The annulment of urban perimeter as a technical tool for urban planning: the unsustainability of the cities in the Brazilian state of Parana

Mirela Thaise MALTA PURIM, PARANACIDADE, Brazil

Fernando DOMINGUES CAETANO, PARANACIDADE, Brazil

Jeronimo Paulo DA CUNHA PIMENTEL DE MEIRA, PARANACIDADE, Brazil

1. Introduction

In Brazil, the Urban Growth Boundary (UGB), called as “Urban Perimeter” and as part of the Comprehensive Plan, is defined by a specific municipal law. It is a polygon that outlines the urban area of a municipality and, by exclusion, the rural area. The spatial distribution of urban occupation in a municipality territory may produce, and in fact this occurs, a plurality of UGB polygons. For legal effects, only the land inside these polygons are recognized as urban land. These polygons demarcate urban settlements, urban expansion areas and specific urbanization areas (communities in rural areas with urban characteristics).

Urban perimeter is the most used urban planning tool in Brazil - present in 85% of Brazilian municipalities (IBGE, 2015) -, to arrange and control urban growth. Besides that, it is also used for tax purposes, since it delimits the areas where municipal property tax can be applied.

However, it is observed that urban perimeter does not play its role due to: i) its original oversize setting; and, ii) its subsequently progressive enlargement. This is an evidence of poor urban planning and technical fundamentals, used to provide throughout the city social housing, gated communities or other typologies as well (Santoro, 2014). This is also reinforced by municipalities’ legislators, managers and technical staff understanding of urban perimeter as a mere instrument to regulate conversion of rural into urban land, allowing without limits horizontal urban expansion pushed by real estate market dynamics. Thus, this common understanding leads to the annulment of urban perimeter as a technical tool for arranging and controlling urban expansion.

This is a relevant issue for the international debate about sustainable urban growth, considering the opposite models of urban development: compact and continuous vs. fragmented and dispersed. According to the United Nations sustainable development requests the ability to ensure that “it meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland, 1987). The former model better applies to the objectives of sustainable urban development considering the three fundamental principles: economic growth, social equality and environmental protection.

Based on this development model, urban planning should consider urban expansion economic feasibility (where benefits exceed investment costs needed to urbanize new areas); social equality (where all citizens of new urban areas access urban infrastructure, facilities and services) and environmental protection (where natural resources are preserved, environmental fragilities are respected and urban expansion negative impacts are mitigated).

Nevertheless, there are, by innumerous perspectives, opposing theoretical sides in the international debate about the real effectiveness of the UGB, or similar, as an instrument to control urban sprawl and, consequentially, to preserve agricultural and natural areas from uncontrolled urban occupation. It can be mentioned, as examples, the initiatives of: Seoul in South Korea (Bengston & Youn, 2006); Melbourne in Australia (Ball, Cigdem, Taylor & Wood, 2014); Brussels in Belgic (Boussauw, Allaert &Witlox, 2013); besides many others in Portland

and in the State of Oregon, in the United States (Mildner, Dueker & Rufolo, 1996; Weitz & Moore, 1998; Jun, 2004).

In this context, this paper's objective is to contribute to the discussion about urban perimeter adequate shaping and dimensioning towards sustainable development in the state of Parana, Brazil. Thus, the following spatial metrics related to urban perimeter are considered: i) gross demographic density; ii) occupation rate; iii) displacement of its centroid from city center; and iv) shape irregularity degree. To produce the required geostatistical information, considering urban perimeters of Parana state municipalities, it is used the GIS application called "SEDU/PARANACIDADE Interativo".

However, initially, aiming to better understand urban perimeters performance in Parana, it is briefly presented the context of Brazilian municipalities concerning: i) their political and administrative autonomy; ii) their competence to legislate on urban issues; iii) the urban perimeter in the context of Brazilian urban legislation; iv) the relation between the urban perimeter and the Comprehensive Plan; and v) the financing system for urban development in Parana, managed by the Autonomous Social Service PARANACIDADE.

2. Urban perimeter as an urban planning tool in federal legislation

Brazil, located in the subcontinent of South America, is a federative republic composed of the indissoluble union of 26 states, a federal district and, peculiarly, 5.570 municipalities. The latter are also federative entities and are political, administrative and financially autonomous. They share duties with the federal and state governments and have their own as well.

According to 1988 federal Constitution, municipalities are ruled by "organic laws" (leis orgânicas), which act in a similar way to constitutions. Furthermore, they ought to legislate about local issues, in compliance with the state and federal legislations. Likewise, they are responsible for their territorial arrangement, through urban land planning, parceling and, use and occupation control. Municipalities ought to plan and implement the municipal development policy, considered by the Comprehensive Plan, which is itself prescribed as an urban planning tool in municipality's organic law.

Even though the definition of urban perimeter, by a specific law, is a municipal duty, there are general legal requirements to be considered regarding federal legislation. According to Braga (2016), the very first reference to municipalities' requirement to define an urban perimeter is the 1966 National Tax Code (Law 6172/66). As stated by this author, the municipal urban property tax can only be charged to real estate owners whose properties are within urban perimeter. Afterwards, in 1999, an amendment to the federal Urban Land Parceling Act (Law 6766/79) set rules to land parceling restricted to urban areas, urban expansion areas and specific urbanization areas, as defined in the Comprehensive Plan by means of the urban perimeter law.

In 2012, an amendment to the 2001 Brazilian Statute of the City (Law 10257/01), which establishes general guidelines to urban policy, defined criteria to be followed when municipalities change the urban perimeter. By means of a specific urban development plan, it must be considered: i) the delimitation of the new urban perimeter; ii) the definition of areas restricted to urban occupation or subjected to special control due to natural disasters threats; iii) the definition of specific guidelines and areas where infrastructure, transport system, public facilities, either urban or social, will be available; iv) the description of land parceling and use and occupation parameters, so that use diversity, employment opportunities and income generation are enhanced; v) the definition of areas for social housing; vi) the definition of guidelines and specific tools towards environmental protection, and historical and cultural heritage preservation; and vii) the definition of an equitable sharing mechanism considering the benefits and the burden arising from urban growth.

Although the Statute of the City addresses the urban perimeter issue in the context of the Comprehensive Plan Chapter, their relationship is fairly weak, as far as the former is not, in fact, considered neither as an urban policy tool nor as part of the Comprehensive Plan. Besides that, the latter is only mandatory to 30% of the Brazilian municipalities: those with more than 20 thousand inhabitants, that conform metropolitan areas and urban agglomerations, that make part of tourism regions, and those where investments may significantly harm the environment or are vulnerable to natural catastrophes.

2.1 Urban perimeter as an urban planning tool in state legislation

The state of Parana, located in the South region of Brazil, is one entity of the Federative Republic of Brazil and is subdivided into 399 municipalities. In its 1989 state Constitution are established guidelines to urban policy, more specific than those in the federal Constitution. Likewise, the state Constitution also defines that Parana cities with population less than 20 thousand inhabitants will receive technical assistance from an urban development state agency to fix general rules for urban land occupation, aiming to guarantee the city and private property's social function. The state agency created in 1996 by law (11498/96) is the Autonomous Social Service PARANACIDADE.

Replacing an older one founded in 1972, its aim is to foster urban, regional and institutional development in favor of Parana municipalities, following state urban policy guidelines, and to encourage them to participate in the formulation of state urban policy and Parana financing system design to support them.

Since 2002, Parana government has established the State Financing System for Municipal Development (Decree 5631/02), which is managed by PARANACIDADE, aiming to finance urban infrastructure and institutional strengthening actions. Among the latter is the Comprehensive Plan. PARANACIDADE provides to state's municipalities its Terms of Reference and related technical support. The delimitation of the urban perimeter is implied.

PARANACIDADE's Comprehensive Plan Terms of Reference content strictly follows the State Urban Development Act (Law 15229/06). Differently from other Brazilian states, it sets the Comprehensive Plan's scope, to be considered by Parana municipalities, which includes:

i) Collection of data, diagnoses and guidelines regarding both urban and rural as well as regional municipality's reality considering environmental, socioeconomic, socio-spatial, public infrastructure and services and institutional aspects;
ii) Guidelines and proposals, establishing municipal urban and rural development policies and a permanent planning system;
iii) Urban legislation: Comprehensive Plan, urban perimeter, urban land parceling, urban and rural land occupation and use control, street network, building code, code of ordinance, and urban instruments as proposed by the Statute of the City;
iv) Investment Plan, according to Comprehensive Plan's priorities, as a tool for municipal capital budgeting;
v) Monitoring and controlling system of Comprehensive Plan implementation based on indicators;
vi) Urban planning and managing administrative unit within local public administration.

This same state law also prescribes that state government will only lend money from the State Financing System for Municipal Development to those municipalities that have a Comprehensive Plan and therefore an urban perimeter law.

Among 152 municipalities of Parana state that signed financial agreements, in the last two years, 81 did not change urban perimeter polygon after Comprehensive Plan's approval, while other 71 did. Most of these (41) have changed it only once in a 10-year period, although 6

have reached up to 25 amendments in the same period of time. This indicates that urban perimeter changes occur in periods shorter than the maximum time gap established by the Statute of the City as mandatory to Comprehensive Plan updating.

3. A theoretical approach to Urban Perimeter and UGB effectiveness as an urban planning tool

The arranging and controlling urban tools effectiveness, as in the case of urban perimeter in Brazil and the Urban Growth Boundary in other countries, has been a controversial subject of international theoretical debate. In a positive perspective, there are those that defend that urban perimeter sets limits on horizontal expansion, contributing to urbanization costs decrease, by making it more compact and sustainable. On the other hand, some doubt about its effectiveness due to the lack of scientific evidence.

According to Braga (2016), urban perimeter is one of the most important urban tools to urban development policy implementation, since it qualifies municipal land for urban use by recognition of areas suitable for urbanization. The author also reinforces that incorrect urban perimeter delimitation, due to its oversize, contributes to increase environmental, social, urban mobility and infrastructure costs.

In line with the need to control urban sprawl, Silva, Silva & Nome (2016) argue that the lack of instruments to arrange and control urban growth, such as the urban perimeter, contribute to worsen citizens' quality of life. The authors point out that, in a country like Brazil, which presents extreme social inequalities, it is a contradiction to defend dispersed, low population density cities, which is inconsistent with sustainable development. This idea brought by all these authors was already present in Mascaro (1986).

Haughton & Hunter (1994) defend high urban population densities in favor of sustainability, because: i) it maximizes the use of available infrastructure and reduces both the relative cost of its implementation and the need for its extension to distant areas; ii) it contributes for reducing commuting, since concentration of people favors economic activities at the local level; and iii) it tends to favor pedestrianism and the implementation of collective transportation systems.

Although some recognize that urban growth control produces more sustainable cities, there is no agreement on formal UGB effectiveness. Jun (2004) compared the metropolitan area of Portland urban growth, which has an UGB, with other metropolitan regions of the United States that do not have it, between 1980 and 1990. The author's conclusion was that in both cases, the process of urban sprawl was similar.

As in Portland, Boussauw, Allaert & Witlox (2013) pointed out that urban sprawl excessive control and compactness in Brussels, capital of Belgium, increased surrounding cities urbanization, intensifying the suburbanization process. Although this phenomenon usually occurs in metropolitan areas, it cannot be ignored that it may happen in any other smaller urban contexts as well.

Another important aspect, regarding urban delimitation, aiming to increase occupation density and optimize the available infrastructure, is urban land price increase. Ball, Cigdem, Taylor & Wood (2014) suggest, from a study of the metropolitan region of Melbourne, in Australia, that land prices rose within the UGB after its enactment. Land price increase and interference with free real estate market forces are some of the main arguments against UGB as an instrument to arrange and control urban space.

In Brazil, as adequately pointed out by Santoro (2014), urban perimeters are, in general, flexible, responding to local real estate market forces, rather than a restrictive and controlling

tool. The author states that urban perimeter laws, in Brazil, are usually modified on a case-by-case basis, without clear urban planning objectives and guidelines.

Although urban perimeter effectiveness to arrange and control urban sprawl can be the subject of important theoretical questionings, the way it has been used in Brazil - flexible and on demand under pressure of real estate market forces – makes it, in fact, an annulled instrument of urban planning.

4. Method of analisys

To achieve this paper's objective, a method, similar to that used by Braga (2016) to the city of Piracicaba – SP, enables Parana municipalities urban perimeter sustainability evaluation through the following 4 spatial metrics: i) gross demographic density; ii) occupation rate; iii) displacement of its centroid from city center; and iv) shape irregularity degree.

The current analysis considers 388 polygons, corresponding to Parana municipalities that have Comprehensive Plan, 97% of the total number. Only the main municipal city urban perimeters are taken into account, although in some municipalities there are more than one urban perimeter that likewise delimit urban occupations within municipal territory.

These 388 municipalities have distinctive features: more than half of them (203) are small (with less than 10 thousand inhabitants) and isolated in the agricultural rural area; some few are located along the Atlantic coast, others conform conurbation areas or belong to metropolitan areas.

For the sake of analysis, Parana municipalities were grouped into 8 populational range sizes, considering 2010 demographic data census, based on the mix of 2 methods of classification: "equal interval" for the 4-lowest population size ranges and "natural breaks" for the other 4-highest ones, taking into account the great population size disparity among Parana municipalities.

The first spatial metrics is gross demographic density. For the sake of its calculation, it is considered 2010 demographic data census relative to main city urban perimeters and urban perimeter areas, as defined by municipal laws, available in SEDU/PARANACIDADE Interativo database. In principle, the higher the gross demographic density, the smaller is urban sprawl.

The second spatial metrics is urban perimeter occupation rate. The urban occupation polygons of Parana municipalities were obtained from the SEDU/PARANACIDADE Interativo, based on 2017 and 2018 satellite images. The indicator value is obtained dividing the total of urban occupation areas within urban perimeter by its total area. In theory, the greater the urban perimeter occupation rate, the greater the arrange and control municipal capacity over urban growth. It should be noted that, high values of urban perimeter occupation rate may also mean that urban perimeter outline is outdated or being disregarded as a tool of local urban growth control.

The third spatial metrics is the displacement of urban perimeter centroid from city center. Its evaluation was done taking into account the distance in a straight line between the urban perimeter polygon centroid and a point considered as the center of the city. Usually, most of urban infrastructure, facilities and services available to population are concentrated in the city center. Therefore, it could be said that the more distant is urban perimeter polygon's centroid from city center, the less equal is urban infrastructure, facilities and services people's access (if its whole area were to be occupied).

At last, the fourth spatial metrics is the urban perimeter shape irregularity degree. It is calculated by the ratio between the length of the current urban perimeter polygon and the length of the circumference of a circle with the very same area, subtracted by one. So zero means perfect regularity. The closer the two measures are, the less irregular the urban

perimeter polygon tends to be, near a circle shape, the most regular and compact geometric figure. The less irregular is the urban perimeter polygon shape, the more likely organized tends to be its occupation (if its whole area were to be occupied).

Thus, the four-spatial metrics here considered allow to evaluate urban perimeter performance towards urban sprawl control, as shown by high gross demographic densities, high occupation rate, low urban perimeter centroid displacement from city center and low degree of its shape irregularity, in favor of environment preservation, commuting costs and emission of air pollutants decrease and conversion of rural into urban land decline, as well as, urban infrastructure, facilities and services rational use. Preventing urban perimeter annulment, aiming to control urban sprawl and guarantee sustainability, is one of the main tasks of local administrations towards the correct use of this tool as prescribed by urban legislation.

5. Results and Discussion

Parana municipalities total urban perimeter area is approximately 6,000 km², corresponding to 3% of state total territory, in the same order of magnitude of world's land surface covered with urban areas, according to Schirber (2005). Yet, the state average urban occupation rate of urban perimeter area is only around 50%.

Figure 1 – Parana urban perimeters
Source: SEDU/PARANACIDADE Interativo, 2018

5.1 Gross demographic density

Urban perimeter gross demographic densities observed in Parana municipalities were classified into three ranges, considering the state average gross demographic density (15 people per hectare) and the minimum gross urban demographic density reference postulated by Braga (2016), which is 50 people per hectare. Here it is also considered a state reference value – 20 people per hectare – obtained from average values of urban parcel size (360 sq meters) and number of residents per household (2.9 people). The three ranges defined, within

Parana state context, are: i) very low (less than 15 people per hectare); ii) low (between 15 and 20 people per hectare); and iii) regular (more than 20 people per hectare and less than 50 people per hectare).

None of Parana municipalities present urban perimeter gross demographic density greater than 50 people per hectare, what makes Parana a fairly low densely urban populated area. Curitiba, the state capital, shows the closest value to Braga's parameter, 40 people per hectare. On the other hand, the municipality of Quatro Barras, in the Metropolitan Region of Curitiba, has the lowest urban perimeter gross demographic density, less than 2 people per hectare (Figure 2).

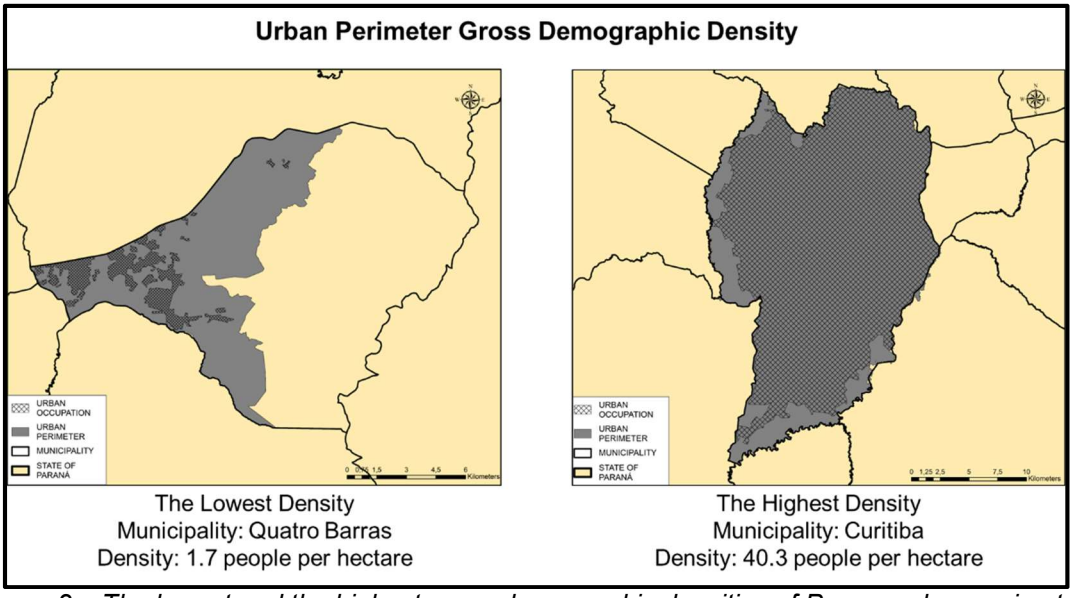

Figure 2 – The lowest and the highest gross demographic densities of Parana urban perimeters
Source: SEDU/PARANACIDADE Interativo, 2018

Table 1 shows the high number of Parana municipalities with densities lower than 15 people per hectare: 242, corresponding to 62.4% of the 388 here considered. The lowest densities predominate in almost all population range sizes, except for the highest, where densities higher than 20 people per hectare prevail. It is possible to assure that, in Parana, the urban development model tends to be of low urban land occupation densities, regardless population size.

Table 1: Number of urban perimeters classified by gross demographic density and population sizes

URBAN POPULATION	GROSS DEMOGRAPHIC DENSITY			TOTAL
	0-14	15-20	>20	
141,958 – 1,751,907	3	0	5	8
68,441 – 141,957	10	4	1	15
31,962 – 68,440	8	5	3	16
16,103 – 31,961	31	5	2	38
7,172 – 16,102	42	21	15	78
4,152 – 7,171	44	17	19	80
2,438 – 4,151	49	16	12	77
524 – 2,437	55	14	7	76
TOTAL	**242**	**82**	**64**	**388**

Source: SEDU/PARANACIDADE Interativo, 2018

5.2 Occupation rate

Urban perimeter occupation rates in Parana show high levels of diversity, being classified into 5 ranges: i) very low - between 8% and 25%; ii) low - between 26% and 50%; iii) regular - between 51% and 75%; iv) high - between 76% and 90%; and v) very high - above 90%.

Table 2 shows that most of urban perimeters in Parana (285) have occupation rates between 26% and 75%, averaging 57.5%. Despite being here considered as a regular rate, there are still 42.5%of non-occupied areas within urban perimeters, in average, which indicates an urban perimeter oversize trend vs. effective demand for new urbanized land.

In general, occupation rate extremes (the lowest and the highest ranges) are concentrated in municipalities with less than 16,000 inhabitants. In these municipalities, where continued, strong demand for new urban land can be reasonably expected to be negligible, the urban perimeter seems to be treated as an unimportant control tool as shown both by its oversize or its undersize (where occupation rate reaches far more than 100%).

Table 2: Number of urban perimeters classified by occupation rate and population sizes

URBAN POPULATION	OCCUPATION RATE					TOTAL
	8 – 25%	26 – 50%	51 – 75%	76 – 90%	> 90%	
141,958 – 1,751,907	0	1	4	2	1	8
68,441 – 141,957	1	8	6	0	0	15
31,962 – 68,440	1	6	7	2	0	16
16,103 – 31,961	4	20	11	3	0	38
7,172 – 16,102	2	22	37	13	4	78
4,152 – 7,171	1	19	35	16	9	80
2,438 – 4,151	2	26	30	17	2	77
524 – 2,437	9	22	31	12	2	76
TOTAL	**20**	**124**	**161**	**65**	**18**	**388**

Source: SEDU/PARANACIDADE Interativo, 2018

Figure 3 demonstrates Parana urban perimeters with the lowest and the highest occupation rates which, in both cases, are inadequate. The urban perimeter of Presidente Castelo Branco Municipality is only 6% occupied, far below Parana state average (57.5%). Even though the real estate market dynamics does not justify such small occupation rate, it can be seen from Figure 3 that there is an urban occupation in the north of urban perimeter, indicating a trend to sprawl into rural areas.

On the other, in Floresta Municipality, the urban occupation maladjustment is characterized by its 158% occupation rate. Here, urban perimeter undersize can be seen as its disregard as an urban control tool.

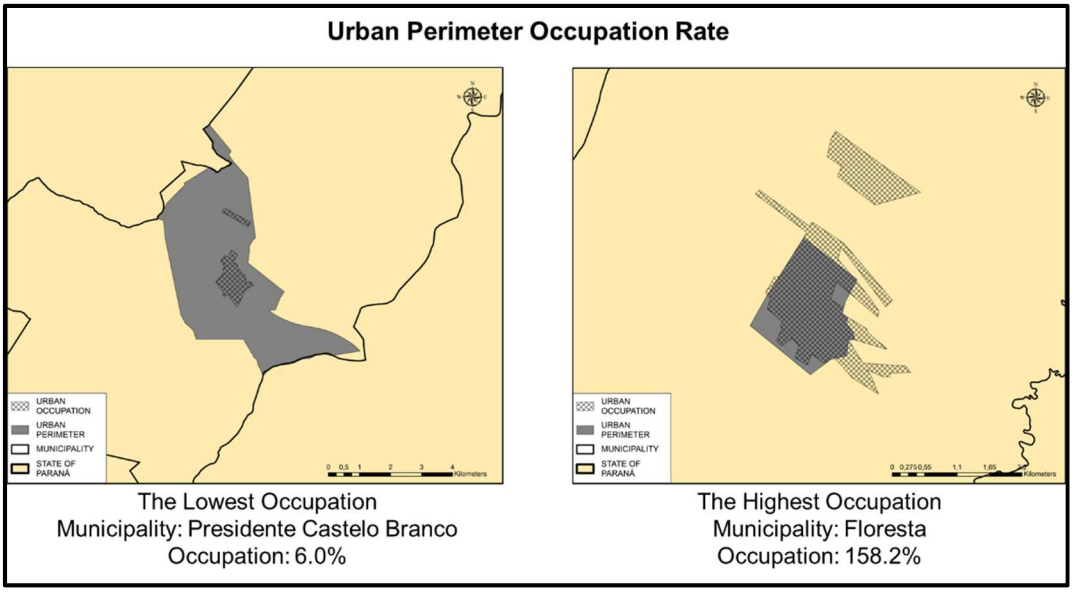

Figure 3: The lowest and the highest occupation rates of Parana urban perimeters
Source: SEDU/PARANACIDADE Interativo, 2018

5.3 Displacement of urban perimeter centroid from city center

Displacement of urban perimeter centroids from city centers were classified into 5 categories: i) very near - between 0 and 0.38 kilometers; ii) near - between 0.39 and 0.89 kilometers; iii) slightly distant - between 0.90 and 2.03 kilometers; iv) distant - between 2.04 and 3.80 kilometers; and v) very distant - between 3.81 and 10.22 kilometers.

Larger municipalities tend to have the greater distances between urban perimeter centroid and city center. Conversely, smaller municipalities usually have the smaller ones (Table 3). Nevertheless, geographical factors that gave rise to some city centers or foster their increase, in Parana, such as maritime foreland and seaside groundwater basin, river borders, conurbation areas, international boundaries, lead to significant displacements.

As examples, it can be mentioned the municipalities of Pontal do Parana (20,920 inhabitants) with 10,221.11 meters of displacement (located along the seacoast); Colombo (212,967 inhabitants) with 6,696.23 meters of displacement (conurbation with Curitiba, the capital state); Paranagua (140,469 inhabitants) with 5,953.16 meters of displacement (located along Paranagua bay); and Foz do Iguaçu (256,088 inhabitants) with 5,531.03 meters (located on an international boundary). In such cases, horizontal urban expansion, within the urban perimeter, tend to make more difficult people's access to urban infrastructure, facilities and services, concentrated in the city center, and therefore cities less sustainable.

Table 3: Number of urban perimeters classified by displacement of urban perimeter centroid from city center and population sizes

URBAN POPULATION	DISPLACEMENT FROM THE CITY CENTER (KM)					TOTAL
	0 – 0.38	0.39 – 0.89	0.90 – 2.03	2.04 – 3.80	3.81 – 10.22	
141,958 – 1,751,907	1	2	1	0	4	8
68,441 – 141,957	4	3	6	2	0	15
31,962 – 68,440	8	4	4	0	0	16
16,103 – 31,961	11	15	6	6	0	38
7,172 – 16,102	31	37	8	2	0	78
4,152 – 7,171	42	27	8	3	0	80
2,438 – 4,151	44	28	4	0	1	77
524 – 2,437	55	12	5	3	1	76
TOTAL	**196**	**128**	**42**	**16**	**6**	**388**

Source: SEDU/PARANACIDADE Interativo, 2018

On the other hand, some municipalities with population over 50,000 inhabitants have very near or near displacement distance values, such as: i) Cianorte (69,958 inhabitants) with 95.70 meters of displacement (isolated city); ii) Paranavai (81,590 inhabitants) with 437.31 meters of displacement (isolated city); iii) Toledo (119,313 inhabitants) with 559.62 meters of displacement (isolated city); and Ponta Grossa (311,611 inhabitants) with 618.18 meters of displacement (regional center). In such cases, urban expansion tends to be fairly well balanced concerning people's access to central urban infrastructure, facilities and services from several regions of the city, optimizing daily city commuting. Figure 4 illustrates two municipalities that belong each to the extreme ranges of urban perimeters centroid displacement in relation to the city center.

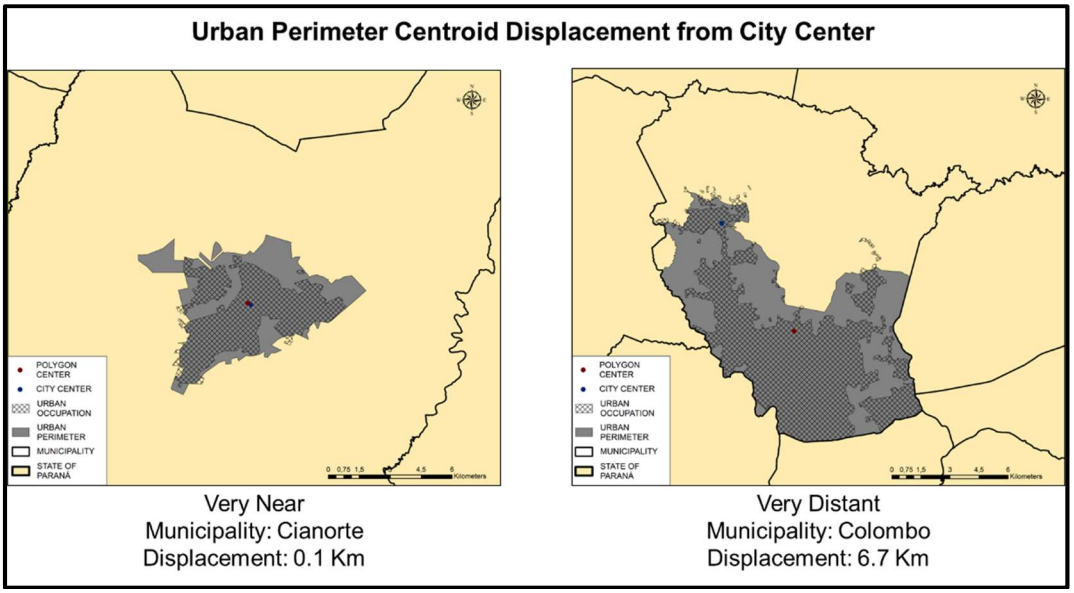

Figure 4: Parana municipalities of the first and fifth range of urban perimeter centroid displacement from city center
Source: SEDU/PARANACIDADE Interativo, 2018

5.4 Urban perimeter shape irregularity degree

Urban perimeter shape irregularity degree aims to identify the level of urban perimeter compactness. If compacted, its shape tends to a circumference; otherwise, the urban perimeter has an irregular form. The proportion of street network extension in relation to urban perimeter area tends to be high, and, consequently, increasing commuting distances and times. The results were classified into 5 ranges: i) regular - between 0 and 0.20; ii) very slightly irregular - between 0.21 and 0.31; iii) slightly irregular - between 0.32 and 0.41; iv) irregular - between 0.41 and 0.52; and v) very irregular - between 0.53 and 0.77.

Table 4 shows that municipalities within the largest population range size have irregular or very irregular urban perimeters, even though it is observed unexpectedly small municipalities classified in this very same category. Most part of the smaller municipalities are equally placed within the other four irregularity range sizes.

Table 4: Number of urban perimeters classified by irregularity shape degree and population sizes

URBAN POPULTATION	DEGREE OF SHAPE IRREGULARITY					TOTAL
	0 – 0.20	0.21 – 0.31	0.32 – 0.41	0.42 – 0.52	0.53 – 0.77	
141,958 – 1,751,907	0	0	0	5	3	8
68,441 – 141,957	0	2	5	4	4	15
31,962 – 68,440	2	2	5	3	4	16
16,103 – 31,961	3	4	12	13	6	38
7,172 – 16,102	5	15	26	21	11	78
4,152 – 7,171	13	12	25	24	6	80
2,438 – 4,151	10	26	21	13	7	77
524 – 2,437	11	21	24	14	6	76
TOTAL	**44**	**82**	**118**	**97**	**47**	**388**

Source: SEDU/PARANACIDADE Interativo, 2018

Urban perimeter irregularity degree may be explained by several factors. Notwithstanding, two prevail: i) federal or state roads (as in Ponta Grossa, Araucaria, Sao Jose dos Pinhais, Carambei municipalities); and ii) land surface irregularity (as in Cerro Azul, Tunas do Parana, Almirante Tamandare municipalities).

Figure 9 illustrates the two Parana urban perimeter extreme irregularity degrees. The most irregular one is Cerro Azul urban perimeter, which adjusts both to land surface irregularity and a federal road. These two aspects lead to the linear shape of Cerro Azul urban land occupation, in north-south direction, limiting street network connections, and the federal road plays the role to link the different regions of the city.

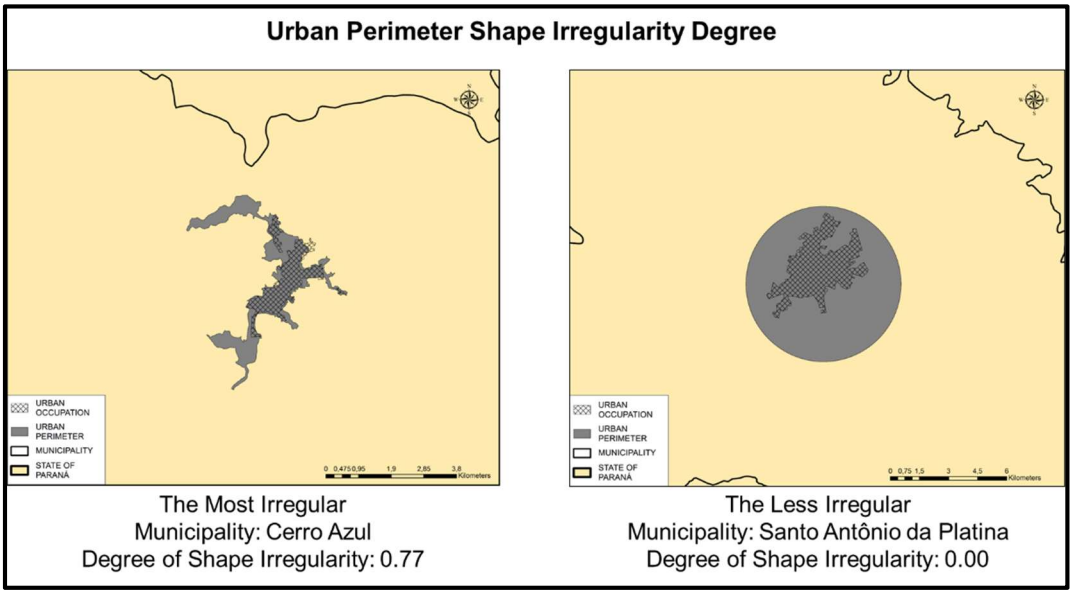

Figure 5: The most very irregular and the most regular Parana urban perimeter shapes
Source: SEDU/PARANACIDADE Interativo, 2018

The urban perimeter of Santo Antonio da Platina Municipality is the opposite case: its shape is a perfect circumference, which, in theory, represents perfect geometric regularity (its shape irregularity degree is zero). However, when comparing the urban perimeter area to the actual occupied area, it is observed that there is no relationship between them, which suggests that this urban perimeter's shape (and oversize) seems to be a pure abstraction, totally disconnected from municipality's reality.

6. Conclusion

Brazilian legislation assigns to urban perimeters, through a specific law, the task of delimiting urban settlements, urban expansion areas and specific urbanization areas, following the Comprehensive Plan guidelines. According to IBGE, urban perimeter is the most used urban planning tool in Brazil. Of the 399 Parana municipalities, 388 have, legally, urban perimeter.

Nevertheless, its effectiveness for arranging and controlling urban occupation may be put into question. This paper evaluates this questioning through 4 spatial metrics: i) gross demographic density; ii) occupation rate; iii) displacement of its centroid from city center; and iv) shape irregularity degree.

The results showed that most of Parana urban perimeters have very low gross demographic density levels, with less than 15 people per hectare. In addition, there is none among Parana municipalities whose urban perimeter gross demographic density exceeds 50 people per hectare, as an evidence of an extensive urban land occupation model, which tends to increase urban costs.

The low urban perimeter gross demographic densities are related, generally, to urban perimeter oversize compared to its actual urban occupied area. In average, Parana urban perimeters are occupied by slightly more than 50%. Considering that Comprehensive Plan, including the urban perimeter, should be updated, at most, every 10 years, the urban perimeter polygons can be considered large enough to comprise urban growth during this period.

Urban perimeter oversize puts at risk urban occupation control, since it contributes to less dense and more fragmented urban occupation. In addition, it also hampers its occupation

arrangement as shown both by urban perimeter centroid displacement from city center and shape irregularity degree.

In general, larger municipalities present greater distances between urban perimeter centroid and city center. Furthermore, those municipalities that comprise conurbation areas, located along international boundaries, seacoast or bays show significant distances as well. In such cases, urban growth within urban perimeter tends to intensify these distances, increasing urban commuting in number and in extent to access urban infrastructure, facilities and services concentrated in the city center.

The evaluation of urban perimeter polygon shapes also shows that the smaller municipalities concentrate most of regular or very slightly irregular polygons, which tend to a circumference. Most of Parana urban perimeter polygons are slightly irregular or irregular, due mainly to surface land irregularity and urban growth along federal or state roads. The urban perimeter irregular shape, if followed by urban occupation, tends to limit urban connections and to increase distances between the various city regions.

Parana municipalities urban occupation pattern, based on both low demographic density and low spatial concentration levels, reduces municipal management performance towards urban infrastructure, facilities and services offer, add to local government poor technical and financial capacities. Increasing distances to overcome in order to attend citizen's demands, rises public and private urban costs, and make cities progressively more and more unsustainable.

It is possible to assert that, in Parana, the annulment of urban perimeter as an urban technical tool may be due to legislators and public managers' political clientelism and to local administration staff institutional weakness. Besides that, this may also be an outcome of Brazilian culture, especially in countryside cities, that associates urban quality of life to horizontal and widespread occupation, based on large parcels and single-family housing, aiming to replicate countryside lifestyle into urban areas. Without changing this paradigm, any urban technical tool aiming to control urban sprawl tends to be annulled.

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