

# URBAN MANAGEMENT MODEL CONCERNING THE ATTENDING CAPACITY OF THE WATER SUPPLY SYSTEM

L. H. A. Lopes<sup>a</sup>, C. Loch<sup>b</sup>, H.-P. Bähr<sup>c</sup>

<sup>a</sup> Departamento de Desenho, Setor de Ciências Exatas, Universidade Federal do Paraná, Curitiba, Brasil, lhalopes@ufpr.br

<sup>b</sup> Laboratório de Fotogrametria, Sensoriamento Remoto e Geoprocessamento, Departamento de Engenharia Civil, Centro Tecnológico, Universidade Federal de Santa Catarina, Florianópolis, Brasil, loch@ecv.ufsc.br

<sup>c</sup> Institut für Photogrammetrie und Fernerkundung, Universität Karlsruhe, Karlsruhe, Deutschland, baehr@ipf.uni-karlsruhe.de

Commission VII, WG VII/4

**KEY WORDS:** Cartography, Developing Countries, Disaster, Impact Analysis, Mapping, Planning, Thematic, Urban

## ABSTRACT:

The worldwide production of potable water represents a without cease enormous challenge. Each year 80 million new persons seek their rights for aqueous resources over the earth surface. Unhappily almost three billion new inhabitants for the next fifty years will be born in lands where scarcity of water is already nowadays present. Brazilians seem not worried with their water reserves forgetting that one deal with a renewable but not inexhaustible wealth. As the administration of urban occupation process reveals its inadequacy in terms of capacity to face water provision in a situation of demand bigger than supply, it is noticeable the conflict between the concessionary company, the municipal public government and citizens of the community, reaching to a point of real degradation of urban, environmental, social, sanitary and economic conditions which culminate in an urban catastrophe. Adding problem is the exodus from rural communities and from big cities whose inhabitants search for better life conditions in smaller urban centres. Water is becoming an expensive wealth. The general objective of the research is to prove the necessity of adoption of a model to support the administration of the urban occupation process, concerning the capacity of the water supply system. Florianópolis attract in the last decade significant number of new inhabitants. With the preconceived idea of establishing as area of study one that could be evaluated through daily water measurements of macro-meters, the elected area was the District of Santo Antonio de Lisboa. The application of linear regression statistical method demonstrates significant correlation between data obtained from the studied area and the ones from Ponta do Sambaqui neighbourhood (pilot area). Thematic maps directed to Ponta do Sambaqui, dealing with number of days that each residence suffered lack of water and number of days of water rationing per habitation, demonstrate de necessity of adoption of the urban management model proposed. Ultimately, the inconvenience of lack of tradition, which leads to, the non-use of topographic maps by de concessionary company, was demonstrated. As consequence of what one would expect from results, other secondary propositions were made, i.e. the direct participation of the inhabitants in the urban management process concerning the water supply system and the permanent concourse of the universities in the evaluation and solution of problems of such importance.

## 1. INTRODUCTION

Migration to urban spaces in the last 50 years is considered one of the main causes of social and environmental unbalance, as many green areas had to be subtracted to unexpected and massive populating growing. Life conditions would be better if the process of human urban spaces occupation were gradual and planned.

Although the world suffers a generalized scarcity of fresh water the Brazilians seem unconcerned with their reserves, which are renewable but not inexhaustible.

Though new water resources could be developed, the restoration of the equilibrium between supply and demand lies on controls of the latter through populating stabilization and educational campaigns against waste on a par with new techniques of water supply.

Due to its importance, conditions for per capita water supply should previously account in urban planning. People education and awareness of the problem are urgent, before the catastrophic exhaustion of water reserves occur (IFRAH, 2002).

The Urban Multipurpose Technical Cadastre represents an extraordinary instrument to the study of urban management (LOCH, 1998), as it associates information about urban real estate, ground characteristics, and special attributes such as landscape, infra-structures and urban equipments, in a way of graphic presentation of easy handling, available to governmental institutions and to the community (LOPES, 1966).

The research pretends to check whether in Florianópolis, a city in development and capital of the State of Santa Catarina in south of Brazil, the demographic expansion, the evolution of street designs and system of urban transportation occur simultaneously with the expansion of the water supply net.

Due to the facilities of access to different places, it is well known how individual and collective transportation influence the aspect of city environments (BRUTON, 1979). As main stimulants of urbanization, these are also responsible for urban growing in the periphery of the cities, where, in accordance to SACHS (1997), occurs an unbalanced occupation of space with undesirable consequences for environmental landscape.

Up to determined limits urban condensation is of interest for city administration, due to bigger social profitability of public equipments and installed substructure basic services, avoiding expenditure of money in peripheral areas where populating increase occur (CONTADOR, 1997). Countries under economical crisis have difficulty to implant adequate plans; as consequence, the utilized urban condensation parameters differ much from the idealized ones, which results in a complete chaos of the urban management (CARVALHO, 2000). The paper must be compiled in one column for the Title and Abstract and in two columns for all subsequent text. All text should be single-spaced unless otherwise stated herein. Left and right justified typing is preferred.

The main function of a water supply system is to furnish fresh water to the community directly in the houses and in quantities compatible with the real necessities. It is highly desirable the establishment of a predictive plan in confrontation with the urban concentration, in order to attain up to date and future results, through integrative actions of public bodies (LLAMAS et GARRIDO, 1997). In companies in charge of water distribution one may depict disarray between project and operation, which results in expansion of the net without observance of technical premises. As consequence water lacks in the faucets due to insufficient pressure and minimum outflow.

When urban expansion runs independently or ahead urban planning generally the law is broken especially because many clandestine water tubing of lower quality are constructed out of control of the distributing company. The constant ruptures of such tubing function as important occult draining points of the water net. These conflicts are source of important social, ecologic, sanitary and economical damages, protagonists of an authentic urban catastrophe.

The catastrophe theory represents a universal method to explain transitions through leaps, discontinuities and unexpected changes in quality (figure 1) (ARNOLD, 1989).

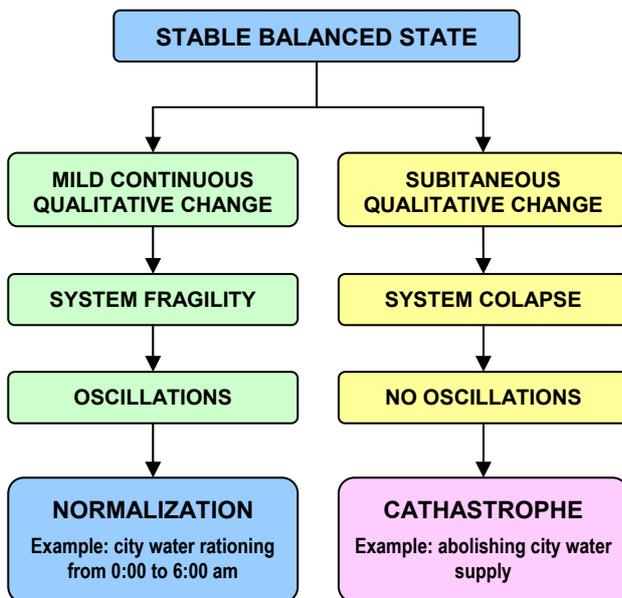


Figure 1 - Diagram of the catastrophe theory. Source: Adaptation from R. Thom in Arnold, 1989.

## 2. MATERIALS AND METHODS

### 2.1 Area of Study

The city of Florianópolis, SC. has an area of 436.5 Km<sup>2</sup>, being localized between the latitudes 27°25' and 27°50' south and longitudes 48°25' and 48°35' west. Its geographic limits comprehend an insular area of 424.4 Km<sup>2</sup> and a continental area of 12.1 Km<sup>2</sup> (figure 2).

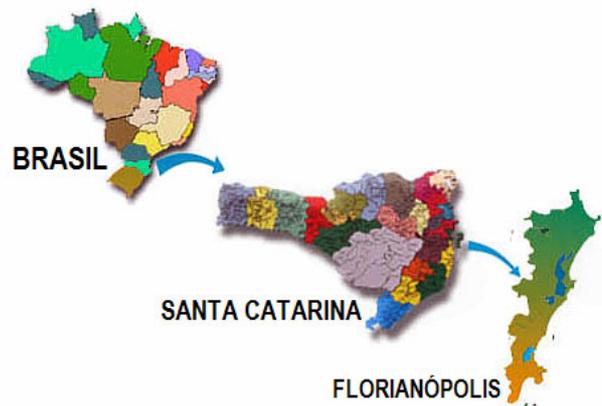


Figure 2 - Outline of the city of Florianópolis. Source: Guia Digital Florianopolis – ed.2002.

To reduce the area of study it was elected the District of Santo Antonio de Lisboa situated in the mid-west of the island, because the following criteria of study were fulfilled in a way to grant representative ness of the global system: daily macro-measurements in confrontation with relative consumer-micro-measurements; daily water necessities relative to home-unities; weather data, particularly envisaged to weekly, monthly and yearly variations.

Otherwise the area (Condominium Mareney, Ostras' street and Brito alley) was elected because of its characteristic supply system of reservoirs along the net and because some areas of the District present variable intensities of urban development. The population of the District is 5.338 inhabitants (IBGE, 2000).

### 2.2 Cartography

In accordance to a aero-photogrammetric survey (scale 1:2000) performed in February 2000 by Aeroconsult Aerolevantamentos e Consultoria S/A a reconstitution of the area of study was obtained and the topographic map of the research was digitalized, as base to all other thematic maps. The aero-survey presented the following characteristics:

- Universal Transverse Mercator Projection – UTM;
- Origin of the distance in kilometres UTM Equator and Central Meridian, the constants 10,000 Km and 500 Km respectively accreted;
- Central Meridian = 51° WGR;
- Coefficient of linear deformation in the middle of the sheet (K) = 1.0003315;
- Vertical datum = Imbituba – SC;
- Horizontal datum = SAD-69;
- Aero-photogrammetric covering – 1:8000 (Jan 2002);

Horizontal and vertical support, re-ambulation and restitution performed in January and February 2000; Cadastral actualisation accomplished from aerophotogrammetric data of May 2002; Level curves equidistance = 1 meter.

### 2.3 Water Supply System

The water supply system (WSS) of the District of Santo Antonio de Lisboa is terminal of the Integrated System of Florianópolis (ISF) and it is constituted by water impounding from Pilões and Cubatão rivers that run in the region of Santo Amaro da Imperatriz. Before reaching the area of study these rivers furnish water to four other regions, plus the continental area of Florianópolis and to six districts of the insular region. The Costa Norte System (CNS) furnishes a complementary amount of water extracted from 22 artesian wells joining the ISF in the vicinity of the area of study, where a retention valve prevents water reflux from ISF and a macro meter allows daily readings of the water volume that comes from the CNS (figure 3).

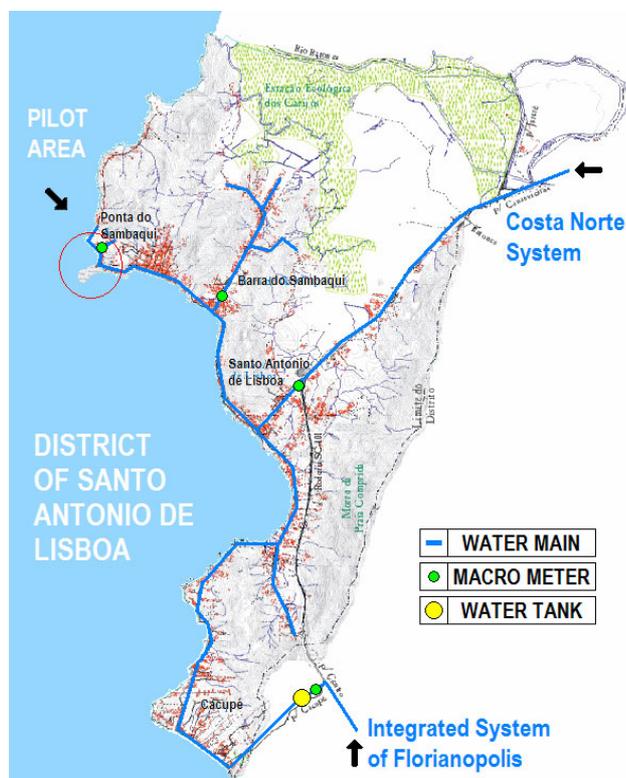


Figure 3 – Schema of Water Supply System District of Santo Antonio de Lisboa

The capacity to suffice the requirements of water by the system were determined by the analysis of the following data: daily measurements of the total pumped in the entrance of the District of Santo Antonio de Lisboa in Cacupé (ISF); daily measurements of total volume distributed in Santo Antonio (CNS) and the daily total volume data pumped to Ponta do Sambaqui (Ostras' street booster).

To determine the efficiency of the net in terms of pressure and outflow, the research did not utilize technical details furnished by the Operational Regional Sector of Florianópolis, due to

their precarious precision, the lack of cartographic base, and an outline containing graphic errors.

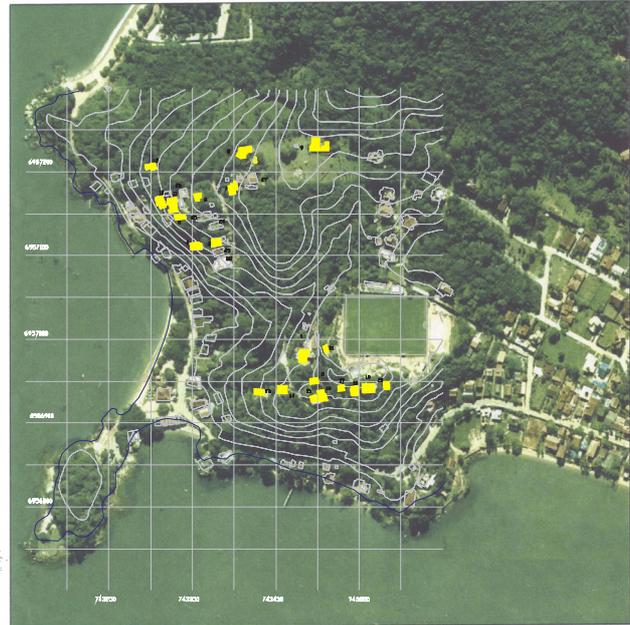


Figure 4 – Aero-image of pilot area with approximate superposition of its aero-photogrammetric restitution.

Figure 4 shows in details the houses with water supply delivered by the CASAN (Water and Sanitation Company) and thanks to a booster with macro-meter localized in that region it was possible to restrict to this region the area of research, as representative of the global system.

The study included a survey of population data, with addresses, individual categories, number of dwellers per residence and possible seasonal increments, capacity of house particular reservoirs and daily necessities, in order to attain autonomy of water usage under circumstances of suspended provision by CASAN.

Although the daily expenditure of water per capita might be variable, the recommended allowance is situated between 100 l/inhabitant/day and 300 l/inhabitant/day (WHO, 2003). A group of authors: BRITO (1943), AZEVEDO NETO et al (1973) and GARCEZ (1988) suggest values depicted in table 1.

Food and ingestion	10
Ablutions	5
Clothes washing	20
Tableware washing	15
Bathing (10 minutes)	90
Toilet flushing (3 x)	30
House cleanliness	10
<b>Total (liters/inhabitant/day)</b>	<b>180</b>

Table 1 - Volume of Daily Water Expenditure per inhabitant.

Through a simulative program developed with the aid of an Excel<sup>®</sup> Net Chart, each case was studied in accordance to daily variations of pumping volume related to water demand

intending to detect normal provision, water rationing, lack and losses, and their effects on effective volume of reservoir. These occurrences are shown in 2 thematic maps.

Figure 5 shows the number of days of water rationing, in a period of 35 months and the number of days that the residences did not suffer the effects of rationing due to the great capacity of their private reservoirs.

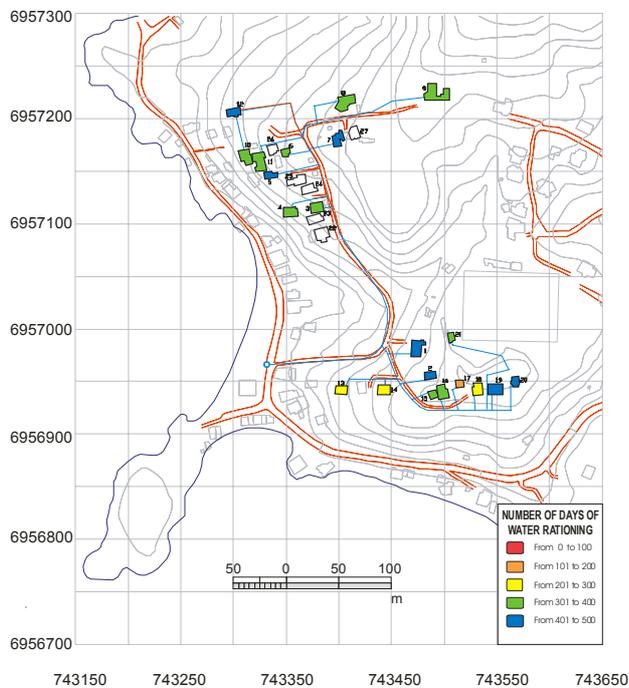


Figure 5 – Thematic map of the number of days of water rationing from February 2001 to February 2003.

Data obtained from the daily volume of water pumped by the booster in Rio das Ostras, plus each residence daily requirements and the capacity of the respective reservoirs, permitted the evaluation of the number of days that each residence suffered lack of water, irrespective of the number of days without water supply (Figure 6).

#### 2.4 Weather Survey

Daily data of minimum, medium and maximum temperature and of precipitation from February 2001 to February 2003 were essential for the determination of their possible relationship with volume distribution data to the District of Santo Antonio de Lisboa, as well as the pumping water volume to the community of Ostras' street.

These data were available from the Setor de Tecnologia da Informação Meteorológica of CLIMERH and EPAGRI in Santa Catarina.

#### 2.5 Statistical Survey

The attainment of dependent and independent variables determined statistical treatment by multiple correlations. Data from the District of Santo Antonio de Lisboa were adjusted to a multiple regression model, considering dependent variables the data furnished by CASAN (total daily volume distributed) and independent climatic data of temperatures and precipitation. Ostras' Street (pumped volumes) and other climatic variables

were respectively treated as dependent and independent ones (LEVIN, 1978) (BUNCHAFT et KELLNER, 1999).

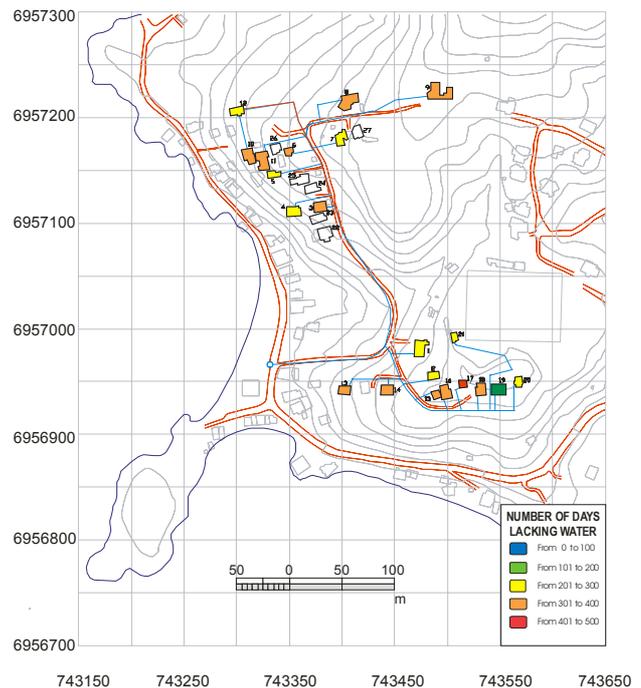


Figure 6 – Thematic map of the number of days lacking water from February 2001 to February 2003.

### 3. RESULTS AND DISCUSSION

Almost one century has elapsed from the observations of BRITO in 1905 about the city of São Paulo concerning water supply, as the author expressed: "...The Institute knows that we do not have a good topographic chart of the city..." and further: "...There was not and there is not a chart nor an outline of water net"...Unhappily those deficiencies are still present 99 years later, portraying the present system in Florianópolis.

#### 3.1 Statistical Validation of Results

The statistical analysis showed that the elected region for study (in Ponta do Sambaqui: Ostras' street, condominium Mareney and Brito alley) was adequate as representative of the District of Santo Antonio de Lisboa, because of significant correlation of total distributed volume plus precipitation and total pumped volume by the Ostras' Street booster.

#### 3.2 Monthly Supply Deficit

The reservoirs by their capacity should prevent lack of water, but they did not, as demonstrate the data from daily pumped volumes in relation with the common daily necessities. One could conclude that monthly supply was adequate in only 4 months of the two years period of study (March, July and October, 2001 and March, 2003)

Even if the supplying Company had accomplished the proposed supply of 15,000 liters, the pilot area of study would yet suffer a monthly deficit related to February and December 2001; January, February, November and December 2002 and January

and February 2003, fact that justify an urgent reevaluation of the program of water supply for Florianópolis.

The study shows also that to possess private reservoirs of great volume capacity is illusory in terms of plenitude of water supply.

### 3.3 Water Supply Simulation

Due to the dimension of the study area and the complexity of the supply system, the program of water supply simulation did not consider possible pressure abatement caused by distance and ground quota differences (NEVES, 1979) (GARCEZ, 1988).

House unities which possess small reservoirs detect early the lack of supply or no supply at all. Otherwise, when private reservoirs are large, detection of water rationing or lack of supply may not occur or may occur lately, when the reservoir capacity is exhausted (figure 5).

When the thematic map is interpreted, the occurrence of few days rationing is not to be considered optimistic, because they only points to the fact that if lacking of water did not occur it was only because of the large capacity of reservoirs. When the Company pumps less or do not pump at all the results for the beneficiaries differ in accordance to the capacity of their reservoirs (Figure 6).

### 3.4 Proposed Model

Ideal conditions of functionality for urban management begin with urban planning, although commonly urban planning comes only after a long process of urban space occupation, concentration and expansion had occurred. Under such circumstances urban planning, that should be a preventive process, will be destined to correct distortions.

The fundamental tool for urban planning is the implantation of the urban technical cadastre, which enables the administrator to the actual knowledge of facts. This way, the entire process will be appreciated in accordance with the geographic information system created from a cartographic base, with constant actualizations, under legal patterns and cadastre surveying.

The model has a sequence of events, from the observance of zoning premises to the Company in charge of sanitary observance, which will study the local conditions for water supply.

It is to be observed that this research concerns the conditions of water supply, but this is only one of multiples elements that must be taken in consideration in the ideal model.

Other decisions must be taken in relation with signs pointed by beneficiaries insofar the quality of the water in the net and in the reservoirs is concerned.

Not less fundamental yet, is the integration of cadastral system of the concessionary company with the cadastral system of the municipal administration, both obligatorily bound to real legal property premises.

## 4. CONCLUSIONS

In spite of pluviometric normality it is evident the vulnerability of the water supply system to attend the requirements and its precarious capacity is attested by the number of days of rationing or lack of water that the beneficiaries have to endure.

The greatest menace to the inhabitants of Santo Antonio de Lisboa is the lack of urban management and the deficient interaction between municipal administration and CASAN. Non-official nets of distribution are created, not as exclusivity

of areas with high ground quotas, without the necessary observance of potability of water.

Although IPUF in partnership with CASAN have invested significantly in aero-photogrametric surveys of the Florianópolis region inexists a geographic information system based on a Multipurpose Technical Cadastre. As it was hypothesized, the study confirms that inexists also relationship between the process of urban occupation and the capacity to attend the demand for potable water distribution.

The system lacks of dependable data that must be collected through trustworthy scientific methods, which foresee, inclusive, adequate calibration of instruments.

Only after the system were able to attend efficiently the present demands it will be feasible future ability to manage gross water from their sources, as well the adequate production of potable water and its effective distribution.

As final conclusion it is not recommended any new occupation of urban space in the area of study, on the face of the present precarious capacity to attend fresh water demand.

## REFERENCES

ARNOLD, Vladimir I. *Teoria da Catástrofe*. Campinas: Editora Unicamp, 1989. 154p.

AZEVEDO NETTO, J.M. de, MARTINS, José Augusto, PUPPI, Ildefonso C., BORSARI NETTO, Francisco, FRANCO, Pedro Nelson C. *Planejamento de Sistemas de Abastecimento de Água*. Curitiba: Universidade Federal do Paraná; Organização Pan-americana da Saúde, 1973.

BRITO, Saturnino de. *Abastecimento de Águas. Parte Geral, Tecnologia e Estatística*. Rio de Janeiro: Imprensa Nacional, 1943.

BRUTON, Michael J. *Introdução ao planejamento dos transportes*. Rio de Janeiro: Interciência, São Paulo: USP, 1979.

BUNCHAFT, Guenia, KELLNER, Sheila Rubino de Oliveira. *Estatística sem Mistério*. v.2 p.143-195. Petrópolis: Vozes, 1999.

CARVALHO, Pompeu Figueiredo de. Instrumentos legais de gestão urbana. Referências ao Estatuto da Cidade e ao zoneamento. In: BRAGA, Roberto, CARVALHO, Pompeu Figueiredo de. *Estatuto da Cidade. Política Urbana e Cidadania*. Rio Claro: UNESP-IGCE, 2000. 114p. p.41-59.

CONTADOR, José Celso. *Um modelo para propiciar equilíbrio urbano*. Arquitetura, Rio de Janeiro, n.16, p.82-89, 1977.

GARCEZ, Lucas Nogueira. *Elementos de Engenharia Hidráulica e Sanitária*. 2.ed. São Paulo: Edgard Blücher, 1988. 356p.

IBGE. Instituto Brasileiro de Geografia e Estatística. *Censo Demográfico 2000*. 2000. Disponível em: <http://www.ibge.gov.br/censo/default.php>

IFRAH, George. *Histoire de l'Eau*. Paris, 1992. Available in Internet: <http://www.saaej.sp.gov.br/polui/declara.htm>

LEVIN, Jack. *Estatística Aplicada a Ciências Humanas*. São Paulo: Harper & Row do Brasil, 1978. 310p.

LLAMAS, José, GARRIDO, Raymundo. Conflictos en el uso del agua para objetivos múltiples. In: *Agua: Uso y Manejo Sustentable*. Seminário Internacional Asociación de Universidades Grupo Montevideo. Buenos Aires: Eudeba, 1997. p.21-51.

LOCH, Carlos. Modernização do Poder Público Municipal. COBRAC 98. In: Congresso Brasileiro de Cadastro Técnico Multifinalitário 3, 1998. Florianópolis. *Anais*. Florianópolis: [CD-ROM], 1998.

LOPES, Luiz H A. *Preenchimento de Vazios e Renovação Urbana. Estudo dos Efeitos das Ocupações em Áreas de Solo Criado*. Florianópolis, 1996. 142p. Dissertação (Mestrado em Engenharia Civil) – Curso de Pós-Graduação em Engenharia Civil, Universidade Federal de Santa Catarina.

NEVES, Eurico Trindade. Curso de Hidráulica. ed.6. Porto Alegre: Globo, 1979. 577p.

SACHS, I. Desenvolvimento sustentável, Bio-industrialização descentralizada e novas configurações rural-urbanas. In: Vieira, P. F. & Weber, J. *Gestão de recursos naturais renováveis e desenvolvimento: novos desafios para a pesquisa ambiental*. Trad. Pontbriand-Vieira, A. S. d. & Lassus, C. d. São Paulo: Cortez, 1997. p.469-494.

WHO World Health Organization. Available in Internet: <http://www.who.int/en/>

#### **ACKNOWLEDGEMENTS**

To CAPES for the financial support. To the Universidade Federal do Paraná, for the opportunity. To the Universidade Federal de Santa Catarina, for the acceptance, especially the Laboratório de Fotogrametria, Sensoriamento Remoto e Geoprocessamento, whose aim is entirely directed to research. To the Institut für Photogrammetrie und Fernerkundung, Universität Karlsruhe for the approval and counseling in the maturing phase of the theme.