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Who Has Access to Water? Case Study of Mexico City Metropolitan Area

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WHO HAS ACCESS TO WATER?
CASE STUDY OF MEXICO CITY METROPOLITAN AREA[1]

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INTRODUCTION

Mexico is a country of contrasts and disparities from economic, social, environmental and cultural viewpoints. With time, economic and social inequities have become increasingly more acute among the regions. While there are people with access to education, health, water, electricity, roads, infrastructural services, etc., there are many others who lack access even to the most basic services.

In terms of water resources, there is an enormous imbalance between water availability and its use. The main economic activities are concentrated in the central, northern and northwestern regions of the country, representing approximately 84 percent of the GDP, but with a per capita water availability of only 2,044 m^3/year. On the other hand, in the southeastern part of the country, where water availability is 14,291m^3/year/per capita, accounts for only 16 percent of the GDP is produced. This region has the highest rates of poverty in the country and lack most type of infrastructural development (Chiapas, Oaxaca or Guerrero states) (OECD, 2003, 2002a, CNA, 2005) (see Figure 1). This means that in the regions endowed with more natural resources, water included, poverty is more acute due to an unfortunate combination of lack of appropriate policies and institutions, which, among other issues, have affected negatively the quality of life of the local populations and the environment they live in.

At the beginning of the 20th century, approximately 80 percent of the population in Mexico lived in settlements having less than 2,500 people. However, by 2000, 60 percent of the population lived in settlements with more than 15,000 people (see Figure 2). The increase in concentration of population in urban and peri-urban areas, many of them under conditions of extreme poverty, has resulted in increased pollution and other stress on water resources and infrastructure.

[1] The author acknowledges the help of Dr. Germán Martínez-Santoyo, Director General of the Water System of Mexico City (Sistema de Aguas de la Ciudad de México) for the preparation of the paper. Dr. Juan Manuel Anguiano-Lozada, Head, Deep Sewerage, Water System of Mexico City, and Dr. Nancy Contreras-Moreno, Professor, National Autonomous University of Mexico, provided invaluable support and insightful comments on this paper. The support of Dr. Yosu Rodríguez-Aldabe, Advisor to the Director General, CentroGEO "Ing. Jorge L. Tamayo," National Research Council for Science and Technology, is also acknowledged. CentroGEO prepared several figures specifically for this analysis.

Approximately 30 million people currently live in settlements having less than 2,500 people. These heavily marginalized areas have low economic productivity, high unemployment and emigration rates, and poor access to services like education, health, clean water and sanitation. Malnutrition, low life expectancy and high mortality rate are also the highest in these areas (OECD, 2002b).

In 2005, in terms of water-related services, 89.8 percent of the population at the national level had access to drinking water and 77.6 percent to sewerage. However, more than 11 million people still lack access to drinking water and over 22 million do not have access to adequate sanitation with the rural areas generally lagging behind in terms of having adequate services (Gobierno Federal, 2005). Coverage of water supply, in the present context, refers to the population that have access to piped water in their houses or their properties, and to the population able to obtain water from other houses, properties, or from a public source. In terms of sanitation, the Mexican statistics include population connected to a public sewer and septic tank, and those discharging wastes directly to rivers, lakes or ravines. Data are not available on either quality or reliability of the services received.

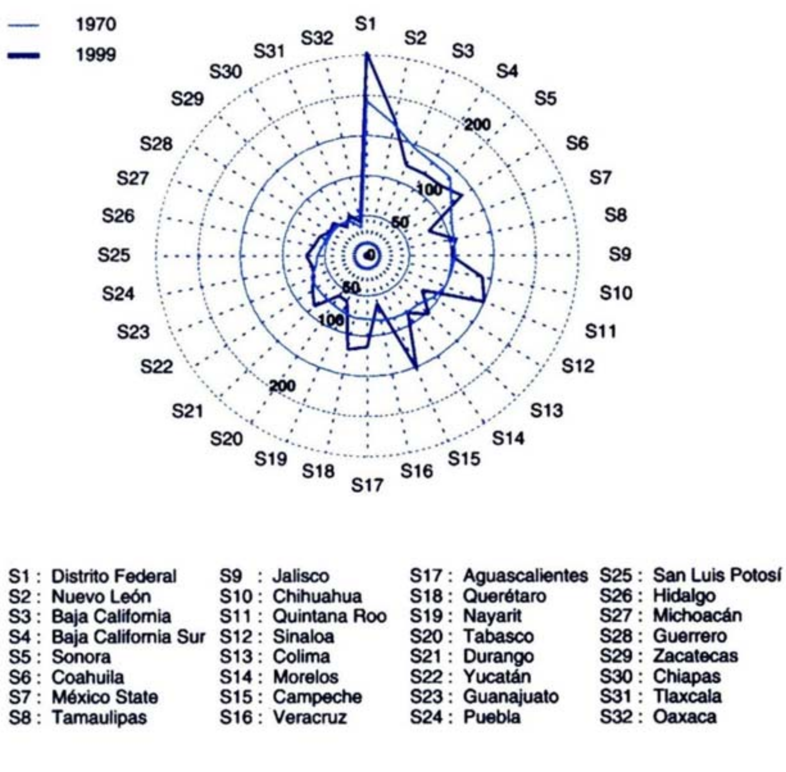

Figure 1. Gross Domestic Product for the different states of Mexico
Source: OECD, Economic Survey, Paris, 2002a

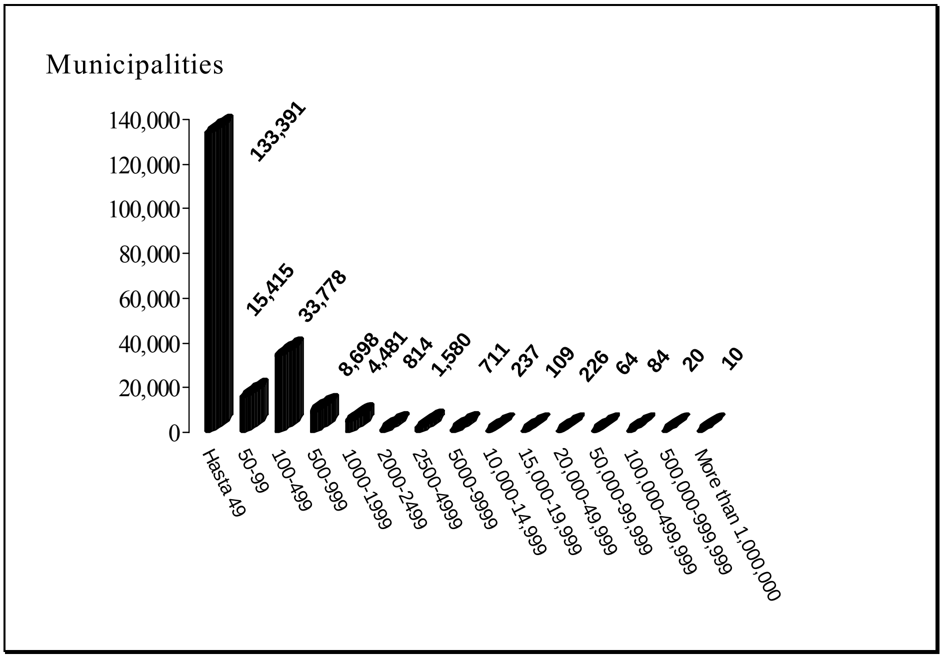

Figure 2. Population distribution in Mexico, 2000
Source: OCDE, Territorial Review for Mexico, Paris, 2002b

The increased urbanisation and high population growth within the City and the neighbouring State of Mexico, resulted in the designation of an area known as Mexico City Metropolitan Area (ZMCM, by its acronym in Spanish). This metropolitan area, with an approximate population of 20 million inhabitants and industries, services and commercial activities that generate 33.2 percent of the GDP, plays very important roles in the country, both from economic and political viewpoints (SEMARNAT/CNA 2000). It faces, however, escalating demands for services in areas like water, sanitation, electricity, education and health, among others.

MEXICO CITY METROPOLITAN AREA

Mexico City is the capital of Mexico. It is located in the Federal District at 2,240 m above the mean sea level (msl) in the southwestern part of the Valley of Mexico. It is surrounded by mountains reaching a height of over 5,000 m above msl.

At the beginning of the 20th century, Mexico City was still in the north-central area of the Federal District. However, due to increased urbanisation, its 16 boroughs cover at present its entire surface area. In fact, according to the Mexican Constitution, the Mexico City is equal at present to Federal District, and both terms refer to the same location.

At present, approximately 9 million people live in 60,203 ha of urban areas and 88,442 ha of rural or conservation areas (land that is left in its natural state, often for groundwater recharge) (see Figure 3). However, these figures do not represent the reality, since both rural and urban development have taken over great part of the conservation areas (PNUMA et al., 2003).

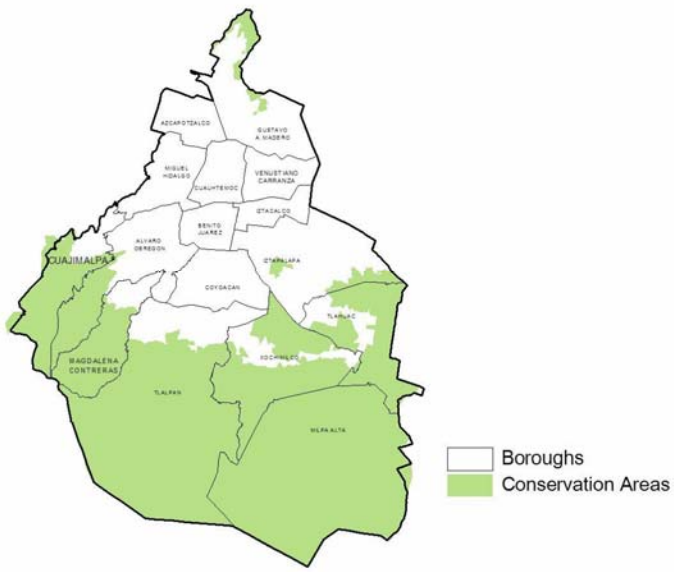

Figure 3. Conservation areas in the Federal District

Source: Centro de Investigación en Geografía y Geomática "Ing. Jorge L. Tamayo", Mexico.

The Federal Government, and much of the industries, education and employment facilities and cultural centres of the country are concentrated in this area. However, the quality of life of the population living in the metropolitan area has decreased significantly in recent years, primarily because of increasing population density, and extensive air, noise and water pollution.

In 1990, the ZMCM included the 16 boroughs of Mexico City and 27 municipalities of the neighbouring State of Mexico. In 1995, it was decided to include within the ZMCM the municipalities of the State of Mexico having the highest population as well as economic growth. At present, according to the National Council for Population (CONAPO, 2000), the metropolitan area includes the 16 boroughs mentioned above, 37 municipalities[2] of the State of Mexico and

[2] These municipalities are the following: Acolman, Atenco, Atizapán de Zaragoza, Coacalco, Cocotitlán, Coyotepec, Chalco de Díaz Covarrubias, Chiautla, Chicoloapan, Chinconcuac, Chimalhuacán, Cuatitlán de Romero Rubio, Cuautitlán Izcalli, Ecatepec de Morelos, Huehuetoca, Huixquilucan, Ixtapaluca, Jaltenco, La Paz, Melchor Ocampo, Naucalpan de Juárez, Nextlalpan, Nezahualcóyotl, Nicolás Romero, San Martín de las Pirámides, Tecámac,

one municipality of the neighbouring state of Hidalgo. However, according to the National Institute of Statistics, Geography and Informatics (INEGI), the ZMCM includes the 16 boroughs of Mexico City and 34 municipalities of the State of Mexico. The INEGI definition will be used in this report.

The ZMCM covers an area of 4,925 km^2 (1,484 km^2 in Mexico City, and 3,441 km^2 in the State of Mexico), representing about 0.25 percent of the national area. The population density varies from 13,500 to 131 persons/km^2. The State of Mexico is the most populated area in the country, with 13.1 million inhabitants, followed by Mexico City, with 8.6 million (INEGI, 2000a). The State of Mexico has also the highest population growth rate of all the states in the country, including the Federal District. During the 1990-2000 period, this state had an annual population growth rate of 2.9 percent, whereas the Federal District had an annual growth rate of 0.4 percent.

The urban growth in the ZMCM has been very rapid and unorganised, which has resulted in acute environmental deterioration, including water and air. The rapidly increasing urban settlements continue invading what used to be protected land, and land use has changed from forestry to agricultural, and finally to urban. This uncontrolled growth in the ZMCM has progressed towards both the State of Mexico and to the rural areas of Mexico City (PNUMA et al., 2003).

The expanding population, as well as the rapidly increasing industrial, services and commercial activities, have represented a formidable challenge for the institutions responsible for providing the necessary services, including water and sanitation, primarily in terms of management, investments and energy consumption. The investments have not only represented high economic costs but also high social and environmental impacts, which have become almost unmanageable (INEGI, 2001).

HISTORICAL DEVELOPMENT OF MEXICO CITY METROPOLITAN AREA[3]

The water supply and wastewater systems in the metropolitan area, as well as in any other location, cannot be analysed without considering the associated human and geographical environment. They have to be considered in relation to issues such as geography, climate, population growth, urbanisation, migration, economic development and social expectations. In the case of the ZMCM, the evolution of the management of water and wastewater systems should be seen as an integral component of a rapidly expanding metropolitan area. Therefore, an overview of the changes that have occurred in the metropolitan area during the last 65 years will provide a better understanding of the water supply and sanitation situation in the region.

In 1940, the Federal District had a population of 1.75 million people, out of which 1.6 million lived in the downtown area (what was then known as Mexico City and now includes Cuauhtémoc, Venustiano Carranza, Benito Juárez and Miguel Hidalgo boroughs). During this decade, the metropolitan area started to grow mainly as a result of increasing economic activities

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Temamatla, Teoloyucan, Teotihuacán, Tepotzotlán, Texcoco, Tezoyuca, Tlalnepantla, Tultepec, Tultitlán, Valle de Chalco, Solidaridad and Zumpango.

[3] This section is based mainly on information from National Population Council, Demographic and Urban Scenarios of the Metropolitan Area, Mexico, 2000.

in the municipalities adjacent to the Federal District.

In 1950, the metropolitan area included the then Mexico City, seven boroughs of the Federal District and two municipalities of the State of Mexico. The population was 2.9 million people, living in an urban area of 26,275 ha, with a population density of 113.5 people/ha. Population density was higher in the downtown area compared to the rest of the boroughs, which included mainly rural settlements (less than 2500 people).

During this decade, Mexico City developed primarily towards the North reaching the limits of the State of Mexico. This resulted in increasing urban activities in both sides of the border, and industrial activities primarily in this state. The National Autonomous University of Mexico was established in the southern part of the City. This was followed by progressive urban development in this area, with middle- and high-income settlements as well as industrial activities. During this period, the government of Mexico City decided not to authorise any additional housing construction. This resulted in formal and informal urban developments in the State of Mexico.

In 1960, the then metropolitan area included Mexico City, 15 boroughs of the Federal District and four municipalities in the State of Mexico. The population had increased to 5.1 million inhabitants within an urban area of 41,690 ha, which resulted in a population density of 123.66 persons/ha. This was an increase of almost 73 percent in terms of population, and more than 58 percent in urban area, in comparison with the situation in 1950.

During this decade, Mexico City, as well as the metropolitan area, changed dramatically not only due to population growth, but also due to very rapid urban, road and industrial developments. There was an explosion of planned (high-rise buildings for low- and medium-income families) as well as unplanned settlements (in areas with very complex topography, mainly in Alvaro Obregón, Iztapalapa, Gustavo A. Madero and Coyoacán boroughs). Restrictions for construction of housing continued in the Federal District, which resulted in an increasing number of informal settlements in the City.

In 1970, the metropolitan area included Mexico City, 16 boroughs of the Federal District and 11 municipalities of the State of Mexico. Population had increased to 8.6 million inhabitants and the urban area had reached 72,246 ha. Massive urbanisation took place in Mexico City. The urban land used increased by 73 percent and seven municipalities were added to the metropolitan area, which reduced the population density to 120 persons/ha. This period witnessed a massive urban explosion of both formal and informal settlements within the overall ZMCM.

In 1980, the population in the metropolitan area had increased to 13.7 million (59 percent in comparison to 1970) and the urban area by another 89,112 ha (23 percent) compared to 1970. The population density had increased to 154 persons/ha.

Between 1980 and 1990, the population in the metropolitan area increased to 15 million people and the urban area covered a total of 40,390 ha (11,306 in the Federal District and 29,084 ha in the State of Mexico), with the highest urban growth in the State of Mexico.

From 1950 to 1995, the population of Mexico City increased from 3 to 17 million people (Table 1). In contrast to the previous decades, during the 1990-2000 period, the annual population growth of Mexico City was only 0.4 percent, compared to the ZMCM, which was 2.9 percent. The main reason for the growth in ZMCM was immigration from the rural areas and from the medium- and small-size cities.

Table 1. Average population of Mexico City Metropolitan Area, 1950-1995 (millions)

	1950	1960	1970	1980	1990	1995
ZMCM	2,982,075	5,155,327	8,656,851	13,734,654	15,047,685	16,898,316
Mexico City	2,923,194	4,846,497	6,874,165	8,8831,079	8,235,744	8,489,007

Source: Demographic and urban scenarios of the Metropolitan Area of Mexico City, 1990-2010. National Population Council, CONAPO, 2000.

Throughout these decades, the population growth and the planned and unplanned urbanisation have resulted in an uneven race for the federal and the local governments to construct infrastructure and provide essential services to the population, including water supply and sanitation (Table 2). An example is the number of houses, which doubled in 50 years, with more than 1.7 million in 1990 in comparison to 600,000 in 1940.

In addition to the explosive population growth, lack of planning, financial, managerial and human constraints, political interference have also contributed to increasing difficulties to provide the basic services to the people concerned. An important issue has been how to provide clean water, sanitation and electricity to the expanding urban, industrial and service sectors of the metropolitan area, with increasingly scarce resources, both financial and natural.

Table 2. Houses with tap water and sewerage services in Mexico City, 1950-1990

	1950	1960	1970	1980	1990
Number of houses	626,262	902,083	1,219,419	1,747,102	1,789,171
Percentage of houses with tap water	45.80	54.40	63.70	69.70	71.50
Percentage of houses with sewerage	----	44.10	78.50	81.70	92.60
Average number of people per house	4.87	5.40	5.63	5.04	4.56

Source: SEN-DGE, VII Population Census, 1950; SPP-DGE, VIII and X Census of Population and Housing, 1980, 1990, 2000, in CONAPO 2000.

The main sources of water for the City have been a combination of surface and groundwater. Due to the increasing population, the extraction of groundwater became a problem as early as the 1940s, both due to increasing abstraction rates and resulting land subsidence.

In 1942, the Lerma Valley project was initiated to transfer water over a distance of 62 km to meet the increasing water demands of the metropolitan area. The first stage carried 4 m^3/s of water. With time, this volume became insufficient. Accordingly, during the 1970s and the 1980s, the Chichinautla system was constructed, the Xochimilco system was enlarged, and the volume from the Lerma River was further increased.

By the 1980s, Mexico City had a supply of water of 50 m^3/s, out of which 76 percent was for Mexico City and the balance for the municipalities in the State of Mexico which are within the metropolitan area. Historically, water supply has favoured the population of Mexico City. In 1990, even though 45 percent of the population in the metropolitan area was from the State of Mexico, they received only 35 percent of the water transported from the external sources. A higher percentage of the population in Mexico City has always received better services compared to the municipalities of the State of Mexico that have been within the metropolitan area. This gap, however, has been decreasing in recent years. The quality and reliability of the water and sewerage services varies, depending upon the physical locations of the houses as well as on the socio-economic level of the population. More people living in the high-income areas have access to services compared to those living in middle-class areas, and more than in the low-income areas.

In terms of sewerage, topography and soil characteristics of the City have made the sewerage construction (used for stormwater and wastewater) a very difficult and expensive task. From 1960, most of the budget for the city for public works was for the construction of the Deep Sewerage, which resulted in a larger number of houses receiving the service, from 44 percent in 1960 to approximately 93 percent in 2000.

Table 3 shows the access in the ZMCM to services such as electricity, water supply and sewerage. More people in Mexico City now have access to such services, compared to the municipalities in the State of Mexico that are part of the ZMCM. This is because Mexico City, being the capital of the country, is much more urbanised than the municipalities, and it has also more economic and political power.

A large number of high-income houses are not connected to the public sewer because they have been constructed on volcanic rocks, which has made it difficult and expensive to build such infrastructure. This is especially the case for many settlements in the southern part of the city, most of which have septic tanks.

Figures 4, 5 and 6 show the socio-economic conditions of the population living in the ZMCM, as well as in the areas that lack water and sewerage services. At present, no information is available for most of the municipalities in the State of Mexico, as well as most of the so-called conservation areas in Mexico City, even though there is an increasing number of people, mainly low-income, who continue to move into these areas.

The quality and extent of the services available to the population depend mainly on the level of urbanisation of the areas where they live. Thus, people living in the urban areas have access to more services compared to the population in rural areas where the services are also less reliable. Information is mostly not available from rural areas.

Table 3. Access to services in the ZMCM in urban AGEB[1], 1990

	Total	Downtown	Municipalities in State of Mexico within the Metropolitan Area	Low-income settlements	High-rise buildings	Middle-income settlements	High-income settlements	Other
Number of houses without electricity	54,048	788	6,814	40,461	3,175	3,598	704	329
Percentage of houses without electricity	**1.8%**	**1.6%**	**2.7%**	**2.1%**	**0.7%**	**0.9%**	**1.1%**	**1.7%**
Number of houses without sewerage	545,836	2,247	96,010	398,218	23,707	17,122	8,532	3,249
Percentage of houses without sewerage	**17.6%**	**4.5%**	**38.5%**	**21.1%**	**5.1%**	**4.4%**	**13.5%**	17.2%
Number of houses without tap water	1,115,262	6,486	133,878	872,222	61,026	36,341	5,309	5,932
Percentage of houses without tap water	**35.9%**	**12.9%**	**53.5%**	**46.2%**	**13.2%**	**9.3%**	**7.8%**	31.5%
Number of private houses	2,147,341	24,075	189,214	1,256,228	375,017	257,919	44,888	9,996
Number of rented houses	678,956	20,837	40,903	448,443	53,788	104,927	10,058	5,444
Percentage of private houses	69.2%	48.0%	75.7%	66.5%	81.2%	65.8%	76.0%	53.1%
Percentage of rented houses	21.9%	41.6	16.4%	23.7%	11.6%	26.7%	17.1%	28.9%

[1] Urban AGEB refers to geographical areas in settlements consisting of 2500 people or more (all municipalities are included even if population is less than 2500). Land use is for housing, industries, commercial, recreation or any other use, but not for agriculture, livestock or forest.

Source: "Resultados definitivos. INEGI, Datos por AGEB Urbana, XI Censo General de Población y Vivienda 1990. Volúmenes del Distrito Federal, Estado de México e Hidalgo. 1992. In: CONAPO, 2000.

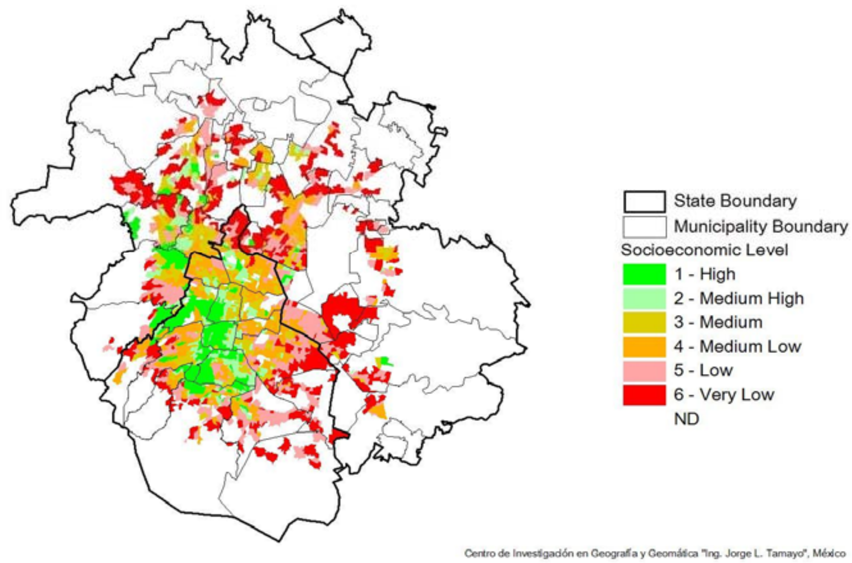

Figure 4. Socioeconomic levels of the population living in the ZMCM
Source: Centro de Investigación en Geografía y Geomática "Ing. Jorge L. Tamayo", Mexico.

The socio-economic levels are defined according to the following parameters:

- percentage of population economically active,
- percentage of population 15 years or older, with at least primary school education,
- percentage of population earning at least five times the minimum wage per month,
- percentage of private houses,
- percentage of houses with tap water, and
- number of people per room living in private houses.

Demographic and socio-economic conditions have a major influence on the overall urban growth, and land use depends on the social and economic conditions of the local population. About 67 percent of the population in the ZMCM can be considered to be in medium to low socio-economic level, about 15 percent are in high and medium to high, and 18 percent to the very low (PNUMA et al., 2003). This means that the land use of the different parts of the metropolitan area reflect the needs and the opportunities of their population. The wealthier areas have better overall living conditions and more assured access to services (e.g. access to water supply and sewerage, collection of solid wastes, schools, hospitals, road infrastructure, etc.) compared to the less wealthy areas.

In terms of access to drinking water, figure 5 shows the location of the settlements that do not have access to water in their houses.

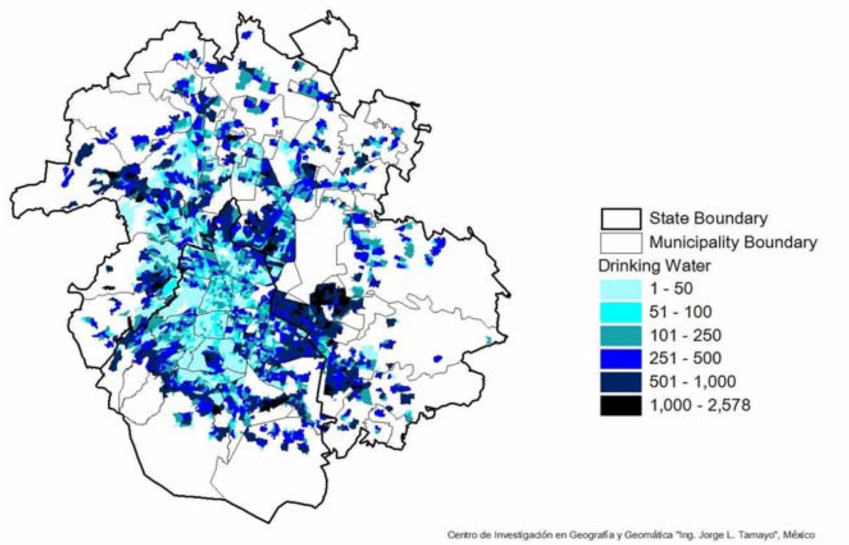

Figure 5. Distribution of houses without drinking water, ZMCM
Source: Centro de Investigación en Geografía y Geomática "Ing. Jorge L. Tamayo", Mexico.

Except for the areas from where no information is available, most of the population have access to tap water. It is important to note that this does not mean that there are no problems in terms of quality of the service or water quality. It only means that most of the houses receive water at low subsidised prices, irrespective of their socio-economic levels.

Figure 6 shows houses that are not connected to the sewer system. Not only houses exist in low-income areas without any access to sewerage, but also houses in medium and high-income areas are not connected to the sewers because of the type of soil on which the houses were constructed. This is the case for many wealthy areas in the south of Mexico City, where people rely on septic tanks, which are often not properly constructed and managed.

Even though there is no statistical information available on the living conditions of the people living in the conservation areas of the City, many of these houses do not have access to water supply and sewerage. The main reason for this is that these areas have developed very fast, and have exceeded, by far, the capacities of the governments at all levels to respond to the needs in a timely and appropriate manner.

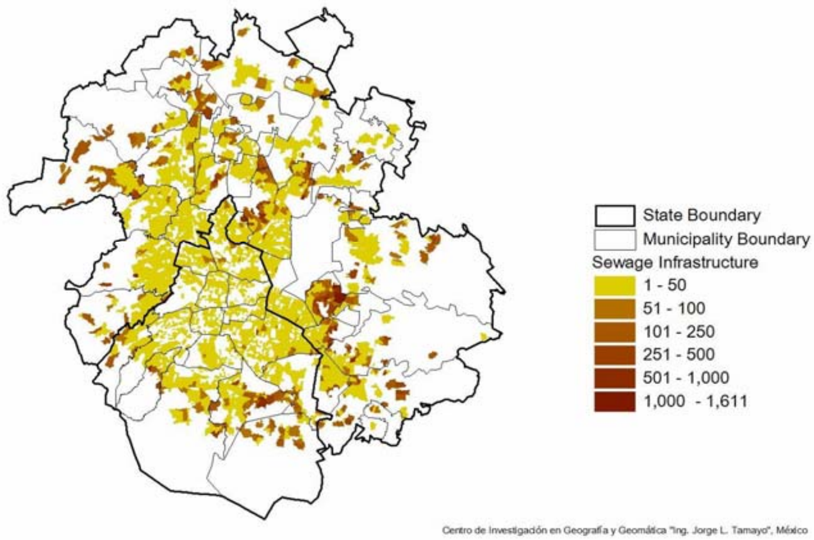

Figure 6. Distribution of houses without sewage, ZMCM
Source: Centro de Investigación en Geografía y Geomática "Ing. Jorge L. Tamayo", Mexico.

For a region having a population of more than 20 million people, which is steadily increasing, the provision of all services, including water supply and sewerage, has been a challenging task. Not all the responsibilities for water supply and sanitation should be exclusively in the hands of the different levels of governments. Population must also develop a sense of responsibility and participate actively in the conservation, protection and management of water resources, since in the final analysis, water supply and sanitation is for their own benefit and use.

CONSERVATION AREAS AND URBAN GROWTH

Conservation of the rural areas is fundamental for the water security of Mexico City since it has a direct bearing on groundwater recharge. Rural areas within Mexico City are considered to be conservation areas under the Law of Urban Development[4]. In Article 30.II, the Law defines conservation area as "the land which should be considered as such according to its location, extension, vulnerability and quality; that which has an impact on the environment and on land use planning; mountains and areas useful for the recharge of the aquifer; hills, valleys and elevations which are natural elements of the land of the City; and land for agricultural and

[4] The Law of Urban Development of Federal District was published on the Official Magazine of Federal District (Gaceta Oficial del Distrito Federal) on 29 January 1996; and on the Official Newspaper of the Country (Diario Oficial de la Federación) on 7 February 1996. It has been modified three times: on 23 February 1999 and published on Gaceta Oficial del Distrito Federal. No. 25; on 29 January 2004, published on Gaceta Oficial del Distrito Federal No. 8-TER, and on 29 January 2004, published on Gaceta Oficial del Distrito Federal No. 8-TER.

livestock activities, for fisheries, forestry, agroindustry and tourism, as well as rural settlements."

Conservation areas are under increasing threat because of steady urban growth. During 1980-2000, 76 percent (377,000 units) of the new houses that were constructed in Mexico City were located in the seven boroughs with most conservation area, mainly in Xochimilco (more than 78,000 houses) and Tlalpan (76,000). Out of the 44 rural settlements that still exist in Mexico City, 35 of them (400,000 people) are located in conservation areas.

Expansion of illegal settlements has also become a critical problem for the City. In 2003, there were 804 so-called irregular settlements with approximately 60,000 families, living in 2,400 ha of land for periods between 10 and 22 years (SMA Programa de Protección Ambiental del DF 2002-2006, in PNUMA et al., 2003). Some 80 percent of these families are in Tlalpan, Xochimilco and Cuajimalpa, and about 20 percent of them live in dangerous places such as river beds.

Land use in conservation areas is becoming increasingly urban (10.3 percent). Forests account for 34.6 percent (70 percent in Milpa Alta and Tlalpan); agriculture for 35.6 percent (more than 60 percent in Milpa Alta, Tlalpan and Xochimilco); pasture and thicket for 16.2 percent (80 percent in Tlalpan and Milpa Alta, mostly for livestock); and 0.01 percent for wetlands (PNUMA et al., 2003).

Even though there are urban land use programmes whose main objective is to control the expansion of rural and irregular settlements in conservation areas, the demand for all types of settlements has been overwhelming. It has simply surpassed any attempts by the public institutions to catch up with the demands for housing and infrastructure, and to provide appropriate services. The net result has been that people often do not have access to even basic services such as electricity, water supply and sewerage, which is especially relevant for settlements in conservation areas. Overall, the demands for housing and infrastructure by all socio-economic levels have been continually increasing. The unsustainable urban growth and inadequate management have resulted in a mounting pressure on the federal and local governments to provide more and better services. At the same time, people are now reluctant to live in a polluted and unsafe environment (PNUMA et al., 2003).

WATER AVAILABILITY

The water supply in the ZMCM depends primarily on local groundwater sources and on interbasin transfers. Mexico City, and the most populated 17 municipalities of the State of Mexico, share the same sources of water, as well as the infrastructure for water distribution.

In 2002, the volume of water supplied to the ZMCM was 2.236 MCM/day (1.200 MCM/day from 374 deep wells; 0.071 MCM/day from 18 springs only for Mexico City, and 0.964 MCM/day from 97 sources of water, such as snowmelt in the case of State of Mexico[5]) (INEGI, 2003). The second main source of water is the Lerma-Balsas and the Cutzamala River systems, which will be discussed later. It is estimated that the ZMCM receives 66 m^3/sec mainly for

[5] Figures include only the municipalities of the State of Mexico where information was available.

domestic supply, with Mexico City receiving about $35m^3$/sec and $31m^3$/sec for the State of Mexico (see Table 4). Within Mexico City, the water is distributed to the users through a primary network of 1,074 km of pipelines (with diameters of 0.5-1.83 m) and a secondary network of 12,278 km (with diameters of less than 0.50 m). The water supply system comprises of 16 dams having a total storage capacity of 2,827.90 km^3 (INEGI, 2000b). Data are not available for the municipalities in the State of Mexico.

Table 4. Water Supply Sources for Mexico City Metropolitan Area

	Federal District (m^3/s)	State of Mexico* (m^3/s)	Total (m^3/s)	Percentage
Internal sources	**20.0**	**25.2**	**45.2**	**68.5**
Wells	19.0	24.8	43.8	66.4
Springs and rivers	1.0	0.4	1.4	2.1
External sources	**14.8**	**6.0**	**20.8**	**31.5**
Cutzamala	9.9	5.0	14.9	22.6
Lerma	4.9	1.0	5.9	8.9
Total	**34.8**	**31.2**	**66.0**	**100.0**
Percentage	52.7	47.3	100.0	

* Only municipalities which are part of the ZMCM.
Source: DGCOH, 1997; CAEM, 2003. In Marañón, 2004.

In 2000, 95.3 percent of the population in Mexico City and 84.2 percent in the State of Mexico had access to water, either with a water connection directly to the house or from common faucets in the neighbourhood (INEGI, 2000a). However, most of the aquifers, springs and rivers which supply water to the ZMCM are located to its west, north and south. Thus, water supply is irregular and unreliable for the people living in the eastern part, who are also most affected by water shortages.

More than 5 percent of the people living in the metropolitan area still do not have access to water. While some of them receive water from the government in pipes, people have to pay water from private vendors. The cost of water (200 litre-containers) often represents from 6 to 25 percent of their daily salaries. Poor people who buy water from trucks pay around 500 percent times more than the domestic consumers. In addition, drinking water for much of the population in the ZMCM comes from 20-30 litre-containers of purified water, which are sold commercially. The reason for this is near universal distrust for the quality of the tap water. This means that not only people with no access to tap water spend a certain percentage of their income buying bottled water, but also people with access to tap buy containers of water which quality control leaves much to be desired. Mexico as a country is, in fact, the second largest consumer of bottled water in the world. Consumption has increased from 11.6 billion litres in 1999 to 17.7 in 2004 (Rodwan, 2004).

In terms of sewerage networks, according to the Mexico City Water System (Sistema de Agua de la Ciudad de México in Spanish), the institution responsible for water supply and sanitation services in Mexico City, in 2005, there were 2,087 km of primary sewage pipes (diameters of 0.6

m of higher) and 10,237 km of secondary network (diameters of less than 0.6 m). The extension of the network will service coverage increases.

The volume of wastewater discharged in Mexico City in 2004 was 2.260 MCM (Sistema de Aguas de la Ciudad de México, personal communication), of which less than 10 percent is treated. No information is available for the State of Mexico.

There are 25 treatment plants in Mexico City and 41 in the municipalities of the State of Mexico that are part of the metropolitan area. These 65 plants have a total installed capacity of 10,174 l/s (6,412 l/s in Mexico City and 3,763 l/s in the State of Mexico). In total, only 9 percent of the annual volume of water supplied to Mexico City is treated. The information on the volume of water treated in the State of Mexico is not available (INEGI, 2000). Nor is it known the number of treatment plants which are currently functional, or the extent to which their capacities are used.

MAIN SOURCES OF WATER FOR MEXICO CITY METROPOLITAN AREA

The ZMCM is located in the Valley of Mexico basin, which is surrounded by the basins of Lerma, Cutzamala, Amacuzac, Libres Oriental and Tecolutla Rivers (INEGI 2001). The Lerma and the Cutzamala River basins, together with the aquifer of the Valley of Mexico, are the main sources of water for the metropolitan area. The aquifer of the Valley of Mexico contributes with 70 percent, the Lerma-Balsas River basin with 9 percent and the Cutzamala River basins with 21 percent. The very few surface water bodies that still exist in the basin of the Valley of Mexico provides only 2.5 percent of water supplied (INEGI, 2000; CNA 1997, b).

Mexico Valley Aquifer

The annual rate of withdrawal from the aquifers is significantly higher than the recharge rate: 45-54 m^3/s is abstracted each year, but natural recharge rate is only about 20 m^3/s. This mismatch has resulted in a significant overexploitation, which has contributed to the lowering of groundwater table by about one metre each year. Steady lowering of the groundwater level increased the land subsidence rate, initially to 10 cm/year, and later up to 30 to 40 cm/year. The average annual subsidence rates in the area of the International Airport of Mexico City is 20-25 cm, and in the City Centre is around 10 cm. It is estimated that the central area of the metropolitan area has subsided by 10 m during the past 100 years (Gobierno del Distrito Federal et al., 2004; INEGI 2001; Legorreta et al., 1997).

However, the problems related to water supply in the metropolitan area extend well beyond the subsidence of the city. For example, the water supply and drainage systems have become not only very large and complex, but also obsolete in many areas. Provision of water services varies in the different parts of the city, tariffs are still heavily subsidised, quality of water supplied leaves much to be desired, levels of unaccounted for water is unacceptably high, and population wastes enormous amounts of water. People living in wealthy areas use up to 600 litres per capita per day, while the corresponding rate in the poor areas is about 20 litres.

Use of deep wells has resulted in increasing iron and manganese contents of water, thus decreasing water quality and making water treatment more expensive. Water infrastructure has become more vulnerable to earthquakes. Overexploitation is reducing soil moisture in the surrounding mountains, which is damaging forest covers and affecting ecosystems adversely.

A very high percentage of water is lost from the distribution networks because of leakages and illegal connections. Inappropriate overall management, aged pipes, inadequate maintenance over prolonged periods, poor construction practices and continuing land subsidence, are contributing to high levels for unaccounted for water. It is estimated that more than 40 percent of water is lost in the network due to leakages, which represents about 130 l/person/day. It is estimated that this volume of water would be enough to provide service to 4 million people (Secretaría de Obras y Servicios, 2002; UNAM, 1997).

Lerma Valley Aquifer

In 1942, the Lerma Valley project (62 km from Mexico City) was initiated to meet the steadily increasing demands of water from the metropolitan area. The first stage was planned and constructed to bring 4 m^3/sec of water to the metropolitan area. It included the construction of five wells between 50 and 308 m deep, for groundwater abstraction, and a 62 km, 2.5 diameter pipe for its distribution. This pipe is laid along the *Sierra de las Cruces*, through the 14 km long *Atarasquillo-Dos Rios* tunnel. Four tanks, 100 m in diameter, and 10 m in depth, were built in Mexico City for storage. This water is then distributed to the City by gravity. The increasing demands for water resulted in the construction of the second stage of the project. Between 1965-1975, some 230 deep wells were dug, which increased the volume of water abstracted to 14 m^3/sec. However, due to environmental impacts and social conflicts, the volume abstracted had to be reduced later to 6 m^3/sec (Legorreta et al., 1997).

The political relationship between the authorities of Mexico City and the State of Mexico have been strongly influenced by the social conflicts that have resulted from the inter-basin transfer of water from the Lerma Valley to the metropolitan area. The main interest of the Federal and the Mexico City governments has been primarily to guarantee water supply to Mexico City. As a way of compensating the local populations, small projects were constructed in the towns that were adversely affected by the water transfer project. The overexploitation of the aquifers in the Lerma area has reduced the fertility of the soils. Agriculture has now become mainly rain-fed, and not irrigated as earlier. The economy of the region and the life of the population have changed significantly (Legorreta et al., 1997).

Cutzamala System

In 1976, the “Cutzamala System” was planned to supply water to the metropolitan area from the Cutzamala River, and thus reduce the overexploitation of the Mexico Valley aquifer. The water is transferred from 60 to 154 km away, and then pumped to a height of more than 1000 m, requiring 102 pumping stations, 17 tunnels and 7.5 km of canals, which makes this project extremely energy-intensive and expensive (CNA 1997b).

Initially, what later became the Cutzamala System, was planned as a hydropower project, called Miguel Aleman Hydroelectric System. Cutzamala was started by taking advantage of the infrastructures for hydropower generation, but the planned water use was changed. Currently, only 3 m^3/s is used to generate hydropower during peak hours and to satisfy the local energy requirements for agricultural and industrial sectors (CNA, 1997b). Due to the magnitude of the project, its construction was initially planned in three stages. The first stage has been under operation from 1982 (4 m^3/s), the second from 1985 (6 m^3/s) and the third one from 1993 (9 m^3/s) (CNA no date, b). During the first stage of the project, water was brought form Victoria Dam and was distributed through a 77 km long and 2.5 m diameter aqueduct, which crosses the *Sierra de las Cruces*. The second and third stages of the project included the construction of both a water treatment plant and a central aqueduct. The implementation of these two stages was very complex mainly due to the height to which the water had to be pumped: 1,100 m. Electricity used to pump the total volume of water from the Cutzamala system only up to the treatment plant is equivalent to the energy that is consumed by the city of Puebla, having a population of 8.3 million people (Legorreta et al., 1997). An overview of the infrastructure for Cutzamala System is presented in figure 7. The elevation at which the different dams and pumping plants of the System are constructed is included.

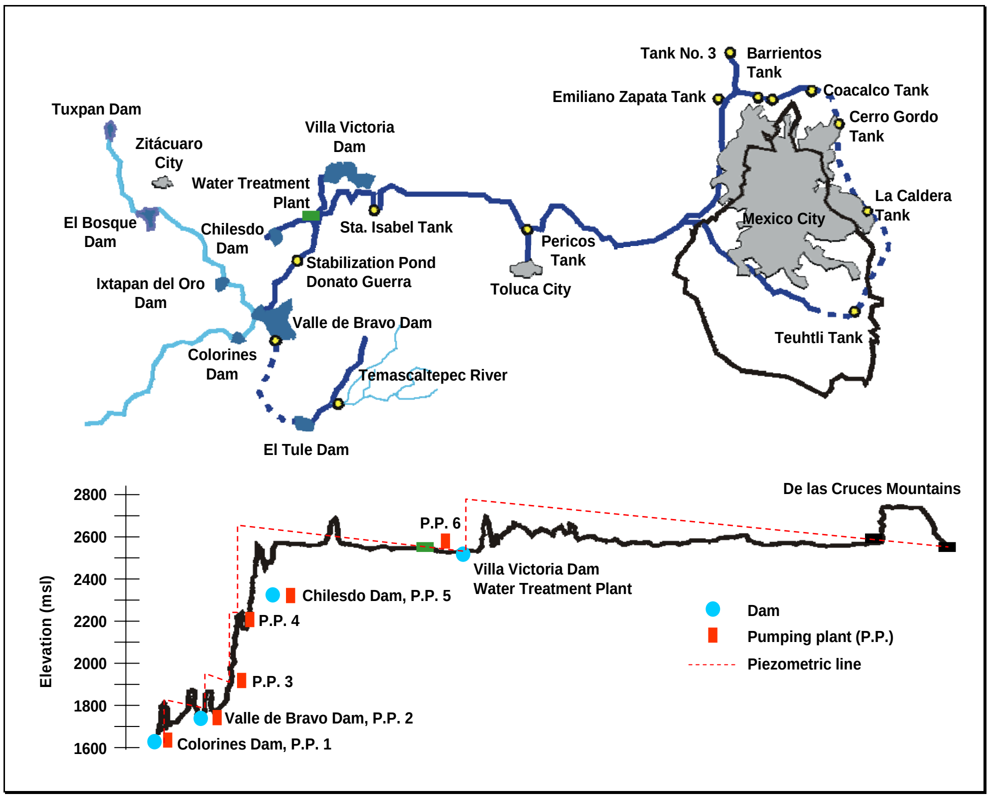

Figure 7. Overview of the Infrastructure for Cutzamala System.
Source: IMTA, 1987, Visita al Sistema Cutzamala. Boletín No. 2.
Instituto Mexicano de Tecnología del Agua, México.

In terms of investments, according to the EIA carried out for the fourth stage of Cutzalama, the total cost of the first three stages of Cutzamala was \$965 million (1996 estimates). If the estimated cost of the earlier hydroelectric plant is added, the total investment cost becomes $1,300 million. The cost of the cancelled hydropower system, having a total installed capacity of 372 Mw, has been estimated at $325 million, at an average cost of $875,000/MW. The total cost of the Cutzamala System at $1300 million (mainly construction and equipment costs) was higher than the national investment in the entire public sector in Mexico, in 1996, in the areas of education ($700 million), health and social security ($400 million), agriculture, livestock and rural development ($105 million), tourism ($50 million), and marine sector ($60 million). Up to 1994, the Cutzamala System alone represented three times the annual infrastructure expenditure of the Ministry of Environment, Natural Resources and Fisheries for 1996, which was more than $470 million (CNA, 1997b).

The annual energy requirements to operate the Cutzamala System are about 1,787 million kWh, representing an approximate cost of $62.54 million. The investment would increase significantly if the costs in personnel ($1.5 million/year) and water treatment process costs were added (CNA, 1997b). If only the operational costs for running the Cutzamala System are considered (about $128.5 million/year), supplying 600 million m^3 of water (19 m^3/s) would mean an average cost per cubic metre of water of $0.214 and an energy consumption of 6.05 kWh/m^3. Hence, the price charged to the consumers, about $0.2/$m^3$, is not enough to cover either the operational costs of the Cutzamala System, or the treatment and distribution costs of water to the metropolitan area.

In addition to the construction of the Cutzamala, about 190 so-called social projects were built for the benefit of some of the people living in the municipalities who are mostly affected by water shortages. These projects were built jointly by CNA and the communities, and consist mainly of construction, enlargement and rehabilitation of water supply and sanitation systems, as well as construction and rehabilitation of houses, schools, and farms. Equally important was the construction and the rehabilitation of roads by CNA, both for Cutzamala and the local population. The cost of these so-called social projects was estimated in 1996 to be equivalent to 5 percent of the direct investment of the Cutzamala, which would represent an additional $45 million (CNA, 1997b). A very important issue that had not been resolved as of March 2006, has been the resettlement of the affected communities due to the construction of the Cutzamala project, who after all these years, still have not received the expected compensation.

The programme on drinking water and sanitation of the metropolitan area considers the construction of a fourth stage of Cutzamala to increase the volume of water transferred to the Valley of Mexico from 0.6 km^3/year (19 m^3/s) to 0.76 km^3/year (24 m^3/s), and to treat 1.3 km^3/year (42 m^3/s) of wastewater. In 1997, the fourth stage of Cutzamala (Temascaltepec project) was to be initiated. This stage included the construction of a 120 m high dam, 743 m long at the crest. The reservoir would have a capacity of 65 millions m^3, and regulate an average flow of 5,000 l/s. The project envisages a 15 m^3/s pumping station, and construction of 18 km of canals and 12 km of tunnels (CNA, 1997b). The water would flow to the Valle de Bravo Dam through a 18.75 km long and 3.5 m diameter tunnel. According with official figures, the initial investment is estimated to be $502 million. Once the fourth stage of the Cutzamala is operational, the volume of water would increase only by 5 m^3/sec of water, from 19 to 24 m^3/sec (Tortajada, 2001).

As of March 2006, Temascaltepec project has not been started because of serious social constraints. The population of some of the villages of Temascaltepec are afraid that the construction of the tunnel will dry up springs (El Naranjo, La Huerta, El Sombrero y El Chilar) and will affect the agricultural production of the area)maize, sugar cane, banana, tomato, melon and peas). Even though the local people who would be affected by the project are against the project (El Universal, December 2005; Agua Latinoamérica, 2004; La Jornada, 15 July 2004; Legorreta et al., 1997), authorities consider the development of Temascaltepec River of utmost importance for the development, not only of Mexico City, but also of the State of Mexico as noted in the Development Plan of the State of Mexico 1999-2005 (Government of State of Mexico, 1995).

Studies have indicated for years, that if the leakages in the distribution system in the ZMCM were repaired, there would be no need to construct the fourth stage of the project. This means that the additional water supply of 5 m^3/s that is being planned with very high economic, social and environmental costs would not be necessary. However, this type of rational planning and management continues to be absent in the relevant water management institutions.

In addition to Cutzamala, the other sources of water that the Federal Government has identified for potential contribution to the water supply of the metropolitan area are the Amacuzac, Tecolutla and Atoyac Rivers (Gobierno del Distrito Federal et al., 2004). The project of the Amacuzac River would include the construction of a 185 m high and 450 m wide dam, with an inundated area of 67 km^2, and having a storage capacity of 4,000 MCM. The dam would be located in the borders between the states of Morelos, Guerrero and Puebla. Water distribution from this site to the ZMCM would require the construction of a 160 km long aqueduct, and, depending on the final design, either two pipes of 4.5 m of diameter, or three pipes of 3.5 m diameter. Water would have to be pumped to a height of 1,825 m, requiring a generating capacity of 4,000 MW. The annual electric power consumption for this system is estimated to be 5 percent of the annual national electric power production, representing 16.5 million barrels of oil per year. It is claimed that this project will make it unnecessary to abstract 50 m^3/sec of groundwater from the Valley of Mexico aquifer any more. The rational is that the groundwater would be used only during periods of severe droughts, or when the other water distribution systems were not working due to maintenance activities (CCE and CMIC, 2000).

Under these conditions, it will certainly be more economical, socially acceptable and environmentally desirable to consider first demand management practices like reduction of unaccounted for losses, water pricing and other water conservation practices, before embarking upon extremely expensive new water development projects, with high social and environmental costs. It has been estimated that each cubic meter of water from the Cutzalama River required an investment of 23 million dollars. This estimate would increase by a factor of four if the source of water were the Amacuzac River (INEGI 2001).

Governmental institutions have basically ignored in the past the potential social conflicts and disruptions that could result from interbasin water transfers. In addition, no authoritative analyses have been made on the nature of the beneficiaries and the people who may have to pay the costs. Surprisingly, even the Environmental Impact Assessment (EIA) for the fourth stage of the Cutzamala System (CNA 1997b) does not consider any social costs. As most of the EIA that are carried out in Mexico, it considers almost physical technical factors: social issues are conspicuous by their absence (Tortajada, 2001, 1999). In 2003, the government of the State of Mexico took the government of Mexico City to court and demanded a compensation of $2.2

billion due to damages caused by over-exploitation of the aquifers and excessive abstraction of water to the detriment of people in the State of Mexico. The decision of the Supreme Court was expected to set precedents for similar cases in the future. However, in October 2005, the newly elected Governor of State of Mexico publicly declared that he would withdraw the court case, since he preferred to work with the Federal and Mexico City governments to find an amicable solution.

Aqueducts: *Cutzamala-Macrocircuito* and *Cutzamala-Aquaférico*

The Federal Government, as well as the government of the State of Mexico and CNA, initiated the construction of two distribution lines in 1980 to ensure a more efficient distribution of water from the Cutzamala System. The Mexico City was constructing a water distribution system known as *"Aquaférico"* which would come from the west, and would supply water to the southern and eastern parts of ZMCM.

In the State of Mexico, the water distribution system is known as "*Macrocircuito*". It would be constructed around most of Mexico City towards the north, and would carry water to the northern, southern and eastern parts of the City (CNA no date, d,e,f). The first stage of this system was inaugurated in October 1994. Both the first and the second stages are now in operation, and provide a continuous supply of 4 m^3/s. This has benefited around 1.4 million people, with a supply of 250 l/capita/day. The operation of the third and fourth stages would increase water availability by an additional 7 m^3/s (total volume of 11 m^3/s), benefiting 4,752,000 inhabitants who live in the eastern and northern parts of the State of Mexico, with approximately 200 l/day/person (CNA, no date d,e,f; CNA, 1997c). The system includes the construction of two pipelines, having a total length of 168.28 km. This is in addition to 58.28 km of pipelines that have already been constructed. The two pipelines will require a surface area of 336.56 ha, plus 71 ha for the storage tanks (CNA, 1997c).

The total investment costs for *Macrocircuito*, between 1987 and 1997, was $78 million, while the estimated cost for the third and fourth stages (1997-2000) was expected to be about $190 million, making a total investment of $268 million. This amount represents almost half of the total public sector budget at the national level for 1995 ($563 million) in the areas of urban development, ecology and drinking water (CNA, 1997c).

The projects were expected to be completed by 2000, but so far the construction has progressed very slowly (CAEM, 2003; Reforma, 9 November 2004).

WASTEWATER MANAGEMENT

The soil of Mexico City is basically clay, and thus susceptible to compaction. Accordingly, the higher the volume of water abstracted, higher is the rate of land subsidence (CNA, 1997b). The sinking of the city has resulted in extensive damages to its infrastructure, including water supply and sewerage systems and degradation of the groundwater quality. It has also required the construction of costly pumping stations to remove wastewater and stormwater from the City.

At the beginning of the last century, the sewerage system (Great Sewerage Canal, *Gran Canal* *del Desagüe*) used to function by gravity. However, this system was disrupted by subsidence, and, by 1950, the uneven settlement of the sewerage network made it necessary to pump wastewater from the small sewerage lines to the level of the main wastewater collector of the city, thus significantly increasing both maintenance and operation costs. The Great Canal has been affected by land subsidence so much, that at present the first 20 km have lost their inclination almost totally. In addition, continually increasing population in the metropolitan area has rendered the wastewater collection and treatment capacity insufficient.

Accordingly, in 1967, a decision was taken to build another main collector for wastewaters for both Mexico City and the State of Mexico as a combined sewage and stormwater network (Deep Sewerage, *Drenaje Profundo*). A system of 60 km of sewerage interceptors and deep collectors were constructed along with a new artificial exit from the basin of Mexico in 1975. By 1997, there were 153 km of tunnels in operation. The Deep Sewerage had to be constructed up to 200 m below the ground level to ensure that it will not be affected by land subsidence (Domínguez, 2000; DGCOH, no date; 1990).

The Deep Sewerage has more than 80 interceptors and carries an average annual flow of 48 m^3/s of wastewater and 14 m^3/s of stormwater through primary and secondary networks. The primary network is 50 km long and 6.5 m in diameter, and it is connected to the secondary network, transporting municipal and industrial wastewater, and stormwater through 3.1 m to 5 m diameter tunnels (INEGI, 1999). The Deep Sewerage system stores, transports and disposes wastewater and stormwater through four artificial channels located at the northern end of the basin of Mexico. The system includes 66 pumping stations, regulatory tanks for flow control, storm tanks, 111 km of open canals, rivers which are now used for transporting wastewater, 16 dams, lagoons. The average volume of wastewater and stormwater that is discharged into the ZMCM sewerage system is 2,897 MCM (INEGI, 2001). In 2004, this was 2,260.23 MCM.

A new interceptor was constructed during 1998-2000 period for the Great Canal. It was to transport stormwater from Mexico City downtown by gravity and thus alleviate the threat of floods in this part of the City. The interceptor is a 1000 m long and 3.1 m diameter, tunnel built 20 m below the ground level, with a capacity of 35 m^3/s (DDF, no date).

Since the City is located within a naturally closed hydrologic basin, it is especially vulnerable to floods. Throughout history, artificial channels had to be constructed to take wastewater and stormwater from of the City. The rainy season in the metropolitan area is characterised by storms of high intensities over short durations. The average annual rainfall in the City is 800 mm: 500 mm in the eastern part and around 1000 mm towards the southern and western parts (Domínguez, 2000). The main collector of the Deep Sewerage was designed to carry about 200 m^3/s of water over a 45-hour period. However, it has carried up to 340 m^3/s. Such sudden fluctuations in the amounts of water that have to be drained create major operational and maintenance problems.

The floods in Mexico City can be explained due to the difference in levels between some parts of the City and the Great Canal, as well as the inability of the sewerage system to pump out all the water during the rainy seasons quickly. For example, due to the subsidence in the City, downtown is 7 m below the highest point of the Great Canal (Legorreta et al., 1997). Since the secondary sewerage network is insufficient to carry high volumes of storm and wastewater, severe problems have been encountered in those parts of the city that are above the East interceptor where the Great Canal has lost its gradient. Many times, wastewater has also flooded the streets in these areas, but for short durations.

Some 30 years ago, the Great Canal could discharge 90 m^3/s. At present, it discharges only 12 m^3/s. Due to this increasing inefficiency, the Deep Sewerage did not receive proper maintenance until 1995, when the heavily silted primary sewerage network could be cleaned. In May 2005, the Water System of Mexico City initiated monitoring activities to check the status of different sections of the main sewerage network of the Deep Sewerage, especially in terms of the infrastructure and level of siltation. The risks presented by sulphuric acid and methane to human beings were nullified by adding a chemical (*Albisol*) to reduce both the acid and the methane to negligible levels. The main findings were that the percolation of water to the tunnels was minor, that concrete of the walls of the tunnel had not deteriorated seriously, and that siltation was not serious enough to prevent water from flowing out the network system.

The 1995 Master Plans for Drinking Water and for Sewerage for the Mexico City (DGCOH, 1997a,b) outlined the different types of strategies, including infrastructure, necessary to improve the supply, storage and transportation of drinking water in the City, as well as the storage, transportation and disposal of wastewater and stormwater out of it. However, these plans also noted that, in addition to very high investment costs, infrastructure would also require several years for construction (DGCOH, 1995a,b). This means that in spite of the importance of the infrastructure as part of a water and wastewater management strategy for the Mexico City, this is not the only alternative available.

One example is the so-called “reuse” of wastewater produced in the ZMCM. The disposal of untreated wastewater has become a serious problem for the metropolitan area, especially when the high volume and the nature and levels of pollutants contained therein are considered. The problems created by the current effluent disposal practices are now affecting neighbouring areas of the region, where wastewater is discharged. This has created very significant health and environment-related problems and concerns.

Globally, ZMCM is now by far the largest single producer and exporter of wastewater that is used for agricultural purposes. From the beginning of the 20 century, wastewater from the City has been diverted to the Mezquital Valley, in the nearby state of Hidalgo, located 109 km north of Mexico City. Otherwise a semiarid region, the Valley has become an important agricultural area by using this untreated wastewater, with 110,000 ha of official and unofficial command area, and more than 50,000 water users in the different irrigation districts.

In the Mezquital Valley, the main crops grown are alfalfa and maize, representing some 60-80% of the total irrigated area. Cultivation of higher-value crops is forbidden by law due to health considerations. This practice of wastewater irrigation has provided added nutrients to soils and it has been a source of water for economic activities. However, for many years, it has also represented a very high risk to the health of not only the population who live and work in the irrigation districts, but also to the consumers (IDRC, 2002).

In 1996, the Inter-American Development Bank approved a $1.035 billion project for the Mexico Valley Sanitation Project. Unfortunately. This much-needed project did not proceed for several reasons, mainly economic and political. In 2004, the Mexico City Water System, Water Authorities from the State of Mexico and National Water Commission, were working jointly with the Inter-American Development Bank and the Japanese Bank for International Cooperation to develop the terms and references to publish three tenders to build four wastewater treatment plants. The total budget for this project was approximately $1 billion, of which IDB would contribute $365 million for the collectors system and JBIC would provide $670 million for the wastewater treatment plants (STAT-USA, 2004, available at www.stat-usa.gov/). No public information is available as to what has happened to these projects. The disturbing fact continues to be that more than 60m^3/s of wastewater continues to be discharged with no treatment whatsoever.

The continuous transfer of wastewater over a century and the excessive irrigation by the farmers to counteract its salinity, have resulted into groundwater recharge of the local aquifer. The groundwater level table has gone up and several springs have appeared, which have become a source of water for the local population. Unfortunately, no serious and reliable study is currently available on the quality of groundwater or the springs in the Valley, as well as their overall impacts on human health and the environment.

Clearly, long-term and rational planning is urgently needed in the ZMCM including an efficient systemic strategy for drinking water and wastewater management. There is an urgent need to formulate coordinated policies for the development and management of the metropolitan area as a whole. Until now, there are no signs that this is likely to occur in the near future. As the National Population Council (CONAPO 2000, p.79) has noted: “there is no long-term planning for the ZMCM in terms of urban development, including provision of services such as housing and infrastructure.” This lack of systemic planning is contributing to increasingly disorganised development of the metropolitan area, which will require a never-ending provision of services such as water supply and sanitation. In addition, technical, managerial and administrative capacities to provide such necessary services is simply not available at present.

WATER PRICING POLICIES

In the ZMCM, drinking water is charged per cubic meter and its price increases with the highest consumption levels. Within the metropolitan area, there is no uniform policy for water pricing. It is decided independently by the governments of Mexico City and the State of Mexico, and even by the few water utilities that operate in some of the municipalities in the State of Mexico.

One of the main problems for the local governments in terms of cost-recovery has been that there were, and still are, numerous water connections that are not registered, and thus consumption through them is neither recorded nor charged. In 2000, it was officially estimated that there were about 2.5 million water connections in the ZMCM: 67 percent domestic, 16 percent commercial and 17 percent industrial (INEGI, 2001). However, these figures represent only approximately 64 percent of the existing connections, the rest are illegal.

Another reason as to why water consumed is not charged in the metropolitan area is because most houses do not have meters. In fact, only 49% of the legal connections are metered. In addition, water users currently pay only 24 percent of the operational, maintenance and administration costs. It is estimated that in 1997, only 43.6 percent of water was billed at the national level (INEGI, 2000b).

In the case of the Mexico City, the local government has recognised the limitations it faces to provide water to its population. Some of the main problems that have been identified include a deficit of water availability of 3,000 l/sec; leakages of more than 30 percent because of poor conditions of the networks; unreliable water supply received by at least one million people; the number of people with no access to water is increasing; and, as of January 2004, Mexico City had not had new sources of water for the previous eight years (Gobierno del Distrito Federal, 2003).

Even though the government expects the implementation of the Stage IV of the Cutzamala System, it has acknowledged that this project, if and when it is implemented, will take several years to be completed. This situation has forced the government of Mexico City to develop an immediate strategy to improve the current situation in terms of providing drinking water to the City. The importance of using economic instruments to improve water and wastewater management is slowly being realised. Water can no longer be considered as a public good that is to be supplied by the State to all the users at highly subsidised prices. The strategy for water management currently includes legal and institutional reforms; participation of the private sector for specific activities, such as billing, meter-reading and leakage repairs; and modifications of the pricing mechanism.

A census of water users was carried out between 1994 and 1996. It included all properties and taps that existed in all 16 boroughs. Users were identified and a users´ register was prepared. In addition, water consumption were measured (which was virtually non-existent earlier) by installing meters in more than 90 percent of the properties. Even though Mexico City has not received additional volumes of water since 1995, the programmes of meter-reading and detection and repair of leaks are claimed to have saved 2.8 m^3/s of water, with which it has been possible to provide more people with drinking water (Marañón, 2005). Table 5 shows some indicators that illustrate the improvements that have been recently achieved.

In terms of perceptions of the users on the quality of water services, the main complaints are on poor water quality, reliability of the service, and pricing (Marañón, 2004). While the differences in opinions may be considered normal within such a large population, the fact remains that there is a very high percentage of poor people in the city and hence special attention has to be paid to ensure that poor people have access to water in a fair and equitable manner.

Table 5. Efficiency indicators for drinking water supply in Mexico City, 1996 and 2001

Indicators	1996	2001
Volume of water delivered	686.6 million m^3	752.2 million m^3
Volume of water produced	1,096.9 million m^3	1,087.0 million m^3
Number of meters installed	737.2 thousand	1,255.9 thousand
Number of users billed	1,477.5 thousand	1,769.1 thousand
Amount of water billed	$1.1 million	$ 3.2 million
Amount of water	$1.7 million	$ 3.8 million

that was paid		

Source: Marañón, B., 2004, Tariffs for drinking water in Mexico City, 1992-2002: Towards water demand management? In: Water pricing and public-private partnership in the water sector, C. Tortajada and A.K. Biswas (eds.) Porrua, Mexico, 61-130.

The evolution of the tariffs structure for the domestic sector is shown in Table 6.

Table 6. Evolution of domestic water tariffs, Mexico City, 1996-2002 (1996=100)

Consumption (m^3)	1996	1997	1998	1999	2000	2001	2002
10.1-20.0	100.0	96.0	81.0	82.9	76.1	72.9	73.4
20.1-30.0	100.0	172.8	169.4	162.6	149.4	143.1	144.2
240.1-420.0	100.0	293.0	275.5	292.7	306.6	319.7	322.7
420.1-660.0	100.0	582.1	613.3	653.6	684.5	714.0	720.7
660.1-960.0	100.0	978.7	1049.9	1138.1	1192.0	1243.0	1254.7

Source: Financial Codes of Mexico City, 1996-2002; and National Index of Prices for the Consumers, Bank of Mexico. In: Marañón, 2003, 2004.

For the State of Mexico, drinking water is also priced volumetrically. Prices also increase with higher consumption levels, as is the case for Mexico City. However, in some municipalities, the tariffs also vary by areas depending upon their dominant socio-economic conditions. Various socio-economic strata have been defined within each municipality, and the people at the higher strata have to pay higher charges compared to the lower strata.

The overall efficiency of water management in the municipalities that are part of the ZMCM is considered to be very low. For example, only 22.5 percent of domestic consumers pay for water as do 48.7 percent of non-domestic consumers. Furthermore, water charges in the State of Mexico are still based primarily on fixed rates. Accordingly, demand management practices have been mostly ignored by the institutions concerned. Table 7 shows selected efficiency indicators for 14 municipalities of State of Mexico, where information is available.

Overall, neither Mexico City nor the State of Mexico have carried out serious studies on tariff structures. Accordingly, pricing has played only a minor role for managing water in the ZMCM.

Table 7. Efficiency indicators for 14 water utilities in the municipalities of the State of Mexico which are part of the ZMCM, 2002

Average rate for domestic users (metered) Amount billed	$ 0.5/m^3 $ 44.5million
Average rate for domestic users (fixed rate) Amount billed	$ 0.5/m^3 $ 132.7 million
Non-domestic users (metered service) Amount billed	$2/m^3 $ 32.9 million
Non-domestic users (fixed rate) Amount billed	$4.3/m^3 $ 134.8 million

Total payment by domestic consumers	22.5 percent
Total payment by non-domestic consumers	48.7 percent

Source: Comisión del Agua del Estado de México (2002). In: Marañón, 2004.

There are many constraints to improve access to water, quality of water supplied, and overall water services. These constraints include issues like the fact that management continues to be very centralised, hierarchical and bureaucratic, pricing structures have not been properly developed, management and technical expertise available to manage water and wastewater systems are inadequate, users have very little say on how water is managed, and lack of transparency.

PARTICIPATION OF THE PRIVATE-SECTOR IN MANAGING WATER IN MEXICO CITY, 1992-2002[6]

The new strategy for water management in Mexico City was launched in 1992 as an effort to promote major structural changes. The idea was that water could no longer be considered as a public good (and, as a result, subsidised heavily by the State), but as an economic good. The institutions concerned faced a severe crisis because of deterioration of infrastructure and economic conditions, inefficiency, and a pricing system based primarily on fixed tariffs. It was also necessary to eliminate heavy subsidies because of financial reasons, and also to promote water conservation. In addition, due to economic constraints, it was not possible to expand and improve the supply to the poorest neighbourhoods. It was considered necessary to encourage private sector participation in different stages of production, distribution and sale of water (CADF, 1993:2-3).

The new strategy had two objectives: guaranteeing the water supply that the city needed for its development in an environmentally-sustainable basis, and achieving financial self-sufficiency for the system (SF, 1997:20; CADF, 1994). Both immediate and long-term measures were planned in order to achieve these two goals. The immediate measures included updating the legal and institutional frameworks, including policy formulations, decision on who would be the authority to reduce or cut off the supply under specific conditions, and charges for discharging effluents into the sewerage system (a previous charge was only one-off payment to the National Water Commission). Concurrently, control was sought over the 10,000 major users who provided more than 60 percent of the revenue of the authority (SF: 1997:23).

These measures were, however, not sufficient to achieve environmental sustainability and financial self-sufficiency. Consequently, the government had to promote two far-reaching measures which proved to be the keys to the new water strategy: water charges based on metering, and a rehabilitation programme for the distribution network to reduce leakages by 10-15 percent (SF, 1997:25; CADF, 1994). It was also considered necessary to eliminate the overlapping functions of the several institutions involved in water management, and ensure the financial self-sufficiency of the water sector in the medium term. These steps were expected to

[6] This section is based on information from Marañón, 2004 and 2005. Important literature on this topic also includes Martínez-Omaña et al., 2004; CCE and CMIC, 2000; and Chauvet-Urquidi, 1999.

contribute to better coordination between water distribution, consumption and pricing and also bring the income and expenditures of the institution in balance.

The objective was to create an institution that, either by itself or through outsourcing, would provide the essential services for drinking water, sewerage, and treatment and reuse of wastewater, in addition to efficiently operate, manage and maintain the related infrastructure (Beristain, 2002). The new institution was expected to be semi-autonomous, and manage all functions and facilities related to water. The main role of the new institution was to introduce a billing system based on metering, and bring the budget for water and sanitation into balance as quickly as possible. The private sector was to be invited to be in charge of distribution, metering, billing, customer support, and maintenance of the secondary networks. However, all these changes should have as little impact as possible on the organised labour, which were powerful groups within the institutions.

On July 14, 1992, the Mexican President issued a decree creating the Federal District Water Commission (CADF, by its acronym in Spanish) as the sole autonomous administrative body responsible for the provision of drinking water, sewerage, and treatment and reuse of wastewater (CADF, 1993). For socio-political (staff reductions and subsequent labour protests) and financial (reduction in income) reasons, a decision was taken to gradually integrate the various functions of all the institutions that were then involved on water supply and wastewater. It was thought that, in the medium term, the CADF would evolve into an institution that would manage all aspects of the service efficiently. This policy was formulated with the expectation that changing water charges from a fixed to a consumption-based one would help to modernise the management of the system and ensure greater financial self-sufficiency (Beristain, 2002).

Contracts

From the very beginning, the approach taken to promote private sector participation in Mexico City was somewhat unorthodox. The plan was for the private sector to take over gradually specific responsibilities. However, not one company was contracted for the tasks, but four. When the invitations were sent out to the private sector, no information was available on issues like the length of the network, names of the users, structure and volume of consumptions, levels of water losses, and billing and collection procedures. In the absence of such financial and operational information, contract negotiation was very difficult.

According to CADF, in order to keep the services under the City government, private sector involvement in terms of sale of infrastructures, or a long-term concession to manage them, was considered inappropriate. Instead, participation of the private sector was introduced through service contracts for specific activities over a limited period of time. The property rights to the infrastructure and the control over the introduction of a new pricing system solely remained in the hands of the City government (CADF, 1995).

The next step was to decide the extent of participation of the private companies. This was partly based on a political decision to maintain control and responsibility of the services in the public sector and partly on how the accounting, financial and operational information on the system could be improved. In order that the City government could retain the responsibility, the process used was somewhat similar to the French *affermage* system. Under this format, the government of the City would retain control and responsibility for the system, as well as property rights to the infrastructure and the authority to set tariffs (SF, 1997).

Three stages were defined in keeping with the policy of phasing in the new system. In the first stage, contracts were to be issued for the installation of meters and consumption-based billing system, as well as for preparing registers of users and connections. Ideally, this was to be done on the basis of contracts that paid fixed amounts to the private companies on the basis of each user and each connection registered, as well as each meter installed (SF, 1997).

In stage two, the contractors were to estimate costs on the basis of metering of the users, billing and updating of the registers of users and connections, and actual collection of bills. The payments to the contractors were to be based, at first, on each meter read and then billed according to actual consumption. Once adequate information was collected, payments would be determined according to a formula based on a percentage of the amount billed in each operational zone.

In the third stage, the companies were to operate, maintain and rehabilitate the secondary water networks, as well as to install systems for leak detection, both visible and invisible. Initial payment was to be by kilometre of pipeline covered, and later on, by the volume of water supplied in each specific zone. In the general contract, this form of payment was called "payment by formula"[7]. The contractors were to be paid according to a formula that established a price differential between a volume of water supplied to the contractor and the income generated by the distribution of that volume of water at the proposed tariffs in the specific area. The companies would operate and maintain the distribution system. If they failed, they would lose income because of non-payment by the users, and their costs would increase whenever there were leakages. This approach was expected to promote efficiency. The overall objective was to provide an improved service to the users and to encourage efficient and rational use of water. The price at which water was supplied to the contractor, and the difference between the supply and the prices, was to be determined once enough information was available on operational costs, extent of leakages, and levels of payment after a certain period during which the system was operational (SF, 1997).

Another factor to note is the use of four companies rather than one. This was because of social and political reasons, which were claimed to outweigh the economic rationale. The finance department of the City claimed that, although in theory there could be a different contractor for each of the stages envisioned, efficiency incentives could be maximised by making one contractor responsible for all of them. This would ensure that the contractor would have a major incentive to install meters properly and promptly, and read them accurately so that their profit could be maximised. Finally, for strategic reasons, the City was divided into four zones (Number 5 of the subsection of Chapter III of the General Bases of Tender). The reasons for this decisions were as follows: a) should one of the companies was unable to fulfil the contract conditions, any one of the other three would be immediately available to take over, thus reducing the monopoly power of each contractor; b) risks of collusion among contractors would be reduced, since there would be less chance for indulging in non-competitive practices; c) work could go on

[7] The manner in which contractors were to be paid in each stage is described in The General Bases of Tender, clause four, section 4.6. Payments Formula are described in pages 34 and 35, subheading 4.6.3.1.

simultaneously in the four areas where the potential for revenue generation was the greatest, thus increasing cash flow; d) four zones could be assigned without the need to pay a surcharge for areas having less than 250,000 connections; and e) the system would help to develop four good companies that would increase competition at the national level.

The areas on which the City was divided were decided on the basis of a lineal programming model. The boroughs assigned to each bidder bordered on each other, thus facilitating full coverage. Areas having the greatest potentials were assigned to all the four different groups so that they could start working at the same time, and generate higher cash flows. The areas would be roughly similar in terms of the number of connections and the overall value of the contracts (SF, 1997). Finally, the contracts were expected to promote competition among the companies and ensure efficient water management in the City.

Funding for the project came from the budget of the City government. In order to obtain the best possible financial terms, CADF made an agreement with the National Bank of Public Works and Services (BANOBRAS in Spanish), which made the Bank an agent to pay for the obligations of the City government under the contract. BANOBRAS agreed to make the payments (C. Casasús, *Construcción*, 1993:31, cited by Martínez-Omaña, 2002:182). The financial impact of replacing a system of fixed charges with one based on actual consumptions required an investment of $152 million in 1992, and close to $3 billion in 1994 (CADF, 1993: 11, cited by Martínez-Omaña, 2002, 182-183). "However, as established in the general contract, the contractors had to offer the City government financing for the activities of the first stage. The payments of the contractors for the work carried out were to be made bimonthly, consistent with the progress made in metering" (C. Casasús, CADF, Bases generales de licitación, contrato general, 1993)". The contractors were also responsible for detecting visible and invisible leaks (Martínez-Omaña, 2002).

Tender and Selection of Companies

The process to initiate private sector participation was initiated in November 1992, when the tender was published. The tender stipulated that bids could be submitted only by companies in which a majority of capital was under Mexican control. By February 1993, seven bids were received. Rather than accepting the most attractive offer, a decision was taken to divide the City into four zones. The general contracts were signed during the last quarter of 1993, followed by the specific first-stage contracts in May 1994, when fieldwork began. The second-stage contracts were signed in November-December 1994. The decision to divide the City into four zones was taken *after* the companies had submitted their bids. This was because senior members of the City government expressed serious concern over handing the responsibility for water supply to one single company. They were afraid that this might lead to a private sector monopoly.

In accordance with the new scheme, 16 boroughs were divided into four zones as follows. Contract details can be seen in Table 8.

- Zone A: Gustavo A. Madero, Azcapotzalco and Cuauthémoc boroughs, with an estimated 298,557 connections.
- Zone B: Benito Juárez, Coyoacán, Iztacalco and Venustiano Carranza, with an estimated 257,825 connections.

- Zone C: Iztapalapa, Tláhuac, Xochimilco and Milpa Alta, with an estimated 327,408 connections.
- Zone D: Tlalpan, Magdalena Contreras, Álvaro Obregón, Cuajimalpa y Miguel Hidalgo, with an estimated 263,789 connections.

Table 8. Contract details, 1994

Zone	Consortium	Partners	Boroughs	No. of connections
A	SAPSA	ICA CIE. Generale Des Eaux BANAMEX	Gustavo A. Madero, Azcapotzalco and Cuauhtémoc	298,557
B	IASA	Socios Ambientales de Mexico (SAMSA) SEVERN TRENT	Benito Juárez, Coyoacán, Iztacalco and Venustiano Carranza	257,825
C	TECSA	Bufete Industrial BANCOMER Lyonnaise Anglian Water	Iztapalapa, Tláhuac, Xochimilco and Milpa Alta	327,408
D	AGUAMEX	GUTSA Northwest Water	Tlalpan, Magdalena Contreras, Álvaro Obregón, Cuajimalpa and Miguel Hidalgo	263,789

Source: CADF, 1994.

According to the tender requirements, each company had to present a proposal addressing the following four areas:

- Client services, including meter reading, billing and customer services. This was to be done through offices in each of the boroughs, where users could apply to be connected or disconnected, change meters, etc. In addition, telephone call centres were to be established.
- Support services, including expertise. The responsibility of this area was to provide quality control and ensure that the procedures in use were always the best possible.
- Contracts and technical services. This included carrying out a census of users, registering meters and updating information on the networks.
- Operations. This would include meter maintenance (during the second stage) and detection of leaks and repairs for the pipelines (Martínez-Omaña, 2002).

Implementation of the general contract was delayed for a variety of reasons, some legal but others due to administrative, political and financial reasons. Although the winning companies were selected in March 1993, the contracts were signed only in September 1993, and were effective from May 1994. The main reason for the delay was a judicial complaint lodged by one of the unsuccessful companies, GMD/Biwater. Administratively, CADF needed time to organise itself internally, and agree with the contractors on operational aspects such as how the work orders were to be issued and paid for. There were also financial problems. The 1994 peso devaluation meant a substantial increase in the cost of the imported meters. There were delays in the installation of meters because the budget assigned by the City government was insufficient to pay for them.

Results According to Main Actors

Based on interviews carried out by Marañón (2004) the main actors (officials, businessmen, academics and society in general) felt that the participation of the private sector had been generally positive. The detailed perceptions of different groups are discussed next.

Institutional Opinions: CADF

The broad consensus view was that the private sector participation had been positive especially in terms of its commercial operations (SF, 1997; Haggarty et al., 2001; Zentella, 2000; Beristain, 2002; Saade, 2002 in Marañón, 2004). The companies were expected to collect basic information on the networks, prepare a register of users, install meters, and charge users for actual volumes of water consumed. Development of an economically sustainable system was considered important and, the system has become more efficient on all the above mentioned issues.

Register of users

An updated and reliable register of users is essential for managing any urban water system. Unfortunately, this simply did not exist for Mexico City. The authorities did not have a clear idea as to the number of consumers it had. Between 1994 and 1996, a general census was completed, including of water connections in all 16 boroughs. After this register was completed, it was possible to bill each user for the actual amount of water consumed. Table 9 shows the number of water connections that were identified each year, between 1994 and 1996 because of this census.

Table 9. Update of water connections in Mexico City, 1994-1996

	1994	1995	1996	Total
Number of users identified (thousands)	544.9	1,074.2	144.8	1,763.9
Networks checked (square kilometres)	83.3	320.4	276.3	680.0

Source: SF, 1997.

Metering

Before 1994, metering of consumption by users was virtually non-existent. The few meters installed were of different types and brands, and they were never properly maintained. In 1994, CADF launched a meter installation programme. In the first year of the programme, 205,200 meters were installed, gradually increasing up to 1,264,500 in 2002 (914,100 were type "A" and 350,400 type "B"[8]). Metering reached more than 90 percent of users, a figure comparable with

[8] The collapse of the peso in 1994 led to a 119 percent increase in the cost of type A meters, and 204 percent for type B. As a result, the 1995 target for installing meters was reduced from 586,700 to 219,300. The plan was to

that in developed countries.

According to CADF, metering promoted water conservation. This view is confirmed by the fact that there have been no serious interruptions to the service, even though the City has not had new sources of water from 1995. The programmes on metering and leak detection and repair have saved substantial volumes of water. However, in spite of this progress, more than 200,000 people in Mexico City still do not have access to water, and an unknown number, especially in the boroughs of Tlalpan and Iztapalapa, receive an intermittent service (Haggarty, et al., 2001, in Marañón, 2004).

Complete metering would require the installation of about 400,000 additional meters, which had not been possible because of issues such as the difficulties in gaining access to isolated and remote areas, and refusal of some users to have meters. Consequently, CADF believed that a certain number of connections would never be metered. The coverage target has, therefore, been set at 95 percent, which means installing some 100,000 meters between 2002 and 2006. This is in addition to those that will have to be installed because of the natural growth of the City.

CADF paid special attention to 16, 050 main non-domestic consumers, representing 0.9 percent of the total users but accounting for 46 percent of the total revenue. The major consumers were managed by CADF itself, including meter-reading and billing. CADF planed to make this process more efficient by introducing remote meter-reading. If so, its revenue from the major users would increase to 60 percent of its total income. The investment requirements for modernising the metering system of the major users can be recovered within one year.

With increasing number of meters in use, their proper operation and maintenance had to receive priority attention. Accordingly, the work done by the contractors needs proper monitoring. Between 2001 and July 2003, the annual maintenance costs for 194,300 meters was estimated at $7 million per year. These costs were recovered from the users and, according to the CADF, the benefits outweighed the costs.

Detection and repair of leaks

In 1998, a major programme was initiated for detection and repair of leaks in the outdated secondary network. It is claimed that this programme saved 2.8 m^3/s of water, which provided benefits to nearly 1.2 million people at an investment cost of $185 million. Government critics, however, argue that the actual water savings were much less than what claimed officially. The critics argue that there was no overall saving because, although the leaks were repaired in certain areas, the pipes fractured further down the line because of increased water pressure, thus contributing to new losses.

Bill collection

There was a charge for supply of water and for the right to discharge effluents to the sewerage

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install both velocity and volumetric meters. The mechanism used for velocity meters (type B) made them more resistant to the suspended solids compared to those of type A. The type B meters were cheaper and the original aim was to install them in areas where the recovery of the investment may be problematic. (SF, 1997:60).

system. Fines were imposed for late and overdue payments. The value-added tax (VAT) was charged to non-domestic users.

Bill collection improved by 70.5 percent between 1992 and 2001, in spite of the fact that tariffs had fallen in real terms since 1996 (Haggarty et al., 2001; Saade, 2002, in Marañón, 2004) (Table 10). Debt recovery from the consumers has been difficult because of a culture of non-payment of the bimonthly bills. While some users cannot afford to pay, some others simply refuse to pay. This culture of non-payment has developed because, historically, bill collection was mostly neglected by the water authorities. Traditional methods of debt-collection, which are very expensive, are being replaced gradually by new mechanisms which may be more cost-effective. These include follow-up reminders to pay the debts, and instalment plans.

Table 10. Bill collection efficiency, Mexico City, 1992-2002

Year	Amount recovered (million pesos)		Index (1990=100)
	Nominal	In real terms (base: 1990)	
1992	471.0	354.2	100.0
1993	572.0	398.3	112.4
1994	712.0	463.1	130.7
1995	769.0	329.1	92.9
1996	1,080.0	362.0	102.2
1997	1,508.3	436.8	123.3
1998	2,053.5	501.4	141.6
1999	2,505.0	544.6	153.7
2000	2,788.4	556.3	157.1
2001	3,159.9	603.9	170.5
2002	3,000.0	551.3	155.7

Source: CADF, 2002.

After all these developments, meters were installed in 72 percent of households. However, this figure increases to 90 percent if a large number of apartment buildings are included where only the total consumption of the entire buildings is measured. Fixed charges are still used for connections that are unmetered, when meters are non-functional, and when meter-reading is impossible.

Efficiency

The efficiency of the water system has improved considerably from 1996 (see Table 11). Between 1996 and 2002, efficiency of water supply has increased from 62.6 to 68.9 percent; monitoring efficiency in terms of measuring water consumption has increased from 49.1 to 90.2 percent; and collection efficiency has improved from 64.8 to 76.9 percent. Overall efficiency (measured as a product of the three indicators mentioned) increased from 19.9 to 47.8 percent. This is in contrast to the situation that prevailed during the late 1980s, where the corresponding efficiency was around 10 percent (Beristain, 2002).

Participation of the private sector has had many benefits which include obtaining basic information on the system in terms of the networks and users, metering, higher revenues, and reduction in water consumption and unaccounted for water. Metering has promoted a culture of savings in both high and low-income households, and the leak detection and repair programme has led to the recovery of 2.8 m^3/s of water (Rodarte, 2002 in Marañón, 2004). However, the overall efficiency of the system has been approximately 50 percent, which means that only half of the investment cost has been recovered. Annual subsidies amount to some $2 billion dollars, which suggests that tariffs may have to be increased (Saade, 2002 in Marañón, 2004).

Rodarte (2002, in Marañon, 2004) emphasises that a sustained increase in water tariffs is not possible in Mexico City, since 72 percent of the population are poor. When the PRI was the party in power, the population of the City was under the impression that water was a public service that would be provided by the State at a highly subsidised rate. PRI was against any efforts to privatise the service. This philosophy was further strengthened when PRD was elected, because its main power base constituted the overwhelming support of the City's poor.

Societal opinion

The perceptions of the people interviewed in the boroughs of Coyoacán, Tlalpan and Xochimilco, were contradictory regarding the impacts of the participation of the private sector. People felt that the newly established offices have made it easier to pay bills, receive responses to inquiries on issues like overcharging, make applications for connections and disconnections, register changes in property ownership, and complain on poor quality service or lack of adequate attention from CADF personnel. This means that the contractors set up an up-to-date information system which simply did not exist before. At least one office was established for every 300,000 users, and, for monitoring purposes, offices were opened in each neighbourhood so that users' data could be checked in situ.

Table 11: Efficiency indicators, Mexico City, 1996-2002

	1996	1997	1998	1999	2000	2001	2002
Physical[1]	62.6	63.0	64.5	66.3	68.0	69.2	68.9
Metering[2]	49.1	80.0	86.0	88.5	90.3	90.1	90.2
Billing[3]	64.8	63.5	76.0	81.7	79.3	83.1	76.9
Overall efficiency	19.9	32.0	42.1	47.9	48.7	51.8	47.8
Volume of water supplied (MCM)	686.6	690.6	691.9	720.2	752.8	752.2	757.5
Volume of water produced (MCM)	1,096.9	1,096.1	1,072.8	1,086.3	1,107.0	1,087.0	1,100.0
Number of users billed (10^3)	1,477.5	1,620.2	1,644.0	1,681.1	1,720.0	1,769.1	n.d
Meters installed (10^3)	737.2	1,051.6	1,137.3	1,187.1	1,228.6	1,255.9	n.d
Number of bills based on meter-reading (10^3)	725.6	1,260.6	1,408.3	1,505.1	1,552.8	1,582.7	1,590.0
Numbers of bills issued (10^3)	1,478.2	1,575.7	1,637.6	1,701.2	1,720.0	1,756.0	1,800.0
Amount billed (million dollars)	224.5	306.5	328.5	306.3	368.8	388.9	425.7
Amount collected (million dollars)	145.3	191.5	255.5	247.0	295.0	327.5	327.5

Source: CADF, 2002, internal reports.

Notes:

[1] Volume of water delivered/Volume of water produced

[2] Number of bills for metered service/Number of bills issued

[3] Amount charged for water/Amount collected

Initially, bills based on meter readings of actual consumptions created general ill-feeling, especially in the poor areas. To a great extent this was because the users perceived the higher bills as an increase in tariffs, rather than an introduction of a consumption-based pricing system. There were demands for tariff reduction and service improvement, as well as claims for overcharging. In some housing estates, residents even prevented the installation of meters.

In terms of overall service received, the general perception was negative, especially in the areas where supply was intermittent. It appeared that there were many more such areas than had been officially recognised.[9] The timing and duration of the supply in such areas varied widely. The supply could be once every three, four, or six days, or even once a fortnight, and for only two to three hours each time. Intermittent supplies dominated in poor outlying areas, squatter settlements, or high-altitude zones because of low pressure. The people living in such areas complained about the inequality in water distribution, and opposed the metering system because they felt that they were being charged for the air that was passing through the metres and not for the water consumed. People argued that they should pay a fixed charge for water and not a bill for actual consumption, as was the case. Haggarty et al. (2001 in Marañón, 2004) emphasize that the problems related to poor service persist, including poor quality of water and intermittent service, particularly in the south and east parts of the City. It should be noted that the reliability of the service remained the responsibility of the boroughs authorities, not the private sector companies.

In 1998, residents of the nine of the 16 boroughs suffered routine reductions in service, and the severity of the problems and the number of people affected varied considerably. Water quality in these areas was perceived to be extremely poor, probably because groundwater contained high concentrations of magnesium, and because the southeasten part of the City is the last to receive water that comes from the Cutzamala System.

Another factor worth noting is that the people, irrespective of their social class and background, were unaware of the private sector involvement in managing the service. Those interviewed felt that the service had improved but they had no idea that this was because of the participation of the private sector. Considering the high degree of politicisation of the population of Mexico City, the authorities probably decided not to have a public debate on this issue, and thus did not inform the population of the roles of the private sector, fearing perhaps that such knowledge might lead to widespread protests (Hiernaux-Nicolas, 2002 in Marañon, 2004).

Institutional arrangements in Mexico City since the mid-1990s have included the participation of the private sector through service contracts, but with the government maintaining control over property rights over infrastructure, responsibility for provision of the service, and authority to fix tariffs (Martínez-Omaña, 2002). The government did delegate certain basic responsibilities to the companies, including meter installation and reading, billing, preparation ad updating of the registers of users and establishment and management of the offices for dealing with the public. However, the companies perform these services in the name of CADF, and not in their own

[9] According to borough officials responsible for water provision, a greater percentage of the population receives intermittent service than admitted by the then operational arm of CADF, DGCOH. The DGCOH, in assigning a volume for a specific zone, assumes that all its residents receive water. However, once the water reaches a neighbourhood, pressure is sufficient only to supply water to a fraction of all households.

names. Accordingly, the consumers, irrespective of their social class and educational level, are unaware of the private sector involvement.

CADF was established as the sole authority in charge of water management in the Mexico City, coordinating the roles of DGCOH and the borough authorities with private sector support. However, this did not happen. Until 2002, CADF managed the contracts with the companies and supervised the activities assigned to the private sector, mainly in the commercial area. DGCOH continued to be responsible for expanding the services in terms of infrastructure, access to water, and operating the primary networks. The borough authorities were responsible for maintaining water and sewerage networks, repairing connections, maintaining pipelines, and administering intermittent supplies in areas of water shortages.

The new strategy made no attempt to change the bureaucratic and hierarchical structure of the water administration, with highly centralised decision-making, no public participation and abundance of red tape. The net result has been a substantial gap between the consumers and the authorities in the perception of the social and geographical realities, especially where water is in short supply. Efforts have been made to bridge this gap through the work of representatives of the consumers whose tasks include aggregating the views and demands of the residents, though some of them have their own personal agendas (Treviño, 1999; Avila, 2003, in Marañón, 2004). The distance between the two sides and the absence of communication simply adds to the ignorance of the consumers on the nature of the current institutional arrangements. The popular view is that the authorities are divided into groups: one represented by CADF, responsible for commercial aspects like metering, billing and collection; and second, the borough authorities, in charge of the distribution of water, management of service interruptions, and leak repairs, and who are always being criticised for shortages. This view corresponds to the reality in the sense that there were different institutions involved in water management. It was not until 2002 that a new body was created: the Mexico City Water System (Sistema de Aguas de la Ciudad de México) to be responsible for the overall water management in the City by merging CADF and DGCOH, although the boroughs continue to cling on to their responsibilities.

Additional Thoughts

Uncertainty surrounded the future of the private sector participation as the contracts drew to a close in August 2003. The companies received no information from the City authorities as to their involvement in terms of their future participation. At the end of 2003, both the sides were negotiating a new agreement that seemed to respond to the general concerns. The government was seeking to maintain the participation of the private sector for the tasks already assigned, but was offering lower rates for each task. It was also proposing to give itself authority to cut off services to the commercial and industrial customers whose payments were overdue, as well as take steps to recharge the aquifer. Finally, responsibility for the water supply was to remain in public hands with the private sector continuing to participate in specific areas.

At present, the Mexico City Water System is responsible for the overall water management in the City. Since all decision-making depends now on one institution instead of several, coordination within the institutions, as well as coordination with the private sector companies could improve with time, resulting in a better overall performance to the benefit of the City and its population. Only time will tell if these expectations will be achieved.

WATER AS A HUMAN RIGHT

For nearly a half century, the human rights movement has tried to expand the areas which can be considered to be human rights. The movement has tried to interpret and reinterpret existing international conventions and treaties to expand the concepts of rights to additional areas, where according to prevailing international agreements, no specific rights currently exist: water as a human right appears to be the results of such an approach.

While there is no direct international convention that stipulates categorically and unambiguously that water is a human right, since water is a basic requirement for survival, many international conventions refer it to its importance in one form or another. A significant part of the discussions on water as a human right are somewhat diffused.

The two most important agreements, which could lead to the possible acceptance of the concept that water is a human right are the International Covenant on Economic, Social and Cultural Rights and the International Covenant on Civil and Political Rights (both available at www.unhcr.org). Both of these Covenants refer to water but do not stipulate clearly that water is in fact a human right.

The United Nations established two committees to oversee the implementation of these two covenants. The Committee of Economic, Social and Cultural Rights (CESCR), which is responsible for overseeing the Covenant on Economic, Social and Cultural Rights, is probably the most important legal consideration in this area. This Committee issued a General Comment (No. 15), which interpreted articles 11 and 12 of the Covenant, and concluded that water is a human right under this Covenant, and some other international legal agreements can be interpreted as promoting this concept (Committee on Economic, Social and Cultural Rights, 2002).

In Art. 17, the General Comment No. 15 states that:

> “State parties have immediate obligations in relation to the right to water, such as the guarantee that will be exercised without discrimination of any kind and the obligation to take steps forwards full realization ….Such steps must be deliberate, concrete and targeted towards the full realization of the right to water.”

In other words, water as a human right has not been established through an international treaty that has been ratified by the governments, but primarily through derivation and inference of existing legal conventions.

The General Comment 15 almost exclusively considers human right to water for human consumption. However, in article 6, it does briefly notes that "water is necessary to produce food (right to adequate food) and ensure environmental hygiene (right to health). Water is essential for securing livelihoods (right to gain a living by work) and enjoying certain cultural practices (right to take part in cultural life)." Subsequently, other water uses and the associated rights are basically ignored, because CESCR concluded that priorities "must be" given to personal and domestic uses, and "should be" given to use of water to prevent starvation and diseases. In other words, CESCR seem to allocate priorities in terms of rights, first to domestic water supply, then to health. The Committee evidently did not consider other water uses as priority issues under human rights considerations. Many experts are likely to disagree with this interpretation.

In Mexico, the governmental institutions as well as the NGOs and the population in general have accepted that clean water and sanitation should be provided to all its citizens. However, this issue was accepted well before water was considered to be a human right. The declaration of water as a human right does not appear to have made any perceptible difference to the water supply and sanitation policies, plans and programmes of the water institutions of the Mexican government at any level.

In Mexico City, the campaign to disseminate information on the economic, social, cultural and environmental rights of the people, including the right to water, was initially started by "DECA Equipo Pueblo, A.C."[10] This organisation, a NGO, in collaboration with the Human Rights Commission of Mexico City and a large number of mostly local NGOs, has campaigned and disseminated information on the various issues related to human rights from 2003.

During a public meeting in Mexico City downtown, in December 2004, a poll was conducted to discern the opinions of the citizens on water quantity and quality issues, as well as other important issues in this area. Only about 150 people were interviewed. Most of them agreed that they enjoy the right to receive potable water, and that they receive all the water they need at an affordable price, and of appropriate quality. The overall service was considered good and water management in the City was considered to be mostly a responsibility of the local and federal governments, and, in very few cases, also as a responsibility of the citizens. A large majority acknowledged the fact that Mexico City does not have enough water to cover the demands of the future.[11]

The results of this poll do not reflect accurately the enormous and increasing problems the people face on a daily basis in terms of water quality and quality. It is likely that the sample was not representative, and/or the respondents were polite and they did not express their actual views. However, the results of this poll are included because it is only such effort that has been carried out in the ZMCM.

DECA Equipo Pueblo, A.C., has also compiled a series of documents that analyse the economic, social and cultural rights for the people, both from the national and international perspectives. This includes the Mexican Constitution on what the group consider refer to human rights (Annex II).

[10] Information on these activities are available at www.derechoalagua.org
[11] The results of this opinion poll are attached as Annex I.

While the activities of the NGOs and many others working in this area are very important, it has to be acknowledged that there seems to be a discrepancy between the perspectives of the government and the NGOs regarding water as a human right. It appears that NGOs feel that if water is considered as a human right, it will automatically "assure" poor, scattered and illegal settlements access to clean water and sanitation. However, the various levels of governments have attempted to provide these services, admittedly sometimes inadequate, even before the movement of water as a human right started, because they have considered these services to be basic needs of the people and should be satisfied. For example, irrespective of whether households pay for their water bills or not, legally water supply cannot be cut, since people must receive a minimum amount of water on daily basis.

If the issue of water as a human right is to be acknowledged by the society as a whole, and there are practical implications on this recognition, then there is an urgent need to disseminate information on this issue. The fact that no government has signed a specific international agreement which stipulates that water is a human right, and that this right is inferred by an UN Committee based on the earlier covenants, have meant that its awareness in the government circles, both in water and development areas, have been extremely low.

CONCLUDING REMARKS

Based on the analysis presented in this report, it is evident that the management of water resources in the ZMCM is very complex. There appears to be an uneven race between the water and sanitation needs of an increasing population, and the planning, investments, technology and management needs required to construct, operate and maintain all the necessary systems efficiently.

The problems of water quantity and quality in the ZMCM are multidimensional and are directly linked to the societal expectations, regional economic development policies and steady increases in population. The government policies have attempted to promote the development of other urban centres to alleviate poverty and to provide improved standards of living as well as quality of life. However, even though the population growth rate in Mexico City during the later part of the 20^{th} century has declined compared to the rates witnessed in the earlier decades, the growth rates in the adjacent municipalities of the State of Mexico that are part of the metropolitan area are expected to increase even further. Accordingly, the problem is likely to remain complex in the foreseeable future. Unless the current trends and management practices change, the future solutions will require very high investment costs to transport more and more water from increasingly distant and expensive sources which also have important economic, social and environmental implications for the exporting regions, higher land subsidence rates due to ever-increasing groundwater withdrawals, reduction in the quality of the groundwater extracted, and higher investments to cover operation and maintenance costs, not to mention the decreasing quality of life of the population living in the region.

One constraint stems from the fact that the demand for living spaces from the continually increasing population has contributed to major changes in land use practices. Concrete and asphalt now cover areas that are needed for groundwater recharge. The southern area of the City is a good recharge area since the soil is broken basalt. However, this area is now heavily urbanised, and hence is also one of the main sources of groundwater contamination because of the absence of a sewerage network which cannot be economically constructed due to the presence of volcanic rocks. Housing complexes are thus built only with septic tanks that are not properly constructed and maintained and, therefore contribute to groundwater pollution.

Changes in land use have also contributed to higher volumes of stormwater discharges to the sewerage system, requiring increasing capacities of the system. The risk of aquifer contamination is enhanced because of disposal of untreated industrial wastewaters directly into the sewerage system, inadequate wastewater treatment facilities, leakages from the sewerage networks, and solid waste illegally dumped in landfills, unlined sewerage canals and watercourses.

There have been evidences of low water quality in the aquifer for several years (Mazari-Hiriart et al., 2001, 2000 and 1999; Mazari-Hiriart and Noyola 2000 in Mazari-Hiriart, 2001; UNAM, 1997; National Research Council et al., 1995). Total and faecal coliforms, as well as bacteria responsible for gastroenteric diseases and acute diarrhoeas, have been found in groundwater in the southern and western parts of the City. Some studies show that the highest contamination of groundwater is in the centre of the Mexico City (Soto et al., 2000 in Mazari-Hiriart, 2001). The gastro-enteric diseases which result from the consumption of polluted water are the second major cause for child mortality (278 per 100,000) in the country; the third leading cause of death for children in the State of Mexico (450 per 100,000); and the fourth in Mexico City (157 per 100,000).

A major constraint to analyse water problems of the ZMCM, or any part of Mexico for that matter, is that of data reliability and accessibility. Official data are often inconsistent, which is a major constraint for decision-making, since decisions have to be taken based on conflicting, or no information. Public have very limited access to information available at the institutions which is often contradictory from one year to another, from one location to another, or even from the same source.

It is obvious that the present approach to the management of the water supply and wastewater in the metropolitan area is neither efficient and equitable nor sustainable. In order to fulfil the needs of an expanding population in terms of water quantity and quality, and to simultaneously maintain a proper balance between the people, natural resources, environment and health, it is necessary to formulate and implement a long-term integrated management plan, which does not exist at present. This should explicitly consider the needs and interests of the different economic sectors in both Mexico City and State of Mexico, and also the numerous existing inefficiencies in management can be overcome. Water allocations for the different consumers need to be systematically planned and be better organised. More efficient institutional arrangements and coordination between the governments of both the regions of ZMCM are essential. Joint and more efficient institutional mechanisms are needed to substantially improve the exiting practices. The relevance and importance of public consultations and involvements in preparing and implementing such plans should not be underestimated. Such stakeholders´ consultations are now conspicuous by their absence.

The participation of the private sector in the provision of potable water has so far been beneficial for the City, even though it has not had any impacts on whether certain areas receive potable water or not. This is because the policies and decisions on water and sanitation services continue, and are expected to continue, being the exclusive responsibility of the government.

The current policies on tariff structures need to be reassessed. At present, there is one tariff, based on the volume of water consumed, for the great majority of the people, irrespective of their socio-economic status, or the place where they live. Since a poor family can have 10 people living in the same house, they often pay more than a rich family of 2-4 persons. A new, realistic and equitable tariff structure needs to be developed which will promote water conservation, improve the financial self-sufficiency of the water institutions, and explicitly consider access to water by the poor, perhaps with targeted subsidies.

Finally, there is no doubt that there is an enormous room for improvement in the existing and proposed practices for water management in the Metropolitan Area of Mexico City. However, a policy that considers exclusively the water sector is unlikely to be successful. It needs to concurrently consider linkages to policies on urban development (so far an issue that has been ignored), migration, industry, energy and environment. It will not be an easy task, but nevertheless, it is an essential task.

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