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TEMPORAL ANALYSIS OF THE TRANSFORMATION WATERSHED RIVER CRICIÚMA TO ASSIST IN MEASUARES FOR MINIMIZING FLOOD

Análise Temporal da Transformação da Bacia Hidrográfica do Rio Criciúma para Auxiliar em Medidas para Minimização de Inundações

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ABSTRACT

This article aims to present a temporal analysis of the watershed transformation and distortion of Rio Criciúma/SC, Brazil. The methodology includes analysis of legislation, the history of floods, the process of channeling and occupation of the river and aerial photographs, dating to the early development plans in the early 1950s. The results showed that master plans as legally allowed channeling of the river, even though the Forest Code in force since 1934 which contains rules for the preservation of margins of rivers. The occupation of the watershed and river channeling Criciúma have been followed in parallel by flash floods. Aerial photographs show the evolution of channel approach from urbanization and the confinement of River Criciúma which reduced its discharge capacity increasing frequency of floods. It is concluded that these tests provide additional measures to assist in monitoring and control of flash floods in the river basin because Criciúma monitoring over time allows the possibility to foresee effective measures. However, the science as hydrology, hydraulics, technical cadastre and even human behavior, must be brought to the scene of the municipal administration because they produce data that are extremely important to support decision making in urban planning.

Keywords: Urban Flooding, River Channeling, Macrodrainage.

RESUMO

Este artigo tem como objetivo apresentar uma análise temporal da transformação da bacia hidrográfica e descaracterização do Rio Criciúma/SC, Brasil. A metodologia contempla análises de legislações, do histórico de ocorrência de inundações, do processo de canalização e ocupação do rio e de fotografias aéreas, que remontam aos primeiros planos urbanísticos no início da década de 1950. Os resultados demonstraram que os planos diretores, permitiram legalmente a canalização do rio, mesmo estando em vigor o Código Florestal desde 1934 que contêm regras para a

preservação de margem de rios. A ocupação da bacia hidrográfica e canalização do Rio Criciúma têm sido seguidas paralelamente por inundações bruscas. As fotografias aéreas demonstram a evolução da canalização, aproximação da urbanização e o confinamento do Rio Criciúma que reduziu a sua capacidade de descarga aumentando a freqüência das inundações. Conclui-se que, estas análises oferecem subsídios para auxiliar em medidas de monitoramento e controle das inundações bruscas na bacia hidrográfica do Rio Criciúma, pois o acompanhamento ao longo do tempo permite a possibilidade de vislumbrar medidas eficazes. Contudo, as Ciências como a hidrologia, hidráulica, cadastro técnico e mesmo o comportamento humano, precisam ser trazidas ao cenário da gestão municipal porque produzem dados que são de extrema importância para apoiar a tomada de decisão no planejamento urbano.

Palavras chaves: Inundação Urbana, Canalização de Rio, Macrodrenagem.

1. INTRODUCTION

Historically, rivers have been a constant presence in the formation and growth of cities. Since the dawn of civilization, as a matter of survival and usefulness, they serve as a resource and means of circulation. These rivers, in hydrological terms are the only way out of the drainage network that make up the watershed in which they are inserted and the behavior of this drainage network depends on its geological, geomorphological, soil and vegetation, as well as characteristics of the incidents.

The catchment areas depend mainly on the availability of components for storage and disposal, as well as the existence of a drainage system set (BLACK, 1977).

Considering the shape of artificiality urban drainage, applied to all Brazilian cities, where all runoff is collected and led out of the basin limits the taxpayer, as the frequent floods tend to increase. You can defend this theory based on urban evolution, when the growth of city centers and the density of buildings and pavements, channel the river system and waterproof the soil indiscriminately without proper planning, ignoring the Protection Legislation riverbanks.

The town of Criciúma, situated in the state of Santa Catarina, has suffered from frequent floods in its urban area, causing great harm to society, with material losses and depreciation of real estate. The river Criciúma, its main drainage basin was treated with contempt since the establishment of the city in 1925, consolidating its urban center without regard to existing legislation at the time. The council was established nine years before the first environmental legislation enacted in Brazil Forest Code of 1934 can preserve the river banks. Criciúma had an accelerated growth, to give birth to the start of the 1950s fueled by coal mining, ore highly valued at the time suggested by the demand after the first world war. However, the first steps toward territorial arise only in 1953 with the enactment of Municipal Law No. 111/53 establishing the division of the urban area into three zones, whose objective was, planning the collection of taxes. In 1956 comes the Law No. 183 regulating the highway plan and in 1957 comes the first Master Plan of the municipality with the Law No. 208.

Although this set of laws were enacted after the publication of the first Brazilian Forest Code in 1934, these did not cover in his articles, measures to preserve the river channel, which was already part of the urban landscape that developed and grew to along its banks. Analyzing the evolution of the master plans of the municipality, since its first release in 1957 until his last in 1999 in any of his articles are guidelines related to preservation and maintenance of the minimum conditions for the river to Criciúma hold its primary function is stormwater runoff.

Three main factors cause the flooding problems present today in the urban area of the municipality of Criciúma:

a) The load of residential waste dumps chemically and biologically altered the basic characteristics of the river, causing also an increase of flow;

b) the channel with full closure of the section of the river, imposed by a deficient Master Plan, which allowed the occupation of coastal areas by buildings;

c) The indiscriminate dumping of solid waste loads of great proportions, which prevent the natural flow of water.

The union of these three factors causes a significant increase in the frequency and proportion of urban flooding in the city center of Criciúma. These events, which lead the city administration to invest in the establishment of a channel regurgitate, assist the river, aiming at reducing the effects of floods.

Governmental actions are public investments in large mounts, for deployment of a complex work that aims to reduce the impacts of floods, and these reactions in a small river that is giving back to people what it receives.

In this context, this research aims to present a temporal analysis of the transformation of river basin Criciúma. Aims to analyze the specific legislation with direct effect on the processing of the watershed; analyze the history of flooding and correlate with the process of channeling the river Criciúma and analyze the progress of urbanization on hydrology and Criciúma River, draining the basin with the main use of aerial photographs.

2. MATERIALS AND METHODS

The materials used in this study were taken from the basin of Criciúma are the following:

a) Base cartographic vectored through analog, georeferenced executed in 1957 for the National Coal in scale 1: 10.000. Source: DNPM.

b) Base cartographic vectored in digital, georeferencedperformed in 2001 at the scale 1:2.000. Source: PMC-City of Criciúma.

c) Aerial photographs of the flight performed in 1956 for the National Coal 1:30.000 scale performed by the company Geofotoscanned in extension “tiff”. Source: DNPM.

d) Aerial photographs of the flight in 2006, hired by the municipality of Criciúma in the scale 1: 8.000 in extension “tiff”. Source: PMC.

e) Land Photographs taken at different dates and acquired by the authors.

The methods include the analysis of legislation, such as urban planning and master plans, which govern and constrain urban growth, correlating with the transformation of the River bed Criciúma.

The analysis of the evolution of canalization of the river through Criciúma urbanization developed with the interpretation of cartographic bases 1957 and 2001 in conjunction with the 1957 and 2006 photographs.

The analysis of the historic flood of occurrence recorded in the archives of the municipal collection during the study period between 1953 and 2011.

The analysis of the implementation of the River Criciúma auxiliary channel is built upon the design and implementation period with in situ observations.

3. DESCRIPTION OF STUDY AREA

The town of Criciúma is located in the state of Santa Catarina, southern Brazil between latitudes 28 ° 37’00’’28 ° 52 ‘30’’South and between longitudes 49 °10’00’’to 49 ° 30’00’’West (Fig 1).

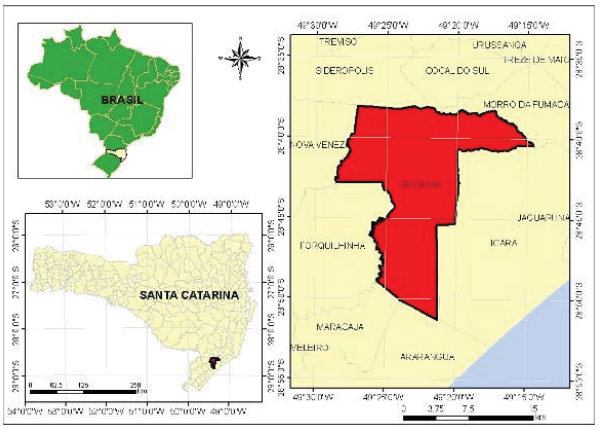


Fig. 1 - Location of the town of Criciúma, Santa Catarina, Brazil.

4. RESULTS

4.1 Analysis the transformation of the riverbed Criciúma

The effects caused by reckless and disorderly development of urbanization on river Criciúma are reminded every day weather forecast as indices of rainfall above normal. But the first studies to indicate that the town planning concerns were not building on

the banks of the river Criciúma. You can view this intention for the foregoing Article 1 of the first Urban Plan of the municipality, Law No. 208 of July 3, 1957.

“Art first - is approved the town plan of Criciúma, authorized by Law nr. 107,

September 22, 1953, with all the specifications in the respective plant, except the following:

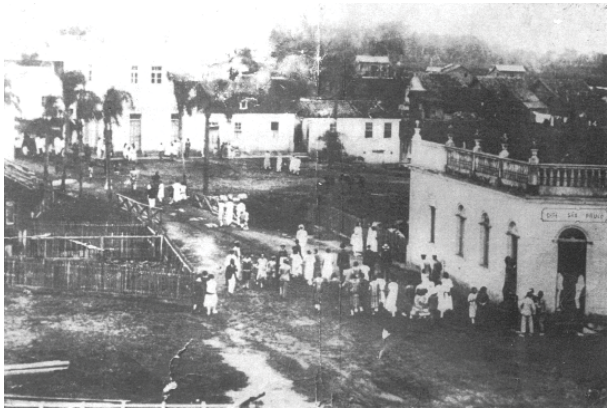
a) Parallel Avenue to the Criciúma River,

in the section between the streets Marechal Deodoro and Henrique Lage.

b) Areas included green spaces in the side of the Mother Church, on land owned by the Archdiocese

§ Single - abolition of the passage indicated in paragraph "a" of this Article shall not affect the river channel from Criciúma, whose route will not be provided in the plan modification.

In 1967 comes the first localized flooding in the watershed of the Criciúma river, a fact that became even recurrent and frequent natural disasters that have befallen the city center, changed the view of those who shape economic policy can influence or decisions about the future growth. This neglect is not a privilege of those who today govern the city, the lack of criteria starts in the first movements recorded in the initial plans of land use along with the consolidation of the urban center along the river Criciúma (Figure 2 a, b).



(a) Beginning of the occupation the city on the margins of River Criciúma in 1920. Source: Photo Zapelini

On the walls of stone, the river will gradually being covered with concrete slab (Figure 4), confining him completely and the bordering land, adding to the areas that once belonged to river. With the River "hidden" also hides the domestic sewage, solid waste and odor, leaving the space is free to move the buildings "within the river. "

Spurred by this fact and aggravated by the lack of supervision and common sense, walls were erected on the line the shores, balconies on the river channel and a series of other irregularities that resulted in decreased river section (Figure 5 a and b). Advances of the buildings on the river Criciúma.

(b) Current Stage of urban occupation in 2011, with the river Criciúma piped and covered by a building. Source: Photo by the author.

At the end of the 1950s were beginning, in the city center, the first canalization of the river Criciúma approximation of the buildings to their margins (Fig. 3 b).

Fig. 3a - Trecho da obra de canalização do Rio Criciúma em concreto armado, década de 1950.

Fig. 3b - Excerpt from the work of canalization of the river Criciúma in granite stone, 1980s.

Fig. 4 - Plumbing in Criciúma in 2011 the river, passing under the street. Source: Photo by the author.

Fig. 5 - (a) Source: author photos.

Fig. 5 - (b) Source: author photos.

As an example we can cite the case of a Shopping Center, located in the central city. In this case, the edifice built not only affects the margins, but also built on the river's flow, making your stroke and the discharge of water occurs in a completely confined below the ground (Fig. 7). This building has their garages with a floor level below the banks of the watercourse (approximately 90 cm) and, as a result, it was necessary to build ramps for vehicle passes from one side to another river.

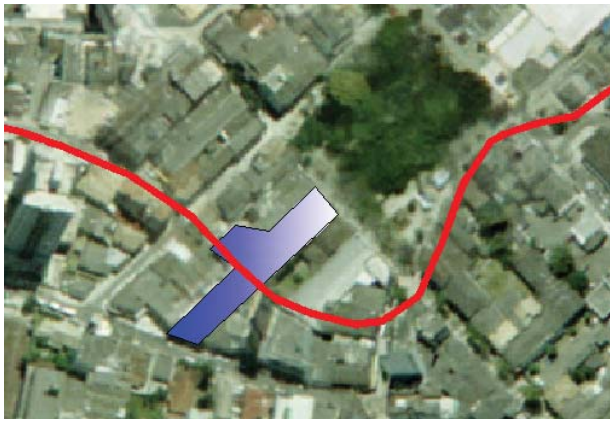


Fig. 6 - Building the mall on the river Criciúma

Fig. 7 - garage of the mall with the crossing over the Criciúma river.

4.2 Analysis of evolution in channeling the river Criciúma amid urbanization

The urban population density and pressure contributed to a significant alteration of the landscape over the years by replacing the natural riverbed Criciúma, on concrete slabs and buildings (Fig 8 and 9).

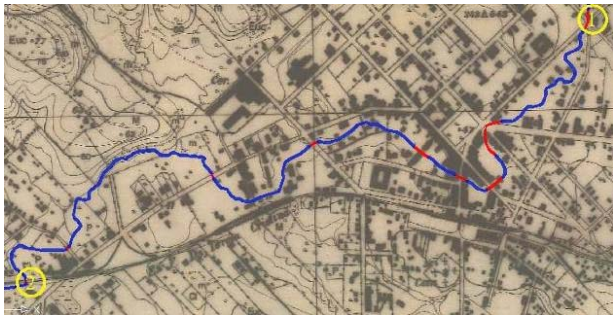


Fig. 8 - Stroke of the river in the city center on the base map, 1957.

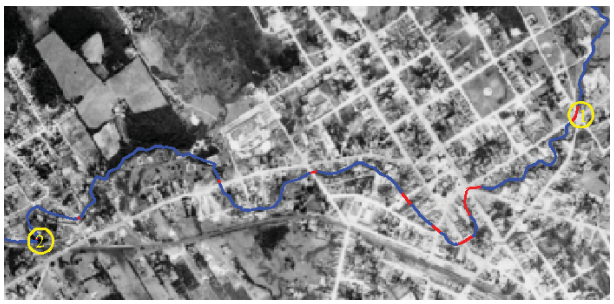


Fig. 9 - Stroke of the river in the city center on the Air 1957.

The analysis of the geographical map of 1957 with the overlay of the river and its layout Criciúma still unique among the sites 1 and 2 permits evaluation of the extent of urbanization and quantification of sections already allocated. In 1957, the section between points 1 and 2, average 2,550 m, and of this total only 409 m were channeled, ie, representing 16.04% of its total. Of this total pipeline, 240 m were located within 169 m of private property and in public areas such as culverts or bridges.

The same analysis was performed using the base map, 2009. It was noted here that there was a reduction of 384 m in length of the section between points 1 and 2, resulting in a total length of 2,166 m for the stretch between these two points. In contrast stretches channeled 362% increase, totaling 1,480 m channeled (Fig. 10 a and b). This increase can be channeled

portions of the associated emergence of some critical points of floodin resulting from heavy rains of low duration.

4. 3. Evolution of floods

The first occurrence of flooding in urban areas in the town of Criciúma, 1957 date of result of four months of rains of long duration and low intensity. However, the first sudden flood, caused by heavy rains and short duration, occurred in 1972, resulting in flooding of street Pedro Benedet, considered one of the most critical today.

Between 1957 - 2011 several events occurred in similar nature:

a) flood caused by rains of long duration and b) flooding caused by high heavy precipitationand short duration (Table 1). The analysis of these events shows that since 1974 there have been no more flooding by overflowing rivers, the events are all linked to flooding caused by rainfalls of high intensity and low duration.

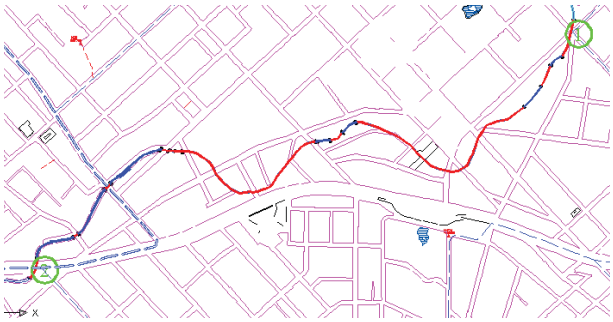


Fig. 10 a: Criciúma River on basemap 2001

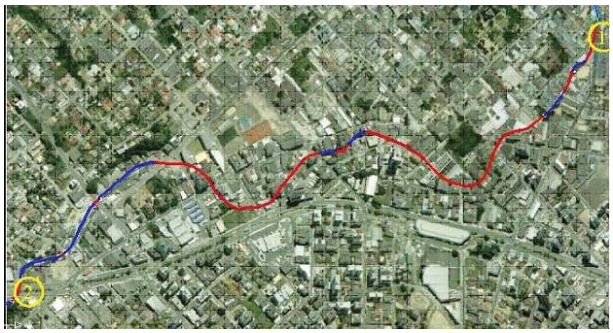
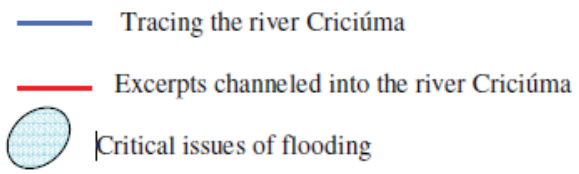


Fig. 10 b: Criciúma River in air photo of 2006

Legend:



The frequency of occurrence is intensified from 1998, culminating in the record of 6 (six) events in 2011.

In 1974 occurred the greatest flood recorded in the southern state of Santa Catarina, as the city of Tubarão most affected by the overflow of river shark. That same year the city center of Criciúma was completely flooded (Figure 11a and b), the consequence of a period of long rains occurred throughout the state of Santa Catarina.

The amplitude and frequency of flood events intensified after 2004 (figure 12 a, b, and c)

Flooding occurred in several streets in the town of Criciúma in 2010.

Fig. 11 a: Street Pedro Benedet in 1974

Fig. 12 a – Street Pedro Benedet.

Fig. 11 b - Street on Janeiro 6 in 1974

Fig. 12b - Square Nereu Ramos

Fig. 12c – Street João Cechinel.

Table 1: Occurrence of natural disasters caused by rains (1957-1967). Source: BERTAN, 2006.

Date	Local	Description of Phenomenon
4/2/1967	City center	Heavy rains
14/2/1972	City center	After two consecutive days Cel Pedro Benedet
2/8/1975	Criciúma	Flooding
27/3/1976	City center and Pio Correa	Heavy rainfall
9/9/1977	Neighborhoods Pinheirinho and University	Torrential rains
10/1/1987	Av. Centenário	Constant rain
23/2/1990	City center	Torrential rains, gusting winds of 80 km / h.
26/3/1998	Ruas João Cechinel, Cel. Pedro Benedet, Araranguá, 6 de janeiro and Av. Centenário	Heavy rains and floods
7/1/2000	Neighborhoods Pio Correa, San Antonio	20 minutes of heavy rain, heavy rains caused by La
18/1/2000	City center	30 minutes of rain
29/2/2000	Próspera, Cristo Redentor, Pio Correa, Av. Centenário and city center.	Torrential rain hauling several neighborhoods
1/3/2000	Cristo Redentor e Centro	Torrential rain hauling several neighborhoods
15/1/2001	Criciúma	30 minutes of torrential rain and strong winds Torrential Rain
25/1/2001	Criciúma	Chuvas Torrenciais
26/1/2001	Criciúma	30 minutes of torrential rain and strong winds
16/2/2001	Av. Centenário, São Cristóvão, Próspera and Pio Correa.	30 minutes of heavy rain
	Criciúma	15 minutes of heavy rain with hail.
7/1/2002	Streets 6 de Janeiro, Marcos Rovaris, Cel. Pedro Benedet and Rui Barbosa	Heavy rains.
7/2/2003	Criciúma	Heavy rains.
10/2/2003	Criciúma	1 hours of rain flooded the Center and several neighborhoods.
12/3/2003	Criciúma: Neighborhoods bairros Centro, Próspera, Vila Rica and Presidente Vargas.	40 minutes of heavy rain.
15/9/2004	South of Santa Catarina	Heavy rains

Fig. 12d – City Center.

4.4 Analysis of Auxiliary channel to Rio Criciúma

Faced with the need for answers to the cry of the community for a solution to the problem of flooding, the municipal public administration starts implementing a help to the river channel overflow Criciúma, whose hydraulic characteristics are no longer able to meet the increased flow generated by contribution of a highly impermeable basin.

The proposed path has three segments with different discharge capacities: a) section 1 (yellow) - discharge capacity of 22.26 m3 / s b) section 2 (red) - discharge capacity of 33.70 m3/ sec) section 3 (black) - discharge capacity of 45 m3 / s. The download of this channel will be in the river overflow river itself Criciúma a point where the pipeline sequence will occur only at intersections with streets. Services and works will be needed in order to facilitate the discharge of the river downstream, stand out among them is the replacement of 04 bridges, with an increase in cross section, and dredging of the river. (Fig. 13).

Fig. 13 - Route help channel the river Criciúma.

The auxiliary channel to the river Criciúma, will run under the central streets, as shown in the isometric diagram shown in Figure 14.

Fig. 14 - Schematic isometric galleries for the auxiliary channel to the Criciúma River.

CONCLUSION

The channeling of the river began Criciúma by granting law, and in 1953, was consolidated in 1957 with aggravating circumstances, because Law 107/1953 projected a boulevard along the entire river with the channeling of Criciúma, and construction would not overlap the gutter discharge. Law 208/1957 to severe contributed to the situation, since deleted the avenue in a critical stretch in the city center and legalized the occupation of buildings by river.

The ignorance hydrology and hydrography and in both by public managers, entrepreneurs as well as those professionals in engineering and architecture allowed the removal of virtually all of the drainage basin and its main river Criciúma. Not even the increased frequencies of flooding could not only reduce the channeling of the river but all its tributaries. The forest code, if it were considered in the legislation, would certainly have contributed to the alleviation of some of the problems, but even today, is ignored based on the permissiveness of the past. As the forest code of 1934 with updates in 1965 and 1989, it is clear actions contrary to this when we present the implementation of a mall in the city center, totally disregarding the provisions of federal law. The complete overlap of the river and Criciúma floor level of their garages, reveal clearly disobeying federal law.

Because of all these stocks over the period analyzed here, today it is necessary to propose solutions that although they are bulky with spending public money, no one has the absolute assurance of effectiveness, if the auxiliary

channel to the river Criciúma, the which is already running. The proposed auxiliary channel and running can relieve some of the problems in the vicinity of where it will be deployed very near and parallel to river.

However, the contribution basin is completely urbanized, and the overflow also occur far from the banks, caused by channeling of the river system, which are responsible for collecting water from storm sewers under the streets and lead them to the river Criciúma, now with his "help", the Auxiliary Channel to Rio Criciúma, which certainly will soon have its own name.

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