Dimensions and approaches for Third World city water security

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A rapid expansion of urban systems, particularly in less-developed countries, pose considerable challenges. Urbanization also provides opportunities for socio-economic progress. Relative contribution from the urban sector to national economic growth is very high. The fate and the role of the socio-economic system in local, regional and national development hinges on many circumstances. Apart from delicate social issues, deficiencies in water provision, internal distribution and a hazardous water and environmental quality represent basic and tangible daily problems. Urban water security requires fresh thinking at two levels. Some kind of basin authority (corresponding to a county council, i.e. a formal administrative and regulatory body for the geographical area within a river basin) in combination with a national water policy is required, notably in countries that contemplate, or are in the process of implementing, regional and sometimes inter-basin schemes to augment supply to growing conglomeration. Similarly, the generation of large volumes of waste water and the associated threat to downstream areas cannot be effectively tackled through conventional urban planning. Within the urban area, and particularly in non-regulated parts, there is an urgent need for institutional arrangements that facilitate operations for providers who have the capacity and ability to function under the prevailing circumstances. Introduction of effective production and treatment technologies are other necessary and urgent prerequisites to reach urban water security in Third World cities.

Keywords: urban expansion; non-regulated areas; water-after-use; independent providers; inter-basin transfer

1. URBAN EXPANSION AND THE WATER CYCLE: THREE DIMENSIONS

Rapid expansion of the urban system has become one of the most striking characteristics of change in large parts of the world. Virtually the entire population growth in the world during the coming decades will occur in, or be concentrated to, urban agglomerations, and most of it in LDCs. Some 90% of the entire global population growth between 2000 and 2025 of *ca.* 1.7 billion people is expected to take place in the urban areas of LDCs (Brockerhoff 2000). Growth of the urban population and activities are concentrated in Asia and sub-Saharan Africa. For some observers, this expansion represents one of the biggest challenges that human kind has ever had to tackle. Others refer to its historical inevitability and emphasize that social and economic progress tends to be associated with urbanization. Historically, and presumably in the future, progress is not confined to urban centres alone. They provide a market for agricultural produce and opportunities and incentives for rural change and development. Similarly, urbanization could play a crucial role in reducing fertility rates.

Socio-economic, demographic and political processes constitute one set of major changes. For this article, it is relevant to link the wide spectrum of social change to the implications of urbanization for water and environmental security. Interfaces and linkages between social phenomena and landscape dynamics are of significant relevance in attempts to analyse the dimensions of sustainability, stability and policy implications. Reference to geographical context and scale is important in such analyses.

Three dimensions in the intricate linkages between urban expansion and water and environmental security are essential. One refers to the possibilities to augment overall supply to cater for the escalating needs and wants. With growing population size, additional supply has to be arranged from sources located outside the boundaries of the cities. A second challenge concerns the distribution and use of water within the urban areas. The difficulties to meet the basic human needs of the entire population, and the wider set of wants associated with a lure of and desire for improvements in the standard of living, and to organize the various services with regard to financial and environmental viability are, indeed, great. A third issue concerns the alarming levels and concentration of pollutants that are generated in these growing agglomerations. Water is an active solvent and will pick up a variety of substances in solid or soluble form when it passes through industrial areas, congested and contaminated streets and pavements, the human body, living quarters,

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Figure 1. Percentage of population living in urban areas in major world regions, 1950, 1975, 2000 and 2025. (a) Percentage of urban population in sub-Saharan Africa, Asia (except Japan), Latin America and the Caribbean; (b) percentage of urban population in the world, in the most developed countries and in less developed countries. (Source: UN (2000).)

etc. Impacts may be most obvious and pressing within the urban area, but downstream and 'down-wind' segments of the drainage basin will also be affected.

2. THE EMERGING URBAN MAJORITY

(a) *Growth with a regional reach*

Urban growth has implications for the size of the 'hinterland' that provides water, energy and other resources to the urban centres. Similarly, the products from the city, including its waste products, will to a smaller or larger degree affect areas and people outside the city boundaries. Small towns have a very limited regional reach, as opposed to mega-cities, which have a wide 'footprint'.

The proportion of urban residents is already high in most OECD (Organization for Economic Co-operation and Development) countries, Latin America and in North Africa and parts of the Middle East. For sub-Saharan Africa and large parts of Asia, the level of urbanization is comparatively much lower. For the latter two regions, a substantial increase in the number of urban residents and in the relative share of the national population could be expected during years to come. Whereas the average

percentage of the national population who lived in urban areas at the turn of the twenty-first century was *ca.* 35% in both Asia (excluding Japan) and sub-Saharan Africa, it is estimated that half of the total population in these two regions will be living in urban areas by 2025 (figure 1). As shown in figure 2, the growth has been astonishingly rapid for cities like Lagos, Bombay (Mumbai) and Sao Paulo (Braga 2000; Vlachos & Braga 2001) and may continue to be so.

Usually, the analyses of urban growth focus on mega-cities, i.e. cities with a population of 10 million or more. Medium-sized and small towns, of one million inhabitants or less do, however, make up a substantial portion of overall urban population. In 2000, *ca.* 28% of the urban population lived in this category of urban areas as compared with 4.3% in megacities (UN 2001). Growth rate in this category could be higher than in the megacities, and water and environmental challenges could also be significant (O'Meara 1999; quoted in UNFPA 2002). More attention needs to be directed to the importance and fate of the medium-sized and small urban centres.

Information about urban growth contains many uncertainties. Boundaries delimiting urban centres seldom include the entire urban area. At the same time, a large proportion of the residents in dense settlements may be difficult to associate with urban trades. Information about size and features in the informal, non-regulated areas is particularly deficient and often missing (Lundqvist *et al.* 2001). It is difficult to estimate the floating population, which could amount to up to one-third of the entire population (Solinger 1995). These circumstances contribute to the extra difficulties in the design of physical systems and other arrangements for water and sanitation and many other services that the people need and demand.

The rate of growth has decreased during recent years. There are indications that congestion, growing price of land in cities, pollution and environmental degradation and decay of infrastructure in combination with new communication technologies and the growth of new types of industries will contribute to a more dispersed pattern in the location of economic activities and, thus, job opportunities. For cities like Sao Paulo and Mexico City, it is observed that industries locate their new factories up to 200 km outside the cities (Gilbert 1996; Pick & Butler 1997). At the same time, it is hypothesized that macro-economic reform programmes in countries like India and globalization of national economies could accelerate urbanization.

Even if the relative increase of urban population has slowed, absolute increase is likely to be considerably higher during the coming years as compared with previous periods. Between 1975 and 2000, the annual average growth in less developed countries was 3.5% and the absolute increase 1.13 billion. For the period 2000 to 2025, the growth rate is predicted to drop to *ca.* 2.4%, i.e. a significant reduction by about a third. But since the population base is much larger now, 1.94 billion in 2000, as compared with 0.81 billion in 1975, the absolute increase of the urban population for the coming 25 years is estimated at 1.60 billion (Brockerhoff 2000).

Within a generation, the countries in the South will probably experience an increase in the urban population of about two billion, or a doubling of the urban

Figure 2. Growth of urban agglomerations, 1950–2015. (Source: UN (2000).)

population. This is a huge figure and at the same order of magnitude as the combined population of the two most populous countries in the world, i.e. India and China at the turn of the century. In 2000, *ca.* 40% of the population in LDCs were living in urban areas. It is estimated that this share will increase to 54% by 2025 (information from the United Nations Population Division; see also Brockerhoff (2000)). The previous urban minority will become the majority in LDCs in probably around 2015 and the previous rural majority will, for the first time in history, be the new minority (World Bank 2002).

As urban areas and populations expand, the demand for water, energy and other resources also expands. Increases in the supply and use of water and other resources, in combination with input of various chemicals, generate tremendous volumes of non-desirable by-products and pollution, far in excess of what can be handled and what is benignly decomposed or diluted. For the largest cities in India, the level of suspended atmospheric particles is three to five times greater than World Health Organization standards. Similarly, it is estimated that '...urban areas account for 80% of carbon emissions, 75% of all wood use and 60% of freshwater withdrawn for human uses including water for irrigated crops consumed by urban dwellers' (UNFPA 2002, p. 18).

Figures on withdrawals of water for indirect urban use illustrate a regional consequence of urbanization. Even if it is true that irrigated agriculture is the sector with the largest consumptive demand on the water withdrawn from rivers and other water bodies, a large share of its products are demanded by the urban population.

(b) Demography, economy and water

Implications from urbanization on the social and economic variables are far-reaching. Similarly, the environmental situation is very much affected by the rapid urbanization. A few statistics from India illustrate that urban demographic growth has consequences at the regional and national levels. As illustrated in table 1, the proportion of urban population in India is still comparatively small although the increase in absolute figures has

been massive during recent decades. While the percentage of the population living in urban areas has increased from *ca.* 17% to 29% during a 50 year period just after independence until the turn of the twenty-first century, the absolute increase has been between four to five times, i.e. from 62 to 290 million. It is estimated that the urban share will continue to increase to *ca.* 40% or 550 million in 2021.

In contrast to a modest level of urbanization in relative terms, the contribution of the urban sector to GDP and government revenues is significant. In 1950/1951, the urban sector contributed *ca.* 29% to GDP and the contribution is now estimated to exceed 50% and may continue to increase. It is claimed that more than 90% of government revenues are accounted for by the urban sector (S. Banerjee, personal communication). This figure should be seen in relation to the sources of the revenues and possibilities for collection. Central government revenues are basically derived from central excise and custom duties, which are from the urban sector. Personal and income tax are also primarily from urban areas as agricultural income is not taxed. Collection rates may also differ between urban and rural settings.

Growth of population and the economy is naturally associated with an increase in the demand for water. Water demand from urban areas has been comparatively low in India, while major efforts have been directed towards the expansion of the irrigation sector for most of the period after independence. The demand from irrigated agriculture continues to be high. But the concern about urban problems and the expectations that a boost of the Indian economy must come from urban sector are mirrored in expectations of a substantial increase in urban domestic and industrial water demand. Projections for 2025, as shown in table 1, are uncertain and may be overstated for industry and energy.

Even if the projections were to be true, the urban system may still only account for a quarter of the entire water demand in 2025. But it is not only the share of the total demand that is important. In regions where most of the overall availability is already harnessed, and where most of the readily available water is allocated to the irrigation

Table 1. Urban population and rate of urban expansion, economic significance of the urban sector in GDP and government revenue and level of water demand in India, 1951–2025.

(BCM, billion cubic metres. Sources: Ministry of Urban Development and Poverty Alleviation, New Delhi; S. Banerjee, personal communication. Figures on water demand and share of withdrawals: World Bank (1998) and Meinzen-Dick & Appasamy (2002).)

	1951	1981	1991	2001 ^a	2011 ^a	2025
total population (millions)	361	683	846	1012	1178	—
urban population (millions)	62	160	217	291	377	—
percentage urban of total	17.3	23.3	25.7	28.8	32.0	—
contribution of urban sector to GDP (%)	29	47	—	> 50	—	—
estimated contribution of urban sector to central government revenues (%) see text	—	—	—	> 90	—	—
level of water demand (BCM)	—	—	—	—	—	—
domestic sector ^b	—	—	—	25	—	52
industry and energy	—	—	—	67	—	228
share of total withdrawals (%)	—	—	—	17	—	27

^a Figures about population projections included in the ninth plan document (2002–2007).^b Includes both rural and urban households.

sector, the growing urban demand implies stiff inter-sector competition and often re-allocation from rural to urban uses.

(c) *Growth, poverty and water*

Macro-economic reforms, which were introduced from the beginning of the 1990s, have stimulated a rapid growth of urban economy in India and other LDCs. Livelihood conditions have improved and the poverty rate has come down, although the number is still high as a result of high rates of population growth. Widespread poverty in combination with a 'soft' legal and regulatory system (where existing laws are not adhered to, or only partially enforced) result in low salaries, poor organization of the labour force and a weak control of working conditions, environmental impacts, etc. Possibilities to hire labour on a casual basis and to run businesses with no or with limited environmental control, and low penalties for proven misconduct, contribute to a flexible and rapid economic growth. Industrial production has increased very rapidly in many countries in the absence of effective planning and with a lax regulatory system (UN 2001).

Rampant poverty, growth and degradation of water and environmental quality are often intertwined phenomena. In the non-regulated areas, poverty, water and environmental degradation and, sometimes unexpectedly, economic growth are parallel and quite intricate phenomena (Lundqvist *et al.* 2001). According to estimates by the World Bank (2002), about 837 million of the urban population lack legal title to land and thus have no formal security of housing and are largely outside the part of society, which is described and taken note of in official statistics. They are squeezed between the insecurity created by the exclusion from the formal part of society, the presence of mafia and other criminal gangs operating in these areas and harsh living conditions in a physical sense. This is the typical situation for people living in shanty towns, favelas, squatters, etc., that is, areas which in most countries are not formally recognized, nor planned for and to which the authorities only provide rudimentary services, if any at all.

Statistics about the share of urban population living under these complex and difficult circumstances are

uncertain and vary between authors. In the State of the World Population Report, it is noted that 37% of the urban residents in Africa live in 'informal settlements' while the corresponding figures for Asia are 18% and 9% for Latin America and the Caribbean, respectively. Four million out of the 10.6 million people in Rio de Janeiro are still residents of such settlements (UNFPA 2002). Other estimates suggest that the proportion of the population forced to live in this context is higher.

A conservative estimate is therefore that one-third, or perhaps up to one-half of the urban population in LDCs live in informal settlements. The fact that a fairly large part of the *de facto* population in urban areas are not counted means that urban planning in a wide sense is not possible. The dimensions of physical structures and organization of services will be ill conceived and, equally bad, the mental image of the city will be deceptive. Among other things, the inhabitants in these settlements have no or limited access to water and sanitation services from the public sector. The World Bank (2002) estimates that half of the population lacks access to water and sanitation in the poorest cities.

3. AUGMENTATION OF SUPPLY: THE FIRST DIMENSION

With the concentration of large numbers of people and economic activities to relatively small geographical areas, the provision of water has to be arranged from sources located in areas at increasing distances from the urban centres.

Long-distance transfer of water to the growing urban system is already necessary in many countries. Probably the largest scheme in this regard, the South-to-North Water Transfer Project, at a total estimated cost of £15 billion, was officially launched at a ceremony at the Great Hall of the People in Beijing on 27 December 2002 (People's Daily 2002). This project represents a new phase of giant water regulation projects on the Yangtse River. Regulation and the production of hydroelectric power had been decided earlier through the Three Gorges project. Urban water demand in China is projected to grow by 60% over the next 10 years, corresponding to an

additional 30 billion m³ or 30 km³. The increase for the industrial sector is estimated to be even higher, or almost 80 km³ (Nyberg & Rozelle 1999). Some of this volume will have to be arranged through inter-basin transfers. Forty-eight cubic kilometres of water are annually to be transferred from Yangtse River in southern China to the northern parts of the country.

Initially, by 2005, most of the transferred volumes are supposed to benefit the Shandong province, located in the downstream areas of the Yellow River basin. During the past three decades, since 1972, the lower segments of the Yellow River have been desiccated during part of the year due to land-use changes, diversions and construction of dams in the upper reaches of the river (Ongley 1999). But a major objective of the transfer scheme is to augment water supply to booming cities in the north. For Beijing and Tianjin '....the water tables will likely be drained down to bedrock within 15 years' (see <http://www.us-embassy-china.org.cn/English/sandt/SOUTH-NORTH.html>). These and other cities are supposed to receive water from the south by 2010. Possibly, the scheme will be operational by 2008, i.e. when the Olympic Games will be held in the capital.

A similar giant transfer scheme is, again, at the top of the agenda in India. The government of India has resumed a perspective plan initially formulated in 1980, to interlink 15 of the major rivers in the country. This project is scheduled to be implemented by 2016, after some years of planning, at a staggering cost of 5600 billion Indian Rupees (*ca.* US\$100 billion). A Web site has been set up to provide information about the project and to invite comments from the public (<http://wrmin.nic.in/interstate/riverlink.htm>). As compared with the transfer scheme in China, the focus does not seem to be so much to cater for the needs related to urban expansion, although the assumptions about future increases in urban water demand suggest that domestic and industrial demands may about double over the next 25 years, as shown in table 1 (Meinzen-Dick & Appasamy 2002). Already today, water sources in the vicinity of the urban centres are not sufficient to cater for aggregate demand. Part of the provision comes from rivers that pass the urban centres, but which originate in other States or areas far away. In some cases, water is conveyed from other basins. Augmenting supply to big cities, both in the north, which is comparatively well-endowed with water, and in the south, does therefore often hinge on inter-state agreements.

The quantity and quality of the supply to Delhi depends, for instance, on agreements with the State of Haryana, located upstream in the Yamuna River. This river is a major source for drinking water in Delhi but Haryana also has a strong interest in its water resources. The State of Haryana is a cradle for the introduction of the green revolution in India and it also has a booming industry. There is thus a big demand for water in the State and the river Yamuna is one of the best options in this regard. The river is also the recipient for the waste from these activities. Yamuna is also a very important source for water supply to downstream cities and communities, including the capital city, Delhi. (Narain 1999). In the south, the Krishna Project, which is intended to augment bulk supply to Chennai (formerly Madras) from the neighbouring State of Andhra Pradesh, has been completed, but

due to leakages in the open channel the quantum of flow is less than anticipated. En route to cities, some water is siphoned off by farmers and other groups. According to Price (2001), only a small proportion of water intended for drinking water purposes in Ahmedabad did reach the city. Apart from causing continuous difficulties for large segments of the population, the absence of an overall augmentation of supply to cities like Ahmedabad is that the municipality will lose even more credibility and people have to resort to alternative solutions, as will be described in § 4.

Examples from India, China and presumably many other countries, illustrate that augmenting supplies to urban centres, which may seem vital for the urban population as well as for national development objectives, can hardly be achieved without socially acceptable programmes for rural areas as well. Urban water security can therefore not be seen in isolation from basin security, i.e. what is acceptable to rural populations and interests.

4. DISTRIBUTION WITHIN URBAN AREAS: THE SECOND DIMENSION

Provided that a reasonable volume of water is available in the urban area, the distribution and actual use of water become central issues. The difficulties for the various segments of the population in gaining access to reasonable amounts of water of decent quality when and where they need it, and at costs that they can afford, is one of the major daily worries for a large fraction of the urban population. In a study of 10 cities in Africa (Senegal, Benin, Ivory Coast, Mauritania, Uganda, Kenya, Burkina Faso, Tanzania, Mali and Guinea), Collignon & Vezina (2000) found that the proportion of the population without access to municipal supplies varied from *ca.* 25% to 85%. The amount of water provided through the public sector arrangements varied from 22–100 l cap⁻¹ d⁻¹.

In relative terms, the situation is less discomfiting in other parts of the world. It is, for instance, officially claimed that 90% of the urban population in India have access to safe drinking water. But 'access' is a relative term. In most cities, availability is limited to certain hours and parts of the cities. For people living at the end of the distribution system, pressure in the pipes is low with repercussions on both quantity and quality. The amount of water that may be tapped and the period when water is accessible are reduced if pressure goes down. Low pressure and inferior quality of the distribution system also means that there will be leakages from the surroundings into the pipe. For people living in the non-regulated areas, provision through public arrangements is particularly deficient.

With intermittent supply or without access to public provisions, people have to resort to other solutions or combination of solutions. Some households invest in storage facilities at home as insurance against times when the system is not delivering. Insecurity at system level will therefore often lead to extra effort and additional costs for the citizens. For most people, it becomes necessary to purchase water from local entrepreneurs and NGOs. Operation of these providers should not be confused with the current expansion of privatization and the operation of commercial companies, who are owned and run by big

international corporations. 'Independent providers' refer to entrepreneurs who, generally, live in the area where they operate and who do this without the support or consent of the municipality.

Water from these providers is, generally, much more expensive compared with the price charged by the utility arranging public water supply. In the Vision 21 report on 'Water for People', examples from different parts of the world show that people have to pay up to 50 times more for water provided through vendors or other local arrangements (WSSCC 2000). It must, however, be recognized that differences in relative prices hide the fact that the charge by the utility is sometimes zero or negligible and seldom more than US\$1 m³. If the above comparison is made with due regard to a heavily subsidized price for some consumers, the big relative difference is less remarkable. A quite common reaction to these price differentials is nevertheless that the situation is horrendous and that the prices reveal an unscrupulous exploitation of the poor by vendors and other entrepreneurs. What is not acceptable is that the poor have to pay much more than the better-off segments of the population. The latter are seldom without access to public services and it is they who are able to benefit from the heavily subsidized public supply. As already mentioned, the situation is most problematic in the unregulated areas of the cities.

The situation is quite complicated. One part of the problem is that the municipalities have not been able to expand services in proportion to rapidly growing needs and demands. Heavy subsidies mean that the sector has a low level of autonomy and that financial and other required resources are simply not forthcoming. In many cases, the municipality has also been reluctant to extend services to areas that are not regulated, i.e. areas which are outside the formal urban area. As mentioned above, statistical information is usually lacking or is unreliable for these areas. And even if the utility would be allowed to operate in these areas, the complex, very dynamic situation and congestion in large parts of the growing urban conglomerations make it extremely difficult to organize services from a centralized agency, which has to follow certain standardized procedures (Lundqvist *et al.* 2001).

Another dimension of the problem refers to the fact that if the utility were to extend services to areas that are currently outside their domain, substantial investments and arrangements would be required. Average cost per unit of water supplied would certainly rise. If subsidies cannot be increased correspondingly, which they obviously cannot, the average citizen who relies on public supply would have to pay more. The current price differential between provisions arranged by the municipality and those arranged by independent vendors or other local entrepreneurs must therefore be viewed in a proper context.

Apart from price, there are other important differences between public systems as they operate today and independent providers. Vendors and other entrepreneurs are, generally, much more responsive to the needs and requirements of the households. They also play a role, although this is still insufficient, in the collection of rubbish. They simply have to adjust to the local situation, otherwise they would risk losing their clients. Independent providers are operating under stiff competition (from competing providers), which is not the case for the utility. They have

sometimes to pay bribes to get access to water, which partly comes from the public system, and because they operate in areas that are not officially recognized, it is risky for them to invest in technical systems that would facilitate water storage and distribution and thus reduce the cost. The reader might wonder about the opportunities for privatization, which is currently a noticeable feature in many countries? So far, it seems as though there are no good examples to show that the private sector will solve the pressing problems in the non-regulated areas and they are therefore not addressed in this article.

A typical situation is thus that one segment of the population is served by the municipality, i.e. the public sector, while another large segment of the population is served by a mixture of different providers. Based on the information in a cross-section of studies on household water provisions from the public sector and from NGOs and independent providers (Collignon & Vezina 2000), a typology of important characteristics of two principal systems is presented in table 2.

To be effective, initiatives from local entrepreneurs and NGOs need the support from authorities in terms of bulk supply of water and authorization to build certain physical structures, to get access to formal credits, to dispose rubbish, etc. For various reasons, authorities are reluctant to extend such support. For various political reasons, municipalities often create difficulties for NGOs and 'independent providers' of water and sanitation services. These operators have, for instance, no way of obtaining formal credit and if they were to invest in physical structures, there is a risk that the authorities would confiscate the installations (since legal title to the land on which the structures are built is often lacking) (Tropp 1998; Collignon & Vezina 2000; Hasan 2000; Kjellén 2001). Due to a lack of capacity and flexibility of the public system, it would be appropriate for the authorities to develop some kind of partnership with independent providers who are able to distribute water to areas and groups of people outside the reach of the public system and that, most likely, will continue to be so for the foreseeable future.

Lack of easy access to water in combination with inferior quality contributes to high rates of morbidity, premature deaths and associated human sufferings. It also reduces the ability to work, both in a profession and in the home. One sick person often requires another person to stay at home to look after them and part of the household income has to be spent on treatment. For Indian urban areas, an index showing 'disability adjusted life year' has been constructed and calculations suggest that *ca.* 30 million life years are lost annually due to poor water quality, sanitation and hygiene (S. Banerjee, personal communication). Morbidity and mortality patterns are naturally correlated with social and physical characteristics. Infant mortality rates are often four to five times higher in poorer areas compared with more affluent areas (UN 2001, p. 43).

It is sometimes argued that the unit cost to arrange water and other services is negatively correlated with density and size. Hence, if more people live in an area, it would be cheaper to supply them with services compared with a situation where the same number of people are more geographically dispersed (UN 2001). This assertion is probably true in a general sense but, with increasing

Table 2. A schematic summary of characteristics of water services as arranged by the public sector and NGOs and independent providers.

characteristics of conventional water provision as arranged by the public sector	characteristics of water services as arranged by NGOs and independent providers
fixed point of delivery, usually a stand pipe or a site where people may collect water; also individual connections to house or plot	deliveries sometimes to a neighbourhood, sometimes directly to the household, i.e. directly to the consumer
price is comparatively low as a result of heavy subsidies	price could be substantial and reflects costs associated with provision of service
quantity delivered determined through decisions taken by authority; sometimes disturbances in supply due to, e.g. power cuts	quantity delivered and sold in response to demand and affordability and could vary from day to day
no or limited incentive for people employed by authority to improve level of service	competition between providers gives the consumers possibility to influence level of service
quality the same for the entire system	quality of delivered water could vary
large volumes of unaccounted-for water	unaccounted-for water is not an issue
monthly or quarterly bills	payment on delivery
impersonal relations between authority and the people receiving water	provider and buyer often reside in same neighbourhood

density, practical problems are mounting and long-distance transfers are extremely costly. With increasing physical compactness and the lack of empty space, it is very difficult to build physical structures through which water may be conveyed but which are needed for sanitation, rubbish collection and disposal, etc. In Dhaka, for instance, a population of 6.5 million live within an area of 360 km², i.e. an average density of 18 000 persons km⁻² (McGee 2002).

In these contexts, the conventional approach is doomed to fail. Initiatives of the local organizations and entrepreneurs are probably better suited to tackle urgent tasks. With reference to experiences from the Oranji Pilot Project in Karachi, it is argued that initiatives from an NGO to deal with waste disposal in a slum area can be economically much more favourable compared with arrangements made by a centralized government agency (Khan 1996; Hasan 2000). Technical feasibility and operational security presume, however, professional technical advice from outside. Another major issue concerns the physical connections and coordination of arrangements in a part of the city: for instance, the non-regulated areas and the bulk supply to the city, the city water mains, structures for storm-water collection etc. With reference to the water supply situation in Dar es Salaam, Kjellén (2001) talks about the 'spaghettization' of physical arrangements, i.e. an increase of individual distribution lines, which are a logical result of a mixture of suppliers and providers and the lack of a clear policy and strong coordinating management system.

5. WATER AFTER USE: THE THIRD DIMENSION

Bulk water supply and also issues of social equity, i.e. the two dimensions of water security discussed above, have been 'first problems'. Authorities have been compelled to devote considerable effort to solve the immediate and daily need for water. What happens to water after it has been used is, regrettably, a poorly understood and equally poorly attended dimension. Humans cannot live without water and we want it to be without odour and

bad taste and we want it to look clean. A certain deviation from what is perceived as the ideal quality may be endured. If degradation of quality is gradual, it might not even be noted because many of the hazardous substances are not possible to see, smell or in other ways detect through human senses. In many cases, it is also difficult and expensive to make proper chemical analyses and to interpret the results of the analyses. The consequences for groundwater quality are particularly difficult to detect. In some cases, the disposal of waste into the ground is done deliberately and, over time, significant amounts of pollutants will be accumulated (Tiwari & Mahapatra 1999; Sampat 2000). Unfortunately, the risk of being detected, let alone punished, for such malpractices is small. The ground is a common pool for the disposal of a wide variety of substances emanating from economic activities and human behaviour at large. Without intention and often unknowingly, we dump various pollutants into the environment, e.g. onto the lawn, outside the house, from the car, etc.

Pollution of water is naturally growing because the ratio of withdrawals and use increases in relation to its overall availability. This third dimension of water security becomes a pressing problem in urban areas because of the high density of activities and because natural streams easily become heavily exploited. Apart from the difficulties in detecting, evaluating the level and severity of pollution and financing appropriate remedial measures, the implementation of desirable change is hampered by the fact the people who encounter the problem are generally not those who are causing them. Impacts are primarily felt by people who depend on water that has passed other areas or activities.

Health implications from contaminated water are well known. Currently, attention must also be paid to its costs in terms of reductions in economic activities and damage to ecosystems. In all of these respects, i.e. human health, agricultural and other production and ecosystem goods and services, the degradation of water quality will have an impact (Lundqvist 1998).

Because the consumptive use is comparatively low within households and in industry, the volume of waste water and effluents increases more or less in proportion to water use and as a consequence of urban demographic and industrial growth. Also, because the number of people and enterprises connected to sewers and treatment plants is low, the geographical pattern of pollution and environmental degradation initially reflects the density of settlement and type of human activity. Over time, the spatial pattern of pollution and the associated environmental change will be modified through the diffusion of pollutants and the assimilative capacity of the area to absorb or dilute the pollutants. The accumulation of pollutants and spatial pattern of the environmental change in river beds, the ground and reservoirs is the result of many interacting circumstances, such as the volume and spread of substances from various sources, their degree of persistence, water flow, chemical, biological and physical parameters, etc.

Data on the volume and types of contaminants affecting water quality are extremely scarce. Some general characteristics may indicate the situation and trend. When water passes through the household sector, its change of quality will primarily be in terms of the addition of bacteriological substances and organic waste. In addition, the use of chemicals and medical components by people, and the spraying of chemicals in living quarters, add to a complex mix of pollution from living quarters. In big cities, the aggregate load from the household sector can be substantial and may affect large areas and large numbers of people in downstream segments of the basin (see Appendix A).

A rapid growth of the industrial sector, energy and transport system in dense urban settlements represents another major factor behind increased water use, quality degradation and environmental change. Similar to the household situation, information about types and volumes of pollutants, their spread and impacts is extremely scarce. Apart from toxic substances, significant problems will occur from salts, which are added, for instance, in textile industries in connection with bleaching and dyeing processing, as described in Appendix B.

It is well known that the withdrawal of water for one sector (say irrigation) may reduce the quantity available for another use such as drinking in the same river basin, i.e. inter-sectoral competition. The same attention is not given to the impact of discharge of effluents by one user on another user. Waste water and industrial effluents generated in urban centres have significant impacts on downstream agriculture, drinking water, fisheries and natural aquatic and terrestrial ecosystems, as described in the two cases from India and China (see Appendices A and B). Regulatory agencies at best concern themselves with compliance with the standards of the particular receiving bodies. They often do not study the capacity of the receiving bodies to assimilate the cumulative waste of many units and from the aggregate urban sector, i.e. industry, households, transport and energy.

As illustrated from the case of Tiruppur (Appendix B), there is a sense of complacency about non-toxic pollutants like salts. The facile assumption is made that it is not cost-effective to reduce this component of the pollution load. This case also illustrates a common tendency to seek end-of-pipe solutions (i.e. waste treatment just before it

reaches the recipient) rather than tackling the source of pollution.

In semi-arid and arid areas, where the rivers are ephemeral, the volume of effluents and waste water forms a major fraction of the flow in the recipients. With a lack of dilution capacity of the recipients, the concentration of polluting and environmentally degrading substances is high and deposition along the watercourse is also high.

Physical structures and technological arrangements and choices are obviously increasingly important in growing urban conglomerations (Maksimovic & Tejada-Guibert 2001). It is necessary to look at both production technologies, i.e. in industry, transport system and energy sectors, and not only technical systems for treatment of the waste. Technological solutions and appropriate institutional arrangements hinge ultimately on human resources: skills, adaptation, responsibility, perceptions, motivation, etc.

Clearly there are two major options for water quality management, i.e. pollution control/prevention.

- (i) End-of-pipe treatment to remove the dissolved salts and other substances using technologies like reverse osmosis. If properly implemented, the load on recipients would be substantially reduced. Experience suggests, however, that it will be difficult to collect all effluents to treatment plants. There are likely to be 'free riders', who will benefit from being connected to a treatment plant without ever contributing to its running costs. In Tiruppur and possibly in other centres, monitoring and control are also difficult because of the large number of IETPs. Finally, the possibilities of removing some substances, i.e. TDS, through conventional treatment technologies are poor.
- (ii) Clean production technologies. In the case of bleaching and dyeing units described in Appendix B, a production technology that uses much less salt and water could be installed. So called soft-flow machines are available and could be installed by the larger units. However, smaller units may not be able to afford these technologies. There is thus a social cost associated with a switch to clean production technologies.

Cleaning-up of the affected areas, including the reservoir downstream of Tiruppur (Appendix B), is also needed if the situation is to be restored to the former condition. Natural regeneration through rainfall may help if the discharge of effluents is stopped or reduced considerably.

Last, pressure to change can come from the consumers of the product. Buyers can insist that the hosiery products of Tiruppur, or any product, should be produced without causing environmental degradation in the region. If there is sustained action by the buyers, then the producers will have no option but to take the necessary steps to control pollution and improve water and environmental quality.

6. APPROACHES FOR URBAN WATER SECURITY

A rapid expansion of the urban system has implications for water policy and management at various levels of society. At a broader level, institutional arrangements,

which go beyond the administrative boundaries of urban areas, are increasingly needed. These arrangements will naturally cover large geographical areas and a variety of water-use sectors and interest groups. Arrangements and implementing agents at lower levels are consequently necessary. Water security hinges on access and use within the various sectors and, ultimately, on the individual industries and households.

(a) Urban areas in a basin and national context

With growing numbers of people and economic activities in urban areas, water demand and use must be related to hydrological realities and to overall development objectives of society. The water cycle and the basin constitute the natural organizing principle that links the water-use sectors in one complex, interdependent system. Urban centres cannot thrive in the absence of adequate supply. But it is equally important that the downstream externalities, which are associated with the use in a particular area or sector are taken into account. A river basin approach is necessary to coordinate and integrate urban water issues with other interests in a basin.

A basin authority could deal with the links to other parts of the basin. Allocation and distribution between conflicting interests and mediation between incompatible claims that may arise due to increased competition and increased loads of pollutants are becoming urgent tasks as a result of growing pressure on finite resources. A basin authority must have the legal powers as well as the technical capability to deal with inter-sector issues. In addition, a basin authority would be a relevant agency for the establishment of a common database for hydrological and geo-hydrological information on water quantity, but also on water quality.

Water policy has been only poorly developed to tackle these issues in most countries. As a result, management has been fragmented, with different agencies responsible for urban and rural areas. Duties and work have been split between sectors, i.e. drinking water, industries, irrigation, fisheries, hydropower, etc., with little or no coordination. However, when aggregate demand exceeds what is realistically available in a basin and when the volumes of waste water and effluents seriously affect downstream interests, either in urban or rural areas, then there has to be an institutional mechanism to deal with the issue.

But as discussed above, many cities depend on inter-basin transfers, which presume negotiated agreements with jurisdictions that are outside the basin. Sometimes, national considerations and central government involvement becomes necessary.

The common denominator is that urban water security may no longer be seen as an issue only for the individual municipality. Regional and also national perspectives are essential.

(b) Access to water and actual use in urban areas

Significant challenges remain within the city. In the discussion above, two of these have been identified. One concerns the situation for the poor, who are largely outside the purview of public policy. A strategy that would facilitate the access of the entire urban population to a dependable and safe provision of water at affordable cost, is urgent. The current mixture of agents who distribute

water, i.e. public sector arrangements and a variety of independent, and, in some cases private sector providers, is not the result of a conscious urban water policy. It is rather a logical outcome of acute human needs in combination with shortcomings in the public system to extend services to a rapidly growing population.

For the poor and particularly for those who reside in non-regulated areas, local entrepreneurs and NGOs are the only options to get access to water if the members of the households cannot get it themselves. With the anticipated continued expansion of the urban population and with the track records of public agencies for water supply, it is not realistic to assume that public sector arrangements will reach the entire urban population in the foreseeable future. And there is no evidence to suggest that the commercial private sector involvement would solve the challenges in this regard.

A partnership is crucial, in particular between the municipality and the independent providers. Collaboration and coordination of efforts between the various providers and city authorities are typically missing. Physical arrangements intended to distribute water to parts of the cities should not be built independently of arrangements in the city as a whole. Similarly, the arrangements for disposal of waste water and other types of waste from one part of a city should be linked to an overall system. A physical network that links various parts of the city to a wider supply and disposal system(s) is economically sensible and would facilitate operations. It is the responsibility of the government or the municipality to make sure that proper and effective regulatory arrangements are in place to enable entrepreneurs to provide services that the utility is unable to offer by itself, which the community members need and are willing to pay for and that serve 'the common good'.

Links between local physical systems for the entire city presume, of course, suitable institutional arrangements and legal provisions to support and regulate activities in local areas and their relations to the municipality.

Another major challenge within cities concerns the massive pollution that is generated both in the household sector and in the industrial sector. A common approach has been to deal with this problem by building effluent treatment plants, i.e. an end-of-pipe solution. However, if the source of pollution is not removed or reduced, an efficient treatment would be very expensive and there is always a risk that some of the effluent will bypass the treatment plants and/or that they will not be operated as intended.

A change of production technologies is necessary, but obviously difficult, as indicated in § 5. Introduction of clean production technologies may reduce the need for labour, and thus increase levels of unemployment, especially for workers with limited skills. It may be impossible to install the new technologies in the small premises that are used today, and, as a result of these circumstances, it may require substantial investment in training and a restructuring of that part of the industrial sector. Problems do obviously vary between small and large industries. With the large numbers of units in the small-scale sector and due to their informal character, special efforts are required to deal with them. The good news is that it is often only some units within a particular

industrial sector that cause the main problem. In the case of the textile industry, for instance, it is the bleaching and dyeing operations that contribute with the main pollution load. Most of the other units involved in the various stages of the textile industry, from processing of raw material to labelling, marketing etc, are not causing major environmental problems.

(c) *A shift in attitude is crucial*

To sum up, urban water security requires a combination of new institutional arrangements and appropriate technological solutions. In both cases, the identification of effective approaches depends on human resources. Even the most well-designed technical system and the 'perfect' institution will not perform properly unless individuals who are operating the systems have the required motivation and knowledge. All parties have to recognize that water allocation and use entail trade-offs between social, economic and environmental objectives.

Mobilization and strengthening of human resources to increase water security does not only refer to the staff in municipalities and other government offices. To achieve water security in urban areas as well as in other parts of a basin, water must be everybody's business (Agarwal & Narain 1999; Cosgrove & Rijsberman 2000).

7. CONCLUSIONS

Rapid rates of urbanization in LDCs are associated with radically new challenges as well as opportunities. Safeguarding water provision to expanding urban centres requires the establishment of some varieties of basin authority and a national water policy. Such arrangements would facilitate the integration and balancing of development objectives and environmental concerns.

Poverty and environmental degradation in urban areas are perpetuated through inadequate water and sanitation services, together with the use of inferior technologies, among other things. Institutional arrangements, which could stimulate initiatives to improve services at an appropriate and affordable technical level, are among the most urgent initiatives in this regard. Reduction and containment of pollution obviously requires technical solutions, both in connection with production and at treatment plants. Similar to the other dimensions of urban security, it also presumes motivation, skills and an ability and willingness to develop and implement necessary and effective strategies, not only by the designated water managers, but by community members at large.

APPENDIX A: WATER RESOURCE LOSS FROM DOMESTIC EFFLUENTS

The Pearl River Delta Economic Zone lies within the Guangdong Province in southern China. The zone contains less than 2% of the national population but accounts for almost 7.5% of GPD. In spite of relatively ample water resources in this part of the country, the major cities have suffered from severe water shortages in recent years. Shortage is, however, not so much dictated by the availability of water in a quantitative sense, but rather due to a continuous lowering of water quality and thus a loss of the resource in

the vicinity of the economically booming centres. A combination of industrial growth and improvements in the provision of water has accelerated the volume of waste and effluents.

Between 1992 and 1998, the *per capita* discharge of domestic sewage increased from 40 m³ to 91 m³ and, in relative terms, the proportion of domestic effluents of all wastewaters generated in the Zone rose from 52 to 75%. The trend was the opposite for industrial effluents, which fell by 17%, and the rate of treating industrial effluent discharges increased by 70%. The use of fertilizers and pesticides in agriculture has also fallen. The result of these trends is a degradation of water quality in the rivers in the region, which can be translated as a loss of the resource. By calculating a water resource 'degradation coefficient' for each major city in the region, the 'degradation volume' of the water resource was estimated. The projections show that losses of the resource caused by pollution may increase from 204 to 352 million m³ from 2002 to 2010. Based on the assumption that domestic water use is 138.7 m³ cap⁻¹, the loss corresponds to the demand of 2.54 million people. With an assumed increase in average water demand and with an expected increase in population numbers, the loss from polluted rivers rises to 537 million m³ by 2020, or 3.68 million people.

The pollution is the result of a booming economy in combination with high population numbers. Pollution from industry and the surrounding agriculture was heavy during the first half of the 1990s. The rivers in the region fell from national class II and III ('clean' or 'slightly polluted') to become 'average' or 'highly polluted' in some cases even worse. Strict pollution control measures in industries have reduced pollution load from those sources, whereas the contribution from the domestic sector has continued to increase. Today, it is necessary to introduce a cross-regional coordination for an effective tackling of the water quality problems (see Zhu *et al.* (2002) and McCann (2002)).

APPENDIX B: ENVIRONMENTAL COST OF INDUSTRIAL GROWTH

Recent development in the town of Tiruppur in South India illustrates the environmental cost and social dilemmas associated with a booming industrial development. From a humble beginning in the 1930s, the hosiery industry in the city has become a true success story in terms of employment, increases in volume and in export value. From 1985 to 1999, the value of export increased from 290 to 30 170 million rupees, and more than half of the urban population make their living directly from this industry.

The phenomenal growth rate has, however, been associated with considerable consequences both in terms of increased inter-sector competition for limited water resources and in terms of pollution. The daily requirements of some 90 million litres of water per day can no longer be met from surface water sources or from groundwater in the vicinity of the city. The water that is available from wells in the city is polluted to the extent that it is discarded by all potential users in the city, including the industry. Some farmers have found it more

profitable, and easy, to sell water to industry rather than using it for agricultural purposes.

Regulation of industrial discharge is done by the TNPCB. In its decisions to allow the industry to function, the TNPCB does not study downstream impact, but merely ascertains whether effluent standards are met. For some parameters like salts and TDS, these standards have been relaxed, without giving sufficient thought to the cumulative impact. The TNPCB does not look at the issue from a river basin perspective. Similarly, the irrigation department built a dam *ca.* 30 km downstream without paying attention to the upstream discharge of industrial effluents, which were likely to flow and accumulate in the reservoir.

Pollution is naturally most directly observed and experienced by the inhabitants of the city. But ongoing studies (Nelliyaat 2003) reveal that the accumulated pollution load discharged by textile industrial units in Tiruppur comes to *ca.* 1.6 million tonnes and that 80% of this load is deposited in the Noyyal basin. Impact is particularly noted in a reservoir. Exposed to the pollution coming to the reservoir from Tiruppur, the farmers in the 20 000 acre command area have refused to use the water from the reservoir.

Complaints from farmers and other groups have contributed to increase the pressure on the industry to economize on water use and to treat effluents and/or recycle it. A significant reduction in the amount of water used per kilo of produced cloth has been recorded, from 226.5 l in 1980 to 144.8 l in 2000. Perhaps more interesting is the construction of a large number of treatment plants. Eight CETPs and 424 IETPs were constructed by 1998. It was assumed that installation of CETPs and IETPs would solve the problem. This did not occur, partly because the treatment plants were not designed to remove TDS. Since the operational cost of the plants is fairly high, and not subsidized, and since control and monitoring are weak, there is a risk that the operation of the treatment plants is not optimal in terms of environmental objectives. Figures from the TNPCB show that the treatment plants have not been effective in controlling TDS. Hence even after the plants were commissioned, the problem continues and downstream damage has not been mitigated (Appasamy 2000; Nelliyaat 2001; MSE 2002). Data were collected from TNPCB and compiled by Prakash Nelliyaat.

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GLOSSARY

- CETP: common effluent treatment plant
GDP: gross domestic product
IETP: individual effluent treatment plant
LDC: less developed country
NGO: non-governmental organization
TDS: total dissolved solids
TNPCB: Tamil Nadu Pollution Control Board