1.4 Demographic Change

Is urbanisation a solution or a problem for improving sanitation?

Learning objectives: to gain insights about the role of demography in sanitation planning and implementation

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Thomas Malthus wrestled with the dynamics of food production and population increase, and in his first *Essay on the Principle of Population* (1798) he stated two principles: population rises geometrically, and food production can only be increased in an arithmetic (linear) fashion. Thus, Malthus believed, recurring famine and death were inevitable to restore the balance between population and food supply. In his time, there were also devastating wars in Europe and a struggle for new agricultural land, and an emerging exodus to colonise so-called virgin lands in other parts of the world. Later, Marx and other social scientists refuted Malthus's principles. It was not until the 1960s, however, that the Danish agricultural economist Ester Boserup revised the principle about the linear growth of food supply. Her studies on agricultural change showed that the frequency of cropping a piece of land had been left out of the analysis, and the spotlight had been on the acreage under regular cultivation (Boserup, 1965). Boserup argued that the increase in population density was a major driving force in developing agricultural technologies rather than trade and applying these new technologies. Boserup made population **density** the independent variable impacting on methods of food production. It is ironic that, in an era when world population grew geometrically in accordance with Malthus's first principle, his second principle of linear increase in food production was shown to be wrong.

Nobel laureate Amartya Sen (1994) formulated three fundamental questions that are pertinent in the present phase of world population growth. The first one is "How close are we to the limit?" As mentioned above, food production has so far matched the number of people. As for the UN population predictions, the world's population will reach its peak of 10 billion in the year 2050 (World Population Projection, 2009). The worry today seems not to be the provision of food, but rather the scarcity of other physical resources and energy. This relates to Sen's second question, "Is food the main issue?" His third question is whether a rational social policy can be voluntary. The one-child policy which China implemented to limit its population growth has not been voluntary. However, the policy was rational in the sense that it has avoided an additional population growth in 30 years of some 400 million people!

In this module we examine the effects of rapid urbanisation on urban sanitation arrangements. To gain insights into what can happen and how, we look at some examples of city development over a century or two. A model for thinking about how to select feasible arrangements evolves from the examples. Publicly run infrastructure or local community solutions are not the panacea that their advocates frequently assume them to be.

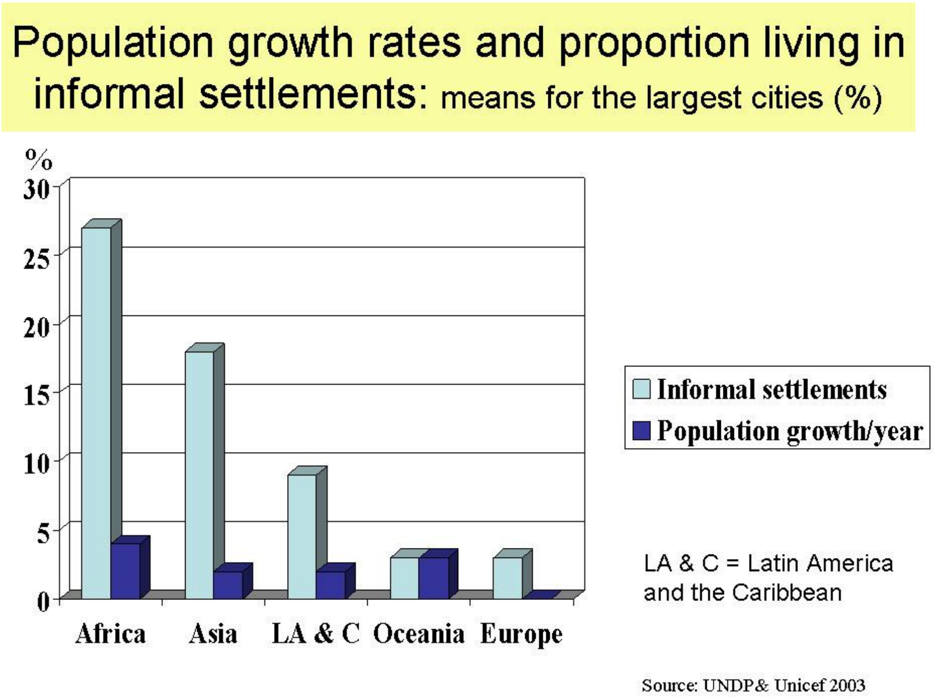
The world population is becoming more urbanised and today every second person is estimated to live in an urban area. The fact that the urban population will double from 3 to 6 billion in less than 50 years (UN, 2007) means that there is a need to build as many houses in the next 50 years as the present number of houses in all urban areas of today! This huge task will convert large stretches of what is presently agricultural land into housing areas.

Many researchers have argued that the world does not have enough resources to supply its present population. Wackenagel et al. (2006) coined the term ecological "footprint" to calculate the amounts of land and water needed to produce food and other essentials and to deal with waste from consumed products. An argument similar to Malthus's second principle emerges: that there is not enough land and water. This is tantamount to saying that local pressure on resources from millions of urban residents in confined geographic areas can only be met by improved efficiency and recycling of materials and resources.

From a strategic point of view, the yet-to-be-built houses will allow us to invest in alternative sanitation arrangements without the normal constraints that apply to retrofitting. This opportunity to develop and install more sustainable sanitation arrangements should be explored for all new areas. An interesting development is going on, for instance, in Bangalore, India's Silicon Valley, a city of seven million. In order to get building permits for big apartment complexes (several hundred flats) contractors must install mini-treatment plants in the basements. The treated water is used for flushing toilets and for gardening (slide 2.1-15). In this way almost half the demand for water is met and the wastewater problem is ameliorated. The residents will with time realise that by not polluting the water too much while using it, they can make sure that the treated water does not smell when it returns to their bathrooms.

Living in a town seems to reduce people's desire to have more than two children per family. Whether this choice is voluntary remains an open question. Economic conditions for urbanites seem to encourage the emergence of a societal norm of having few children. The effect is that global population will stabilise around 2050. The shift to small families means that a larger proportion of the population is of an economically active age for a few generations, and therefore can produce more goods and services (Rosling, 2010). The urban population will have the potential to invest more time and resources in the sanitation sector.

1.4 - 3



About two out of every 10 people in the developing world were without access to safe water in the year 2000; five out of 10 lived without adequate sanitation; and nine out of ten lived without their wastewater being treated in any way (IMF & World Bank, 2003). The focus here is on urban residents.

The diagram in the picture shows a likely link between the rate of population increase in major cities and the proportion of people living in informal settlements, with the exception of Oceania. The higher the population growth rate, the larger the proportion of residents live in informal settlements. In African cities, one in four residents lives in an informal settlement. In Asian cities, the figure is almost one in five. Services provided to residents in such areas are often rudimentary, and residents have to come up with their own solutions such as dug latrines and wells. The fact that residents find their own solutions to meet their needs is not intrinsically bad, and we should learn from it.

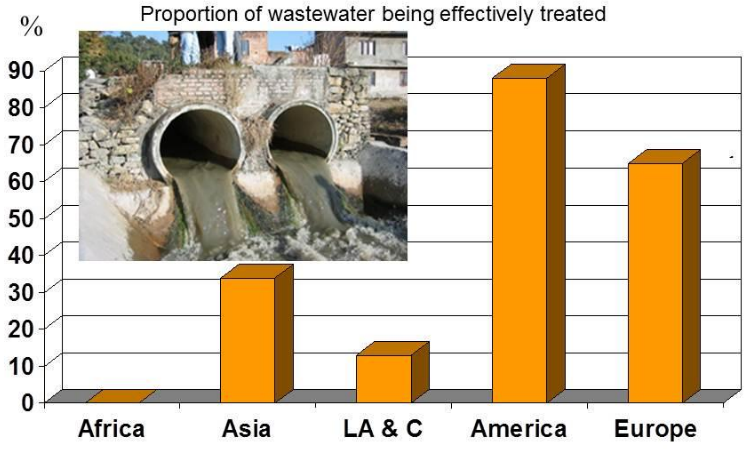
Informal settlements are not planned by authorities, and the authorities seem to lack the human resources, and sometimes the interest and proper organisation needed for such things as tax/fee collection to manage such settlements. Where a city's capacity to perform its duties is weak, private initiatives fill in the void. A myriad of individual, private and civil society activities make the city work anyway.

The diagram does show a static picture of what has happened during the urbanisation process up to the year 2000. It does not display the dynamics caused by the continuous upgrading of existing slum areas while new slums are added at the periphery of the expanding cities. Newcomers to town start from the bottom in their housing career as tenants or self-builders. It is likely that landlords and others who provide housing do not have information about non-conventional affordable sustainable sanitation and water options. The demand for housing is usually high and landlords do not have to compete by offering improved houses for the poor newcomers. Also, there is no cooperation between landlords and authorities, which is needed to improve district-wide sanitation arrangements. What is often missing is a market with products such as sustainable toilets and small-scale water treatment units, and masons, plumbers and other skilled workers who can install them (see Module 2.3).

We explore to what extent residents and authorities are able to cater for sanitation and water needs for a rapidly increasing urban population.

City council capacity to do its part

1.4 - 4



Source: UNDP & Unicef, 2003

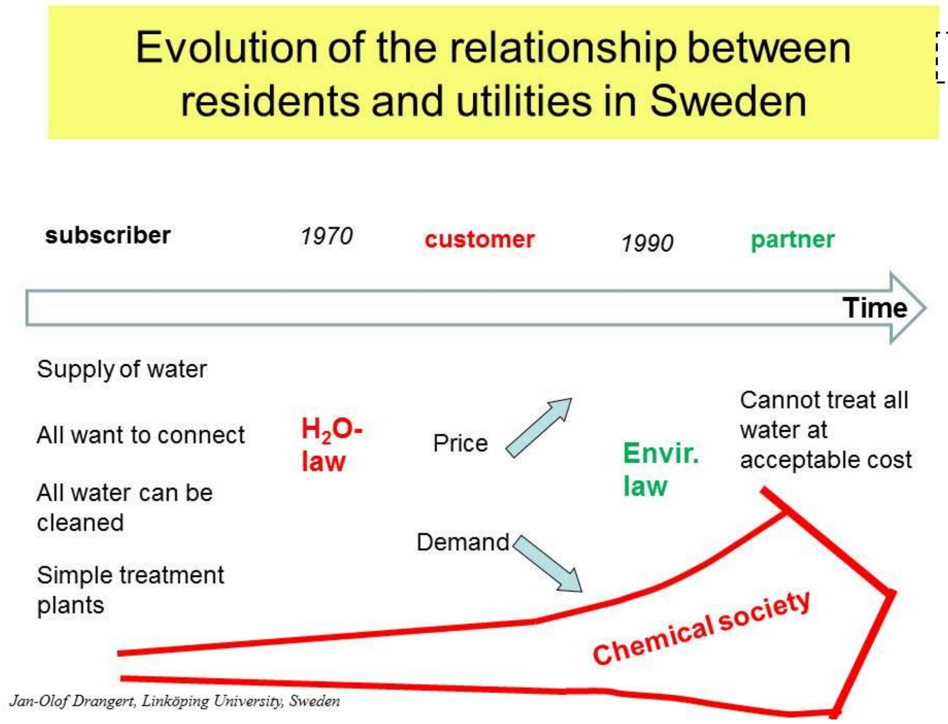
The graph above shows the proportion of wastewater from urban areas that is being effectively treated (rural areas are not of concern here). In Asian cities 65% is not effectively treated; in Latin America the figure is 86%; and in Africa 100% of wastewater is not effectively treated. The data corroborate the impression from the previous picture about rapidly expanding large cities being likely to fail to achieve high service levels. Africa, with the highest rate of urbanisation, is the region with the lowest rate of effective treatment. Latin America, with the second-highest growth rate, is second, and Asia with third-highest growth rate is third.

There are at least two issues that should be brought up in connection with the data presented here. Urbanisation leads to high, urgent demands for safe water, and is accompanied by the disposal of correspondingly large volumes of wastewater. City councils’ capacities to meet these demands fall short of expectations in most cities of the world. Often one can use the effectiveness of wastewater treatment as a litmus test for council capacity more generally, since if they fail in this sector, they are also likely to fail in many other sectors. A combination of factors led to the present conditions, and here the focus is on the contribution of rapid population growth.

It seems obvious that any treatment is better than no treatment. But we must not fall prey to the belief that all treatment has to be done in a wastewater treatment plant (WWTP) and forget that microbes also work in a situation where the wastewater is thrown on the ground. We need to keep in mind that even an efficient treatment plant without the capacity to treat all water during heavy rainfall may discharge substantial volumes of organic and other substances to the receiving water (slide 1.3- 17). More importantly, a wide range of consumer goods is disposed of via wastewater pipes. Unfortunately, modern WWTP are not designed to treat all of the 30,000 chemical compounds that households discharge in the wastewater. Usually, the plant monitors only 5–10 of these, while reduction rates of the rest are not monitored at all.
The label WWTP, therefore, does not adequately describe the performance of such plants and may be misleading.

In addition, all sewers leak and have over the years polluted the groundwater under every town. Cities with a low provision of WWTPs could even have an advantage from the point of view that they have a choice of selecting an appropriate treatment method without having already invested large amounts in a technology which may be inappropriate. This may also enable them to plan for the treatment, not only of today´s wastewater but also of the anticipated contaminants in future wastewater.

1.4 - 5

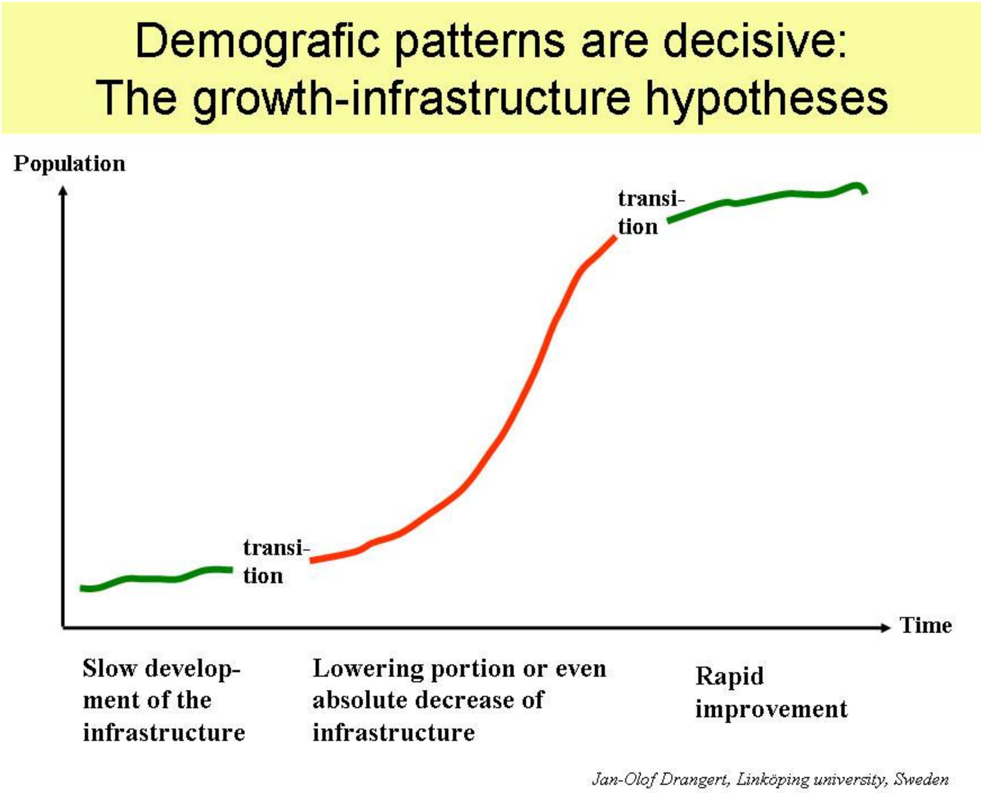


Urban dwellers in Sweden were gradually connected to water supply and sewers in the first half of the 20th century. Subsidies made it cheap to connect, and the understanding was that the wastewater was taken care of in a proper way. However, after having discharged untreated wastewater for a long time, nature reacted by algae blooming and eutrophication. The government responded by facilitating the building of wastewater treatment plants by generous subsidies (still tax money). In 1970 a new water law required all utilities to be self-sustained operating on a ‘no profit and no loss’ basis. Previous investments had to be repaid and therefore the utilities raised the water tariffs for households and industry. The immediate response from industry was to save water by conscious conservation. Soon households followed suit. The result was that the price hike did not bring higher incomes, so the utilities raised the tariffs even higher causing even lower demand. For the first time the utilities realised they were working on a market and had to adjust by employing economists to find a balance between costs and income. This took more than a decade to achieve by cost-reducing measures and treating the water users as *customers*. Previously they were treated as *subscribers* who were only expected to pay the bills they received.

As our chemical society slowly evolved, say after 1940s, a host of chemical compounds were introduced in household products. Improved economic standard allowed the growing population to buy ever more goods, so the challenge of collecting, sorting, treating and reusing them became evident. However, a common societal response was to only establish bigger landfills and longer wastewater pipes bringing the effluent further out in lakes and Oceans. A result is that residents are not aware of the limited utility capability and thus do not care what they dispose of. Similar developments were recorded in most countries and cities around the world.

In 1990 the central government enacted a new stricter environmental law forcing water utilities to improve the treatment of wastewater. This is not really possible because the content of the wastewater become increasingly complex with lots of new chemical compounds. The modern wastewater treatment plants are not designed to reduce all 30,000 chemical compounds found in normal household wastewater (Module 4.5). The utilities came to realise that they needed the cooperation from the customers for this endeavour. They initiated a dialogue to ask customers not to throw unwanted material in the toilet or flush down hazardous waste into the sink. This shift in the relationship between residents and utilities is taking place and residents are viewed as *partners* in improving the quality of household wastewater.

1.4 - 6



Demographic characteristics, both density and growth rate, are of fundamental importance for water and sanitation management as indicated in the two previous slides. The graph above shows a hypothesised relationship between the rate of population increase in a town or expanding urban area and the capacity of authorities to organise access to water and disposal of human and household waste. The multi-dimensional causes of changes in population growth are not dealt with here, and times when these changes take place are only indicated as transition periods.

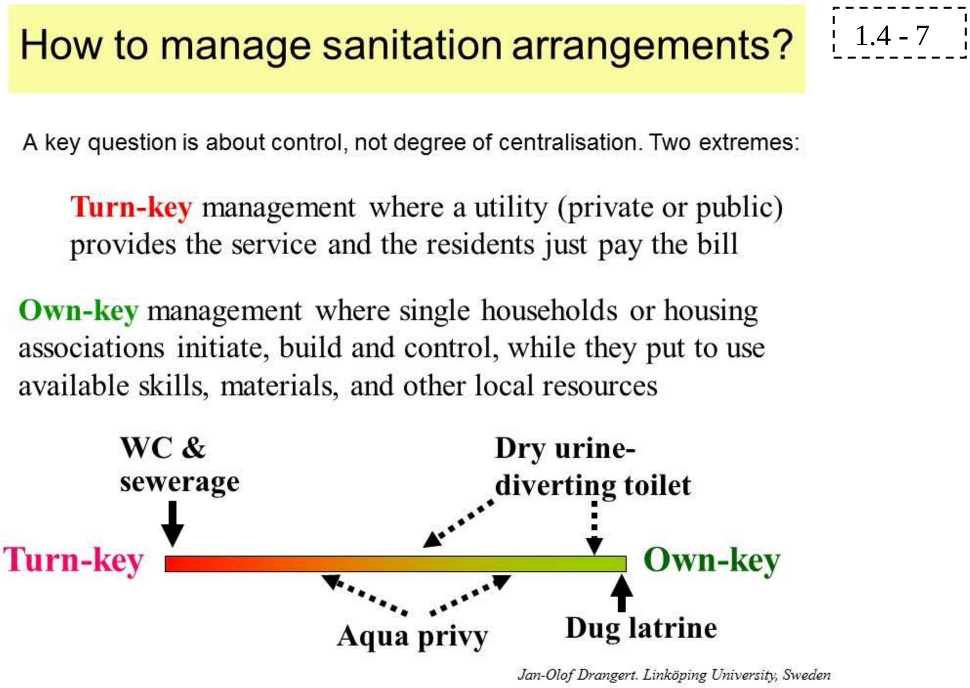
Hypotheses: When the population is ***small and stable or growing slowly*** (left *green* curve), strong social links among kin and other groups contribute to a cohesive community where societal norms reign fairly uncontested. A relatively large proportion of the residents belong to the economically active age group (Drangert, 1994) and therefore the human capacity to implement arrangements is good. The hypothesis is that at such times, community leaders are fairly reluctant to embark on major changes to the infrastructure. Although the financial capacity may be present, the leadership focuses on managing low-budget services to the residents, rather than acting as entrepreneurs involved in a rapid "modernisation" process funded by higher taxes. In the absence of external forces such as central government intervention, most community needs will be satisfied by arrangements that individuals and small groups initiate and control, using locally available skills, materials and other resources.

During periods of ***rapid population growth*** (middle *red* section of the curve), on the other hand, social cohesion tends to weaken and public sector management, including the collection of fees, is often less efficient. The hypothesis is that under such conditions the existing communal infrastructure operates poorly and that little, if any, expansion of the public infra-structure takes place – a decline is more likely. Even if personnel are trained and installations rehabilitated, such measures soon fall into disrepair due to the demographically induced structural stress. The task of authorities is simply **unmanageable**. Small and large informal areas develop. Residents, especially newcomers to town, are obliged to use their own initiative to solve, for instance, the provision of water and disposal of wastewater and human excreta. Their chosen solutions may fall short of what professionals consider to be desired.

Since the tax base and/or managerial set-up and other related council functions are not adequate in this phase, the option to invest in, for instance, conventional infrastructure is hardly present. The search for improvements needs to focus on solutions that do not require substantial inputs from the public sector. Such arrangements are commonplace and do take into account the existing sociocultural and economic constraints and yet, at times, they are sustainable. But they are rarely recognised or appreciated by the formal sector. However, authorities could assist with relevant information and advice on improvements, which would be possible within their limited capacity. The opposite is not uncommon, that staff and inspectors threaten to close down local arrangements with the argument that they are not up to standard. This boils down to harassment since the authorities do not have the capacity to provide municipal arrangements.

The rapid population increase will sooner or later ***slow down*** (right *green* section of the curve), however, and as a result the social cohesion and administrative capacity will improve. The whole city is again manageable. The hypothesis is that authorities will have the interest, capacity and financial strength to invest in and manage water and sanitation arrangements. The evolving water and sanitation system may still be a combination of municipal council installations and citizen's arrangements.

Before proceeding with the analysis of links between population patterns and conditions of sanitation in urban areas, we need to introduce a vocabulary for this purpose. The next slide provides a useful outline of various management options.



Sanitation in today's cities is far from sustainable and new solutions are in demand in both rich and poor countries. We need to assess what human, financial and other resources are available and how to combine these for more efficient performance. In Module 1.2 the management of natural resources was discussed from the perspective of preservation and in Module 1.3 the role of the sanitation sector in recycling water and nutrients was in focus. Here the focus is on management from a human resources perspective.

A crucial management question is **who** is to take on the responsibility to manage various parts of a sanitation system. There are two extremes of management (not to be confused with centralised and decentralised arrangements).

Turn-key management. A utility (private or public) provides all services, while residents only pay. The term "turn-key" was initially used to describe a type of project that is constructed by a developer and sold or turned over to a buyer in a ready-to-use condition. This approach was thought to bypass many steps on the economic development ladder. *Turn-key* arrangements of piped water and sewerage, presently the most sought-after systems, can provide a household with one cubic metre of water "from the wall" and get rid of the same amount of wastewater "through the floor" each day without bothering anyone in the household. This is one of several attractive attributes of the piped system. A positive perception of this technology has been transferred successfully to almost all groups, including residents in developing countries with no such service. However, the system costs money and needs to be operated efficiently.

A typical water bill (in Sweden) covers about one-third of the total actual costs. The rest is paid for as part of the house rent to meet the costs of the initial connection fee and installations in the kitchen and bathroom. Previously, subsidised initial investments were paid for through taxes, while part of the cost of maintaining the pipes is pushed forward in time through neglected maintenance. The total cost for a family's daily water consumption of about 1 m^3 is some US$ 6–7 which is an ordinary income from half an hour's work. This, in turn, equals the average time spent every day by many rural women in Tanzania to fetch water for their families (Drangert, 1993). The difference is that the Tanzanian family only acquires perhaps 50–100 litres of water of lower quality.

Piped systems can provide good service, and their main limitations relate to the high investment cost, and lack of proper maintenance of pipes and good wastewater treatment in many countries. For instance, half of London's water mains are thought to be more than a hundred years old and a third could be over 150 years old (Deloitte, 2011). Even if the investment costs for sewerage were to be subsidised in poor periurban areas, there is often insufficient water for all additional WCs in the area.

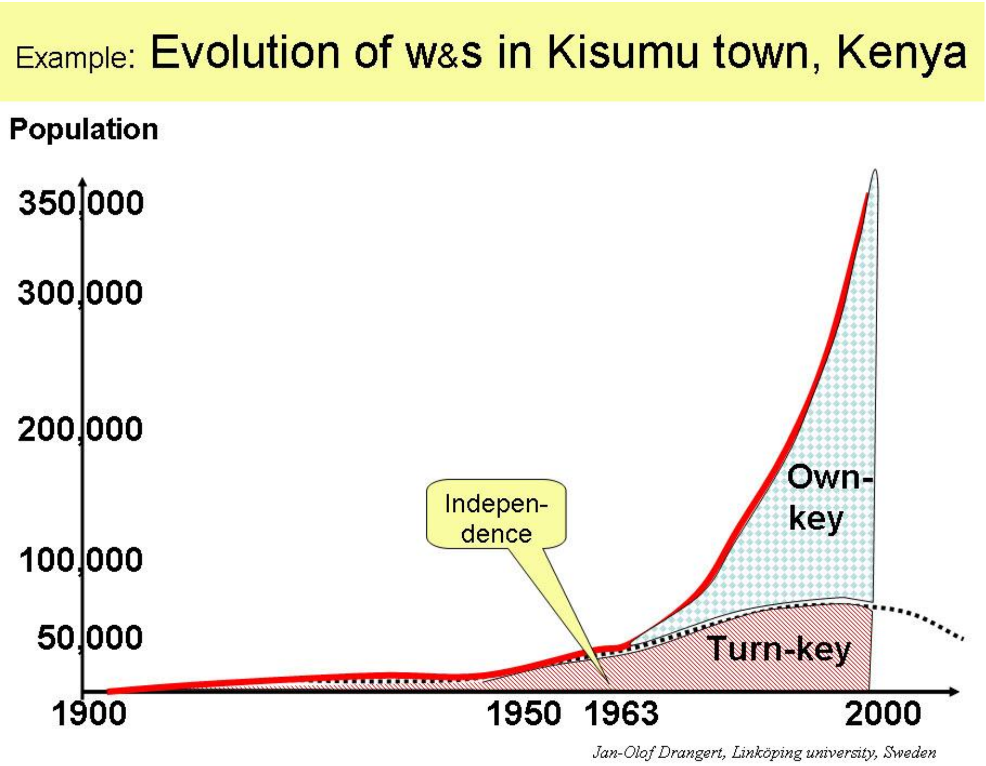
Own-key management. Single households or housing associations initiate, build and control the arrangement. They put to use available skills, materials, and other local resources. The most common *own-key* solutions in urban areas are dug wells and pit latrines. However, there are many up-market technical arrangements as is shown in Module 2.1.

Own-key arrangements require some initial investments and usually time to operate them. However, they typically need a minimum of technical skill to operate and maintain. Time input may involve emptying urine in the garden, composting organic material, or putting grease on a hand-powered water pump. Part of the operation and maintenance work, such as collecting faecal matter, may be done by a contractor for a fee.

Pit latrines work rather well as low-cost, *own-key* installations. However, due to the number of users in dense periurban settlements latrines seem to be difficult to maintain. Unless the soil has a high capacity to drain the water used for anal cleansing and from the bathroom soakaway as well as entering rainwater, stagnant water may become a problem. Moreover, if the fluid in the pit percolates into the saturated zone, the groundwater will become contaminated and can transport micro-organisms to nearby wells (WHO, 2006). Ideally, a vertical safety distance of 1.5–2 metres should remain between the bottom of the pit and the highest groundwater level in all seasons.

The following two urban water and sanitation stories from a town in Kenya and another in Sweden illustrate how the above hypotheses (slide 1.4-6) can be tested in terms of own-key and turn-key management.

1.4 - 8



In 1900 there were very few towns in East Africa. Exceptions included Old Kampala in Uganda and the coastal towns of Bagamoyo, Zanzibar, Kilwa, and Lamu established by Arab traders and with water and sanitation solutions of Arabic design. A study of the development of sanitation and water arrangements in Kisumu town on Lake Victoria in Kenya during the 20th century provides some insight into the relationship between demographic change and water and sanitation infrastructure (Drangert et al., 2002).

Kisumu is situated on the eastern shore of Lake Victoria, the second-largest freshwater lake in the world. The town was founded in 1901 as a port town on the railway line from Nairobi to the lake region to serve agricultural exports from Uganda. Initially, the residents of Kisumu were largely people connected to the operations of the railway, shipping and related commercial services. Later on, fishing and large-scale farming in the hinterland dominated the town's economic activities, and after World War II urban industry and public administration expanded. The proportions of turn-key and own-key water and sanitation arrangements are indicated in the diagram above, together with population data.

Professor W. J. Simpson from the Ross Institute in London presented statistics of the number of annual deaths from plague that came to the notice of the medical authorities in the township. Deaths ranged from 4 to 71 a year during the period 1904–1913. Colonial Office records indicate that Kisumu had only 400 inhabitants by 1910, and population growth was slow. Initially, the small town was regarded as disease-ridden, and this made the authorities vigilant and proactive. Existing records show that the colonial administration developed the first piped water supply in the town in 1907 when lake water was pumped up to a tank above the township (Anyumba, 1995). However, the water supply for the European houses was derived from rainwater tanks attached to each house, possibly for fear of the plague. All refuse was removed twice daily, a drainage system was installed, and a sanitary inspector was employed. "*Rat destruction, street by street, ward by ward, house by house, and premises by premises*" (Simpson, 1914) was carried out. Professor Simpson rated the houses erected for the African employees as excellent and well lighted and also rat-proof. A bucket collection system for excreta was run by the authorities, and in 1916 incinerators for both night soil and rubbish were introduced. However, the bucket collection system was not used in the European part of the town, where there were flush toilets and septic tanks.

The town grew and sanitation and water arrangements were gradually upgraded with a high coverage of water supply and sewerage (picture). By restricting the influx of rural people Kisumu retained well-managed water and sanitation arrangements. Towards the end of the colonial period, two sewage disposal lagoons were completed to handle the growing amount of sewage. This situation compared favourably with the conditions in UK at the time.

After Kenya's independence in 1963, the population grew five-fold within two decades. A major reason for this unprecedented growth was that the independent government lifted earlier colonial restrictions on migration of the African population into towns. Also, incorporation of the densely populated periurban areas in 1972 contributed significantly to the population increase. Some of these newly incorporated suburbs were supplied with lake water from standpipes and water kiosks (Anyumba, 1995). Little has been added on since that time, with the exception of a World Bank project that put up a new suburb with 180 single-family houses fitted with water and sewerage, and well-drained tarmac streets. The Japanese aid agency (JICA, 1998) estimated that about 60% of the residents were served with at least some piped water. However, only 8% of those served had a continuous supply, 34% had a limited supply, and 58% were supplied from water kiosks.

The 40% with no access to taps, and a very large number of households with intermittent piped water, had to buy water from vendors or private wells when the municipal council was unable to deliver. Roof-catchment was only provided by some landlords and private homes.

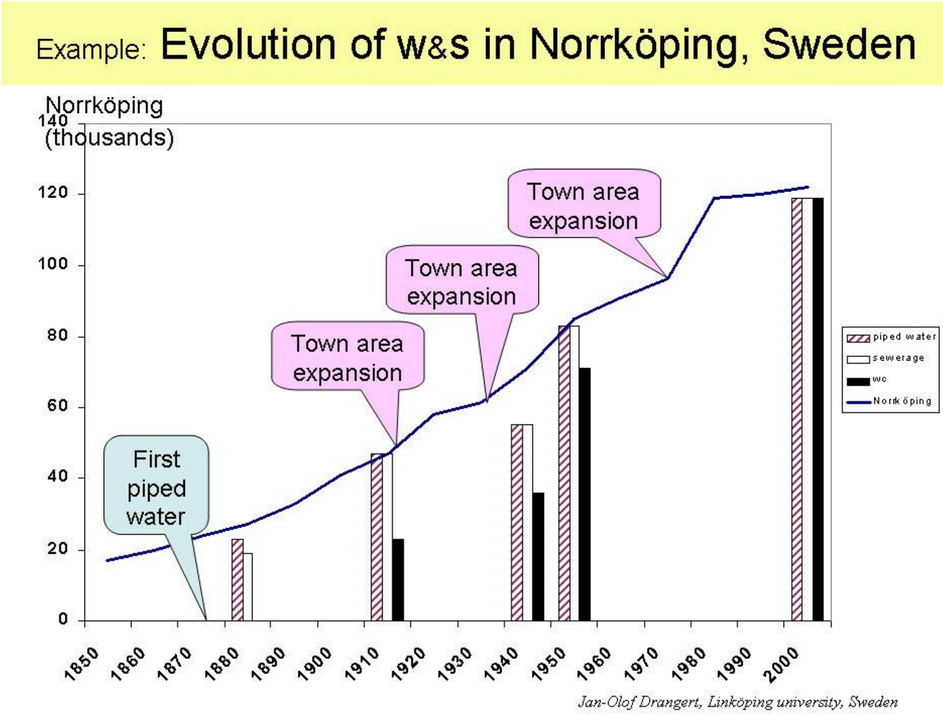
The council phased out the bucket system for night soil in the 1970s without expanding the sewerage, and residents had to dig latrines in the suburbs. The latrine pits dotted the whole area, and jeopardised water quality in nearby wells. The sewage system served only the central part of the town and the effluent reached the lake untreated, except for the portion that entered the two treatment ponds. An advanced wastewater treatment plant was built in 1969 with donor funding and it was renovated in the mid-80s. Since 1999 this communal plant has not operated because of non-payment of electricity bills. The exhauster service for emptying pit latrines and cesspools has deteriorated sharply since the late 1980s. And much of the drainage is poorly maintained.

Water fees earn little since many of the individual water meters are out of order (JICA, 1998). Still, water and sewerage charges amounted to 100 million Ksh or 45% of the total revenue base for the council in 1995/96, while the actual expenditure for water and sewerage was 129 million. A serious problem arose later when a major water user, a beer manufacturer, moved away from Kisumu after it had been denied permission to develop its own water source. The result was that the council remained with its expenditure almost unaltered but it had lost half of its revenue. The non-payment of the electricity bills mentioned above is a result of this.

The low service standard of the municipal water and sewerage department can also be understood from the fact that only 102 out of a total of 326 positions were filled in 1997, and most of the vacancies appeared at senior levels. A government paper of 1999 recognised that such institutional weaknesses prevent the proper operation and maintenance of water supplies.

Conflicting interests between the council, the town clerk and other officers within the council were reported by the press, together with rumours that some influential decision-makers owned the vendor-business in the town and obstructed any rehabilitation of the system. The central government ended its support of the water services and donors were cautious about becoming involved. The Japanese government, for example, offered to support a large-scale water supply and sewerage project in Kisumu but the proposal was conditional on improvements to future water management (JICA, 1998). Few people believe that this large-scale turn-key arrangement will take off in the foreseeable future.

The picture illustrates the disastrous evolution of public turn-key provision of water and sewage by the municipal utility. When the city rapidly became big, the residents "went small" and they organised and installed own-key arrangements despite periodic council harassment.



1.4 - 9

The town of Norrköping was one of Sweden's leading industrial towns in the second half of the 19th century, dominated by textiles manufacturing. Swedish towns are small on an international scale, and so is Norrköping. There were some 17,000 inhabitants in 1850, 41,000 in 1900 and today the number is about 120,000 (see graph). Although there were some decades of peak in-migration to Norrköping in the 1880s and 1890s, its growth rates were still far below those of Kisumu town in the second half of the 20th century.

Piped water and sewers were installed in the 1870s only after a big donation from a wealthy manufacturer. The water intake was situated upstream of the town while the wastewater was discharged untreated at several points. The donor stipulated that the piped water must be free in order to benefit the many workers' households in town. It was cheaper to build and provide (by gravity) workers with good water than to treat all industrial wastewater from the many factories along the river. (It took another half a century and heavy fish deaths before the industries started to treat their effluent). It was estimated that 85 per cent of the households got water taps in the yard or indoors, while some 70 per cent were connected to a sewer. Initially, there were only a couple of flush toilets in town, and almost all excreta were collected in buckets and used together with cow dung as a fertiliser on nearby fields.

A generation later, in 1910, almost all households had a sewer connection, and piped water at least to the kitchen. Almost half of the houses had flush toilets (the highest urban coverage in the country at that time) while the rest relied on a bucket system (Drangert & Hallström, 2002). In the year 1900 the council started to charge the users for water despite the undertaking to the donor that the water would be free. When nearby areas were incorporated into the town in 1910 and 1935, little or no effort was made by the council to provide these areas with centralised water. Therefore the proportion of water coverage decreased during those years. The subsequent period of slow population growth made possible a rapid increase in coverage of water, decentralised sewers and WCs. The same was true for a big expansion of the city in 1972 (slide 2.3 - 11). Practically all houses and flats were connected to a communal decentralised system by the end of the 20th century.

These developments fit quite nicely to the hypotheses. The initial investment was enabled by a donation, without which it is likely that the piped system would have been delayed several decades (compare Kisumu town where the colonial government put up the initial funds). Since the 1950s the few *own-key* arrangements were restricted to distant homes which were too expensive to connect. They had indoor water pumped from a dug well in the garden and a septic tank and infiltration bed near the house. In some low-density areas neighbours organised their own small water association for supplying water.

The city council agreed to spend money on the operation of the water supply and sewerage and on some expansion of the system once it was established (thanks to the private donation). However, the council was reluctant to provide services to the newly incorporated informal areas despite the fact that many tax-paying workers from the city's manufacturing industry lived there.

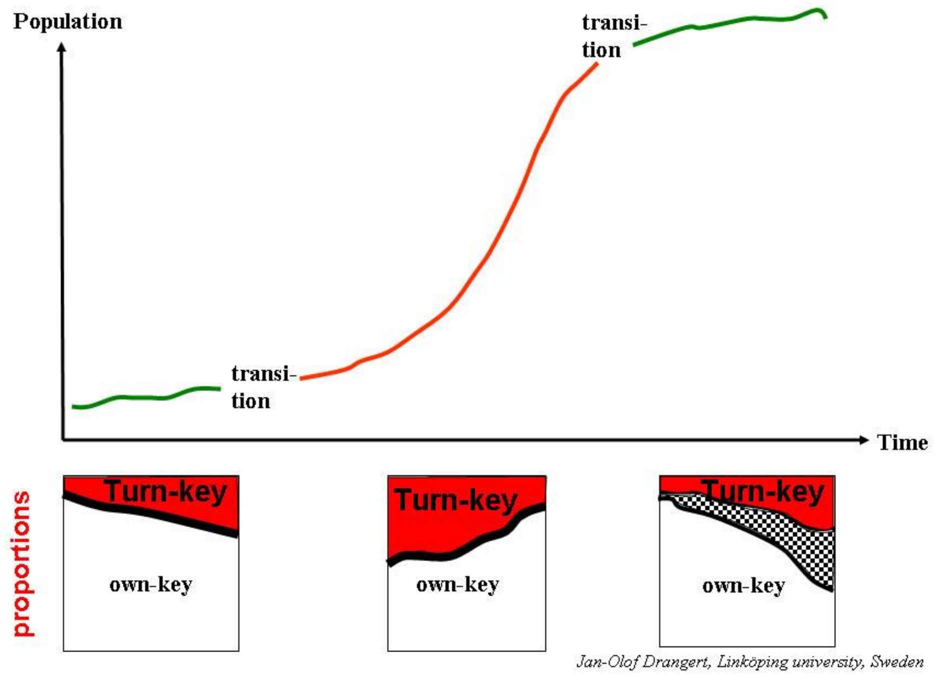
A different lesson is that by the time all residents were connected to the water and sewerage they had lost their option for an alternative system. The water by-laws prohibited alternatives in the utility's sewage catchment area. Households connected in the 1990s, for example, had already paid the connection fee of US$15,000 and additional costs for the pipes into the house. They were therefore reluctant to add a new investment for an individual household arrangement. The system has become inflexible with few avenues for trying out sustainable alternatives.

A reason for considering an own-key solution is the rising cost for the utility services. Energy prices have sky-rocketed since the first oil crisis in 1973 and the cost of pumping water to households and wastewater back to the centralised treatment plant has increased dramatically. Had the city network (slide 2.3 -11) been designed today, the energy cost would have been given more consideration than it was in the mid-20th century. The likelihood is that a more decentralised system would have been designed.

This account of the evolution of water supply and sewers would be incomplete if treatment of wastewater is left out. All household wastewater was discharged untreated to the river up to the 1960s. By that time, serious instances of fish death and emerging algae bloom in the nearby estuary were recorded. Outdoor bathing was a thing of the past. The city invested in a modern wastewater treatment plant in the late 1960s, and, as is common practice, the treated wastewater from households and industries was piped far out in the bay. New physical town plans forced industries along the river to close down or move to new industrial zones where they had to abide to the stricter environmental laws concerning discharges. Fifty years on the fish is returning but bathing is still not allowed.

Hypotheses on best management option

1.4 - 10



The previous two examples can be easily understood by using the concepts of *own-key* and *turn-key* arrangements and management. This terminology is useful for analytical purposes despite the experience that in real-life situations a system can be a mixture of the two. Anticipated service provision outcomes during the three demographic regimes are shown in the boxes. *Own-key* arrangements dominate in phase one, and the expansion of turn-key installations is slow. As the population starts growing faster, the proportion of *own-key* arrangements increases again, while the number of people served by turn-key arrangements may increase initially and later decrease due to inability of city councils to provide communal services. Urbanites apply their own resources to achieve local solutions; and in many areas they survive thanks to their own arrangements and efforts.

When the population stop growing fast both the proportion and number of urban residents having access to turn-key arrangements begin to increase. The checked area in the right-hand box between turn-key and *own-key* arrangements represents households which have a real choice between own-key and turn-key management. They may even use the turn-key services only part of the year e.g. during long dry seasons and relieve the utility the rest of the year. At the same time, the council may be reluctant to support or even allow *own-key* arrangements.

Kisumu and Norrköping towns developed the way the hypotheses predict. Both started as small towns with moderate population growth that did not require turn-key arrangements to start as early as they did. A private donation kick-started the building of a water supply and sewerage in Norrköping. The driving force seems to have been a combination of philanthropy and an awareness that it would be much more profitable to allow industries to continue to pollute the river while providing the workers free piped water of decent quality from an upstream intake. Kisumu, by contrast, was part of a colonial plan to expand export of the region's produce. There was a need to improve the public health situation and the British tradition of providing housing to railway and maritime workers resulted in an up-to-date water supply and sanitation system. However, it required a long-term government subsidy to survive.

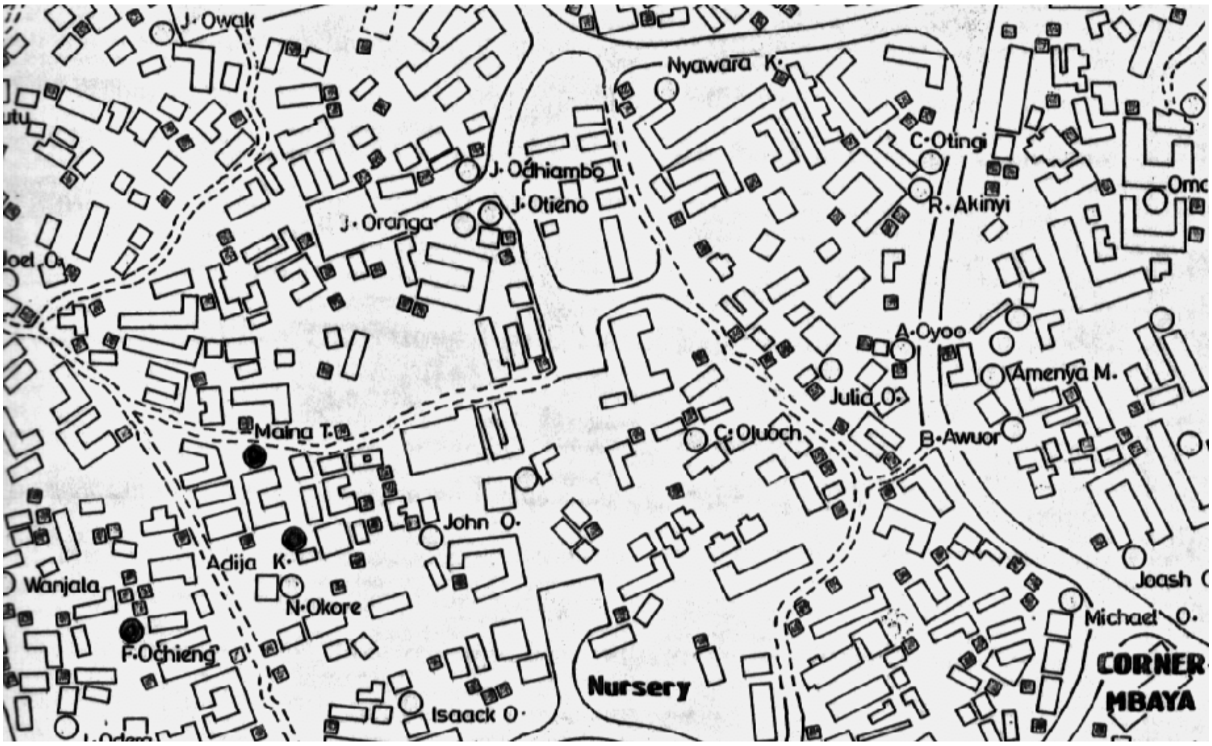
Norrköping continued to grow at a moderate rate all the way up to the year 2000, and never entered the rapid growth regime. The closest it got was when new areas were amalgamated and the utility failed to rapidly connect them to the decentralised system. The turn-key arrangements have been working well for the residents, but they also have to pay the full cost of the system.

Kisumu continued to grow at moderate controlled speed up to the end of the colonial period and the council ran a cost-effective water supply and sanitation system with bucket collection for a large part of the population and sewers for the office and commercial areas.

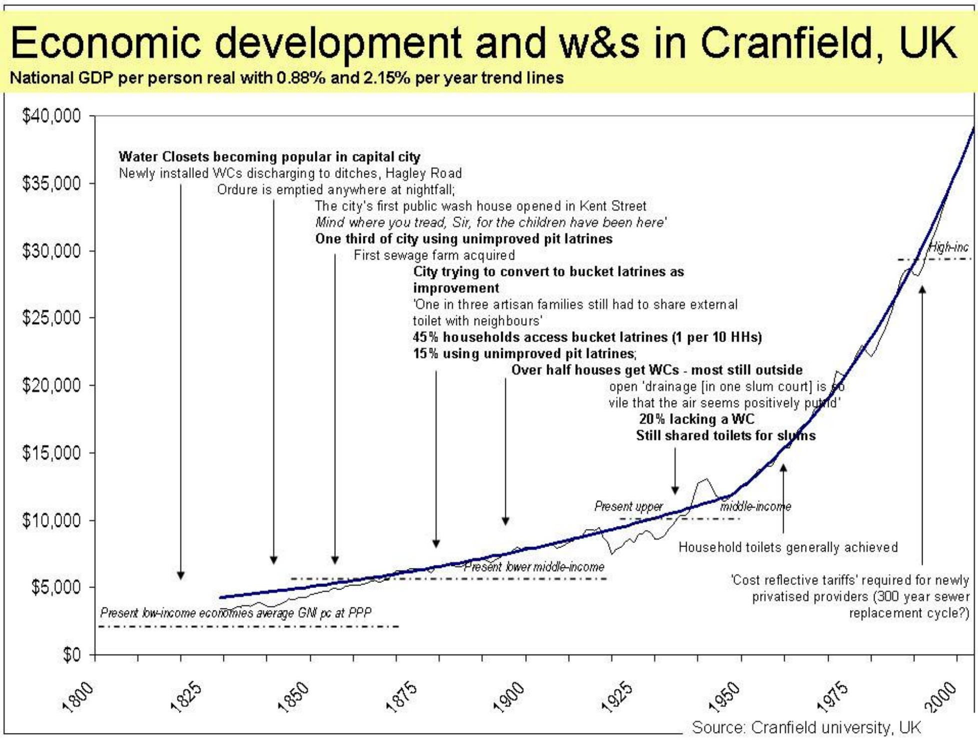
The post-colonial period after 1963 has been one with extremely rapid population growth that has put heavy stress on the municipal council, to the extent that it failed to provide water and sewage services to most of the new residents. The social cohesion in the community seems to have deteriorated progressively. The management of the council has become more and more politicised over the last few decades. The existing infrastructure deteriorated and provided only a small portion of the residents with reliable water and collection of wastewater. The bucket collection service and latrine-pit emptying has ceased altogether. Today, the majority of Kisumu residents live in periurban permanent or semi-permanent houses on small plots with dug latrines and possibly a well. Well water is sold to neighbours and water vendors supply wealthier households with water at high cost.

The hypothesis holds for Kisumu during the period of rapid population growth, during which service levels have deteriorated. The growth is ongoing, and few residents seem to believe that a turn-key arrangement will be in place in the foreseeable future.

Map fragment of the Manyatta Gonda area in Kisumu with wells and dug latrines



Source: Drangert et al., 2002. Ring = well, filled square = pit latrine



1.4 - 11

A different way of interpreting the evolution of water supply and sanitation is to relate existing arrangements to residents' average income, calculated as GDP per capita. The picture indicates the average income level on the vertical axis and the blue curve represents discounted increase in income over the period 1800 to 2000. The national GDP per person with 0.88% and 2.15% per year trend lines makes up for the lack of city-related data on economic status.

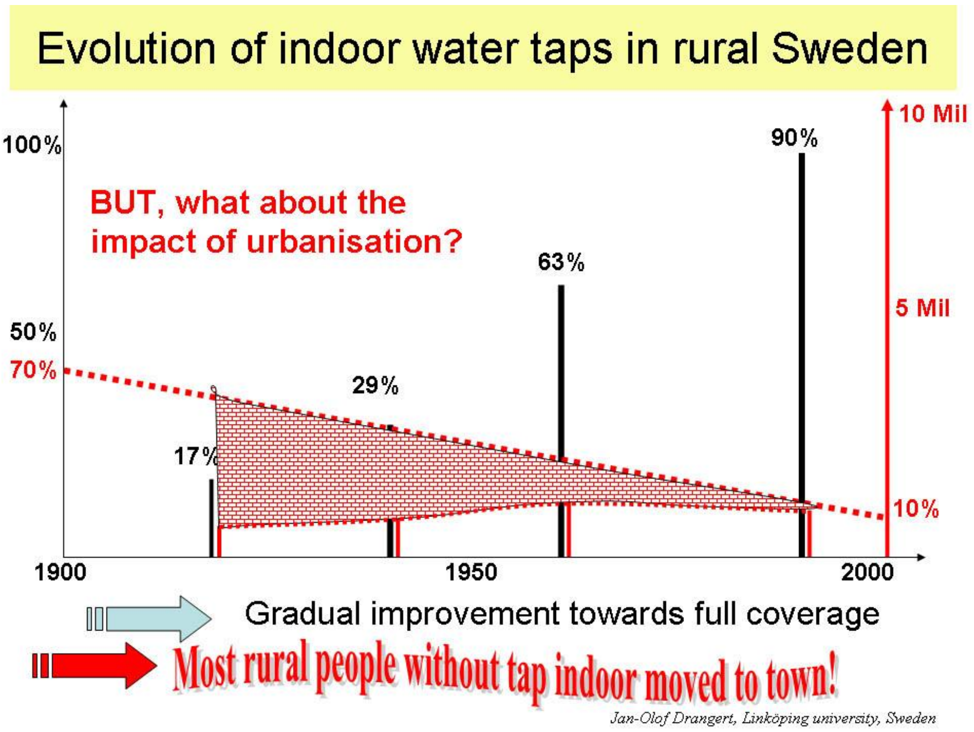
The picture shows the development of water and waste services in the medium-sized town of Cranfield in the UK. This time the evolution is not related to population growth but is described in terms of how rich the community (country) is. The picture provides a good visual description of the evolution in the city.

WCs were already getting popular in London in the 1820s, when the first WC was installed in Cranfield and evacuated into open ditches. The ordure was disposed of anywhere at nightfall. Half a century later the council opened its first sewage farm to take care of the wastewater. Open defecation was still common among children and there was a saying "*Mind where you tread, Sir, because the children have been here*." At this time, one-third of the residents still used unimproved pit latrines and the authorities tried to introduce a bucket system to improve the sanitary conditions. By 1880 approximately 45% of households had access to a bucket latrine, but it was shared with some ten other households.

By the year 1900, half of the households had a WC but oftentimes it was outside the house or flat. The likely reason was that they functioned poorly and emitted a foul smell. As late as the Second World War, 20% of households still lacked a WC. The evolution in Kisumu, Kenya, should be compared with this situation in the backyard of the colonial power.

Full WC coverage was achieved in the 1960s; almost a century and a half after the first flush toilet was installed in the city. In medium-sized towns such as Norrköping and Cranfield the evolution is likely to be similar. The pit latrines were abandoned and the council tried to improve its bucket collection system. Around 1880 about half of the households had access to bucket latrines, while 15% still used unimproved latrines.

1.4 - 12



Sanitary improvements in rural areas may or may not be related to demographic changes such as densification, rapid growth or the exodus of young people to towns. A common view aired in the international debate is that rural living conditions should be improved in order to make people stay on and thereby relieve cities from disastrous growth. Some interesting lessons on social dynamics can be gained from investigating the introduction of indoor water taps in rural homes.

Rural households in Sweden usually had their own dug well from which they took water by the bucket to the house and to the stable or cow shed. In the second half of the 19th century, when cast iron made hand pumps affordable, it became popular to install them on the well. Only later did it become fashionable to install a small hand pump of cast iron in the kitchen. Later, when electricity reached the countryside the hand pumps were replaced by electric pumps. Data from 1918 tells that the proportion of rural households with a water tap indoors was 17 per cent, by 1941 the figure had risen to 29 per cent, and by the year 2000 to almost 90 per cent. This suggests that through gradual improvement, eventually all rural house-owners had installed tap water indoors (the water was pumped from the wells). However, it took a century to achieve.

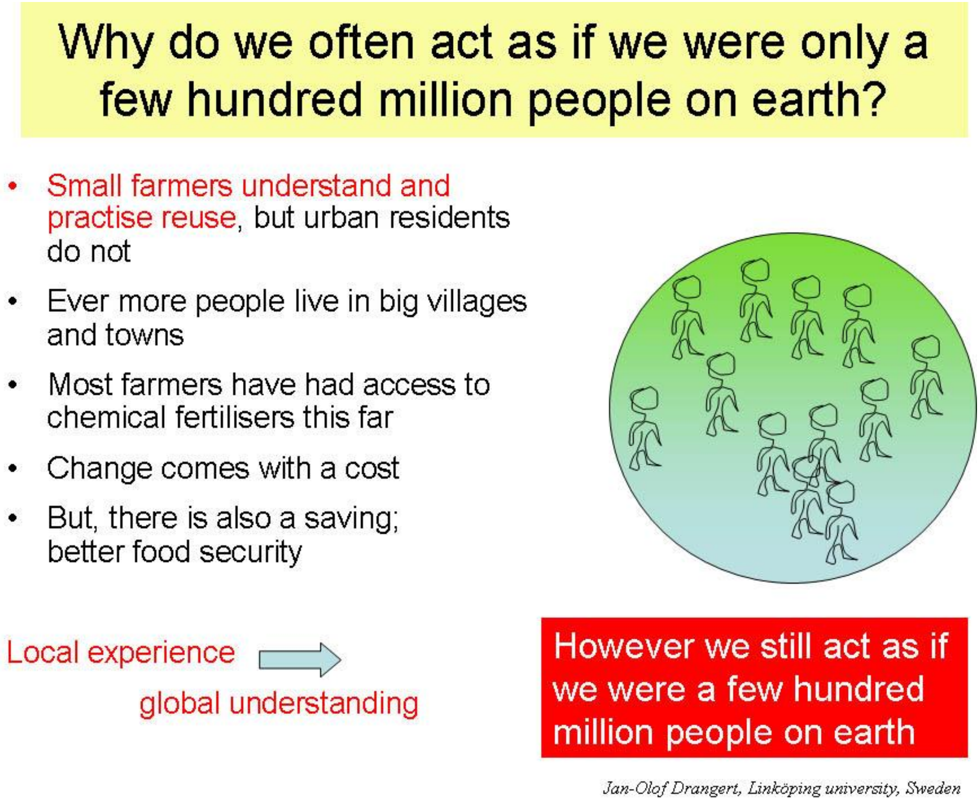
This interpretation is challenged when taking migration from rural to urban areas into account. The rate of urbanisation was uniform over the whole century (picture). In 1900 some 70 per cent of Sweden’s five million people lived in rural areas and towards the end of the century 10 per cent of 9 million did so. This means that about 3.5 million lived in rural areas in 1900 and 900,000 in the year 2000. Thus, the actual *number* of rural residents with tap water (red dotted curve) rose from roughly 600,000 (17% of some 3.5 million in 1918) to 900,000 (100% of 900,000 in 2000). The shaded area shows rural dwellers with no tap water indoors.
The conclusion is that rural homes with water indoors increased, while most rural residents with no indoor water tended to move to town instead of improving their rural homestead!

The latter interpretation provides a totally different understanding of how universal indoor tap water came about – not by gradual expansion but by migration to towns where an indoor water supply was available. We may add that the Swedish government did not run projects to support tap water, but during some periods they provided loans for improving rural housing.

The Water Decade strategy of (donor) governments to provide rural water had never been tried in the developed world. Therefore, when international bodies decided on slogans such as ‘Water for All’, they did something that had never been tried before. The prospect of success was slim, given that the rich countries experienced an easier situation with rural populations that were declining – rather than the situation in developing countries where numbers are stable or increasing and the rural populations are aging.

Ester Boserup introduced a new angle to the analysis of change in agricultural communities when she singled out population density as the autonomous factor making for a steady intensification of agricultural production (Boserup, 1965). She believed communities with a sustained population growth and increased density stood a better chance of achieving economic development than communities with stagnant or declining populations. This is similar to the situation with indoor tap water in rural Sweden. However, she made her thesis subject to a qualification: it may not be true of communities which have a *very high* rate of population growth and which are already densely populated, and are therefore unable to undertake the investment necessary for introducing still more intensive methods of agricultural cultivation. A similar approach to analysing the development of the sanitation and water sector in rapidly growing societies should be used in order to be useful for policy and strategy decisions.

1.4 - 13



It took more than 50,000 years to reach the first billion mark for Homo sapiens by the year 1800, and only ten years to add the latest billion people on the globe. We have difficulties to understand this pace. Collectively we still behave as if there were only some hundred million people on the globe. We focus on improving living standards for everyone without taking into account the available natural resources and the globe´s resilience. Of late, awareness about climate change may help us to understand the demands that 9 or 10 billion people will place on the world’s resources (slide 1.1-15).

The closed loop was well understood and widely practised a century ago in the developed countries, and presumably also in developing countries. In the 1950s cheap fertilisers flooded the rich countries and gradually also former colonies. At the same time, urbanisation took off and fewer people had experience of farming. On the one hand, food production has grown faster than population due to improved management over the last century. For instance, production per hectare in Sweden has increased tenfold. At the same time, sanitation systems have become more centralised (sewerage) and involve less recycling as people move into more dense settlements, and thus the sanitation system has become invisible and less easy to understand. The concept of the closed loop simply faded away, and the flush system took over the sanitation sector (slides 1.3-2 and 2.2-2). Instead of bringing the human-derived nutrients back to soil where it belongs, sewage was simply emptied into water bodies. It is only in the last 50 years that wastewater has been treated to some extent before being released.

We started this module by asking whether urbanisation is a problem or a solution to sustainable futures. In a demographic sense the fundamental outcome of moving to town is that the number of children goes down. In most rural areas the decision to have two or four children is not restricted by economic reasons, since the two extra kids do not need an extra room for themselves, and their parents can produce the food by an increase in productivity (Boserup) or from an extra piece of farmland (Malthus). The decision is more likely to be guided by cultural influences. Parents in urban areas are also culturally guided, but this time to expect to extend the flat and to BUY clothes and other things that the extra kids need. Also, they have to BUY more food and the money for that can only be earned through work or spending less on other items.

The above exploration shows why one can expect higher numbers of children in rural communities than in urban areas.

The main challenge with high population growth – in both rural and urban areas - lies with providing public services for all newcomers. This is because the family is usually responsible for housing and feeding, while the public sector is responsible for health services and schooling. Such services require that parents pay higher taxes for their children's schooling etc. Few of them see the connection between the family decision to have more children and the necessity to pay taxes or fees for public services, particularly if the education system is of poor quality. If no extra taxes are collected, the standard of schools will surely deteriorate.

The school sector can illustrate what happens if all families send four children instead of two to school. There must be twice as many teachers and classrooms available. Let us assume that the total population of a country is 23 million, that the growth rate is three per cent, the fertility rate is five per cent, and that each class has 35 pupils and one teacher. Over a period of seven years the cumulative requirement will be about 28,900 extra teachers and classrooms (slide 5.3-19). At least four new teacher training colleges would be needed per year to train the extra number of teachers, each with a capacity to train 1,000 teachers annually. Additional institutions to train trainers of teachers will also be needed. This is a daunting task that few countries can manage. Resourceful families in cities solve the problem by spending money on private schools for their children. The majority cannot do so, and there are not enough teachers available to fill all schools.

Governments cannot keep up with demands for services caused by rapid population growth and the situation becomes unmanageable, not because there is a lack of good planners, but because of the magnitude of the task. This applies to all public services that require financing through taxes or fees. This is confirmed by present development where most urban families can afford to build or rent houses, but authorities lag behind in organising acceptable water and sanitation arrangements in rapidly growing cities.

New ways to approach urban infrastructure are needed. The link between sanitation and food production has become less visible ever since the introduction of chemical fertilisers and sewerage. However, a likely scenario is that the understanding of closed loops will increase as the agricultural sector realise that they cannot afford to purchase chemical fertilisers (See Module 1.3). Decision-makers in cities may experience other push factors for closing the nutrient loops. One is that sewerage itself causes problems e.g. how to dispose of large quantities of contaminated sludge, and the increasing energy costs to pump effluent in pipes may also prove unaffordable. Change comes with a cost for urban residents, and one of those costs is the need to adopt new sanitation practices which involve some new routines.

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