

FLOOD CONTROL AND URBAN DRAINAGE MANAGEMENT IN BRAZIL

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Urban development and main issues

The urban population has grown at a faster rate during the last decade in Brazil (from 56% in 1970 to 82% in 2000) which formed large urban areas (metropolitan areas) with a main center and several neighboring towns. Among the largest cities in the world eight out of ten are in developing countries. In Brazil there are more than 12 cities with more than one million inhabitants.

This urban growth has been characterised by irregular expansion of the peripheral areas, not paying much attention to urban regulations related to the Urban Master Plan, and specific land development rules, besides the irregular occupancy of public areas by low income populations.

These development results in a high population concentration in small areas, poor public transportation, lack of some water facilities, polluted air and water. These poor environmental conditions are the main concern for quality of life of developing countries. These usually are some of the causes for this:

- Low economic income and unemployment;
- Lack of planning and public investment to guide urban expansion: since the price of infrastructure required for new developments is greater than or close to the market value of the lots (low income enterprises), it is not implemented, and in the future the county has to pay for it or leave the neighborhoods in unhealthy conditions;
- Restrictive measures incompatible with the economic reality: In Brazil, the protection of water source areas led to restrictive laws that conditioned disobedience. These laws prevent the use of the areas where the water supply sources are located, but the government does not buy the property. In this situation the land owner loses economic value of the property and still have to pay taxes. Ultimately, this causes disobedience because the areas were invaded by the low income population at the invitation of the proprietors themselves, as a means of negotiating with the government.

Thus there are the legal and illegal city. It requires law enforcement and more realistic policies regarding: land use infrastructure developments and investments.

Impacts due to urban runoff and occupation of the flood plains

Storm runoff can produce floods and impacts on the urban areas due to two processes which could occur integrated or isolated, Flood Plain and Flooding due to urbanization.

Flood plain:

These are natural floods which mainly occur in medium and large sizes rivers. Since, in the Urban Master Plan of most Brazilian cities, there is no restriction on building housing in the flood risk areas, a sequence of low flood years being reason enough to develop new building in flood risk areas. However, when a larger flood occurs, flood damage increase and the municipality is requested to invest in flood protection in this area (see below).

União da Vitória/Porto União: In figure 1 the floods levels of Iguaçú river at União da Vitória and Porto União (two cities in the border of two Brazilian States) can be observed. Between 1959 and 1982 there was only one flood above 5-year return period. As one can see from table 1, most of urbanisation in Brazil occurred during this period. The floods after 1982 produced significant damages to the community (table 2) and important conflict with Power Plant downstream the city. The population blamed the dam and its operations. This conflict was developed since 83 and aggravated in 92 when another large flood came and conflict increased. A ONG was created by the population and the following studies were developed: an assessment of the impacts, flood zoning and the negotiation with the Power Plant Company for flood warning and land occupation(Tucci and Villanueva, 1997).

Table 2 Flood losses at União da Vitória and Porto União(JICA, 1995)

Year	Losses US\$ millions
1982	10.365
1983	78.121
1992	54.582
1993	25.933

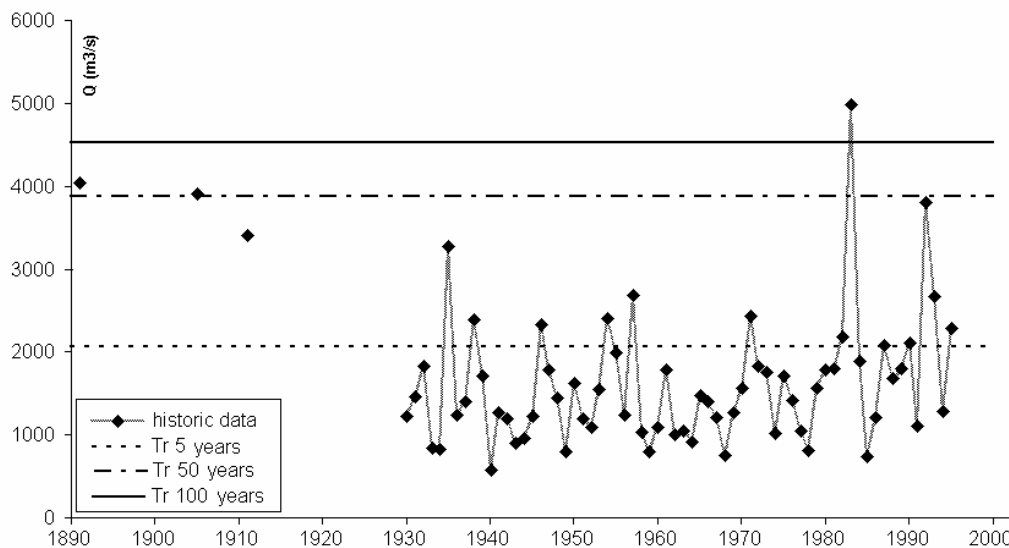


Figure 1 Maximum flood levels in Iguaçú river at União da Vitória (a basin of approximately 25,000 km²), Tucci and Villanueva, 1997)

Estrela is a small town in South of Brazil in which important part of the population has German origin. This city is located in the border of Taquari river (27,000 km²) basin. During floods this river can increase its level until 18 m in one day. The flood plain was occupied by low income population and in 1979. When the Urban Master Plan was developed, a flood zoning was planned (Rezende and Tucci,1979) recommending restriction to the occupation of this area. It was implemented by county legislation, but the town did not have enough funds to transfer the population and to give economical alternative for the land owners. In order to solve this problem the county administration allowed the increase of the construction area in downtown in exchange of flood plain area. It created a economical market for the these areas which would lost value after the city flood plain restriction. During the last 22 years the flood losses has decreased, but the main issue has been to hold the legislation and enforcing it. There were many attempts to change the legislation in order to occupy again these areas.

Flooding due to urbanization:

The flood frequencies and magnitudes rise due to the occupation of land with impervious surfaces and runoff conduit systems. In Brazil, there are not source control and impacts are transferred to downstream in the major

drainage. The economic flood losses in almost every medium to large cities are sky high. In figure 2 one can see the increase of floods events and the urban population in Belo Horizonte (2,7 millions inhabitants).

Urban drainage planning is a process that is best begun whilst a basin is still in its natural conditions and urbanisation is about to proceed. Taking as the point of departure the population density and occupation type, planning scenarios are identified for each economic area of the city. If the hydrologic model is to predict the volume and time-distribution of urban runoff satisfactorily, the urban characteristics given in the scenario must be related to the parameters of the hydrologic model, with urbanisation typically represented by the proportion of impermeable area and characteristics of the drainage network.

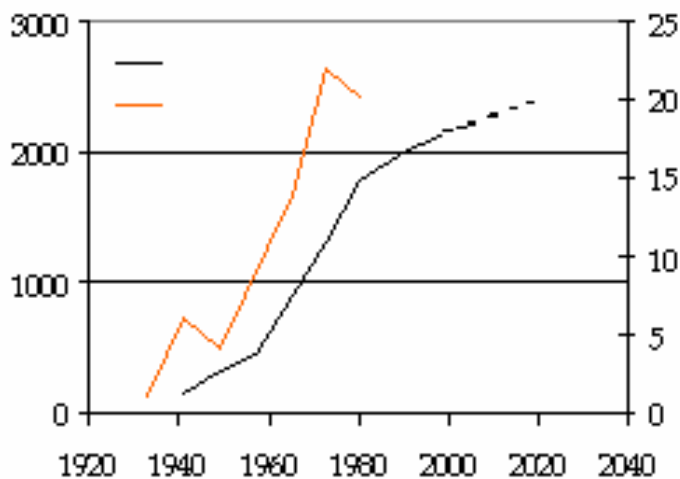


Figure 2 Population increase and flood events in Belo Horizonte, Brazil: (scale in the left is the population increase; in the right is the number of events; in the horizontal, years; yellow number of events; black population increase)

Flood Control in Metropolitan Area of Curitiba: The Metropolitan Area of Curitiba (RMC) (State of Paraná, Brazil) has 2,5 million inhabitants. Most of its urban area was developed in the Upper Iguazu River Basin which has a basin area of 1000 km² in J. Belem (Figure 3). The main tributaries presented in figure 3 have an area of 100 km² and the highest urban concentration is in Belem sub-basin.

Iguazu River has a large natural flood plain due to the small river conveyance and bottom slope. During the flood months the hydrograph is damped by the storage capacity of the valley and the regional administration ruled against occupation of the floodplain. However, since 1980 there were heavy pressures for occupation of the flood plain. It was done through invasion of public green areas and by unapproved developments and occupation. In July 1983 and January 1995 two major floods occurred with severe damages of US \$ 50.3 millions and 40.2 millions, respectively. The 1995 flood had a seven day rainfall with more than a 100 years of return period (largest in the 110 years of data). The time of concentration in the main river is about of seven days.

The main causes of the floods in this area are: increase of flood flow frequency due to the urbanization; flood plains occupation by the population; flow obstruction due to urban works such as bridges, land fill, poor drainage projects. The usual approach would be to increase the Iguazu river capacity to cope with the 50 or 100 year flood. Under these conditions the population would occupy the floodplain. Since upstream basin are in development, the peak flow peak will increase in the future scenario. In this situation the flood will come back and the cost of control would be higher, since there would be no free space to improve the river capacity. This situation occurred in the Metropolitan Region of São Paulo.

Therefore the main approach to flood management was the following (figure 4):

In the main river (Iguaçu): Create a storage area in the Iguaçu river in the Metropolitan Area as a larger park (300m to 1km wide and area of about 20 km²). The boundaries are: (i) a channel, which creates a limit to urban settlement pressure and increases the river flow capacity and (ii) the Iguaçu River (Figure 4);

In the tributaries: Development of the Urban Drainage Master Plan for the Metropolitan Region using the following principles: (i) developments of urban parks in the tributaries to damp the peak flow increase of the uncontrolled upstream area; (ii) regulation for the controlled area.

The occupation of the park area was small and the resettlement of this population should be done before or together with channel construction, because after that the area will increase its market value. Law enforcement inside the park is a challenge, but since its limits are developed and infra-structure was installed usually there are not invasion.

The channel and the park are in the development. The park has 20 km² of area which includes: environment reservation area, small lakes, many recreational facilities, aquatic sports lanes among others. The Urban Drainage Master Plan for the Metropolitan Area was finished and the changeling is to implement it through many counties.

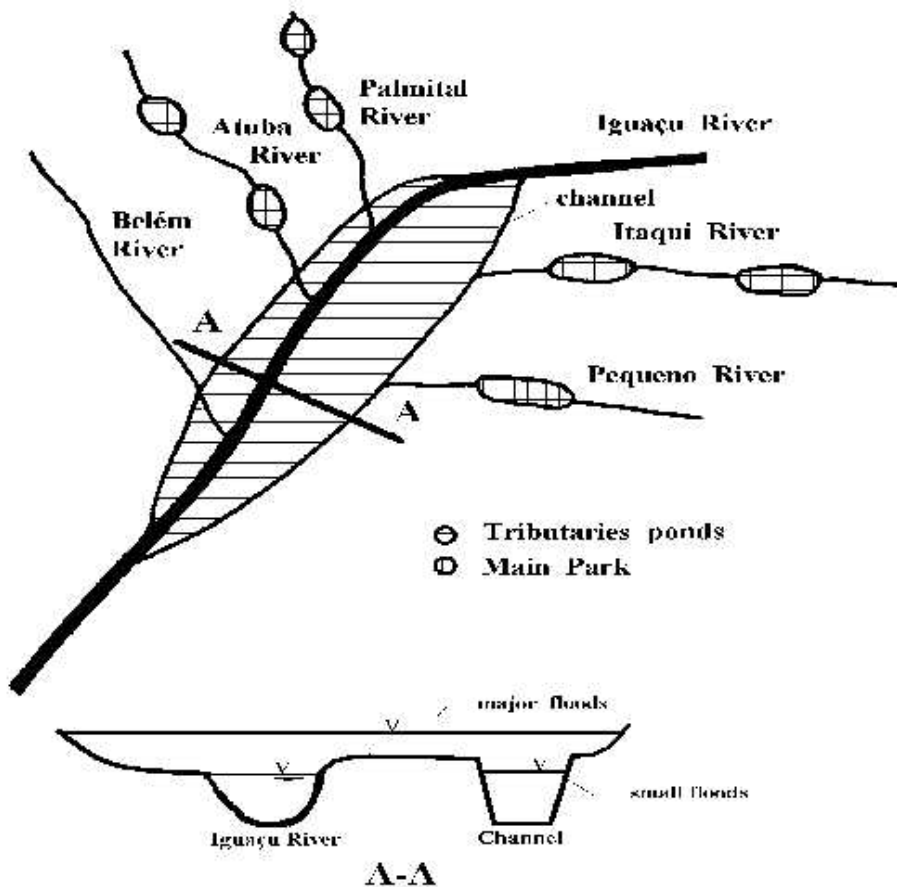


Figure 4 Flood Control in Metropolitan Area of Curitiba