Population and Water in American Metropolises: Mexico City, New York and São Paulo*

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Abstract

The paper compares the three largest metropolitan areas of the Americas (Mexico City, New York and São Paulo), in terms of population size, growth history, density and age structure, and in terms of access to water, conflicts over the use of water, and distance from which water is transported, in order to: identify the demographic components of water availability as a limit to growth; call attention to the primacy of population mobility and distribution as central issues; assess the prospects of achieving balance between population size and access to water; and consider the case for ecological-economic zoning as a tool for sustainability.

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Introduction

The Americas, and their three largest countries, are not among the world's crisis zones in terms of water availability. The United States and Brazil, in particular, are water abundant; but even Mexico – at the national level – has reasonable water/population ratios. Their three largest metropolises, however, illustrate a crucial fact regarding population and resources: **where** population is located vis-à-vis water supplies translates into periodic or long-term crises and may be a fundamental limit to metropolitan growth. New York, São Paulo and Mexico City all grew – and continue to grow – for reasons which are not strictly tied to access to water. All now import their water from hinterlands no longer so easily available nor so politically disposed as in the past. This paper examines similarities and differences among these situations, in the search for demographic constraints on water access in the three major metropolises of the Americas.

Specifically, we ask How do **growth histories** affect current and prospective water use in the metropolis? Does growth fueled by internal vs international migration have different consequences? Does the "window of opportunity" created by rapid fertility decline in Mexico and Brazil offer any respite from water scarcity? Or is population deconcentration – some aspects of which are already visible – an imperative of sustainable development? How do demographic changes such as the increase in one-person households (reflecting changes in family structure and population aging) affect standard projections of water use per inhabitant? What is the difference in population momentum among these three metropolises and What does this tell us about the prospects for sustainability?

One of the problems in comparative urbanization is the definition of the area considered urban. Different definitions for "urban agglomeration" and "metropolitan region" are well-known. In this paper, we use the United Nations definition of urban agglomeration: "… the de facto population contained within the contours of a contiguous territory inhabited at urban density levels without regard to administrative boundaries. It usually incorporates the population in a city or town plus that in the sub-urban areas lying outside of but being adjacent to the city boundaries" (http://esa.un.org/unup).

It is important to point out that the definitions of "metropolitan region" are different for each of the cases we are examining here. In spite of the official definitions in each of

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these cases, there is no consensus among researchers in terms of the precise limits of each of the metropolises and their areas of influence.

In 1950 the population of Mexico City was 3,205,569[7] and of Sao Paulo, 2,198,096[8]. Relatively high fertility rates and internal migration produced 1970 populations of 6,889,504[9] in Mexico City and 5,885,475 in Sao Paulo. By 2000, Mexico City had reached a population of 8,605,239, while Sao Paulo had 10,398,576 inhabitants. It was, then, during the second half of the twentieth century that these two cities experienced such rapid growth, and the expansion of their built-up areas incorporated neighboring municipalities in their socio-economic dynamics, marking the rise of metropolitan regions. At this time, the Metropolitan Zone of Mexico City (ZMCM) is composed of a conurbation of 40 municipalities and the Federal District. The Metropolitan Region of São Paulo[10] (RMSP) is composed of 39 municipalities.

The case of New York is different, in that in 1950 the city already had 7,891,957 inhabitants. The consolidation of its settlement pattern and the spatial redirecting of its population, principally in the direction of suburban areas, meant that the city reached 1990 with 7,322,564 inhabitants. But the city experienced population recuperation in this decade, and by 2000 the Census showed a population of 8,085,742 inhabitants .[11] The New York City (NYC) Metropolitan Area has an area of approximately 28,000 km^2, and includes five boroughs, Long Island, most of New Jersey, southwestern Connecticut and portions of New York State's lower Hudson Valley and Catskill Mountains regions[12].

Population growth

In 1950 New York was the largest city in the world. The expressive urbanization of the second part of the 20th Century, including in Latin America, changed this situation. Table 1 shows the growth of the largest American urban agglomerations since 1950.

In Latin America, the growth of urban population was the result of two major processes. On the one hand, the population growth which resulted from the so-called "second phase" of the demographic transition. On the other hand, the transformations of rural areas, in terms of land ownership (land concentration) and of the modernization of agriculture led to the movement of vast contingents to urban areas. In this process, for example, the urban population of Brazil increased from 19 million in 1950 to 138 million in 2000.[13]

Table 1. Population evolution in the largest urban agglomerations of the Americas, 1950-2005 (millions).

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[7] DEPUALC-CELADE Data Bank.

[8] Data on the municipality of São Paulo were obtained from Fundação SEADE (http://www.seade.gov.br/).

[9] The data refer to the Federal District, according to Cenecorta (2003).

[10] Created by federal law in 1973 and regulated by state law in 1974.

[11] See http://www.census.gov/population/www/documentation/twps0027.html

12 Degaetano, A. T. A Temporal Comparison Of Drought Impacts and Responses in the New York City Metropolitan Area. Climatic Change. Volume 42, Number 3, July 1999. Pp 539 – 560.

[13] See Carmo, R. L. "Urbanização, metropolização e recursos hídricos no Brasil". In. Dowbor L. e Tagnin R. A. Administrando a água como se fosse importante. São Paulo: SENAC, 2005.

Urban Agglomeration	1950	1960	1970	1980	1990	2000	2005
Mexico City	2.883	5.012	8.769	13.010	15.311	18.066	19.013
NY-Newark	12.338	14.164	16.191	15.601	16.086	17.846	18.498
São Paulo	2.313	3.969	7.620	12.089	14.776	17.099	18.333

Source: http://esa.un.org/unup

The six-fold population increase of the last 50 years in São Paulo and Mexico City created major problems in terms of infrastructure supply, of which water treatment, sewage and garbage collection are the most significant in terms of quality of life.[14] All of these services improved over the last few decades, although sewage treatment is still far from being adequately addressed.

There are major differences in terms of population concentration in each of the urban agglomerations. Table 2 reveals the remarkable concentration of Mexican population in Mexico City, which reached a peak in the 1980´s. The same process can be seen in the United States (at a different order of magnitude), while in Brazil the relative concentration in São Paulo has remained steady over the last few decades.

Table 2. Population residing in the largest urban agglomerations of the Americas as a percentage of total population of the country, 1950-2005.

Urban Agglomeration	1950	1960	1970	1980	1990	2000	2005
Mexico City	10.4	13.6	17.3	19.3	18.4	18.3	17.9
NY-Newark	7.8	7.6	7.7	6.7	6.3	6.3	6.2
São Paulo	4.3	5.5	7.9	9.9	9.9	10.0	10.0

Source: http://esa.un.org/unup

In terms of growth rates, there is a clear tendency to decline in São Paulo and Mexico City. Despite the negative variations during the 1970´s, New York presents positive rates in the last decades.

[14] Problems associated with the rapid expansion of the São Paulo Metropolitan Área were studied by Roberto Luiz do Carmo, A água é o limite? Redistribuição espacial da população e recursos hídricos no Estado de São Paulo, doctoral thesis in Demography, University of Campinas, Campinas, 2001. Water availability in Mexico City has been studied by Haydea Izazola, "Agua y sustentabilidad en la ciudad de México," Estudios demográficos y urbanos 47, vol. 16, núm.2, mayo-agosto, México, D.F., pp. 285-320 (2001). A discussion of differences in water sevices in México City and São Paulo, and associated sócio-economic factors, may be found in Haydea Izazola and Roberto Luiz do Carmo, "México e São Paulo: expansão metropolitana, desigualdade social e a questão da água," I Congresso da Associação Latino Americana de População, ALAP, Caxambu-MG, Brasil, 18- 20 September 2004.

Table 3. Average annual growth rates in the largest urban agglomerations of the Americas, 1950-2005 (%).

Urban Agglomeration	1950-55	1960-65	1970-75	1980-85	1990-95	2000-05
Mexico City	5.53	5.67	3.96	1.62	1.84	1.02
NY-Newark	1.38	1.38	-0.39	0.29	1.04	0.72
São Paulo	5.40	6.50	4.65	2.05	1.53	1.39

Source: http://esa.un.org/unup

Population growth patterns in Mexico and Brazil are basically a function of internal migration followed by fertility decline, while New York's growth is due to the increase of international migration in recent decades. Nevertheless, the expansion of these urban areas has some points in common, one of which is the horizontal nature of this growth. Urban sprawl, a term which calls attention to the negative aspects of this growth, affects water access directly. The extension of piped water and the collection and treatment of sewage in far-flung peripheral and suburban areas competes with the improvement of services in the denser, built-up areas of the city. In Brazil, the collateral damage wreaked by the considerable discontinuities in the pace of urban growth and services includes water-borne diseases and dengue fever (mosquitoes find ideal breeding places in inadequate storage facilities in peripheries without proper supply).

Even with increasingly lower growth rates, it is important to consider the question of absolute numbers. An annual growth rate of 1% means, for each of the regions under consideration, an additional 180,000 persons per year. How to provide decent living conditions for this significant number of new city residents is a central issue. This concern does not imply any neo-Malthusian perspective, given the large number of variables involved.

Density and the spatial pattern of population distribution in the metropolis

Although there are significant differences in terms of the definition of spatial units in these metropolitan areas, the process of metropolitan expansion took place in similar ways. Expansion occurred from an initial settlement, growing to connect up to other administrative spaces, increasing the contiguously settled urban area.

The dispersed pattern of growth (urban sprawl) is clear when we analyze the territorial expansion of the metropolitan regions, examining the increase of the built-up area. All three cities have expanded their area of direct influence in this way.

There are, however, significant differences. While a horizontal pattern has prevailed in Mexico City, with expansion occurring via a predominant increase in the number of low-rise houses, in São Paulo there is a much greater verticalization, simultaneous with an expansion of the built-up area in the direction of unoccupied spaces in the metropolitan area. In these two cases, a large share of the buildings are low-income households, with their characteristic high density and poor quality of construction. Notwithstanding this prevalence, it is also common to find, especially in São Paulo, squatter settlements located in spaces near luxury buildings.[15] New York, on the other hand, has higher construction standards and an expansion characterized by the suburbanization of its higher income population.

This expansion must also be considered from the point of view of population density. Thus, while New York and São Paulo still have manageable densities, Mexico City's high levels have been a reason for concern. While in the Metropolitan Region of Mexico City population density reaches 13,000 inhabitants per km^2, in São Paulo this figure is 2,180 inhabitants per km^2; in the Brazilian context, with a national density of 20 inhabitants per km^2, this is exceptionally high.

A major component of water management in the future is the modernization of the extensive distribution system in all of these cities. Reducing the loss of water in antiquated piping is a key to meeting water needs. The lesser the extent of the urban area and the higher the density, the more viable this will be.

Water resources issues

The three urban agglomerations import water from more than 100 km to meet their water demand. Although historically the location of the original metropolitan agglomerations was related to water availability, population growth was stimulated by other factors and serious supply problems are now common.

Considering water use, it is important to point out present and potential conflicts among stakeholders of each region. In the case of New York State, 57% of freshwater withdrawals are used to supply thermoelectric power generation and 36% for public water supply[16]. In Mexico City, on the other hand, approximately 65% of water use is for household consumption, while in São Paulo, household consumption accounts for 88% of the supply. Industrial activities compete for this water.

Access to water at the household level in Mexico City and São Paulo is related to social class and these inequalities accentuate the social injustice of these societies. Conflict situations are not uncommon, especially during the drought season, when water scarcity is most dramatic. In this paper we discuss some of these situations, in an attempt to evaluate and qualify the limits placed by water availability on population growth.

In summary, the paper will compare the three largest metropolitan areas of the Americas, in terms of population size, growth history, density and age structure, and in terms of access to water, conflicts over the use of water, and distance of water transportation, in order to: identify the demographic components of water availability as a limit to growth; call attention to the primacy of population mobility and distribution as central issues; assess the prospects of achieving balance between population size and access to water; and consider the case for ecological-economic zoning as a tool for sustainability.

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[15] See Meyer, R. M. P.; Grostein, M. D. and Biderman, C. São Paulo Metrópole. São Paulo: Editora da Universidade de São Paulo: Imprensa Oficial do Estado de São Paulo, 2004.
[16] http://ny.water.usgs.gov/htmls/pub/stratplan/WSC_Strat_plan_Avail.pdf

Water: questions to be considered for each region

Water has always had an important role in the constitution and consolidation of settlements. In the case of these three cities, the proximity of water was fundamental: the Hudson River for New York; the lakes on which the Aztecs built their settlement, later Mexico City; and the importance of the Tietê River for São Paulo, which was the point of departure for the settlement of the interior of the country.

An important aspect of the discussion of water resources, however, is distribution. Distribution is irregular in space and time, with seasonality and variable cycles of drought and heavy rainfall. The variation, associated with infrastructure problems, is extremely significant for the metropolises of Latin America.

The over-use of ground water in Mexico City

At the beginning of the 20th century, 60% of the water supply was obtained from surface water and the rest from wells in the Valley of Mexico. Today, only 2% is surface water, while 68% is from the aquifer, and 30% of the total is supplied by importing water from neighboring river basins. (Legorreta, 2004). The water is transported over a distance of 127 km and pumped a thousand meters uphill to the Valley of Mexico.

The economic, environmental and social costs of this model of supply are aggravated by the over-exploitation of the aquifer. It has been calculated that only 50% of water extracted returns to the aquifer, which severely compromises the city's soil (Academia de la Investigación Científica, 1995).

In the light of this dependence on the local aquifer and on neighboring basins, the city faces a paradox. It is estimated that the basin of Mexico City receives an estimated rainfall of 210 m^3/s, the proper management of which would meet the demand of the population and of the different activities of the capital, as well as prevent regular flooding[17]. However, rainwater runoff is mixed with sewage, a situation which has been aggravated with the development of the aquifer's recharge zones. In addition to this, the losses caused by poor hydraulic infrastructure conditions are greater than one-third of supply. On the other hand, only 3 m^3/s of sewage is treated, which is insufficient for even 5% of the city's demand for water.

In 2000 the availability of water in the Metropolitan Region of Mexico City was estimated at 63 m^3/s, for a population of 18 million persons, which means an average daily availability of approximately 300 liters. This includes not only the demand of the population for its direct use, but also includes industrial and municipal use, as well as losses, which result in an availability of only 38 m^3/s. Of this total, 33% is used by industry, commerce and services, leaving 25 m^3/s for human consumption. That is, there is a per capita availability of 120 liters per day, considerably less than the recommendations of the World Health Organization (150 liters) and of the Mexico City government's estimate for meeting the needs for cooking and hygiene (196 liters). To cover these

[17] The National Water Commission estimates that the average annual precipitation is about 7 billion m^3, corresponding to 222 m^3/s, of which 80% evaporates, 11% filters into the soil and 9% is surface runoff.

minimum needs, the city would need 31 m^3/s in the first case and 41 m^3/s in the second, exclusively for human consumption.

This deficit in water availability in Mexico City, approximately 3 m^3/s, together with the complexity of its population and of the diversity of hydraulic infrastructure, leads to an unequal distribution of water, leaving the poor population in a situation of exclusion, which aggravates its vulnerability to health risks. In some marginal areas of the city, per capita consumption is between 19 and 24 liters per day, in periods of more or less regular supply by trucks. This consumption is reduced to a minimum of four liters per day in the rainy season, when road conditions hamper this service (García Lascuráin, 1995).

Legorreta (1997) estimated that consumption is 38 liters per capita per day in the poorer sectors, between 275 and 410 liters in middle class sectors, and between 800 and 1,000 liters in groups in better economic conditions. Paradoxically, the price paid by groups in the worst economic situation is substantially greater than that paid by groups in better economic situations, who enjoy piped water supply service. It has been calculated that the subsidy to consumers with piped water service represents 66% to 90% of the real cost of supply.

These data, which show the inequality existent in water supply for the population of Mexico City, are based on case studies which prevent generalizations. Census information can be fundamental for understanding the dimensions of household situations regarding supply, although it does not provide data on consumption. The 1990 census revealed that 90% of households in Mexico City had access to drinking water. However, the census information did not capture the regularity in the supply of water. The 2000 population and housing census, besides the traditional information on access to basic services, included a questionnaire applied to a 10% sample of households in the country. This questionnaire included questions on the frequency of supply, which contributes to an understanding of the problems of access by the population.

According to the sample data, in 2000 approximately 97% of the 4,385,000 households in the Metropolitan Zone of Mexico City had access to drinking water, but only 68.8% of households enjoyed inside plumbing, while 27% had outside access. The connection to the sewage collection network reached 90% of households.

The fact that households are connected to the supply network, with or without inside plumbing, does not guarantee the continuous supply of water. Of all households connected to the supply network, 83% had service every day; almost 10% had service every other day, 3% twice a week, 2.1% once a week and 2.4% sporadically.

However, there are differences in supply depending on whether households have inside plumbing or not. Almost 89% of households with inside plumbing receive water on a daily basis, versus 69% who do not have inside plumbing but receive piped water outside the home.

But even receiving water every day does not mean that supply is continuous, that is, 24 hours a day. The questionnaire included an item on the frequency of supply for all households which had daily supply (83% of the total, with or without indoor plumbing). Only 63% enjoyed a continuous supply, while 21% receive water during part of the day, and the rest (16%) did not reply. This last situation may suggest that they too did not have a constant supply.

Thus, the universe of households which have inside drinking water, every day, during the whole day, is reduced to 1,747,715 of 4,385,071 households, 40% of all households which were counted in the ZMCM. Thus the ZMCM is far from the nearly universal coverage which the overall figures, from conventional census data, suggest. The majority of the population is either partially or totally excluded from continuous supply, apart from the question of water quality.

New York City

The history of the search for water in the higher elevations of the basins of the Delaware and Hudson Rivers dates from the 19th century, with the construction of reservoirs 65 km from New York[18].

For working with the issue of water, the most adequate spatial unit would be the river basin. The basic data required for analysis of questions like population and consumption, however, are only available at the administrative level (county, state, municipality, etc.). In the case of New York, in spite of the fact that at the state level there is ample water availability, drought episodes of in recent years have created scarcity in some regions[19].

In terms of water use, considering consumptive use[20], distribution is the following: public supply (9,728,500 m^3/day), domestic use (537,528.2 m^3/day), irrigation (134,382 m^3/day) and industry (1,124,266.7 m^3/day). At the same time, is important to point out the large amount of water used for hydroelectric power generation. In a context of drought, the coincident demand for water to public supply and energy generation could induce a conflict among the demands. In the São Paulo Metropolitan Region one crisis with exactly these components happened in the year 2001.

Today, New York City has the largest unfiltered surface water supply in the world. Every day, some 4,921,033 m^3 of water from this vast system is delivered to eight million New York City residents, one million more consumers in four upstate counties and hundreds of thousands of commuters and tourists. The New York City Water Supply System includes a watershed of 5,099,68 km^2 across eight counties north and west of the City: Westchester, Putnam and Dutchess on the east side of the Hudson River and Delaware, Greene, Schoharie, Sullivan and Ulster in the Catskill Mountains, west of the Hudson.

The system's 19 reservoirs and three controlled lakes contain a total storage capacity of 2,195,537,800 m^3. The three reservoir systems were designed and built with various interconnections to increase flexibility by permitting exchange of water from one to another. This feature mitigates localized droughts and takes advantage of excess water in any of the three watersheds.

In comparison to other public water systems, New York City's system is both economical and flexible. Approximately 95% of the total water supply is delivered to the consumer by

[18] See http://www.nyc.gov/html/dep/watershed/html/history.html

[19] Degaetano (1999) discusses the 1995 drought; the state also had drought periods in 2001 and 2002.

[20] Volume of surface and underground water absorbed by agriculture, transpirated or used directly in the formation of plant tissue, plus losses to evaporation in the cultivated area, expressed as units of volume per unit of area. It also includes all activities in which the use of water causes a reduction in water resources, such as industrial or domestic consumption.

gravity. Only about 5% of the water is regularly pumped to maintain the desired pressure. As a result, operating costs are relatively insensitive to fluctuations in the cost of power. When drought conditions exist, additional pumping is required.

Under the agreements that allowed New York City to construct the water supply system, the City is required to furnish, upon request, supplies of drinking water to municipalities and water districts in eight northern counties where water supply facilities or watersheds are located.

There are more than 60 connections to the Water Supply System by upstate communities. Those connections provide an average of 454,249.2 m^3 a day to approximately 1 million people. Any connection to the City Water Supply System is made at the local community's expense. Communities pay for all water consumed at a rate on par with in-City rates.

According to Principe et all (2000) the water consumption in New York City is almost 560liters/person/day.

São Paulo: the search for water in distant regions, a sustainable strategy?

Most of the municipalities of the Metropolitan Region of Sao Paulo (RMSP) are located in the Upper Tietê basin[21]. The location of this population concentration has become a problem, in light of the location of the higher part of the basin, which means that the quantity of water available for supply is insufficient for meeting expanding needs. Differently from what happens in the ZMCM, the RMSP is supplied mostly by surface waters.

In terms of water availability, the Upper Tietê Basin suffers significant water scarcity. In the case of the metropolis, the proximity of the headwaters of the Tietê River basin means that the water available for use is insufficient for the enormous demand. The problem has been serious since the 1970s, when the Cantareira System, which imports water from the Piracicaba/Capivari/Jundiai basin, was built. This system consists in a complex of tunnels and reservoirs which transport water for more than 100 km. The urgency felt today derives from the fact that the Piracicaba/Capivarij/Jundiai basin is undergoing rapid urban growth, in addition to the growth of industrial and agricultural activities, significantly increasing the regional demand for water. In times of drought, water availability is a serious concern. In the Piracicaba/Capivarij/Jundiai basin, water availability in the dry season is 400 m^3 per person per year, while in the Metropolitan Region of Sao Paulo water availability in the dry season is on the order of 200 m^3 per person per year. For the sake of comparison, water availability in the Middle East is 450 m^3 per person per year. The situation is serious, especially in the prolonged dry season.

Total consumption of water in the basin exceeds, by a considerable margin, its own water production. The production of water for public supply is today 63.0 m^3/s, of which 31,0 m^3/s are imported from the Piracicaba River basin, located to the North of the Upper Tietê. Another 2.0 m^3/s come from other smaller reversions of the Capivari and Guaratuba Rivers. The Upper Tietê basin consumes 2.6 m^3/s for irrigation. Industrial demand is

[21] Of the 39 municipalities of the RMSP, 5 belong to neighboring basins. These municipalities outside the basin had a population of 137,000 inhabitants, according to the 2000 census, that is, only 0.8% of metropolitan population.

partly met by the public system (15% of the total distributed) and partly by using underground water of the metropolitan region itself.

Simultaneous with low water availability is considerable water loss in the water transport system. The reduction of these losses, whether in the pipelines (for which the State is responsible), or in buildings (for which consumers are responsible), would provide room for maneuver in order to support the growth of demand. The average losses in the transport of water are estimated at 40% for both Brazil and Mexico. Besides this, there is the question of the demand which exceeds what is recommended for the satisfaction of basic needs, that is, waste. For this reason, in the projections of demand carried out for the Upper Tietê Basin Plan[22], a slight reduction in consumption per capita was introduced, from today's 253 liters/person/day – including in this figure non residential consumption – to 244 liters/person/day (a reduction of 4%).

The present situation of water scarcity in the RMSP has led to a series of conflicts[23]. Among the major issues is urban consumption versus hydroelectric energy. This is the specific case of the Billings Reservoir which, although constructed in the 1920s for electric energy production, has been seen in recent decades as an alternative for supplying the RMSP. The problem is that generating energy continuously, requires pumping the polluted water of the Tietê River to Billings. However, this pumping compromises the quality of the water of the reservoir, making it unusable for urban consumption. In the last few years, pumping has been prohibited. However, the recent energy crisis in Brazil raised the issue again: every drop of water is disputed. Water legislation, which establishes that human consumption take priority in relation to other uses, has prevailed.

In terms of access to basic supply infrastructure, coverage is relatively good. In the case of treated water, according to information from the 2000 census, of the total of 4,994,933 households in the RMSP, 95.5% are in a favorable situation, i.e., they have access to the general supply system and have inside plumbing in at least one room.

The Brazilian demographic census includes an item on household characteristics in both the sample and non-sample (which is applied in all households in the country) questionnaires, which includes a set of questions on access of each household to basic services of water, sewage collection and garbage collection). This information was collected in 1970, 1980, 1991 and 2000, with little variation in the categories, which allows the comparison of changes over time in household conditions. Thus, Brazil has a reliable evaluation of service coverage. However, the census does not incorporate detailed questions on the continuity/intermittency of supply as in Mexico in 2000. There is information from the state company (Sabesp) responsible for supply in 32 of the 39 municipalities, which suggests that there is no rationing of water, due to public works in the 1990s. Nevertheless, several years of low rainfall put the system on alert, due to low levels of water in more than 300 reservoirs. This led the firm to conduct an intense campaign to reduce consumption in 2004, offering a bonus to consumers who managed to reduce their consumption by 20%. From the perspective of the firm, one of the major problems is the high consumption per person, which according to estimates for 2001, was approximately 160 liters/person/day for

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[22] The Basin Plan, elaborated by the River Basin Committee, is the legal instrument which directs the activities to be carried out in the management of water resources.

[23] These conflicts are presented in Carmo (2001).

the set of municipalities served by the firm and 200 liters/person/day in the Municipality of Sao Paulo[24]. These aggregated data do not permit a comparison with the ZMCM, although there seems to be greater water availability in the RMSP, considering the annual average. In periods of prolonged drought, the situation in the RMSP becomes critical.

As to sewage collection, census data show that of the total of 4,994,933 households in the RMSP, 81.4% are connected to the collection network, 6.2% use septic tanks, 4.9% use cesspools and 4.3% dump sewage directly into lakes or rivers.

It should be noted that many experts doubt the reliability of this information, since household members often do not know or are uncertain about the destination of sewage. Even with these reservations, this information is important.

Garbage collection reaches 98.5% of households in the RMSP, 95.6% of them by garbage trucks and 2.9% by dumpsters in the neighborhood.

This set of three services is fundamental for meeting the needs of the population, as well as for maintaining environmental quality. More detailed research, such as that carried out in Mexico, is necessary to identify the regularity and intermittency of these services.

Meeting the direct needs of the population, however, is not enough. The destination of the garbage collected at households is fundamental for environmental quality. In 16 of the 39 municipalities of the RMSP this final destination is considered inadequate[25]. That is, the risk of contamination of the region's aquifers is very serious. This situation provokes concern, in view of estimates that approximately 7.9 m^3/s (249 x 106 m^3/year) of water is extracted from the various aquifers of the Upper Tietê basin, by way of 6 to 7,000 tube wells in operation, in a universe of more than 9,000 wells which have been drilled.[26] In respect to the use of subterranean water, estimates are that 480 new wells are drilled annually, increasing withdrawals. Precise data, however, do not exist. If prices charged for treated water by water companies are maintained, this scenario will likely be amplified, considering that the investment to dig a well is relatively low and is only done once. Considering today's prices, a large-scale user can have his well amortized in little more than 8 months (without considering here the costs of maintenance).

The uncontrolled exploitation of aquifers can lead to serious problems, including loss of water, whether by over-exploitation and reduction of aquifer supplies, or by introducing contaminated water from more superficial portions of the aquifer to deeper levels, generally more protected. There is an important issue related to the use of underground water: the contamination. In the year 2005 the Environmental State Agency (CETESB) alerted about the danger of the use of the underground water, due to contamination by heavy metals.

In the same way, collecting domestic sewage does not guarantee environmental quality. Indeed, we have seen the contrary in Brazil, since a large part of sewage which is collected ends up being dumped directly into streams and rivers, with no treatment whatsoever. In the present situation, even considering the Tietê Project, which received large-scale investments, approximately 32% of the population in 2000 were still not served by sewage treatment, according to FUSP(2002). Projections suggest that the lack of service will fall to

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[24] http://www.sabesp.com.br.
[25] Source: Fundação SEADE. **Anuário Estatístico do Estado de São Paulo 2002.**
[26] Source: FUSP (2002).

17% in 2005, 10% in 2010, 8% in 2015 and 7% in 2020. In spite of the relative reduction, even in 2020, it is predicted that a population of nearly 1.4 million inhabitants will not be served, representing a very relevant proportion. Even with major investments, then, more than two decades will be needed to overcome the problem of sewage treatment. Meanwhile, rivers which could be used for water supply, such as the Tietê for example, are used as canals for the transport of sewage.

There is still one important point to be considered with respect to services: who are excluded from basic sanitary services? In a recent study, Marques et al (2004) point to the existence of 2,000 squatter settlements in the municipality of São Paulo, with an estimated population of 1.16 million inhabitants and 287,000 households. According to Census Data in the year 2000 only 49% of the households in these settlements have access to this basic service of sewage collection.

Water management initiatives

The importance of the water issues is reflected by the initiatives to face the problem in it one the metropolises.

In the case of New York, there is a negotiation evolving the City administration, upstate communities, State agencies and environmentalists. It resulted in a Memorandum of understanding that includes new Watershed Rules and Regulations, a Land Acquisition Program, Water quality Partnership Programs and an effort to improve the water quality monitoring.

In Mexico it was created by the national government the "Coordinación Regional de la Cuenca del Valle de Mexico" (Regional Coordination of Valle de Mexico River Basin). The subject of this institution is to coordinate of the policies about forests management, biodiversity and water. This integral approach has a participatory perspective of the different agents concerning the water issues.

In the case of São Paulo Metropolitan Region, there is a specific legislation about the watershed protection, since the beginning of the 1970´s. The problem is the lack of enforcement, many times due to specific sector's political interests. The occupation of protected areas had been accepted during these 30 years, and now it results in compromising of the reservoirs which supplies the metropolitan region. There are a new set of Laws, 1991 State of São Paulo Law, and 1997 Federal Law. These Laws bring new instruments for the management, as the River Basin Committees ("Comitês de Bacia Hidrográfica"), which are based on the participation of different stakeholders in decisions, and the decentralization of decisions.

Fundamental considerations regarding the sustainability

Despite the differences among the studied metropolises, there are few aspects that are common and bring preoccupations in terms of sustainability of the urban growth.

In this way, one of the most important issues is the spatial expansion of these metropolitan areas. In the cases of Mexico and São Paulo, the expansions are happen through the occupation of risk areas and environmental protected areas. On the one hand this process lead to risks for population quality of life. On the other hand this process means pressure over the watersheds and areas of aquifers recharge.

This aspect of organize the spatial expansion of the metropolises are focused for each one of the metropolises studied. The acquiring land program adopted by New York seems to be very effective. In the case of Mexico and São Paulo, a better articulation among the stakeholders is the central point to the effort to discipline the land use.

In fact, for the next few decades the population of these metropolitan areas will still growing. The old proceedings, like import water from distant regions, are not so feasible. The value of water is clearer today, what creates resistance for large transferences of water among the river basins.

In the middle term the improving in fixtures, the investments to decrease the water loss in the supply system (that reaches 40% in Mexico and São Paulo), the preservation and expansion of watershed protected areas and other practical actions, can give more time to investments (social, political and economic) in the spatial redistribution of population.

The levels of water consumption are also an important question. The very high consumption in New York City (500 liters/person/day), and very low consumption in Mexico Metropolitan Region (30 liters/person/day in some neighborhoods) led us to think about how much is enough, in terms of environmental use.

One first sign of the unsustainable situation is the conflict among different water users. The recent cases, evolving different users in the tree metropolitan regions, are point out for the urgency to find long term solutions.

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