RETHINKING SUSTAINABLE SANITATION FOR THE URBAN ENVIRONMENT

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ABSTRACT: Sustainable urban sanitation presents one of the most significant service delivery challenges related to poverty alleviation and sustainable development in the decades to come. To illustrate what putting sustainable sanitation into practice realistically means is crucial. In the developed world, the challenge is to initiate a transition from disposal oriented, water-based infrastructure regimes towards more sustainable, reuse oriented, and productive sanitation regimes. Decentralised approaches to "productive sanitation" (including e.g. the production of biogas, fertilizer, water for irrigation, etc.) with a source-separation focus (separation of flow streams with different properties) allow for considerable cost and resource savings and are thereby increasing sustainable. In the developing world, the sanitation challenge is about leapfrogging dead-end approaches and technologies as an opportunity, especially for those areas which are currently without sanitation services, and to overcome the huge service backlog. This paper gives an initial overview of the current state of urban sanitation with a North-South perspective, followed by a discussion of the new role of sustainable sanitation systems in future eco-cities. Planning innovations for urban sanitation, initial lessons learned and current challenges faced are addressed. Context specific challenges and opportunities are illustrated in a variety of urban settings, from non-tenured low-income settlements (slums) to middle- and high-income inner-city areas, to stimulate action on the ground.
KEYWORDS: urban, environmental sanitation, infrastructure, productivity, reuse & recycling

1 INTRODUCTION

Today it is widely recognised that sanitation is a core precondition for development. In the beginning of 2000, over 25% of the developing world's urban population lacked adequate sanitation. Approx. 80% of all diseases and 25% of all deaths in developing countries are caused by polluted water (United Nations, 1992). In many low-income areas the modern city inhabitants suffer from ill health, lost income, inconvenience and indignity, particularly due to the lack of proper toilets. 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, Haller, and Bartram, 2007). In order to address the most severe problems caused by poor sanitation the focus needs to be in the fast growing cities of today. In the city of the future "sanitation" will be intermingled into other infrastructure and management processes in a way completely different from what we see today. Productive sanitation systems that produce e.g. renewable energy from biogas, or fertiliser (from the nutrients contained in excreta and waste water) will be fitted into general city planning in a mosaic of decentralised and centralised systems - using a range of technological components. This paper is intended to serve as an "eye-opener" for innovative approaches to sanitation and is dedicated to illustrate what putting sustainable sanitation into practice realistically means. It focuses on sanitation in the urban sphere, but underlines the relevance of addressing the rural-urban interface and the importance of avoiding negative downstream consequences. The "sanitation crisis" has to be addressed in a way that helps to bridge the existing gap between urban planners and sanitation engineers. Bridging this gap is considered essential to move the sustainable urban agenda forward. An integrated trans-disciplinary approach and the development of a language that both communities can understand and develop ownership for, are therefore required.

2 LOOKING BACK TO MOVE FORWARD

Based on available sanitation technologies and systems, concepts and visions for sustainable cities address amongst other things “reuse of energy from wastewater through biogas”, “reuse of wastewater and greywater for irrigation” and “reuse of nutrients from human excreta to recover limited resources like phosphorous”. However, it was only about 150 years ago, that around the globe nutrients where already reused as a resource in urban sanitation systems. We can learn for the future, if we better understand why excreta management in many European cities changed fundamentally at the end of the 19th century – and what may be the framework and conditions that will provoke the next fundamental change in the near future.

Collection, transport, and reuse of excreta and wastewater in agriculture were practiced around the world for millennia. In Europe, for example, this continued well into the middle of the 19th Century in urban areas, and the marketing of excreta derived fertilizer was a thriving business (Brown, 2003). In China, soil fertility has been maintained over millennia, despite high population densities. This knowledge however was culturally codified and based on a poor understanding of disease transmission, and as such left those involved in the transport of excreta and the farming population particularly exposed and vulnerable to disease (Bracken, Wachtler, Panesar, and Lange, 2007). However, whilst excreta reuse addressed the sanitation problems of settlements and contributed to securing agricultural productivity, it did not become the conventional approach to sanitation we know today in industrialised countries. At the time of its demise in industrialising countries there appear to have been three main driving factors that generally put an end to the reuse of excreta in agriculture:

- Firstly, urban settlements had grown dramatically, and the logistical challenge of removing the excreta from densely packed city centers to increasingly distant agricultural areas proved too great. Sanitary conditions in the hearts of major European cities degraded dramatically, as they choked on their own waste. In nineteenth century Britain an average of 26% of children died before the age of 5, in the cities this average was over 50% (Brown, 2003).
- Secondly, the development and widespread implementation of industrialised pipeline borne domestic water supplies from the 19th century also made widespread use of flushed sewerage possible. Water flushed systems dramatically transformed the situation, with sewage being flushed into nearby rivers. Water borne sanitation greatly increased the volume of sewage and diluted nutrients, making it impossible for them to be recovered and reused on land as they were previously.
- Thirdly, the nutrient demand of farmland was met by the start of the 20th century for all three major nutrients (N, P and K) using affordable chemical fertilizers, making any efforts to recover and reuse the nutrients and organic material from city waste uneconomical.

At the turn of the 20th century it seemed the urban sanitation problem was solved – at least in the global North. Cities became cleaner, healthier places to live, even for the poor, and farmers had access to chemical fertilizers to feed growing cities. This model was exported around the world and the water-borne sewer system became the standard approach for urban areas of industrialised countries and indeed around the world - but it has not benefited the urban poor in the global South.

In many ways, the sewage systems of the 19th Century were an emergency solution to a social health crisis, and for 150 years engineers have continued to try and perfect this system. 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. Later, when the effects of the resulting severe river pollution became obvious, mechanical treatment of wastewater was introduced, followed in time by biological treatment for the degradation of organic substances, and tertiary treatment to remove nutrients and reduce eutrophication of the receiving water bodies. These three steps now represent the present state-of-the-art in wastewater treatment. These conventional sewer systems have improved the public health situation in towns, cities and countries that can afford the massive installation, operation and maintenance cost. However they have also caused severe problems, like polluted and squandered fresh water resources, broken nutrient cycles, impoverished soils, and high monetary cost. For almost half of the world’s population, the estimated 2.6 billion people who do not have access to adequate sanitation today (WHO/UNICEF JMP, 2005), “end-of-pipe” systems remain both unaffordable and inappropriate. An estimated 2.2 million people, most of them children under the age of five, die every year as a result of illnesses caused by contaminated drinking water and poor sanitation and hygiene in developing countries. At the same time soils are impoverished and nutrients lost to water bodies as the “end-of-pipe” paradigm discourages recovery and reuse. In Africa, 85% of arable land is losing an average of 30kg of nutrients per hectare per year (Morin, 2006).

3 THE STATE OF URBAN SANITATION

The growth of cities and the implications for resource consumption and climate change will be the single largest influence on development in this century. The year 2008 marked the first time in history that half of the world’s population lived in urban areas, a population of over 3.3 billion urbanites. If the population growth rate continues at this speed the total urban population will reach 4.9 billion in the next 20 years. Cities are today the focus of all major economic, social, demographic and environmental transformations. However, they are also increasingly the focal point for world poverty as informal settlements and slum areas expand. Since the majority of urban growth will continue to occur in the cities of the developing world, what happens there will have real impacts for the rest of the world, both negatively and positively.

Although urbanisation offers economic opportunities, the 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. Increasing the provision of sanitation services to the urban multitudes is a challenge that urgently needs to be addressed. While urban sanitation coverage had risen to 79% in 2008, the global statistics hide large discrepancies between the “haves” and “have-nots”, regionally as well as within individual cities. It is too early to claim a victory on urban sanitation coverage and indeed, the increasing complexities and diversity of cities will make reaching the remaining under-served populations that much more challenging. Solutions will require recognition of a variety of typical urban settings and an innovative approach to linking them to appropriate sanitation systems. Water and sanitation is usually worse in small urban centres. In world averages, urban centres with less than 100,000 inhabitants have the lowest proportion of their population served with piped or well water on premises, with flush toilets and with sewer systems. On average in these areas less than 40% of the population have flush toilets while in cities with 1 to 5 million inhabitants the proportion is more than 70% and in cities with 5 million plus it is more than 80%. (UN-Habitat, 2006)

3.1 Scale of the Sanitation Problem

As hinted at above the size of the urban waste problem is huge, and growing. In terms of strictly human excreta, given that an average human produces about 1.5 litres a day, a city of one million would excrete 1500 cubic meters of waste daily. This is of course only excreta and does not include the volumes of greywater and solid waste that are quickly piling up in the waterways and byways of today’s growing cities. Even when some form of “improved” sanitation service exists; it is often just transporting the waste to another location without proper treatment or disposal. The most obvious examples are found in the lack of facilities and infrastructure in the urban areas of developing countries. For example, a 1990 survey of Delhi showed that 480,000 families in 1100 slum settlements had access to only 160 toilet seats and 110 mobile toilet vans (Chaplin, 1999). Additional statistics from India show that only 17 of 3,700 cities and large towns have any kind of primary sewage treatment (Davis, 2006). Other countries report similarly low treatment rates, for example Argentina reports treating 10% of this sewage and Colombia only 5%, while only 2% of cities in sub-Saharan Africa have sewage treatment, and only 30% of these are operating satisfactorily (UNESCO/IHP & GTZ, 2006). In generally, 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.

However, proper disposal of human waste remains a challenge even in the “developed” countries of Europe and North America. Until 2007 only 349 out of the 571 big cities of Europe (population greater than 150,000) complied with the treatment requirements of the Urban Waste Water Treatment (UWWT) Directive. In fact, 17 of these cities had no treatment at all. In southeastern European countries (Turkey, Bulgaria, Romania) approximately 40% of the population is connected to wastewater treatment facilities. (Commission of the European Communities, 2007)

Present urban waste water management include amongst others the following main problems:

- Sewage streams with different properties are mixed and are not treated and reused according to their specific properties.

- Contamination of freshwater resources such as groundwater by leaking sewers, on-site collection and treatment systems like pits and septic tanks, as well as surface water bodies by discharge of treated and untreated sewage.
- Centralised sewer born systems incur high investment and service costs, are not flexible and are not secure against catastrophes.
- For existing on-site systems, faecal sludge management is generally missing.
- Uncontrolled reuse of polluted sewage by millions of farmers in developing countries.

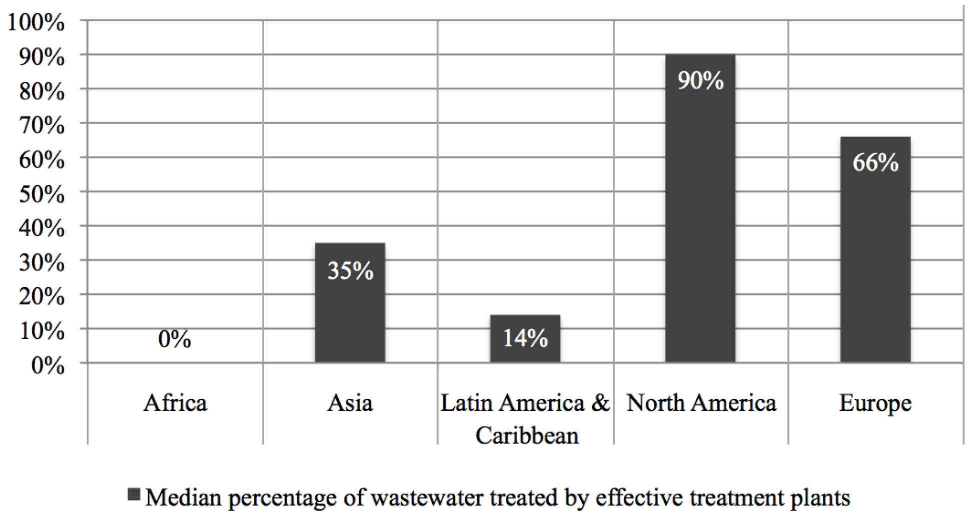

Figure 1 Percentage of wastewater that is being effectively treated worldwide (WHO/UNICEF, 2000)

4 SUSTAINABLE SANITATION IN THE URBAN CONTEXT

4.1 It's our future

Worldwide, there are a number of concepts and visions, on what future cities could look like. So-called "Eco-Cities" or "Sustainable Cities" are presently amongst others planned for example in China (e.g. Dongtan) and in South Korea (e.g. Public Administration Town). Since the beginning of the ecological movement in the 1960s, worldwide cities and districts have been developed or redeveloped using the concept of sustainability as a leading design criteria. Curitiba (Brazil), the Solar City in Linz (Austria), the City of the Sun in Alkmaar (The Netherlands), Freiburg Vauban and Luebeck Flintenbreite (Germany) are only a few of many existing examples. Recently developed approaches such as "Eco-City movement", "Sustainable Cities", "Permacity", "Ecological (or aquatic) Footprint of Cities", "2000-Watt Society", or the concept of "Environmentally Sound Technologies" (Schuetze et al., 2008) aim to contribute to the (re-) development of the urban environment according to the concept of sustainability. In some of these new approaches the topic "water and waste management in the urban context" is explicitly addressed, and some of them can be seen as ways to put "Integrated Water Recourse Management" (IWRM) into practice. Whether these examples are seen as dreams or as more pragmatic approaches, they all claim to allow for a better tomorrow and are based on the logic of the definition of "sustainable development" (Brundtland Commission, 1987). "Sustainable development" relates to what a society agrees on as being a desirable future. Pragmatic concepts, as well as attractive visions, do both play their role when a society decides on future steps to take. This direction can be described in goals and objectives – as it has been done e.g. in the "Bonn Charter for Safe Drinking Water" (IWA, 2004) and in the "Draft Vienna Charter for Urban Sanitation" (IWA, 2009).

4.2 Getting ready for change

Whenever wastewater management is addressed more seriously in the above approaches, it becomes clear that in the city of the future "Sanitation" will be intermingled into other design, infrastructure and management processes in a way that is completely different from what we see today. Urban vegetation with constructed wetlands integrated in the urban water cycle will contribute to better spatial quality and city climate. Wastewater from households and industry will be kept separate to facilitate economical reuse. Wastewater will in general be treated to the need of the next user. Fertilizer required for urban vegetation and agriculture can be produced from the nutrients that are contained in wastewater. Additionally biogas plants fed with wastewater and organic waste can produce renewable energy. As a result a mosaic of different technologies or subsystems based on different approaches can form the sanitation system of a city, such as: centralised and decentralised, conventional and closed-loop, high-tech and low-tech, separated or combined treatment of flow streams, as well as traditional and innovative. 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 for involved actors, such as architects, urban designers, planners and sanitation engineers.

4.3 The role of objectives and criteria to guide decisions towards sustainable development

One way of guiding the decision-making processes towards social, economic and ecological sustainability is to use sustainability-oriented criteria when comparing and choosing sanitary 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 therefore helps gear 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 on how this sector can be fitted into the intricate 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 (in the form of “story telling”) for the future that a society wants to achieve. The terms “objectives”, “criteria” and “indicators” are often used and have specific “roles” in the discussions and decision making around sustainability. 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” would be one of the general objectives for decisions linked to sanitation planning, a context specific objective could be, “health protection of the working population that are involved in reusing wastewater in agriculture”. Criteria would be recognised 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 decision linked to sanitation planning, a context specific objective could be the “protection of urban water bodies for urban recreation, increase of quality of life in the city, and reduction of travelling demand”. Criteria would be identified by the “specification of appropriate types of water related urban recreation sides” which meet the demands of the population. The related indicator would be the “distance and required travel time to reach the next water based recreation area 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.

4.4. Sustainability in sanitation

Several attempts have been made to address sustainability as the guiding principle for the design of sustainable sanitation systems. The focus of related publications is amongst other things on sanitation systems as such (e.g. SuSanA, 2007), on “environmental sound technologies” for water use efficiency in the urban and domestic environment (e.g. Schuetze et al., 2008), or on urban excreta management (e.g. IWA, 2009).

The general definition of “sustainable development” (Brundtland Commission, 1987) can be broken down to the level of “urban sanitation” as: “*urban sustainable sanitation is one that meets the basic sanitation needs of all population segments of the present generation within a city (principle of equity)* *without compromising the present and future generations living inside and outside of the city to meet their own needs*".

Technologies and management models applied in sustainable sanitation systems will look different in a desert city in Africa, in a flood-prone monsoon city in Asia or in a city on the foothills of the Alps in the temperate climate of Europe. In each of these cities, the inhabitants of low-income settlements and high-end apartments might have quite different preferences and priorities when selecting a sanitation system that they find suitable for their situation. Tradition, religion and cultural habits may play an additional role for accepting specific systems. The selection of criteria for sanitation systems is context specific, and hence it is difficult to describe general criteria for sustainable sanitation. When improving an existing and/or designing a new sanitation system, context specific sustainability criteria should be identified which refer to ecological, economical and social aspects (SuSanA, 2007).

4.5 Definition of sustainable urban sanitation systems

"The sanitation system should comprise from the cradle to the final destination all parts of the sanitation system, including: the users and other stakeholders demands and needs, collection, transport, treatment, reuse or final disposal of human excreta and domestic wastewater, organic household wastes, with option to include as well industrial wastewater, storm water, solid waste, animal manure or other agricultural wastes" (NETSSAF, 2006). This broad definition explicitly recognises that sanitation is more than simply an element contained entirely within the water cycle. These boundary conditions also deliberately include the social aspect of sanitation, the economic and logistical side, and the idea of resource management, as well as any indirect impacts, costs or benefits of the system. Setting the boundaries of the sanitation system sets the basis for the comparison of entire systems, rather than simply comparing different technical elements of the system. The same boundaries have to be used for all systems so that the comparison will reflect the true conditions of the problem to be solved.

As a consequence of different regional or local environmental, economic and socio-cultural conditions, sustainable urban sanitation systems can only be realised in a context-specific way. Due to this, no single sanitation system can be considered universally sustainable. However, if the sanitation system is to be made sustainable, a more holistic planning and decision making process is needed, which is geared towards finding sustainable solutions in a broader sense. Sanitation decisions therefore need to be made on the basis of a much broader range of criteria than the ones used presently and using appropriate planning approaches.

5 PLANNING FOR SUSTAINABLE SANITATION IN CITIES

Planning for sustainable sanitation in cities needs to bridge the gap between different practice communities such as architects, urban designers, planners, and sanitation engineers. Shifting trends in planning theory and the spill-over of that thought process into other disciplines means incorporating new principles into the way sanitation planning is done. When planning for example the complex realities of the one billion people currently living in informal urban settlements worldwide, some radical rethinking is required. While it is certainly true that "...there is little evidence that any overarching approach has had any significant impact in the complex situations faced by the urban poor and those charged with delivering sanitation services to them" (Tayler, 2008), this paper attempts to map out briefly the key issues that need to be addressed if there is to be progress in replicating good practice and moving to scale. Due to many factors, such as the current status and heterogeneity within the urbanised area, the challenges of delivering sanitation services are markedly different between cities as well as areas within the city itself. Despite this diversity there are common guiding principles available. Some key issues and pointers for adopting successful planning approaches are discussed below.

5.1 Understand power relations

A thorough stakeholder assessment is the first and most important step in understanding the complexity of urban and societal dynamics. This should include making different interests transparent at an early stage. Other issues of great significance when dealing with urban development are corruption and clientelistic relations. While it will not always be possible to deal with the intricacies of local level politics and deeply rooted vested interests, people-centered and transparent planning approaches can provide guidance by promoting the greatest possible transparency in planning decisions.

Stakeholder assessment, institutional mapping, or regulatory review tools of analysis are effective for scrutinizing existing power relationships and vested interests in an urban context. This must include formal and informal institutional arrangements, public, private, and 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 this also pertains to the many fault lines that run through local communities: religious, ethnic, social class, caste or gender.

5.2 Build partnerships - reaching consensus

Good partnerships and participatory programmes begin when actors come together to achieve a common goal based on agreed priorities. Of great importance is developing local champions at community and/or municipal level which can drive forward the process. Wherever possible, one should utilise participatory action planning methods to converge 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.

5.3 Ensure effective participation

It is today acknowledged that stakeholder participation is a linchpin to catalyse change and craft people into active participants of their own development. 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. Real user participation is 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. In order to achieve good participation, it is of great importance to empower local people through raising their skills and capacities. The key issue here is information-sharing from the outset of any project or programme. Individual and collective capacity developments deserve special attention - 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 (Goethert and Hamdi, 1997).

5.4 Aim for closed-loop solutions

In line with the concept of ecological and economical sustainability, waste should be considered as a resource and its reuse should be encouraged from the very start of any planning process. When introducing closed-loop options to the planning agenda it is important to consider the policy and user implications of these systems. Specific sanitation policy may not be written to include innovative and closed-loop designs, but there is an increasing body of environmental legislations (e.g. EU Water Framework Directive, renewable energy initiatives, and environmental pollution laws) that can be used to justify systems that will recycle water, nutrients, or energy. In addition, since closed-loop solutions often mean introducing new technologies, experience shows that education and the implementation of case studies can be the first step for building awareness and in convincing stakeholders and actors (such as users and the legislature) about safety, advantages and convenience.

5.5 Drivers of sanitation

Sanitation improvement has many drivers and sources of motivation, not only including the existing sector institutions and their agendas, but also individual aspects such as customs and habits, context specific practices and status, or desire for reuse. Sanitation systems must be adapted to meet the needs of the user, but they also need to be marketed appropriately to increase their popularity. Marketing messages for sanitation need to be adapted to what the local population sees as a driver for improving their sanitary condition. To bring urban sanitation coverage to scale, new innovative tools must be adopted and applied in a context specific way.

6 SANITATION SYSTEMS

Sanitation systems - contrary to sanitation technologies - consider all components required for the adequate management of human waste. 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 or adequate and 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 potentially also treatment and reuse of all products such as urine, excreta, greywater, and 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, and that take into account technology components for storage, collection, transportation, treatment, discharge or reuse at these levels.

Sanitation systems can be distinguished as being water-reliant ("wet") or non-water reliant ("dry") with regard to the transport of excreta. This systematic distinction is used in characterising sanitation systems (e.g. NETSSAF, 2006; Water and Sanitation Program, 2005; The World Bank, Water and Sanitation Program-South Asia & Government of India, Ministry of Urban Development, 2008). Next to water-reliant or non-water reliant another distinction can be made in the various degrees of separation of incoming wastes, such as urine diverting sanitation systems, which keeps urine separate from faeces from the very beginning. On the other hand sewered sanitation systems mix faeces, urine, flushing water, and greywater as well as wet or dry anal cleansing materials, and in many cases even rainwater, 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. It is also important to note the similarity in naming convention between products and flowstreams. For example, blackwater is a product, but the entire process of collecting, treating and disposing of blackwater is referred to as the blackwater flowstream. Similarly, greywater can be managed separately as an independent product, but when it is combined and treated along with blackwater, the flowstream is referred to as the "blackwater mixed with greywater" flowstream.

The classifications "wet" and "dry" give only a limited 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 with a promising combination of different technologies, the following categorisation is given (based on (NETSSAF, 2006) and (Tilley, et al., 2008)

- Wet mixed blackwater and greywater system with decentralised treatment
- Wet blackwater system
- Wet urine diversion system
- Dry excreta and greywater separate system
- Dry urine, faeces and greywater diversion system
- Dry excreta and greywater mixed system

7 ENTRY POINTS FOR IMPLEMENTING SUSTAINABLE URBAN SANITATION

The background knowledge discussed in the previous sections is a basic condition for the implementation of sustainable sanitation in the urban environment. As already discussed, planning situations, legal frameworks and the technical options themselves can vary depending on specific urban settings. To provide sustainable sanitation for a whole city can be seen as a daunting task. However a strategy that helps to start now, and develop a better base for decisions, is to analyse what are the typical entry points for action, and the related representative settings in a given city. Even though each situation is unique, a useful tool for understanding the complexity of the urban setting is to characterise a number of typical urban contexts or settings which house the overwhelming majority of urban residents and offer the greatest potential for reconfiguring urban infrastructure regimes in cities of the future (SuSanA, 2008):

- Tenured or non-tenured Low-Income Settlements (slams and slums)
- Tenured or non-tenured Peri-Urban Settlements
- Planned Urban Development
- Non-residential Buildings
- Inner city middle and high income settlements with potential for upgrading

The typical urban settings can be used as templates to illustrate how the dynamics between physical, demographic and socio-economic factors within each of these settings present different challenges and opportunities for the provision of sustainable sanitation. Sustainable sanitation options for different urban settings will vary, depending on the different regional or local environmental, economic and socio-cultural conditions. Although every situation is different and adapted solutions have to be developed based on the specific basic conditions of each location, the guiding principles for comparable urban settings can work as entry points for the design, planning and implementation of adapted sustainable urban sanitation solutions.

Tenured or non-tenured low-income Settlements are settlements with maximum population densities reaching up to 2000 persons per ha (e.g. in Dharavi, India and Kibera, Kenya). Generally there is sparse if any formalised form of sanitation. Typically suggested incremental improvements are the installation of small mobile pit-emptying units owned and operated locally, as well as community or publicly run sanitation blocks, buying and selling water, connected to waste management systems and nearby sewers, if available. More sustainable approaches may include collective treatment and reuse systems, community based organisation, independent service providers, community sanitation blocks connected with on-site bio digestion for energy production, the local use of greywater and the reuse of sanitised sludge in urban agriculture.

Tenured or non-tenured Peri-Urban Settlements are settlements with population densities between 100 – 300 persons per ha (e.g. Dodoma, Tanzania). Due to the low population density compared with most of urban low income settlements, there is high prevalence of peri-urban agriculture and more space is available for individual or community sanitation. However there is often low awareness about the consequences of unsanitary conditions and practices. Human waste is often disposed in simple pits, which are covered, left and re-dug in new locations. Independent services for sewage and waste management are usually rare. Typically suggested incremental improvements are the installation of double pit latrines (emptied manually) or pour-flush toilets, septic tanks and leach fields (a health threat in the case where shallow groundwater is used as a drinking water source). More sustainable approaches may include decentralised systems, such as dehydration and compost toilets (e.g. “Urine Diversion Dehydration Toilets” (UDDT)) and greywater gardens, or semi-centralised reuse orientated solutions, such as biogas systems or constructed wetlands.

Planned urban development areas are settlements with population densities that are dependent on the type of development and income of the residents (high, middle or low). These generally planned areas offer a great potential for sustainable urban development and sanitation solutions with the integration of rainwater harvesting, as well as separation and reuse systems for greywater, human waste and organic solid waste. Typically applied technologies include sewers, septic tanks or pit latrines, which can contribute to the contamination of groundwater. Management and maintenance is often missing. Typically suggested incremental improvements are pit latrines for low-income settlements and septic tanks with connections to small-bore sewers. More sustainable approaches may include community-level, semi-decentralised treatment and reuse options, including shallow sewers, greywater gardens, allotment gardens, productive constructed wetlands, biogas-systems, UDDTs or even vacuum systems.

Non-residential buildings can have public functions, be communal or tourism facilities or office buildings. Public buildings are crucial for providing affordable services in cities particularly to low-income residents. Schools play an important role in awareness building and behaviour change. Sanitation systems in public buildings have to meet the demands of users, which may have different habits. The fact that people use facilities without owing them means that the level of care and ownership is low, which consequently leaves the facilities in a poor state of maintenance. Poor hygienic conditions are the main reason for low user acceptance of sanitation facilities in public spaces. In high-income areas with sewer systems, typically standard water born sanitation systems can be found. In low-income areas without sewer connections typically a few pit latrines are provided at schools while unmaintained poor flush toilets may be provided at markets or hospitals. Operation and maintenance must be carefully planned, since the management structure is the crucial element of a public facility. Typically suggested incremental improvements are communal urinal and/or (pour) flush toilets to a sewer main, operated and maintained by organisations and financed with user fees. More sustainable approaches may include constructed wetlands, greywater gardens, UDDTs, community sanitation blocks, bio digesters, vacuum systems and membrane technology.

The four typical settings and structures presented above house the overwhelming majority of urban residents and offer the greatest potential for reconfiguring urban infrastructure regimes in cities of the future.

Existing inner city middle and high income settlements also house a large proportion of urban residents, particularly in urban areas which face only limited growth, or are even shrinking, such as in parts of Europe. However although, many of these areas are in most cases already equipped with sanitation systems, they have potentials for upgrading, particularly regarding environmental and economical criteria. Existing wastewater treatment plants can be optimised for treatment efficiency and energy consumption, e.g. by anaerobic digestion. (SuSanA, 2008)

8 THE WAY FORWARD

It is suggested that each city starts now to introduce productive sanitation systems using the entry points indicated above and the principles summarised below. To learn already today how the general idea of "sustainable sanitation" can best be applied and adapted to the individual local conditions is a good investment in monetary and social terms. Urban complexity is part of the reason why sanitation today still belongs to the world's most imminent, least well-resourced problems. However, in the holistic approach towards sustainable sanitation outlined in this paper, the complexity of the urban context provides not only problems, but also distinct opportunities. The chances of successful sanitation provision lie in exploring linkages to more sectors than solely water supply and sanitation. Some possible opportunities for the way forward are summarised below.

8.1 Economic and business opportunities

It is now accepted that sanitation brings a higher rate of return than initial investment, and not only in terms of health impact (Hutton, Haller, and Bartram, 2007). Urban sanitation systems comprise a range of processes that represent potential business opportunities. These may include small-scale service provision for construction of appropriate system components, collection, transport, storage and processing/recovery of products from sanitation systems (e.g. biogas, fertiliser, soil conditioner or irrigation water).

Other opportunities exist in:

- Resources management (dealing with resources that are scarce in the local context and evaluating how a sanitation system can reduce resource pressure)
- Surveys, analyses, and impact evaluation (e.g. market surveys, institutional analysis, impact evaluation of previous sanitation strategies, and sustainability assessments)

The promotion, development, and implementation of sustainable sanitation systems in an urban context need to be based on three pillars: (a) local demand, (b) appropriate local supply, and (c) an enabling environment (policy, regulation, legislation, etc). Addressing these pillars increases effectiveness as discussed in the following section.

8.2 Create local demand

Merely supply driven sanitation programmes have not proven effective - often the supplied facilities are not accepted and deteriorate quickly. Creating ownership, by contrast, proves to be a major success factor. Thus, sanitation provision must be more demand oriented. Tools for creating local demand include:

- Community led behavioral change campaigns (e.g. Community-led Total Sanitation (CLTS) in India)
- Social marketing approaches
- Awareness raising campaigns
- Hygiene promotion

In the process of demand creation, no special sanitation option should be imposed onto users. However, only if sufficient information on sustainable sanitation options is available for a given context can a truly informed choice be made. Demonstration projects may play an important role here, as they allow comparison and the chance to experience different options.

While in a rural context individual households may choose their technology of choice independently, in an urban context, a multitude of stakeholders are involved in this decision making process and many decisions can not be made on an individual household basis. Accompanying measures including educational and empowerment approaches are therefore necessary to provide information on innovative options to improve sanitation provision and the health situation, and to influence hygiene behaviour.

Ensure appropriate local supply of hardware, labour and software skills

Following on from the Bellagio Principles (WSSCC, Eawag Sandec, 2000), sanitation problems should be solved on the lowest appropriate level. This can be achieved by developing responsive supply chains of goods and services. Wherever possible these should draw on local experience with good practice examples, e.g. small scale hardware producing and service providing companies, capacity building for community sanitation workers, well-managed community toilets, successful combinations of sanitation provision and urban agriculture or biogas production and the like.

8.3 Understand and work towards an enabling environment

Local authorities and governmental institutions are responsible for establishing the framework conditions for the implementation of sustainable sanitation systems. They can, however, be more directly involved by initiating local, regional or national sanitation programmes which promote or even require sustainable approaches (e.g. Case study on Cagayan de Oro, Philippines, SuSanA 2008b).

Governments are also responsible for ensuring the creation of an enabling legislative environment making it possible to implement and use sustainable sanitation systems to their full potential. A primary goal is to bring on board local administration and decision makers as local champions for better sanitation solutions. The development of an enabling environment for sanitation includes the following, which will in turn create local demand for sustainable sanitation options:

- Awareness raising campaigns and lobbying
- Targeted workshops
- Advocacy material for decision makers
- “Learning alliances”, e.g. (IRC, 2009)

With the 2015 Millennium Development Goals (MDG) end target date now in sight, programmes at a national, regional and local level must gain traction. There will be no quick fix to these problems; no blue-print solutions and no substitute for long term policy and practice commitments to get sanitation back on track. By learning from the experiences explained in this briefing, and adapting this to local conditions, practitioners and policy makers have an opportunity to make an impact on the lives of millions of urban settlers. To do so requires courage and conviction:

- To develop coherent institutions, with consistent operational responsibilities and accountabilities;
- To foster innovation, technical and non-technical in nature, through legal and regulatory adaptation;
- To 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;
- To support and lobby at training institutions, universities, research institutes and donors to ensure that more and better quality technical capacity is developed, so we become capable of coping with the pressures and challenges of modern day water and sanitation service provision.

Sanitation has been a taboo subject for too long. The UN International Year of Sanitation 2008 has kick-started the process to change this. It has raised consciousness about sanitation and impacted operational change that will affect future generations. The time to act is now.

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