URBANIZATION, WATER AND HEALTH IN BRAZIL: ASPECTS OF DENGUE FEVER EPIDEMICS

Roberto Luiz do Carmo

Universidade Estadual de Campinas (UNICAMP) [1]

Departamento de Demografia (IFCH/UNICAMP)

Núcleo de Estudos de População (NEPO/UNICAMP),

Campinas - São Paulo

Brazil

roberto@nepo.unicamp.br

XXVI International Population Conference
IUSSP – Marrakech 2009 – 27 September 2 October
Session 207 – Environment and health

---

[1] Department of Demography and Population Studies Center (NEPO), University of Campinas (UNICAMP).

URBANIZATION, WATER AND HEALTH IN BRAZIL: ASPECTS OF DENGUE FEVER EPIDEMICS

Abstract

This paper provides an overview of the implications of the Brazilian urbanization process on water use, calling attention to the spatial distribution of population (migration) and the availability of water in different parts of the country. The text analyses the main types of water consumption and the health impacts of the urbanization process, through the analysis of dengue fever epidemics since 1990.

Introduction

The water cycle, stimulated by the continuous processes of evaporation and precipitation, leads many people to the erroneous idea that water is an infinite resource. But in fact the volume of water in the earth's atmosphere has remained virtually unchanged since the beginning of human presence on the planet. In contrast however, very significant changes in natural environments have taken place over the last two centuries (since the Industrial Revolution), changes that have affected the amount and quality of the water available for human consumption.

Rosegrant (1997) shows that there are extremely serious inequalities in the availability of water among the regions of the world. The availability *per capita* in Africa for example, was 9,400 m^3 // year/person in 1994. In Asia (not including Oceania) it was 5,100 m^3/year/person, and in Europe (not including the Soviet Union) it was even lower, 4,600 m^3/year/person. In North and Central America on the other hand, availability was 21,300 m^3/year/person while it was 48,800 in South America. The trend indicated by Rosegrant shows a fall in water availability due to increased demand and, for the year 2000, he estimated availability of 5,100 m^3/year/person in Africa, 3,300 in Asia, 4,100 in Europe, 17,500 in North and Central America, and 28,300 in South America.

Besides irregular spatial distribution and increasing demand, one must also consider the seasonality and the climactic variations during longer cycles. Together, these factors have led to situations of water shortages in many parts of the world. Historically, such shortages have been faced by the implementation of public works for transporting water over long distances, as did the Romans with their famous aqueducts. However, the complexity of social organization in recent times and the conflicts caused by increased demand have made this solution of transporting water from one region to another more and more difficult.

In today's context, among the factors involving water resources, the most plausible human reaction would seem to be to control demand. The increased demand occurs mainly due to demographic growth, addressing populations' direct needs (public supply, for example) and indirect needs (such as the increase in production of consumer goods and foodstuffs).

The pressure exerted by the growing population on available environmental resources is usually considered the most important aspect in discussions on environmental issues in general, and specifically, regarding the water problem. Therefore, one of the most important questions regarding the relationship between population and water resources is the impact of continuous demographic growth on water resources which remain constant through time. This is basically a neo-Malthusian perspective, according to which it is sufficient to control population growth in order to maintain a situation of equilibrium in the relationship between demand and availability.[2]

However, one must go beyond this perspective, which tends to be simplistic. The relationship between population size and demand must be more clearly analyzed, especially considering that affluence is a further factor to be considered. In other words, populations with more favorable economic conditions are usually those with higher *per capita* consumption Seckler (1998).

It is also important to call attention to the fact that there are many different intervening factors regarding environmental resources in general, and water resources in particular, that can be taken to improve our use of the water that is actually available. A number of measures can be taken toward better management of water resources, aimed at reducing waste and increasing the possibility of satisfying the growing demand. In other words, the type of use that is made of water resources is the main point to be considered.

---

[2] See Falkenmark (1994).

In this paper, we provide an overview of the implications of certain aspects of demographic dynamics on Brazil's water resources (ou supply), calling attention to factors such as the spatial distribution of the population and the availability of the water. We will also present an analysis of the main types of water consumption, conflicts among the divergent demands for water, and impacts of the urbanization process on the available water. One of these impacts is the re-emerging dengue fever epidemics, related to the lack of basic infrastructure services like water pipelines, sewage and garbage collection.

It is not an easy task to provide a national panorama, due to the size of the country and the specific aspects inherent to the relationship between population and water. One of the major difficulties involved resides in the choice of a spatial unit of analysis that will allow researchers to deal with these two groups of phenomena at the same time. This is especially complex because one of the factors involved is in the sphere of social dynamics and the other in the field of the natural sciences. The sources of data on spatial distribution are very diverse, and demographic phenomena are described by administrative limits (states, municipalities and census blocks). Information regarding water resources on the other hand is based on river basins (although river basins can be grouped into larger basins or subdivided into micro-basins). The fact is that there is no coincidence between administrative units and the boundaries of the river basins, a fact that requires one to make adjustments and approximations in order to work with the two databases.

Another problem is the availability of recent data on the various aspects of water resources. A national information system on water resources is now being developed, but what is currently available for much of Brazil are estimates or isolated calculations on the quality and quantity of water resources. Only the State of São Paulo has easily accessible data, although also not entirely reliable, with an appreciable historical series, a fact that allows researchers to evaluate the evolution of some of the standards regarding water over time. For this reason, at many points the text will refer to examples of São Paulo, although other states, such as Bahia, also have information that is becoming better known.

Spatial distribution of population and water resources

Approximately 23% of all the fresh water on the planet is in South America, and 12% is in Brazil. That is, the availability of water in Brazil is relatively high.

Nevertheless, distribution throughout the country is unequal. There are great expanses of fresh water in the Amazon basin, and significant semi-arid areas, especially in the northeast. Historically, the occupation of Brazil was strongly influenced by its waterways and the proximity of water resources was a major factor for the construction of cities.

Barth (1999) considers water scarcity to occur when water availability is between 1,000 and 2,000 m^3/year/person; in severe scarcity, this level falls to below 1,000 m^3.

Observing the great Brazilian river basins shown in Table 1, it can be seen that the volume of water available per person per day is much higher than the minimum considered adequate in almost all the basins. The exception is Eastern Atlantic Basin 1, with approximately 1,800 m^3/year/person, placing it in a condition of water scarcity. According to Barth (1999), the worst situation is seen in the states of Pernambuco (1,300 m^3/year/inhabitant) and Paraíba (1,400 m^3/year/inhabitant). Other northeastern states, such as Rio Grande do Norte, Alagoas and Sergipe, with approximately 1,700 m^3/year/inhabitant, are also in an unfavorable situation. The Federal District (Greater Brasilia) also falls within this category of 1,700 m^3/year/inhabitant, associating high demographic concentration with location near the headwaters of major river basins.

It is important to consider that the average availability shown conceals broad differences in seasonality. That is, in the drier months of the year the availability of water is often much lower.

Table 1 shows the ample water availability *per capita* existing in Brazil as a whole: in terms of the volume of surface water, Brazil is surpassed only by Canada.

However, it is important to note that spatial distribution of both water resources and population are extremely irregular. While the Amazon Basin drains almost half of Brazil, less than 5% of Brazilian population lives in this area. The Paraná River Basin, on the other hand, which covers approximately 10% of the country's territory, serves about 1/3 of its population.

According to Barth (1999), there is reason for concern when one analyzes the scope of the sub-basins, as can be seen in the State of São Paulo. The Upper Tietê River Basin, which is home to the 18 million inhabitants of the São Paulo Metropolitan Region, has 171 m^3/year/inhabitant available, and is therefore probably one of most critical areas in the country. Only with the reversion of water from other basins is the Upper Tietê River able to supply 210 m^3/year/inhabitant, but this reversion makes the Piracicaba River Basin fall from its natural availability of 1,595 m^3 to 566 m^3. In dry periods the potential conflict between these two regions is acute, especially since these are the two most important industrial regions in Brazil.

Table 1. Basic information on the Brazilian river basins Water resource

Traditionally water use is divided into two categories: consumption uses, where there are losses between what is drawn from the waterways and what is returned; and non-consumption uses, where there are no losses.

Among consumption uses are irrigation and urban and industrial uses; non-consumption uses include hydroelectric generation, river navigation, aquaculture, ecological uses, recreation and leisure.

This categorization has been questioned, since to generate hydroelectric energy for example, a certain flow of water must be maintained in the turbines, restricting availability for other uses, such as navigation.

We will analyze here the three main uses of water in Brazil: urban (residential and commercial), industrial, and agricultural (irrigation). Approximately 80% of the water consumed on the planet is used for irrigation (Lanna, 1999) and in overall terms, this is the major use of water. It is important to recall, however, that urbanization and industrialization processes have increased their share in water use, either by increasing the demand brought about by direct use, or by using bodies of water as recipients of the effluents of these processes, which in itself is a type of water use. Using the waterways as receivers of sewage or other types of waste is one of the characteristics of the urbanization process adopted in Brazil.

Urban use

Brazil went through a process of intense urbanization during the second half of the 20th century. Of the 52 million Brazilians in 1950, approximately 36% lived in urban areas, whereas, in 2000, 81% of the 170 million Brazilians lived in urban areas. The demographic displacement toward the cities was enormous, and had serious consequences. In absolute terms, the urban population rose from 19 million in 1950 to over 137 million in 2000. State investments to improve the infrastructure of the cities were insufficient, a situation that generated considerable poverty and destitution in the cities. The lack of urban infrastructure compromises the quality of the environment and directly affects the water resources, especially with regard to sewage management.

According to the Brazilian Census Office (IBGE),[3] of the 4,425 municipalities in Brazil in 1989, only about 47% had sewage collection systems, and in the 5,507 municipalities in existence in 2000, approximately 52% had some kind of sewage system: a 24% increase in the number of municipalities, while sewage systems increased only 10%.

The National Census of 2000 (Table 2) showed another reason for concern: 8.3% of the private households in the country had no bathroom or any other type of sanitation facilities. This situation is quite unequal from one state to another, but it is important to emphasize that this proportion reaches 43% in Piauí and 40% in Maranhão. On the other hand, it is only 0.4% in São Paulo and 0.9% in Rio de Janeiro.

The number of permanent private households connected to broader sewage systems is still relatively low, serving less than half the entire country. It should be noted that the Federal District (Greater Brasilia) and the State of São Paulo have the highest coverage (over 80%), whereas Tocantins and Rondônia have the lowest.

It should also be mentioned that the lack of sewer systems tends to be more serious where demographic density is higher. In situations where sewage is left in the open-air or deposited in simple cesspools, the higher the density, the greatesr the risk of contamination of water tables.

[3] Fundação IBGE. *Pesquisa Nacional de Saneamento Básico, 2000.*

Table 2. Sewer services in permanent private households for Brazil and by State, 2000

Sewage collection is important since it is a decisive factor in public health. However, there is another aspect to be considered, namely, the treatment of collected sewage. The same survey applied by the Brazilian Census Office indicates that the areas in the country with sewage collection are divided into the 1/3 that treat the collected sewage and the 2/3 that provide no type of waste treatment: the sewage produced is simply poured *in natura* into bodies of water or into the soil. Approximately 85% of the areas that do not treat the collected sewage simply discharge it into rivers. This type of procedure, which is common in Brazil, compromises the quality of water used for local supplies. One of the most serious effects is that the municipalities upstream compromise the quality of the water of those downstream.

Besides the question of sewage, there is also the problem of trash and garbage. According to data from the Census of 2000, approximately 75% of permanent private households in the country are provided with trash collection services. However, more than 190,000 households (0.4%) throw trash and garbage directly into some body of water (rivers, lakes, or the ocean). In the State of Amapá this proportion rises to 6.3%, and in Amazonas it is as high as 3%. Even considering that these states lie in areas where the volume of water is very great, the damage to these waterways may be significant with the passing of time.

Also regarding the destination of trash, approximately 7% of the households informed the census that they throw their trash into vacant lots, the proportion being higher in Maranhão (27%) and Ceará (23%). This inadequate disposal of trash may directly influence the situation of the local water resources, eventually flowing into the waterways or contaminating water tables.

Another aspect to be considered in the discussion on urbanization is water drainage. The style of waterproofing that characterizes urban areas, with cities growing along the floors of valleys without respect to the natural marshes of the rivers, means that floods are becoming more and more frequent, and more dangerous. According to the Brazilian Census Office (IBGE), approximately 79% of the municipalities with over 20,000 inhabitants in 2000 provided urban drainage services. However, approximately 73% of these have no instruments in place to regulate their systems.

In general, it can be said that the hydrological cycle of large Brazilian cities is divided into two phases: rationing and floods.

Besides consumption, strictly speaking, there are losses in intake systems that are sometimes significant - as high as 50% in many municipalities. Table 4 shows how this loss occurs in the administrative regions of the State of São Paulo. It is impressive that a region with relative water scarcity, such as the basin of the rivers Piracicaba/Capivari/Jundiaí, presents losses of approximately 70%.

These losses in the intake systems result mainly from the lack of investments in system maintenance, systems which are usually old and unable to address increasing demand.

Another aspect to be considered in the discussion on urbanization is water drainage. The style of waterproofing that characterizes urban areas, with cities growing along the floors of valleys without respect to the natural marshes of the rivers, means that floods are becoming more and more frequent, and more dangerous. According to the Brazilian Census Office (IBGE), approximately 79% of the municipalities with over 20,000 inhabitants in 2000 provided urban drainage services. However, approximately 73% of these have no instruments in place to regulate their systems.

Table 3. Destination of trash and garbage from permanent private households, for Brazil and by state, 2000

In addition, one should also consider that the way in which the Brazilian cities expanded, without governmental planning and usually based on the interests of speculative real-estate capital make both the implementation of new systems and the maintenance of those already in operation more expensive. The process of "expoliação urbana," described by Kovarick (1983), has been a constant in the development of Brazilian cities, characterized by the subdivision of areas at considerable distances from already occupied regions, creating enormous empty spaces and discontinuous urban growth, with the empty areas serving as value reserves for speculative capital. This trend might be described as urban sprawl with specific Brazilian characteristics.

Table 4. Volume of water captured per capita (liters/month), water measurement per capita (liters/month) and water loss rates (%), by river basins in the State of São Paulo, 1992 and 1995

Industrial use

According to Lanna (1999), the amount of water used by industry varies greatly, since use depends on the raw materials, the product, technology, and the amount of recycling. In this regard, one ton of steel can be produced with $5m^3$ or with 190 m^3 of water, and one ton of paper can consume between $57m^3$ and 340 m^3.

Considering industrial activity in general, the water factor has a very low relative cost in relation to other aspects of production. Some companies have, nevertheless, invested in the reduction of their water use, either by making changes in their industrial processes or by re-using water.

Irrigation

Irrigated agriculture in Brazil occupies an ever-growing area. The demand is increasing, especially in areas of agricultural expansion such as the Central-Western region. It has been possible to increase soybean production through the use of advanced technology, by which the fragile soil of dense woods is converted into soil capable of high production rates. Productivity in areas of dense woods has evolved much more than in other areas of soybean production in the world.

The intensive use of the soil, however, represents a serious risk, since it requires high investments in management. Where management is inadequate, the risk of erosion and silting of the waterways rises, as has been noted recently in some places.

The use of irrigation is one of the pillars of support for the technological package that characterizes agriculture development. The expansion of the use of irrigation raises number of questions related to the efficiency of the processes involved and to ecological impacts when used on a broad scale.

Urbanization and dengue fever

While dengue fever is an important issue today, between 1923 to 1982 there were no registered cases in Brazil. During the 80's, especially at the end of the decade, the situation changed, with an increasing dispersion of cases in the country, especially in urban areas.

The lack of regular water supply and public garbage collection which accompanied Brazil`s urbanization process created conditions for the proliferation of potential breeding sites for *Aedes aegypti* (the main mosquito vector for dengue) TTauil, 2001). Ad hoc solutions such as precarious reservoirs for potable water and disposable recipients which accumulate water, like used cans and plastic and glass bottles aggravated this problem. The pattern of consumption is also important in this equation, considering that modern industries produce large volumes of disposable material, and the final disposal of garbage is inadequate, making possible the existence of small water reservoirs that will be used by the mosquito.

Is also important to consider that propagation of the dengue virus and the spread of dengue vectors are favored by the high intensity, frequency, and speed of private and public transportation. The transportation of goods and materials is important, but the migration and commuting of people, to work or to study, is also an important issue. One infected person can transport the virus and contaminate others. It is an important issue, especially in Brazil, where migration flows and spatial mobility are very common. Especially in metropolitan regions this aspect is very important, and raises concerns about the possibilities of dissemination of disease in an epidemic situation.

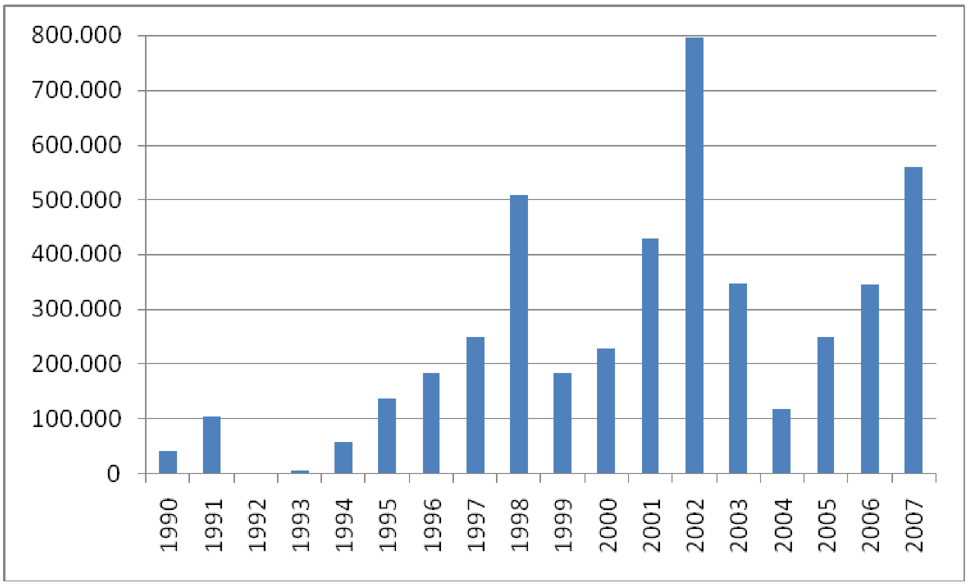
There are also environmental aspects that create favorable conditions for the mosquito, such as high humidity and temperature. In this regard, it is relevant to consider the impact of global warming to epidemic dengue diffusion on the long term.

The relationships among these factors are complex and can help explain the re-emergence of dengue, the most important arbovirus in the world today, affecting thousands of people each year.

In Brazil, there is an oscillation in the total number of notified cases since 1990, with peaks in the years 1998 (507,715), 2002 (794,219) and 2007 (559,954) (Graph 1).

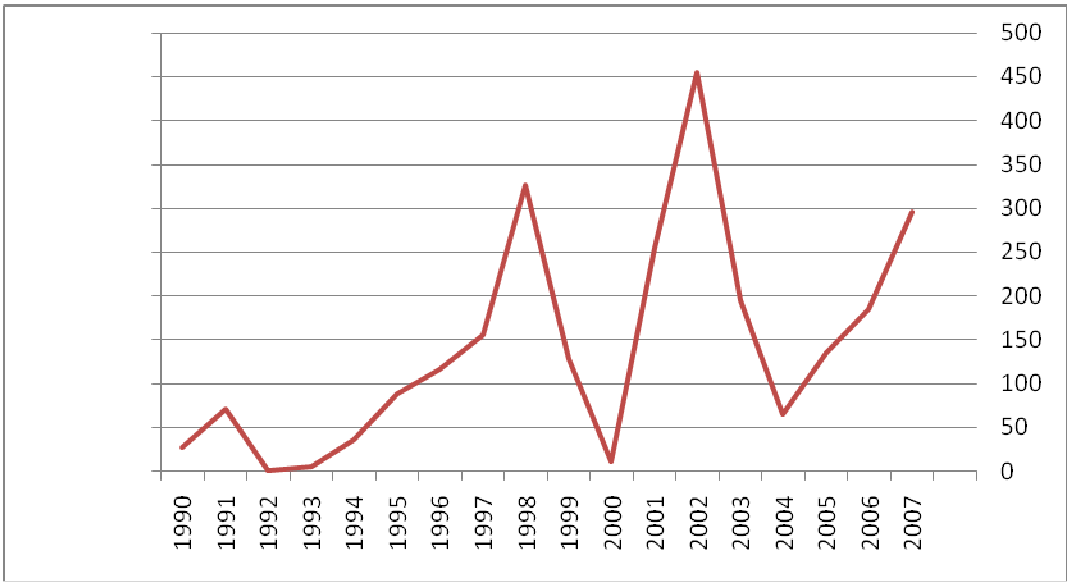
Despite the efforts of federal and local government, there is a lack of continuity in contol measures. The complexity of interrelated aspects -, environmental, biological, infrastructural and cultural - explains the increased incidence in these years (Graph 2).

Graphi 1. Total number of notified cases of dengue fever in Brazil, 1990-2007



Source: http://portal.saude.gov.br

Graph 2. Incidence of dengue fever (per 100,000 inhabitants), 1990-2007



Source: http://portal.saude.gov.br

The situation of the country can also be observed in some of the most urbanized regions, like the municipality of Campinas in São Paulo State. Campinas has one million inhabitants. It is one of the most industrial and economically developed areas of the country. The process of urbanization during the last 40 years has changed the landscape, bringing a concentration of low income workers to the periphery of the city, opening new areas and creating the Metropolitan Region of Campinas, composed of 19 municipalities and 2.5 million inhabitants.

The mobility of the population across the boundaries of the Campinas Metropolitan region, and the circulation of population that comes from other parts of the country, have created the conditions for a dengue epidemic.

As in the national context, the largest number of dengue cases occurred in the years 2002 (1,187) and 2007 (7,096).

Using GIS methodology the distribution of cases in the municipality of Campinas was associated with socioeconomic characteristics of the population, using census tract database (Lima et al. 2006. This methodology made it possible to identify some of the intervening elements in the configuration of an epidemic situation.

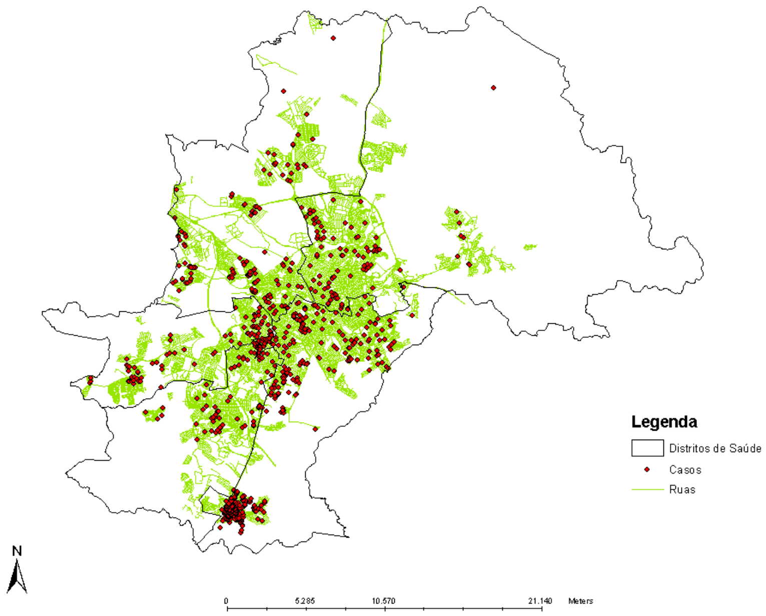
Figure 1 shows the distribution of dengue cases over the 950 km^2 of the municipality in the year 2002. The concentration in the south part of the city is evident.

This region was recently occupied by low income populations, and thethe lack of infrastructure is notorious.

Figure 2 shows the 2003 epidemic. Despite the lower number of cases, these are more dispersed over the municipal territory. There are some concentration of cases in poor regions of the city, but there are also cases in the center. These case are related to two different situations. On the one hand, there are several old buildings used for groups of low income families (*cortiços*). On the other hand, there are households with gardens and ornamental plants whose pots provide ideal locations for mosquito procreation.

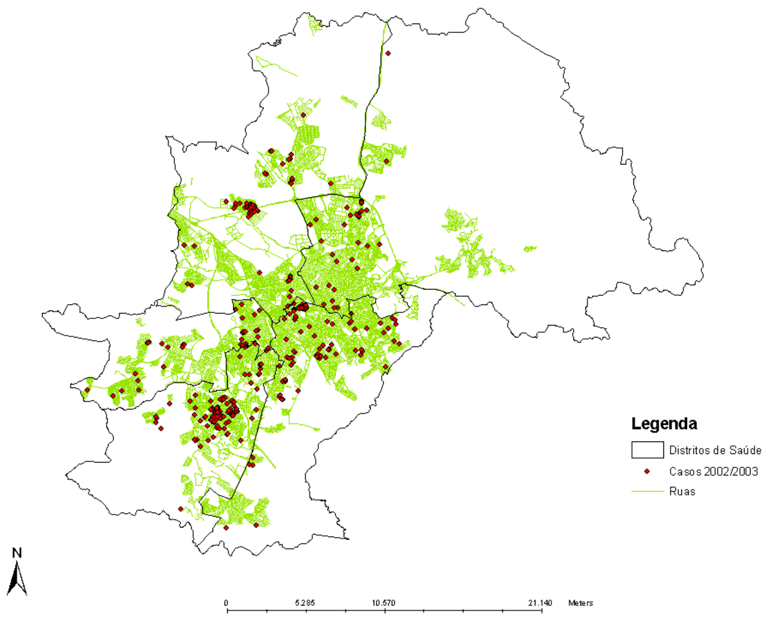
In terms of policy this kind of spatial distribution of dengue cases means different approaches. For the south region of the city the most evident action is investment in infrastructure. And the center of the city requires more effective communication with wealthier groups, calling attention to cultural procedures in terms of maintaining domestic plants and gardens.

Figure 1. Distribution of dengue cases in the city of Campinas, São Paulo State, 2002 (N=1,187)



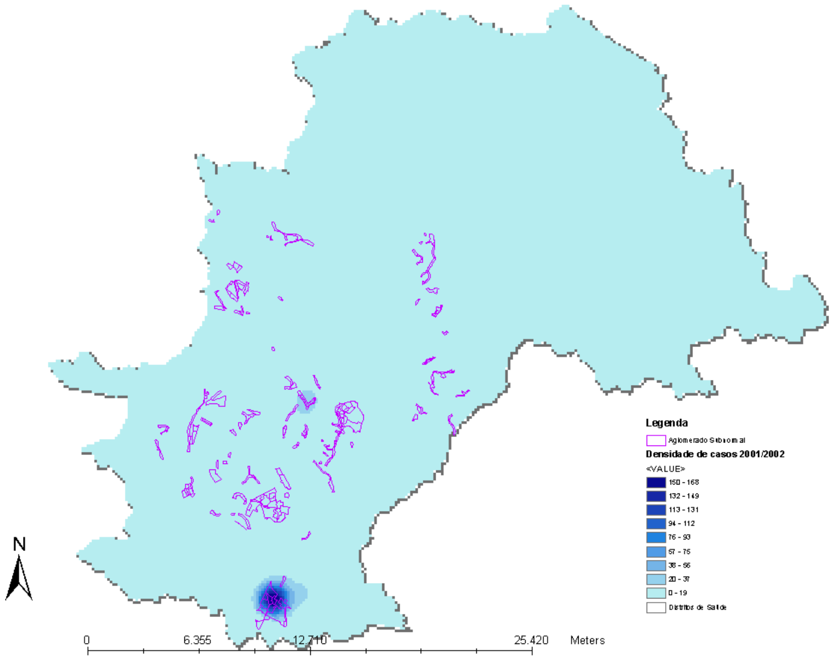
Source: Lima et al. (2006)

Figure 2. Distribution of dengue cases in the city of Campinas, São Paulo State, 2003 (N=382)



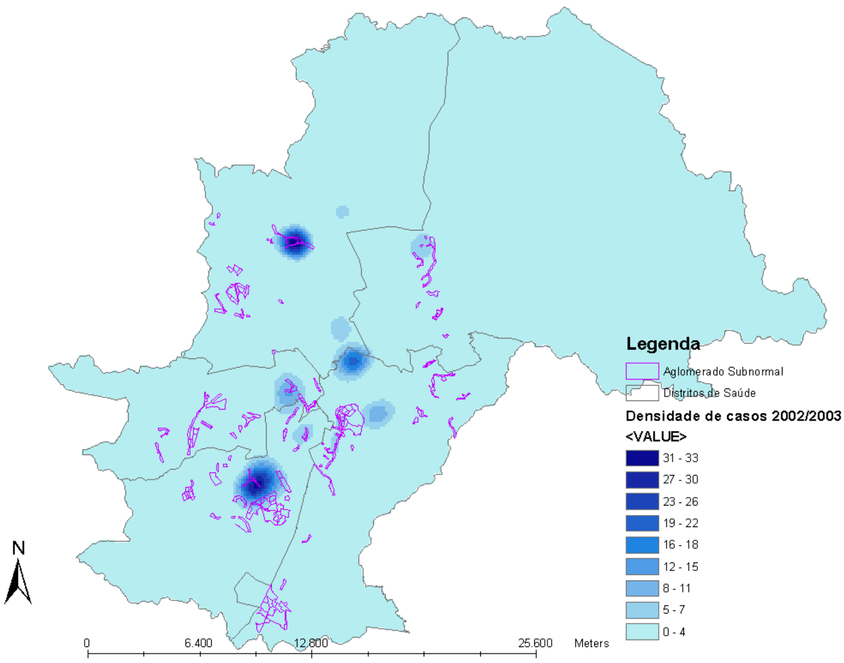
Source: Lima et al. (2006)

Figure 3. Kernel density of dengue cases in the city of Campinas and location of slums, São Paulo State, 2002



Source: Lima et ali. (2006)

Figure 4. Kernel density of dengue cases in the city of Campinas and location of slums, São Paulo State, 2003



Source: Lima et ali. (2006)

Final considerations

This text sought to show that Brazil has an immense volume of available fresh water, but the uses to which this essential resource is submitted has caused situations of relative scarcity in some regions of the country. Therefore, unless attitudes are taken in the near future, the situation may worsen.

Examples of efforts that are indispensable for the preservation of the country's water resources include watershed protection, recovery of the gallery forests, and development of sanitation programs (sewage collection and treatment), better allocation of economic activities which require high volumes of water, and the acknowledgement of water as a finite resource.

The complexity of urbanization/water relationships is expressed in the analysis of dengue fever epidemics, which superimposes the challenges of growing urbanization without infrastructure services and the results of irrational water use. To create an efficient health policy for the control of dengue fever, it is important to consider a wider range of aspects, including infrastructure, socioeconomic aspects, demographic dynamics and cultural issues. Only an integrated approach can be effective.

References

BARTH, F. T. Aspectos Institucionais do gerenciamento de recursos hídricos. In: REBOUÇAS, BRAGA e TUNDISI, J. G. Águas doces no Brasil: capital ecológico, uso e conservação. São Paulo: Escrituras Editora, 1999.

BRAGA, Ima Aparecida e VALLE, Denise. ***Aedes aegypti*: histórico do controle no Brasil**. *Epidemiol. Serv. Saúde*, jun. 2007, vol.16, no.2, p.113-118.

CAMARA, Fernando Portela, THEOPHILO, Regina Lúcia Gonçalves, SANTOS, Gualberto Teixeira dos *et al*. **Estudo retrospectivo (histórico) da dengue no Brasil: características regionais e dinâmicas**. *Rev. Soc. Bras. Med. Trop.*, Mar./Apr. 2007, vol.40, no.2, p.192-196.

CAMPOS, J. N. B. Mercado de águas em áreas limitadas: uma experiência e uma proposta. In: SIMPÓSIO BRASILEIRO DE RECURSOS HÍDRICOS, 13, 1999, Belo Horizonte. **Anais...** Belo Horizonte, 1999. (CD-ROM)

CANALI G. V. et al. (eds). **Water Resources Management: Brazilian and European Trends and Approaches.** International Week for Studies on Water Resources Management (1999 apr. 19-23: Foz do Iguaçu, Paraná). Porto Alegre: ABRH, 2000.

CARMO, R. L. and RAGNIN, R. Uso múltiplo da água e múltiplos conflitos em contextos urbanos: o caso do reservatório Billings. In. HOGAN et al. (orgs.) Migração e ambiente nas aglomerações urbanas. Campinas: Núcleo de Estudos de População/UNICAMP, 2001.

EMPLASA. **Por dentro da Grande São Paulo.** São Paulo, 1993.

GUBLER, D. J., 1997. Dengue and dengue hemorrhagic fever: Its history and resurgence as a global health problem. In: *Dengue and Dengue and Hemorragic Fever* (D. J. Gubler & G. Kuno, eds.), pp. 1-22, New York: CAB International.

FALKENMARK, M. Water Availability as Carrying Capacity Determinant: a new factor in third world demography. In: ZABA, B.; CLARKE, J. (eds.). **Environment and population change.** Liege, Belgica: International Union for the Scientific Study of Population, Ordina Editions, 1994.

KELMAN, J. Evolution of Brazil's Water Resources Management system. In. CANALI (2000).

KETTELHUT, J. T. S. Several Reflections on the Water Law Implementation Process. In. CANALI (2000).

KOWARICK, L. **A espoliação urbana**. Rio de Janeiro: Paz e Terra, 1983.

LANNA, A. E. Hidroeconomia. In. REBOUÇAS, BRAGA e TUNDISI, J. G. Águas doces no Brasil: capital ecológico, uso e conservação. São Paulo: Escrituras Editora, 1999.

LIMA, V. L. C. ; CARMO, R.L. ; ANDRADE, V. R. ; RESTITUTTI, M. C. ; SILVEIRA, N. Y. J. . Utilização de Sistema de Informação Geográficas na Rotina de Controle da Dengue - . Boletim Epidemiológico Paulista, São Paulo, n. 3, p. 9-13, 2006.

ORGANIZACIÓN METEOROLÓGICA MUNDIAL (OMM)/ORGANIZACÓN DE LAS NACIONES UNIDAS PARA LA EDUCACIÓN, LA CIENCIA E LA CULTURA (UNESCO). **Hay Suficiente agua en el mundo?** OMM/UNESCO, 1997.

ROMERA e SILVA, P. A. **Água: quem vive sem?** São Paulo: Ed. Ver, CTH, 1998. 109 p.

ROSEGRANT, M. W. **Water Resources in the Twenty-First Century:** challenges and implications for action. Washington: International Food Policy Research Institute, mar.1997. (Food, Agriculture, and the Environment Discussion Paper 20)

SECKLER, D.; et al. **World Water Demand and Supply, 1990 to 2025:** scenarios and issues. Colombo, Sri Lanka: International Water Management Institute, 1998. (Research Report, 19)

TAUIL, Pedro Luiz. **Urbanização e ecologia do dengue**. *Cad. Saúde Pública*, 2001, vol.17 suppl, p.S99-S102.

TABLES

Table 1. Basic information on the Brazilian river basins

Water Basin	Area (1000 km^2)	%	Population 1996	%	Density (inh/km^2)	Flow m^3/s	Water availability (km^3/year)	Per capita availability (m^3/year/inh)	(m^3/day/inh)
1 Amazonas	3,900	45.8	6,687,893	4.3	1.7	133,380	4,206.3	628,938.2	1,723.1
2 Tocantins	757	8.9	3,503,365	2.2	4.6	11,800	372.1	106,219.3	291.0
3A Northern Atlantic	76	0.9	406,324	0.3	5.3	3,660	115.4	284,063.4	778.3
3B Northeastern Atlantic	953	11.2	30,864,744	19.6	32.4	5,390	170.0	5,510.4	15.1
4 São Francisco	634	7.4	11,734,966	7.5	18.5	2,850	89.9	7,659.0	21.0
5A Eastern Atlantic 1	242	2.8	11,681,868	7.4	48.3	680	21.4	1,835.7	5.0
5B Eastern Atlantic 2	303	3.6	24,198,545	15.4	79.9	3,670	115.7	4,782.8	13.1
6A Paraguay	368	4.3	1,820,569	1.2	4.9	1,290	40.7	22,345.5	61.2
6B Paraná	877	10.3	49,924,540	31.8	56.9	11,000	346.9	6,948.4	19.0
7 Uruguay	178	2.1	3,837,972	2.4	21.6	4,150	130.9	34,099.9	93.4
8 Southeastern Atlantic	224	2.6	12,427,377	7.9	55.5	4,300	135.6	10,911.8	29.9
Brazil	8,512	100.0	157,070,163	100.0	18.5	182,170	5,744.9	36,575.5	100.2

Source: adapted from Freitas and Santos (1999)

1. Amazonas: Xingu, Tapajós, Madeira, Purus, Juruá, Javari, Jari, Trombetas, Negro, and Juruá

2.Tocantins: Araguaia, Lower Tocantins (States of Tocantins, Maranhão), Upper Tocantins (Goiás, Distrito Federal)

3 A. North Atlantic: Oiapoque and the coast of Amapá and Pará

3 B. Northeastern Atlantic: Mundaú, Paraíba, Capiberibe, Beberibe, Paraíba do Meio, Piranhas, Jaguaribe, Paranaíba, Itapecuru, Northeastern Coast

4. São Francisco: Upper São Francisco (Minas Gerais), Middle São Francisco (Bahia and Pernambuco)/and Lower São Francisco (Alagoas and Sergipe)

5 A. Eastern Atlantic (1): Vaza Barris, Itapicuru, Paraguacu, das Contas, Pardo, Jequetinhonha, Coast of Bahia, Mucuri

5 B. Eastern Atlantic (2): Doce, Coast of Espírito Santo, Costa of Rio de Janeiro, Paraíba do Sul

6 A. Paraná: Iguaçu, Piqueri, Ivaí, Sucuriu, Paranapanema, Aguapeí, Peixe, Tietê, São José do Dourado, Grande, Paranaíba

6 B. Paraguay: Upper Paraguay (Mato Grosso), Middle Paraguay (Mato Grosso do Sul)

7. Uruguay: Upper Uruguay, Ibicuí

8. Southeastern Atlantic: Coast of Rio Grande do Sul, Guaíba, Itajaí, Coast of Santa Catarina, Ribeira do Iguape, Coast of São Paulo

Table 2. Sewer services in permanent private households for Brazil and by State, 2000

State	Total Households	General sewage or rainwater drainage system		Without bathroom or toilet facilities	
		Total	%	Total	%
Brazil	44,795,101	21,160,735	47.2	3,705,308	8.3
Rondônia	347,194	12,815	3.7	37,866	10.9
Acre	129,439	25,247	19.5	26,752	20.7
Amazonas	570,938	114,171	20.0	72,932	12.8
Roraima	74,451	7,973	10.7	8,367	11.2
Pará	1,309,033	96,890	7.4	157,745	12.1
Amapá	98,576	6,062	6.1	6,839	6.9
Tocantins	280,281	7,710	2.8	73,000	26.0
Maranhão	1,235,496	113,766	9.2	491,594	39.8
Piauí	661,366	26,479	4.0	283,985	42.9
Ceará	1,757,888	376,884	21.4	431,247	24.5
Rio Grande do Norte	671,993	111,034	16.5	67,839	10.1
Paraíba	849,378	245,493	28.9	159,082	18.7
Pernambuco	1,968,761	674,278	34.2	303,020	15.4
Alagoas	649,365	99,293	15.3	128,242	19.7
Sergipe	436,735	121,457	27.8	59,012	13.5
Bahia	3,170,403	1,094,223	34.5	762,450	24.0
Minas Gerais	4,765,258	3,249,313	68.2	240,191	5.0
Espírito Santo	841,096	473,109	56.2	21,762	2.6
Rio de Janeiro	4,253,763	2,659,082	62.5	38,331	0.9
São Paulo	10,364,152	8,466,151	81.7	45,076	0.4
Paraná	2,664,276	1,003,340	37.7	56,069	2.1
Santa Catarina	1,498,742	292,268	19.5	23,619	1.6
Rio Grande do Sul	3,042,039	834,294	27.4	74,164	2.4
Mato Grosso do Sul	562,902	66,619	11.8	13,215	2.3
Mato Grosso	645,905	101,149	15.7	53,443	8.3
Goiás	1,398,015	424,472	30.4	65,732	4.7
Federal District	547,656	45,7163	83.5	3,734	0.7

Source: Brazilian Census Office (IBGE) - *Demographic Census of 2000*

Table 3. Destination of trash and garbage from permanent private households, for Brazil and by state, 2000

State	Total Households	Collected by cleaning services		Thrown into rivers, lakes or the ocean		Thrown into vacant lots or the street	
		Total	%	total	%	total	%
Brazil	44,795,101	33,263,039	74.3	193,505	0.4	3,102,584	6.9
Rondônia	347,194	190,578	54.9	1,089	0.3	17,749	5.1
Acre	129,439	64,645	49.9	3,584	2.8	18,372	14.2
Amazonas	570,938	327,565	57.4	17,380	3.0	39,526	6.9
Roraima	74,451	50,366	67.6	408	0.5	6,055	8.1
Pará	1,309,033	630,739	48.2	32,105	2.5	166,130	12.7
Amapá	98,576	65,220	66.2	6,192	6.3	5,481	5.6
Tocantins	280,281	149,778	53.4	312	0.1	33,508	12.0
Maranhão	1,235,496	379,379	30.7	12,639	1.0	333,130	27.0
Piauí	661,366	258,624	39.1	1,931	0.3	129,389	19.6
Ceará	1,757,888	895,144	50.9	9,826	0.6	399,343	22.7
Rio Grande do Norte	671,993	458,221	68.2	2,016	0.3	78,583	11.7
Paraíba	849,378	523,224	61.6	5,487	0.6	102,915	12.1
Pernambuco	1,968,761	1,231,611	62.6	19,308	1.0	356,750	18.1
Alagoas	649,365	399,960	61.6	6,951	1.1	117,805	18.1
Sergipe	436,735	282,495	64.7	2,802	0.6	60,593	13.9
Bahia	3,170,403	1,587,321	50.1	17,474	0.6	624,754	19.7
Minas Gerais	4,765,258	3,564,125	74.8	16,671	0.3	248,788	5.2
Espírito Santo	841,096	605,931	72.0	2,811	0.3	40,040	4.8
Rio de Janeiro	4,253,763	3,591,508	84.4	10,853	0.3	64,024	1.5
São Paulo	10,364,152	9,669,061	93.3	13,642	0.1	58,711	0.6
Paraná	2,664,276	2,162,458	81.2	3,009	0.1	46,219	1.7
Santa Catarina	1,498,742	1,198,949	80.0	1,343	0.1	19,962	1.3
Rio Grande do Sul	3,042,039	2,504,745	82.3	3,180	0.1	49,001	1.6
Mato Grosso do Sul	562,902	448,984	79.8	471	0.1	8,904	1.6
Mato Grosso	645,905	439,479	68.0	873	0.1	26,990	4.2
Goiás	1,398,015	1,087,138	77.8	1,093	0.1	46,134	3.3
Federal District	547,656	495,791	90.5	55	0.0	3,728	0.7

Source: Brazilian Census Office - Demographic Census of 2000

Table 4. Volume of water caught per capita (liters/month), water measurement per capita (liters/month) and water loss rates (%), by river basins in the State of São Paulo, 1992 and 1995

	Water caught per capita (liters/day)		Water measured per capita (liters/day)		Water loss rate (%)	
	1,992	1,995	1,992	1,995	1,992	1,995
State of São Paulo	260.6	288.8	153.5	157.8	41.1	45.4
Mantiqueira	191.0	210.9	155.2	165.8	18.8	21.4
Paraíba do Sul	230.7	272.2	125.8	147.2	45.5	45.9
Northern Coast Norte	357.3	357.8	257.7	210.8	27.9	41.1
Pardo	344.5	384.1	176.1	53.0	48.9	86.2
Piracicaba/Capivari/Jundiaí	294.1	256.4	105.9	74.4	64.0	71.0
Upper Tietê	253.5	310.3	168.9	194.0	33.4	37.5
Santos Costal Area	403.6	435.8	245.9	221.7	39.1	49.1
Sapucaí/Grande	258.2	260.5	156.6	163.2	39.4	37.3
Mogi-Guaçu	271.3	233.0	164.5	118.4	39.4	49.2
Sorocaba/Middle Tietê	289.8	158.4	155.0	76.2	46.5	51.9
Ribeira de Iguape/Southern Coast	138.3	163.2	97.1	100.4	29.8	38.5
Lower Pardo/Grande	302.0	396.4	185.6	260.1	38.5	34.4
Tietê/Jacaré	285.8	322.7	197.0	181.6	31.1	43.7
Alto Paranapanema	123.1	187.1	89.2	99.7	27.5	46.7
Turvo/Grande	210.6	241.1	66.7	132.4	68.3	45.1
Tietê/Batalha	187.7	240.4	81.0	146.2	56.9	39.2
Médio Paranapanema	214.6	179.4	120.2	109.5	44.0	38.9
São José dos Dourados	146.1	208.2	102.0	172.7	30.2	17.1
Lower Tietê	257.2	308.3	137.7	145.2	46.5	52.9
Aguapeí	205.5	213.5	99.5	122.3	51.6	42.7
Peixe	221.0	228.3	129.9	116.0	41.2	49.2
Pontal do Paranapanema	194.2	268.5	119.9	125.0	38.3	53.5

Source: Adapted from: Seade Foundation/*Pesquisa Municipal Unificada - PMU*. The water loss rate is obtained by subtracting the volume measured from the volume caught. This result is divided by the volume caught and multiplied by 100.