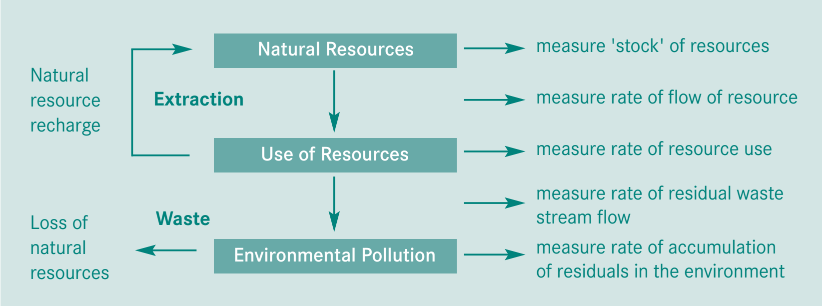
The concept and the term of sustainability goes back to forest management and was first introduced by the German tax accountant and mining administrator Hans Carl von Carlowitz, regarded as the father of sustainable yield forestry. He wrote the "Sylvicultura Oeconomica", the first comprehensive treatise about forestry in 1713. Faced with the ongoing clear cutting and disappearance of wild forests in central Europe, and with a continuing need for timber, he introduced the concept of sustainable forestry, which provides the preservation of the forest stock as natural resource for the timber industry under the motto: "Live from the harvest and not from the substance."

Sustainability requires therefore that the current generation manages resources in a way that leaves a stock of resources to future generations that is no less than the current stock. The natural environment performs the function of the resource stock for the human economy, providing essential resources and services including the assimilation of wastes. Obviously there are many natural resources (for instance phosphorus, oil and metallic ores) that cannot be recharged and whose consumption is thus inherently unsustainable.

According to World Health organisation (WHO, 1992), a consideration of the different levels of renewable resource use requires a separation of the environmental effects into two categories. Firstly, the exploitation of renewable resources beyond the maximum sustainable yield (Porritt, 1992) and, secondly, the use of the environment to absorb production and consumption wastes. Concepts for environmental protection and sustainable development should therefore focus on human activities and the use of resources, particularly those that are identified as non-renewable.

Understanding the conceptual link between resource consumption and production of waste is fundamental to measuring waste management practices (see Figure 4.2). The diagram also illustrates that different

Fig. 4.2: **Relationship between natural resources consumption and environmental pollution** *(Parkinson, 1994)*



methods may be used to measure resource consumption and the associated generation of pollutant wastes.

The critical linkages between resource consumption and waste generation patterns are often overlooked in existing systems for environmental management. Subsequently, sustainable management of resources can only be achieved once improved systems of resource accounting have been developed. In order to achieve this, methodologies to quantify resource consumption and the related production of waste are required.

Although it is widely perceived that water plays a crucial role in sustainable development, some researchers have noted that the Brundtland report does not specifically address the problems associated with the sustainable management of water resources (Varis and Somlyódy, 1997). The concept of "Integrated Water Resource Management" (IWRM) stresses the need for a policy framework to overcome the many problems that can arise in a watershed area as a result of uncoordinated use and abuse of increasingly scarce water and water related resources.

The Global Water Partnership defines IWRM as "a process that promotes the coordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (GWP, 2010).

Better management of upstream water resources is one important aspect to achieve sustainable urban water systems, but will not automatically lead to an improved access to water among already deprived residents. Avoiding urban water pollution and waste generation is important, but if urban water policies focus narrowly on saving water, the water that is saved is unlikely to find its way to the poor urban residents who need it most. Hence IWRM explicitly addresses the integrated improvement of water and sanitation provision by the application of adapted "Environmentally Sound Technologies" (Schütze et al., 2008).

4.2 Introducing Concepts of Urban Sustainability

This section looks at how the concept of sustainability applies to the urban environment and looks at some promising pathways to sustainable urban development. These range from zero emission settlements to visionary eco-city urban designs.

4.2.1 Sustainable urban development

The objective of waste management in a sustainable city is to turn waste into a resource and keep the remaining urban wastes and environmental pollution within the absorptive capacity of local and global sinks (van Vliet, 1996). Therefore, in a sustainable community, waste production must be minimised by utilising resources efficiently, for example through applying the so-called 3R strategy of Reduce, Reuse, Recycling". The remaining pollution must be limited to levels, which do not damage the natural environment or the ecological systems, and do not disrupt the health of flora and fauna. However, responses to environmental problems in urban areas tend to focus on various isolated symptoms, and subsequently these problems are inclined to be addressed in a compartmentalised manner. It is apparent that the impact of human societies upon the natural environment is directly attributable to the level of consumption of resources and the methods that are employed to manage the resultant generated waste and associated pollution problems. It is not only population growth but also the growth in the levels of consumption and the way of resource management that drives current unsustainable urban development. Furthermore consumption increasingly relies upon resources from distant parts of the planet.

The concept of a sustainable city calls for a reappraisal of the many diverse elements of structural form and human activity that constitute a city (Cooper, 1994), as well as the hinterlands that support the city's activities.

Different approaches have been developed to stimulate and encourage the widespread adoption of concepts of sustainable urban development. Popular contemporary concepts are for example the following:

- The concept of "cities as sustainable ecosystems" has been developed under the umbrella of the United Nations Environment Program (UNEP). It describes an integrated approach for the sustainable development of cities, both in the developing and the developed world. (Newman, 2008)
- The "transition towns" initiative follows a re-localization of politics, economics and culture towards autonomous and self-sufficient communities. It is currently being tested in small towns in the United Kingdom and Ireland. The aim is to create towns, which are resilient to the effects of limited resources such as fossil fuels and the effects of climate change. However topics such as the limited availability of non-renewable resources - like phosphorus - are not addressed. (Hopkins, 2008).
- The "eco- or green city" movement seeks to integrate sustainability concepts in the planning, design, construction, service and management of urban areas on different levels, from new neighbourhoods in existing cities to totally new cities. Sustainability aspects are for instance considered regarding issues like land use and ecology, transport, water efficiency and waste management, energy and atmosphere (such as reduced carbon dioxide emissions), as well as materials and resources. Selected examples for such "eco-city" concepts are briefly discussed in section 4.2.3.

4.2.2 Urban metabolism and the sustainable city

Due to the high population densities in cities, it is evident that the land on which urban centres are built and their immediate surroundings cannot support the demands for resources by their residents. Virtually all the resources that are required for a city to function originate from locations outside of the city boundaries and many are imported from remote locations.

In urban systems, demands for resources are largely determined by the activities of the urban population, which can reach beyond the limits of the system to satisfy their needs (Waller, 1977). These are subsequently processed by various human activities and concentrated in the waste products of the city. However, most of the world's urban poor have consumption levels that are so low that they contribute little to waste generation. Water use is below 50 litres per capita and greenhouse gas emissions are minute by global standards. On the other hand, most "rich" cities are extremely poor in their reuse of resources and produce high levels of waste residuals that result in significant pollution problems.

The widespread recognition of these problems has initiated mounting concerns of the capacity of cities to meet the objectives of sustainable development, expanding upon the definition of sustainable development in the Brundtland report. Stanner and Bourdeau (1995) for instance, define a sustainable city as one which "provides a liveable and healthy environment for its inhabitants; meeting current needs without impairing the capacity of environmental systems to satisfy the needs of future generations". Consequently a sustainable city may be defined as "an agglomeration that satisfies the objectives of sustainable development" and this requires "an integrated approach towards resource management".

The term "urban metabolism", adapted from biological and medical sciences, can be used as a metaphor to aid scientific understanding of the health of a system (Ness, 1993). The metabolic requirements of a city can be defined as the materials needed to sustain urban activities. The comparison of a city to an organism provides a convenient analogy for analysing the input of resources and energy and the output of wastes flows. The urban metabolism can be analysed by fluxes of nutrients and the alterations to the natural flows caused by urban agglomerations (Beck et al., 1994). Today's cities import vast quantities of resources in the form of products and materials including water, gases and organic matter (both fossil fuels and food) and release corresponding quantities of emissions and waste. Unlike natural systems, which are characterised by full resource recovery and balanced energy and carbon flows (Repetto, 1986), urban systems change the structure of natural ecosystems and are characterised by open material flows (Niemczynowicz, 1993).

Fig. 4.3: **Linear metabolism cities consume resources and create waste and pollution** *(Source: Giradet, 2009)*

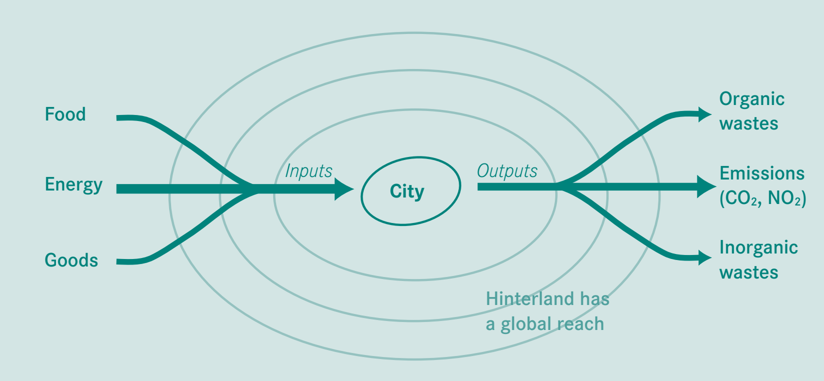
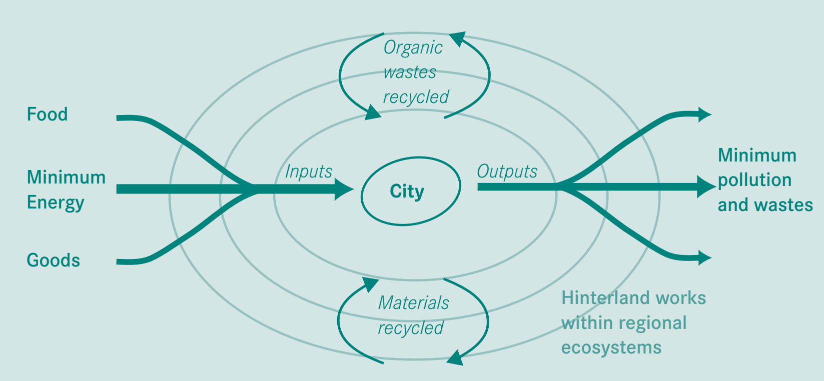


Fig. 4.4: **Circular metabolism cities reduce consumption and pollution and recycle and maximize renewables** *(Source: Giradet, 2009)*



Generally, today's cities consist of linear metabolism systems. In contrast to the recycling-oriented cities of the pre-industrialized period discussed in Chapter 3, the nutrient management system of today's cities has changed from these predominately circular to much more linear processes (see Figures 4.3 and 4.4). The concept of urban metabolism may be extended to consider the overall demands for food, water, fuels and other raw materials, and to assess the potential impact of their use on the biosphere. Thus, in the long term, the impact of cities on the global environment can be described by analysing the flows of natural resources that support their activities.

The impact of the urban metabolism may affect downstream populations or the greater region around the city. And – as many resources "digested" in the urban metabolism come from far away – pollution, environmental damage, and threats to human lives through contaminated water, can also occur at great distances. These negative impacts may have been exported to the places from where the intake of the cities consumer goods originates. The following example is used to illustrate this: In Freiburg (Germany) wastewater treatment and solid waste management works well and keeps the city itself quite clean. The local consumption of tap water per day and person is around 100 litres. However, the people of Freiburg consume about 6,000 litres of so-called "virtual water" per capita and day. This is the overall water consumption used to produce the goods consumed in Freiburg (AK-Wasser BBU, 2006).

4.2.3 Putting sustainability objectives into practice

It is obvious that urban areas on their own cannot be entirely sustainable, unless we include the hinterland and all the areas which provide the resources for the urban metabolism. However, their pattern of development has a significant impact on the overall sustainability of our planet. There may be no clear internationally acknowledged definitions of the terms "sustainable urban development" and "sustainable human settlements". However, the focus needs to be on how to put the related political goals into practice – hence on developing concepts for the incorporation of sustainable development policies, administrative and economic practices in a city.

There are already an increasing number of international examples of urban development, which aim to be sustainable, ecological or green, and in which aspects of sustainable development are leading design criteria. Integrated design strategies, which are relevant for this publication on sustainable sanitation in cities, combine issues such as of water and organic waste management, energy efficiency, renewable energy production as well as urban landscaping and agriculture. Examples for integrated system and design approaches including urban sanitation are for instance:

- The multiple uses of greened urban landscapes and buildings for recreation and an improved ecological status, as well as the collection, retention, treatment and reuse of rainwater and sewage.
- The decentralised production of biogas, compost or bio-char from concentrated wastewater and organic waste and the reuse of products in greened urban landscapes and buildings.
- The reuse of processed excreta and nutrient rich wastewater in urban landscaping and agriculture.
- The recovery and reuse of thermal energy from sewage as well as the use of processed sewage or rainwater for evaporative cooling.

Figure 4.5: Perspective aerial view of the master plan for "Masdar City" (Foster & Partner)

Some of the most ambitious projects for sustainable urban developments are to be found in Asia, where the construction of complete "Eco-Cities" is underway. One of them is the "Sino-Singapore Eco-city" in Tianjin, China, which held its ground-breaking ceremony in October of 2009. It aims to complete the implementation of its integrated land use, transport planning, water and wastewater treatment and renewable energy plan within 15 years. Another example is the city of Masdar (Abu Dhabi), which aims to be the first zero emission settlement worldwide. However the focus in Masdar (Figure 4.5) will be on zero carbon dioxide emissions and not on the implementation of sustainable water and sanitation systems. Prominent examples of green buildings are the Commerzbank building in Frankfurt, Germany (Foster Associates) or the master plan for Istanbul's green urban development (Ken Yeang). Recent European examples include the Solar City in Austria, Freiburg-Vauban and Hamburg-Flintenbreite in Germany, Beddington Zero Energy Development (BedZED) in England, or Hammarby Sjöstad in Stockholm, Sweden.

Contemporary sustainable architecture and urban designs offer very few examples of integrating the potentials of sustainable sanitation systems and the on-site management of resources. However, the use of collected rainwater and purified sewage for local water bodies and irrigation are first approaches for the integration of sanitation systems. Subsequently presented design examples for green buildings and master plans for green urbanism indicate that there is an immense potential for realigning sustainable sanitation systems with sustainable urban development.

Example 1: Solaris Building, Singapore

The "Solaris" building in Singapore is located in the research and business park in central Singapore (Figure 4.6). The plan for the mixed-use building has been certified BCA GreenMark Platinum, Singapore's premium sustainable building benchmark. The ecological design features include a 1.5 kilometre long ecological zone, which connects the ground level and the basement with a so-called "Eco-Cell", a cascading sequence of roof-gardens at the building's highest levels. The continuity of landscaping is a key component of the project's ecological design concept as it allows movement of organisms and plant species between all vegetated areas within the building. The aim is to enhance biodiversity and improve the micro-climate. The Eco-Cell allows vegetation, daylight and natural ventilation to extend into the underground car park levels. The building's landscaped areas are irrigated with rainwater, which is collected from the building's roofs and ramps. The storage capacity facilitates over five days of irrigation via recycled water between rainfalls (Hamzah & Yeang, 2010).

Figure 4.6: Perspective view of the Solaris Building in Singapore, completed in 2010 (Hamzah & Yeang, 2008)

Figure 4.7: Perfumed Jungle in Hong Kong. (Vincent Callebaut Architectures, 2007).

Figure 4.8: Perfumed Jungle in Hong Kong. (Vincent Callebaut Architectures, 2007).

Example 2: Urban Jungle, Hong Kong

The visionary project "Urban Jungle" proposes to expand Hong Kong's territory through the extension of a naturalized urban landscape at the Central Waterfront (Figures 4.7 & 4.8). The goal is to combine high-end real estate with urban ecology. The real estate development aims to produce more energy and biodiversity than it consumes. (Vincent Callebaut Architectures, 2007). The significant amount of green vegetation and wetlands which is included in the plan offers great potential for integrated urban design and architecture with sustainable sanitation systems, the decentralised reuse of water and nutrients and renewable energy production.

4.2.4 Measuring sustainability of urban developments

The past decade has seen the spread of national and international indicator-based environmental auditing systems which take into account cost-efficiency, energy consumption (carbon emissions) and pollutants that have a longer term and wider scale impact. These aim to incorporate a wide range of indicators within an analytical framework in order to account for the enormous number of complex interactions between different systems (physical, biological, and social). A comprehensive methodology that takes into account all of these factors is a complex procedure, since it is increasingly difficult to include all aspects of sustainability.

Rating systems and certifications have proved useful for driving sustainable innovation in the industrialised world where developers are competing for market share. No matter which overarching concept is applied, the use of nationally agreed performance targets is regarded as important for the widespread adoption of sustainable urbanism (Farr, 2008).

The following selected assessment and certification tools also include aspects of sustainable sanitation. The tools offer the possibility to investigate potential synergies between different sectors, such as water and energy. A good example is the heat recovery from domestic grey water, which can significantly contribute to energy savings for warm water production. However, the tools are based on different methodologies with different weightings for specific issues and use either quantitative or qualitative criteria. Hence the results of one tool cannot be directly compared with another tool:

- The US-developed Leadership in Energy and Environmental Design for Neighbourhood Development (LEED-ND) initiative of the United States green building council defines “sustainable urbanism” as an integration of walk-able and transit-served urbanism with high-performance building and high-performance infrastructure (www.usgbc.org).
- The British Building Research Establishment Environmental Assessment Method (BREEAM) is developed to calculate and compare the environmental performance of buildings and areas (www.breeam.org).
- The Dutch GreenCalc system is a tool which has been developed for the calculation, assessment and comparison of the degree of sustainability of buildings (www.greencalc.com).
- The certification system for sustainable building of the German DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen - German Sustainable Building Council) has been developed to achieve a holistic evaluation of the sustainability of buildings in six areas (ecological, economic, social and technical quality, as well as location and progress) and with 49 criteria (www.dgnb.de).

A further sustainable indicator framework gaining popularity is the concept of a city's "ecological footprint". In simple terms, this measures the aggregated land area required to support various urban communities and is an important indicator of the sustainability of a city (Rees, 1992). The ecological footprint is a measure of resource uses which highlights areas where consumption is exceeding environmental limits. The ecological footprint uses units of bio-productive area (gha - global hectares) to assess the nature and scale of the environmental impact of a country, region, community, organisation, product or service". While the Earth's biological capacity is around 1.9 hectares per capita, the ecological footprint of the world average consumer in 1999 was already 2.3 hectares, which is some 120 per cent of the Earth's biological capacity (Wackernagel et al., 2006).

In 2003, the average footprints in gha per capita for the USA, the UK, Switzerland and China were 9.5 gha, 5.6 gha, 4 gha and 1.5 gha respectively. Residents of cities have particularly high footprints in comparison to the national averages. For instance, Shanghai's footprint is 7 gha and London's 6.63 gha. A further development of the ecological footprint is the water footprint, an indicator of water use that looks at both direct and indirect water use of a consumer or producer. The water footprint of an individual, community or business is defined as the total volume of freshwater that is used to produce the goods and services consumed by the individual or community or produced by the business (Water Footprint Network, 2009).

4.3 Wastewater and Excreta Management in the Sustainable City

It is evident that future developments towards sustainable sanitation have to integrate excreta, wastewater, and waste management (for example: Durchschlag et al., 1992; Rauch, 1996; Schuetze, 1998; UNESCO, 2006). But this integration has rarely been a design criterion for the existing sanitation infrastructure. Usually the primary objective is to convey waste away from areas of human habitation , for instance in the case of today's urban drainage systems. Consequently, sufficient flows of water are required to convey particulate and dissolved waste matter from the urban environment back into the receiving water bodies and, consequently drainage systems are dependent upon the availability of sufficient quantities of water. With increasing water scarcity this water will not be readily available in many parts of the world.

For an integrated management of excreta and wastewater in cities we need to move to a different level in our thinking, taking into account the above described increasing shortage of water combined with higher prices for energy, water and fertiliser. If we reverse conventional thinking by putting the focus systematically on the outputs of productive sanitation systems and their (potential) value, new opportunities become obvious. Several authors (UNESCO, 2006;

SuSanA, 2008; Murray, 2009) suggest to first check if there is real demand for products from a sanitation system and then design the sanitation system around this demand. If, for instance, irrigation water is scarce, consider to provide adequately treated wastewater, if energy is scarce, consider the production of biogas from wastewater, if soil-conditioners or fertilisers are scarce or expensive, system design should accommodate this context specific need.

As a result, in a sustainable city, nutrient rich organic wastewater could be returned to urban or peri-urban agricultural land – and this would at the same time help to reduce the accumulation of nitrogen- and phosphorus-based compounds in the aquatic environment and would reduce the growing consumption of freshwater in urban areas. Developing concepts which allow integrated reuse and recycling in high-density neighbourhoods or in buildings (as discussed earlier) will become a top priority for densely populated cities. A good relationship with their hinterland and the transport of resources and products between the cities and the hinterland is another important feature that needs attention of both city-planners and sanitation engineers.

Overall, sustainable sanitation systems should be designed to be:

- Comprehensive (by considering all waste streams, especially those that are by-products of processing steps, for example faecal sludge or nutrient rich water).
- Re-use oriented (by using waste streams beneficially whenever possible and disposing them in a safe and appropriate way if reuse or recycling is not possible).
- Appropriate (by examining a comprehensive suite of technology options to determine the most appropriate and cost-effective site specific solutions).

The potential of recovering energy and nutrients from sewage and excreta is however increasingly addressed – for example when central or decentral treatment systems produce biogas or when research is under way to analyse at which market price the recovery of Phosphorus from sewage may become economically viable. These attempts could be seen as a first step for developing wastewater management and sanitation systems towards closed loop systems or a circular urban metabolism.

4.4 Sustainability criteria for urban sanitation

A mosaic of different technologies or subsystems based on different approaches will form the sanitation system of a given city: centralised and decentralised, conventional and closed-loop, high-tech and low-tech, separated or combined treatment of flow streams, as well as conventional tweaked with innovative options. Appropriate solutions can be developed based on the adjustment of the local basic conditions with available technologies, related management solutions as well as the enabling environment such the social, legal and institutional framework. In practice, the huge variety of different technical and operational combinations may represent a considerable challenge, as well as an opportunity for all stakeholders involved: architects, urban designers, planners and sanitary engineers.

The SuSanA publication "Towards more sustainable sanitation" underlines that when improving an existing and/or designing a new sanitation system, context specific sustainability criteria should be identified that refer to ecological, economical and social aspects (SuSanA, 2007). For the development of sustainable urban sanitation systems the following sustainability criteria must be met:

Health and hygiene: includes the risk of exposure to pathogens and hazardous substances that could affect public health at all points of the sanitation system from the toilet via the collection and treatment system to the point of reuse or disposal and downstream populations. This topic also covers aspects such as hygiene, nutrition and improvement of livelihood achieved by the application of a certain sanitation system, as well as downstream effects.

Technology and operation: incorporates the functionality and the ease with which the entire system, including the collection, transport, treatment and reuse and/or final disposal, can be constructed, operated and monitored by the local community and/or the technical teams of the local utilities. Furthermore, the robustness of the system, its vulnerability towards power cuts, water shortages, floods, etc. and the flexibility and adaptability of its technical elements to the existing infrastructure and to demographic and socioeconomic developments are important aspects to be evaluated.

Financial and economic issues: relate to the capacity of households and communities to pay for sanitation, including the construction, operation, maintenance and necessary reinvestments in the system. Besides the evaluation of these direct costs also direct benefits , for instance from recycled products (soil conditioner, fertiliser, energy and reclaimed water) and external costs and benefits have to be taken into account. Such external costs are for example environmental pollution and health hazards, while benefits include increased agricultural productivity and subsistence economy, employment creation, improved health and reduced environmental risks.

Socio-cultural and institutional aspects: relate to the socio-cultural acceptance and appropriateness of a system, such as convenience, system perceptions, gender issues and impacts on human dignity, the contribution to food security, compliance with the legal framework and stable and efficient institutional settings.

Environment and natural resources: involve the required energy, water and other natural resources for construction, operation and maintenance of the system, as well as the potential emissions to the environment resulting from use. It also includes the degree of recycling and reuse practiced and the effects of these (for example reusing wastewater; returning nutrients and organic material to agriculture), and the protecting of other non-renewable resources, for instance through the production of renewable energies (such as biogas). Concepts that concentrate on reducing CO_2-emissions are relevant if we look at sanitation systems with the link to consumption of energy in treatment and transport or to the production of energies such as biogas.

This chapter has linked the international discourses on sustainable development, green urbanism and eco-cities to the topic of urban sanitation. By first defining the critical elements of what constitutes a sustainable urban sanitation system, in the following chapters 5 and 6 it is investigated how strategies for the widespread implementation and application can be developed.

5 Framework for Dealing with Urban Complexity

Jonathan Parkinson
Jennifer McConville
Anna Norström
Christoph Lüthi

This chapter sets out a framework for disaggregating the complexities of the urban environment by means of spatial analysis according to different domains. These domains are aligned to household, neighbourhood and city level. An analysis of the physical and environmental factors combined with an assessment of the social groups and institutional structures within these domains , as well as the respective incentives for being involved in sanitation improvements, forms the basis for the identifying opportunities for intervention. This chapter provides examples of typical urban environments where opportunities for improvement exist. The framework presented here is a starting point for the planning and technology assessment processes that will be further elaborated in chapters 6 and 7.

5.1 Factors of Urban Complexity

Experiences indicate that projects often fail because proposed solutions are only partial solutions. Whilst addressing one problem, they may miss or neglect other challenges in other areas. Often, technological solutions are the primary focus, whilst social, institutional, organisational and other factors are not addressed adequately. Such partial solutions may fit well with some dimensions but generate problems in other dimensions. Consequently, projects and new technologies whose characteristics are not well designed and aligned with their specific context run a high risk of failure.

Whether concepts for sustainable sanitation will be successful therefore depends on how well they are embedded into the existing context. As described in Chapter 2, the characteristics and conditions which are common in the urban setting result in complications that challenge the implementation of sanitation projects. In order to understand the large variety of potential influences in the urban context, these context factors are categorised into the following four categories:

1) Physical and environmental factors

Physical and environmental factors cover both the natural and the built environment and include factors such as geographic/topographic conditions (for example ground slope and groundwater levels), existing sanitation facilities, and other urban infrastructure, such as housing. These factors, along with population density and demographic developments will have an influence on whether centralised or decentralised options will be more promising. In addition, local climate factors such as for instance temperature and precipitation determine whether water scarcity is a key issue to account for in sanitation schemes.

2) Technological and legal factors

Technological and legal factors have an influence on the overall sanitation system design and consequently the technical feasibility and operational performance of sanitation technologies. Specifically important are the technical norms and standards that influence the dimensions and design of these technologies. These include both official standards and those that have become accepted in practice but are not officially recognised. Whilst written norms can be difficult to meet, unwritten ones may be harder still. Technical norms and standards can influence the types and levels of service which are put in place. In addition, they can also influence the cost of delivering certain types of service and whether or not they officially count as improved sanitation, and therefore contribute towards national or local targets. Both of these factors may have a strong influence on investment decisions (IWA, 2008).

3) Socio-cultural and economic factors

Socio-cultural and economic factors include a wide diversity of cultural and societal values, religious conventions, user preferences and established practices which determine whether a novel approach will be accepted by its users. Adapting a sanitation system to meet these diverse needs and cultural norms is a formidable challenge. Economic factors can be closely linked to social demographics and also include a wide range of factors that influence decisions to invest in sanitation at all levels. Purchasing power of potential users is as important to consider as the state of public finances, debt burden and welfare funding. The costs of a sanitation system need to be affordable at all levels of society.

4) Institutional and regulatory factors

Public institutions and private actors are integral to urban service delivery and provide different kinds of resources needed for sanitation projects. There is a wide range of institutional issues that influence the successful delivery of sanitation services, including organisational competencies, human resources, knowledge and skills, as well as financial capital. The regulatory mechanisms that determine how these institutions operate are also integral to the overall functioning of the various institutions and the incentives that they have to perform.

5.2 Sanitation 21 Framework

Clearly, sanitation related decisions need to be made on the basis of a much broader range of criteria than the ones that have been used by public health engineers in the past. A list of general as well as the context specific objectives can be used as a starting point for a more holistic approach to urban planning. As described in Chapter 4, this should include sustainability and objectives which are related to ecological and environmental as well as economical and operational issues.

This book uses the Sanitation 21 (S21) planning framework developed by the International Water Association (IWA, 2006) as the basis for the exemplary analysis of the existing environment and sanitation systems options. The S21 framework divides the city into different domains for decision-making and intervention from household to city level. The framework uses each domain as the basis for analysis of stakeholder's interests and sanitation system options. These domains include household, neighbourhood, district and city level – each of which can be characterised by a distinct set of characteristics which influence the most appropriate form of a sanitation system.

- ***The household level*** is the private domain within which households for instance families, individuals and small units take investment and behavioural decisions.
- ***The neighbourhood level*** is the continuum of "areas" in cities within which households either act jointly, are jointly represented by the political process or can be organised for planning purposes. The neighbourhood level may be defined socially by a cohesive community or by political boundary, for example a city ward. In many cases the boundaries between the "community" and the ward are blurred, particularly where local elected councillors are active. The importance of the *political* ward/district will vary in different institutional contexts.
- ***The city level*** is the level at which services are centrally planned and organised, and financial decisions are taken.
- ***The level beyond the city*** is the domain in which policy and practice is set which impacts onto decisions made at the city level.

The S21 framework integrates the analysis of domains into a three step planning framework that guides the analysis and selection of appropriate sanitation systems. These three steps provide a basic entry point for structuring the complexity and building an appropriate planning process to address the critical factors outlined above. This chapter will focus on the first step of understanding the existing context. The rest of this book will build on this framework and provide more details about how to approach these three steps.

Step 1 - Understanding and analysis of the existing context

The first step focuses on mapping and analysis of the physical, social and institutional environment across the different domains of the city. Based upon this analysis and an understanding of different stakeholder requirements, it becomes more feasible to enter into a dialogue about the areas of the city to be targeted for improvement and the potential improvement options. This analysis can therefore be used as the basis for identifying "entry points" (see section 5.4) for example those areas in the city where the local context is identified to be conducive for improvements. Chapter 6 will provide more guidance on how to create dialogue and build this context evaluation into the planning process.

Step 2 - Consideration of potential sanitation technologies

The second step of the Sanitation 21 planning framework focuses on a consideration of potential sanitation technologies and how they can be configured to ensure that the system solves the problem of household sanitation but without creating downstream environmental problems that affect the livelihoods of others and the wider economy. Those technologies that are seen to only satisfy the interests in one domain at the cost of the interests of other domains are considered to be inappropriate. For example, a system that satisfies only household level interests whilst creating a downstream pollution problem is not considered to be sustainable. Thus, the most optimal solutions are those that satisfy all domains of the city. In line with the concept of sustainability, waste should also be considered as a resource and its re-use should be encouraged from the very start of any planning process. Details of the ways to approach this assessment are included in chapters 6 and 7.

Step 3 - Assessment of each of the potential options in terms of the likelihood of success

The final step focuses on an assessment of each of the potential options defined in "Step 2" in terms of the likelihood of success at each level and domain. This should take into account the operation costs and cost recovery arrangements to pay for these costs, as well as management requirements and resource requirements including skills, manpower, and time. The assessment should look closely at the risks associated with different parts of a specific system. Technologies or management arrangements that are likely to fail due to poor monitoring or lack of resources are not likely to be sustainable. The question of whether a technology will work is a critical part of the selection process within sanitation planning and the systems approach to technology assessments (discussed in Chapter 6).

5.3 Understanding and Analysis of the Existing Context

Due to the large number and variety of contextual factors, it is a challenge to track and adequately incorporate these when planning sanitation projects. What makes this challenge more complicated is that the various context characteristics are located in different sectors (for example water supply, health regulation, waste management), as well as in different domains, including the household, neighbourhood,

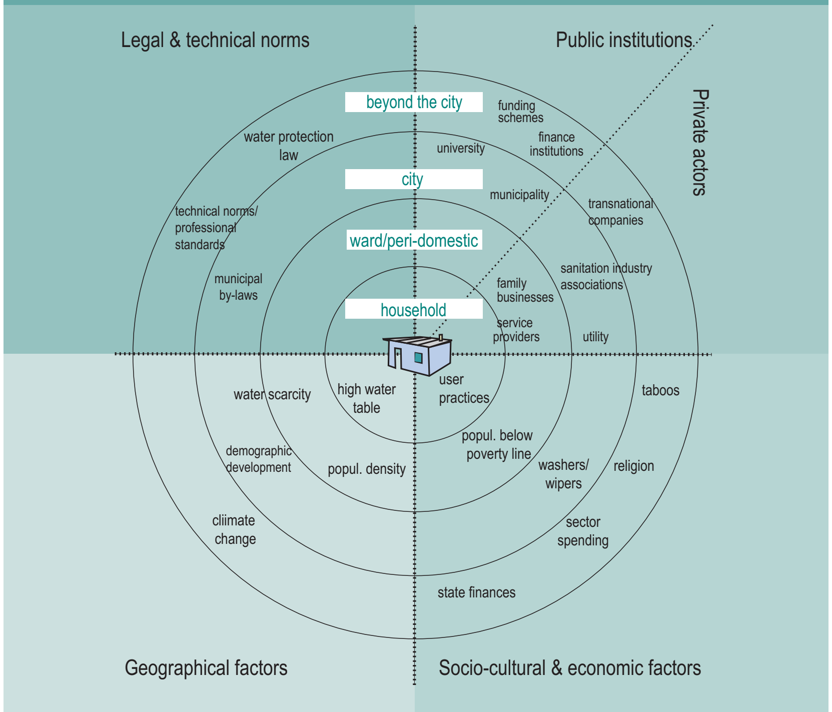


Fig 5.1: **Multi-level map for identifying institutional, organizational and context factors** *(Source: Authors).*

city and external to the city. Furthermore, contexts are often not coherent, which means that there might be conflicting demands or conditions between domains or contextual factors. Since the move towards sustainable sanitation will probably require the introduction of novel techniques, it is particularly important to critically consider all contextual factors, from operational and financial sustainability to human capacity and management arrangements. The following section attempts to map the different contextual factors within the various domains (Figure 5.1). Filling in this figure can be a useful exercise for identifying critical issues and where they will impact. A context analysis should cover all four areas of contextual factors; however there will be some overlap between the factors that will simplify the assessment process. The approach below combines physical and technological factors in an assessment of the built environment. Similarly the social and institutional context (right half of Figure 5.1) can be combined in an assessment of stakeholder perspectives and capacities. Examples for the appropriate management of all these factors will be discussed more detailed in the framework of the planning process in Chapter 6 and implementation in Chapter 8.

5.3.1 Analysis from a physical and technological perspective

A categorisation of land use and settlement types is an important first step to be used as the base for the planning framework and to support decision-making processes. It involves the definition of boundaries of the various settlement types within the urban area according to land use, physical settlement characteristics and a rough assessment of the socio-economic status. This spatial approach facilitates a consideration that different neighbourhoods may require different solutions to sanitation problems according to local conditions.

Some of the baseline data can probably be obtained from existing documentations (reports, maps and other secondary sources). There are often various planning documents that provide information about infrastructures and sanitation services, but the data contained within them may be out of date and hence inaccurate. However, data sources may not cover the entire city; information about informal areas may be especially scarce. Where data is lacking, it will be necessary to undertake site visits in order to gain a perspective of the situation on the ground and develop a broad overview of the current situation related to environmental sanitation. Discussions with local residents during site visits will help to gather additional information about existing infrastructure and services, faecal sludge and wastewater disposal and reuse.

In most established settlements, some level of investment in sanitation services will already have been made, whether by government agencies, households or others. The condition and functionality of these existing facilities will have a strong influence on the options for improvement. Site visits can be used to confirm the existing type, coverage and functionality of sanitation infrastructure and services in the different neighbourhoods.

Infrastructure and facilities should be mapped according to the domains. It is necessary to identify the different components of the system, that link to different communities, as well as other spatial information. The mapping can be used for the identification of the following information:

- Coverage and quality of household latrines and on-site sanitation.
- Extension and quality of drainage and sewerage networks.
- Locations of water bodies which are recipients of wastewater and faecal sludge discharges (both formal and informal dumping sites can be marked).
- Areas where wastewater is used for irrigation.

One approach towards the identification of service deficiencies is to identify those areas where the demand for services outstrips the supply. Gaps are identified where supply is not sufficient to cater to the demand. Areas that are not sufficiently served by environmental sanitation services are considered to be under "stress". The level of stress is defined as the extent of the gap between demand and supply at a given area. This can be done for sewerage as described by Balachandran et al. (2009) in which the demand-supply gap assessment was done at individual drainage-zone level covered by the existing central sewerage system and separately for zones without central sewerage system.

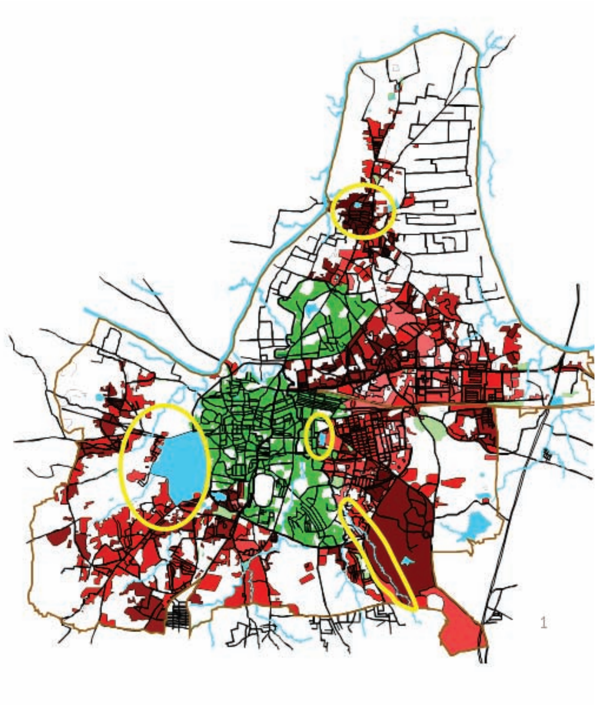


Figure 5.2: Mapped sanitation stress areas of Kolhapur, India; red: DBNS stress areas, (darker=higher stress); green: non-stress areas; encircled in yellow: areas prioritised by the Municipality (Balachandran et al., 2009).

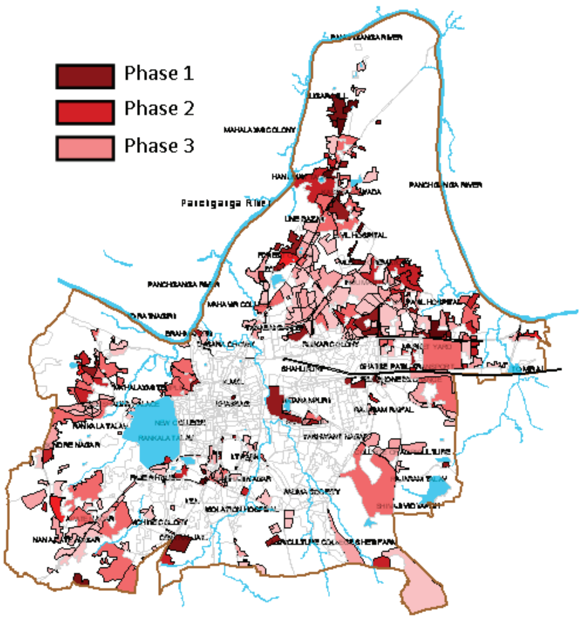


Figure 5.3: Phasing based on stress areas (Balachandran et al., 2009).

The outcome of this gap assessment can identify areas for priority attention. Although problems related to service deficiency may be due to a lack of services, in many cases the problems are compounded by the fact that those services that do exist are poorly operated and maintained. An assessment of the quality of services can be carried out at the same time as the surveys to collect information about infrastructure coverage. The assessment should focus on areas where service coverage is obviously deficient and environmental health conditions are acute. Thus, the problem is not necessarily only a quantitative issue but also a qualitative issue. Community members and other local stakeholders are also important sources of information to confirm where sanitation problems are most severe. The areas with the highest levels of stress are possible priority areas of intervention, although the final decision on priority areas needs to also take into account social and institutional factors.

5.3.2 Analysis of the existing social and institutional context

This is a process to identify and systematically assess factors related to the social and institutional context that may affect the uptake and/or sustainability of innovative sanitation technologies and novel management arrangements. Similar to the physical and technological assessment described above, the assessment also uses the different domains at household to city level to identify existing service providers, NGOs and community based organisations prior to an analysis of stakeholders interests or "drivers" at each level. As described below the process follows the following 3 steps:

1. Identify key actors in each domain and assess their interests, motivations and incentives.
2. Understand what external factors drive decisions in each domain.
3. Identify and assess capacities in each domain for implementation and long-term management.

The assessment of these three levels can be used as a starting point for assessing the context within which sanitation systems are operating and a reference point for prioritisation of interventions.

1. Identify interests of key actors

The first step in the institutional assessment is to identify the relevant stakeholders, actors and service providers that have direct or indirect involvement for each of the different components of the system. Typical examples of public authorities include ministries and other governmental agencies such as regulatory bodies, municipalities and local authorities, or public utilities. Public institutions may also include professional associations, universities and research institutes. Although the municipal authorities, utilities and sometimes governmental agencies are the most obvious service providers, there is likely to be a range of small-scale operators involved in the provision of sanitation services. Thus, private actors include all sorts of firms ranging from small engineering companies responsible for installation or operation of sanitation facilities up to large, multinational firms in the field of technology development or full service provision. Informal operators are often particularly active in the areas where the official service provider is unable to operate.

There is a wide range of interests and objectives which may come into play when an urban sanitation system is being planned. Beyond health and environmental protection, other interests of different stakeholders are likely to include economic development, poverty reduction, improved urban planning or reduced operational costs. Although each stakeholder is likely to have a different set of interests and motivations, each is valid and need to be recognised in the development of a city-wide sanitation plans. The following example from the Sanitation 21 framework summarises how interests and stakeholder priorities may vary between different domains:

Household level

For obvious reasons, households are most interested in seeing improvements to their living conditions and their immediate local environment. Although health is rarely a factor that household mention specifically as a reason for improvements, households often have concerns about the quality of their living environment and many are aware of the health risks associated with inadequate sanitation facilities. In addition to the more obvious physical conditions, the factors that motivate households to improve their sanitation facilities include privacy and safety for family members.

Neighbourhood level

The interests at the neighbourhood level tend to be focused upon cleanliness but may also include health, particularly where responsibilities for health services are devolved to this level. NGOs are closely involved with community development activities and therefore recognise the importance of sanitation. Status may also be a factor. For example, some NGOs and civil society organisations view improved collective service delivery as a means to general stronger social cohesion.

City level

Generally at the city level the focus shifts markedly away from the interests at the community level (amongst others convenience, status and access), towards protecting the economy and environment of the city, and meeting externally-established targets. Health also becomes more prominent here, as major outbreaks of diseases impact directly on the political credibility and economic attractiveness of the city. Where financially independent utilities exist, financial considerations will also come into play at this level. The objectives of city authorities are strongly influenced by the political nature of the authority itself and the external incentives that they face through higher levels of government (incentives which may be created by financial flows, penalties, electoral relationships and law). Elected municipal governments may have an over-riding interest in cleaning up the city and preventing outbreaks of disease. Enlightened politicians may also see the importance of sanitation even though they may have vested self interests as they realise that improving public services are vote winners.

Beyond the city

At this level, primary objectives are rarely concerned with household access and more focused on the impact exerted by the city on wider society. Health and access to sanitation remain important concerns, but from a political perspective national governments are strongly committed, at least on paper, to a general improvement in health status and in meeting the MDGs. It is probably only at the "beyond city" domain that international commitments to targets such as the MDGs become relevant. The relationships with water users downstream (which may be international users) may also impact at this level. Considerations around the management of water and food resources, the protection of the environment and macro development considerations (usually focused on economic development) come into play. Further "downstream" external policy drivers become more important, so that wards may be influenced by city politics and cities by national policies, financial structures and economic priorities.

2. Understand external factors and power relations

The way different interests interact and dominate depends to a large extent on power relations and incentives between actors in different domains. For instance, the interest of a design consultant to minimise reputational risk by recommending a conventional solution involving networked sewerage with limited technical innovation may, for example, outweigh the interests of poor households whose interests are to gain privacy and dignity while minimising upfront costs. Thus, poor households may remain excluded because connection fees to the network are prohibitively high. It is important to recognise that that attitudes and interests in different domains change over time and are strongly affected by external factors, such as levels of poverty and the nature of city authorities and utility service providers, which tend to influence decision making. For example poverty, tenure security or insecurity, and the relationship with service providers will all influence how households act, even if their objectives are clear.

While it will not always be possible to deal with the intricacies of local level politics and deeply rooted vested interests, people-centred and transparent planning approaches provide some support for more effective planning decisions. Tools, such as stakeholder assessments, institutional mapping or regulatory review, can be effective for analysing existing power relationships and vested interests. Such an analysis would ideally include formal and informal institutional arrangements, public, private, civil society institutions and focus on groups or individuals whose interests are likely to diverge. Understanding the dynamics and the regulatory environment of an urban setting is a prerequisite for producing informed planning solutions. Clearly, such tools also help to address the many influencing factors that run through local communities: religious, ethnic, social class, caste or gender.

3. Assess capacities in each domain

Although the effectiveness of an organisation may also be compromised by the lack of sufficient equipment or transportation, technical problems are often intrinsically linked to management and institutional inadequacies. Often a deficiency in an easily identifiable area of service provision is identified as the primary source problem, when in reality the deficiency identified is a symptom of a larger problem related to

Table 5.1 Example of social and institutional contextual factors in different domains *(IWA, 2006)*

Domain	Interests/Objectives	External Factors	Capacity Issues
Household	**Primary** - Status - Cleanliness - Convenience **Secondary** - Health	- Levels of poverty - Access to service providers - Influence on down-stream systems - Land tenure	Gender relations, decision making within the household. Interests likely to be highly dynamic over time.
Neighbourhood	**Primary** - Status - Cleanliness - Community services **Secondary** - Health	- Levels of poverty - Access to service providers - Influence on down-stream systems	Community cohesion is important.
Ward/District	**Primary** - Status - Cleanliness - Health **Secondary** - Environ. protection - Economic development	- Relations with the city (political and social) - Financial structures	Role of wards in political processes. Local budgets/ability to raise funds locally. This level of analysis may not always be relevant.
City	**Primary** - Environ. protection - Economic development - Formalisation of the city - Health - Utility cash flow **Secondary** - Achieving water and food security - Promoting urban and rural development	- Decentralisation - Economic priorities and profile - Strength of external policy drivers Note: also the importance of seemingly insignificant policies which often drive technical decisions.	City institutions may them-selves be disperate and even in conflict. May include elected body, administrative body, utility, etc.
Beyond the city	**Primary** - Environ. protection - Economic development - Achieving water and food security **Secondary** - Achieving equity and increasing access - Meeting the MDGs	- Economic priorities and profile - International/regional water sharing issues - Political priorities	River basin management is usually weak, particularly institutions. Basic environ. legislation may over-ride holistic planning. Also consider power relations btw. the city and external/ national institutions.

institutional performance. Thus, the effectiveness of organisations involved in services provision is dependent upon their organisational structure, management capacity and human resources. The process of problem identification and diagnosis requires a fundamentally different approach than those that focus solely on technical issues. There is a need to evaluate in detail the managerial processes to see where there are embedded institutional problems. In addition, a key consideration is the need to assess not only the capacity of the staffing, but the staffing structure and the incentives which motive staff to perform. Each position in the organisation needs to be valued and rewarded according to performance. For example, a situation where only higher levels of management and technical staff are rewarded creates disincentives to the rest of the workforce to be innovative and supportive in providing a quality service.

5.4 Identifying Entry Points for Action

Rather than trying to improve sanitation services throughout the whole city, a more realistic approach and effective strategy is to focus on those areas that are identified to be priority areas as well as being conducive for sustainable improvements. This approach to targeting intervention has already been adopted in some countries, for example in Indonesia (Box 5.1). The outcome of the context assessment (step one of S21) provides the basis for identifying entry points for priority action. Agreement on target areas can also be facilitated through a participatory decision-making process (see more in Chapter 6).

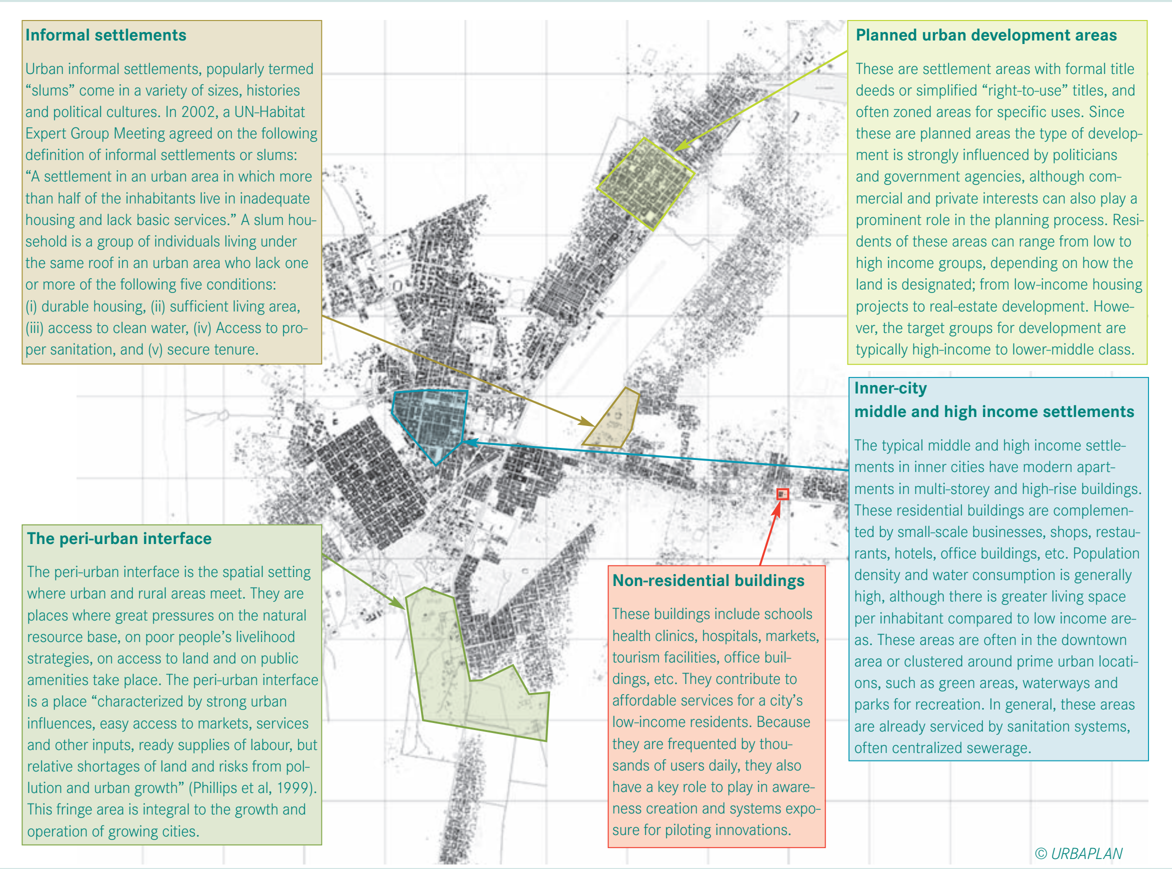
In identifying entry points, it is important to keep in mind that areas should be selected because they represent opportunities for making an impact. The greatest impact may be made in particularly stressed areas or where certain contextual factors provide an opportunity for change. Communities where sanitation is particularly poor are obviously priority areas. However, there may be reasons why it is difficult to implement a project to improve the situation, for example if the residents are squatting illegally on the land. Therefore, there will be a need to resolve these problems before proceeding. Other areas may not be so critical from a household perspective, but may be identified as areas where new technologies can be introduced so as to mitigate downstream pollution problems. It is important to think of the city as a patch-work of different domains and physical environments which each present their own challenges and opportunities. Improving urban sanitation may seem impossible when considered in its entirety. However, by breaking the city into patches, the puzzle becomes much easier to solve. The rest of this section presents five typical urban settings that can act as entry points for addressing priority actions.

The five typical urban contexts described below illustrate how the dynamics between physical, spatial, demographic and socio-economic factors within each of these settings present different challenges and opportunities for the provision of sustainable sanitation. These examples also highlight the fact that a range of sanitation technologies and management arrangements are required to solve the magnitude of urban sanitation service deficiencies. Even in small towns and urban centres, there is generally a need for a variety of sanitation technologies to serve a range of socio-economic residential areas as well as sanitation services for institutions. These are for example schools, hospitals and public places such as bus or railway stations.

1) Informal settlements

Although there are huge challenges regarding the physical constraints (high density and marginal environment) and governance of informal settlements, and it is not feasible to consider that families living in these areas can benefit from the level of service in formalised and higher income areas, these are areas where relatively small investments per household can result in considerable benefits. The lack of sunk investments in sanitation infrastructures also means that there are opportunities to introduce new systems and technologies. Although the ability to pay is generally low, the demand is great. Hence, there is

Fig. 5.4: **Entry points for action in the urban setting**



usually a strong potential to utilise social assets to contribute towards construction (labour) and community management structure. In many cases the challenges of space within slums mean that the only logical sanitation interventions are communal facilities which are often combined with washing facilities. The construction of such communal sanitation systems can be instrumental to establishing a municipal presence in the community which strengthens local political processes. It can also provide an opportunity for local business to generate jobs, which contributes towards the wealth and stability within the community. Public toilets can also be run through community-based organisations with income generation through user fees. Community management of these toilets can also be a way to build enthusiasm and support for other initiatives such as improving drainage systems, street cleaning and general building improvement.

2) Peri-urban interface

The peri-urban interface offers the greatest potential for wide scale uptake of reuse-focused sanitation solutions due to lower population densities and the location of urban agricultural activities. On the one hand, their peripheral location means that communities living in these areas are less likely to be connected to the main citywide service, the availability of space and proximity to agriculture allows greater opportunities for decentralised technologies and reuse of treated effluents and sludge. Since these areas are also growing quickly into more formalised urban areas, they also offer the potential to explore acceptance and practicability for innovations that could then be replicated. The peri-urban context is a transition zone from rural to urban, which will one day be considered fully urban. Therefore, these areas are also potential starting points and case study areas for introducing what can become the urban technology of the future.

3) Planned urban development areas

These areas offer a great potential for implementing innovative sanitation solutions that contribute towards sustainable urban development due to the lack of existing infrastructure, which provides an opportunity to start from a clean slate, making them more flexible and open for possibilities. Amongst others the integration of rainwater harvesting, greywater separation and re-use, organic solid waste management, irrigation of public space and recreational areas, incorporation of urban agriculture and biogas production) are all potential options.

4) Non-residential buildings

Non-residential buildings offer a special opportunity for innovative sanitation technology since it can be possible to implement systems that individuals do not have at home. They offer the opportunity to develop new ideas before bringing them to scale, especially since the large number of users offers great exposure for new systems. They can therefore act as training centres for piloting technologies and promoting changes in sanitation related behaviour. Schools in particular can play an important role in promoting health, hygiene and behaviour change.

Non-residential buildings can also offer opportunities to try innovative management and financing structures. The appropriate solution will depend on the type of building, its use and the ownership and division of responsibilities for service. For example, a biogas system can be linked to the energy sector either by using the gas on-site or selling it on the market to create revenue to pay for operating the sanitation system.

5) Inner-City middle and high income settlements

Although upgrading or retrofitting existing systems can be a complex task and it may be difficult to overcome the inertia of existing habits, these settlements also offer key opportunities. Upgrading and retrofitting of systems does not require installing a completely new system, but can be achieved through replacement of certain functional groups, such as improved water-saving toilets, waterless urinals, or separated drainage systems for greywater. Through a series of upgrades the entire system can take a step-wise approach towards sustainable sanitation.

Many of the existing systems in these areas are reaching the end of their design lifetime and are in need of upgrading, which presents an opportunity for improvement. In other situations, new policy and regulations regarding sustainability or a political will for "greening" the city can be drivers to intervene. The fact that these areas are generally better off and there can be more money available for investment will certainly help.

Box 5.1 SANIMAS approach and City-wide Sanitation Strategy (CSS)

In Indonesia, the SANIMAS (Sanitasi oleh Masyarakat, or Community Sanitation) is a response to national policy to promote community-based involvement during the planning and development of infrastructure facilities, including sanitation. It focuses on the provision of sanitation services for low income communities in peri-urban areas. Based on the city development plan, peri-urban areas are defined and agreed upon by the Pokja (City Sanitation Working Group) members consisting of staffs from related local government institutions, NGOs and local universities. Population density, concentrations of low income communities and existing sanitation infrastructure are identified, in order to define high risk area(s) calling for priority action. If a high risk area is located within the defined peri-urban area, the application of the SANIMAS approach is the guiding option.

Source: Wibowo and Legowo (2009).

6 Planning for Sustainable Sanitation

Jennifer McConville
Anna Norström
Christoph Lüthi

Planning is what you do when you try to transform knowledge into action. The available knowledge base will for example define the number of alternative solutions for a specific problem and therefore steer the course of future actions. This chapter deals with the planning of sustainable sanitation for urban and peri-urban areas and its importance for achieving more sustainable forms of urban development. The first section of this chapter addresses shortcomings of past approaches to sanitation planning as a way of highlighting areas that need more attention during the planning process. Then, new trends in planning are introduced, followed by a discussion of recent innovations in planning tools for improving sanitation conditions. In particular this chapter highlights the need for communication between stakeholders, the use of sustainability criteria to guide planning decisions, but above all the need to remain flexible and creative in the search for locally adapted solutions.

6.1 Challenges for Planning Approaches

Ever since the beginning of urban civilisation 5,000 years ago, humans have to some extent been planning urban environments and their corresponding services and infrastructure. Since the 19th century, urbanism and urban planning has developed into a field of knowledge and practice that views the city as an object for study, intervention and control under the responsibility of specialists and experts capable of streamlining interventions through policies, plans and projects. Hence, the traditional planning approach to urban sanitation infrastructure has been one in which planners and engineers assess the needs of a given planning area, and then decide what type of service will be provided. Further development has been initiated by the connection of newly built or peri-urban areas to the existing systems, or by adjustments, such as addition of new treatment steps, made necessary by new regulations or emerging problems discovered by investigations within the sector. In many cases, sanitation projects focus on small neighbourhoods because of the logistical challenges of linking local and city-wide solutions. Sanitation planning therefore becomes a process of stitching together individual systems and neighbourhoods, both horizontally and vertically across the city.

With rapid urbanisation in the developing world, there are large parts of cities which are completely neglected by mainstream planning. The majority of urban populations live in informal, unplanned settlements which are "illegal" or "unauthorised", and the combination of the pace and scale of population growth in these areas is essentially undermining the efforts of city and municipal administrations to plan and guide urban development. In addition, current urban planning departments are often heavily biased towards solutions for controlling formalised city zones, and thereby often neglect infrastructure options for enabling pro-poor and/or pro-environment development. In many countries the problem is further complicated by the compartmentalisation of responsibilies, as well as the prevalent project-based approach to urban development practiced by donor agencies and government ministries which leads to fragmentary solutions, often depending on sector and/or donor interests.

The most common mistake in sanitation planning and implementation is that the most important issues have not been taken into account. These are the expressed needs and conditions of the users of the sanitation facilities as well as of other important stakeholders such as landowners, politicians, financial institutions, as well as users of wastewater or other products generated from sanitation systems. Often the planning process has focused around a favoured technology and little attempt was made to include the views of users when large schemes and new neighbourhoods were planned and implemented. Criticism of this supply-driven approach to sanitation, especially in developing countries, has highlighted several additional problems (Wright, 1997). First, the high initial cost of such supply-driven large-scale, technocratic projects often restricts competition for construction contracts to large-scale operators, excluding smaller and medium-size local contractors, and making the system both expensive and more elite. Secondly, the institutional capacity for operation of these systems is often weak or non-existent, meaning that mechanisms are not in place to recover investment, operation and management costs, which leads to a degradation of service provision, maintenance and limits possibilities for service extensions. These problems can be found in sanitation projects around the world, across all levels of development. Finally, since the costs for these capital-intensive solutions are so high, public investment to improve sanitation coverage and subsidise interventions in poor urban areas is very limited. Even when sanitation is subsidised the main beneficiaries tend to be neighbourhoods that can afford higher levels of services (such as sewers, septic tanks and household water connections). The poorer neighbourhoods tend to be excluded for both, cost and technical reasons, so that those who need the subsidy most are still unable to benefit from it. Even if solutions are sought for low-income neighbourhoods, they tend to be "one size fits all" solutions without adaptations for specific user needs or environmental conditions which can result in health risks and environmental pollution.

The increasing rates of social and spatial transformation, now occurring in urban areas, has highlighted the inadequacies of past planning approaches. In addition, new approaches to systems thinking and

Figures 6.1 and 6.2: Photos highlighting some of the drawbacks of supply-driven sanitation: defunct sewage treatment system, Kumasi, Ghana from the 1970s (top) and an incomplete donor funded latrinisation program, Mauritania, 2004 (bottom). Source: © Sandec

sustainability have infiltrated the agendas of politicians, planners, and advocates, as well as businesspeople. Sustainable development represents new and complex planning situations where a wide variety of information needs to be used; including various sources of practical, professional and scientific knowledge. The interrelations to be considered extend far into the future with a corresponding uncertainty regarding, among other things, demographic change, climatic change and technical development. The traditional planning process with its emphasis on technical and economic aspects needs to be broadened to include criteria for institutional capacity, cultural issues, and public participation. There is also a need to integrate the urban area into the whole water catchment area to avoid sub-optimization where environmental problems are simply transferred downstream or to neighbouring communities. For the same reason, it is important that planning includes all the different urban settings found in the city, as described in Chapter 5. Development and therefore planning should build on the local basic conditions and potentials, existing infrastructures, natural systems as well as social and cultural traditions.

6.2 Current Trends in Planning Theory

In the past, generally most infrastructure planning and urban service delivery was characterised by a high degree of centralised control, little local accountability, and little involvement of the end users. However, there is a growing realisation that new methods are needed to tackle the challenges of increasing diverse and fragmented cities. Current trends in sanitation planning draw on theories of collaborative planning and the use of sustainability criteria. Over the last decades several new planning approaches have been developed and tested, based on a switch to participatory approaches that respond to user needs and criteria-based decision-making to take into account a variety of perspectives.

6.2.1 Communicative Planning

The perceived failure of top-down and supply-driven approaches in many parts of the world have led critics to propose alternative theories such as incremental, strategic and communicative planning methods. These methods attempted to simplify planning by breaking it into steps, while at the same time widening the scope by giving diverse interest groups and stakeholders a say in the process. Popular themes in modern planning are collaboration, consensus building, deliberation and participation. Many of these trends mirror similar movements in other disciplines to holistic and interconnected approaches; such as system thinking in engineering and sciences, or the move from government to governance in political science. The trend is generally a move away from designs and plans that can stand alone as isolated entities, towards process-oriented approaches that acknowledge the complex inter-linkages between society, environment, and technology.

The focus is no longer on the plan itself, but rather the *process* of developing the plan.

One popular theory is the communicative approach which seeks to understand planning problems from multiple viewpoints through a process of open dialogue and exchange. In an ideal open dialogue people should enter the discussion with an open mind and without their own agendas, and work with others to analyse the problem and identify the best solution. Through this process the participants should learn from each other and gain an understanding of other viewpoints that will enable all to come to a consensus on the best way forward. Healey (1996) defines communicative planning as a set of practices and dialogue between actors through which policy ideas are developed, disseminated and translated into action. Underpinning this theory is the assumption that individuals are knowledgeable subjects with the capacity for autonomous action within the social relations which shape their identities. Communicative planning theory envisions a process of consensus-building where participants share their perspectives and stories, and through discussion they develop alternative future scenarios where all the actors have a role (Healey, 1996; Innes & Booher, 2003). In contrast to rational planning that has been dominant in the top-down approaches described earlier; the communicative planner works to mediate the community discourse rather than create a technical plan (Campbell & Fainstein, 2003).

The communicative approach to planning is in line with the demand-driven and participatory models that are now widely promoted and accepted within the field of sanitation. Participatory tools are commonly recommended in strategic planning frameworks and many success stories and award-winning projects around the world have applied such methods (for example Sulabh International Social Service Organisation and Community-Led Total Sanitation (CLTS) experiences). The origin of many of these tools is often based in Participatory Rural Appraisal (PRA) and SARAR (Self-esteem, Associative strengths, Resourcefulness, Action-planning and Responsibility) techniques (Selener et al., 1999; Srinivasan, 1990), which seek to stimulate individuals to identify and solve their own problems. Tools like PHAST (Participatory Hygiene and Sanitation Transformation) aim to overcome community resistance to change by creating a space for dialogue and raising awareness of the consequences of poor sanitation. While the hygiene message in these tools often targets individual behaviour change, they have also been effectively used for community mobilisation and creating demand for sanitation (see section 6.4.3). The sanitation community recognises that public participation enables the creation of an informed public demand and that listening to that demand at the planning level greatly increases the chances that the services offered will be appropriately matched with user priorities and needs (Wright, 1997; GHK, 2002).

These novel planning approaches for sustainable sanitation infrastructures require also changes in the planning and decision making process of planners, engineers and other experts, as they rely not only through technical reasoning, but by assuring that solutions are in line with the desires and priorities of the political authorities, local communities, and other stakeholders. By following the communicative planning model, the planner becomes established as a negotiator and intermediary between stakeholders with conflicting visions and priorities (Innes, 1995). In addition, by inviting a wider range of stakeholders to the table, such process-oriented approaches, mean that planners and engineers are required to work between various institutional levels and social networks. The role of the planner is increasingly that of a facilitator, managing information flows and exchanges between interest groups. Planners need to work closely with a variety of actors in order to make sure that their voices are heard and considered in the final outcomes. However, their role is not longer solely to gather and manage information, but also to work in conflict resolution, facilitation and negotiation. Sustainable solutions can not be worked out solely at the drawing table, but need to bring all stakeholders on board, working together towards a common vision. In addition, education of planners and engineers has to change to adapt to this new task and include elements such as capacity building in facilitating and how to work with multi-stakeholder participation.

6.2.2 Using criteria in the planning process

Planning in its most general sense is about decision making and can be defined as "a process of making choices among the options that appear open for the future and then securing their implementation" (Roberts, 1974). One way of guiding the decision-making processes towards social, economic and ecological sustainability is to use sustainability-oriented criteria when comparing and choosing sanitation systems. Such criteria should be used across the entire range of planning, implementation and operation levels – from the macro to the micro level. Developing and using such a context-specific list of criteria to indicate the overall sustainability of a sanitation system thereby helps gearing the decision making process towards the issues relevant to the different stakeholders, and away from basic economic and techno-centric discussions. This allows more room for the implementation of innovative sanitation solutions that are tailored to the needs of the system users (Tischner & Schmidt-Bleek, 1993).

Along with criteria, some general and context specific objectives are required for the definition of sustainable sanitation and for the development of a guiding vision of how this sector can fit into the complex organism of the "city of the future". The set of objectives and criteria should therefore not be based on complex computer models, but based on the description of a vision for the future that a society wants to achieve, in form of "story telling". An example from the emerging economies of Asia is the planning of the Sino-Singapore Tianjin Eco-city, designed to cover 34.2 square kilometres. It is the result of a collaborative agreement between the Governments of China and Singapore to jointly develop a socially harmonious, environmentally friendly and resource-conserving city in China (Box 6.1).

Box 6.1: Eco- city Tianjin

Designed to be practical, replicable and scalable, the Tianjin Eco-city was the first experiment to entirely plan and build a new city in an ecological manner. The Master Plan of the Sino-Singapore Tianjin Eco-city was jointly developed in 2008 by the China Academy of Urban Planning and Design, the Tianjin Institute of Urban Planning and Design, and the Singapore planning team, led by the Urban Redevelopment Authority. In the planning of the Tianjin Eco-city, one of the main guiding principles was to adopt a holistic approach towards creating and designing a liveable, efficient and compact city, which would be developed in an ecologically sound and environmentally sustainable manner. For the Sino-Singapore Tianjin Eco-city a set of 26 Key Performance Indicators (KPIs) were defined, 22 of which were quantitative and 4 that were qualitative. The KPIs were formulated with reference to national standards in China and Singapore together with international standards, and were divided into four groups:

1. Good natural environment,

2. Healthy balance in the man-made environment,

3. Good lifestyle habits,

4. Developing a dynamic and efficient economy.

According to the leading planners of this project, there were seven distinct innovations in this planning: protection on natural ecological structure; land use layout planning; green transportation; ecological neighbourhood planning; cultural context preservation; water resource utilisation; and energy saving. Building a system of KPIs into the planning process was especially useful and has been copied by many other eco-city planners (Ma, 2009).

Criteria for sustainability need to be developed in close cooperation with all relevant stakeholders and take different aspects into consideration, such as health and hygiene, technology and operation, financial and economic issues, socio-cultural and institutional aspects, as well as the environment and natural resources (SuSanA, 2007). What may be judged as sustainable in one context might not be the same for another setting. There is an extensive range of criteria that could be considered during the planning process and as a starting point for assessment of sanitation systems from a wider perspective (Kvarnström et al., 2004). However, it is impossible to identify a complete list of factors that will affect the sustainability of a sanitation system without knowing the specific context, therefore any list would need to be expanded or reduced for each specific case. In the discussions and decision making around sustainability, the terms "objectives", "criteria" and "indicators" are often used and have specific roles. To clarify these roles, two examples are presented that illustrate the relations between these terms when used in the context of urban sustainable sanitation.

Example 1: In the case that "health protection of the entire population" is one of the general objectives for decisions linked to sanitation planning, a context specific objective could be, "health protection of the working population that is involved in reusing wastewater in agriculture". Criteria would be identified by the "identification and specification of the types of water-related diseases" relevant for this part for the population. The related indicator would be the percentage of this part of the population affected by the specified diseases. The target value would be the percentage to which the population affected by these diseases should be reduced.

Example 2: In the case that "environmental protection and sustainable use of resources within and outside the city" would be one of the general objectives for decisions linked to sanitation planning, a context specific objective could be the "protection of urban water bodies for urban recreation to increase the quality of life and reduce travelling demand". Criteria would be identified by the "specification of appropriate types of water related urban recreation sites", which do meet the demands of the population. The related indicator would be the "distance and required travel time to reach the next water based recreation site of the specified type". The target value would be the reduction of the distance and travel time to suitable water bodies from specific areas to a specific level.

6.3 The Planning Process

In order to better understand the process of planning, it is helpful to break it down into steps. The steps within a planning process act as a logical structure for developing dialogue, creating participation, and guiding action forward (Örtengren, 2004). Generally, it is the easiest way to think of planning as a series of linear steps that will provide answers to the three basic questions in planning:

1. Where are we now?
2. Where do we want to go?
3. How do we get there?

In reality the process of answering these questions will not be linear, as many things can happen at the same time and there will undoubtedly be iterations and repeat ion of ideas and actions taken. However, any planning process will in general follow the same key steps during the process of planning. These steps are called by different names depending on what literature is used. According to McConville (2008) the following five universal steps can be identified: (1) Problem Identification, (2) Define Objectives, (3) Design Options, (4) Selection Process, and (5) Action Plan for Implementation.

Step 1: Problem Identification

This step defines the context of the current situation and the scope of the problem to be addressed. It is the core of the first question in strategic planning, "Where are we now?" It requires an understanding of the existing sanitation structures, as well as stakeholder attitudes and institutional realities. Here planners should also identify external and internal risk factors and assumptions. Useful tools during this stage include "Political, Economic, Social, and Technological" issues (PEST) and "Strengths, Weaknesses, Opportunities, and Threats" (SWOT) analyses (Örtengren, 2004).

Step 2: Define Objectives

This step defines a vision of the future by answering the question "Where do we want to go?" It should include participatory approaches to identify the interests and priorities of the various stakeholders. Planners should recognise potential conflicts and competing priorities between interest groups. Collaborative planning theory would stress the need to recognise that reaching an acceptable consensus on objectives often requires compromise and equitable treatment of all interest groups (Hajer & Wagenaar, 2003). The objectives themselves should also meet criteria requirement for sustainable sanitation. Useful tools during this step include participatory assessments, such as Participatory Hygiene And Sanitation Transformation (PHAST) and Community-Led Total Sanitation (CLTS), and setting Terms of Reference (ToR), (Kvarnström and af Petersens, 2004).

Step 3: Design Options

The next three steps work to answer the question of "How do we get there?" The first part of this is to identify possible solutions. This step relies heavily on the principle of technical flexibility in order to generate a wide range of potential solutions. Potential options should be generated based on a systems perspective of required functionality. Therefore, both centralised and decentralised systems with the potential to meet the objectives should be considered (Ridderstolpe, 2000). It may also be possible to mix technologies that serve different demographic domains, or different waste flows (for instance greywater, urine and solid waste), see further discussions in Chapter 7.

Step 4: Selection Process

The selection process includes feasibility studies and critical comparison of the potential solutions. The chosen solution should be matched to technical objectives, affordability, and managerial capacities in the local context. A variety of analytical and decision-support tools exist to aid in these feasibility assessments (for example LCA and EIA). Multi-Criteria Decision Support Systems (MCDSS) are also commonly used when there is a need to identify trade-offs between a variety of information, often including both quantitative and qualitative data, as it is the case with sanitation. The advantages of using criteria-based decision-making are that it can increase transparency, stakeholder participation, and optimization by application of several criteria in the decision process (Wiwe, 2005). The selection process should also be a participatory process and include stakeholder input on potential designs.

Step 5: Action Plan for Implementation

This step is not explicitly stated in all planning processes. However, it is the core outcome of the previous steps as it translates the decision process into a direct plan on how to reach the agreed objectives (Örtengren, 2004). The action plan is the actual planning document or strategy which details how to implement the chosen technologies and supporting capacity building exercises. It will normally include a timeframe for objectives to be met, as well as the roles and responsibilities of the stakeholders.

6.4 Innovations in Sanitation Planning

In planning, participation between different stakeholders is becoming increasingly common, as is the use of sustainability focused criteria. The tools presented below are examples of the latest thinking on how to do sanitation planning. They embrace many of the planning principles presented earlier, especially those of participation, criteria-based decision-making, and exploring a wider variety of choices that can fulfil people's drivers for sanitation. However, these tools are not silver-bullets, and the given examples illustrate that there is no single, correct way of planning for sustainable sanitation and that each approach has specific advantages and disadvantages depending on the local context as well as the available skills and capacity.

The rest of this chapter presents some novel approaches to sanitation planning for urban and peri-urban areas, particularly "Open Wastewater Planning" (OWP) and "Household-Centred Environmental Sanitation "(HCES). The approaches have a lot in common as they highlight the role of planning in development and integration and recognise that stakeholder involvement is a prerequisite to effective planning. Due to its focus on community involvement in all planning steps the ideal context and strength of HCES is in unplanned and unserviced urban and peri-urban areas in low and middle-income areas. However, in both approaches there is a focus on treatment results rather than specific technologies, although HCES also specifically highlights that waste should be seen as a resource. In OWP, the analysis of possible solutions is based on how well they meet the "Terms of Requirements" (TOR) which are ideally set through a participatory process with stakeholders and local government to include both primary functions and practical considerations. A common denominator is the importance for all stakeholders to reach a joint target image, which can then make it possible to take decisions and work towards that image at different levels in spite of known or unknown uncertainties.

The tools presented here are by no means the only ones available, but they are intended to provide the reader with better insight into the way of sanitation planning that follows the guiding principles given above. In addition to these two planning tools, awareness-raising methods are introduced as complementary participatory sanitation tools for mobilising communities.

6.4.1 Open Wastewater Planning

Open Wastewater Planning is a simple and flexible method that can be used for planning both on the macro level and on the micro level to find the right sanitation solution. It guides a decision-making process based on site conditions and an assessment of the environmental impacts.

Open Wastewater Planning is a methodology developed in Sweden by Ridderstolpe (2000). It has been expanded by consultants (Kvarnström & af Petersens, 2004) and during field works in Eastern Europe (Bodik & Ridderstolpe, 2007). The framework for this method is derived from the "Best-Available Technology" principle in which the technology which is most economical and feasible should be chosen. However, in addition to economics it seeks to develop a better understanding of the objectives for having a sanitation system in the specific local context. The various options can then be compared based on the stated objectives for the system and a selected solution that will best meet them. Through this process it promotes locally adapted solutions and the development of new technologies as it encourages planners to consider the whole system and its functionality rather than only one specific technology.

Open Wastewater Planning encourages a participatory approach that is led by an independent expert who has a good knowledge of sanitation solutions and the local policy context. The process places an emphasis on the initial stages of planning through setting the boundaries of the system, the designated planning area for and defining the objectives of a sanitation system in a participatory way. Although it takes extra time and money in the early planning phase, it can be argued that such an approach is more cost-effective and leads to more sustainable choices in the long run (Bodik & Ridderstolpe, 2007).

The process is performed in five steps:

1. Problem identification
2. Identification of boundary conditions
3. Terms of requirement
4. Analysis of possible solutions
5. Choice of the most appropriate solution

The first step of problem identification is a participatory step that should include the viewpoints of multiple stakeholder groups , to gain a more holistic view of the sanitation situation. This step therefore requires the identification of the stakeholder groups and their roles. Afterwards a system boundary can be defined for the technical limits of the sanitation system. This can include the specification of the served community, water supply and the reuse of treated products in agriculture or for the augmentation of freshwater bodies. The boundary conditions should also include more than the physical boundaries, but also potentially limiting socio-economic patterns, natural environments, and political conditions. The first two steps develop what the process refers to as the Terms of Requirement, or objectives for the sanitation system. The TOR should be comprehensive and include requirements for health, water and natural resource protection, costs, technical reliability, user satisfaction, and management issues. These first three steps should all be done in a participatory manner with the community members, which is what makes this process so intensive during the initial stages.

The final two steps develop and compare the technical solutions for the local problem. Different technical options that should meet the TOR are designed and analysed during step four. This step will include expert input and designs, but the options need to be described in a way so that the community can understand them and how they can meet the objectives that were defined in the TOR. The outcome of the fourth step should be at least three selected options that are presented to the stakeholders for evaluation and selection of the most appropriate solution. The evaluation process is done much like a multi-criteria decision-making process where each option is ranked against each objective. Finally selected should be the option that best fulfils the TOR.

A central part of this process is the weighting of different objectives throughout the process, and the internal discussions and dialogue that should arise between user groups. For example, users of the system generally have more practical requirements for the technical functionality, O&M and cost, while the authorities and legislative bodies can be more concerned with meeting environmental and health criteria. This method stresses the importance of bringing in all sides of the issue to the debate and including their needs in the planning process. It is not a process that allows for the mathematical calculation and evaluation of options against objectives, but rather a tool for bringing stakeholders to the table and discussing in a structured and facilitated manner the best possible solution to a mutual problem.

Box 6.2: Open planning of sanitation systems

Step 1: Problem identification

This step focuses on the causes of the problem and recommends a participatory approach to problem identification . Hence, also the identification of stakeholder groups and their roles. The process can then be performed using participatory methods such as the Logical Framework Approach (LFA) or Participatory Hygiene and Sanitation Transformation (PHAST).

Step 2: Identification of boundary conditions

Step two delineates the scope of the problem and hence the range of action for solutions. Identification of the boundary conditions should define the technical limits of the sanitation system (community served, water supply, recycling to agriculture), but also potentially limiting socio-economic patterns, natural environments, and political conditions. An analysis of SWOT (Strengths, Weaknesses, Opportunities and Threats) is here a useful exercise.

Step 3: Terms of requirement (TOR)

The TOR for assessing sanitation alternatives are usually set through a participatory process with stakeholders and local governments. The requirements can be divided into two groups: primary functions and practical considerations. The primary functions include regulation compliance for health, water, and natural resource protection. The practical considerations are more geared towards user concerns and include costs, technical reliability, user satisfaction, and management issues.

Step 4: Analysis of possible solutions

The analysis of possible solutions is based on how well potential technologies meet the Terms of Requirement (TOR). Options should be evaluated against the TOR and at least three possible options should be selected for the presentation to the community in the following step. A matrix scoring exercise can be useful here.

Step 5: Choice of most appropriate solution

The results of the analysis in step 4 are presented to the stakeholders. The differences how each system fulfils the TOR are clearly explained. The final selection of the most appropriate solution is done by the future users of the sanitation system.

Source: Kvarnström and af Petersens, 2004

Box 6.3: Swedish Case Study: The island of Lambarö

A case study from Sweden illustrates how use of the Open Wastewater Planning (OWP) framework led the municipality to explore a wider range of solutions to problems with the water supply and sanitation services in a small area within Stockholm municipality. Lambarö is an island located in Lake Mälaren just offshore (175 m) from mainland of the capital and is hence part of the peri-urban environment around Stockholm. The 57 households (17 for year-round residency and 40 summer houses) currently rely on on-site water and sanitation facilities. However due to regulations there is a need to improve the existing systems. Therefore an OWP process was initiated with a group of local stakeholders. They participated in several meetings in which the following requirement, criteria and functions for any future water and sanitation system were identified:

- The sanitation system shall comply with treatment requirements as stated by Swedish EPA (Environmental Protection Agency) for on-site sanitation located in environmentally sensitive areas.
- The sanitation system shall be economically sustainable, with operation and management costs that are reasonable in comparison to treatment level achieved by the system.
- The water supply shall be of high quality.
- The water supply shall satisfy the current water demand and that of the projected future growth.
- Other criteria that were considered include flexibility, site-specific adaptation, nutrient recirculation, reliability and robustness, user aspects, environmental consideration, organisational and legal issues.

According to phase four of the planning framework, the following technical options were evaluated for their ability to meet the criteria defined by the stakeholders:

- Option 1: On-site water and sanitation,, using lake water or private wells and urine diverting dry toilets.
- Option 2: On-site water and sanitation, using lake water/private wells and water closets.
- Option 3: Municipal water and sanitation, by establishing a community-owned network for water and wastewater for the island with connection to the closest connection point within existing water and wastewater jurisdiction (on the main land).
- Option 4: Municipal water and sanitation, through enlargement of the Stockholm municipal water and wastewater jurisdiction to serve the island.

The user representatives and environmental authorities were very much in favour of option 4 and after discussion the participants in the OWP process deemed it the best option to meet the TOR. However, the Stockholm Water Company refused to take on the costs for enlarging their system and only agreed to Option 4 if the community would bear its own costs. This meant that Lambarö residents will pay twice as much as normal users to connect to the system.

Source: Kvarnström & McConville, 2007

6.4.2 Household-Centred Environmental Sanitation (HCES)

HCES is a demand-led planning approach for urban environmental sanitation which places the household and neighbourhood at the core of planning and implementation. It is a step-by-step planning approach specifically designed for unplanned and unserviced urban and peri-urban settings.

HCES was developed in the year 2000 by a representative expert group under the auspices of the Water Supply and Sanitation Collaborative Council (WSSCC) in Geneva. HCES is based on the Bellagio Principles (WSSCC/Eawag, 2005) which focus on human dignity and quality of life, involvement of all stakeholders in decision-making, and waste considered as a resource with maximum use of recycling and reuse potential. The HCES planning approach deals with the most immediate social priorities of rapidly urbanising areas of the developing world, for example sanitation, water and waste. It is a radical departure from the centralised planning approaches of the past and recalibrates decision-making to include those who count most: the users.

Decisions on determining the type of basic services to be implemented is heavily based on the actual needs and means of the users and is done in close consultation with all stakeholders, including the private sector as a potential service provider. This is carried out in a 7-step planning process outlined in the new HCES guidelines currently under development by Eawag/Sandec. The planning steps are organised in three main groups: Appraisal (steps 1-2); Engagement (steps 3-6) and Implementation (step 7). The previous 10-step framework published by the WSSCC and Eawag (WSSCC/Eawag, 2005) has been streamlined and simplified after initial validation in the field.

A precondition for adopting the HCES approach includes understanding and working towards a so-called enabling environment. An enabling environment can be seen as "the set of inter-related conditions that impact the potential to bring about sustained and effective change" (*ibid*). This includes the political, legal, institutional, financial and social conditions that are created to encourage and support certain activities. An enabling environment is important for the success of any development investment; without it, the resources committed to bringing about change will be ineffective. This means, for example, that if the existing sector policies or design codes and regulations do not allow for decentralised wastewater treatment options, a participatory planning exercise like HCES will not be very effective.

Program management is usually assured by local development partners (NGOs or research institutions) but could also be carried out by development-oriented local authorities. The HCES approach has recently been field-tested in several towns in Africa, Asia and Latin America, with a focus on unserviced urban and peri-urban settings.

Figure 6.3, 6.4, 6.5: Images of HCES process in Dodoma: Original unimproved simple pits before (top), options workshop (middle), new improved demonstration facility (bottom).
Source: © Sandec

The selected pilot urban areas include a dense informal settlement in Kangemi, Nairobi, a peri-urban settlement on the city fringe of Dodoma, Tanzania, an inner-city unserved settlement in Vientiane, Laos and a small town setting in Burkina Faso.

The HCES approach was developed to address the deficiencies identified with previous planning methodologies and to build on new approaches developed by the UNDP and World Bank in the 1990s. Preliminary field results from these pilot projects suggest:

- Multi-stakeholder planning processes take time. The HCES planning method necessitates a longer timeframe than expert-driven planning processes. If issues like capacity development and informed choice at community and municipal authority level are taken seriously, then enough time should be allocated. However, slow progress with the planning and implementation of sanitation systems can result in frustrations at the community level if this process takes too long.
- Although the HCES planning approach is a flexible method which enables (but does not prescribe) a fixed solution or technology, stakeholders are conservative and often prefer to choose known solutions, for instance disposal-oriented rather than re-use oriented.
- HCES, like the other multi-stakeholder planning tools are consensus-oriented planning frameworks. But what happens when the different actors fail to reach a consensus? This was the case in the Nairobi pilot project, where major differences between landlords and tenants blocked an improvement of the existing poor sanitation coverage (better sanitation facilities = higher rent). The quality and trust of the facilitator or mediator is therefore of greatest importance for reaching consensus between different stakeholder interests.

6.4.3 Participatory planning tools

This section describes participatory planning tools that are variously used in sanitation and hygiene approaches in urban contexts. Participatory planning approaches were developed in the 1980s and 1990s to try to overcome the limitations of planning as a purely technocratic exercise. Most well-known is the PRA method ("Participatory Rural Appraisal") which has since been adopted for urban use. Tools typical of PRA are semi structured interviewing and focus group discussions. PRA includes these tools and goes beyond them by being participatory and empowering rather than extractive. The behaviour and attitudes of facilitators are fundamental in PRA, and more important than the methods. Much PRA uses group activities to facilitate information sharing, analysis, and action among stakeholders.

Box 6.4: Household-Centred Environmental Sanitation

Step 1; Process ignition and hygiene promotion

Preparing the ground and "triggering" the community for action, initial stakeholder assessment.

Step 2; Launching of the planning process

Identify key actors at each level. Assess the range of interest groups, carry out stakeholder analysis, and agree on project committee or task force.

Step 3; Detailed assessment of the current situation

Analysis of existing services/infrastructure and the enabling environment. Diagnosis of main problems and deficiencies.

Step 4; Prioritising and Validation

Assessment of people's priorities using a variety of tools (pocket voting, participatory assessments, focus group discussions, etc).

Step 5; Service options for environmental sanitation

Identify possible solutions and technology options based on systems perspective. Build pilot technologies to give beneficiaries the opportunity to test and assess pre-selected options. Allow informed choice before making final selection.

Step 6; HCES action plan

Produce planning document which details how to implement the agreed objectives including institutional, financial, technological and maintenance considerations. Main output: costed action plan.

Step 7; Implementing the action plan

Implementation of the environmental sanitation service plan using measurable indicators and benchmarks.

Although originally developed for use in rural areas, the PRA approach and methods have been employed successfully with applications in health, poverty, sanitation and numerous other domains, including urban and organisational settings.

In a community, PRA activities can have many combinations and sequences of methods. PRA tools are continuously being invented. Some of the most commonly used are:

- Social and resource mapping and modelling
- Matrix scoring and pocket voting
- Wellbeing ("wealth") ranking
- Causal linkage diagramming
- Sorting and/or ranking cards or symbols

Box 6.5: HCES in Chang'ombe, Dodoma (2007 - 2009)

Together with local partners, Eawag-Sandec successfully implemented the household-centred approach in the unplanned settlement of Chang'ombe on the outskirts of Dodoma, Tanzania's capital. The HCES planning approach produced an urban environmental sanitation service plan for the 35,000 inhabitants focusing on household sanitation and drainage problems.

The multi-stakeholder process involved the service utility, the municipality, NGOs as well as neighbourhood committees involved in the water and sanitation sector. The demand-oriented approach involved:

- a participatory assessment of the status-quo utilising household interviews, focus-group discussions and key informants;
- assessing user priorities and preferences, behaviour and willingness to pay;
- a participatory discussion and assessment of viable system and technology options including technical, institutional and financial considerations;
- construction of the three selected demonstration facilities in Chang'ombe (Fossa alterna, VIP toilet and a urine-diverting dry toilet) for the community to use, operate and compare different solutions to test user acceptance before replication;
- setting up a "micro-finance for sanitation" project with US$ 35,000.- seed funding for unserved households in Chang'ombe.

The planning process was organised by a three-member task force including a facilitating local NGO, Dodoma municipality health department and a representative of the Chang'ombe community. Through several public community workshops, the planning approach managed to fully integrate the end-users in all planning stages and achieve more sustainable solutions agreed upon by all stakeholders. A further unintended outcome was the utility's renewed interest in faecal sludge management for on-site sanitation. This was demonstrated by the utility, which has purchased of a new exhauster truck to serve settlements with on-site sanitation.

Source: Eawag-Sandec, 2008

PRA is particularly useful in setting the agenda for a peri-urban or slum community to work towards sustainable sanitation solutions.

Another tool is "Community-Led Total Sanitation" (CLTS) that was initiated in Bangladesh in 1999 as an innovative methodology for eliminating open defecation in rural areas (Kar, 2005). However, it has also been applied in urban areas in the Kalyani Municipality near Kolkata, India (Stockholm Environment Institute, 2008). CLTS uses a participatory approach similar to PRA to empower local communities to stop open defecation and promote the building and use of latrines through community action. The approach helps community members to analyse their own sanitation practices and the potential for spread of faecal-oral diseases within their community. The CLTS approach works through the creation of a sense of disgust within the community, which triggers collective action to improve the sanitation situation. The idea is to use peer-pressure through public recognition of the problem to induce behaviour change. The method has proved successful in Bangladesh and has since been applied in other South and Southeast

Asian countries, as well as several African countries.

The Household-Centred Environmental Sanitation (HCES) approach presented earlier, also includes participatory tools which trigger community action and awareness. HCES places the household and its neighbourhood at the core of the planning process and through a flexible, but guided process, builds a community's momentum for action. Likewise, the Open Wastewater Planning approach is a flexible and simple method guiding decision-making based on site conditions and an assessment of the environmental impacts. It is geared towards an institutionally more structured environment. See "Introduction to Hygiene and Sanitation Software" in Chapter 9 for more details about these approaches.

6.5 Recommendations

If these new trends for participation and criteria-based planning are to be implemented, the entire process of planning and management needs to remain flexible so that changes and improvements can be made as new information becomes available. Besides flexibility, future trends also call for inclusiveness and cooperation with other sectors, such as creating links between water, energy and waste for more efficient resource management. The resulting demand for integrated systems will require planning to adopt a more participative approach while at the same time efficiently managing complex criteria and information flows. The case from Indonesia (Box 6.6), illustrates this merging of "top-down" and "bottom-up" planning approach by incorporating both the participatory approaches of collaborative planning and expert-led thinking needed for criteria planning (WSP, 2009). Depending on the given context, a combination of the planning tools presented above may be appropriate, in addition to the application of appropriate awareness-raising tools. Sanitation planners need to increase their flexibility and creativity by experimenting with different methodologies, as well as critically evaluating them to find out what works in their specific setting.

Box 6.6: Planning for Progress in Indonesia

The Government of Indonesia in partnership with the World Bank Water and Sanitation Program (WSP) has developed an innovative response to the growing sanitation crisis. At the core of the Indonesia Sanitation Sector Development Program (ISSDP) is a focus on city-level planning and capacity building. The aim of the program is to assist Indonesia in meeting national sanitation goals by supporting six medium-sized municipalities (Surakarta, Jambi, Payakumbuh, Banjarmasin, Denpasar and Blitar) to produce city-wide sanitation strategies.

The planning process promoted by the program is built around several key features. First, it avoids "blueprint" approaches to infrastructure development that assume the city is a blank sheet onto which new services can be drawn. Instead, it starts by identifying what already exists and how it can be improved, in incremental steps if necessary. In this way it recognises that planning is a continuous process, not a one-time event, and that plans must be reviewed and updated. Secondly, it places special emphasis on institutional and financial aspects of service delivery, as well as the need for effective communication with service users. Thirdly, the ISSDP breaks down a complex planning process into discrete, manageable tasks, emphasising the importance of sound information for decision making. Similar to the entry-point or city domains approach outlined in Chapter 5, the ISSDP recommends breaking the town into zones and using surveys from representative parts of town to provide data that may be incomplete or unavailable at the city level. Finally, it recognises the need for both for strategic, city-wide decision making by local government, and for active support and engagement at community level. In this way it combines the need for expert input with planning suggestions from neighbourhood proposals.

The process begins with an assessment of existing infrastructure and collection of data from both secondary (demographic statistics) and primary sources (surveys, observations). Data sets are analysed by professionals and a set of maps are produced that divide the city into zones based on four levels of public health risks. The maps and other information are distilled into a "white book" which details the city sanitation status, key problems and priority areas, and issues requiring attention. These books form the basis for the development of a comprehensive city-wide sanitation strategy. The strategy includes plans for infrastructure development and rehabilitation, but also details how sanitation services will be operated and sustained, both physically and financially. The strategies include incremental goals and budgeted action plans, emphasise the needs of the poor, and stress the need for creating user demand and catering to their preferences in service delivery.

The program supported and facilitated the planning process but did not undertake it directly. Instead, full time facilitators supported by roaming experts worked in each city to provide guidance and specialised services as needed and asked for by the local government. By April of 2008, all six cities had formalised a citywide sanitation strategy. One of the key values to emerge during the planning process was the sense of local ownership of the problems and solutions.

Source: WSP, 2009

7 SUSTAINABLE SANITATION SYSTEMS

7 Sustainable Sanitation Systems

Arne Panesar
Rahul Ingle
Thorsten Schütze
Christian Zurbrügg

A sanitation system consists of a multi-step process in which human excreta and domestic sewage are managed by a sequence of technologies from the point of generation to the point of reuse, recycling or safe disposal. This chapter introduces a range of sanitation systems and different types of technologies associated with these systems. Seven system templates are used to explain flow streams for different sanitation systems, including "wet" and "dry" technologies. These are illustrated by case studies from different parts of the world.

7.1 Why a Sanitation System Approach?

To address the sanitation Millennium Development Goal challenge, numerous technological innovations have been developed. But with such a wide range of technologies that may be appropriate in different settings, difficulties with communication and knowledge dissemination hinder informed decision making and the integration of all sanitation elements. This chapter categorises different sanitation systems according to the related processes and the resulting products. Different systems are presented diagrammatically using a "flow-stream" concept in which technologies are grouped and used to construct seven different systems. This method for organising and defining sanitation systems helps to facilitate informed decision making by consideration of an integrated approach. By using a complete sanitation system and its technology configurations from user interface to reuse and disposal, other required aspects can be considered such as operation and management, service and supply chains as well as interactions with various stakeholders and actors.

A sanitation system - contrary to a sanitation technology - considers all components required for the adequate management of human wastes. Each system represents a configuration of different technologies that carry out different functions on specific waste inputs or waste products. The sequence of function-specific technologies through which a product passes is called a flowstream. Each system is therefore a combination of product and function-specific technologies designed to address each flowstream from origin to reuse, recycling or safe disposal. Technology components exist at different spatial levels, each with specific management, operation and maintenance conditions as well as potential implications for a range of stakeholders. Starting at the household level with waste generation, a system can include storage and potential treatment and reuse of all products such as urine, excreta, greywater, rainwater, organic solid waste from the household and agricultural activities or manure from cattle, at or near, the source of waste generation. However, problems can often not be solved at the household level alone. The household "exports" waste to the neighbourhood, town, or downstream population. In such cases, it is crucial that the sanitation system boundary is extended to include these larger spatial sections; those that take into account technology components for storage, collection, transport, treatment, discharge or reuse at these levels.

Sanitation systems can be distinguished by being water-reliant or non-water reliant with regard to the transport of excreta. This systematic distinction is used in characterizing sanitation systems for example. as in the Philippines Sanitation Sourcebook as well as the NETSSAF coordinating action project.

Next to water-reliant or non-water reliant another distinction can be made in the various degrees of separation of incoming wastes. Urine diverting sanitation systems, as the name says, keep urine separate from faeces from the very beginning. On the other hand sewered sanitation systems mix faeces, urine, flushing water, greywater as well as wet or dry anal cleansing materials resulting in a waste product classically called wastewater. It is important to note that, depending on the degree of waste mixing or separation, various "flowstreams" can be distinguished which consequently must be accounted for in the subsequent functions of the sanitation system.

"Wet" and "Dry" indicate the presence of flushing water for the transport of excreta. This however only gives a certain indication of how wet or dry the collected waste materials will be. Although flushing water might not be used (and would not therefore qualify as a "Dry system") a system may nevertheless contain anal cleansing water or even greywater. Also, Wet systems are characterised by the production of a parallel product: faecal sludge. In wet systems then, the faecal sludge flowstream must be taken into account and treated accordingly with its own set of process- and product-specific technologies until the point of reuse or ultimate disposal. As an example for a set of sanitation systems, the following system categorisation is given, which is based on the findings from NETSSAF (Network for the development of Sustainable Approaches of large-scale implementation of Sanitation in Africa) (NETSSAF, 2007).

7.2 System Categories

This section discusses seven different categories for practically proven sanitation systems. The borders between the specific systems are flexible and combinations between the different systems are possible. Therefore sustainable sanitation systems can principally be assigned to the seven system categories discussed in the subsequent sections. For each category one case study is presented to illustrate how the system approach has been translated to the design of real systems. The

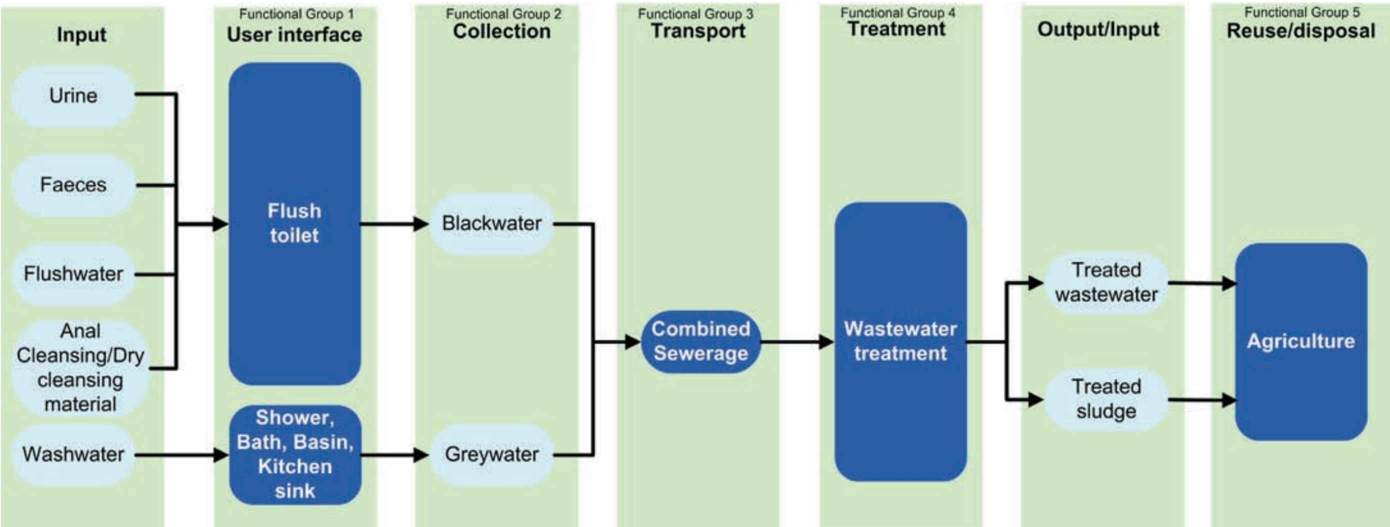


Figure 7.1: System template providing a schematic overview of the specific inputs of a sanitation system (left column), their transformation in the four functional groups "user interface", "collection", "transport" and "treatment", the specification of two outputs for the fifth functional group "reuse/disposal" (in this example "nutrient reuse in agriculture").

examples are presented only briefly without detailed data. References to detailed descriptions of the case studies are provided for each case.

Figure 7.1 shows an exemplary template for sanitation systems describing how inputs enter a sanitation system via a specific user interface and how the specific flowstreams pass through the different functional groups in which they are transformed prior to final reuse, recycling or safe disposal.

7.2.1 Wet mixed blackwater and greywater system with offsite treatment

In this system, all wastewater that is created by households, institutions, industries and commercial establishments are collected, transported and treated without stream separation. There are different user interface technologies available for the collection of blackwater. These can be by high- or low-volume cistern-flush toilets, or pour-flush toilets. After collection, blackwater is mixed with household greywater as it leaves the house; the mixture (referred to as "wastewater" for simplicity) is transported to a centralised (offsite) treatment plant. Then a wide array of technology options for wastewater treatment can be applied. Transport technologies may be pipes with gravity flow, pressure flow, or vacuum systems. Such systems are generally called "conventional sewer systems", as used most frequently in cities around the world. They entail a cistern flush toilet as a user interface. Excreta together with greywater - and often even stormwater - is discharged into a sewer which leads to a centralised wastewater treatment plant before the treated effluent is discharged into the environment. Additionally to conventional sewer systems new approaches and technologies have been developed to take into account the limited financial capacities of societies with low and middle income. So-called "simplified sewer systems" (see also section 7.2), also called condominial sewers have less stringent design criteria, are located in backyards or sidewalks, rather than under the roads, and can be constructed by and together with the community.

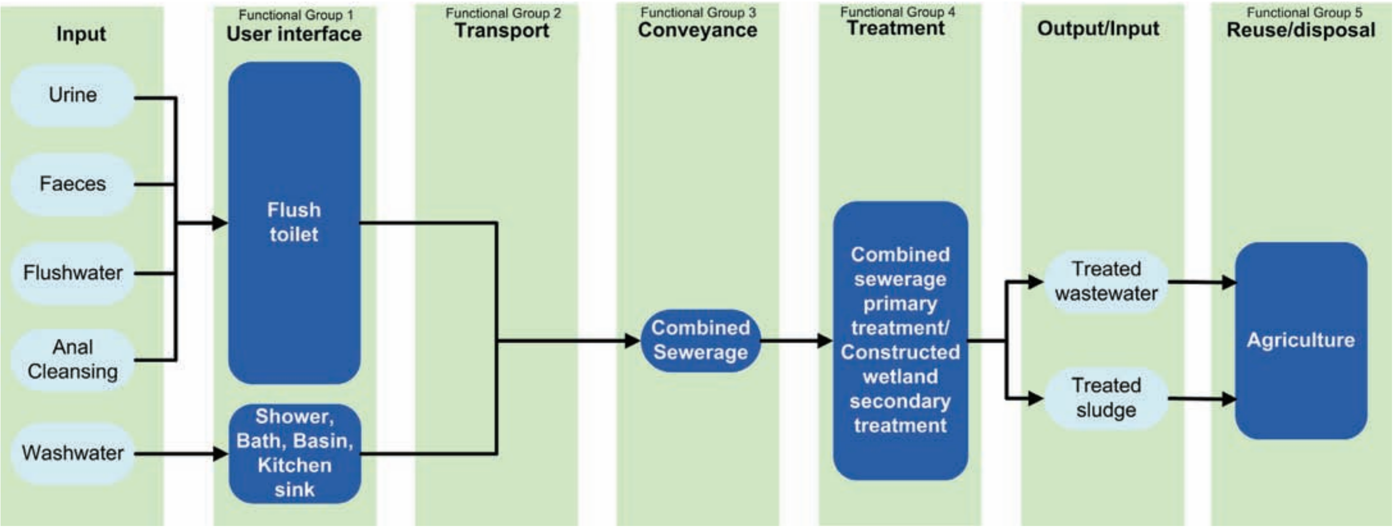


Figure 7.2: System template for the conventional mixed sewage system in "Haran Al Awamied", Syria. A combination of centralised sewers, pre-treatment and secondary treatment allows the reuse of nutrient rich water in the nearby peri-urban agriculture.

These simplified systems have been successfully applied in Brazil and other countries of Latin America limited without significantly affecting the choice of treatment technology.

Case study: Haran Al Awamied, Syria

The wastewater from approximately 7,000 residents of the peri-urban settlement "Haran Al Awamied", located 40 km from Damascus, Syria, is treated at a centralised treatment plant. The treatment plant consists of a settling tank for pre-treatment and a sub-surface, vertical flow constructed wetland for secondary treatment. The treated effluent from the constructed wetland is reused in agriculture. The sludge is dried and harvested along with the reeds and is reused in agriculture. The space requirements of constructed wetlands per capita are inferior to that in temperate climates, which reduces land costs. Ownership to keep the system running is increased, as farmers that are aware of the value of the nutrient- rich irrigation water are involved in the system management. Figure 7.2 shows the various flowstreams in this system configuration. More detailed information on this case study can be downloaded from: http://www.susana.org/lang-en/case-studies

7.2.2 Wet mixed blackwater and greywater system with decentralised treatment

This system, like the previous one, is characterised by flush toilets (full, low, vacuum or pour flush toilets) at the user interface. Here however, the treatment technology is located close to the source of waste generation. Depending on the plot size, the treatment technology will be appropriate for one house, one compound or a small cluster of homes. Accordingly, transport before treatment is limited to short distances mostly by gravity sewers. There are various low-cost technology options for on-site wastewater treatment, which differ from those typically used as centralised, off-site technologies. Examples include septic tanks, filters, constructed wetlands, anaerobic baffled reactors, and biogas plants, among others. Although it is commonly practiced, pits should not be used as disposal sites for mixed wastewater systems.

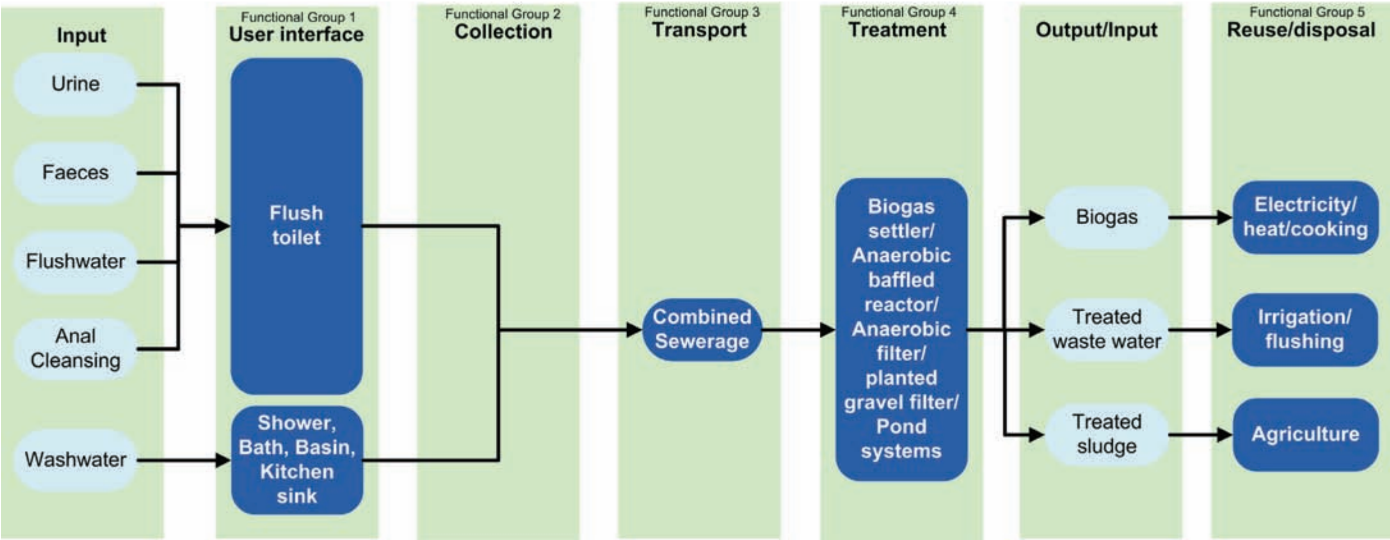


Figure 7.3: Template for the decentralised mixed sewage system in Kolhapur, India. A combination of decentralised combined sewers, wastewater treatment and reuse of nutrient rich water in peri-urban agriculture is applied.

Case study: Kolhapur, India

The municipal corporation in the city of Kolhapur, India, has introduced a master plan that incorporates decentralised sanitation technology options for its residents. It recommends decentralised technology options for residential areas for biogas generation, which can be used for cooking, heating and lighting. The applied technologies include biogas settlers, anaerobic baffled reactors, anaerobic filters, planted gravel filters and polishing ponds. The treated wastewater is used for irrigation of gardens. The treated sludge will be reused in agriculture. Figure 7.3 shows the various flowstreams of the proposed system in relation to the functional groups.

7.2.3 Wet blackwater system

In this system, urine, faeces and flushing water (blackwater) are collected, transported and treated together. However, greywater is kept separate. Since greywater accounts for approximately 60% of the wastewater produced in homes, this separation simplifies blackwater management. A very common and frequently practiced example of this system is the double-pit pour flush toilet. This technology allows users to have the comfort of a pour-flush toilet and water seal, without the trouble of having to pump out the sludge, since it is removed only once it has matured into a solid, humic-like substance. Other technologies can involve anaerobic treatment for blackwater with biogas production. To avoid malfunctioning of the blackwater treatment technologies, a separate system for greywater management must be implemented. Since separated greywater contains few if any pathogens, and usually low concentrations of nitrogen and phosphorus, it does not require the same level of treatment as blackwater or mixed wastewater. Greywater can be recycled for irrigation, toilet flushing, exterior washing, and other water-conservation measures.

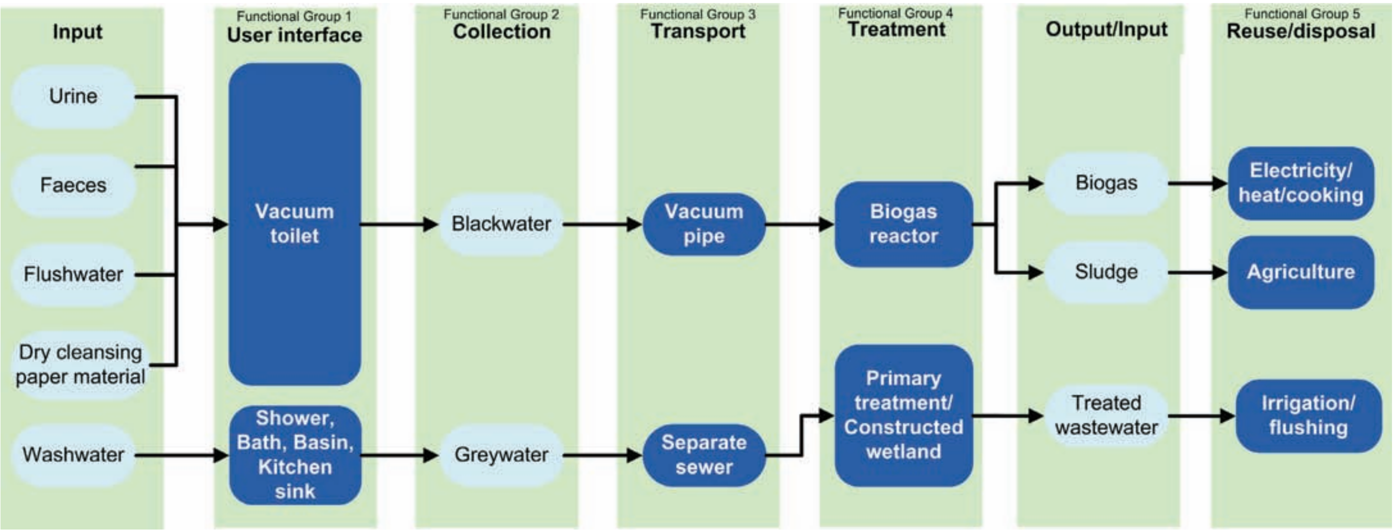


Figure 7.4: Decentralised mixed sewage system in Lübeck Flintenbreite, Germany. A combination of decentralised separated sewers, greywater treatment in a constructed wetland and anaerobic digestion of blackwater in a biogas reactor is applied.

Case study: Lübeck Flintenbreite, Germany

In the Flintenbreite neighbourhood of Lübeck, Germany, a housing estate for up to 380 residents was designed, with the focus on energy and water efficiency as well as the reuse of organic wastes and nutrients. The housing estate is not connected to the city's centralised sewer network and consists of a decentralised sanitation system. All houses feature vacuum toilets that collect the blackwater separately. The households' organic waste is processed together with gardening waste and with the blackwater in an anaerobic digester and a biogas plant. The biogas is used in a combined heat and power generator for the production of electricity and heat. The slurry consists of digested residues and is used as a fertiliser and soil conditioner in farming. The greywater is treated separately in constructed wetlands. The purified effluent is discharged into a nearby creek. Figure 7.4 shows the flowstreams with their corresponding functional groups. More detailed information is available on the internet: http://www.susana.org/lang-en/case-studies

7.2.4 Wet urine diversion system

In this system, faeces, flushing water and greywater are collected, transported and treated together but urine is kept separate. The diversion of urine from the other flowstreams requires a specific user interface, known as a urine-diverting toilet. Urine can be either collected with or without flushing water. The objective of the urine separation is (usually) to keep the nutrient rich urine free of pathogens and to ultimately facilitate its reuse. In this wet urine diverting system, the faeces are flushed with water (brownwater) to an off-site treatment facility. Sometimes the urine is mixed with a small amount of flushing water, in which case the product is referred to as "yellowwater".

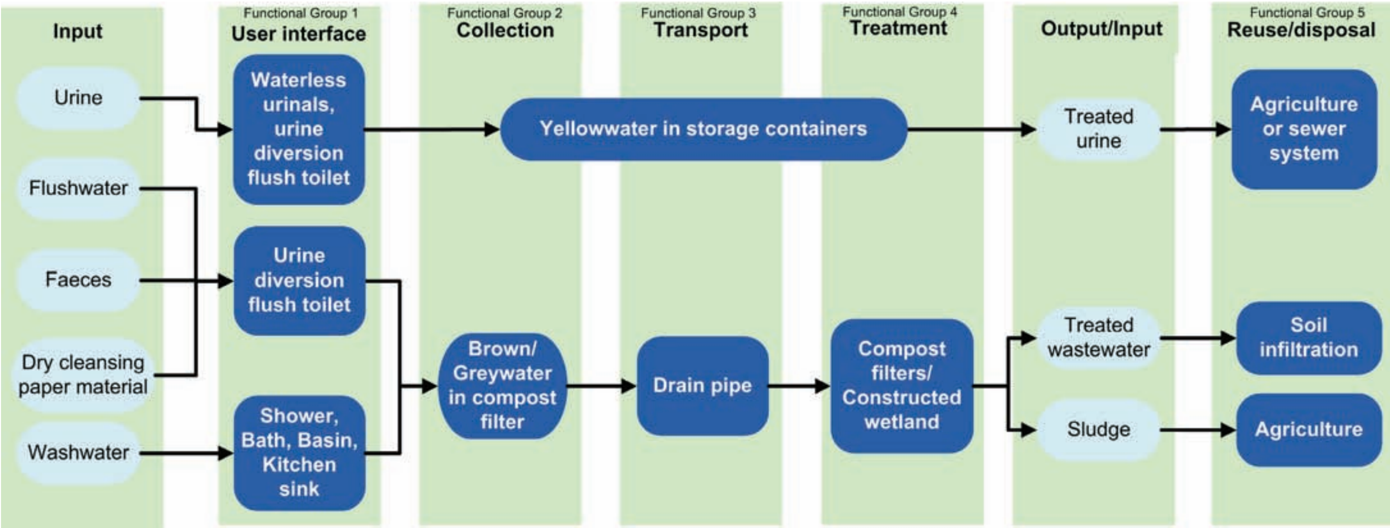


Figure 7.5: Wet urine diversion system in the Solar City Pichling in Linz, Austria. A combination of decentralised separated sewers, yellowater storage, nature orientated grey- and brownwater treatment as well as the reuse of products, such as composted sludge, urine and treated wastewater is applied.

Case study: Linz, Austria

In Solar City Pichling, located in Linz, Austria, a sanitation system was implemented which includes 127 urine diversion flush toilets plus 20 urinals for 88 households and a primary school. The brownwater and greywater is mixed and pre-treated through a filter, in which solids from this sewage flowstream are removed and pre-composted. The filtrate is treated in a subsurface vertical-flow type constructed wetland. The separately collected urine and composted sludge are used in agriculture as a fertiliser and soil conditioner. The treated and purified wastewater is infiltrated into the soil for the augmentation of groundwater resources. Figure 7.5 shows the various flowstreams in relation to the functional groups. More detailed information is available on the internet at: http://www.susana.org/lang-en/case-studies

7.2.5 Dry excreta and greywater system

Here excreta - a mix of urine and faeces - are discharged at the user interface without using any flushing water. In this system the greywater is collected separately. Although the mixture of urine and faeces may be slightly wet, the system is referred to as "dry" simply because there is no flushing water. Depending on the cultural habits, anal cleansing water may or may not be included although smells and flies are minimised if the mixture is kept as dry as possible. Generally, the system is typically characterised by "drop and store" latrines or composting toilets popular in northern Europe. The separated greywater should be treated as close to where it is generated (on-site-treatment) as possible. The excreta may be further treated off-site. Generally, off-site treatment is only performed to improve hygienisation (especially in the case of single pits that are emptied before the contents can be completely digested). Proper operation and maintenance significantly influence the performance of these facilities. It is possible to either reuse the recovered resources (greywater and/or treated excreta) or to dispose of them when interest in resource recovery and reuse is lacking.

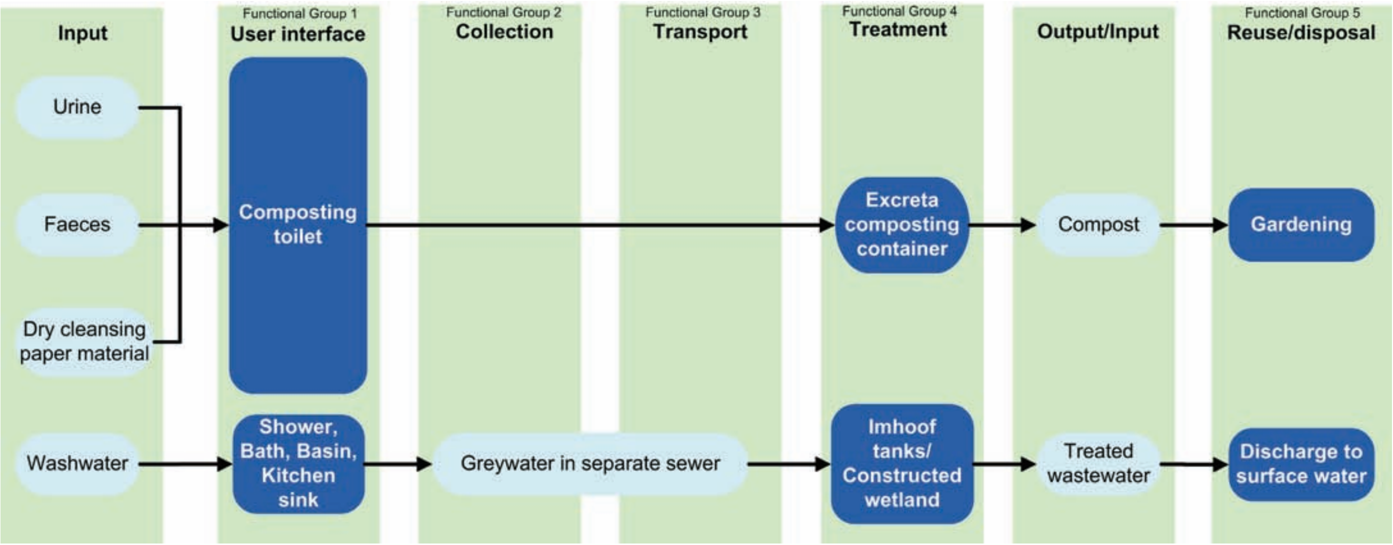


Figure 7.6: Template for the dry excreta and greywater system implemented in Hamburg, Germany. A combination of decentralised compost toilets, separate sewers, greywater treatment as well as the reuse of products, such as composted faeces and organic wastes are applied.

Case study: Hamburg Allermöhe, Germany

The eco-settlement Allermöhe in the city of Hamburg, Germany, features a decentralised sanitation system for 36 single family row-houses. Each household is equipped with an own composting toilet (Clivus Multrum) and an integrated composting chamber in the basement of the buildings. Urine, faeces, toilet paper and organic kitchen waste are composted together with oak bark in a well-ventilated unit. The compost from the composting chamber is emptied every 2 years and used as a fertiliser and soil-conditioner in the gardens. The greywater is treated in a constructed wetland and the treated wastewater is discharged into an open surface water body. Figure 7.6 shows the flowstreams with their corresponding functional groups. More detailed information is available on the internet at: http://www.susana.org/lang-en/case-studies

7.2.6 Dry urine, faeces and greywater diversion system

This system is characterised by the separation of urine, faeces and greywater into three different flowstreams, and, where anal cleansing water is used, a fourth flowstream. In this way, each flowstream can be more appropriately managed in terms of its volumetric flow, nutrient and pathogen content and handling characteristics. The diversion facilitates more targeted treatment and end use for the different fractions. This system requires a urine-diverting user interface. Urine is collected through the front outlet and conveyed to a collection vessel (a tank in larger, more expensive systems or a jerry can in smaller, simpler systems), a garden or possibly a soak pit, if the urine is not brought to use. Through the rear outlet the faeces are collected in a container located underneath the toilet. Dry cleansing material (such as toilet paper) can be dropped through the rear outlet, although it is often kept separate. Some urine-diverting squat pans are also equipped with an additional outlet for anal cleansing water which is then treated, in a separate flowstream.

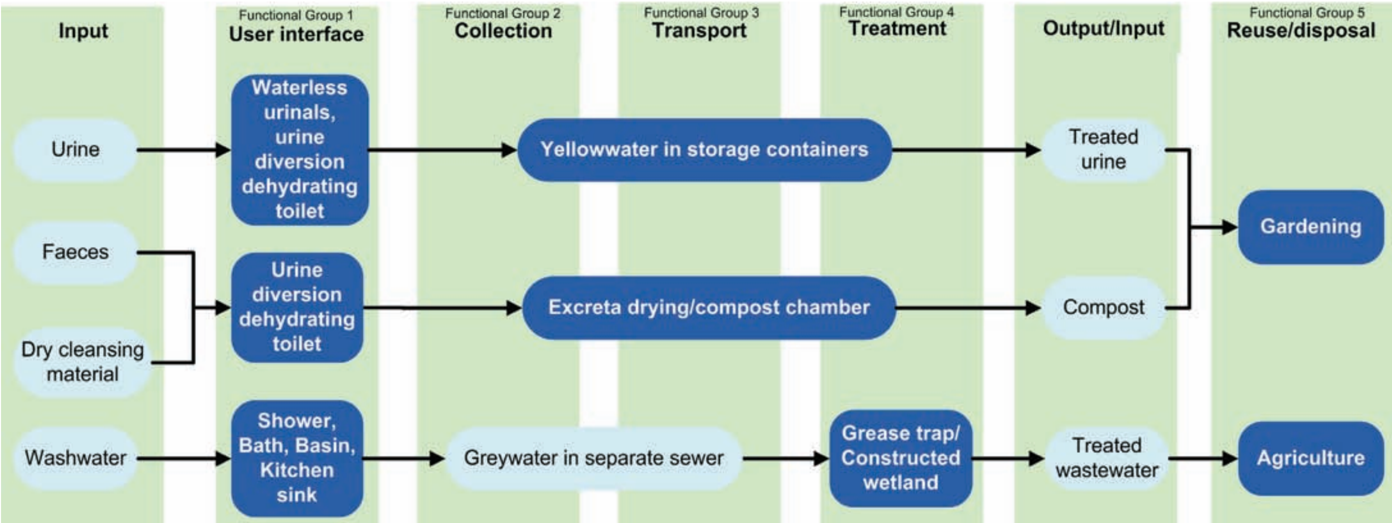


Figure 7.7: Template for the urine diversion system at Chorillos School in Lima, Peru. Flowstreams of yellowwater, faeces and greywater are collected and processed separately. The final products (treated urine, compost and treated greywater) are used in the school garden.

Case study: Chorrillos School in Lima, Peru

In the Chorrillos School, in Lima, Peru, two double vaulted Urine Diversion Dehydrating (UDD) toilets with waterless urinals have been constructed for the students. The front portion of the UDD toilet and the waterless urinal are both connected to a jerrycan for collection. Faeces are collected in the chamber below along with sawdust used as drying material. The greywater is treated in a constructed wetland and the treated water is used in irrigation. The dried faeces and the liquid urine are used as fertilisers for gardening. Figure 7.7 shows the flowstreams with their corresponding functional groups. More detailed information is available on the internet at: http://www.susana.org/lang-en/case-studies

7.2.7 Simplified sewers

Simplified sewer systems are comparable to centralised sewage systems but they are characterised by small sewage pipelines and significant lower investment costs. Sanitation systems which combine such sewers with the decentralised and semi-decentralised treatment of specific flowstreams are an appropriate solution for densely populated urban environments. Compared with conventional sewer systems, simplified sewer networks use smaller diameter pipes laid at shallower depth and at a flatter gradient than conventional sewers. For example, a simplified sewer network with 100 mm diameter pipelines laid at a gradient of 1 to 200 (5‰) can drain over 200 households with 5 people each and with a water consumption of 100 litres per person and day. In-house water supply is not essential for simplified sewer networks. In Orangi, Pakistan, for example, a simplified sewer system was installed in an area with a low water consumption of 27 litres per person and day, using public standpipes. Experience from densely populated urban settlements in Brazil show that simplified sewers can be realised with lower investment costs than on-site systems such as VIP latrines or pour-flush toilets. However, simplified sewer systems must be integrated with locally adapted sustainable sanitation systems for the treatment and safe disposal of the specific flowstreams.

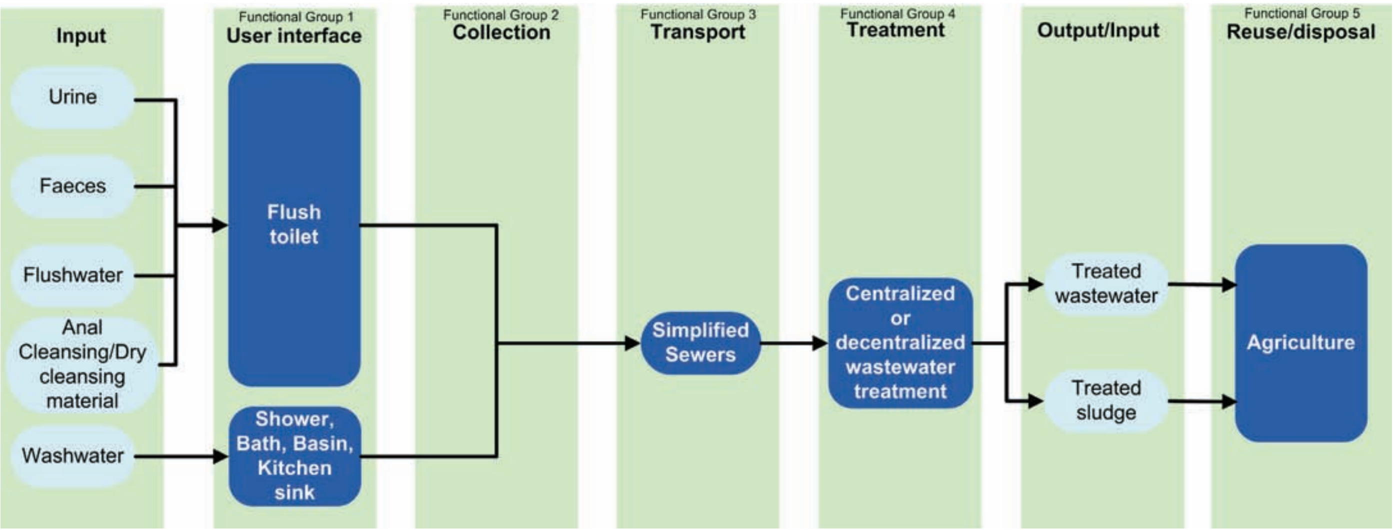


Figure 7.8: Template for simplified sewer systems in Brazil. All flowstreams are mixed with each other and are treated end of pipe. The products, treated wastewater and sludge, can be reused in agriculture for irrigation as well as a soil conditioner and fertiliser.

Case study: Communal Sewerage Systems in Brazil

During the 1980s a so-called "condominial" or communal approach to the construction of sewerage networks was developed in Brazil as a response to the challenges posed by expanding services into poor peri-urban neighbourhoods. In order to reduce construction costs, individual household connections to the street sewer were replaced by so-called "condominial branches" that run alongside the houses. These "condominial sewers" are conveniently located under pavements in front of houses or in backyards. This permits the adaptation of the network to local topographic conditions and different urbanisation patterns. In addition, the design can include the installation of decentralised wastewater treatment facilities in order to avoid the costs associated with transporting wastewater over longer distances. In addition to some technological innovations, the two key elements to the approach are the provision of services to a collective of households and the development of a closer relationship between service providers and users, encouraging the two parties to come to an agreement and to facilitate service expansion and adaptation to local needs and constraints. Experiences in Brazil illustrate how the model has been successfully applied to urban neighbourhoods as diverse as the "Rocinha slum" in Rio de Janeiro and the affluent "Lago Sul" and "Lago Norte" districts of Brasilia. In the city of Brasilia the "condominial approach" was used to expand sewerage service to half a million people in 24 urban areas (WSP, 2005). The two most prominent features of this experience were the achievement of universal access at very low financial cost to the utility company as well as the way in which the technology was adopted by the utility company to provide sewerage connections to both rich as well as poor communities. In the city Salvador de Bahia the "condominial" model was also applied to sewerage on an unprecedented scale, serving over one million people. However, in contrast to Brasilia, the condominial system in Salvador was adopted in a gradual and more experimental manner, motivated by the extremely dense and unplanned urbanisation patterns as well as the specific topography of the city, which is characterised by very steep slopes. See Neder (2010) for further information about condominial technology.

This chapter has presented a brief overview of different sanitation systems, which can be more or less appropriate for specific locations, following one of the key tenets of this publication that sustainable solutions can only be developed in an integrated and context related manner. The seven sanitation systems presented in this chapter have highlighted the different flowstreams and resulting products and outputs together with logistical and management aspects that must be considered in a systems approach to sanitation. The final chapter of the book presents entry points for action and successful case studies from around the globe.

8 PUTTING PLANS INTO PRACTICE

8 Putting Plans into Practice

Christoph Lüthi
Jochen Markard
Jonathan Parkinson

The book has highlighted that the challenge for urban sanitation is not simply a technical problem related to engineering constraints, but also a question of the integration of water and sanitation infrastructure planning within land development and management plans. In addition, these plans need to be mixed with a new set of management processes that are orientated towards attaining urban sustainability goals. This chapter focuses on putting plans into practice, underlining issues of implementation relating to social mobilisation, sanitation promotion and the creation of enabling environments. We initially elaborate on some of the key challenges for introducing new approaches and reasons why projects fail before discussing possible tools to avoid these pitfalls and examples of what has been found to work. Inspiration for the way forward is given through a series of ten examples, in a variety of contexts from around the globe, where sustainable sanitation systems have been successfully implemented.

8.1 Challenges for Innovation

When innovative sanitation projects fail or have difficulties in scaling-up, a variety of contextual factors and constraints may be at work. The Kunming case (Box 8.1), for example highlights how the neglect of several key socio-cultural factors impacted the program outcomes. Similar to the Kunming case, low demand for sanitation or particular toilet models is often reported as a key barrier for introducing novel techniques (Etnier et al., 2007; Parkinson and Tayler, 2003). In addition, where there is a general lack of awareness by potential users, and municipalities and utilities have little knowledge about the full operational requirements of sanitation options, the uptake of innovative approaches is likely to remain low. This lack of priority and knowledge of sanitation options often results in preference for long-established techniques and proven methods, especially by large-scale funding programs and government agencies.

Unfavourable regulatory frameworks and inconsistencies in institutional structures may also contribute to project failure. Performance criteria and design guidelines for innovative approaches may be ill-defined or non-existent; or there may be strong regulations in place that favour centralised wastewater treatment. In addition, implementation of innovative technologies often require an active involvement of local resident and other stakeholders; a challenge when public authorities and government agencies typically make decisions regarding regulations and technology selection in domains outside of these local levels. Introducing more sustainable sanitation options may therefore require the establishment of new organisational and institutional arrangements to bridge the gap between users and regulators.

The need for new regulations and organisational arrangements is related to another critical issue affecting program outcomes: capacity for operation and maintenance. As shown in Kunming and other cases, lack of management expertise and insufficient attention to operational requirements often results in systems that are not used at a local level (cf. Parkinson & Tayler, 2003). One way of addressing this issue is to find opportunities to develop the capacity of local level stakeholders. For example, one strategy could be to identify the local business structures (for example family businesses, small trade, informal suppliers and providers) that exist in the local context which may be able to take responsibility for some of the tasks related to operating and maintaining sanitation options.

Another challenge with introducing new sanitation systems is that user habits (for example deep rooted cognitive psychology reinforced by daily routines and social pressures) can prove difficult to change; often despite well-intended educational and social marketing campaigns. Thus, the acceptance of novel approaches is often hampered because people see little reason for changing established defecation practices. For example, socio-cultural factors can result in significant barriers for the use of ecological sanitation systems which promote the use of human excreta as fertiliser for food production, even though these may well have been practised for centuries in rural communities.

8.2 Instruments to Support the Uptake of Sanitation

Although the challenges outlined above are real there are also a number of tools and strategies available that can address them. One of the keys to facilitating the successful uptake of sanitation involves understanding and applying the laws of supply and demand. A basic lack of understanding of supply and demand relationships for latrines often means that well-intentioned sanitation improvement projects are vulnerable to failure if they fail to meet customer needs and expectations (as described in Box 8.1: Kunming case). Studies from around the developing world show that sanitation is facing a number of common problems related to demand and supply: lack of awareness of the importance of sanitation, a low satisfaction with existing sanitation technologies, poor supply chains and lack of financing mechanisms. In order for a project to be successful there is a need to generate a "demand" for sanitation and to ensure that there is a "supply" of latrine components to meet this demand. Specific components of the supply and demand chain are related to demand creation through marketing, enhancing the supply chain and creating opportunities for financing of sanitation.

Box 8.1: Kunming case: source-separating sanitation

In the city of Kunming (China), a pilot project with the aim to introduce urine-diverting dry toilets in a peri-urban area was set up in 2005. The project was piloted by the Swiss Federal Institute of Aquatic Science and Technology (Eawag) and the Kunming Institute of Environmental Science (KIES) in collaboration with the Yunnan Academy of Social Sciences (YASS). Urine separation at the source in Kunming's peri-urban areas was the main goal for this project. This was due to the heavy pollution of Lake Dianchi, which is heavily eutrophied due to phosphorus and nitrogen from the wastewater of Kunming (World Bank, 1996). The Provincial Government was keen to promote low-cost alternatives to sewer-based systems that stemmed the flow of nutrients into the lake. The Provincial Environmental Protection Bureau in particular supported more sustainable alternatives to conventional sewerage, especially for less densely populated peri-urban areas.

A major challenge of the Kunming pilot project was to introduce a novel approach to sanitation in a very hierarchically organised assembly of public authorities with a strong tradition of top-down decision-making processes. After an initial piloting with around 120 urine-separating dry toilets (see Figure 8.1), this solution was adopted by government agencies and integrated into the official Five-Year Plan for Kunming's peri-urban interface (Task Force, 2001). It was especially this latter phase of development that failed. In the following, we provide a brief review of the events.

As part of the scale-up phase, YASS developed recommendations for provincial and municipal policymakers which were based upon the findings of the pilot project. In 2001, officials decided to include the urine-diverting dry toilets (UDDT) into the official Provincial Five-Year Plan as a solution for reducing pollution loading at the source for rural and peri-urban areas (Task Force, 2001). Over the next five years 20,000 UDDT toilets were installed in households in and around Kunming. Although there has been no systematic evaluation of this project, estimates show that less than 10% of the newly-built units are actually in use today. Anecdotal evidence suggests that former UDDT toilets attached to households are today used for storage and in one case a 5-seat public toilet had been converted to a chicken coop. When asked, villagers said they understood how the UDDTs worked, but they found them to be "inconvenient."

Better results were achieved with government subsidised bio-digesters that were also introduced in the area. In contrast to the UDDTs, approximately 50% of the bio-digesters are being used because (1) families see the immediate benefits from the cooking gas (and because they can still apply the safe "solids" to their fields) and (2) Yunnan EcoNetwork, a local NGO, has undertaken an ambitious education program in regards to the proper construction, use and maintenance of bio-digesters. (Bockmann, 2009)

Why did the efforts of the Provincial Environmental Protection Bureau of Yunnan Province fail so spectacularly with regard to the UDDTs? A closer look at the contextual factors show that although the 110 new source separation toilets were shown to be a success during the pilot phase of the Sino-Swiss research project in Zhonge Village, the scaling-up of UDDTS at the provincial level neglected key socio-cultural factors:

- The provincial administration followed a typical supply-driven approach, failing to address real demand at household level.
- A specific UDDT technology was imposed on the beneficiaries, regardless if they expressed interested in reuse of excreta or not.
- Households were not accustomed to have their toilets built within their houses, but rather in a separate outhouse.

It was the neglect of socio-cultural particularities that was the main reason that led to the failure of the up-scaling programme. What had worked well previously in one selected village as a result of a concerted education and sensitisation campaign at household level, failed when applied at a large-scale without the same efforts toward social mobilisation. To compound these factors, the officials from provincial government responsible for the project were more concerned about fulfilling bureaucratic quotas laid out in the Provincial Plan, than to ensure that households actual used the latrines. This example is also a warning to the premature expansion and roll-out of small-scale pilot projects at provincial or national scale. (Source: E. Medilanski, 2006)

Figure 8.1: Urine-diverting dry toilets built in Zhonge Village in the pilot project phase (Source: Lin Jiang 2007, Eawag).

8.2.1 Sanitation promotion through marketing

A key to managing the demand side of sanitation provision is creating an effective marketing strategy through understanding community priorities and drivers for sanitation. Although one of the fundamental aims of improved sanitation is improved public health, health benefits are not usually the main driver for investment in sanitation from a household perspective. In fact, in the vast majority of situations, the decisions about whether to invest in improved sanitation are more related to personal interests and there are a range of factors other than health that influence demand. Marketing experts understand that the level of demand for improved sanitation is dynamic and depends on:

- ***Awareness*** - households knowing that sanitation goods and services exist and have benefits which could satisfy their interests (usually status, cleanliness, convenience, privacy, safety, and occasionally health).
- ***Priority*** – household having sufficient finances and interest to prioritise expenditure towards sanitation (for instance, making the decision to build a latrine rather than buy a television).
- ***Access*** – households may prioritise sanitation and show a willingness to invest but will not proceed to invest if they cannot find a mason to build a toilet or if they do not meet legal requirements for a formal connection to the sewerage network.
- ***Reliability*** – households may often hesitate in making an investment in sanitation if they are unsure about the "downstream" system. For example, where utilities have a poor reputation for operating and maintaining collector sewers households may not want to invest in a connection, especially if they feel they are powerless to influence the utility's performance in their area. Such hesitations are often overcome for example through the intermediation of a local councillor who can act as an intermediary for a poor community with the utility company.

To stimulate a demand for improved sanitation there is a need to focus upon the benefits of access to sanitation from the perspective of the users, for example marketing for convenience, prestige and status, cleanliness, privacy, and safety (notably for women). Accompanying measures including educational and empowerment approaches are therefore necessary to provide information on innovative options to influence hygiene behaviour and improve sanitation provision. Approaches that can be used to raise awareness and promote improved sanitation include awareness raising campaigns and lobbying, targeted workshops, but increasingly a market-orientated approach is gaining prominence.

Sanitation marketing is a new approach towards promoting sanitation which recognises that sanitation components and household facilities are a "private good" whilst acknowledging the inherent "public good" associated with improved community health. Sanitation marketing is inherently a demand-driven approach, which aims at motivating residents to invest in sanitation facilities via a range of different social incentives. Social marketing techniques involve the use of marketing principles similar to those commonly used for commercial promotion of products, applied to the achievement of social goals, including those related to better hygiene and sanitation. As described in Box 8.2, there are four principles behind this approach, the 4 Ps: product, price, place and promotion. Social marketing has been developed and widely adopted in a number of other sectors as well.

A number of international and national programmes and initiatives are now actively promoting social marketing as a key element in scaling-up sanitation programmes (for example Water and Sanitation Program, Global Sanitation Fund, and various programmes funded by the Bill and Melinda Gates Foundation). The most well known programme using social marketing at scale is the World Bank-WSP "Total Sanitation and Sanitation Marketing Project (TSSM)" programme currently being implemented in India, Indonesia and Tanzania. It combines the promising approaches of community-led total sanitation and sanitation marketing to generate sanitation demand and strengthen the supply of sanitation products and services at scale. For more information about the TSSM programme, see WSP (2010).

Box 8.2: The 4 Ps of social marketing

Product: This may be a tangible item (for example a latrine), a service (such as pit emptying) or a practice (for instance washing hands with soap). Commercial marketers want to sell the product; social marketers are specifically interested to see customers using it correctly or behaving differently.

Price: In contrast to commercial pricing which must cover all costs, social marketers can choose to subsidise certain items in order to reach the poor, who may also have social and other "costs" to overcome.

Place: The product needs to be available to the target group. Public channels such as government outreach workers or private shops and artisans can bring the market closer to the customers.

Promotion: Creating demand for a totally new product or service is more challenging than the commercial practice of winning market share from competitors.

Source: WSP, 2004

Social marketing can also be designed to promote improved hygiene behaviours, a key component of improved sanitation; as is the case with the promotion of hand washing with soap. In this instance there are opportunities to work in partnership with soap marketing companies as it is also in their commercial interest to encourage habitual hand washing with soap. Please refer to the further reading section in Chapter 9 for more on sanitation marketing.

8.2.2 Enhancing the supply chain

Once a marketing campaign has been successful in creating demand for sanitation, there is need to establish a dependable supply of goods and services. This means that materials are readily available for construction and maintenance of sanitation systems, and that there are locally available human resources to supply these services. An example of efforts to reinforce the supply chain is the "SaniMarts" which are often included in social marketing schemes. These shops are pro-actively established where there is a perceived gap in the market for provision of sanitation goods and services. The SaniMart receives an initial input of stock, including products priced at a level that people can afford. The objective is that the mix of products on sale and affordable prices will enable the shop owner to make a living. Each shop is staffed by a trained sanitation promoter who gives advice to customers about constructing, maintaining and using a latrine. The shop can also introduce customers to groups of masons trained in latrine construction who help build the latrine at agreed rates or simply offer advice.

8.2.3 Financing of household sanitation

Financially, a long-term vision for a sustainable sanitation system should be to avoid the use of public finances via subsidies in household systems as much as possible, since this tends to suppress the willingness of households to utilise their own financial resources and lead to a culture of dependency in which residents expect external support to improve their household toilet. At the same time, subsidised sanitation systems fail to install a sense of ownership, which undermines an interest and willingness to maintain the facilities (WSSCC, 2009).

Rather than to subsidise households directly, funds should be used to support the supply and increased availability of sanitation system components or effective services for maintaining systems in use. More specifically, the money can be used to help establish production centres, supply chains and maintain providers that enable households to purchase components and services that are affordable and of good quality. However, poor households may still require assistance, either through direct financial subsidy or by offering subsidised materials and technical assistance for construction.

There is clearly a need to make greater investments to promote sanitation and appropriate financing schemes can be used to mobilise household-level finances. This may involve working with NGOs and private entrepreneurs to create alternative flexible financing options that enable householders to reduce the burden of the capital investment by sharing the cost with others and/or paying back investments over a period of time (Heierli, 2007). Micro-financing can also be used as a means to get householders to invest in sanitation. A micro-financing scheme can provide opportunities for poor households to access funds for improved household sanitation and drainage. The credit scheme should be based upon market research of locally based demand, appropriate financial and accounting systems, as well as an understanding of the borrower and intermediary capacities. Interest rates need to be based on the cost of funds, administration and labour costs, loan loss allowances, margin for inflation and a return on capital.

8.3 Understanding and Working Towards an Enabling Environment

Although the process and approach to implementing a sanitation program is important, it is equally important that these actions take place in an enabling environment. In other words an environment that allows for innovation through supportive policy, institutions, capable public and private actors and effective participation. The enabling environment covers the full scope of arrangements through which public institutions (national and local governments or utilities) and other actors work together to develop and manage sanitation systems. An enabling environment requires that a number of interested stakeholders and organisational structures are active and engaged, or at least open to working for sanitation improvements. These stakeholders may include:

- Formalised organisational structures, rules and regulations, and technical or professional standards of good practice.
- Private and public operators responsible for planning, installation and operation at local and regional levels.
- End-users - both users of sanitary facilities at household level and end-users of products or resources like biogas, compost or greywater.

Stakeholder participation, institutional development and capability development are key elements of an enabling environment that need particular attention and are further explained in the rest of this section.

8.3.1 Ensure effective participation

It is widely acknowledged that stakeholder participation is a linchpin to catalyse change and make people active participants of their own development. Good partnerships and participatory programmes begin when actors come together to achieve a common goal based on agreed priorities. Real user participation is however constrained by numerous factors such as the absence of secure tenure rights, inappropriate technical standards, rigid technocratic planning methods, and time-bound project management requirements. It is therefore crucial to first consider if a favourable (or unfavourable) policy context or enabling environment exists.

User participation can take on many forms and degrees of empowerment, from weak "participation by consultation" to an empowering "interactive participation", where stakeholders are fully involved in analysis and action planning right down to project implementation. The choice of which approach to use depends on the complexity of the issues and the purpose of the engagement. There is no "one-size-fits-all"-formula but a number of tools and techniques that can be applied. For example, the planning approaches presented in Chapter 6 gave an overview of possible participatory planning tools.

Wherever possible, participatory planning methods should be used to bring together the interests of stakeholders and pool resources. This should start with a realistic and thorough assessment of different stakeholder perspectives to make diverging interests and claims transparent. It should be noted however, that partnerships are not always easy and it takes considerable effort and time to maintain them and to keep them going over time. It is therefore critical to focus on developing local champions at community and/or municipal level who can drive forward the process.

8.3.2 Institutional development

Failed institutional arrangements at local and regional levels (here termed as "disabling environments") can explain much of the underperformance and dysfunctions resulting in failed investments, declining services and poor cost recovery prevalent in so many places. Whether or not they involve private providers, these arrangements fail the urban poor who are disenfranchised in both the market and public policy arena. Overcoming this and forming a sound institutional framework mean addressing issues of knowledge availability, regulations and political will. The following key features are prerequisites of a sound institutional framework in both developed and developing country contexts:

a. **Knowledge and Skills:** The capacity to provide services effectively and efficiently is the backbone of sustainable service provision. This includes well-trained engineers and planners at all levels (local, provincial and central government), but also private sector and NGO stakeholders who have their role to play. That is why capacity building and on-the-job training is crucial to improve service delivery and expand coverage in rapidly urbanising areas.

b. **Separation of regulatory and operational responsibilities**: In many countries, there is no clear distinction between regulation and service provision. Public institutions are often doing both things within different branches of government. A sound institutional set-up requires a clear distinction between:

(1) Policy formulation at national (ministry) level,

(2) Regulatory framework with independent institutions responsible for performance of monitoring and evaluation, and

(3) Service provision at local level which can guarantee increased coverage and improved service delivery.

An important guiding principle is "no responsibility without authority" meaning that all actors must have clearly defined roles and delegated authority when performing their defined roles. Different forms of successful commercialised, corporative, municipal or community-based delivery models exist today, some of which are featured in section 8.4.

c. **Innovation friendly regulatory framework:** Existing laws, technical norms and professional standards are all part of legal frameworks which strongly influence investment decisions and sector innovation. In many countries current legislation is overly restrictive, preventing re-use and blocking innovation. In the worst case unrealistic standards keeps the urban poor un-served, stipulating flush toilets and sewers as the norm for all urbanised areas.

d. **Political will and policy frameworks:** Elected governments and municipal authorities that demonstrate political will and are able move beyond the fragmentation of responsibility and accountability for sanitation between competing institutions are showing the greatest progress in sanitation coverage. Bangladesh is a good case in point since it has been able to increase sanitation coverage in rural and urban areas from a low 39% of the population in 1990 to over 53% in 2008 (WHO/ UNICEF, 2010). This was achieved by a determined political commitment of the Government of Bangladesh and the linking of sector policy and strategy to the national Poverty Reduction Strategy Paper (PRSP). Policy targets outlined in the National

Sanitation Strategy Paper (GoB, 2005) are realistic, targeted and clearly outline the objectives, the principles to follow and most importantly, the institutional roles and responsibilities to achieve those objectives.

e. **Socio-cultural factors:** A key feature of an enabling environment is a respect and consciousness of the local socio-cultural landscape, especially in complex urban and peri-urban settings. People from different origins, ethnic backgrounds and social norms create the heterogeneous nature of urban settlements, making it difficult to advance "one-size-fits all" solutions. Neglect of socio-cultural factors and acceptance has led to the failure of many well meaning projects and programmes simply because people's acceptance was taken for granted (as has been shown in the Kunming example above). We need to understand behavioural and socio-cultural factors in order to identify the incentives that will trigger demand for sustainable sanitation by urban households

Building an enabling institutional environment means addressing these perquisites and bringing on board local administration and decision-makers as champions for better sanitation solutions. Local authorities and governmental institutions generally have the mandate for establishing the framework conditions discussed above, ensuring the creation of a legislative enabling environment, which makes it possible to implement and use sustainable sanitation systems to their full potential. When properly motivated local authorities can produce even greater impacts by initiating local, regional or national sanitation programmes promoting or even requiring sustainable approaches. To do so requires courage and conviction in order to:

1. Develop coherent institutions, with consistent operational responsibilities and accountabilities;
2. Foster innovation, technical and non-technical in nature, through legal and regulatory adaptation;
3. Encourage stronger and more deeply rooted peer-to-peer learning amongst key stakeholders (utilities, government, public/private sector providers) in order to help address common problems in common operational situations;
4. Support and lobby at training institutions, universities, research institutes and donors to ensure that more and better quality technical capacity is developed, and capacity is developed for coping with the pressures and challenges of modern day water and sanitation service provision.

8.3.3 Local-level capacity building

In order to achieve good participation and a functional institutional arrangement, it is of great importance to empower local people through raising their skills and capacities. Clearly, a sanitation system in the urban context is not merely a set of technical infrastructure that can operate in isolation from the rest of the urban environment, but rather a socio-technical system that interacts with people, politicians and business. Sanitation solutions require technological expertise, but also an understanding of the socio-cultural context, the institutional framework to support operations, financing mechanisms, and marketing to promote the solutions and create public buy-in.

The complexity in this institutional environment means that personnel responsible for solving the sanitation problems requires diverse skill sets and management capacities; not least an ability to understand different programming approaches and assess various risk factors. A diverse set of actors will need to work together to find an appropriate sanitation solution that is adapted to the complexity of the local context. Thus, throughout this discussion of it is important to keep in mind that local capacity will need to be developed at both, the individual and collective level; individual capacity referring to particular skills individual people in the community have and collective capacity referring to a community's capacity to organise, mobilise and support collective actions (Hamdi and Goethert, 1997).

The concept of capacity building focuses upon training and skill development, as well as the development of effective organisations for planning and management. The main focus is often on gaining new skills and actions that can be implemented (Peltenburg et al., 1996). However, proper capacity development also requires creating the right conditions for this learning to happen by ensuring that organisations are able to support individual staff members. This means giving them responsibility and incentives for learning, which in turn will provide them with the motivation and energy to make a difference. As shown in Figure 8.2, this needs to be supplemented by action to promote an enabling environment with supportive institutional and legal frameworks for sustainable sanitation.

Capacity building is a long-term process, which starts with the recognition of the resources and capacities that already exist at various levels and then building upon them (Edelman and Mengers, 1997). In this context, capacity building refers not only to municipal government, but also to enhancing the capacity of community groups and NGOs as intermediaries and organisers, as well as assisting the private sector to expand its contribution to development and management. Capacity building is often identified as one of the underlying themes in implementation strategies and aims at strengthening institutions at all levels, as well as general development of human resources.

Figure 8.2 **Concept of capacity building** *(Peltenburg et al, 1996)*

This often entails a high degree of community participation in the processes of planning, implementing, and evaluating the sanitation intervention (Haman and Brown, 1994). Of course, this should be done in a manner that recognises cultural differences and strives for gender equity.

Important components of capacity-building involve:

- ***Strengthening and improving management*** in terms of building technical, financial and managerial capabilities;
- ***Upgrading institutional and technical capacities*** of the key actors to help identify, understand and evaluate complex urban environmental problems;
- ***Establishing co-operative partnerships*** with government, elected and official, civil society organisations, and the private sector to deal with cross-cutting challenges;
- **Utilising participatory tools** in planning, decision-making, and political processes which facilitate the development of a common vision, articulation of needs and joint action.

The development and performance of country-level training institutions should be enhanced so that they can play a pivotal role in capacity building. These institutions need to be adequately equipped to provide men and women with training to enable them to effectively plan and manage sanitation facilities at the national, provincial, district, and community level. However, this is an area that needs improvement. For example, there are only a few training institutions in the Asia region that offer specialist courses on the design and management of sanitation systems. The result is limited awareness and low dissemination of appropriate technologies. Where courses and training materials exist, they tend to focus upon technical aspects of specific types of wastewater treatment technology. These say little about the management aspects or the way in which wastewater management needs to be integrated with planning systems for delivery of urban infrastructure and services. Greater communication of knowledge and sharing of experiences can go a long way towards improving capacity to implement and manage sustainable sanitation systems.

An effective way of bringing together the required local expertise and building synergies are so called "learning alliances". These are multi-stakeholder processes with the objective of building relationships, sharing information and experiences, and planning for solutions to common problems that cannot be solved by a single stakeholder. The learning alliance provides a platform and a framework for sharing experiences, analysing progress and challenges. These alliances can enhance district and municipal harmonization, coordination and collaboration. In addition, it is hoped that they will lead to more cost-efficient and effective hygiene programmes, sustainable sanitation facilities and enduring hygienic behaviours[1].

1 Detailed information from the International Water and Sanitation Centre (IRC) website at: http://www.irc.nl/page/14957.

8.4 Examples of Successful Implementation

This chapter closes with examples from around the globe where plans have successfully been put into practice. It provides ten examples of sustainable sanitation in a variety of urban contexts from five continents. Proven examples from both "rich" and "poor" cities are provided for each of the five urban contexts presented earlier in Chapter 5 (Figure 8.3). The highlighted examples for urban sustainable sanitation range from small, residential "eco-settlements" in the United Kingdom and Germany to the large-scale dissemination of urine-separating toilets in South Africa. The two examples from Mumbai and Nairobi show that even in the most challenging of urban environments, incremental improvements towards sustainable urban sanitation is possible. High-end developments from New York City and London present cases for more frugal and resource-saving urban solutions. Most of the examples presented below are still at pilot scale. However, if we want to have city-wide sustainable systems tomorrow, we have to start innovation on a pilot level today.

Fig. 8.3: **Overview of different case studies of sustainable sanitation for different urban contexts**

Context 1: Informal Settlements/Slums

Urban informal settlements, popularly termed "slums", cover a broad range of settlements that come in a variety of sizes, physical appearances and political cultures. In 2002, a UN-Habitat Expert Group Meeting agreed on a consolidated definition of slums, "a slum household is a group of individuals living under the same roof in an urban area who lack one or more of the following five conditions: (1) durable housing, (2) sufficient living area, (3) access to clean water, (4) access to proper sanitation, and (5) secure tenure" (UN Habitat, 2003).

The first slum case study exemplifies a new generation of communal sanitation coverage for the densely populated slums of Africa and South Asia. It combines community-managed provision of basic services with community facilities and bio-digesters to produce gas for cooking or heating. A second example presents communal latrines from a World Bank funded slum sanitation program which combines community action with community-owned and community-managed sanitation facilities.

Case study 1: Communal Bio-Centres in Kibera, Nairobi, Kenya

Type of project: Public sanitation blocks connected to biogas digesters

Project period: 2008-2009

Project scale: Densely populated neighbourhood of Kibera housing around 20,000 inhabitants.

Location: Gatwekera Slum Village, Kibera, Nairobi

Bio-centres apply ecological sanitation principles to ensure that human waste in community sanitation blocks is turned into energy by producing gas through bio-digester systems and producing fertiliser as a by-product. Fertiliser usage is being explored through awareness-raising of community and engagement of stakeholders in the forest department. The forest department is targeted because of the proximity of the Ngong forest in the project area of Kibera. The effluent/slurry which comes out of the bio-centre is substantially treated and will be subjected to further treatment using septic tanks or filter beds. These options are still being explored.

The bio-centres are designed for the provision of 6-8 toilet cubicles and four bathrooms at the ground floor serving around 600 customers per day. The payment per visit is Ksh 2 for the toilet use. A household can pay Ksh 80 monthly (US$ 1.5) to use the toilet. Shower facilities cost Ksh 10 per visit, including soap. Bio-centres also feature a community hall or offices on the first floor. The sanitation block thus doubles up as a meeting point and resource centre for the community. Renting out this space for social functions is a further source of income.

Figure 8.4: Communal bio-centres built in Gatwekera Village in Kibera are an example of how incremental improvements in improved sanitation services can provide an income source for community members, biogas for heating water and improved sanitation and hygiene. © David Crosweller

Figure 8.5: Community toilet blocks from the Slum sanitation Program (SSP) in Mumbai. The Mumbai SSP sanitation blocks provide the users with a sense of ownership towards the toilet block which helps to improve the operation and maintenance. © *Stefanie Keller*

The bio-centres are managed by community based organisations (CBOs) in Kibera where centralised sanitation (sewerage system) is absent or inadequate. To ensure that it is properly managed, the CBO members are trained in operation and maintenance, business planning, good hygiene practices and group management. The cost of implementing a bio-centre with a digester of 31.5 m^3 and one story is US$ 22,800 (2009). The project is usually implemented by the CBOs after an initial capacity building process. Finding enough space for new infrastructure in Kibera is a real challenge. The CBO provides the space for the bio-centre and it is one of the preconditions for the CBOs to be assisted with a bio-centre. They can either:

- Demolish old structures which belong to their members with a small compensation or;
- They can use existing space after agreeing with the owners. To ensure ownership of space, the provincial administration must approve the site by providing a letter of approval.

Case study 2: Slum Sanitation Program (SSP), Mumbai, India

Type of project: Community sanitation blocks with toilets and a community hall

Project period: 1997-2003 (stage I), 2007-2012 (stage II)

Project scale: 330 community toilets with 5,100 toilet seats within the various slum areas

Location: Different slum areas in Mumbai, India

Despite Mumbai's status of being the most important economic and financial centre of India, more than half of Mumbai's citizens live in one of the 2,000 cramped slums. These slum dwellers lack access to water supply and sanitation facilities. There is a deficiency of 64,000 toilet seats within the slum areas. Due to the lack of O&M, almost 80 % of the existing public toilets are in a very bad condition. Furthermore, most of the public toilet blocks provided by the city corporation have neither water nor electricity. As a result of the poor conditions of these public toilets, together with the long queues (especially in the morning), a big portion of the slum dwellers defecate in the open. In addition, due to the absence of O&M, stray dogs often took possession of these toilets.

The World Bank funded SSP project design asked the slum dwellers to form CBOs with the support of local NGOs. These communities have the duty to pay the monthly running costs as well as the one time contribution of 100 Indian Rupees per adult for their toilet block. In return, they are directly involved in planning, designing and the construction of their communal toilet block. Furthermore, they bear the entire responsibility for their toilet block after construction. There are community halls on top of the sanitation blocks which allow for various activities such as English courses, sewing courses and computer lessons.

Context 2: The peri-urban interface

The peri-urban interface is the spatial setting where urban and rural areas meet. They are places with great stresses on the natural resource base, on poor people's livelihood strategies, on access to land and on public amenities. The peri-urban interface is a place characterised by strong urban influences, easy access to markets, services and other inputs, ready supplies of labour, but relative shortages of land and risks from pollution and urban growth (Phillips, 1999). This fringe area is integral to the growth and operation of growing cities.

The two examples of peri-urban interventions come from South Africa and Egypt. The South African example of eThekwini features the largest number of built and utilised urine diverting dry toilets on the African continent - almost 80,000 households now utilise UDDTs thanks to a generous municipal subsidy scheme. Affordable waste treatment systems for the smaller and mid-sized towns are sorely lacking. The Egyptian example features solids-free sewers and stabilization ponds, connecting and successfully treating the waste of 3,000 inhabitants of El Moufty El Kobra Village in the Nile Delta at full cost recovery.

Figure 8.6: The UDD toilets in eThekwini were installed because it made sense as low-maintenance alternative to VIPs. The image shows the inside of the standard UDDT model. © *Duncan Mara*

Case study 3: Urine diverting toilets (UDDTs) in eThekwini Metropolitan Area, South Africa

Type of project: Urine diverting toilets (UDDTs)

Project period: Since 1999

Project scale: 80,000 households outside of the waterborne sewage line

Location: eThekwini Metropolitan Municipality, eThekwini, South Africa

The eThekwini Municipal Water Services Department was looking for cost-effective alternatives to waterborne sewage for the vast peri-urban settlements of eThekwini metro area, which were unlikely to be connected to the city's sewerage in the short to medium-term. To date, almost 80,000 urine diverting dry toilets have been installed in eThekwini's peri-urban interface, thanks to a subsidised approach by a national government funded programme. The standard UDDTs feature double vaults with a brick and mortar base and superstructure with a plaster finish and a pre-cast concrete floor slab. Ventilation pipes are provided to control flies and odours. The optimum storage period is about 1 year to ensure the safe handling of faecal material collected from the toilet vaults. Each UDDT unit costs between US$ 800 to US$ 1,000.

Interesting to note is that the eThekwini urine diverting toilets were not introduced for the purpose of reuse of excreta or urine, but to provide a viable alternative to conventional VIPs, especially where hard rock or high groundwater precluded the construction of VIPs. It was also a policy response to huge problems emerging in regularly emptying permanent VIPs. Social marketing techniques were utilised, addressing people's real needs: no smell, safety, comfort, convenience,

Figure 8.7: The decentralised treatment plant in El Moufty, Egypt today serves as a model for safer and more environmentally friendly wastewater treatment for smaller Egyptian settlements with populations between 3,000 to 5,000. © *Duncan Mara*

privacy and a marketable product. Acceptance is high as most peri-urban households were previously using unimproved pit latrines. On-going research projects are currently focusing on urine reuse and the production of struvite powder which can be used as an easy-to-use fertiliser. Thus, this technology offers opportunities and flexibility for future improvements. The UDDT toilet technology was endorsed as a sustainable toilet option for South Africa by the Minister of Water Affairs in September 2008.

Case study 4: El Moufty solids-free sewers, Nile Delta, Egypt

Type of project: Decentralised Wastewater Management Project for a village in the Nile delta

Project period: 2002-2005

Project scale: Settlement with 3,000 residents

Location: El-Moufty El Kobra Village, Governorate of Kafr El Sheikh, Nile River Delta, Egypt

The El Moufty project was executed during 2002-2005 with support of the GIZ Decentralised Wastewater Management Project in Egypt. It features a fully operational decentralised wastewater treatment plant for a population of 3,000. The entire plant is operated under the supervision of the local water and sewerage company and by a village association. The collection of monthly operation service fees (around US$ 1.25 per household) ensures full cost recovery for all operational expenses and allows for savings against future repairs and replacements. The system features locally-adapted technology with 7 km solids-free sewer pipes of 100mm diameter, 1 interceptor tank per household and 6 stabilization ponds situated 500m from the village. Faecal sludge collected from the interceptor tanks is dried on sludge drying beds and the hygienized dried sludge (approx. 15 m^3 per year) is used on the surrounding fields of the settlement as free fertiliser. Investment costs were around 3 million Egyptian Pounds (approximately US$ 380,000) and operating costs per month are currently around US$ 300 per month.

The entire system was built by a local contractor in a record 6 months-time under supervision of the GIZ project. The entire system which has been successfully operational since 2005 is also cheaper for the households to maintain than the widespread cesspit emptying system, where cesspits must to be emptied up to four times per month.

Context 3: Planned urban development areas

Planned urban development areas represent a variety of infrastructure that is supported and formally planned by the city. These can range from low to high income areas, depending on how the land is designated; from low-income housing projects to real-estate development. However, the target groups for development are typically high-income to lower-middle class. These are settlement areas with formal title deeds or simplified "right-to-use" titles, and often zoned areas for specific uses. Since these are planned areas the type of development is strongly influenced by politicians and government agencies, although commercial and private interests can also play a prominent role in the planning process.

Figure 8.8: The decentralised treatment of blackwater and greywater in the Flintenbreite estate saves costs and makes a utilisation of nutrients possible. © *Martin Oldenburg*

Following is Northern Germany's showcase urban housing estate which features decentralised treatment of blackwater and greywater, and water conservation innovations. The second case is an early example of an eco-neighbourhood built near Hamburg; featuring dry toilets and greywater treatment. The development was co-funded by municipal and federal governments, addressing several sustainability issues in the built environment.

Case study 5: Lübeck Flintenbreite Bremen, Germany

Type of project: Urban housing estate with its own operating company

Project period: Since 1999

Project scale: Settlement with 150 residents (currently) scheduled for 280 residents

Location: Flintenbreite, Lübeck, Germany

The Flintenbreite project started in 1999 with the support of the Municipality of Lübeck who was interested in installing a new form of urban living. Despite its urban location, the estate is not connected to a public sewer system but rather has its own facilities for the production of energy and the treatment of wastewater. The houses in the settlement were built with the intention of saving energy and water, as well as the reuse of water and nutrients.

Houses were equipped with vacuum toilets for the collection and transport of blackwater. Using this technique the water consumption for toilet flushing is reduced down to 1 Litre per flush. Blackwater is mixed with bio-wastes and treated in a biogas plant. Residues from the biogas plant are used by farmers as fertiliser on their farmland. The biogas is used for the production of electricity and water for heating in a combined heat and power unit. Greywater from households is treated in constructed wetlands and the effluent is discharged into a creek nearby. Due to the separation of blackwater and greywater the effluent quality is very good. In addition, stormwater in the area is infiltrated in areas nearby the houses. By this the costs for the installation of stormwater pipes for drainage are reduced significantly. Overall the

Figure 8.9: Aerial view of the Hamburg Allermöhe eco-settlement. © Hansestadt Hamburg, Amt für Stadterneuerung

water consumption rates at Flintenbreite are nearly half of the German average values.

All house owners are shareholders in the operating company which supplies the houses with water, electricity, and warm water. The inhabitants take also responsibility for services like wastewater treatment and bio-waste collection. The operation fee for the services is approximately 15–20 % lower than normal public service costs. Calculations of lifetime costs for the wastewater system show equivalence of costs compared with the conventional urban wastewater system despite its small scale.

Case study 6: Eco-settlement Hamburg Allermöhe, Germany

Type of project: Residential settlement in peri-urban fringe south of Hamburg

Project period: Since 1983

Project scale: 36 middle-class family-owned houses with around 140 residents

Location: Eco-settlement Neu-Allermöhe-Ost, 15km southeast of Hamburg

This small eco-settlement is part of the new peri-urban district Neu-Allermöhe, where 3,800 new houses were constructed during 1982-1994. It is one of the first ecological settlements in Germany; actively promoted by the city of Hamburg and the German Federal Ministry of Transport, Building and Housing. The innovative decentralised sanitation system includes composting toilets, a constructed wetland system and rainwater harvesting. The architecture of the settlement is adapted to the specific toilet designs, allowing up to 4 toilets connected to one composting container. The waterless toilet system saves up to 2,000 m^3 water yearly for the entire settlement. The composting chambers produce about 40 litres of compost per person/year, which is used as a fertiliser for gardening and the common green area of the settlement. The constructed wetland (vertical flow sub-surface wetland) covers an area of 240 m^2 and has a treatment capacity of 15 m^3 per day. The actual inflow in 2008 was 10-13 m^3/day. The treated greywater is discharged into the neighbouring channel and not reused.

Context 4: Non residential buildings

This typology includes schools, health clinics, hospitals, markets, religious and office buildings, and other areas open for public use. These are buildings frequented on a regular basis both for work and leisure and as such they can contribute to affordable services, especially for a city's low-income residents. Because they are frequented by thousands of users daily, they also have a key role to play in awareness creation and systems exposure for piloting innovations.

Figure 8.10: An Iko public toilet in Machakos, Kenya offers clean and well managed public toilets for users, combining attractive business opportunities with innovative environmental friendly solutions. © *Ecotact Kenya*

Well-run public toilets in urban areas are still an exception but the case from Machakos, Kenya shows that innovative management (franchise system), combined with waste reutilisation can provide attractive facilities while creating new job opportunities in the service sector. In addition, the importance of educational facilities for teaching about sustainability cannot be understated, as it is here where young people are exposed to sustainable and hygienic practices and habits. The example from Chorrillos School in Lima features closed-loop systems with water conservation and greywater reuse.

Case study 7: Inner City Public Toilets - Iko toilets, Machakos, Kenya

Type of project: City-centre public toilets

Project period: since 2008

Project scale: 100 Iko toilets are planned across Kenya by 2010

Location: Machakos town centre, Kenya

Iko public toilets offer a wide range of innovative features for public sanitation facilities, such as attractive architecture. In addition, supplementary business services like shoe shining, newspaper vendors, soft drinks and snacks, safe storage lockers, and more, add attractive business opportunities. Improved management through a franchise mechanism ensures that locals are involved in operations, enhancing O&M, and accruing benefits in the process. A local university (Kenyatta) is developing a week-long module for capacity development of the franchise system, especially targeting youth and women.

Treatment of the human waste collected at these public toilets is also a key component of the business plan. They use concepts of re-utilisation in the treatment process to make sanitation a profitable business:

- Biogas production from bio-digesters;
- Urea from harvested urine (use of waterless urinals);
- Compost from the slurry that is rich in organics and nutrients.

There has been positive uptake of this approach throughout Kenya. For example, ten Kenyan local authorities have signed on for an initial 100 units, and ten companies in Kenya are providing sponsorships for these units for branding (for example Kenya Breweries, Rototanks).

Figure 8.11: Outdoor UDD toilet with gravel filter bed for greywater (bottom right). © Christoph Platzer

Equity finance will be provided by Acumen Fund and Care Enterprise Canada and hopefully by the African Development Bank to expand the approach beyond Kenya.

Case study 8: Chorrillos School, Lima; Peru

Type of project: Public school featuring blackwater and greywater reuse systems

Project period: 2007-2008

Project scale: Special education facility serving around 30 pupils

Location: San Christoferus School, Chorrillos, Lima Peru

This school for mentally disabled children features water-saving technology and on-site greywater and blackwater treatment. Additionally, a composting system for organic and garden waste reduces solid waste generation. Greywater from laundry, the school bakery and kitchen is treated in a vertical flow constructed wetland featuring a papyrus reed bed. Double vault urine diversion (UDDT) toilets were constructed as outdoor toilets near the playground with ventilated vaults for dehydration of faeces. Both boys' and girls' toilets were adapted to the particular needs of the handicapped children. The operation of the facilities is performed by the school janitor, who lives on the school compound. Thanks to water reuse and the constructed wetland, the entire school grounds (0.6 ha) have been transformed into a green oasis featuring a soccer field and school garden with flowers and herbs. The economic benefits include a reduction of freshwater consumption by half thanks to grey- and blackwater reuse.

Context 5: Inner-city middle and high income areas

The typical middle and high income areas both in the North and the Global South feature modern apartments in multi-storey and high-rise buildings. Ideally, these developments are mixed-use and complemented by small-scale businesses, shops, restaurants, hotels, and office buildings. Population density and water consumption is generally high, and there is greater living space per inhabitant compared to low income areas. These areas are often in the downtown area or clustered around prime urban locations, such as green areas, waterfronts and parks for recreation. In general, these areas are already serviced by sanitation systems, often sewered systems.

The first example is the Beddington BedZed project, the UK's premier urban eco-settlement just outside of London. Although most innovations in BedZed are centred on zero fossil energy use and achieving a carbon-neutral footprint, there are interesting features for water-saving and wastewater bio-filtration as well. Secondly, the case of Solaire in New York shows an inner-city, green residential development that is a model for high-income real-estate segments and presents a great example of how water reuse can be a beneficial and economical tool in green building design for inner-city areas.

Case study 9: Beddington Zero Energy Development (BedZed) Sutton, UK

Type of project: England's first and largest eco-community

Project period: 2000 - 2002

Project scale: 82 residential homes for 220 residents and 1,600 m^2 office space

Location: London Borough of Sutton, 40 minutes South East from London

This innovative "*zero fossil energy*" residential development combines a number of innovative features that saves energy, water and reduces waste. It consists of 82 residential homes with mixed ownership (private, shared ownership and 15 reserved for social housing), plus 1,600 m^2 of work space featuring a shop, a café, a health centre and childcare facilities. BedZed's main objective was to reduce the environmental impact at every level without compromising modern living standards. The project was developed by the Peabody Trust, a London housing association and charity.

The energy systems feature 777 m^2 solar panels and all homes are installed with low energy lighting and energy efficient appliances to reduce energy requirements. BedZed receives power from a small-scale combined heat and power plant (CHP). The heat from the CHP provides hot water, which is distributed around the site via a district heating system of super-insulated pipes. BedZed features 81% reduction in energy use for heating and a 45% reduction in electricity use, compared to the local average.

Figure 8.12: Beddington Zero Energy Development (BedZed). Innovative residential developments in high- and middle income areas of developed countries can significantly change wasteful lifestyles, and over the years change residents' behaviour. © *Marcus Lyon*

Water use at BedZed has been reduced to 72 litres/day (2009), which presents a significant 58% reduction in water use compared to the local average. Low flush toilets, smaller bathtubs and rainwater re-use help achieve this. One innovation at BedZed is the use of a reed-water bio-filtration system that purifies blackwater into greywater for use in non-potable applications such as toilet flush or water for gardening. Also, 60% of solid waste is recycled at BedZed.

The total development costs for BedZed sum up to 17 million Euros and the price of a BedZed home is 20% higher than the average price of an apartment in the same area (middle-class development). After seven years of operation it is obvious that a bigger neighbourhood would have allowed economies of scale for the CHP reed-water bio-filtration system.

Case Study 10: The Solaire, Battery Park City, New York City, USA

Type of project: High-end residential units in downtown Manhattan

Project period: 2001-2003

Project scale: 250 residential units on 27 stories (33,160 m^2)

Location: 20 River Terrace, Battery Park City, Downtown Manhattan, New York, USA

The Solaire is one of 5 innovative residential developments in Battery Park City on the waterfront of the Hudson River in New York City. The centrepiece is a decentralised, close-loop treatment system. It features a 95 m^3 /d (25,000 gallon) on-site blackwater treatment system utilising membrane bioreactor technology (GE Zenon membrane). The 65 m^2 treatment system is located in the building's basement and includes a series of cast-in-place concrete tanks. The first step in the process is a collection and settling tank where large solids are removed. The wastewater then flows to the bioreactor, which contains active bacteria used to digest the biodegradable waste. The ultra-filtration membranes are immersed directly into the bioreactor. The treated water then enters a central reuse water reservoir which feeds the different non-potable water-use systems within the building. This includes water reuse for toilet flushing, cooling systems, on-site laundry units and irrigation. The Solaire also features an irrigated vegetated roof improving the micro-climate. Construction materials used a high amount of recycled content.

Figure 8.13: Solaire Apartments on the Hudson River features on-site wastewater reuse in downtown Manhattan. © *Edward Terry*

This is the first inner-city "green" residential high-rise building in the United States and it boasts a 75% reduction in freshwater consumption compared to comparable base residential buildings in New York City, and a 56% reduction in wastewater discharge. There is a 45% reduction in electricity demand and energy use is 35% below New York State Code requirements. Although this innovative inner-city development entailed higher construction costs, these are offset by energy savings and savings on rising utility costs in New York City.

Contact: info@thesolaire.com

9 FURTHER READING

9 Further Reading

BOOKS

Chapters 2 & 3

A Renewable World: Energy, Ecology and Equality
by Girardet H. and Mendonça M. Green Books 2009.
This book describes strategies in policy and practice for reducing energy consumption and carbon emissions, and sustainable food production from around the world. It describes how these approaches provide opportunities for generation of local employment and support the development of both micro and macro economies. In addition, social and political processes related to civil participation and local democracy that are required in this transformation are considered through examples of existing initiatives. Also available as a free download from: www.worldfuturecouncil.org/a_renewable_world.html

Reusing the Resource: Adventures in Ecological Wastewater Recycling
by Steinfeld C. and Del Porto D. Ecowaters Books 2008.
This publication profiles more than 30 successful ecological wastewater management systems highlighting such techniques as using plants to stabilise, clean, filter and use up wastewater or discharging it to be used again to flush toilets or irrigate plants. These scenarios save money and do a better job of protecting public and environmental health, turning what was a disposal challenge into an amenity and a resource. Written for engineers and non-technical individuals, this book is inspiring and easy-to-read, with plenty of information showing that the solution to water pollution is to "grow" it away.

The Story of Phosphorous, Sustainability implications of global phosphorous scarcity for food security
by Cordell, D. published by Linköping University, Sweden 2010.
This recent PhD thesis analyses the many ways that global phosphorus scarcity poses a serious threat to future food security: from imminent peak phosphorus to ineffective global governance. The book proposes a new global goal - phosphorus security - to guide future sustainable improvements. The annex provides published papers on issues of food security, future resource scenarios, etc.

Chapters 5 & 6

Urban Sanitation: A Guide to Strategic Planning
by Tayler K., Parkinson J. and Colin J.   ITDG Publishing Rugby, UK 2003.

This publication outlines the nature of urban sanitation problems, identifies strategic responses to them, and sets out practical ways in which these principles can be applied. It covers critical aspects of the strategic planning process: sanitation and hygiene promotion, information collection and analysis, technology choice, and participatory workshops. Targeted mainly at decision makers.

Introduction to Hygiene and Sanitation Software: A Selection of Approaches
by Peal A, Evans B, and Van Der Voorden, C. WSSCC 2010.
This document describes the various hygiene and sanitation "software" approaches that have been deployed over the last 40 years by NGOs, development agencies, national and local governments in all types of settings - urban, informal-urban and rural. The main purpose is to address the lack of clarification in the sector about the terminology and language used and provides a "ready reference" or introduction to some of the more commonly-used approaches.
Also available as a free download: www.wsscc.org

Social Perspectives on the Sanitation Challenge
Van Vliet, B., Spaargaren, G., and Oosterveer, P. (editors) Springer Science +Business Media.
This book presents a collection of social scientific papers dealing with innovative sanitation concepts, perceptions and decision-making support. It comprises a valuable resource for political scientists, environmental engineers and urban planners whose work relates to meeting the MDG sanitation target by 2015. Its empirical scope stretches from sanitation in Western Europe to Sub-Saharan Africa.

Chapter 7

Compendium of Sanitation Systems and Technologies
by Tilley E., Lüthi C., Morel A., Zurbrügg C. and Schertenleib R. WSSCC/ Eawag 2008.
This sanitation compendium orders and structures a huge range of information on over 50 tried and tested technologies into one concise document. The reader is provided with a useful planning tool for making more informed decisions and working towards sustainable sanitation solutions. Also available as a free download: www.sandec.ch

Also available in French, Spanish and Vietnamese.

Every Drop Counts - Environmentally Sound Technologies for Urban and Domestic Water Use Efficiency
by Schuetze T. (editor) et al. TU-Delft and UNEP, UNEP Nairobi 2008
This sourcebook gives a comprehensive overview on available Environmentally Sound Technologies (ESTs) for water use efficiency in urban and domestic environments. The book focuses on criteria for selecting ESTs and includes a CD-ROM containing capacity building

materials as well as an Excel-based model entitled *WiseWater*, a tool designed to analyse the application potential of ESTs.
Also available as a free download: http://www.unep.or.jp/ietc/publications/water_sanitation/everydropcounts/index.asp

Wastewater Management: Source Separation and Decentralisation
by Larsen, T.A., Udert, K.M., Lienert, J. (eds.) - IWA Publishing 2011 (forthcoming)
In this book, the advantages and challenges of source separation and decentralised wastewater treatment are analysed from the point of view of resource efficiency. The importance of urban water management for the resources water, energy, and nutrients are highlighted, and a number of socio-economic issues are discussed. The main challenges posed for example by hygiene, acceptance and monitoring are also treated in detail, as well as the process engineering possibilities for resource efficient handling of different wastewater sources. In the last two chapters, the international experience on source separation as well as an interesting outlook on the future is presented.

Chapter 8

Decentralised Wastewater Treatment Systems (DEWATS) and Sanitation in Developing Countries, A Practical Guide
by BORDA - Bremen Overseas Research and Development Association, published by WEDC Loughborough University, UK 2009.
This handbook summarises state-of-the-art examples for DEWATS: Decentralised Wastewater Treatment Systems for developing country contexts. It summarises a decade of BORDA's experience with successful wastewater treatment systems in China, India and Indonesia. Issues discussed in the handbook include planning and implementation, design principles, DEWATS technical options as well as trouble-shooting for system malfunction. Very much a practitioner's manual for use in the field.
Can be ordered at: office@borda.de

Capacity Building for Ecological Sanitation - Concepts for ecological sustainable sanitation in formal and continuing education
by the UNESCO-International Hydrological Programme and GTZ GmbH, Paris 2006.
This publication deals with the educational aspects linked to ecological sustainable sanitation. It aims to close the gap on transmission of relevant knowledge and capacity building on how to apply ecological sustainable sanitation in various contexts. The publication contains chapters on capacity building, knowledge management and provides various examples of 2-5-day workshops on ecological sanitation from around the world.
Can be ordered from: www.gtz/org/ecosan

INTERNET

www.ecosanres.org

The EcoSanRes (Ecological Sanitation Research) website provides a wealth of information on sustainable sanitation including factsheets, publications and books, plus links to many resources including the active ecosanres discussion group and international knowledge node partners.

www.gtz.de/ecosan

The GIZ program on "Sustainable sanitation – ecosan" is concerned with promoting sustainable sanitation in the wider sense, as well as ecological sanitation (ecosan) where the focus is on reuse in agriculture. This website offers technology reviews for some relevant technologies such as urine diversion dehydration toilets (UDDTs), composting toilets, biogas sanitation and constructed wetlands. It also contains conference presentations, a worldwide ecosan project list and an ecosan publication database as well as a photo database.

www.iwawaterwiki.org

The **IWA WaterWiki** provides a platform for the global water community to interact and share knowledge online. This is the place for water professionals worldwide to interact, share information and increase understanding. Interested persons must first register and create a personal profile.

www.sandec.ch

Eawag-Sandec's website features many downloadable research documents and guidelines on environmental sanitation, faecal sludge management and appropriate sanitation technologies, including the Compendium and other planning guides.

www.sswm.info

The Sustainable Sanitation and Water Management Toolbox is an open source integrative tool for capacity development on the local level. The toolbox helps in finding an answer to the following core question: With what kind of processes, measures or tools can I optimize my local sanitation and water management system and make it more sustainable? The toolbox helps in searching for a special case or tool to optimise water and wastewater use is long and arduous, and it is easy to loose orientation and get lost in details. The SSWM Toolbox allows users to find all relevant information and plan own approaches, while keeping a holistic approach in mind. It combines process and planning tools, software and technological approaches and links them with publications, articles and weblinks, case studies, training material and presentations.

www.susana.org

The Sustainable Sanitation Alliance (SuSanA) is a loose network of organisations working together to achieve the MDGs through knowledge sharing and joint publications. The website is a great repository featuring Conference presentations, project films, documents and case studies on sustainable sanitation both in urban and rural contexts in relation to its 12 thematic working groups as well as design and teaching tools and information on the partner organisations which make up the Alliance. The alliance is now also active on Facebook, YouTube and Twitter, providing information on its ongoing activities in the area of sustainable sanitation.

www.wsscc.org

The Water Supply and Sanitation Collaborative Council (WSSCC) is a global multi-stakeholder partnership organisation that contributes to the broader goals of poverty eradication, health and environmental improvement, gender equality and long-term social and economic development. The website features numerous guidelines and advocacy tools focusing on rural and urban water and sanitation.

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The demands of sustainable development require us to rethink the current approach towards the way in which we dispose of our waste. Considerable progress is being made in the areas of solid waste recycling and renewable energy production but the sustainable management of human waste is an area that is still in its infancy. However, the need for sustainable sanitation is becoming critical due to the need to safeguard fresh water sources from contamination, recycle valuable nutrients contained in excreta for food production, and to conserve energy.

Sustainable Sanitation in Cities seeks to define what sustainable sanitation means in the urban context and how this can be achieved within the constraints and complexities of the urban environment. The authors redefine the relationship between sanitary engineering and urban planning and thus contribute to the ongoing debate on urban sustainability. The book is dedicated to innovative approaches to sanitation and illustrates what putting sustainable sanitation into action means in practice.

Sustainable Sanitation in Cities is a joint open source publication of the Sustainable Sanitation Alliance and International Forum on Urbanism. This book can be downloaded from: www.susana.org and www.ifou.org

The Sustainable Sanitation Alliance (SuSanA) is a loose network of over 120 organisations from 45 different countries working together to promote sustainable sanitation solutions in urban and rural contexts through knowledge sharing and joint publications.

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SWEDISH WATER HOUSE

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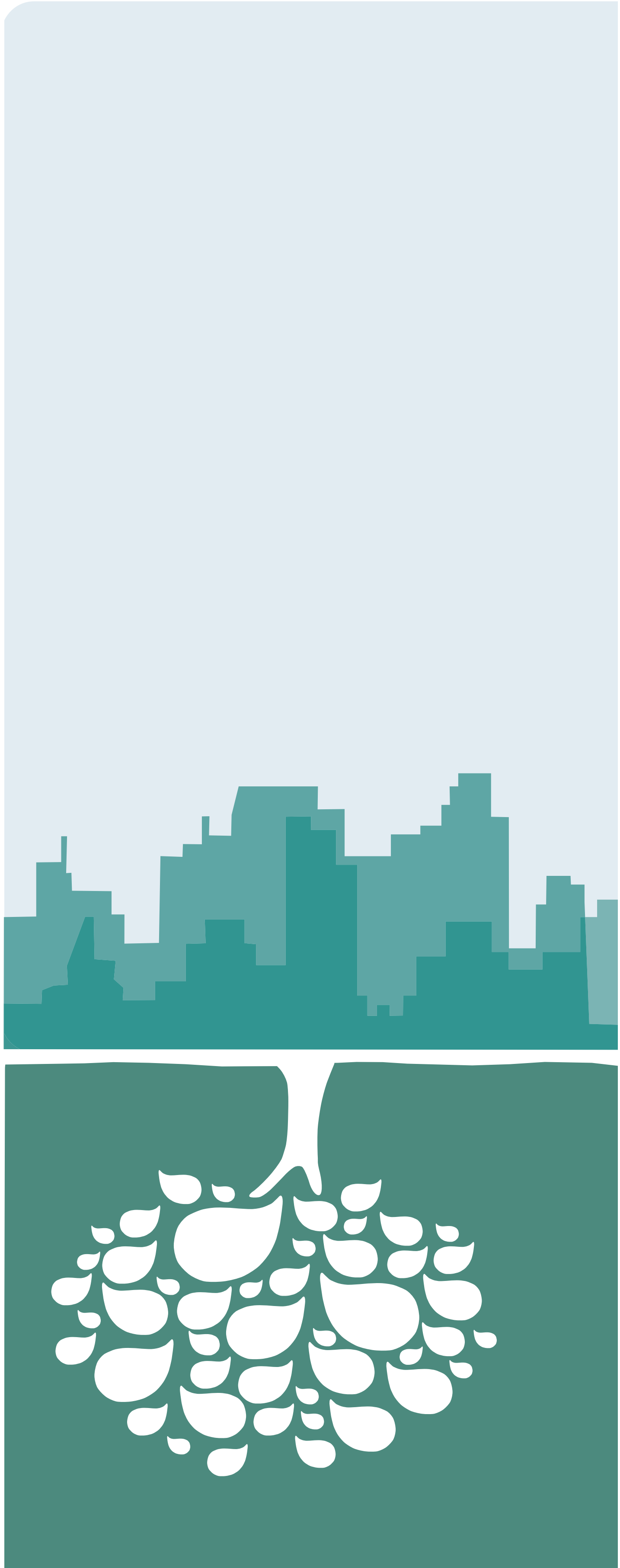

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