Flood control and urban drainage management in Brazil

Carlos E.M. Tucci

On the outskirts of many of Brazil's citites, poor people illegally occupy public areas, without sanitation or other infrastrucutre and often in flood-prone areas. This article outlines urban plans that take into account the need for a flood storage area, alternative living space for the poor, and compensation for private land owners.

Eight out of ten of the largest cities in the world are in developing countries. Brazil is no exception: here there are more than 12 cities with over one million inhabitants. Metropolitan areas have grown up to encompass a main centre and several neighbouring towns.

The peripheral areas have expanded without much attention to urban regulations. In particular, low-income people have often occupied public areas, resulting in overcrowding, poor public transportation, shortage of water facilities and polluted air and water. Causes of invasions include:

- low incomes and unemployment
- lack of planning and public investment to guide urban expansion. Since the cost of the infrastructure required for the new developments is greater than the market value of the lots, it is not built, leaving it either for the county to pay for the infrastructure or the neighbourhoods to remain in an unhealthy condition.
- restrictive measures incompatible with the economic reality. In Brazil, laws to protect water-source areas prevent any sort of land use. In this situation the land owner loses the economic value of the property but still has to pay taxes. As a result, land owners themselves often invite poor people to invade the areas, as a means of negotiating with the government.

'land owners often invite poor people to invade flood plains as a means of negotiating with the government'

Thus there is a need for effective law enforcement but also for more realistic policies regarding land use, infrastructure developments and investments.

Impacts of urban runoff and occupation of the flood plains

Storm runoff can produce flooding in the urban areas as a result of either natural flooding by rivers or urbanization.

Flood plains

In the urban master plan of most Brazilian cities, there is no restriction on building housing on the flood plains of rivers. After a number of low-flood years, new houses are built in flood-risk areas. However, when a larger flood occurs, flood damage increases and the municipality is requested to invest in flood protection (see below).

Estrela is a small town in the south of Brazil, located on the border of the Taquari River (27 000 km^2) basin. During floods, the river can rise by 18m in one day. The flood plain was occupied by low-income people. When the urban master plan was developed, flood zoning was planned, and it was recommended that the occupation of this area be restricted. It was implemented by county legislation, but the town did not have enough funds to relocate the population and provide an economic alternative to the land owners. To solve this problem, the county administration allowed construction in the downtown area in exchange for the flood plain area. This created an economic market for those areas that had lost value after the city flood plain restriction. Over the past 22 years flood losses have decreased, but the main issue has been upholding and enforcing the legislation. There have been many attempts to change the legislation in order to occupy these areas again.

Flooding due to urbanization

The frequency and height of flooding increases when land is built upon with impervious surfaces and runoff conduit systems. In Brazil, there is no source control and impacts are transferred downstream in the major drainage. The economic losses due to flooding in almost every medium-to-large city are huge. In Figure 1 one can see the increase in flood events in Belo Horizonte as the urban pop-

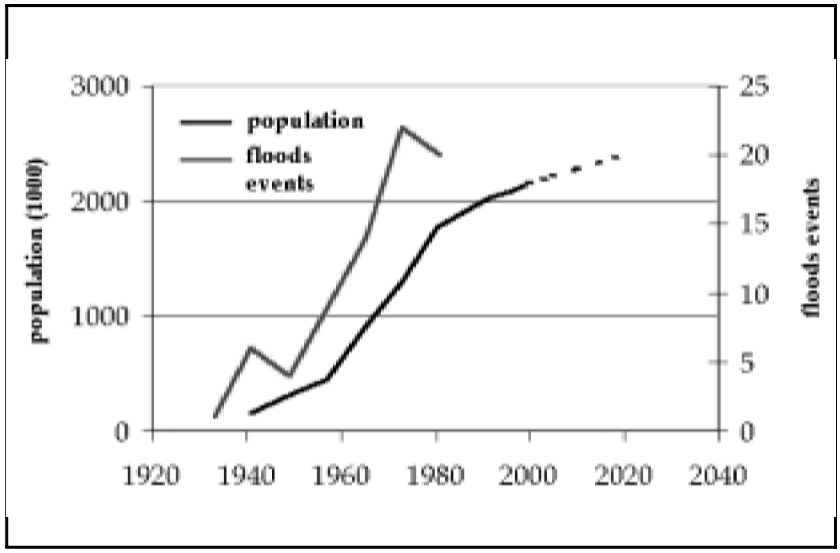


Figure 1
Population increase and flood events in Belo Horizonte, Brazil

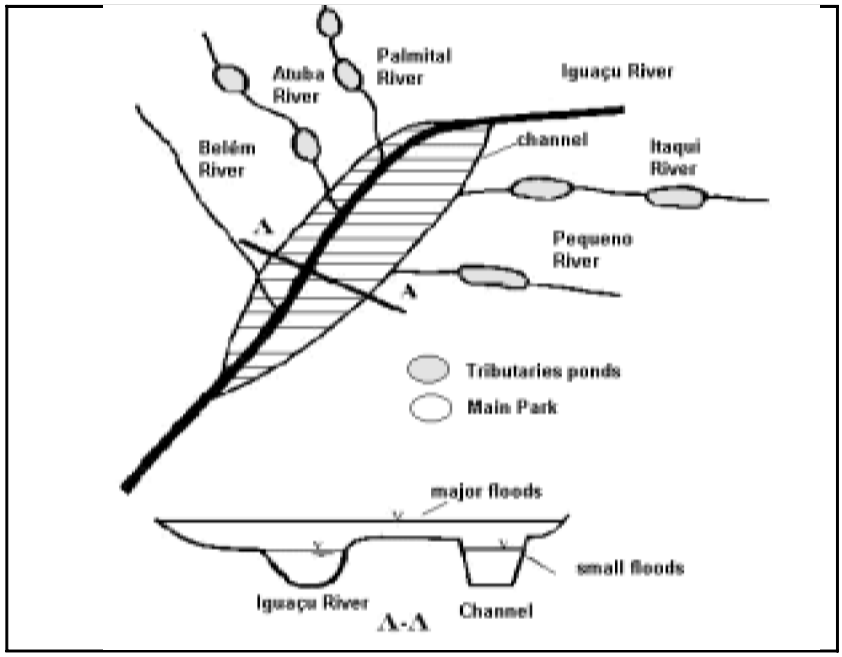
ulation grows (2.7 million inhabitants).

Urban drainage planning is a process that is best started while a basin is still in its natural state and urbanization has barely begun. 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 hydrological 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 hydrological model, with urbanization typically represented by the proportion of impermeable area and characteristics of the drainage network.

Flood control in the Metropolitan Area of Curitiba

The Metropolitan Area of Curitiba (State of Paraná, Brazil) has 2.5 million inhabitants. Most of the urban area is in the Upper Iguaçu River Basin which has a basin area of 1000 km^2. The main tributaries have an area of 100 km^2 and the highest urban concentration is in Belem subbasin.

Figure 2
Flood control in the Metropolitan Area of Curitiba



Iguaçu 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 flood plain. However, since 1980 there have been invasions of public green areas and unapproved developments and occupation. In July 1983 and January 1995 two major floods occurred with severe damage costing US$50.3 million and $40.2 million, respectively. The 1995 flood had a 7-day rainfall with a return period of more than 100 years (largest in the 110 years of data). The time of concentration in the main river is about seven days.

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

The main approach to flood management is shown in Figure 2.

- *In the main River Iguaçu*. A storage area in the form of a large park has been created in the metropolitan area (about 20 km2 in area). This is bounded by the river on one side and a channel on the other, which creates a limit to the urban settlement and increases the river flow capacity.
- *In the tributaries*. The urban drainage master plan has created urban parks in the tributaries to damp the peak flow increase of the uncontrolled upstream area; the plan also includes regulation of the controlled area.

The occupation of the park area has been small and the resettlement of this

'urban development is much more spontaneous than planned'

population should be done before the channel is constructed, because after that the area will increase its market value. Law enforcement inside the park is a challenge, but since its limits have been defined, usually there are no invasions.

The channel and the park are still in construction. The park includes: a nature reserve, small lakes and recreational facilities. The challenge now is to develop similar plans elsewhere.

Social aspects of flood management

Flood management in developing countries such as Brazil requires first of all an understanding of the social behaviour of the population, since the urban development is much more spontaneous than planned. Public parks are often invaded by low-income people, and the local administration has to bring in the police to regain the area. Since the administration does not have enough policing capacity, and it tends to react slowly, many neighbourhoods are illegally occupied. Law enforcement is also difficult because after a few years these squatters can own the land and the justice system will then protect them. This may be a way of distributing resources to the poorer members of society, but it does create difficulties in risk planning.

We have learned a number of lessons in this process.

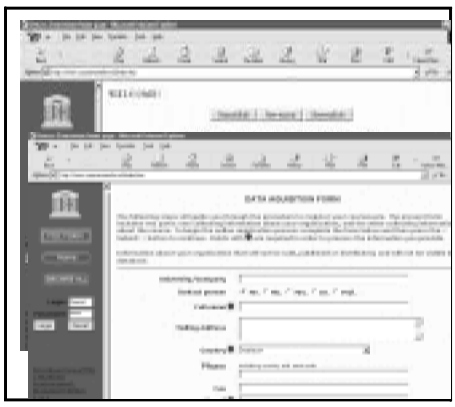
- When public areas are developed there are fewer invasions.
- When regulating high-risk areas owned privately one needs to give an economic value to the land. In some cities the land owner cannot use the flood risk area or the water supply basin area but still has to pay taxes. The land owners' reaction has been to allow poor people to occupy the land in order to sell it to the county.
- There are often 'legal' and 'illegal' regions of the city. Usually the legal region is managed through legislation and law enforcement but in the other areas space must be set aside space for flood storage in public parks.

about the author
Carlos Tucci is a member of the Institute of Hydraulic Research, Federal University of Rio Grande do Sul – Porto Alegre-RS Brazil. He can be contacted via the editor.

Software review

Hydrology courseware database

UNESCO is building a database of electronic courseware related to hydrology. There is a growing interest worldwide in e-learning, and considerable research into new forms of education and learning. Information and resources are everywhere nowadays, and face-to-face education is no longer the only way to train or retrain. This database, still in its acquisition phase, provides efficient access to information on the latest developments in the field of hydrology. It is also designed in such a way that it can easily be extended to other knowledge domains.



The database is being developed by UNESCO, IHE Delft and UNAM Mexico as a courseware catalogue/index of computer-assisted or computer-based learning materials that are available in the public domain. The catalogue is accessible free the UNESCO web site.

The database has been developed using the Internet-based CDS-ISIS products and also includes an HTML interface with a data acquisition form and a search interface. Using the search interface, queries to the database can be performed and a list of the items answering the query output.

The database has been structured so that all separate courseware units can be described in a separate record. The field 'category' is included, which is set to 'hydrology' for this database, but which would identify any other knowledge domain of interest to UNESCO in the future. The field 'subcategory' identifies the different areas within hydrology where courseware is available:

- atmospheric hydrology
- unsaturated zone hydrology
- saturated zone hydrology
- surface water hydrology
- regional hydrology
- special topics.

The data acquisition form includes items identifying the information providing organization. This information will not be sold, published or distributed, nor is it visible in the database. It is being collected to give the provider the potential to change the information at any time.

The database can be downloaded free-of-charge by anybody.

Ioana Popescu, IHE, Delft, The Netherlands