



# **BRAZIL: FLOOD MANAGEMENT IN CURITIBA METROPOLITAN AREA**

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**Abstract.** Information is provided on approaches and flood management measures taken to protect a densely populated urban area of Brazil. Of interest are the conceptual and structural approaches to control and prevent population invasion of reserved flood storage areas. The study also contains practices/lessons with potential to be transferred/applied to other regions.

## **1. Location**

The Metropolitan Area of Curitiba (RMC) is located in the State of Paraná, Brazil, in the southern part of the country. Most of this urban area was developed in the Upper Iguaçu River Basin, which has a basin area of 1000 km<sup>2</sup>. There are a number of tributaries, most of which have basin areas of about 100 km<sup>2</sup>. The area has 2,5 million inhabitants, with the highest urban concentration in the Belem Basin and other neighboring basins.

## **2. Nature of floods**

In the RMC there are two types of floods:

*Floods due to urbanization*, which occur mainly on the tributaries of the Iguaçu River. These usually happen in the downtown area of Curitiba and in the highly urbanized cities forming part of the Metropolitan area. Due to urbanization the floods have increased by a rate of six. In downtown Curitiba there are many channels to transfer floods from one point to another, the construction of which has resulted in a high cost for the municipalities.

*Floods due to low river capacity* as a result of: (i) flood plain occupation by the population; (ii) flow obstruction due to urban infrastructure such as bridges, landfill; and (iii) inefficient drainage projects. Although the regional administration ruled against occupation of the floodplain, since 1980 there were strong pressures, which resulted in the invasion of public green areas and unapproved developments and land occupation. In July 1983 and January 1995 two major floods occurred with severe damages amounting to US\$ 50.3 million and 40.2 million, respectively. The 1995 flood was the result of a seven-day rainfall (largest in the 110 years of data). The critical flood volume duration in the main river usually is seven days.

## **3. Flood management and mitigation measures**

As a component of a Sanitary Program (PROSAM) dealing with environmental impacts on the Metropolitan area of Curitiba and funded by the World Bank, a *Flood Management Project* was undertaken with the objective of developing flood measures taking into account urban constraints and minimizing their economic and social impacts. The project, initiated in 1996, had the following staged steps:

- *Emergency measures*: preliminary studies and actions for minimizing flood impacts; these were developed at the beginning of the project and already helped to decrease some local floods;
- *Medium term* flood control measures: studies and actions required on the Iguaçu river;

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- *Long term measures:* projects and actions to be planned on the tributaries, together with the Urban Drainage Master Plan for the Metropolitan Area.

To solve the flooding problem of the Iguaçú River, according to past practice the usual approach would have been to carry out construction works to increase the river capacity so as to cope with the 50 or 100-year flood. Under these conditions, because of the fact that flood frequency decreases as a result of these works, the population would feel protected and start to occupy the floodplain. Parallel to this, after a few years the development of the upstream basin would increase the flood frequency and peak of the floods. Under such a future scenario, there would not be more space available to allow increasing the section width of the channel, since the flood plain would be occupied. Thus, flood control would only be possible by means of dykes (with pumping station and internal drainage), or deepening the river along a reach of at least 50 km, all of which would represent a very high cost.

In view of all the above, the adopted conceptual approach was as follows: (i) to create a space for flow and storage in the flood plain of the main river (Iguaçu); (ii) to develop a way to control the population invasion of the flood plain; and (iii) to develop the Urban Drainage Master Plan for the Metropolitan Region for the tributaries. In accordance with this, the following project activities have been undertaken:

- *Main river (Iguaçu):* the flood plain of Iguaçu was to be preserved as storage area along the Metropolitan Area. A park 300 m to 1 km wide and an area of about 20 km<sup>2</sup> was planned. The boundaries of this area are a channel on one side and the Iguaçu in the other. The channel was planned in order to create a limit to urban settlement pressure and to increase the river flow capacity for the Iguaçu basin in this area. The main recommendation was that the park had to be designed and implemented together with the channel construction.

The channel has been constructed and the park is under development. In a small fraction of the park there was some population, but they have been resettled to other areas. There have been no major floods since 1995, but for the last years' conditions it has solved the problem of invasion. Most of the area was bought by the State and its development was done with minimum costs. Some areas have been reserved for the development of wetlands in order to improve the water quality of some tributaries (still in a project phase).

- *Tributaries:* the Urban Drainage Master Plan for the Metropolitan Region (UDMP) was to be prepared on the following principles: (i) establishment of urban parks on the tributaries to damp the potential increase in the peak flow of the uncontrolled upstream area; (ii) implementation of the regulation regarding enforcement of source control on new developments in those counties where the tributaries are located. Strategic parks were to be planned to reserve storage areas in order to damp those floods not controlled by regulation and law enforcement.

The UDMP has been developed and some cities started its implementation. For this purpose, numerous meetings were held with the counties. It was seen that some economical incentives and law enforcement were required to bring all counties to participate in the UDMP. This would require: (i) law enforcement of the water legislation: all changes in the flow conditions from urban areas now would require water permits; and (ii) the establishment of an investment fund through which the county could receive funds to develop the UDMP within its boundaries. The institutional arrangements necessary for the whole process have presented some obstacles, and several recommendations were made to the State Government on this issue. Furthermore, these programs have not been implemented yet partly due to economical difficulties of the State (although some counties started the UDMP implementation using their own resources).

Finally, a flood warning system has been developed by the SUDHERSA (State Institution in charge of the flood management). There is a telemetric system of rainfall and runoff stations which transmit information to a center, where flood forecasts and warning for the main river system are



issued, using a mathematical model. The urban areas require very small lead times. The main difficulty for SUFHSA has been to keep the qualified personnel under current economic constraints of the State.

#### **4. Integrated urban drainage management**

The following actions are needed for integrated urban drainage management:

*Prevention planning:* city development plans should take into account urban drainage flood plain areas. Source control and non-structural measures are the main choices at this planning stage. Some of these measures are related to: (i) the increased public use of the designated green areas which prevent invasion, thus making undesirable settlement much more difficult. In some cities, invasion of public spaces has been discouraged by the existence of barriers such as river channels, roads or railway lines; (ii) reserve areas for retention of storage in parks; and (iii) tax incentives for conservation of flood risk areas.

*Source control measures:* the planning should control the impacts at their source, creating public responsibility towards the problem. This control has a distributed characteristic but has to be seen in an overall picture.

*Park retention ponds as a drainage control reserve:* sub-catchments lying within the city boundaries or close to them should allow for future development by evaluating their capacity for settlement and the limits to which they can reasonably be developed. Limits can be defined for increases in the peak flow resulting from augmentation in impervious areas, and by planning public facilities such as parks with urban retention ponds, to which floodwaters can be diverted. Such areas can be used to lessen the impact of high flows within cities, but must be designated as such before they are invaded or developed by private interests.

*Institutional elements:* regulation of minor drainage taking into account the peak flow increase; regulation of land use in flood plains; tax incentives for conservation areas and for already constructed areas for drainage control; public procedures to control and legislation enforcement based on local conditions; increased law enforcement at a site level when it is already partially developed.

*Public participation:* use public poll about urban drainage facilities and requirements; create a public consultation through NGO representative for plans and projects related to urban drainage at all stages of their development; and increase the public awareness of the urbanization impact on urban drainage.

*Increase availability of hydrological data:* lack of these data and also of physical ones are a chronic problem in urban areas of developing countries. It causes inadequate design projects in many cases with higher costs. A program of data acquisition and development of methodologies for use of data in production of information for urban drainage are important requirements for sound urban drainage planning.

#### **5. Main lessons learned**

- Urban flooding is one of the major threats to cities. Most of the existing public policies in developing countries are neither technically, socially nor economically sustainable. Integrated Urban Drainage and Flood Plain Master Plans are the main instruments needed to develop a sustainable policy to manage flood impacts in urban areas.
- Integrated urban drainage management is based on goals and objectives related to the well being of the population and environmental conservation. Urban drainage and flood control master plans need to be developed based on urban space, hydrological conditions, hydraulic



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network and environmental conditions in order to reduce flood risks. Usually the main goals of such plans are the: (i) regulation of the use of flood plain areas through legislation and other non-structural measures; (ii) prevention and relief measures for low frequency floods; and (iii) Improvement in the urban drainage water quality.

- There should be a strong interaction between urban land-use master plans, urban drainage and flood control master plans and other city plans related to water supply and sanitation and solid waste management. Land-use is closely related to urban drainage. Therefore, urban drainage master plans should be essential components of urban master plans.