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Reducing the Water and Waste Footprints of Megacities

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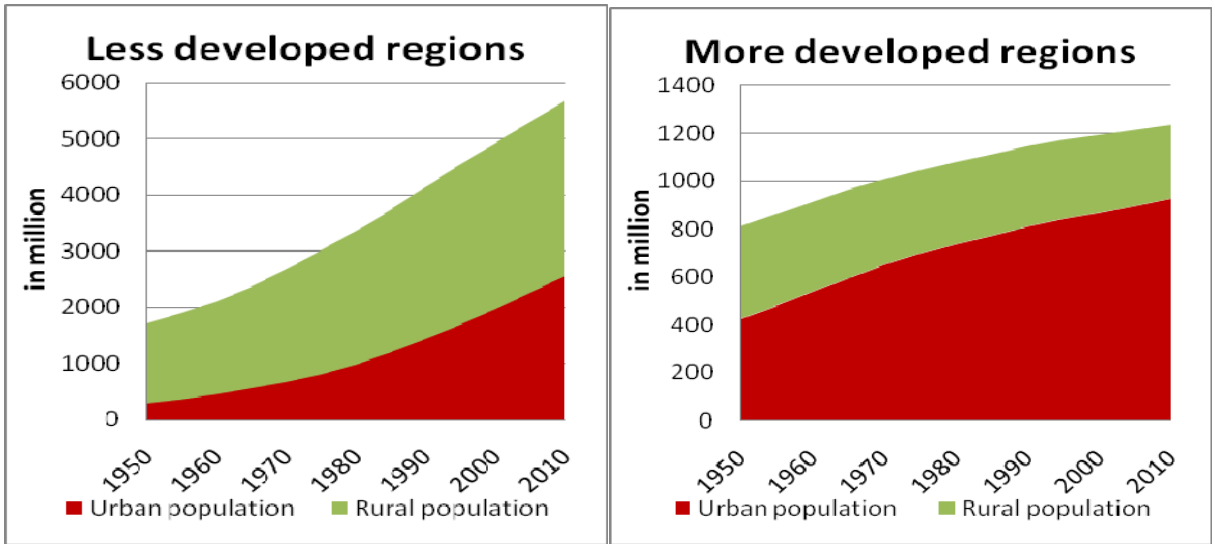
The challenge of urbanisation

Humanity is faced with manifold changes in the global environment that have an impact on the capacity of the earth system to sustain life. These effects are summarised with the term "global change" and include drivers such as population growth, climate change and urbanisation. Urbanisation is one of the main drivers of global change and comprises socio-economic transformation processes as well as linkages between cities and the environment.

With respect to socio-economic transformation, we can distinguish two main processes: the first is global population growth. Total world population rose from about 2.5 billion in 1950 to 6.9 billion in 2010 (UN 2009), whereas the ratio of population growth and demographic distribution is divers: some regions in Africa and Middle East are still growing rapidly and are expected to do so in the future, whereas other are declining (Europe) and we observe aging population in regions such as Europe and East Asia (WWAP 2009, p. 30). The second process is an increase in share of urban population on the world's population. It is estimated that in 2008 world population was equally split between urban and rural areas, marking the transition from a rural dominated to an urban dominated world (WWAP 2009, p. 31). Figure *1* illustrates this separately for less and more developed countries. In more developed regions rural population has been decreasing since the 1950s while urban population increased by 54 % in 2010. In developing countries the effect of urbanisation has approached even faster since annual growth rates are up to five times higher than rural population growth rates (UN 2009). While in 1994, of the 10 largest cities of the world, only three were in developed countries, by 2015, only two, Tokyo and New York, are expected to stay in this list. However, whereas Tokyo's population is estimated to increase by less than 5 % during this period, cities like Jakarta, Karachi, Lagos and Dhaka are expected to grow by 60 % to 75 % (Varis et al. 2006, p. 377–378). The United Nations Population Fund estimates that 95 % of increase in urban population takes place in developing countries, especially in Africa and Asia (UNFPA 2007).

Figure 1: Rural and urban population growth



Source: UN 2009.

Varis et al. (2006) also point out that the difference of megacities in developed and less developed countries is the growth rate of the city compared to its economy. While in developed countries the size of the city grew concomitantly to its economy, the economic growth of megacities in developing countries cannot keep up the population growth rates. Therefore, megacities in developing countries were economically not able to harness financial and human resources to provide their residents with the necessary water-related services and the existing facilities could not be properly maintained (Varis et al. 2006, p. 378).

Another trend observed in megacities in developing countries is that most urban growth occurs in informal urban areas, where residents have little access to safe drinking water or adequate sanitation services, increasing the danger of water- and sanitation-related diseases. For waste management of megacities, the informal sector also plays an important role: It can contribute to recycling activities; however, informal waste handlers are prone to adverse health effects.

These developments have massive impacts on the physical environment of megacities such as the supply of water and the disposal of waste. To address the limits of the environment's capacity in an urbanising world, the approach of ecological footprint, developed by Wackernagel (1994) and Rees (1992), measures the land area required to support any given population.

Focusing on the water and waste footprints in emerging megacities, we first analyse the current situation and the most pressing problems which we discuss in more detail in the following sections. Finally we derive some policy recommendations.

Water footprint of megacities

Around 1.1 billion people globally do not have access to improved water supply sources, 2.4 billion people do not have access to any type of improved sanitation facility. The most affected are populations in developing countries, normally peri-urban dwellers or rural inhabitants (WHO 2011). While the use of sources with improved drinking water in urban areas is higher (94 %) than in rural areas (76 %), it can barely keep up with urban population growth in cities (JMP 2010, p. 18). There is general agreement that population growth, economic growth, urbanisation, technological change and changing lifestyles and associated consumption patterns are the main factors influencing water use (WWAP 2009).

Besides the supply of drinking water, megacities indirectly consume water through food and other goods with are transported into the city. In order to illustrate the extent and location of water use in relation to consumption patterns, the concept of ecological footprints can be applied to water. In this context it is defined as "the total volume of water used in the production of the goods and services consumed by an individual or community or produced by a business" (WWAP 2009, p. 101). Since megacities import food from agricultural areas in their surroundings or international food trade, which is produced using water, the water footprint of megacities goes far beyond the availability of its limited resources. Varis et al. (2006) state that "megacities alone import as much virtual water as what crosses national borders in all the international food trade." (Varis et al. 2006, p. 381). Megacities also import enormous

amounts of other resources such as energy, metals and fiber products, which can interrupt hydrologic systems, both qualitatively and quantitatively (Tortajada 2008, p. 153).

The provision of water in most megacities is done by publicly owned and managed utilities, a model that is likely to continue (WWAP 2009, p. 105). This institutional framework, however, does not perform well since governments have multiple, fragmented institutions with responsibilities that are often not clearly defined or overlap with each other. In order to meet increasing water demand of all sectors, megacities require large investments as well as major water planning and management changes. But the poor institutional framework makes long-term decisions almost impossible, resulting in escalating degradation of the urban environment (Tortajada 2008, p. 151–152).

In order to reduce the water footprint of megacities and to sustain water use and provide it efficiently to the various users, water management needs to take action through multiple ways on the supply side as well as on the demand side (see Box 1). Since these actions partly overlap with waste footprints of megacities, we will first provide an overview on waste management and then conclude with a recommendation of steps towards a reduction of water and waste footprints as well as a sustainable provision with water and waste management in megacities.

Box 1: Water management in Singapore

Singapore is a fast growing city-state in Southeast Asia. Its population doubled from 2.4 million inhabitants in 1080 to 4.8 million in 2010 (UN 2009). Located on islands, the population density is the third largest of the world. High population density combined with very limited renewable freshwater resources makes water an extremely scarce good with only 140m^3 water per capita per year. Therefore, Singapore imports about half of its consumed water (Varis et al. 2006, p. 390). Water is imported from Malaysia under a long-term agreement since 1927 and in order to decrease the dependence on water import, the government has set up a “Four Tap Strategy”. The four pillars of this strategy are water recycling, using rain water, desalination, and imports. By 2010, Singapore had constructed 5 Newater plants, a desalination plant and a new water barrage to increase rainwater supply. The Newater/Desalination plants have the capability to supply 30 % of Singapore's water needs (SGPressCentre 2010). Due to the limit of rainwater catchment, new investment is being planned with a tender for 2nd and larger desalination plant to be constructed by 2013 (SGPressCentre 2011). In addition, the government introduced and refined a tariff system, which has been the main reason for the gradual decrease of unit water consumption (Varis et al. 2006). Varis et al. (2006) ascribe high importance to government factors such as the development of a professional staff policy, the creating of a strong anti-corruption legislation and culture as well as an autonomous management body “Public Utilities Board of Singapure” in improving water management.

Waste footprint of megacities

With the growth of cities and the increasing numbers of megacities, waste output of cities rises for two reasons: First, the consumption level can be seen as the main driver of per capita waste production (UN Habitat 2008), and many rising cities, especially in Asia, are experiencing rising incomes. This leads to higher per capita growth rates of waste generation in larger cities (Sharholy et al. 2008). Secondly, urban population is expected to grow as described above, adding to the growth rate of waste megacities have to cope with. The situation is especially critical in developing countries where only a fraction of the waste is collected; most is instead burned at roadside or dumped illegally in open spaces and water bodies. This “unscientific” disposal leads to environmental and health problems which are aggravated by the high population density urban areas. Furthermore, many cities face the problem of land scarcity making landfills not a lasting solution.

In developing countries, solid waste is characterised by a high share (40–60 %) of biodegradable waste which could be used for composting. However, waste segregation is the exception, not the rule in many of these countries; for example in India, 90 % of municipal waste ends up in open dumps and landfills (Sharholy et al. 2008). In rural areas, a higher share of compostable material is informally reused as animal feed or fertiliser[1]; in the cities the high share of moisture and its low calorific value of unsegregated waste prevent its use for incineration (Unnikrishnan and Singh 2010). Potential resource lay not only in the high share of organic content in urban waste, waste of cities which are richer than rural areas also inherits a higher share of valuable recycling materials such as paper, glass or metals. The lack of segregation, however, lowers the quality and hence the value of the recycled materials.[2]

In many developing countries, there is a large informal sector population which makes a living of waste picking and recycling activities. The share of this sector can reach up to 2 % of the labour force, in megacities several 10,000 people are often working under hazardous conditions; many of the rag pickers being women and children (UN Habitat 2008). Organic waste and diseases can pose a problem especially in rainy seasons. Dumping poisonous hospital or industrial together with municipal waste poses additional risks for waste pickers who collect recyclables from landfills. Dismantling waste of electronics (e-waste) with crude physical methods, such as burning the plastic of cables to obtain the copper inside, is particularly dangerous. The sheer quantity of informal waste handlers in developing countries’ megacities leads to a recycling share for plastics which exceed the share of some developed countries. In Delhi for example, 100,000 rag pickers collect about 17 % of the waste and save the city a cost of Rs 220 million (about 3.5 million Euro) annually (Sharholy et al. 2008). In China, the informal sector often repairs electronics and sells them to poorer provinces for reuse, thus reducing waste in a productive manner (Chi et al. 2011). On the

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1 Contamination of waste with inorganics and high cost for transportation out of large megacities to peri-urban or rural areas limit reuse, particularly in Asia (Furedy 2004).

2 See also box 2 for an example of increasing the value of waste by introducing segregation.

other hand, the collection efficiency is much higher in areas or cities with private contractors or where NGOs are employed for collection (UN Habitat 2008).

The informal sector can both be a complement or a competitor to formal recycling industry (Chi et al. 2011). While informal waste pickers are flexible in their work and can lead to the recycling of valuable resources, they can be posing a threat to the development of a formalised recycling sector by competing for valuable recycling materials. Informal waste handlers often can offer a more competitive price for recycled materials as they are not bound to environmental, health or fiscal regulations.

Effective control of the informal sector is virtually impossible because of its flexibility; this lack of regulation can in turn exacerbate the social and health situation. The competition from the informal sector can be a threat to the formal sector if its existence leads to supply problems in the formal sector (Chi et al. 2011). This complicates setting up a formalised recycling system and financing improved infrastructure. A transformation into a formalisation of the waste sector hence depends on giving the affected people an incentive to work under a new system; an example is described in box 2.

Box 2: "Waste to Wealth" project in Delhi

Delhi is a fast growing megacity with already more than 20 million people in the metropolitan area, but the city's capacities for landfills are to be exhausted. Waste is brought to central collection points where waste is transported to offsite dump yard at a high cost. The "Waste to Wealth" project is introducing pick-up of segregated waste on which can be better recycled. Waste pickers who previously used to search for recyclables in collecting points were recruited to pick up the waste on a house-to-house base for a small fee; students of a local college were engaged in creating a waste inventory at the planning stage and raise awareness for the project. Biodegradable waste transformed into compost which is either sold or used in community parks where it directly improves the quality of life of the participating municipality. Revenues from recycled materials increased because of improved quality and quantity. This benefit is shared with former waste handlers who now experience reduced health risks as the waste is already segregated.

The project reduced health impacts and created sources for revenues. Furthermore, the remaining expensive waste transports to offsite dump yards were minimised, and greenhouse gas emissions could be reduced. Initial financing in the form of interest free loan or a subsidy however is necessary to start such a project.

Source: UN Habitat, http://www.unhabitat.org/bestpractices/2004/mainview.asp?BPID=2683.

Solution strategies to reduce the waste and water footprints of megacities

In order to reduce waste and water footprints of megacities and alleviate the problems related to large footprints, most successful examples show that a strategy is needed that tackles the issue from several angles simultaneously. Institutional and financial improvements have to be accompanied with setting an incentive structure for firms and households to adopt the new infrastructure. Furthermore, it is important to apply tailor-made solutions that take into account local characteristics, such as a large informal sector. Linking issues like health and environment which are closely related to waste and water footprints both at an institutional level for improved planning and at the actual implementation level can help. For the long run, education can make an impact and the development of lifestyles will play an important role for the determination of future evaluation of waste and water footprints.

Institutions

Water and waste management is decided among several decision-makers within governments such as health, education, agriculture, housing, industry, energy, economic development and environment. Since in many countries parallel decision mechanisms exist at the regional, state (provincial) or local (municipal) government level, the role of these government structures is critical in water management (WWAP, p. 4). Hence, public sector reform is one of the most important strategies for sustaining water and waste coverage and service. These reforms should also consider the need to extend waste and water services to informal urban settlements (in partnership with citizens groups or informal private sector operators). This is a priority in cities where slum populations account for a large share of the urban population (WWAP 2009, p. 105).

Therefore, to successfully alleviate waste and water problems of megacities, it is crucial to involve many affected stakeholders. In the case of waste management, a key to make use of waste for reuse or recycling is to promote segregation, e.g. by doorstep sorting of waste (Furedy 2004). This increases the quality of waste for recycling and hence the profitability of reusing resources and use organic content for energy generation or for composting. Including workers from the informal sector into this process can mitigate the competition between the formal and informal sector. Considering water management, stakeholders do not only include actors in the water sector, but also decisions concerning food and energy security, employment, disaster preparedness (e.g. floods), environmental sustainability and other social goals influence on water. It is therefore crucial that stakeholders, business or individuals involved in the water sector inform and influence decisions in this broader framework of decision-making processes. Thus, leaders in the water sector need to ensure that decision-makers outside the water sector know the constraints and options for water resources and help them implement their decisions efficiently and effectively (WWAP 2009, p.4).

Finance

One of the main problems of waste and water management in developing countries is the poor financial situation that sets a high barrier to finance costly infrastructure for waste and water management.

The UN identifies user tariffs, public expenditure and external aid as only viable funding sources and claims that resources to these sources should go along with efficiency measures to control operating costs and careful project selection and design to ensure the best return to scarce resources (WWAP 2009, p.8). However, in many counties only a small share of investments into the economy is controlled by governments, which on the other hand determine the conditions that will attract or distract investments. This calls for an interactive process, in which governments involve leaders in the private sector such as finance, industries and in the civil society (non-governmental organization, community-based organization). At the same time, it needs to be ensured that investments in new water sourcing for megacities do not adversely impact the water needs of other groups or sectors.

Firms can also play a role in private public partnerships and support financing infrastructure such as recycling centers which are in the formal rather than the informal waste sector. However, it is necessary to take the local circumstances into account, for example the large quantity of the people in the pre-existing informal sector who make a living from waste handling. Furthermore, the possibly diverging interest between government and firms need to be analysed. Firms understandably demand a high return on investment in the uncertain – at the same time, water and waste usage fees have to remain affordable and firm's profits need to be balanced with low prices which are required to provide access to services for the poor. Fee collection, however, requires some institutional framework. A payment system in the water sector, for instance, can only be enforced if water use is properly metered. For the waste management sector, an effective institutional setting must discourage illegal disposal as an alternative to a fee system.

Business activities which support sustainable water management include the CEO Water Mandate launched at the 2007 UN Global Leadership Forum, the World Economic Forum's call for a 'coalition' of businesses to engage in water management partnerships and the World Business Council for Sustainable Development's creation of a water diagnostic tool and water scenario planning supports (WWAP 2009, p. 36).

Another avenue for financing in the waste sector is to exploit the clean development mechanism (CDM) of the Kyoto protocol. Uncontrolled landfills lead to generation of methane, which is having a global warming potential 21 times larger than carbon dioxide. Greenhouse gas emissions that are avoided in projects carried out in developing countries can be credited, the sale of certified emission reductions (CERs) can be used as a stream of revenues to finance infrastructure which would otherwise not be profitable. Revenues additional to fees from waste management can make a contribution to consolidate legitimate profit interests of firms and affordable waste fee schedule for low income residents of megacities. Besides reducing GHG emissions, CDM projects currently carried out also provide additional benefits such as reducing the health hazards of landfills or exploiting the energy content of waste by generating electricity from landfill gas (Unnikrishnan and Singh

2010). To date, waste management projects are underrepresented in total CDM projects, particularly composting projects (Rogger et al. 2011).[3]

A single financial source (user fees, public expenditures, foreign financing) is often not sufficient or has other negative impacts, e.g. too high reliance on user fees might be deterring to dispose waste correctly. It is therefore necessary to carefully analyse each megacities' situation to find a suitable solution.

Incentives for households and firms

Setting incentives for households to participate is also important in developing countries, in which dumping or burning waste illegally is a common alternative which comes at little private but high social cost. This could happen through direct incentives by NGOs who provide information on waste segregation or carry out community projects (i.e. where the households directly profit from their acting, such as community composting) or public institutions in the form of regulation aiming to reduce illegal dumping.

Furthermore, fees for households can and should be levied, but have to be affordable for residents. In contrast to developed countries, where fees for waste collection can be used as a price signal to incentivise for a lower waste footprint, in developing countries with weak law enforcement, too high fees are likely to drive behaviour towards illegal disposal of waste.

Companies have an incentive to assess and reduce their water footprint for the need of controlling costs, managing risks such as safeguarding access to water but also because environmentally friendly operating firms can conciliate goodwill of customers.

Long term strategies

In order to reduce water and waste footprints in megacities it is crucial to foster a culture of long-term planning that seriously takes implications for sustainable environmental management into account and that abolishes short-term profit making. Investments in sustainable water and waste management systems contribute to long-term social and economic development.

Many societies tend towards lifestyles with higher resource use, but at the same time the sustainability of ecosystems providing the desired goods and services need to be sustained. It is therefore a major challenge in the future to decouple growth of waste/water footprint and economic growth. To meet this challenge, education will play an important role in the long term to raise awareness of finite resources and to provoke behavioural change.

[3] Rogger et al. (2011) claim that composting is having a large effect top sustainable development inter alia by transforming the high share of biodegradable waste in developing countries to a valuable resource. However, there are methodological problems which reduce the financial attractiveness of such projects.

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