

## Social and environmental vulnerability of the urban dynamics of Curitiba, Paraná, Brazil

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### Abstract

Considering the increase of violence in large urban areas in Brazil, this research aims at verifying the relationship between the environment and society vulnerability and crime rates in Curitiba, Paraná State, Brazil, as a case study. Based on the theoretical references of the present work, the environmental constraints, landscape components, and socioeconomic conditions were assessed. In this context, the relation between social-environmental vulnerability and homicide number was determined based on spatial analysis techniques, notably geographically weighted regression (GWR). The results show that this model explains 95.3% of the homicide incidence in the neighbourhoods of the city. However, when the local coefficients of determination values ( $R^2$  I) are considered, this percentage is lower in central region (20.0% - 40.0%). Therefore, it is concluded that the reduction of the social and environmental vulnerability would be a determinant factor to decrease the criminality levels in Curitiba.

**Keywords:** Environmental constraints, Landscape components, Socioeconomic conditions, Crime rates, Critical regions, Urban planning, Management of cities.

## INTRODUCTION

The Brazilian urbanization process was late and accelerated; since between 1960 and 2010 the urban population went from 45.0% to 85.4% (IBGE, 2018) and, in most cases, without the adequate planning, which contributed to intensify problems of the environment and the society, especially in metropolitan regions, where the areas of environmental and social degradation are directly related (Hogan and Marandola Júnior, 2006).

This relation is due to the pressure exerted by the real estate market, where the low-income population occupies unsuitable places for urbanization, breaching the current environmental legislation, specifically the permanent preservation areas (APPs - áreas de preservação permanente) of rivers, which contributes to the occurrence of floods (Tucci, 2008). These factors establish a relationship between social-environmental vulnerability, social inequality, and its impact on the quality of life of urban populations.

According to the Brazilian Forestry Code (Brasil, 2012), the APPs aim at preserving water quality and biodiversity, maintaining soil conditions and ensuring the well-being of the population. Besides the conservation of the natural resources, the protection of these areas is related to people's quality of life, since, according to Tucci (2008), the impairment of APPs, particularly in an urban context, is one of the main factors which contribute to the aggravation of flood occurrence.

Taking this into account, populations affected by disasters tend to attribute the environmental constraints as the main reasons of losses and difficulties, leading them to accept the risk as something inevitable (Ribeiro, 2010). Public managers and the media in general have been using this same approach, which has discouraged an appropriate reflection about this matter.

On the other hand, according to Ribeiro (2010), if the after-disaster situations are understood as a result of pre-existing social conditions, it becomes evident the responsibility of public entities in proposing policies, programs and projects that aim at improving the quality of life of marginalized populations and their social rescue in order to minimize the psychological, material and social damage of these people (Freeman, 2013).

It is important to highlight that, according to Couto (2013), the social exclusion caused by living in marginalized spaces of society, such as in those

environmentally vulnerable, contributes to the development of drug trafficking as an economic alternative, thus being a palliative solution to the lack of opportunity to these individuals.

In this way, the establishment of parks and plazas, a responsibility of municipal governments, would be relevant to maintain the environmental conditions and improve the population's quality of life. Nevertheless, due to the lack of maintenance and ineffective management, these places are often related to insecurity, violence and drug problems (Cozens, 2008).

Considering the theoretical assumptions presented above, this study aims at establishing the interconnection between social-environmental vulnerability and violence in the city of Curitiba, Paraná State. A study developed by United Nations Children's Fund (UNICEF, 2002) shows that drug use by young people is higher in classes A and B (21.6% and 20.5% respectively) than in classes D (16.5%) and C (11.4%). However, Cruz and Sá (2011) points out that the lack of leisure options and recreation in irregularly occupied areas contribute to the sense of social exclusion and not belonging to the city and the consequent increase of violence and consumption of psychoactive substances.

## MATERIALS AND METHODS

In order to assess the socio-spatial determinants or triggers of crime in Curitiba, it was considered the analysis of various aspects. Regarding the **environmental constraints**, flooded areas, in 1987, and subjected to flooding (IPPUC, 2001) and APPs, defined from a buffer of 30 meters along the water courses, in accordance to the Federal Law nº 12,651, of May 25, 2012 (Brasil, 2012), were mapped. The analysis of **landscape components** was carried out according to the following characterization:

a) of open public spaces, consisting of:

a.1) conservation units in Curitiba, defined by Municipal Law nº 9,804, of February 3, 2000 (Curitiba, 2000), including: Conservation Parks, Linear Parks, Leisure Parks, Biological Reserves, Relevant Native Forests and Conservation Forests, and Leisure Forests;

a.2) other typologies, such as squares, gardens, environmental gardens, animation axes, and environmental cores;

b) of irregular occupations, registered by the Institute for Research and Urban Planning of Curitiba (IPPUC, 2016);

Aiming at identifying the **socioeconomic conditions** of the vulnerable population, the following data from the 2010 Census (IBGE, 2010) - the last performed - were considered:

a) global and adults (people aged 18 years or over) demographic density;

b) literacy - percentage of literate population, that in this research was considered the individuals who can both read and write with understanding a short simple statement in his/her known language (IBGE, 2010:26);

c) income - average values of the total nominal monthly incomes of people aged 10 or above;

Regarding **violence rates**, it was considered the number of victims of crimes related to death in 2010 (IPPUC, 2010).

The data collected was organized by neighbourhood, because some information is only available in this area.

To determine the relationship between homicide rate and landscape components, environmental constraints and socioeconomics conditions, the geographically weighted regression (GWR) was used. In this model, the parameters were estimated for each studied area, so diversity of values indicate the impact of local variation in the dependent variables on explanatory variable (Fotheringham et al., 2002, and Charlton and Fotheringham, 2009). These processes were developed in ArcGis 10.6 software, considering the following items:

a) dependent variable - number of homicides per neighbourhood;

b) independent variables:

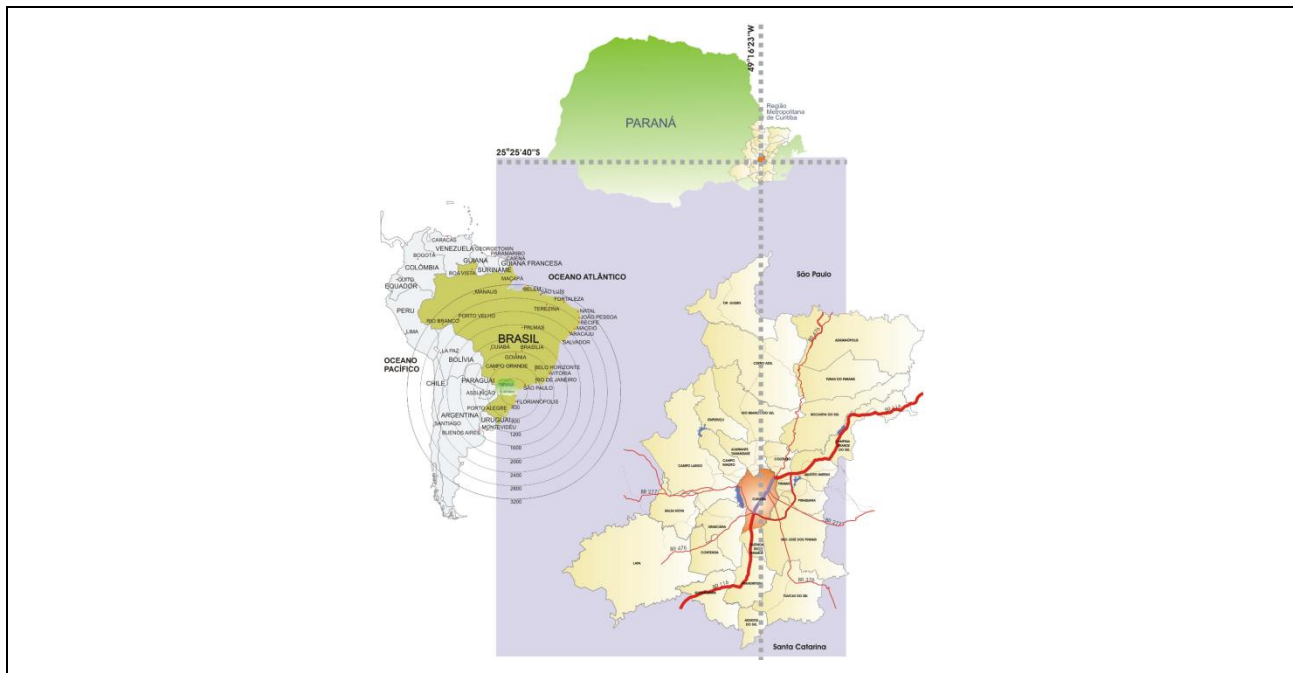
b.1) environmental constraints - total of the APPs and areas subject to flooding;

b.2) landscape components - total of the locals designated to open public spaces and with irregular occupations;

b.3) socioeconomics conditions - data on average income of the population; demographic density and literacy rate.

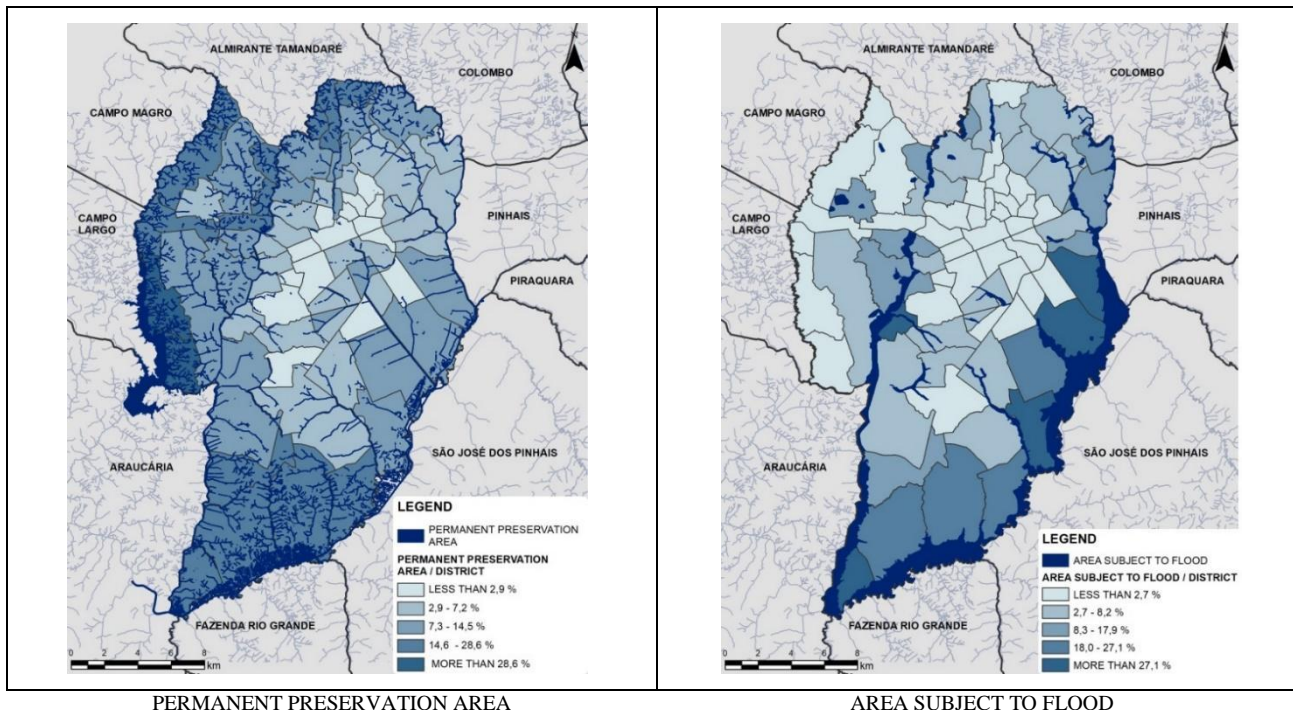
## RESULTS AND DISCUSSION

Located in Southern Brazil (Figure 1), Curitiba is the capital of the state of Paraná, with a population of 1,908,359 people and demographic density of 4,027.04 people per sq km; it is the eighth most populous municipality of the country (IBGE, 2017). Its territory comprises 75 neighbourhoods, which were defined according to patterns of land occupation and socioeconomics characteristics. Those that present the greatest **environmental constraints** to urban development due to water resources, by the need to preserve the areas along bodies of water (Figure 2: left) or the flooding risk (Figure 2: right), are in the outlying areas of the municipality.



**Figure 1:** Location map of Curitiba

Source: Based on IPPUC (2012).



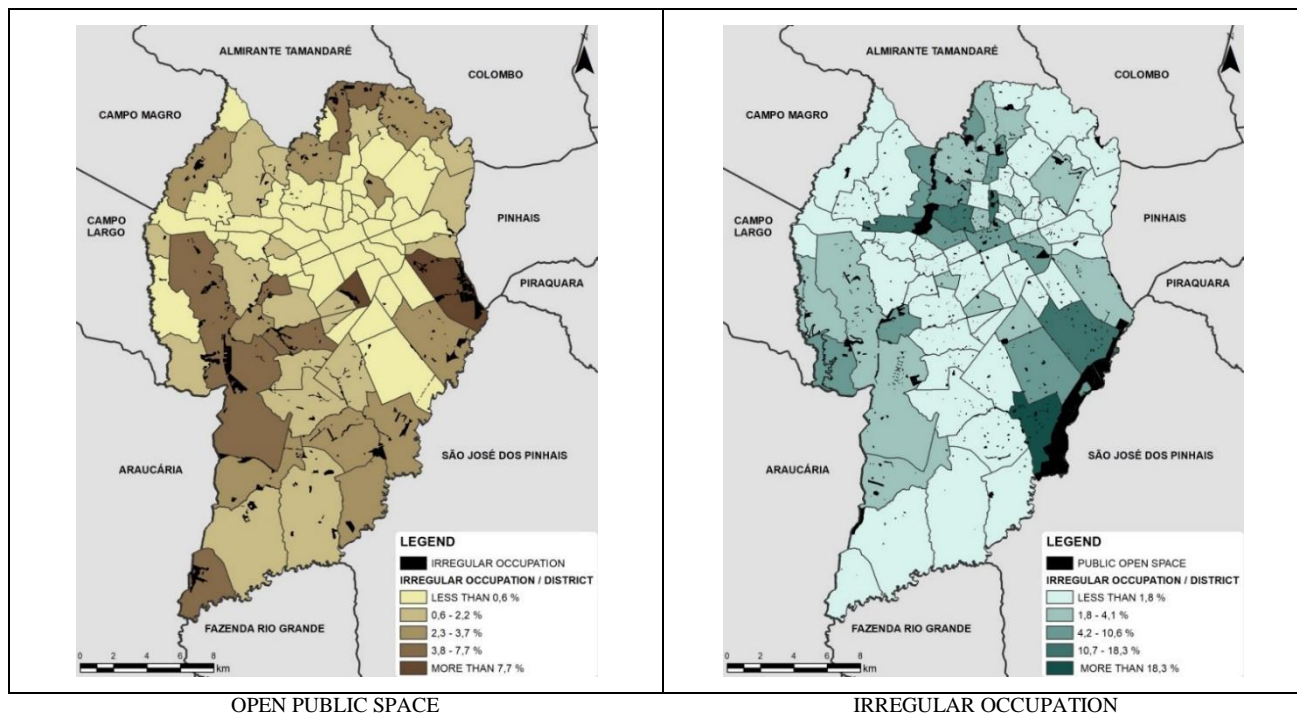
**Figure 2:** Characterization map of the environmental constraints in Curitiba

Source: Based on IPPUC (2001, 2018).

Among the **landscape components**, it is notice that most part of the irregularly occupied areas are included in the neighbourhoods with greater percentage of environmental constraints. As observed in Figure 3 (left), Curitiba’s main irregular occupations are located in outlying regions. On the other hand, in the central part of the city, where the land price is higher, and the environmental conditions are more favourable to the urban occupation process (Gutberlet, 2008), they are not detected.

At the beginning of the current decade, nearly 162,000 people lived in irregular occupations (IBGE, 2010). Considering that, about 21.0% of them (approximately 13,000 residences - IPPUC and COHAB-CTBA, 2007) registered in Curitiba are subject to environmental risks, that is, the young population that inhabits these areas would have lower quality of life, being more exposed to drug trafficking and consumption (Abramovay et al. 2002).

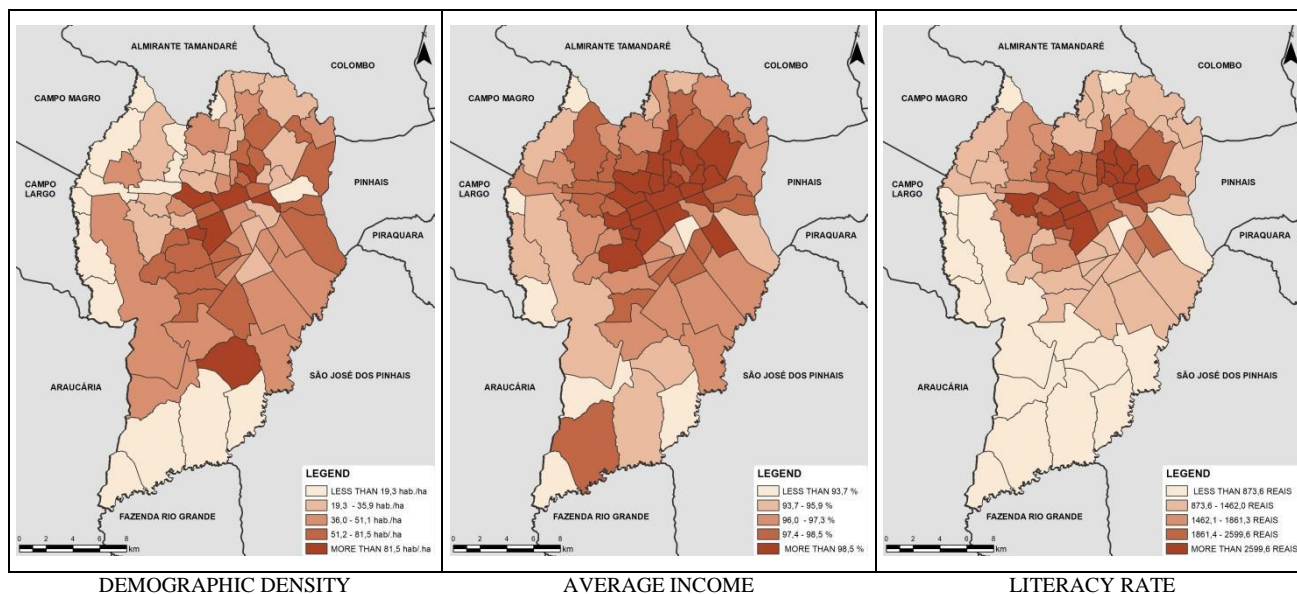
Concerning open public spaces, it is stand out those located in the neighbourhoods to the east and west of the municipality due to the presence of parks and other types of conservation units. However, leisure parks, squares and gardens are distributed throughout the municipal territory. It is still verified the lack of these locals in Southern portions of the municipal territory (Figure 3: right).



**Figure 3:** Characterization map of the landscape components in Curitiba

Source: Based on IPPUC (2016, 2018).

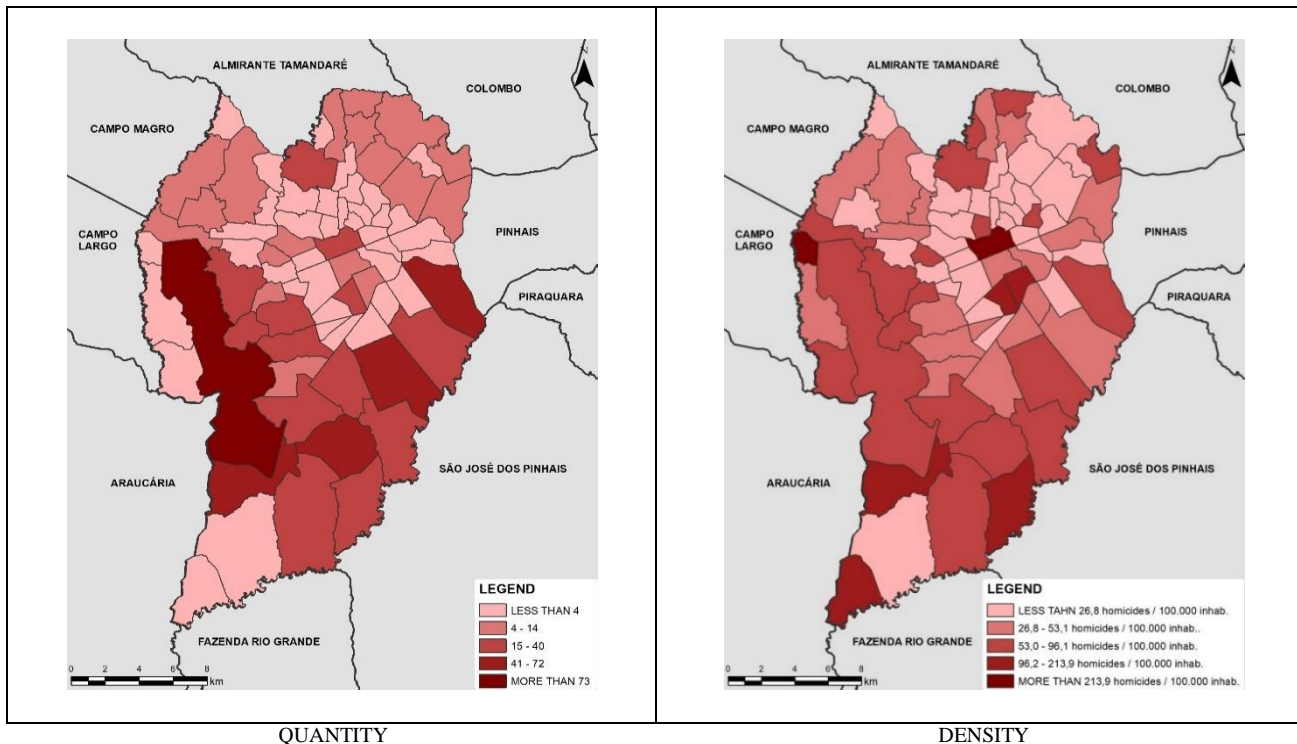
Considering the analysis of the **socioeconomic conditions**, it is observed the concentration of the population in the central areas and the gradual reduction of the income levels and literacy as neighbourhoods move away from the centre (Figure 4), as also commented by Klein and Walker (2005).



**Figure 4:** Characterization map of the socioeconomic conditions in Curitiba

Source: Based on IBGE (2010) and IPPUC (2018).

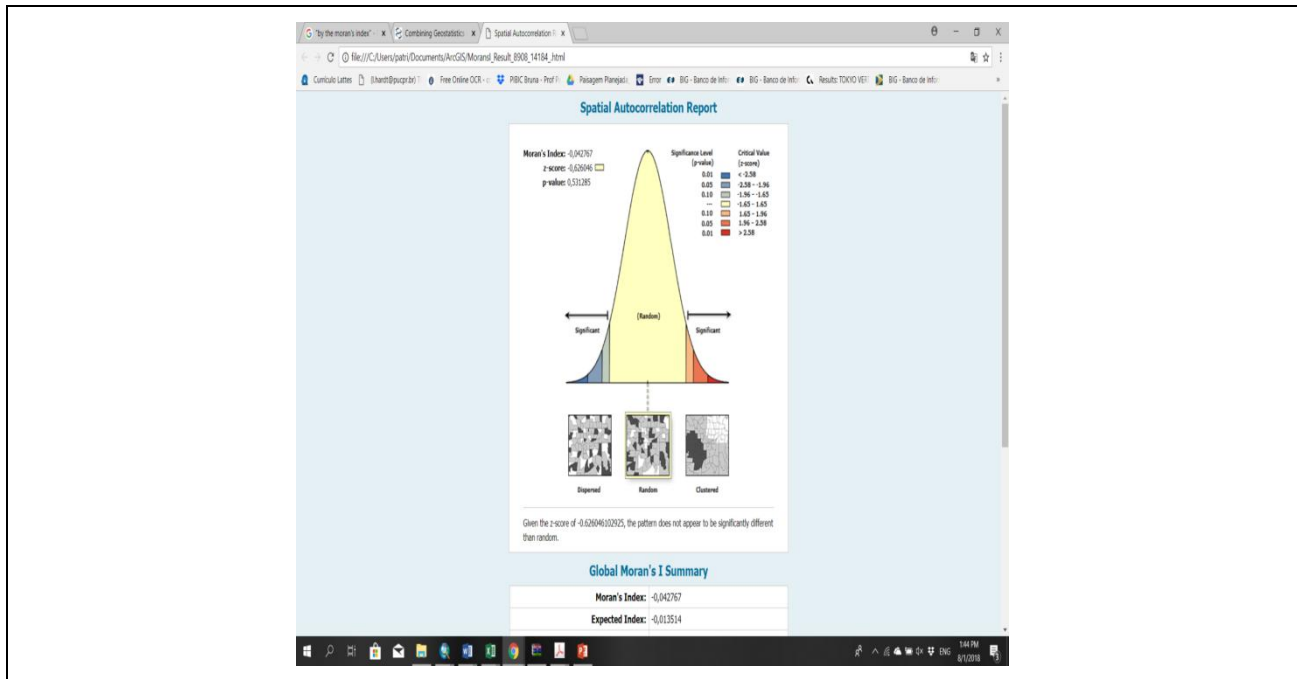
Based on the analysis of the variables cited by Alves (2006), income, young population, literacy level, education and proximity of habitations to water courses, also investigated in this study and applied to the reality of Curitiba, it is verified that according to these criteria the population most exposed to environmental risks is located in the most peripheral regions of the city. These issues can be confirmed with the analysis of Figure 5, in which it is observed that the central portions of Curitiba have lower rates of homicides.



**Figure 5:** Characterization map of homicides in Curitiba

Source: Based on IPPUC (2010, 2018).

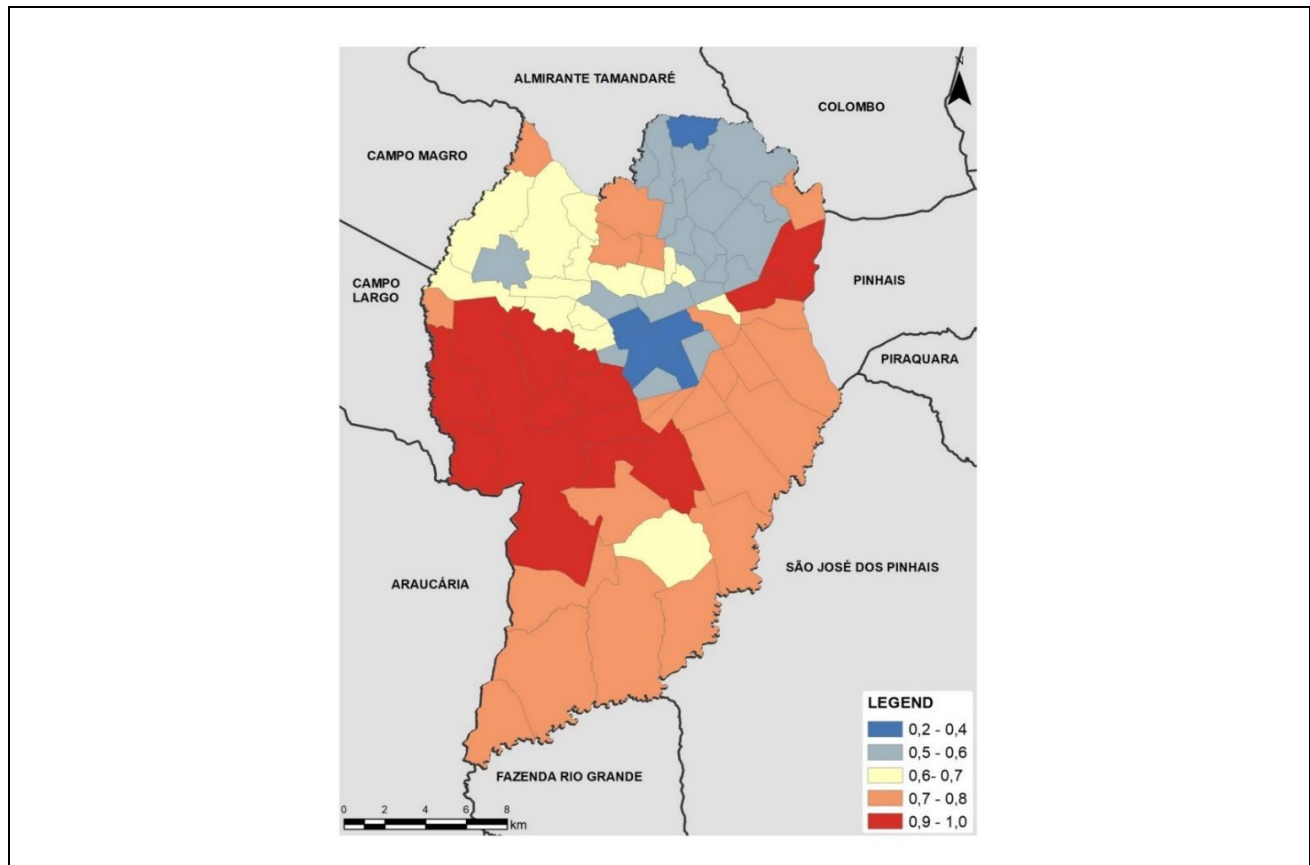
The results obtained from the weighted geographic regression analysis confirm that the environmental constraints, landscape components and socioeconomic conditions selected in this study explain approximately 95.3% of the crime occurrences in Curitiba. The existence of spatial autocorrelation of the results was calculate by the Moran’s Index of the model residuals (Figure 6), which shows that there is no evidence of spatial relation of the data (values close to zero).



**Figure 6:** Graphic of spatial autocorrelation - Global Moran Index

Source: Based on geographically weighted regression (GWR).

According to Figure 7, that the selected model is adequate to the majority of neighbourhoods, since the local coefficients of determination values ( $R^2$ ) are higher than 0.7, that is, they explain approximately 70.0% of the crime rate variation in Curitiba, being less when applied to the central and northern regions of the municipality, indicating that the selected variables are not sufficient to determine violence indexes in these areas.



**Figure 7:** Characterization map of the local coefficient of determination ( $R^2 l$ )

Source: Based on geographically weighted regression (GWR).

## CONCLUSION

The conceptual foundations presented allowed the selection of aspects related to social-environmental vulnerability with greater interference on crime rates. According to the characterization of the environmental constraints, landscape components and socioeconomic conditions, it is possible to observe that Curitiba's urbanization process presents similar patterns to those from other Brazilian metropolitan, where the impoverished people are concentrated in regions with greater environmental constraints and more distant from central areas.

Regarding the relation between the two subjects of the study, the spatial distribution analysis of the selected variables, associated to the geographically weighted regression technique, validate this hypothesis, considering that the adopted model explains 95.3% ( $R^2$  global) of crimes incidence in Curitiba. However, when analysed the local determination coefficients ( $R^2 l$ ), the results are less significant in central areas, indicating that other variables should be added to explain the occurrence of criminal acts in these locals.

The main limitation of this study is the data aggregation by neighbourhood, since this methodology doesn't allow identifying the specificities of each area. Nevertheless, this research results can provide subsidies to urban planning and management, being effective for both monitoring and proposing actions and projects that aim to minimize socio-environmental impacts and reduce urban violence rates in cities.

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