COMPREHENSIVE ASSESSMENT OF THE FRESHWATER RESOURCES OF THE WORLD

URBAN WATER - TOWARDS HEALTH AND SUSTAINABILITY

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FOREWORD

A rapidly growing demand on freshwater resources, resulting in increased water stress in several parts of the world, increasing pollution of freshwater resources and degraded ecosystems, made the UN Commission for Sustainable Development in 1994 call for a Comprehensive Assessment of the Freshwater Resources of the World. The final report (E/CN.17/1997/9), prepared by a Steering Committee consisting of representatives for UN/DPCSD, UN/DDSMS, FAO, UNEP, WMO, UNESCO, WHO, UNDP, UNIDO, the World Bank, and Stockholm Environment Institute, is presented to the CSD 1997 and to the UN General Assembly Special Session June 1997.

Within the process of the Assessment a number of background documents and commissioned papers were prepared by experts with various professional background. The document *Urban Water – Towards Health and Sustainability* is one of these. As a scientifically based document, any opinion expressed is that of the author(s) and does not necessarily reflect the opinion of the Steering Committee.

Stockholm, June 1997

Gunilla Björklund
Executive secretary
Comprehensive Freshwater Assessment

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ABSTRACT

Few would dispute that urban water systems should be both healthy and sustainable. Ideally, along with efficiency, these are central pillars in every urban water strategy. Unfortunately, the narrow pursuit of health can undermine the sustainability of water systems, and vice versa. Such trade-offs must not be rationalised away, but recognised in order to develop diversified and better aimed water strategies. It is crude policies, such as promoting health by providing free water for all, or promoting sustainability by charging everyone high prices, that create the steepest trade-offs. Trade-offs are far less evident with more sophisticated policies, targeting particular users or uses, and built upon a better understanding of water related disease, hydrology, markets and politics. Our ignorance is however no excuse for inaction: there are many obvious things that need to be done. But nor is the need for action an excuse for remaining ignorant: there remains a great deal of relevance to learn regarding urban water, and how it relates to both health and sustainability.

1. INTRODUCTION

Defining the Sustainable City and the Healthy City

Broadly defined, a sustainable city embodies all the good qualities a city can have, and perhaps a few more besides.[1] A healthy city is much the same.[2] Yet the goals of sustainability and health, more narrowly defined, are by no means identical. And however valiantly one tries to extend the concept of the sustainable city to cover contemporary deprivations, it implies a special concern not to compromise the future. Likewise, however valiantly one tries to extend the concept of a healthy city, it implies an emphasis on traditional environmental health concerns.

In looking at urban water issues, this paper adopts a narrow usage. Perfectly sustainable water systems would, according to this narrow definition, be indefinitely maintainable, and would not undermine the ecological systems and natural resources upon which the city depends. Perfectly healthy water systems would minimise water related diseases, and meet all of the residents' basic water needs. Whether a sustainable water system is healthy, or a healthy one sustainable, is left open. This allows two of the main challenges for 20th century urban water systems to be kept conceptually distinct, and avoids conflating interrelation with identification. While it is important to try to make the pursuit of sustainability and health complementary, it is equally important not simply to assume conflicts away.

Water and Sustainability: A Problem with a Past as Well as a Future

Water is universally recognised as a critical resource, but the sustainability of water supplies is often overlooked in planning for a city's future. This is not a peculiarly modern problem. Writing in the 14th century on "Requirements for the planning of towns and the consequences of neglecting those requirements," Ibn Khaldûn placed water for human consumption first in the list of resources whose negligence had made a number of Arab cities of the past "very ready to fall into ruins, inasmuch as they did not fulfil all the natural requirements of towns" (Khaldûn, 1981, pp. 238-239). His concern is echoed in modern texts, describing cities straining the limits of their water supplies (Anton, 1993). Modern technologies, with their much greater capacity to draw on distant supplies, shift but do not eliminate urban water supply constraints.

In the last two centuries, urban growth and industrialisation have also added to the range of pollution burdens which can threaten the ecological sustainability and health of cities. Many coastal zones, rivers and downstream inhabitants have been gravely damaged by urban polluters who use water to carry away hazardous pathogens or chemicals. This strategy of displacing urban environmental burdens onto the water systems has also long been questioned, perhaps most eloquently by Coleridge, who penned the following lines at the end of a poem on Cologne in 1828:

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[1] In a recent and not untypical attempt to develop measures of urban sustainability, it was agreed that "environmental integrity, social well-being and economic viability are the three components of urban sustainability" (Dilks, 1996). In this classification, health is subsumed under social well-being.

[2] The Milan Declaration on Healthy Cities, for example, explicitly subsumes sustainability by including it as a guiding principle, and claiming that "Health depends on sustaining the world's natural resources, as well as the quality of the natural and built environments" (Tsouros, circa 1992).

The river Rhine, it is well known,
Doth wash your city of Cologne;
But tell me, Nymphs, what power Divine
Shall henceforth wash the river Rhine?

The Rhine today is less central to the “washing” of cities like Cologne (though some would say the burden has yet again been displaced rather than removed), and the quality of the water in the Rhine has improved as a result. However, more populous, more industrial, less wealthy cities are polluting their waterways on a far larger scale, and Coleridge’s question still resonates.

Nineteenth century commentators also criticised the manner in which new urban technologies, and water borne sewerage systems in particular, interrupted the “circulus” of nature (Reid, 1993, pp. 53-70). Again, it is even possible to find a literary reference, this time in Victor Hugo’s *Les Misérables,* where he laments the “blindness of a bad political economy” which allowed faeces to be carried off with water rather than used in the fields. Also an advocate of assigning monetary values to environmental problems, he claimed that: “Each hiccup of our cloaca costs us a thousand francs. From this two results: the land impoverished and the water contaminated. Hunger rising from the furrow and disease rising from the river” (p. 1257 of Signet Classics paperback edition).

Water and Health: A Problem with a Future as Well as a Past

If seemingly modern issues of urban water, nutrient cycles and sustainability have actually been with us for centuries, seemingly old fashioned issues of water, poverty and infectious diseases may unfortunately be with us for centuries to come. Reports based on government statistics indicate that in the early 1990s about one fifth of urban dwellers in the South were without adequate access to safe water and about one third were without adequate sanitation, and what governments define as adequate may still be far from healthy. There are roughly three million deaths every year from diarrheal diseases, most of which could probably be averted by the better use of water. While water related health problems are likely to remain far more severe in the South, some are beginning to re-emerge in wealthier countries. The 1993 diarrhoea outbreak in Milwaukee in the American Midwest, where more than 4,000 were hospitalised after being infected with a parasite in the municipal water supplies, was a challenge to Northern complacency (World Health Organization, 1996, p. 38).

Unhealthy and yet Sustainable Urban Water Systems

The current burden of water-related diseases (see definitions below) in urban areas is not, by and large, the outcome of the city-wide water supply and pollution problems that threaten sustainability. Low income urban neighbourhoods and households are more likely to lack water because they cannot access the city’s water supplies than because those supplies are limited. A comparatively healthy overall water balance can be accompanied by extremely unhealthy conditions in disadvantaged neighbourhoods. Indoor piping and low water prices may be the rule in one neighbourhood, while residents of a squatter settlement nearby must choose between a heavily polluted stream and extremely expensive water from vendors. Water may be clean in the pipes, but heavily contaminated by the time it has been carried home, stored, and ladled into a guest's drinking vessel. For many of the more disadvantaged urban dwellers, water scarcity and life-threatening water pollution are not future prospects given unsustainable practices, but current realities. Only concerted actions, based on better science, more respect for local knowledge, and politics that create a continuous pressure for improvement, are likely to make significant headway.

Unsustainable and yet Healthy Urban Water Systems

Alternatively, a city's water future may be grim even when cheap and reasonably clean piped water remains widely available. Indeed, many of the measures employed to address urban environmental health problems, such as providing low-price piped water supplies and water borne sewerage systems, can add considerably to the water-environment burden of a city. Thus the water use patterns of middle income mega-cities are particularly unsustainable, despite the fact that the average prevalence of water-related diseases is likely to be lower than in smaller but poorer urban centres.

As such, the health and sustainability aspects of urban water systems are both important, but worth keeping conceptually distinct. In wealthy cities where piped water and water borne sanitation is universally provided, sustainability can be a very useful organising principle for water system improvement. Improvements should not be a threat to health, of course, but it is in the domain of sustainability, more narrowly defined, that most progress needs to be made. Alternatively, in the more disadvantaged neighbourhoods, where water scarcity and quality problems are a serious and immediate threat, the water agenda ought to be developed around a concern for health and welfare. Improvements should be sustainable, of course, but sustainability is not appropriate as an overarching goal, however progressive this may seem.

Outlining the Remainder of the Paper

The next section of this paper concentrates on water and urban health, reviewing the "sanitary revolution" of the 19th century, the nature of the water related diseases that still afflict most disadvantaged urban dwellers, and the relationship between water, poverty and illness. Much was achieved in the 19th century, despite beliefs we would now regard as dangerous nonsense. Perhaps equally surprisingly, when capital intensive solutions are not an option, as is the case in most areas where sanitary conditions remain a serious problem, science still provides very limited guidance for water and sanitary improvement. The tendency to focus on a few simple threats, such as contaminated drinking water, has helped obscure a broader ignorance. There are a number of both scientific and institutional issues to resolve before the "brown" agenda can justifiably be called an "easy" agenda. More efficient finance and infrastructure alone will not be sufficient.

This is followed by a section which concentrates on issues of water and sustainability. The urban growth of this century, with the appearance of mega-cities as well as an unprecedented number of, much less noticed, smaller cities, is central to future urban water development. Linear material flows which underpin urban life allow urban dwellers to abuse natural resources and displace the burdens of both pollution and resource scarcity to faraway natural and human habitats. These processes too are poorly understood, and pose a range of seemingly intractable institutional problems. While some particular threats are well understood, it will not be enough to tackle just these. Just as poverty does not explain water-related ill health in low income cities, so affluence does not explain the water-related threats to sustainability that urban economic development can bring. On the other hand, achieving sustainability while maintaining urban affluence is inherently difficult.

In many contexts there are trade-offs between health and sustainability. However, as indicated in Section 4, improvements in water management which build on a better understanding of the physical and institutional aspects of water systems, can minimise the extent to which health must be traded for sustainability, and vice versa. Crude policies for improving health through water supplies, such as price controls and the extension of capital intensive water borne sewerage systems, tend to bear a high sustainability burden. Crude policies for improving sustainability, such as instituting high water prices and letting the market "decide" how the water should be allocated, tend to bear a high health burden. Generally, however, better informed, more efficient, and less politically compromised efforts to improve health or sustainability create fewer trade-offs, and can even make the pursuit of these goals complementary.

2. WATER AND URBAN HEALTH

2.1 The Sanitary Movement, Water Science and Water Engineering

The sanitary movement was in many respects the environmental movement of the 19th century: it brought attention to hazardous side effects of urban development; it engaged public figures as well as scientists in debating unresolved scientific, political and moral issues; and it changed the course of urban development. Despite a lack of scientific consensus, and considerable pressure to do nothing to interfere with economic growth, a great deal was accomplished, especially in affluent cities. To some degree, problems were displaced rather than resolved. But a health transition was accomplished along the way, and the level of collective action achieved bodes well for the contemporary environmental agenda. On the other hand, this history also raises a difficult question for the environmental movement. Have the 'old fashioned' problems of water, local sanitation and health lost their prominent place on the environmental agenda because they are less important globally, because our environmental horizons have expanded, or because these 'old fashioned' environmental problems are no longer critical in the affluent parts of the world?

Most 19th century European cities were very unhealthy places to live. Mortality rates were far higher in the rapidly growing urban centres than in the surrounding countryside. In many cities mortality rates exceeded birth rates, and only rapid rural-urban migration allowed them to expand. The poor quality of the drinking water and the lack of wash-water must take at least part of the blame.

The Sanitary Movement and Broader Environmental Concerns

Looking back, it is easy to view the sanitary improvements of the 19th and early 20th century as feats of science and engineering, now perhaps rendered less glamorous by an awareness of their broader environmental inadequacies. At the time, one might argue, scientists were just discovering that the routes of disease transmission involved human waste and microbially contaminated water. When engineers devised means for cutting off many of these routes with piped water, water quality control, and sewerage systems, they had to rely on existing science. It was hardly surprising that they failed to consider the consequences of introducing water borne sewerage on, for example, nutrient cycles. Such sophistication had to await late 20th century environmentalism.

As indicated in the introduction above, this interpretation is seriously misleading. Partly because human waste was widely used as a fertiliser, a loss was quickly perceived when it no longer got to the fields (the intent of many of the water borne sewerage systems was originally to deposit waste on farmers' fields). The debates concerning sanitary improvement in the 19th century were as wide ranging as the environmental debates of today. And in any case, many of the major public health improvements were undertaken before the bacterial theory of disease was established, and scientific opinion on the relation between water and health was deeply divided. The theories that lost out in the course of scientific advance were often as supportive of sanitary improvement as those which won. For example, the once reputable scientific view that ill health was brought on by miasmas, a sort of air pollution that could disturb the balance of humours in one's body, was often used to justify efforts to improve sanitary conditions. Indeed, some historians have argued that miasma theory, with its holistic tendencies, provided more support for general cleanliness and the removal of filth, than the bacterial theories which tended to place the emphasis on particular pathogens (Rosen, 1993).

The Sanitary Movement and Public Debate

Furthermore, sanitary improvement in the 19th century was not the preserve of experts it was to become in the early 20th century. Just as in contemporary environmental debates, scientists were brought in by all sides, to justify both environmental intervention and *laissez faire*. And at the height of the public health movement, debates about water and health engaged not just scientists and engineers, but a whole panoply of public figures. Indeed, there was considerable popular interest in sanitary improvement. The General German Exhibition of Hygiene and Life Saving held in 1883 attracted 900,000 people to Berlin over the course of five months (Ladd, 1990). It was only later, when a conventional approach to water and sanitation had been established, that public interest in such events waned, and experts took over most of the key positions. As Hamlin notes, we are again entering a period of uncertainty about water, and must again learn to debate water issues in public (Hamlin, 1990). In this context, it is important to take the right lessons from the 19th century experience.

Ironically, one of the dangers of treating the sanitary revolution as a scientific and technical achievement is that, even as it exaggerates the importance of science in the past, it ascribes an unduly limited role to science in the future. This applies especially to the notion that an understanding of microbial disease transmission brought about the sanitary revolution, and more generally the epidemiological transition away from infectious diseases in the North. Such accounts not only overstate the significance of such scientific breakthroughs as John Snow's demonstration of the link between cholera and drinking water, but also mask the profound ignorance which remains regarding the transmission and evolution of water related diseases. Certainly a great deal has been learned, but not so as to provide any easy answers.

Sanitary Improvement as a Technical Fix

Once economic growth and a set of public health measures, including piped water and sewerage, were found to reduce the incidence of most water related diseases to comparatively insignificant levels, the motivation to understand them better fell drastically. Debates about which specific measures underpinned the epidemiological transition seemed academic when the whole package was clearly desirable. Moreover, as practitioners find in so many sectors, funding for environmental service utilities was easier to justify when uncertainties were ignored. Even some people working in the water sector came to believe that getting people clean drinking water was the key to reducing water borne diseases. More generally, piped water and articulated sewerage systems came to be viewed as the technical fix for the urban health disadvantage. For the greater part of this century, the accepted wisdom has been that the urban health-related goal in the water and sanitation field should be to provide every dwelling with piped water and a water closet, or the closest possible equivalent. Indeed this was very much the premise of the Water and Sanitation Decade (the 1980s), which had as its global target "to provide all people with water of safe quality and adequate quantity and basic sanitary facilities by 1990" in (World Health Organization, 1981, Annex 1, p. 52).

However, for many urban dwellers in the South, such technical fixes remain as elusive as ever. Public investment in capital intensive infrastructure is becoming less rather than more prevalent, and the private sector is unlikely to fill such a large and costly gap. With less costly systems, there is still enormous uncertainty surrounding the long-standing environmental health issues relating to water and sanitation. Once one leaves the areas where water comes out of indoor taps and faeces are flushed away with the press of a button, there is still the need for a holistic approach to environmental health issues involving water. There are numerous local externalities, which relate local water supplies with sanitation, insects, waste disposal and a host of community-level environmental problems (McGranahan et al., 1996). There is clearly a need for local collective action, articulated and supported both nationally and internationally. In short, there is a need for a new, less patrimonial, more sophisticated environmental health movement.

Urban Water and Modern Environmentalism

Northern environmentalists have recently managed to broaden international policy debates to include water and sustainability, introducing a number of complex and poorly understood challenges in the process. The Global Freshwater Assessment reflects this success. It is likely that today's theorising about sustainability will one day seem as quaint as the miasma theory of disease. Indeed, the notion that filth and impurity give off a miasma that can disturb the balance of humours in the human body is not so very different from the concern that cities disturb the water system and hence the balances of nature. Miasma theory helped underwrite an active holistic approach to sanitary improvement at a time when reductionist science was in danger of fostering inaction. Sustainability debates are hopefully providing much the same for broader environmental concerns. Unfortunately, however, they are in danger of further marginalising the environmental health concerns that spurred the urban based sanitary movement of the 19th century, despite the large numbers of people for whom these concerns are still central.

2.2 Water and Infectious Diseases

Overall, the situation regarding environment and health in disadvantaged neighbourhoods is not unlike the typical situation encountered in regard to the broader sustainability problems globally: it is far easier to make a long list of preventative steps which taken together would undoubtedly reduce the environmental health burdens considerably, than it is to demonstrate the importance of particular hazards and prioritise particular measures. Water is critical to the transmission of many diseases. In arguing for the importance of water, it is common to oversimplify its role, and overemphasise the significance of contaminated drinking water. Actually, the role of water in washing pathogens away from the path of potentially infected people is at least as important as its role in bringing pathogens to people. As a result, in areas where faecal-oral diseases are endemic, how much water people get, and how they use it, is probably more important than its quality.

There is still enormous uncertainty, however, concerning how faecal-oral diseases are most often transmitted, and which interventions are likely to make the most difference. Moreover, the accumulation, flow and quality of open freshwater is critical to the spread of malaria, dengue fever and a variety of other vector borne diseases. Here too, better quality water is not a sufficient remedy, and if pursued unthinkingly can even facilitate disease transmission. In combating water related diseases, it is possible to identify a few measures, such as hand-washing and applying oral rehydration therapy that are sufficiently general and important to advocate widely, but for the most part the simplest solutions come at a very high cost. Overall, while far more could be done on the basis of existing knowledge, a better understanding of these processes could still make an enormous difference.

Misleading Simplification

Consider the selection of quotes provided in Box 1. The message is simple, and seems to confirm what every world traveller experiences - bad water makes people ill, and there is a lot of bad water about. And yet water contamination is only one, perhaps quite small, aspect of water related disease transmission. The statistic of 80% probably derives from the enormous number of episodes of diarrhoea which are estimated to occur every year: about 4 billion in 1995 (World Health Organization, 1996, p. 24). While for someone unfamiliar with the nuances of health statistics this figure is very misleading, since an episode of diarrhoea is far less severe than most other disease episodes, diarrhoea is undoubtedly associated with a great deal of morbidity and mortality. Indeed, diarrhoea still competes with acute respiratory infection for the position of principal childhood killer. Thus the more serious concern is that most of these statements falsely suggest that these diseases are the result of water contamination.[3] In fact, water relates to disease in a wide variety of ways, with water contamination only one of many aspects.

[3] Despite these quotes, we have not been able to find any official WHO document ascribing 80% of diseases to water contamination.

Box 1. Misleading waterlines

"It has been estimated that as many as 80 percent of all diseases in the world are associated with unsafe water"
(Hofkes, E. H., (ed.) 1983. Small Community Water Supplies: Technology of Small Water Supply Systems in Developing Countries, p. 9)

"Clean drinking water is essential for our health: according to the World Health Organisation 80% of all diseases are caused by polluted water"
(Van der Veken, M. and Hernandez, I. 1988. Women, Technology and Development, p. 11)

"An estimated 80 per cent of all diseases and over one third of deaths in developing countries are caused by the consumption of contaminated water…"
(UNCED 1992, Agenda 21, paragraph 18.47)

"Eighty percent of all disease in developing countries is spread by consuming unsafe water"
(Platt, A. E. 1996. Infecting Ourselves: How Environmental and Social Disruptions Trigger Disease (Worldwatch Paper 129), p. 42)

"Let us not forget that about 80 percent of all diseases, and more than one third of all deaths in developing countries are caused by contaminated water"
(UNEP, News Release, World Water Day, 22 March 1996)

Water Related Transmission Routes for Infectious Diseases

Table 1 presents a classification of water related transmission routes. With the *water-borne* route, water brings the pathogens that people ingest to become infected - in such cases contaminated water really is the culprit. With the *water-washed* route, people become infected because water failed to carry the pathogens away - it is the absence of washing that is used to define the route. *Water-based* transmission refers to infections whose pathogens spend part of their life cycle in aquatic animals. Transmission via *water-related insect vectors* refers to diseases spread by insects that breed in or bite near water.

Table 1. Environmental classification of water-related infections (I), and the preventive strategies appropriate to each

Transmission route	Preventive Strategy
Water-borne	Improve quality of drinking water Prevent casual use of unprotected sources
Water-washed (or water-scarce)	Increase water quantity used Improve accessibility and reliability of domestic water supply Improve hygiene
Water-based	Reduce need for contact with infected water[a] Control snail population[a] Reduce contamination of surface waters[b]
Water-related insect vector	Improve surface water management Destroy breeding sites of insects Reduce need to visit breeding sites Use mosquito netting

[a] Applies to schistosomiasis only.

[b] The preventative strategies appropriate to the water-based worms depend on the precise life-cycle of each and this is the only general prescription that can be given.

Source: Cairncross, Sandy and Richard G. Feachem. *Environmental Health Engineering in the Tropics: An Introductory Text*. 2nd ed. Chichester: John Wiley & Sons, 1993.

Classifying Water Related Diseases

The relation between transmission routes and types of disease is far from perfect, although similar classifications have long been applied to water-related infections. What is presented in Table 1 is a variation of the classification developed by David Bradley in the early 1970s, upon which most current classifications are based (White et al., 1972). The original terminology distinguished water-borne, water-washed, water-based and water-related infections, often leading people to conflate the possibility that a disease may be borne by water with the much stronger claim that it is usually or always borne by water. In fact, the distinction between water-borne infections and water-washed infections has always been problematic, as Bradley has made very clear:

> *"All infections that can be spread from one person to another by way of water supplies may also be more directly transmitted from faeces to mouth or by way of dirty food. When this is the case, the infections may be reduced by the provision of more abundant or more accessible water of unimproved quality" (Bradley, 1980, p. 12).*

Unfortunately, as the quotes in Box 1 above clearly demonstrate, such qualifications are often neglected, with most cases of diarrhoea and dysentery ascribed to water contamination. The more recent text upon which Table 2 is based forgoes elegance to avoid this sort of misinterpretation, and combines the water borne and most water washed infections into the more illustrative class of "faecal-oral" infections.

Table 2. Environmental classification of water-related infections (II)

Category of Infection	Type of Infection
Faecal-oral (Water-washed or water borne)	Most diarrhoeas and dysenteries
Other Water-washed	Infectious skin diseases and louse-borne typhus
Water-based	Schistosomiasis, guinea worm, etc.
Water-related insect vector	Malaria, dengue fever, etc.

Source: Based upon Cairncross, Sandy and Richard G. Feachem. *Environmental Health Engineering in the Tropics: An Introductory Text*. 2nd ed. Chichester: John Wiley & Sons, 1993, where a far more complete listing of diseases can be found.

How Much Do We Know About the Transmission of Water Related Diseases?

The tendency to ignore the considerable uncertainty that still surrounds these infections and how they spread often creates the impression that expert opinion is vacillating. The following statement in the World Health Report 1996 illustrates this seeming instability:

> *"It was long thought that contaminated water supplies were the main source of pathogens causing diarrhoea but it has now been shown that food has been responsible for up to 70% of diarrheal episodes" (World Health Organization, 1996, p. 38).*

Unfortunately, such statements suggest that the remaining uncertainties are minimal, though with terms like "up to," any real commitment to accuracy is avoided.[4] In fact, the relative importance of the different routes *faecal-oral* diseases can take remains in large part a mystery (and need not always involve a *faecal-oral* route). Nor is this simply a matter of not knowing in sufficient detail what conditions are like in the more disadvantaged neighbourhoods. Conditions are sufficiently bad in most under-serviced neighbourhoods that any number of possible transmission rates could explain a high level of faecal-oral disease. Indeed, experts are often left wondering why the prevalence of faecal-oral diseases is not higher in many neighbourhoods (Drangert et al., 1996).

Flies play a potentially important but largely unknown role in the transmission of faecal-oral diseases (Chavasse et al., 1994). Faecal pathogens are known to flow via groundwater from pit latrines to nearby wells, but there is enormous uncertainty in how far is safe (Stenström, 1996). Numerous behavioural patterns can affect the likelihood that people, and especially children, will directly encounter faecal material and ingest it, but these are difficult to identify let alone prioritise (Boot and Cairncross, 1993; Cairncross and Kochar, 1994).

The paths of transmission which particular *faecal-oral* pathogens will actually favour depend on a variety of features, such as the infectious dose, persistence, and multiplicability in food (Mara, 1996), and some paths may to lead to people likely to be

[4] Although no source is given, it seems likely that the upper limit of 70% is from a WHO commissioned paper which estimated that "On the basis of the predicted impacts of controlling transmission associated with poor personal hygiene, and water supply and sanitation, food as a vehicle may contribute to the transmission of between 15 and 70% of all diarrhoea episodes. This range is so wide as to be of little value, but the available data do not permit more precise estimates" (Esrey et al., 1985).

immune. The measures which can be taken to prevent transmission also depend upon where the transmission takes place, and it can be important to distinguish between transmission within the domestic domain as opposed to transmission in the public domain (Cairncross et al., 1995). Moreover, people may engage in defensive behaviour when the hazards are perceptible, which itself changes the effects of certain hazards, and needs to be taken into account when designing policy responses (Alberini et al., 1996).

Water Quality Versus Water Quantity

Looking specifically at the alternatives of improving water quality or improving people's access to sufficient quantities of water as a means to reducing the transmission of diarrheal diseases, there is a good case to be made for claiming that too much attention is given to water quality (Cairncross, 1990). It is difficult to find clear epidemiological evidence distinguishing between the effects of improving water quality and providing better access to water, but while a number of studies have demonstrated the importance of providing more water to poor households, the evidence with respect to water quality is more ambiguous (Esrey and Habicht, 1986).

It has been suggested that one of the reasons many studies fail to find a significant association between improvements in water quality and diarrhoea prevalence, is that most contamination occurs in the home while tests for faecal contamination are typically made at the well or tap (Esrey and Habicht, 1986; Huttly, 1990; Lindskog and Lundqvist, 1989). Indeed, a number of studies have documented higher concentrations of faecal coliforms in household water containers than at their sources (Benneh et al., 1993; Lindskog and Lundqvist, 1989).

However, it is far from certain that contamination that occurs in and around the home is comparable to contamination from outside. A recent and influential study contends that "In-house contamination does not pose a serious risk of diarrhoea because family members would likely develop some level of immunity to pathogens commonly encountered in the household environment. Even when there is no such immunity, transmission of these pathogens via stored water may be inefficient relative to other household transmission routes, such as person-to-person contact or food contamination. A contaminated source poses much more of a risk since it may introduce new pathogens into the household" (VanDerslice and Briscoe, 1993, p. 1983). However, the empirical evidence in support of these claims is very limited, and the argument itself depends heavily on some behavioural assumptions one would expect to be culture dependent. If, for example, children play freely in the neighbourhood and drink in the homes of neighbours, then a sharp distinction between in-house and communal water contamination is not convincing (Pickering, 1985).

Most of the complications mentioned up to this point suggest that water quality receives too much attention relative to the role of water in washing away pathogens. Another generally ignored complication, the evolutionary implications of different water systems, suggests a rather different conclusion. In placing obstacles on some of the routes of disease transmission, not only is the rate of transmission altered, but so are the evolutionary pressures brought to bear on the pathogen. It has been argued that interrupting water-borne routes will put in motion evolutionary pressures towards less virulent strains of, for example, cholera (Ewald, 1994). To put it crudely, pathogens that rely more heavily on personal contact lose out if their hosts are immobilised, while those that are *water-borne* do not. Thus, so the argument goes, eliminating the water-borne route creates evolutionary advantages for strains that are not debilitating. Ewald derives estimates that suggest that taking account of evolutionary pressures would radically alter the benefits ascribed to water purification in Bangladesh, turning it from an uneconomic alternative to a measure costing one tenth as much per life saved as vaccination. Thus, rather than immunising the potential hosts, one would leave larger scope for less virulent pathogens, to the disadvantage of the more dangerous strains.

Another role water has to play in faecal-oral diseases lies in their treatment. Dehydration is usually the proximate cause of death in fatal cases of diarrhoea, and can often be treated with water and oral rehydration salts. Initially developed in Bangladesh, this simple measure has been heavily promoted by UNICEF, and it has been estimated that around half of diarrhoea cases are now treated with oral rehydration therapy (Bellamy, 1996).

Water and Insect Vectors

Other than faecal-oral diseases, the most important category of water related disease is the last: water related insect vector (see tables 1 and 2). Malaria, filariasis, yellow fever, and dengue fever are all classified as *water related diseases* because their vectors breed in water. Malaria alone kills an estimated 1-2 million people annually, and there are up to half a billion new cases every year, second only to diarrheal and respiratory infections (World Health Organization, 1996, p. 24). The role of water contamination in the transmission of these insect borne diseases is very ambiguous, however. Indeed, one of the reasons malaria is typically more prevalent in rural than in urban areas is that most malarial mosquitoes, like humans, prefer clean water. Urban water pollution can actually help protect residents from malaria, though some malarial species have found urban water niches. The mosquitoes which carry dengue haemorrhagic fever have generally been more successful in finding urban water niches, and often breed in household water containers. Such containers tend to be more common where water supplies are intermittent, but are only indirectly linked to water contamination.

Despite the complexity of these various water related diseases, in affluent cities they are only rarely a problem. While experts may debate exactly how and why this epidemiological transition takes place (Mosley et al., 1993; Smith and Lee, 1993), inadequate sanitation in the broad, 19th century sense is closely associated with poverty. Poverty alleviation would seem to be one of the most obvious means to achieve improvements in environmental health (Bradley et al., 1991). Indeed, one possible justification for leaving the issues of water, sanitation and health off the environmental agenda is that the solution is poverty alleviation and infrastructure provision, not environmental management. For a variety of reasons, however, such justification is weak at best.

2.3 Water, Poverty, Illness and the Need for Collective Action

Water, Sanitation and the New Environmental Agenda

Growing or new environmental problems command more attention than declining or endemic problems, for obvious reasons. One obvious reason is that declining and endemic problems seem to be 'under control,' while growing problems give the impression of 'getting out of hand.' A second obvious reason is that the articulate, powerful and wealthy have typically already managed to avoid the declining problems, but are often potentially at risk from the new and growing problems (often associated with increasing wealth). Both of these reasons help to explain the fact that the long-standing problems of water and health sit rather uneasily on the contemporary environmental agenda, which is still dominated by the concerns of the more affluent North.

Water and Sanitation Coverage and Expansion

While the long-standing problems of water and health affect a declining share of the urban population, they remain extremely severe, especially in lower income cities and neighbourhoods. It is of little consolation to those without to learn that others now have hygienic toilets and good water supplies. And given the numbers (and shares) involved, those without cannot be dismissed as an unfortunate aberration. In 1980, the United Nations General Assembly proclaimed the International Drinking Water and Supply Decade, with the aim to attain "safe water and sanitation for all by 1990" (World Health Organization, 1981, p. 1).[5] In the end of decade review, considerable progress was claimed, as indicated in Table 3, and numerous references were made to achieving water and sanitation for all by the end of the century.

However, the optimistic international statistics often seem to be at odds with local studies, and there are reasons to believe that such coverage figures exaggerate the progress to date (Satterthwaite, 1995). The international statistics are based on government estimates, with very little guidance given on what constitutes adequate water and sanitation. Such statistics, and especially their progression over time, are taken to reflect on government performance. Thus there is continuous, and often increasing, pressure to interpret 'adequate' liberally.

Table 3. Summary of urban water supply and sanitation coverage levels in developing countries: 1980 and 1990

	Urban Water Supply		Urban Sanitation	
	1980 %	1990 %	1980 %	1990 %
Africa	66	79	54	68
Americas	78	90	56	82
South-East Asia	64	73	30	50
Eastern Med.	83	91	57	79
Western Pacific	81	91	93	92
Total	75	85	60	74

Source: World Health Organization. 1992. *The International Drinking Water Supply and Sanitation Decade: End of Decade Review (as at December 1990).* CWS Series of Cooperative Action for the Decade. World Health Organization (Geneva).

Increasing Emphasis on Financial and Environmental Sustainability

In the wake of the Water and Sanitation Decade, the dominant approach and the goals of water and sanitary improvement changed (Serageldin, 1994). In the influential Dublin Statement of the International Conference on Water and the Environment of January, 1992, the target year for universal coverage for all was shifted back to 2015

[5] The Resolution 35/18 of the General Assembly of the United Nations actually only "*Proclaims* the period 1981 - 1990 as the International Drinking Water Supply and Sanitation Decade, during which Member States will assume a commitment to bring about a substantial improvement in the standards and levels of services in drinking water supply and sanitation by the year 1990" (World Health Organization, 1981, Annex 2, p. 56)

(ACC/ISGWR, 1992), and cost recovery was promoted more vigorously than service coverage. This reflects a more general shift in emphasis and approach. Both physically and organisationally, more emphasis is now put on sustainability. Physically, more attention is being paid to ensuring that ecological damages are taken into account. Organisationally, more attention is paid to ensuring that the water provision is financially viable. Improvements are sorely needed in both of these areas. On the other hand, it is important that more attention to ecology and finance does not mean less attention to health and environmental justice.

The current emphasis on financial sustainability in water provision has developed in tandem with a more market-oriented approach to service provision. The promotion of simple organisational approaches to water and sanitation provision has long proved as attractive as the promotion of simple accounts of how faecal-oral diseases spread. The notion that governments could simply plan their way to improved water and sanitation was clearly misguided. To some degree, recent advocacy of cost-recovery through user fees and private sector involvement is yet another enticingly simple prescription, that aims to correct some real flaws in existing practice, but will become pernicious if it is widely accepted and adopted as a new orthodoxy.

Shifting Responsibilities Between Public and Private Sectors

Last century, the notion that by freeing up markets one could provide the solution to water and sanitary problems would have seemed almost perverse. Markets were far more pervasive in the urban areas than in the more tradition bound countryside, and urban filth and high mortality rates were associated with the market-oriented cities. Experience with unregulated private action helped to justify the public health movement, and eventually the view that the government had to provide urban water and sanitary services. But just as market failures once helped to justify public control, more recent public failures have helped justify a shift back towards private sector solutions. Unfortunately, shifts back and forth along the public-private axis do not represent progress.

In both the public and private sectors there are serious problems creating and maintaining the right incentives with respect to water and sanitation. Efforts to promote one or the other sector often involve exaggerating the problems of the opposing sector and ignoring or arguing the problems in the favoured sector away. Thus, private sector proponents tend to ignore the fact that, especially in low income areas, water and sanitation involve a host of externalities and public goods problems. Similarly, public sector proponents have long ignored the fact that subsidies justified on public health grounds are often systematically diverted to wealthy households and neighbourhoods where public health risks are minimal.

Re-examining the Allure of Centralised Water and Sanitation Systems

The physical complexity in the relation between water and health, as summarised in the previous section, involves a series of environmental interrelations. These interrelations make it inappropriate to treat water and sanitation as normal, partible economic goods, which ought to be bought and sold in the same manner as, for example, bicycles or rice. If water is allowed to accumulate on someone's land and become a breeding ground for mosquitoes, it is not just the water user that is affected. If water is used to wash faecal material into a street-side gutter, it is not just the water user that is affected. And if water is not used to maintain hygiene and a child falls sick, the child's playmates are placed at risk. Where such practices are or could become common, water prices cannot provide sufficient signals on how and when water should be used. And these practices are potentially widespread in most deprived neighbourhoods without piped water and sanitation systems.

As well as being convenient for the careful user, one reason for the success of traditional piped water and water borne sewerage systems has been that, in the right circumstances, even the careless find it more trouble than it's worth to allow water to accumulate, flush sewage into a gutter, or generally engage in unhygienic practices that threaten public health. The piping itself severs many of the more hazardous environmental interconnections. The water leaves the piping only to enter the drains, often seconds after it emerged. At least in the technologies' centres of origin, all that is required of the user is a few norms which, once adopted, are easier to follow than to flout. To collect and store water in a bucket, and efficiently use small quantities of it, demand a far better understanding of the physical processes and the health risks involved than does running a modern household. Indeed, many environmental services such as piped water and sewerage connections not only displace pollution problems, but also shift both the intellectual and practical burdens of environmental management from the households to the government or utility company (McGranahan and Songsore, 1994).

Another attraction of piped water and sewerage has been that the resulting system is amenable to relatively tight, centralised control. Engineers can design the system, and a water utility can manage it. Technologically and environmentally, using water to carry away human waste has numerous serious drawbacks. But, being well designed for centralised control and management, the piped systems are in other ways a civil engineer's and a civil servant's dream.

Some Practical Obstacles to the Public Provision of Water and Sanitation in Deprived Areas

In a great number of urban areas, however, universal coverage with piped water and sewers is just that: a dream. In very low income settlements, it is simply unaffordable, for either residents or their governments. Moreover, centralised control, and the desire to retain it, can easily become a liability when public finance is inadequate, good governance is problematic, or the government simply does not respond to the needs of the currently unserved. Such conditions are all common, particularly when both public and private finance is very scarce. Often, the result is low priced services that the utility can not afford to extend. As a result, the subsidies which do exist often go to the wealthy who, even without the subsidy and given the alternative of having a poor service at a low cost, would choose pay the full economic cost for adequate services. Those people who would need subsidies to be convinced to pay for healthy water and sanitation often end up having to pay exorbitant prices for inadequate services. In a somewhat perverse manner, the fact that utilities are forced to charge low prices often precludes them from expanding their coverage, and those not connected end up paying market prices for artificially scarce water and sanitary facilities (McGranahan *et al.*, 1996; Serageldin, 1994).

Local Collective Action and Water and Sanitary Improvement

Given the problems getting either private enterprises and public utilities to provide suitable water and sanitary services to low income communities, it is tempting to look to NGOs and CBOs to provide the organisational solution. Indeed, many of the more sophisticated attempts to promote a market oriented approach to water and sanitation also emphasise the importance of local participation (Serageldin, 1994), which eventually must mean some form of local organisation. As described above, many water-related diseases involve spatially delimited public goods. Where such diseases are endemic, one's health depends very much on the water and sanitation practices of other member's of one's household and neighbourhood. The built facilities (e.g. wells, standpipes, latrines, condominial sewers) are often shared. If neither the public sector nor private enterprise can secure healthy local water supplies and sanitation, perhaps the responsibility should be given to the local communities and CBOs, working with the support of NGOs.

As long as the public sector is providing subsidised water and sanitation in wealthy areas, advocating unsubsidised participatory solutions in low income neighbourhoods is inequitable and probably inefficient. Indeed, however well the local communities managed to solve their water and sanitation problems, the economic signals would be perverse: subsidies where resource externalities predominate and economics indicates a need for taxes, and no subsidies where health externalities predominate and economics suggest subsidies are warranted. Moreover, there is a serious danger that attempts to roll back the state and support local initiatives, will succeed in the former and not in the latter, leaving already disadvantaged communities even worse off.

There are undoubtedly a number of good reasons to support local initiatives, and what could loosely be termed "community empowerment" for water and sanitary improvement. Indeed, the arguments for greater local participation and empowerment extend to other aspects of environmental management (Douglass, 1991; Douglass et al., 1994; Yacoob et al., 1994) and urban management generally (Abbott, 1996; Yeung and McGee, 1986). However, just as the abstract notions of the perfect market and the perfect planner should not be allowed to divert attention from uglier realities, so also the perfect community must not be idealised. Well organised, representative community organisations do not emerge from the complex terrain of local politics simply because planners state it should be so. Many of the more successful examples of community based initiatives have involved outside support (Hardoy and Hardoy, 1991; Hasan, 1990), including but not only from NGOs. In any case, one of the more important advantages that well organised communities have is an ability to go beyond local initiatives when necessary, and negotiate effectively with private sector and public sector actors.

Synergies Between the Public, Private and Voluntary Sectors

More generally, there is a growing recognition that when the activities of the state, the private sector and the voluntary sector can be made complementary, or even merged, considerable synergies result (Evans, 1996a; Evans, 1996b; Ostrom, 1996). Arguing over the advantages and disadvantages of plans, markets or voluntary organisations, may actually divert attention from the opportunities for achieving such synergies. Perhaps more attention needs to be paid to how the sectors interact, and to providing mutually supportive environments, and less to fighting for one sector over another. This sort of approach is at least implicit in the contemporary jargon of "enabling policies," "public-private partnerships" and the like. "Co-production" has been used to refer to the creation of goods with contributions from private and public sectors, and sanitary improvement has been cited as a good far more efficiently co-produced than produced within one sector alone (Ostrom, 1996). Thus for example, the condominial system (Mara, 1996) which has proved to be successful in spreading comparatively low cost sanitation in several cities of Brazil, works through combining the centralised provision of trunk lines with active local involvement in financing, maintaining and even designing the connections to people's homes (Briscoe, 1993).

There is no guarantee, however, that cross-sectoral partnerships will create positive synergies. For example, a situation where a public utility controls the low priced public water supply, but private vendors redistribute the scarce water, lends itself to a pernicious form of private-public partnership. Public sector employees may seek private gain through restricting water supplies and entering into partnerships with the private sector vendors to capture some of the rent (Lovei and Whittington, 1993). Indeed, many of the same circumstances which prevent the public sector from providing services to low income settlements (including governance problems, low public sector wages, public utility financing shortfalls, illegal land settlement, and politically powerless residents), also threaten the viability of public-private partnerships.

Poverty Alleviation as a Means of Environmental Health Improvement

Ultimately, poverty alleviation would seem to be the ideal means to solve water-related health problems in low income urban settlements. Certainly it is a solution that few would openly object to. And once people are clearly willing to pay for adequate water and sanitation themselves, there are numerous comparatively successful organisational models to choose from, involving varying degrees of public and private control. Moreover, many of the water-related health problems are compounded by other aspects of poverty, such as malnutrition. Why not concentrate efforts on creating better economic opportunities, and let people buy their way out of the environmental poverty?

Unfortunately, economic development cannot be relied on to eliminate poverty any more than it can be relied on to solve environmental problems directly. Indeed, poverty, like environmental degradation, is a symptom of unbalanced economic development rather than a technical incapacity. The poor do not lack healthy water systems only because they cannot afford them, but also because they lack the local political space to organise, and the political leverage to make the public sector respond to their needs. Moreover, illness is not just a result of poverty, it contributes to poverty. In any case, it is precisely because neither free markets nor central planning readily address the problems of water, sanitation and ill health, that so much more needs to be done. Were it simply a question of getting prices right or designing the right technical interventions, water and sanitation would not be a serious problem in the first place. Giving up because there is no straightforward solution is entirely inappropriate.

Despite all the complexities and obstacles to improvement, better water and sanitation has been and will probably continue to be one of the more tractable problems which beset low income neighbourhoods. There is still a great deal for both experts and residents to learn about water-related illness. If a concerted effort is made to create and share such knowledge, health should improve considerably. In a great many cities, the organisational approach to water and sanitary improvement could be greatly improved.

It may be difficult to generalise about what an improved organisation would look like (except perhaps to make the obvious point that it must tap local collective initiative, as well as governmental and private sector enterprise). But that does not mean that improvements are difficult to devise. Indeed, the misguided search for simple and replicable solutions has itself helped ensure that there are still many opportunities for locally tailored improvements. Moreover, while problems of politics and governance undoubtedly plague efforts to improve water-related health problems, water and sanitation improvement is far less politically contentious than most other avenues for empowering low income residents.

Overall, water-related health problems are closely correlated with, but not reducible to poverty. These health problems also persist because they remain poorly understood, the appropriate institutions to address them are lacking, the political as well as economic demands of those affected are often ineffectual, and, when capital intensive solutions are absent, the physical characteristics of water related disease transmission creates a range of externalities and public goods problems. There are a number of relatively simple measures which deserve continued promotion: among residents this could include oral rehydration therapy and more handwashing; among public utilities this could include removing water subsidies to relatively affluent consumers and minimising connection costs in low income areas. But there is also a need for a more holistic approach to urban water and health, through which progress could be made on numerous fronts simultaneously. To some extent, water related health issues are already on the contemporary environmental agenda: they appeared quite prominently in Agenda 21, for example. By and large, however, in the more formal arenas water-related health problems in low income areas are perceived as a residual problem, that do not involve the complexity and uncertainty, or the institutional challenge of the new sustainability issues. This perception is incorrect.

3. WATER AND URBAN SUSTAINABILITY

3.1 Urban growth

Global urbanisation has been one of the defining features of this century, and as we move into the next century close to half of the world's residents are urbanites. A sharp distinction between urban and rural settlement has become increasingly inappropriate. Blaming urbanisation for burdens which just happen to originate in urban areas is even less appropriate. Nevertheless, for water, as for other resources, urban growth is a critical parameter, and the unprecedented urban growth of the twentieth century is a matter of some concern. At very least, this growth has helped define the water challenge of the 21st century.

Urban Growth and the Industrial Revolution

Before the 19th century the level of urbanisation had remained at just below 10% for several hundred years (Bairoch, 1988). The percentage of population living in urban areas in Europe and the Americas was around 75% in 1994 (United Nations, 1995). Urban growth and higher levels of urbanisation started with industrialisation in Europe and the Americas, closely tracking economic growth until the Second World War, by which point the initial urban transition was largely complete in much of Europe and

North America. The slowdown in urbanisation rates may reflect a natural tendency for share variables to change more rapidly in the middle of a transition (the point of inflexion) than towards the end, when the upper limit (theoretically 100%) is being approached. Or, it may reflect a change of attitude toward the city, to which the new trend toward deurbanisation in some countries, for example in the United States, can be attributed.

Technological change favouring urban activities is still the most obvious explanation for contemporary urbanisation, as it was in the past (Williamson, 1988). The rural-urban divide in wealth, wages and access to services remains significant. Migrants generally do better economically by moving to an urban area. As during the European urban transition, there has been a great deal of concern about over-urbanisation. Efforts to curb urban growth have been notably unsuccessful, however, and using over-urbanisation as an excuse for not dealing with urban problems has been counterproductive (Swedish International Development Cooperation Agency (SIDA), 1995).

Overall, the urban growth rates in Third World countries have been spectacularly high: 4% per year in 1950-1955; over 5% in 1955-1960; and between 3.5 and 4% up to the 1990s. For cities such as Lagos, Nigeria, and Dhaka, Bangladesh, average annual growth is still beyond 5% (United Nations, 1995). Starting from already high numbers, this involves some 400,000 more people in each of these cities every year.

In addition to unbalanced technical change, much of the urban ‘explosion’ in Third World countries derives from high overall population growth, coinciding with the middle of the urban transition. Infant mortality rates have fallen quickly (from above 200 per 1000 births to around 100) over a few decades in the middle of this century. This process took over a hundred years in the now “developed” world, where it also took a hundred years for birth rates to respond to declining death rates (Bairoch, 1988). However, in the Third World today, there is also a tendency toward declining birth rates. Urban growth rates are also declining, even in Africa, the least urbanised but most rapidly urbanising continent, with a 1990-1995 rate of 4.4%, expected to become closer to 3% by 2020 (United Nations, 1995).

Urban Growth and Shortfalls in Infrastructure

With the current world urban population growth of 2.5%, there is an addition of over 60 million urban dwellers each year (United Nations, 1995). Most of this growth is occurring in poor regions that have the least means for providing infrastructure and acceptable housing. Even though shantytowns may have been around for as long as cities have, their prevalence can be spurred by rapid urban growth. A United Nations World Housing Survey of sixty-seven large cities in the 1970s concluded that the average proportion of the population living in shantytowns was 44% (Bairoch, 1988). In spite of problems with definitions and fragmentary data it is clear that too many urban dwellers today live with substandard housing conditions.

High urban growth *in combination* with poor economic development can create enormous problems, but problems with poor housing should not be automatically attributed to urban growth, as pointed out by Hardoy and Satterthwaite (1990):

> *"Since 1900, the population of the Los Angeles - Long Beach urban agglomeration has grown more rapidly than that of metropolitan Calcutta. Today, both have close to 10 million inhabitants. But no one would suggest that the scale and nature of housing problems in the two centres is comparable" (p. 101).*

More and Larger Cities

Apart from unprecedented urban growth during this century, there has also been an appreciable rise in the upper limit on city size and a marked increase in the number of very great cities. In 1950, only New York and London had a population of 8 million or more (defined by the United Nations as 'mega-cities'), but two decades later 11 cities had become mega-cities (United Nations, 1995). Many excessively spectacular projections about future proliferation and size of mega-cities have been made, and are now being scaled down. Hardoy and Satterthwaite (1990) provide an example: "Mexico City's projected population for 2000 was 31.6 million in the [United Nations] Population Division's 1973-5 assessment but down to 25.8 million in the 1984-5 assessment" (p. 99). In The 1994 Revision of World Urbanization Prospects, Mexico City's size in the year 2000 is estimated at 16.4 million (United Nations, 1995). Of course, while 16 million only represents half of the estimate provided in the 1970s, it is still an awesome size.

Table 4. Urban population and city size, 1990

Size Class	Number of Cities/ Agglomerations	Percentage of Urban Population
> 10 million	12	7%
5-10 million	21	7%
1-5 million	249	21%
.5-1 million	295	9%
< 500,000	?	56%

Source: *World Urbanization Prospects: The 1994 Revision: Estimates and Projections of Urban and Rural Populations and of Urban Agglomerations*. United Nations. 1995.

Table 4 above shows that close to 14% of the urban population in 1990 lived in cities of more than 5 million people. However, over 50% of the urbanites lived in urban centres of less than half a million people. As regards environmental problems, there is no reason to believe that these will be less prevalent in smaller cities, particularly if one admits inadequate household water and sanitation to be environmental problems (McGranahan and Songsore, 1994). In most Third World nations, smaller urban centres are likely to have a much lower proportion of their populations served by piped water and sewage systems, and even less effective pollution control and land use planning, than larger cities. Furthermore, it does not require a heavy concentration of industry to bring about serious pollution problems in a small locality (Hardoy et al., 1992).

The Regional Resource Burden of Large Cities

Large urban agglomerations do create special challenges for achieving sustainable urban living. With the sheer size of the city, its capacity for generating its own resources diminishes, and water and other resources may have to be drawn from far away. Low density urban sprawl can be especially wasteful in terms of land use, and augments infrastructure costs as well as energy use and air pollution. Water supply systems become increasingly large and complex, in particular where metropolises are created out of smaller cities with originally independent water systems. And the larger the city, the larger the total generation of waste and pollution - all the more difficult for the local ecosystem to absorb.

While the increasing size of cities may further cement the urban linear material flows, to determine the environmentally most appropriate size of a city is as fruitless as attempting to pinpoint the economically ideal city size. A city's ability to grow in harmony with the surrounding ecosystem depends on the natural setting of that particular city. More generally, it is primarily the wasteful practices of the urban-industrial age that strain the world's resources, and not urbanisation in itself. With existing technologies and institutions, it can be easier to collect and treat wastes carefully when people and activities are concentrated in urban centres. Thus, the total impact on the environment might be less in a city than if the same people were dispersed throughout the countryside (with the same consumptive life-styles). However, existing urban development patterns should not be defended on the grounds that existing patterns of rural development are equally burdensome. It is necessary to address the urban deficiencies directly.

3.2 Displacing the Burden.

Cities and their citizens cannot sustain themselves by drawing only on the resources within the city boundaries, and with increasing water use, sources further and further afield are often tapped. Similarly, the wastes cannot be absorbed within the city, but are displaced to the surrounding ecosystem. In the quest for new clean water and ways of disposing wastes, cities may appropriate both historical and spatial hinterlands, and through over-exploitation or pollution, undermine ecosystems and people's livelihoods far away in space and into the future. The capacity to displace environmental burdens increases with wealth and the development of centralised water supply and sanitary systems. In poor neighbourhoods, inadequate access to water and sanitation has primarily local effects, while integrated urban infrastructure allows better off segments of the population to draw on a larger resource base, protect themselves from exposure, and displace hazardous or unpleasant pollutants. Middle-income mega-cities often have particularly severe impacts on the regional ecosystem, but the wealthier, often much cleaner, cities in the 'North,' may still impose an enormous 'ecological footprint' on global hinterlands. As the environmental transition becomes 'complete,' many of the effects become globalised, contributing for example to climate change, which may alter hydrological cycles differentially across the world. As problems of insufficient water quantities and water pollution are transferred from the local to the broader environment, the challenge shifts from one of maintaining human health to one of preserving the integrity of life support systems for future generations.

The Invisibility of Linear Material Flows

Circular material flows cannot be kept within the confines of a city, where most of the ground is paved and food production can only take place on a very limited scale. Circular flows extending beyond the bounds of the city are more feasible, but not at all characteristic of existing urban development patterns. The risks associated with linear flows are rarely immediately evident, however. Indeed, the material flows characterising cities of the post-industrial era are to a large extent invisible to the cities' inhabitants. The overuse of resources and overloading of waste sinks often take place at a considerable distance from the city, and even there, may not become evident until a number of irreversible ecosystem damages have occurred. Many of the most resource and waste intensive cities are superficially getting cleaner.

Compounding this visibility problem, tracking the physical pathways of environmental impacts provides at best a partial picture of the environmental effects of a given urban demand. Markets and other mediating institutions also determine the resource repercussions of a given change in demand. In one set of circumstances, for example, by reducing demands being met by a local reservoir it may be possible to reduce pressure on distant water bodies. Thus, if there is an overall decline in demand, the reductions may occur at the more costly and distant sources. In another set of circumstances, efforts to reduce the demand on local sources may shift demand, rather than savings, to the more distant sources. Thus, if overall demand remains constant, savings from local sources may be compensated by increased consumption of the more distant sources. What scenario actually applies depends in part on the physical characteristics of the water system, but even more on the institutional context.

Urban Encroachment on Life Support Systems

Most of today's cities are located on prime agricultural land or near valuable ecosystems, so even though the estimated land surface dedicated to urban uses is only 1% of the Earth's total surface (World Resources Institute, 1996, p. 58), urban expansion affects the Earth's most productive ecosystems. Such losses are serious in nations with limited arable land. Urban expansion also threatens marine and lacustrine ecosystems: 42% of the world's cities with more than one million inhabitants are located along coastlines (World Resources Institute, 1996, p. 61), and many of them have been experiencing unprecedented growth. There are strong economic pressures to develop coastal areas, because of the attraction of shoreline locations, and coastal wetlands have been a particular locus of conversion. Apart from land conversion, nearby urban markets may induce over-exploitation of certain fish stocks or other resources, as well as outright destruction of natural habitats.[6]

Cities interact with their hinterlands (and hinterlands interact with their cities - their markets) in a number of ways - many of them highly complementary. However, while natural resources tend to be drawn in to the city, the flow of 'wastes' tend to lead *from* the city along different pathways and towards destinations far from their sources. Water, being a major metabolic medium of the urban system, with 60 to 100 times the rate of

[6] The draining or filling of marshes is often viewed as beneficial since wetlands may be breeding places for disease vectors such as malaria mosquitoes. Indeed, the elimination of wetlands an important part of many environmental health strategies. The WHO/UNEP Community Action Program kit for *Insect and rodent control through environmental management* guides action: "In the community: Drain or fill marshes, swamps, puddles, etc." (World Health Organization and United Nations Environment Programme, 1991). This is expressed less bluntly in Kerr (1990): "The draining and filling in of swamps and marshes may be necessary if they are the source of malaria-carrying mosquitoes" (p. 43).

the flow of fuel (White, 1994, p, 125),[7] is an extremely effective means of environmental displacement, but one which virtually precludes the recirculation of, for example, nutrients.

The History of Using Water to Displace Environmental Problems

Cities have a long tradition of using rivers, lakes and coastal waters as receptacles for diluting and dispersing wastes. The river Aire, flowing through Leeds in England, was described in the 1840s as follows:

> *"It was full of refuse from water closets, cesspools, privies, common drains, dung-hill drainings, infirmary refuse, wastes from slaughter houses, chemical soap, gas, dye-houses, and manufactures, coloured by blue and black dye, pig manure, old urine wash; there were dead animals, vegetable substances and occasionally a decomposed human body" (Cited in Wohl, 1983, p. 235).*

The introduction of water-borne sewerage systems, whereby increasingly large quantities of sewage were poured into water bodies, initially without any type of treatment, tended to increase the problems of surface water pollution. At the end of the 19th century, some fifty years after London had embarked on its great sewerage scheme, the Bazalgette's sewers were daily pouring close to 700 thousand cubic meters of sewage into the river Thames, constituting about one-sixth of the total volume of the river water. The seeming lack of concern for river pollution may be attributed to the larger concern for the still very high death rates in most Northern cities in those times. This is illustrated by a statement in 1898 by Edwin Chadwick, perhaps the most famous sanitary reformer:

> *"Admitting the expediency of avoiding the pollution, it is nevertheless proved to be of almost inappreciable magnitude in comparison with the ill-health occasioned by the constant retention of pollution [i.e. excrement] in the most densely-peopled districts" (Wohl, 1983, p. 239).*

This view was supported by the fact that with the extension of the sewerage system, death rates *were* declining, in spite of the increased river pollution. Still, the problems of river pollution were debated, and during the last decades of the past century "a conviction gradually developed in [the British] Parliament and among sanitary and environmental reformers that the prevention of river pollution should be . . . 'an indispensable requisite of every system of sewage disposal which can lay claim to efficiency'" (Wohl, 1983, p. 243).[8]

The awareness of the need to protect the ambient water quality was not generated by concerns for the health of the public, but for the threats severe pollution imposed on the life support systems of the cities. The minutes of evidence of the Royal

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[7] The metabolism metaphor has been used to describe cities as parasites which damage their 'host' - the environment (Douglas, 1983; Girardet, 1992). The concept, a variation to an input - output model where resources, through activities, are turned to residuals, can give guidance towards enhancing the complementarity of the city and its host, making the relationship more symbiotic and less parasitic.

[8] Girardet (1990) notes that while London's sewage problem was solved by building an extensive drainage system, to keep Britain's farm land fertile, guano (bird droppings) were shipped over the Atlantic from Chile.

Commission on the Prevention of River Pollution from 1866, are full of complaints from professional and amateur fishermen that their livelihood or sport was endangered. To impose controls of pollution in those times, as today, raised serious concerns that it might lead to severe economic dislocation. Some steps were taken to form river boards, placing river pollution control in other hands than those of local bodies, but legislation was ineffective, giving precedence to industrial interests over those of public health and conservation (Wohl, 1983). National legislation, accepted standards of water quality, and larger scale sewage treatment would not be implemented until the next century, and the quality of the Thames' water would not be substantially improved until the 1970s.

The Role of Centralised Systems in Displacement

If each household or neighbourhood has to deal with its own human waste problems, the faecal material is unlikely to travel very far (except if there is a convenient stream or river). Faecal pollution burdens are commonly displaced from the home environment through water closets and articulated waterborne sewerage systems, and from the city environment through the lengthening of sewage outfalls or disposing of sewage sludge into the sea or landfills, or to the atmosphere through incineration. Similarly, localised water scarcity within the city may be displaced through the extension of piped water supply systems. As the central authority assumes the responsibility for providing all citizens with adequate amounts of water, to 'fill the pipes' may entail importing water from faraway systems. While dam construction and water diversions allow urban expansion and stable water use with less regard to hydrological fluctuations, river flows are reduced, and water shortages (or pollution burdens) are transferred to downstream riverine habitats.

Where the extension of the centralised systems is limited, so too is the displacement. In many low and middle income cities, public water and sewerage systems only serve the more affluent segments of the population, and hence, in many poor neighbourhoods, pollution burdens as well as water scarcity are retained locally.

Localised Urban Water Scarcities

Localised water scarcity is problematic in many squatter areas and other localities where groups of people are excluded from the use of public water systems, and lack the means to develop private facilities. For example, low income areas in Nairobi, Kenya, consume some 35 percent of the domestic supply, but account for almost two thirds of the population. The city's per capita consumption is about 90 litres per day, but only 20 litres per day in low income areas (and over 200 litres in high income areas) (Lamba, 1994). In the case of Guayaquil, Ecuador, the average production and supply capacity of the existing facilities would allow each inhabitant an average daily consumption of 220 litres, but daily consumption ranges from an average of 307 litres per inhabitant in the well-to-do parts of the city to less than 25 litres for those supplied by private water sellers (Swyngedouw, 1995).

While the differences in consumption levels often vary between different geographical areas, reflecting the 'limit' of the piped network, public, private and 'natural' systems can work alongside each other, but still without relieving the poor of their water problems. In Jakarta, where less than 20% of the households have piped water, most households use wells as their main drinking water source, and over 20% buy drinking water from vendors (Surjadi et al., 1994). However, the quality of the groundwater differs across the city, and in some areas high salinity makes this water unfit for drinking.[9] Wealthy households in these areas are more frequently connected to the piped public water supply, while the poor usually buy their drinking water from vendors. Hence, a majority of the richer households will pay the lower official price, while most of the poor pay a ten times higher price per litre from ambulating vendors.[10]

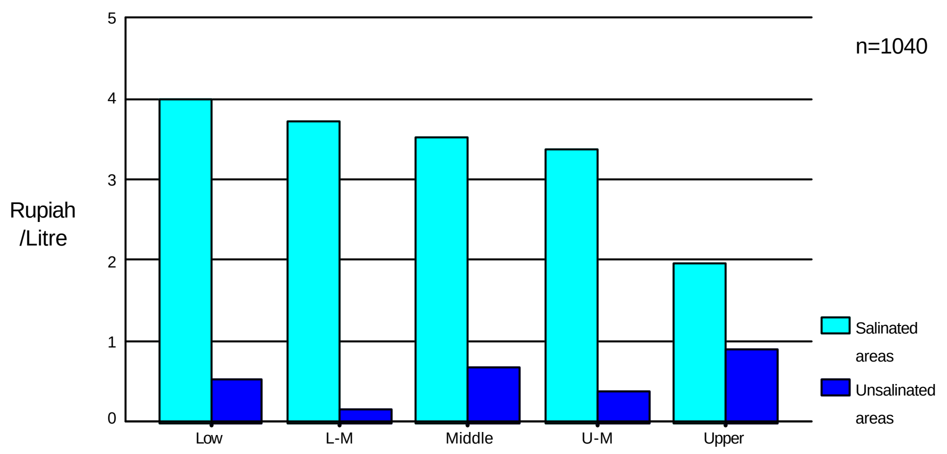

Figure 1. Average price paid per litre of drinking water in Jakarta, by geographical features and wealth quintiles.

Data source: Stockholm Environment Institute and Atma Jaya Catholic University, Household Environment Database, 1991/92.

Note 1: The survey was undertaken in Jakarta DKI. Note 2: The five wealth groups, of roughly equal size, relate to a wealth index based on the households' tenure of consumer durables. Note 3: Mineral water users are excluded. Note 4: At the time of the survey there were approximately 2,000 Rupiah to one US Dollar. The average price of from water vendors was 5 Rupiah per litre, while the litre price from PAM (Jakarta's municipal water authority) for a household consuming fifteen cubic meters a month was about half a Rupiah.

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[9] The high salinity in large parts of Jakarta is often cited as an example of salt water intrusion due to overuse of the aquifer. However, water in these parts of Jakarta may have been brackish for thousands of years, and salinity (except in very limited areas) should not be attributed to abstraction (Rismianto and Mak, 1993). Both piped and well water in Jakarta is heavily contaminated with faecal material, and virtually everyone, except a minority using bottled water, boil their water before drinking. This is clearly anthropogenic pollution, but has also been a problem for centuries (Abeyasekere, 1987). On the other hand, chemical pollution is also widespread, at least in the groundwater, and is a more recent problem.

[10] The high vendor prices in Jakarta are often attributed to imperfect competition. To overcome that, an aggressive standpipe investment program to reduce the distances between neighbourhood taps was implemented in the late 1980s and early 1990s, and the municipal water enterprise permitted all households with a metered connection to resell water starting in April 1990. There are indications of some benefits derived from the deregulation (Crane, 1992; Lovei and Whittington, 1991; Lovei and Whittington, 1993), but vendor prices have remained high. This can be attributed to lack of information to households about the legality of reselling water (which may still make very little difference to the actors on the informal water markets), or, that the price of the resold water actually reflects a high scarcity value, indicating that the major problem is the insufficient quantities of water of acceptable quality available in large parts of Jakarta.

The average prices paid by different wealth groups in different geographical areas are summarised in Figure 1. Poor households in saline areas pay on average almost 4 Rupiah per litre, while the richest households in saline areas on average only pay 2 Rupiah per litre. In areas with “potable” groundwater, however, the poor can resort to well water which is not paid for, and hence pay less than the average richer person, who still is more likely to have a piped water connection and pay the official price for water (Kjellén *et al*., 1996). These price differentials reflect the fact that the urban poor are more dependent upon the residual natural water resources of their own localities, while the wealthy have come to depend upon a man-made system that spreads the burdens over a far broader area.

The situation in Jakarta reflects a somewhat extreme example of a common tendency for the poor to rely on “secondary” water markets for drinking water, being unable to access the municipal water distribution system directly. That in many parts of the world the poorest segments of the urban population suffer from chronic water scarcity does not just reflect their lack of market “command.” There is ample proof that poor city dwellers often pay more per litre of drinking water than the richer urbanites (Bhatia and Falkenmark, 1993; Kjellén *et al.*, 1996; Swyngedouw, 1995; World Bank, 1988). Often, the principal difficulty is to get a water connection, not to pay for the water.

From Health to Sustainability Concerns

Poor sanitary environments take their toll on health rather than on the ecological foundations of the city. Faecal-oral diseases are endemic in densely populated settlements that lack adequate water supply and sanitation. In better serviced neighbourhoods, ample amounts of wash-water help reduce transmission, and pathogens, most of them in human excreta, are flushed away through a public sewerage system. Where treatment is lacking, pathogens may well appear in ambient waterways, but are less likely to be encountered, especially by households from the polluting areas. In some cases polluted ambient water is ingested, directly or by eating seafood, especially uncooked ‘filter-feeders.’ There may also be adverse health effects where wastewaters are used for irrigating crops. However, the main impact of urban sewage is on the health of aquatic life, and not public health.

The release of pollutants from urban areas threatens ecosystem integrity in numerous ways. Alterations in the levels of dissolved oxygen and nutrients, salinity and acidity change the environmental conditions to which the aquatic life are acclimated to. While it is difficult to identify and assess specific causal relationships that threaten biotic communities, species are lost to extinction, and impoverishment of biotic diversity can lead to less stable and less productive habitats (Covich, 1993). Adverse ecological effects may also affect economic productivity in the short run.

An Extreme Example of the Displacement of Water Burdens

Mexico City has evolved as a mega-city in a water scarce region essentially through the ‘successful’ displacement of both water pollution and water shortage, see Box 2. The mining of groundwater and large water transfers allow a per capita use of over 300 litres per day, sustaining forty-five percent of the country’s industry and serving ninety-four percent of the city’s population of over 15 million people (Joint Academies Committee on the Mexico City Water Supply, 1995). The alteration of the natural hydrological system was a prerequisite to the city's expansion. The Valley of Mexico, originally a closed basin, was artificially opened in the 1700s in order to control flooding. This has also enabled Mexico City to remove its effluents out of the basin. Without this, or some alternative form of displacement, Mexico City's aquifer would have been destroyed by pollution long ago. Still, poverty prevails, and the city has yet to supply all its people with water: 6% of the population - almost a million people - have neither household connections nor neighbourhood standpipes. These are likely to suffer from water scarcity, facing greater health risks, but imposing less of a water resource burden. And even among the connected households, average water consumption levels are far less than those of Mexico's Northerly neighbours.

Box 2. Mexico City - the epitome of environmental displacement

In the time of the Aztecs, the city of Tenochtitlán was the centre of a large empire that already depended on imported resources, mostly agricultural products appropriated from subordinated groups in other areas. But the water supply system relied only on the immediate surroundings, with aqueducts bringing spring water onto the urbanised island in the saline Lake Texcoco. The valley's drainage used to enter the lake system, and the Aztecs had constructed earth dikes to control flooding and to separate fresh water lakes from brackish ones. In the place of ancient Tenochtitlán is now Mexico City, which has gradually overtaken most of the former lakebeds, progressively drained since colonial times, and some hillsides, contributing to soil erosion and increases in flash floods.

Mexico City relied mostly on spring water until the mid-1850s, when the discovery of potable ground water under artesian pressure was followed by a well-drilling surge. Over time, pressure has been lost and many natural springs dried up.*⁾ With the realisation that groundwater supplies were being depleted, construction of an aqueduct to import water from a neighbouring basin was initiated in the 1940s. Today, a quarter of Mexico City's water, or around 16 cubic metres per second, is imported from the Lerma and Cutzamala basins. The total extraction from Mexico City's aquifer is over 55 cubic metres per second (of which 42 are used for the city, and the rest for agriculture).

Groundwater abstraction and artificial drainage of the valley have led to land subsidence, which over the last 100 years has lowered the central part of the city by an average of 7.5 metres. This exacerbates flood problems and in order to confine storm water, dikes have had to be built and pumping has been required to lift drainage water that used to flow by gravity. Because subsidence rates vary, many structures (including sewers) have been weakened, and some buildings lean dangerously, a phenomenon which is made more serious by frequent seismic activity. Since the 1950s, when many wells in the city centre were closed, the subsidence rate in the central area has stabilised at around 6 cm/year, but in other areas sinking velocity can be up to 40 cm/year.

Mexico City's effluents are carried by the General Drainage System and out of the basin through tunnels at the North end of the valley. The dry weather flow is estimated at 44 cubic meters per second, consisting mainly of untreated municipal wastewater. Some 10% of the wastewater is treated, not out of concern for the receiving water courses, but to enable reuse within Mexico City. The treated water is re-used for landscape and agricultural irrigation, groundwater recharge, industrial as well as recreational purposes, but the sewage sludge is returned to the sewer system.

The environmental and economic burdens of Mexico City's unsustainable water use are only to a limited extent being borne within its boundaries. Water revenues collected in the city account for less than 10% of the government's expenditure for providing the water. Pollution, while also damaging local irrigation and causing algal bloom in Lake Texcoco, is mostly displaced to the Tula Basin (contributing to the spread of parasitic diseases through wastewater irrigation) and eventually to the Mexican Gulf. Chronic water shortages are in great part transferred to the Lerma and Cutzamala basins, from which water is imported. The tapping of groundwater beyond its rate of renewal is a way of appropriating "historical" hinterlands and displacing water shortages to future generations (though it is already hitting back at the city though land subsidence).

Sources: 1) Anton, D. J. 1993. *Thirsty Cities: Urban Environments and Water Supply in Latin America*. Ottawa, International Development Research Centre. 2) Ezcurra, E. and Mazari-Hiriart, M. 1996. Are megacities viable? A cautionary tale from Mexico city. *Environment.* 38(1):6-15, 26-35. 3) Joint Academies Committee on the Mexico City Water Supply. 1995. *Mexico City's Water Supply: Improving the Outlook for Sustainability*. Washington, DC, National Academy Press.

*) The rate of recharge is difficult to measure, but declining water levels demonstrate that more water is leaving the system than entering. Overdrafting of the aquifer, whose water table declines one metre per annum, has been occurring at least since the early 1900s. Artificial recharge of the aquifer has been practised since the 1940s, but rather as a means to alleviate flooding than to counteract over-exploitation

Wealth Creation and the Appropriation of Hinterlands

Because of their ability to innovate, humans are not bound by a 'carrying capacity' defined by existing technology. However, a major component of humankind's 'ingenuity' has been to draw on an increasingly extensive resource base, and displace waste to increasingly distant locations or diffuse it more broadly. In other words: "From the beginning of the European empires of the sixteenth century to the industrial empires of the present, the richer people in the richer countries have appropriated *global* hinterlands to meet the needs of their increasingly urban citizens" (White, 1994, p. 57). These developments have accelerated during the last fifty years. As put by Rees (1992), "…the five-fold increase in the scale of human economic activity in the post-war period has begun to induce ecological change on a global scale which simply cannot be ignored in planning for human settlements" (p. 122). Larger cities' pull on resources, in these days through trade, may be one of the major historical changes happening to planet Earth. The urban-industrial society is displacing resources such as soil nutrients or fossil carbon into the sea and to the atmosphere, and mixing some of the more hazardous wastes into toxic 'cocktails.'

Empirical Observations on Pollution and Affluence

Multi-national studies support the view that city-wide pollution problems increase initially with economic development (as more pollution is generated and also displaced from the home and community), but subsequently decrease with further economic wealth (Grossman and Krueger, 1995; Shafik, 1995). The level of dissolved oxygen in rivers tended to decrease in the worst off rivers in low-income countries in the 1980s. In China, only five of fifteen river stretches near large cities sampled by UNEP's Global Environmental Monitoring System in the mid-1980s were capable of supporting fish. During the same period the level of dissolved oxygen increased in the cleanest rivers in high-income countries (World Bank, 1992).[11] Phosphorous levels have declined markedly in many Western European rivers from the end of the 1970s, primarily because of intensified wastewater treatment, but also the substitution of phosphorous in detergents (Stanners and Bourdeau, 1995). Wealthier cities tend to have more stringent environmental legislation and the institutional means to ensure compliance, as well as more resources to spend on environmental quality. But even in the richer North, river pollution problems are frequently 'displaced' rather than 'solved.' Sometimes sewage outfalls are only extended in order to avoid local pollution effects, and even where wastewaters are treated, the sewage sludge may be dumped at sea.

A Clean City with a History of Pollution

The cleanest cities of our times are among the wealthiest, with good quality water supplied to both industry and households and most effluents treated in order not to foul the local or the regional environment. In these cities the epidemiological transition away from water-related infectious diseases has been virtually completed, and persistent

[11] Wastewaters containing nitrates, phosphates, or other nutrients produce a radical increase in plant growth, of which a large proportion falls to the seafloor to decompose, in receiving waters. The increased volume of organic matter quickly depletes the dissolved oxygen from bottom waters, and threaten fish reproduction. Ironically, while rivers and coastal waters are continuously fertilised through effluents containing phosphates and nitrates, agricultural productivity is in many countries to a large extent maintained through commercially produced inorganic fertilisers, of which nitrates and phosphates are primary ingredients.

environmental problems tend to have poorly understood, indirect or delayed impacts on human health. Many currently very 'clean' cities in the developed world have for long periods of time been releasing polluted water, thus accounting for far more than their share of the build-up of contaminants in the oceans.

Stockholm, Sweden, situated on the boundary between the lake Mälaren and the Baltic Sea, proudly dubs itself as one of the cleanest cities in the world, at least when it comes to the water environment. Still, the city has passed through a trajectory, maybe less critical, but still similar to that described above for London. For much of the last century, the mortality rate was higher than the birth rate, at least in part as a result of water related diseases. Then the quality of local ambient waters went from bad to worse with the increased use of water closets, and by the 1930s the waters were considered unhealthy and bathing houses were closed down. Treatment of wastewaters started in 1934, and by the 1970s treatment had been extended to having all wastewater mechanically, chemically and biologically treated before being released into the sea. Lake Mälaren, the city's water source, was also regulated to avoid brackish sea-water and (treated) wastewaters to enter from the sea, and upstream sources impairing the quality of lake waters were addressed through co-operation with other municipalities around the lake. As the emission of phosphorous and oxygen-demanding substances have been considerably reduced, plankton production in the inner archipelago has decreased and water has become clearer. Trout have been restocked, and annual swimming competitions, suspended in the 1920s, were reassumed in 1976.

Stockholm has been successful in addressing the regional impacts on its water system and its immediate water surroundings are remarkably clean. Also, over half of the sewage sludge produced is used as agricultural fertiliser, but problems remain relating to the acceptability of this practice (Stockholm Vatten, 1996). While Stockholm may not qualify as a 'hotspot' of obvious pollution to be addressed along the coasts of the Baltic, emission of nitrogen has remained unchanged and still favours plankton production in the outer archipelago. Much 'historical pollution' remains in sediments. For the Baltic Sea, the more large-scale problems, relating to long-range transport of pollutants through both water and air, exist in the open sea (Ambio, 1990), to which historically Stockholm may be a major contributor.

Indirect Routes of Undermining Water Systems

With cleaner cities and city surroundings, the major challenge is again shifted, now towards the more far-reaching threats of the urban-industrial systems to global ecology. High energy consumption, based largely on fossil fuel, is to a large extent an attribute of wealthy cities in the 'North' - especially those with colder climates requiring extensive heating. This contributes to global climate change whose predicted effects include sea-level rise and increased variability of local hydrological cycles.

The purchasing power of urban elites and the masses of middle-class urban consumers to a large extent dictates which commodities are produced, and even the production processes. As regards diets, urban dwellers generally eat more meat and water-intensive crops. To produce one kilo of wheat requires some 500 litres of water, a kilo of rice, up to 2000 litres, and some 20-50 thousand litres of water per kilogram of meat. To produce one automobile consumes (directly and indirectly) close to 400 cubic meters of water (Ehrlich et al., 1973, pp. 107-8). Increasing numbers of more environmentally aware and concerned citizens prefer goods that are produced in ways that are less damaging to the ecosystem, but such preferences are not easy to translate into effective demands.

Summing Up

The ecological impacts of city water use are closely linked to the displacement of the environmental burdens. While the ability to displace is low in conditions of poverty, poor cities, or poor city dwellers, that have to cope with low levels of water use and effluent displacement would rarely have a large 'ecological footprint.' The more serious burdens are maintained within the locality and take their toll on human health. Activities which threaten ecological processes increase with wealth creation, though in many cases the capacity to mitigate that threat also increases.

Middle-income cities which displace the effluents of their more wealthy residents, but fail to take significant controlling measures, and leave an significant share of the population unserved, can end up combining serious health and sustainability problems. Mega-cities epitomise the regional impacts. Wealthy cities' (and wealthy city dwellers') impact on water systems tends to be more indirect: Water demands may have stabilised and infrastructure is well developed, in many places also including the treatment of wastewater. In spite of cleaner city and even regional environments, higher consumption of water intensive food items may induce changes in faraway agricultural systems and final deposition of wastes may sometimes include exports to other countries. Rather than through water pollution per se, water systems are still affected by emission of air pollutants, in the wealthiest of cities, most critically emission of greenhouse gases.

The displacement process can be portrayed as an intensification and expansion of linear material flows, a major feature of city metabolism. In the extreme this process could lead to the cumulative loading of waste substances into the sea, the atmosphere, and other sinks, eventually undermining our life support systems completely. As with the environmental health problems, but on a spatially far broader scale, this presents both a physical and an institutional challenge. Physically, we still understand far too little about the water systems upon which we depend. Institutionally, we have yet to create the incentives to ensure that when we do understand what needs to be done, we have good reason, both individually and collectively, to do it.

3.3 Water, Wealth and Sustainability

Different Perspectives on Sustainable Development

Although a city and its citizens cannot be self-sustaining, urban systems should be capable of developing production and consumption patterns that do not unduly compromise the local, regional or global ecological balance. Unfortunately, unless one interprets "unduly compromise" very loosely, this is not a simple achievement. From an ecocentric perspective, urban expansion almost inevitably compromises sustainability by reducing ecological system efficiency and integrity at numerous levels. But even from an anthropocentric perspective, urban development typically threatens sustainability, not least through its effects on water systems.[12]

A major principle of sustainability is not to compromise the future; for economists not to deplete resource stocks and for ecologists to preserve biodiversity and not to exceede critical threshold levels. There are however a great variety of views regarding the place of humans in a sustainable world, as well as the confidence in technological innovation and resource substitution as means of avoiding Malthusian scarcity.

On the anthropocentric side, the 'Brundtland Report' saw the main urban challenge as that of service provision in cities in developing countries, and was quite optimistic about the future of urban centres in industrial countries: "The combination of advanced technology, stronger national economies, and a developed institutional infrastructure give resilience and the potential for continuing recovery to cities in the industrial world. With flexibility, space for manoeuvre, and innovation by local leadership, the issue for industrial countries is ultimately one of political and social choice. Developing countries are not in the same situation. They have a major urban crisis on their hands" (World Commission on Environment and Development, 1989, p. 243).

From a different perspective, however, while the local and regional problems in many less affluent cities may indeed be acute, the 'creeping crises' of the resource base depletion, global warming, ozone depletion and acidification (Wärneryd et al., 1995) is the major threat to global sustainability. Affluent city dwellers are more responsible for these global threats, which have resulted from the high aggregate use of non-renewable resources and waste accumulation. From an ecological viewpoint "humankind remains a creature of the ecosphere existing in a state of obligate dependency upon many products and processes of nature" (Rees and Wackernagel, 1994, p. 364), and intergenerational equity would be expressed, not in terms of productive stocks of capital, but rather: "Each generation should inherit an adequate stock of natural assets *alone* no less than the stock of such assets inherited by the previous generation" (Rees and Wackernagel, 1994, p. 376).[13] Urbanites, while physically and psychologically distanced from the ecosystems that sustain them, appropriate carrying capacity through trade. From this perspective, the urban impact on sustainability has been globalised.

Population, Affluence and Technology

No single factor (urbanisation, population growth, technology, ever increasing affluence in the Western world, etc.) can be singled out as the root cause for humanity's

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[12] The distinction between an ecocentric and an anthropocentric perspective is exemplified by the very different meanings attached to efficiency, productivity and even richness in ecology and economics respectively. In ecology these terms refer to ecosystem characteristics relating to energy conversion, carbon fixation and species diversity. In economics the same terms all relate to the satisfaction of human needs or desires. Urban development almost inevitably decreases ecological efficiency, productivity and richness. Its short term impact on economic efficiency, productivity and wealth is likely to be positive. In terms of sustainability the ecocentric and anthropocentric perspectives are closer, since processes that continuously degrade the ecosystem are likely to be both economically and ecologically unsustainable. However, the anthropocentric interpretation is less environmentally strict, since, at least in principle, ecological degradation need not compromise human welfare. Thus, to say that an ecologically unsustainable practice is undermining economic sustainability is a claim about the real world, not a tautology.

[13] "Biogeophysical sustainability is the maintenance and / or improvement of the integrity of the life-support system on Earth" (Munasinghe and Shearer, 1995, p. xxii).

increasing threat to global sustainability. Ehrlich et. al. (1973) portray the human impact through a 'web of blame,' where the environmental impact equals *population x consumption of goods per person x environmental impact per quantity of goods consumed,* abbreviated as "impact equals population times affluence times technology" (p. 206). As relations are multiplicative they reinforce each other; an environmentally disruptive technology is thus more damaging in a large rich population. However, the factors are not independent, with both demographic patterns and technologies differing systematically between rich and poor societies.

The environmental displacement processes described in the previous section adds a layer of complexity to this environmental impact equation, for it is difficult to compare environmental burdens that express themselves differently over space and time. Thus, if one prioritises immediate threats to health, low income cities score lowest, if one prioritises city-wide and regional impacts, newly industrialising cities score lowest, and if one prioritises global impacts and includes indirect effects, then wealthy cities score lowest (McGranahan and Songsore, 1994).

Moreover, at every level good environmental management makes a difference. Effective removal of health threatening and 'poverty related' environmental hazards are made easier by more resources in the hands of society, but are just as contingent upon effective governmental action and public health policies (McGranahan and Songsore, 1994). As regards environmental problems of regional or city-wide importance, where emission levels have eventually come to decline with rising incomes, environmental legislation, institutional reforms and incentives to reduce environmental impacts have been the proximate motivation for improvement (Arrow et al., 1995). Hopefully, the same will one day be said of the global issues.

The global sustainability outlook depends to a large extent on the evolution of aggregate resource consumption levels. Regarding overuse of global sinks, equity concerns may be less critical from a physical point of view, and are not captured in aggregated models and figures, but will be of utmost importance in forming amelioration strategies. It is tempting to apply the principle of subsidiarity, and allow local institutions to deal with local environmental problems, city governments to deal with city level problems, and for global mechanisms to be devised to address with global threats. However, this would be neither fair nor effective. It would be unfair inasmuch as it gives governing institutions the responsibility for coping with the problems of affluence, but not those of poverty. It would be ineffective inasmuch as local initiatives are also critical for global problems, and, as argued in a previous section, local initiatives need international support whether they are globally or locally oriented.

From Displacement to Replacement

Many of the regional water burdens of cities can be alleviated by improved collection and treatment of wastewaters, and the use of sewage sludge as agricultural fertiliser. This implies improvements to existing systems following the convention of using water as the means for transporting wastes, but often a re-orientation of sewage works to function as 'fertilizer factories rather than as disposal systems'(Girardet, 1992). Recycling in this sense would entail 'curving' the current 'open ended' linear flows, increasing 'exchange' with the rural hinterlands (farmers), rather than a 'closed loop system.'[14] Challenges for improvement relate to keeping sludge clean from toxic pollutants, distance to farming communities, city growth, climate and the availability of fresh water (Dalhammar and Mehlmann, 1996). Traditional (pre-industrial) systems of waste water disposal may provide useful models for more natural, ecologically compatible systems, costing much less than modern high technology (Niemczynowicz, 1993). Purification of wastewaters may be technically possible, but still not economically viable even for the world's richest cities. The fixed standard (capital intensive) sewage treatment model of the North is increasingly challenged in favour of approaches with flexible (and more participatory) standards, balancing the trade-offs between cost and water quality (Serageldin, 1994).

To be successful, such changes will require new institutional forms and that new interest groups capable of providing new technologies be built up. Existing, centralised, waste disposal systems are very path dependent: once a particular approach has been selected, strong forces can come into play ensuring that this approach be extended rather than replaced. The technologies are readily available, and even the education system becomes oriented towards their use. To change this path will undoubtedly take considerable effort, and is likely to be uneconomic in the short run.

Refining Dilution

A more refined, and less damaging, way to 'displace and dilute' can be achieved by adapting to and not exceeding critical thresholds in terms of damaging the natural ecosystem. This entails making maximum sustainable use of nature, or, inversely, induce maximum survivable damage. Water bodies' vulnerability to contamination depends upon the volume of flow which determines how effectively the pollutants are dispersed; large rivers are less vulnerable than small rivers and lakes tend to be more susceptible to contamination than the seas. Following an approach of 'sensible dilution,' uniform water quality standards may not be strict enough to protect some inshore waters, such as lagoons, from irreversible pollution damage, but overly strict for other better-flushed waters. Nevertheless, effluent standards tend to be determined on the basis of broad political goals rather than on the water quality and self-purification capacity of the receiving water (Odegaard, 1995).

To apply this approach extensively in a centralised fashion would require both a profound knowledge of local conditions, and very sophisticated and incorruptible government regulations. On the other hand, it is not yet clear what sort of participatory standards are feasible. Again, there is likely to be a need for new institutional forms.

Conservation Through Higher Prices

Partly as a reaction to the call for closed cycles, *reducing* the linear flows is increasingly seen as a potential avenue for modifying and ameliorating the effects of the presently mainly linear systems. Curbing water use (and waste in particular) may be addressed by

[14] Completely circular systems may seem attractive. But, as an energy intensive endeavour, they still belong to the expensively bought 'technological fixes' rather than as a 'natural' solution. As expressed by Jackson (1996): "The suggestion of complete materials closure of the industrial system … seems hopelessly demanding from an economic point of view. What is less obvious is that it is actually impossible from a thermodynamic point of view… …We could come close to closing a particular material cycle if we supplied sufficient high-quality energy to the task. But supplying this energy is itself a thermodynamic process, unavoidably dissipating more materials and more energy" (p. 55).

demand management, where 'management' is a euphemism for reduction (White, 1994). The volume of the water flow through cities with well developed infrastructure is essentially determined by the demands. The immense throughputs, especially of the wealthier cities in the world, can be reduced through awareness campaigns, price signals as well as water saving technologies.

The use of price signals is gaining increasing international support. That "water has an economic value in all its competing uses and should be recognised as an economic good" has been adopted as the guiding principle for water management at several international meetings, notably at the International Conference on Water and the Environment: Development Issues for the 21st Century, held in Dublin 1992 (ACC/ISGWR, 1992), and is actively promoted by international agencies such as the World Bank. Given the economic value of different uses, such water allocation is in most cases likely to favour urban water use over agricultural uses, but could also mean that environmental uses are compromised unless nature's needs can be effectively monetised.

Problems with Externalities and Water Pricing

For price signals to guide actors towards sustainable water use, they need to reflect the full environmental cost - the intended or unintended environmental effects of polluting or abstracting the water. The price would reflect the value of the foregone opportunity for other potential users of the same water, or in the case of pollution fees, foregone opportunities because of degraded quality. While damages compromising societal needs are difficult to correctly appreciate in monetary terms, damages to natural environments that are not exploited can be far harder. When dealing with resources like water, efficient (economic) allocation is inherently problematic for a number of reasons:

> *"Water's vital and often revered role has led many societies to restrict selling water and pricing it to reflect its full cost and scarcity. But even in the absence of societal reservations about treating water like other goods, the nature of the resource makes it difficult and in many cases impossible to establish efficient markets. . . Efficient markets must satisfy two conditions. First, there must be well-defined and transferable property rights… Second, a market transfer is efficient only if the full benefits and costs are borne by the buyers and sellers. Both conditions are likely to be violated for water resources" (Frederick, 1993, pp. 22-24).*

Market allocation of water needs efficient institutions to avoid distortions ranging from monopolistic practices and impacts on third parties to protecting the environment and safeguarding equitable allocation for basic human needs. For example, in the absence of mechanisms for protecting common property resources, farmers in Northern California, USA, sold surface water rights to California's State Water Bank, but replaced the sold water by pumping (unregulated) groundwater (Brickson, 1991, cited in Frederick, 1993).

Marketing of pollution or abstraction rights, giving opportunities for environmental groups to purchase rights (without using them), can put price tags on environmental values, but can be very difficult to manage, and ignores important differences on the demand side. First, it is not at all clear that the economic burden of protecting the environment should fall primarily on the environmentally aware. If saving water is a public good, then it is highly inappropriate to expect environmentalists to voluntarily purchase water protection on the market. Alternatively, in an area where water use is necessary for public health, it is also inappropriate to have people paying full resource costs.

Price based demand management approaches make most sense in situations where different users, or on a more aggregate level - different uses, are competing for the same water. The most obvious rivalry for water resources on the larger scale is the competition between agricultural and urban water abstraction, but the (often unintentional) use of water for dispersing pollutants may be equally challenging within and around cities.[15] Basin wide approaches are needed to defend downstream users from undue appropriation of water by upstream users, and, in particular, to defend environmental needs.

Ecological Cities and Barriers to Change

While current urban practices can be improved in numerous ways, adjustments to existing systems will fall far short of any real change of the material foundations of the city. It is argued that "only a radical break with modernity can overcome the multidimensional crisis characterizing our epoch and hasten the necessary restructuring of the built environment of our cities and its relation to the wider natural ecology" (Yanarella and Levine, 1992). Whether an 'ecological city' is achievable or not can be debated, as can the meaning of 'ecological' in the urban context. These uncertainties make any concerted action towards a fixed goal impossible. For water, its many different functions in society, conflicts of interests, as well as insufficient knowledge about many of the environmental effects, adds to complexity (Odegaard et al., 1996).

Barriers to substantive changes include the already (expensively) built-up environment in the developed world[16] as well as conceptual, institutional and social barriers towards changing existing systems. Stricter pollution controls have setbacks in terms of economic dislocation - raising concerns of 'deindustrialisation' in many developed countries. Relatively little hope is given to 'technocrats' to solve fundamental problems - many of the present urban environmental challenges (such as traffic congestion) are the *unintended* outcome of *intentional* decisions. While citizens' scope for action is to a large extent hindered by being a small part of a much larger system, the

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[15] São Paulo, Brazil, provides an instructive example of severe trade-offs between the competing uses for municipal supply, electricity generation and that of waste dilution. The Billings reservoir was built in the 1920s in order to take advantage of the Serra do Mar drop toward the Atlantic, to produce hydroelectric power. The system included a pumping station to take water from the lower Pinheiros river into the reservoir. At that time the river was not yet polluted, but now it contains highly contaminated urban wastewaters and storm waters, a mixture which is pumped into the Billings reservoir. In order to maintain the municipal water supply, the reservoir has been divided into two parts separated by a relatively permeable earth dam that allows flow in both directions. The smaller part supports the municipal supply, and the larger, lower level part, receives the water from Pinheiros. Pumping continues, in the dryer season in order to keep electricity generation going, and during rains to avoid flooding in the São Paulo municipality (Anton, 1993; Jacobi and Carvalho Teixeira, 1995).

[16] This is often used as an argument for having developing countries 'take a lead' in adopting more environmentally friendly technologies, avoiding the errors of developed countries. The danger with such approaches are that they easily overlook many of the virtues of the existing systems in developed countries. The old virtues, as much as the flaws, of 'old' systems must be kept in mind when developing new.

push for system change may need to come from active concerned citizens. Urban areas are often held out as potential centres of origin for substantive changes:

> *"The ecological challenge with which industrial society is confronted is thus not only a question of technology, but above all a question of lifestyles and social values. In this respect we need innovations and ecologically sound solutions to problems in civilization. History has shown that such solutions may be found, given the will to survive, just because of the innovative power of cities" (Hahn, 1991, p. 7)*

While social values are important for legitimising and reinforcing urban systems and technologies, they do not necessarily support ecological restructuring. (Top down) environmental education may be a prerequisite for 'grass root' city dwellers to actively pursue more ecologically sustainable lifestyles. Furthermore, well educated citizens can be much more effective in voicing their concerns, and pushing for broader policy changes. The major benefit, however, of relying on local initiatives, is that it is at the local level that lifestyle changes need to be made, and taken alone tools like pricing and regulation are in danger of seeming oppressive, and are in any case not likely to be sufficient for the task. Increased democratisation, through participation of city dwellers in the decentralised planning may be the only viable way for real change, regardless of whether people are 'reduced to mere consumers' or are seen as pro-active agents.

There is still a serious institutional problem to be addressed, however, if cities are to take a lead role in the pursuit of sustainability. If one city concentrates its efforts on cleaner streets and another city on reducing it contribution to global warming, one city ends up with cleaner streets and both end up in a slightly more sustainable world. Unless some higher incentive is given to the city that attempts to address global warming, a city-based effort is almost certain to stall. The search for "win-win" opportunities is useful in its way, but cannot provide the basis for a long term strategy.

4. WATER FOR HEALTHY AND SUSTAINABLE CITIES

Cities are to a large extent the product of selfish pursuits. People settle, work, trade, and invest in the city primarily to serve their own ends, rather than those of the city as a whole. Often these self serving pursuits inadvertently contribute to the dynamism and attraction of the city. But they can also unintentionally contribute to environmental problems, undermining public health and sustainability. One of the age-old roles of urban government has been to help manage the urban environment, including its water systems, and to prevent some of the excesses of unregulated development. With the rapid urban growth of the last two centuries, urban health and sustainability have emerged as critical international concerns, and motivated concerted actions within civil societies as well as governments. The sanitary movement of the 19th century and the environmental movement of the 20th century have both been urban-based, and gathered considerable public support. Unfortunately, much remains to be accomplished, with regard to both health and sustainability, and not least in relation to urban water systems.

Unity Through Diversity

Looking across today's variegated world, environmental awareness clearly requires a different focus in different cities. A city's water strategy and politics need to evolve around the most pressing needs for that particular city. And, needless to say, but overwhelmingly difficult to implement, a water strategy should address the needs of all citizens. Since living conditions in many cities vary radically, this can entail parallel strategies targeting different issues for different water users in different parts of town. Thus in a single city it may be appropriate to target conservation for households in one area, network extension and increased water use in another area, and to develop different policies with regard to informal and formal sector enterprises. Such policy variation is superficially inconsistent, but only if one adopts the simplistic view that everyone is entitled to inexpensive water, or that everyone should have to pay the full economic cost for their water. Actually, economic efficiency alone would dictate a very different approach in areas where public health is at risk due to water scarcity, from areas where, for example, neighbours are competing to have the greenest lawn.[17] In short, a standardised approach to urban water management will be divisive while an approach that serves everyone needs to§ diversified.

Superficially, emphasising the distinction between health and sustainability concerns might seem to add to sectoral divisions and policy fragmentation. However, to achieve coherence, as well as balance, differences as well as similarities need to be recognised. Perhaps because they are both environmental problems, while environmental health and sustainability involve quite distinct threats, they are structurally rather similar. Threats to both sustainability and health are principally the unintended outcome of human pursuits. Often the threats are hard to perceive. Considerable headway can often be made through holistic responses, centred on abstract and somewhat vague concepts such as *cleanliness* with respect to health and *natural* with respect to sustainability. Both pose a challenge to science inasmuch as the processes remain poorly understood, and to governance inasmuch as the environmental inter-connections create a host of what economists term externalities.

Local Action Based on Local Realities

As indicated in previous sections, it is not surprising that health concerns dominated during the 19th century. In many of the world's most affluent and dynamic cities - the motors of the industrial revolution - environmental health conditions were appalling. Currently, sustainability concerns dominate, at least in the international environmental arena. Again, this is not surprising. In the world's more affluent cities, water related diseases are no longer a major concern; the more obvious challenge is whether these cities' relatively newly found water affluence can be sustained. However, if the urban environmental agenda is to gain grass-roots support internationally, it will need to take the local environmental problems, and contemporary urban health concerns, back on board.

As the environmentalist cliché "think globally, act locally" suggests, sustainability issues have a multiplicity of scales. The city scale has been regaining prominence, but not principally because the damage caused by urban centres is better recognised. For water, as for many other environmental concerns, urban areas do concentrate damaging

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[17] To the extent that additional water is contributing to a public good, such as the control of infectious diseases, if prices reflect the full marginal cost of water there will be inefficient under-consumption. To the extent that additional water is contributing to a positional good, such as achieving a greener lawn than the neighbours, the same prices will result in inefficient over-consumption.

activities. But more important, for there to be a transition to more sustainable development, urban areas must also become concentrations of environmental improvers. Local *initiatives* are increasingly seen as central to achieving sustainability. And it is from this perspective that the pursuit of sustainability needs to be grounded in local urban realities.

One urban reality, however, is that the immediate health and welfare aspects of water, rather than the longer term sustainability aspects, remain the more pressing environmental concerns for a great many of the less affluent urban dwellers. If cities and urban neighbourhoods are to become the "grass roots" of environmental reform, then the environmental agenda must encompass the more pressing "grass roots" concerns. However environmentally aware, a low-income peri-urban dweller lacking piped water and sanitary facilities is likely to be more concerned with water and sanitation than with water and sustainability. The importance of local initiatives is increasingly recognised in the context of environmental health improvement in low income settlements (Douglass *et al.*, 1994; Hardoy *et al.*, 1992). This greatly reinforces the potential for creating a more broad based urban environmental movement, encompassing both health and sustainability concerns.

International Cooperation

Despite the need for locally tailored solutions, international cooperation is important. This applies to both health and sustainability. The need for international cooperation is self evident as regards sustainability, where international water bodies and cycles are often threatened. But it also applies to environmental health improvement, where the hazards are predominantly local. The sanitary movement was unequivocally international, despite the local nature of the environmental problems addressed. Its success was predicated on the fact that reformers from different countries shared science, practical experience and inspiration. In today's world of jet-hopping and global conferencing, there is no dearth of opportunities for international exchange. Unfortunately, these opportunities have not been capitalised upon to create a coherent approach to urban environmental improvement. More specifically, the urban environmental agenda remains fragmented.

For most developing countries, international development cooperation is of course as important as the international exchange of ideas and experience. Still, external financial assistance poses yet another challenge to good governance and local participation. The international influence on local water systems is not surprising, given the pivotal role of international financing of water development in many Third World cities. Indeed, it is critical that donors make every effort to ensure that aid funds are not misappropriated. And there is an inevitable tension between the interests of local residents and the interests of local governments and government officials: interests that correspond in official rhetoric, North and South, but rarely in practice. This tension does not, however, justify supporting projects and policies which ignore the expressed desires of both local citizens and their governments, to conform to an externally defined environmental agenda. Rather it makes the job of defining a politically appropriate water strategy that much harder.

Challenges For Governance

The pursuit of both environmental health and sustainability also poses challenges to good governance because the beneficiaries are not usually well represented in government. Groups with serious water-related health problems typically live in conditions of poverty, and are politically as well as economically disadvantaged. Groups severely affected by a water-related threat to sustainability include especially future generations. Representing the interests of the poor poses quite different political challenges from representing the interests of future generations. On the other hand, the justification is similar, and there is at least one strong political reason for addressing these two sets of interests simultaneously: it is critical that representing the interests of future generations not be used as an excuse for sacrificing the poor, and vice versa. Both of these groups are almost inevitably included in political rhetoric, but easy to ignore in policy implementation.

Orthodox water policies do not provide a sound basis for pursuing either environmental health or sustainability, at least in part because these most affected groups do not have sufficient voice. The process of defining the goals and principles of water policy faces the same risk of being hijacked by more influential segments and entrenched groups as any other political process, especially where democracy is fragile or non-existent. Even where democracy is secured, the interests of future generations are not thereby represented. On the other hand, the potential for making headway is considerable, since there is very little public opposition to the pursuit of public health and sustainability. This makes well designed policies, participatory mechanisms, and good science especially important, as they provide the means to create urban environment strategies that are enforceable in addition to being well intentioned.

From Productionist Logic to Demand Management

In practice, piped water and sewerage systems in developing countries often fail to reach the neediest parts of the population, but still create considerable city-wide environmental burdens. When water supplies are expanded in disadvantaged areas, residents are rarely given the hygiene education needed to ensure that they can meet their own health needs effectively. Alternatively, water companies find themselves lagging further and further behind in supplying ever increasing city populations with clean water. They run structural deficits and often operate with ad hoc interventions as and when additional funding becomes available. According to the World Bank, in most developed countries consumers pay water rates covering all recurrent costs and a large share of capital costs, while in developing countries water prices cover only a third of the average cost of supply (World Bank, 1992).

The politically determined tariffs and the negative returns on water sales, the historical preoccupation with massive engineering structures for the production and transmission of water, and the bias towards providing unlimited quantities of water to industry and well-to-do households; these all contribute to both chronic water shortages and the systemic exclusion of large parts of the population from access to the available water. Based on the notion that the water requirements are given and will be met only if the supply system expands, it is as if a 'productionist logic' directs water companies towards new investments and consequent dependence on external finance and its inherent technological bias (Swyngedouw, 1995). This has led to many gigantic engineering projects, made possible in the 1970s through ample access to international loans. For many countries, this has contributed to an enormous foreign debt. It has increased access to water for millions of people, but both economic and water resources have been squandered in the process. And it has opened the door to reactionary water policies which address the economic and resource inefficiencies, and can claim to do no worse, and perhaps even a little better, with respect to the currently unserved.

Demand management questions the basis of 'productionist logic,' treats the volume and pattern of water use by individuals, households, businesses, farmers, etc. as variable, and aims to change the behaviour of consumers either voluntarily (prices, education, etc.) or involuntarily (regulation or centralised interventions). Where supply ends and demand starts in the water distribution system is debatable, but a common denominator for demand management, as it is currently used for water management, is to encourage use efficiency and water conservation - at all levels. The tendency is to emphasise water conservation. However, in areas where access to water is insufficient, and water scarcity is creating health problems, demand management should involve increasing supplies accompanied by hygiene education.[18] More generally, while demand management is typically viewed as a tool for achieving more sustainable water systems, an alternative form of demand management is central to the more sophisticated attempts at improving environmental health. Thus, just as demand-side conservation is increasingly seen as critical to water resource management, demand-side hygiene behaviour is increasingly seen as critical to water related health improvement (Boot and Cairncross, 1993; Cairncross and Kochar, 1994).

Involuntary methods, such as rationing, have been a frequent response to water shortages, especially short-term and severe ones. However, interruptions to water services, intentional or not, have several adverse effects. Apart from lowering the pressure in the system (increasing the risk of cross-contamination from wastewater), necessitating additional investments (household storage cisterns and sometimes booster pumps), and disrupting both economic and social activities, it is doubtful how effective it actually is in curbing consumption. In anticipation of water cuts, households may tap more water than is actually required during the time of service interruption, water of which large proportions are subsequently wasted. Also, where all households are filling (automatically or manually) their cisterns during that part of day service is provided, peak demand may be higher than what it would be given a continuous service (Hughes, 1995). Moreover, water interruptions pose a variety of health risks, and have been found to be statistically associated with a higher prevalence of diarrheal disease (Benneh *et al.*, 1993). In many circumstances, providing a continuous rather than intermittent supply of water can save both water and money (Hughes, 1995).

Higher water prices can be an efficient way of curbing aggregate demand (as long as metering, billing and revenue collection actually take place). While low volume users are less likely to respond to price changes, high volume users (with declining marginal utility), such as industries, commercial establishments and also affluent households

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[18] A World Bank policy paper defines demand management as "The use of price, quantitative restrictions, and other devices to limit the demand for water" (World Bank, 1993, p. 5). However, a broader characterisation of demand management taken from economic terminology is "The general objective of demand management is to ensure that aggregate demand is neither deficient relative to potential gross national product…nor overfull" (Collins Reference Dictionary of Economics).

should reduce water consumption in response to higher water prices.[19] In areas with dangerously low water consumption, pricing and other components of water policies should not target conservation *per se*, although in many circumstances better demand-side management will lead to water savings even in disadvantaged neighbourhoods.

Targeting Wastage Rather than Usage

More generally appropriate than reducing consumption is the goal of reducing waste by preventing leakage from the supply systems. How much water leaks out of a system is rarely known; it typically falls under the general category of *unaccounted for water*, which, strictly speaking, includes all water which is not metered. Ranging from unintentional (technical) leaks from the pipe system, to water distributed to official non-paying customers, such as for fire-fighting or sometimes military camps, unaccounted for water in many cities hovers around half of the quantities supplied (Leitmann, 1993; Nickum and Easter, 1994; Swyngedouw, 1995). A lot of the unaccounted for water is of course put to beneficial use, even though all of it presents a severe challenge for utility companies' financial sustainability. Leaks, however, with the exception of groundwater recharge, have no benefits. Rather, they contribute to accumulation of stagnant water, disrupting transport as well as providing breeding grounds for many disease bearing vectors. Furthermore, they can create negative pressure in the water pipes, allowing sewerage to enter the water system. Even in the short term reducing leakage can lead to significant savings, and simultaneously provide health benefits.

Affordability and Efficiency - Beyond the Water Tariff

The main argument for keeping low water prices to urban households is that poor urban dwellers can not afford to pay the full cost of meeting basic human water needs. Although there is evidence of exorbitant water prices in many poor areas, these prices typically often only reflect what is paid for the highest value uses; drinking and cooking. Water for washing and cleaning would rarely support such high prices, and such uses may be severely compromised if all water prices are uniformly high. Furthermore, evidence of high willingness to pay for water must not overlook the social cost of other consumption opportunities foregone, nor the personal deprivation and public cost of insufficient water for hygiene.

To overcome affordability problems, water tariffs often allow a lower unit price for small consumers; a "lifeline rate" with a unit price that would be augmented with higher levels of consumption. Given the nature of water distribution in many poor areas, where existing facilities tend to be shared by many users, the desired effect may however not materialise even for those with water connections. A household selling water to its neighbours will have a higher meter reading, and may, in spite of servicing a higher number of people, pay more per unit of water (Whittington, 1992). While a progressive tariff may serve to dissuade some wealthy households from using water carelessly, it can thus also be a burden on households who share water meters or sell water.

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[19] Household water consumption has in many countries been shown to be relatively inelastic to changes in prices (Frederick, 1993), but still presents high elasticity to income (Warford and Julius, 1977). That the rich use more water than the poor would, apart from having better access to the supply and more money to spend, also stem from the larger use of water consuming domestic appliances.

Furthermore, official pricing policies may only be directly relevant for those households that receive their water directly from the utility. Where water distribution networks only serve parts of the urban area, subsidised "lifeline" rates are highly unlikely to benefit more than a small minority of the poorer urban dwellers. And worse, where universally low water prices render utility companies unable to expand the network to under-serviced areas, the exclusion of the poor is made permanent. With constrained supply leading to high price differentials, the end result may even be that while the water consumption of the wealthy is subsidised, the poor are effectively being charged more than what the cost would be, given an economically efficient distribution system.[20] In the extreme, charging higher prices for water, at least to affluent users, could benefit the poor, and also encourage conservation among businesses as well as households using municipal water for gardening and washing cars. However, there is no guarantee that a more financially viable utility will extend services to low income areas, even if water prices are set to cover costs.

Effective demand management, for both sustainability and health, requires going beyond water pricing. To pursue water sustainability in an effective manner there are a wide variety of possible measures, many of which have other environmental benefits. Indeed, it has been estimated that the 1992 U.S. Energy Policy Act, which mandates water efficiency standards for all residential faucets, shower heads and flush toilets, could eventually result in a decrease in all domestic water uses of 20% (Raskin et al., 1995). With respect to health, demand side management can also involve a variety of measures, ranging from cross subsidising household connection costs to community consultation in designing payment systems to the promotion of selected technologies and hygiene behaviours.

The Importance of Being Well Connected

There is a great deal more to water affordability than the official water price, and for many households the connection cost alone matters more than the water price. The economic justification for subsidising the connection cost for low income households is more compelling than that for water itself. Health studies indicate that having a water source in the home does make an appreciable difference. Subsidising new connections in deprived neighbourhoods can help target the incentives, and provide a greater incentive than equivalent subsidies on water itself. As the success of institutions like the Grameen Bank indicates, low income households have difficulties raising capital. They often face the equivalent of annual interest rates of several hundred percent. Thus, for poor households, making it easy and inexpensive to obtain a water connection can be economically much more important than equivalent financial resources devoted to keeping the price of water low.

Alternatively, when water prices rise, or household incomes fall, it is possible to use demand management to provide alternatives to disconnection. Even in the U.S. there is a significant population of low income households for whom water bills seem unaffordable. To avoid disconnection, and the bad publicity this creates, some utilities

[20] The term "subsidised water" is often used indiscriminately when referring to consumer prices lower than the supply cost. Strictly speaking, however, a water subsidy would be a payment from the government to the water suppliers, enabling them to reduce water prices and still cover the costs of meeting the higher water demand (see entry for *subsidy* in Collins Reference Dictionary of Economics). When the suppliers are forced to lower prices without full compensation, it might be more appropriate to say that the *lack* of subsidy constrains supplies.

are practising demand management, and exploring options such as financial counselling, arrearage forgiveness, payment discounts, income-based payments, lifeline rates, targeted conservation, disconnection moratoria and flow restriction (Beecher, 1994). Yet such measures, in a somewhat different form, are even more important to low income cities, where, as both recent riots and epidemiology duly demonstrate, disconnection is not just a private affair.

Redefining the Actors

Virtually all large scale urban piped water systems have been developed through public channels. Still, it is only the 'transformation of nature's water' and bringing it to the city which is typically a wholly public activity. The 'urbanisation of water' is in many countries organised through a mixture of public and private systems. In developing countries, while more affluent households and powerful enterprise tend to be served through a wholly public system, poor households more typically rely on private systems often reselling water from the public system (Swyngedouw, 1995).

A holistic approach to urban water - from abstraction to return to the water cycle - needs to encompass all the actors of the water's pathway through the city. This should include the often large numbers of households that do not have house connections. Where individual connections may not be possible, utilities should have approaches to deal with groups as well as with individual households, requiring yet more differentiation of tariffs. Alternatively, developing intermediary institutions, which can help ensure that utilities' practices meet local community needs, can considerably lessen the gap between centrally developed policies and local concerns.

As mentioned above, the state, the private sector and the voluntary sector can be made complementary, and much attention, especially within development projects, has been brought to citizens' groups' roles in water management. Collective action within neighbourhoods can do a lot to resolve sanitary problems. However, the relative efficiency of many community organisations should be no excuse for governmental inertia, partly because effective neighbourhood solutions are often contingent upon the prosperous relations and support from governmental agencies.

There is no Easy Agenda

To provide households with water supply and sanitation services has been referred to as an 'easy task,'[21] but recognising the complexities regarding unequal income distribution, the externalities involved and problems of democratic representation of the poor, as well as the enormous backlog in achieving targets, this is presumptuous. There is a need to recognise the complexities and aim at understanding them better, and how they relate to other problems and priorities city dwellers and urban governments have to deal with.

All implementation is in a sense testing of old or new concepts under new circumstances. Some 'success stories' such as the Orangi project in Pakistan or

[21] As an example, Serageldin (1994) writes: "The old agenda - the provision of water supply and household sanitation services - is clearly a relatively 'easy' task if sensible financial policies are adopted, since consumers want and are willing to pay for these services. Yet only a handful of developing countries have been successful in carrying out this 'easy task' in an efficient, responsive, and financially sustainable way. The new agenda, which centers on management of wastewater and the environment, is a much more difficult and expensive undertaking, and one in which successes (in terms of efficiency and financial sustainability) are few and far between even in industrial countries" (p. 25).

condominial sewerage systems in Brazil are frequently described in international publications (Briscoe, 1993; Serageldin, 1994; United Nations Centre for Human Settlements (HABITAT), 1996; World Resources Institute, 1996). We can learn from these examples about old and new technologies or how systems of finance can be successfully combined, or how much can be achieved by individual charismatic leaders with social commitment and the right support from governmental agencies. But underestimating the level of skills, commitment and ingenuity that can bring about success in this difficult area may be counter-productive. As the specific nature of the problems vary between cities and parts of cities, any 'standard' solution has to be adapted rather than replicated. Furthermore, a lack of humility to the task tends to put inordinate blame on those daring to take action,[22] and discourages prominent leaders and professionals from pursuing endeavours in the area.

No Excuses, but Humility to the Task

The challenge to make our cities more healthy and more sustainable is indeed enormous. Poor sanitary environments at this very moment continue to bring death, disease and human deprivation, and water pollution and overuse is increasingly threatening our life support systems, regionally and globally. The need for action is certainly there. Disciplinary and institutional boundaries must be transcended. Local knowledge and scientific knowledge must be brought together into well targeted and well coordinated efforts. However, the policies for good coordination, as the knowledge base for well informed strategies, are still in the making. Underestimating the complexity of the task, regardless of whether the challenge is to improve health or sustainability, may lead to costly mistakes. Our ignorance is no excuse for inaction: there are many obvious things that need to be done. But nor is the need for action an excuse for remaining ignorant: there remains a great deal of relevance to learn regarding water, health and sustainability.

5. SUMMARY OF CONCLUSIONS

Health and sustainability are two major challenges for urban water politics, and important goals which few would dispute. But neither will be accommodated by self-centred pursuits of groups that are well-off today, as both health and sustainability concerns relate to respecting and addressing needs of groups which, for obvious reasons or not, are poorly represented politically. Urban health essentially involves furthering the interests of today's poor, while ecological sustainability entails protecting the rights of future generations. When narrowly pursued, health and sustainability goals can conflict and create trade-offs between the interests of future generations and today's poor.

Modern technologies of urban water supply enable cities to draw on distant water sources and displace hazardous effluents. Comparatively clean and affluent cities have to a large extent transferred water (and other environmental) problems from the neighbourhood to the city, and from the city to the region and on to the globe as a whole. Hence, water supply and pollution challenges are pushed on to distant ecosystems or future generations. While displacement of burdens can improve urban

[22] A notorious number of water supply projects are described as 'failures.'

environmental health, it threatens to undermine the natural systems on which city life ultimately depends.

More efficient water systems, reducing leaks and wastage while stimulating hygienic water use, can make cities healthier to live in but less strenuous to the natural systems on which they depend. While demand management is typically viewed as a tool for achieving more sustainable water systems, an alternative form of demand management is central to the more sophisticated attempts at improving environmental health. Thus, just as demand-side conservation is critical to water resource management, demand-side hygiene behaviour is critical to water related health improvement. A city's water strategy and politics need to evolve around the most pressing needs for that particular city, and need to be diversified in order to address different priorities also within the city. Standardised approaches to urban water management will be divisive and may as well miss the target.

Pushing water issues back and forth along a private-public axis is hardly likely to improve efficiency of either sphere. Rather, increased attention is required towards 'internalising externalities' and improving accountability of both. Acknowledging the different constituencies and raison d'être of public entities and private enterprise (and NGOs) can help define relationships that favour society's goals, but avoid deviations such as 'public-private profiteering.' A major potential for improving urban water systems may be found in the ways households, community based organisations, water vendors, utility companies and city governments interact.

Capital intensive centralised systems, apart from physically providing water and removing effluents, also relieve citizens of the intellectual burden of dealing with water issues. Because expensive centralised systems are financially difficult to implement in many cities, local and less comprehensive systems are increasingly sought for and implemented through community participation. However, the relative efficiency of many community organisations should be no excuse for governmental inertia, partly because effective neighbourhood solutions are often contingent upon the prosperous relations and support from governmental agencies. Furthermore, less comprehensive systems (with a longer and less predictable route for water from the tap to the drain) require more sophisticated management skills at the local level, and more accurate knowledge at the household level about water, hygiene and safe sanitation. Similarly, shifting from the linear centralised systems in order to improve prospects for sustainability, requires households to have a much better understanding of the natural processes as regards the treatment of wastes as well as the health risks involved.

How water systems can support both healthy and sustainable cities involves a complex web of physical, social, economic and political interrelationships. Unrecognised complexity helps explain why clean drinking water receives undue emphasis in discussions of water-related disease transmission, and water consumption receives undue emphasis in discussions on sustainable water systems. Unfortunately, catchy but misleading messages often influence policy. Indeed, specialists sometimes allow misrepresentations to persist on the grounds that misguided attention is better than no attention.

It is easy to believe that urban sanitary problems were essentially solved with the discovery of microbes and the development of modern environmental services. In fact, the complexes of local environmental health problems which helped motivate the sanitary movement more than a century ago, still constitute a major challenge for scientists, governments and citizens alike. With the view that more attention must be brought to the more serious challenge arising from the broader sustainability issues, household environmental problems, such as inadequate water and sanitation, are too often portrayed as part of an old agenda which is just not completed as of yet. Rather than being an ‘easy’ area, the localised environmental problems of the poor are relatively ‘easy’ to misdiagnose or ignore.

Meanwhile, enormous attention is brought to the sustainability threat of mega-cities, due to many excessively spectacular projections about their future proliferation and size. However, over half of the world’s urban population live in cities of less than a million inhabitants. The main challenge of the 21st century may not be how to deal with mega-cities, but how to secure safe and sustainable water environments for increasing numbers of low income residents in small and medium size urban centres.

While prospects for improvement are great, they will by no means come cheap or easy. Major challenges for science remain to increase our understanding of water related threats to health and sustainability, and for politics to build on accurate understanding of the problems for the benefit of the underrepresented constituencies. While sustainability problems, like poor sanitary environments, have been with us for thousands of years, they will unfortunately insist on coming with us - more challenging than ever - into the next millennium.

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