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URBAN POTENTIALITIES: A TEMPORAL ANALYSIS IN THE LARANJAL DISTRICT IN PELOTAS/RS

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ABSTRACT

This study analyzes urban potentialities in Laranjal district in Pelotas/RS and shows that it is possible to manage land use through the use of urban configurational models, specifically urban convergence, and foresee future scenarios for the allocation of businesses and services. In this way, this technique can be used to manage land use as opposed to static urban zoning in which activities are rigidly assigned to urban sectors without considering the demands and accessibility to these offers. Thus, the study was conducted by modeling the potential in a time frame of an urban scenario and its results were compared with another scenario in a time interval of 20 years. For the investigation, statistical probability analyzes were carried out with Pearson's "chi-squared" test among the results obtained and the subsequent scenario. A high correlation was obtained and the degree of adherence between the variables highlights the effectiveness of the model as a descriptor of the urban scenario. This premise reinforces the logic that it is possible to manage the urban environment, foresee scenarios, assign public qualification and urban design policies with the effect of enhancing solutions for the actors that interact in the urban scenario.

Keywords: Spatial analysis. Urban modeling. Geographic information systems. Urban planning. Land use.

POTENCIALIDADES URBANAS: UMA ANÁLISE TEMPORAL NO BAIRRO LARANJAL EM PELOTAS/RS

RESUMO

Este estudo analisa as potencialidades urbanas no bairro Laranjal em Pelotas/RS e evidencia que é possível manejar o uso do solo a partir do uso de modelos configuracionais urbanos, em específico a convergência urbana, e antever cenários futuros para alocação de comércios e serviços. Desta forma, pode-se utilizar esta técnica para manejo do uso do solo em oposição ao zoneamento urbano estático em que as atividades são rigidamente atribuídas a setores urbanos sem considerar as demandas e a acessibilidade a essas ofertas. Desse modo, o estudo foi conduzido pela modelagem das potencialidades em um recorte de tempo de um cenário urbano sendo seus resultados confrontados com outro cenário num intervalo temporal de 20 anos. Para a investigação foram realizadas análises estatísticas de probabilidade com o teste "chi-*squared*" de Pearson entre os resultados obtidos e cenário posterior. Obteve-se alta correlação e o grau de aderência entre as variáveis evidencia a eficácia do modelo como descritor do cenário urbano. Essa premissa reforça a lógica de que é possível gerir o ambiente urbano, antever cenários, atribuir políticas públicas de qualificação e de desenho urbano com efeitos de potencializar soluções para os atores que interagem no cenário urbano.

Palavras-chave: Análise espacial. Modelagem urbana. Sistemas de informações geográficas. Planejamento urbano. Uso do solo.

INTRODUCTION

Through the course of the world industrialization, in the nineteenth century, cities became the location of human concentration. The twentieth century was the century of world urbanization, were the predominance of cities over the countryside was accentuated, and to these days the urbanization process continues at an accelerated pace (Mello, 2021). The exception are the very peripheral and economically impoverished regions, which remain with clearly rural characteristics. In recent studies, the United Nations has estimated that 55% of the world population lives in urban areas and projects that this number will reach 70% by 2050 (Un, 2019). However, urban settlements occupy less than 3% of the territory in the global land use occupation composition (Bechtel, 2015).

In this scenario, urban planning has great relevance and serves as a mediator of human processes and activities in cities, among its various actors. The use and occupation of urban land has generated discussions and proposals in tune with the growth of cities for more than a century. However, traditional approaches have brought little effectiveness in the planning process and generated inequities regarding the rights to the city. Contrary to the static planning of the classic activity zoning, it is necessary to understand that the urban space is dynamic and is in constant transformation. This should make planning observations and mediations a proactive process in tune with these changes with the purpose of mitigating any distortions and promoting the balance of forces of the actors present the in public space.

For an effective urban intervention process, it is necessary to understand the actions and decisions of the multiple urban agents[1] in their daily interacts in the urban environment, since these assumptions reveal information about the why and how of the decisions they make. By doing so, it is possible to generate better policies, actions and interventions needed in the urban environment with a reasonable base of mediation instruments to identify emerging problems and evaluate different policies or possible decision responses (Peter, 2008).

The urban environment is a complex artificial system generated by incremental transformations made by the urban actors in response to the existing city along time. In order to understand the process of land use occupation dynamics, there are theories and computational models developed in decades of urban studies that can, under specific aspects, shed light on the evaluation of the transformations within the city. According to Medeiros (2006) the city is a physical element, a concrete and tactile object – just like the buildings it contains – and it is also articulation, connection, integration and dynamism. Its basic structure is physically composed of built stocks connected by spaces and infrastructure, whose functional purpose is to support economic, social, cultural and environmental processes (Faria, 2010). The city is considered the socially organized space that has assets and resources capable of materializing innovations and generating cooperation between the economic environment and the citizen (Pires, 2006). These peculiarities allow us to speculate, among other things, that the urban environment can be understood through its morphology and the actors and processes responsible for its dynamics. This demands the ability to detect a vast system of structural signals, and provides, in a dynamic way, readings and understandings of an urban organism at all scales (Maretto, 2014). For that purpose, it is necessary to develop methods that quantitatively describe these characteristics and allow objective comparisons between cities (Nilsson, 2019).

In a structured way, it is possible to represent in some extent these specific aspects into mathematical and computational models. The use of modeling and simulation is a way of conducting scientific research, parallel to traditional induction and deduction (Axelrod, 1997). A model is a representation of reality, in which the representation is made through the expression of certain relevant characteristics of the observed reality. These characteristics should be sufficient to provide a simplified and understandable picture, in order to help in the understanding of the represented system (Echenique, 1972). Specifically, urban modeling is the process of identifying and developing, through appropriate theories, relevant computer programs that, based on a mathematical or formal model, can be confronted with data compiled by other means in order to calibrate and validate them before their use (Batty, 2009). With the advancement of computing and enhanced processing capacity, it has become a recurring practice in advanced studies about the dynamics of cities, which would not have been possible in remote times (Batty, 2021).

There is, in this sense, a wide range of studies which use computational models to generate insights about the urban environment. Among them is Space Syntax, which studies urban space as a

[1] Urban agents are individuals, organized groups of people, companies, firms, real estate agents, property owners and public authorities that act, interact and transform the urban system.

constraint for flows and consequently influences the materialization of social practices (Hillier, Hanson, 1984). Concurrently, in a deeper way, we have Krafta's propositions (1996). The author proposes several centrality measures based on Freeman's (1977) original Betweenness Centrality measure. Krafta offers a probabilistic model with a number of measures built on the detailed description of urban configuration and the probabilistic choice of the user in the relations of demand and supply in the urban system. These measures have been demonstrated as more suitable to describe urban structure more than traditional measures (FARIA *et al*., 2024; DALCIN, 2022; MARASCHIN *et al*., 2023).

The articulation of the urban public spaces, associated with the unequal distribution of population densities and facilities, produces a strongly influential network that impacts how people use urban space and how urban agents read opportunities (Souza; Maraschin, 2021). The choice, as well as the satisfaction of demand, will be the function of the relative position (centrality) and attractiveness of the places of supply. Krafta’s proposed model simultaneously offers measures that describe spatial opportunity values of demands and convergence generated by the offers. It also detects spaces that have potentialities for the allocation of new offers due to the actual distribution of population and facilities. Concomitantly, it can offer a picture of the stability of space in terms of the possibility of changes in land use (Krafta, 1996).

The present study works upon the aforementioned aspects to offer an interpretation of urban scenarios, considering the potentialities of the district of Laranjal, in the city of Pelotas, RS. The analysis compares the results of potentialities obtained in the year of 1999 and the state of businesses and services present in the year 2020. The observations aim to verify the performance of the potentiality measure to capture and predict the allocation of new offers in this time interval. Modeling was processed in the Urban Metrics application (Saraiva; Polidori, 2016).

METHODOLOGY

The study area is the district of Laranjal in the municipality of Pelotas, RS. This choice is due to the relatively small scale and isolated character of this district, and also to its intense urban dynamics in the last decades. The district is a seaside neighborhood which has a very significant fixed resident population rate, and also is a place of leisure in the city. The area is a typically residential neighborhood with a predominance of single family-residential houses. According to the Pelotas Master Plan, the Laranjal district has a height limit for buildings up to 7 meters, except on the main avenues where the limit is 13 meters. However, in the entire neighborhood, there are only three buildings that have more than two pavements. The district is about 20 minutes from the city center of Pelotas and has access to Laguna dos Patos on one of its main avenues (Figure 1).

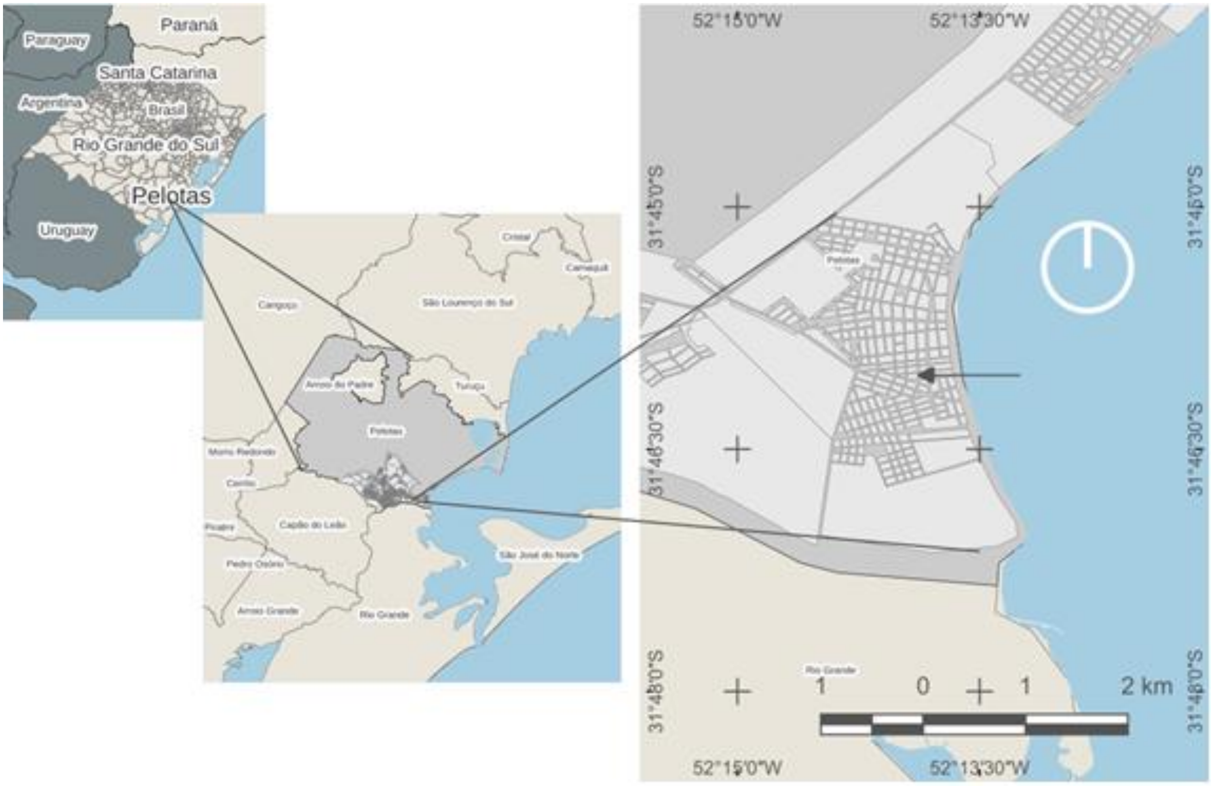
In order to evaluate the performance of Krafta’s potentiality measure in the district of Laranjal/Pelotas, RS, we worked following the procedures shown in Figure 2. In general, the methodology was based on the review of the relevant literature and the construction of a theoretical conceptual model of the methods for the proposed evaluation. However, unlike most previous studies, our approach adopted a very detailed representation of urban spatial structure, representing the street network by road segments and private spaces by individual urban lots. This type of spatial representation can generate more specific results in the modeling, since the proposed representation reflects a discretization at one of its most detailed possible levels of cartographic generalization, without harming the computational processing in the proposed analysis scale.

ACQUISITION AND PRE-PROCESSING OF DATA – INPUTS ON THE MODEL

Spatial representation

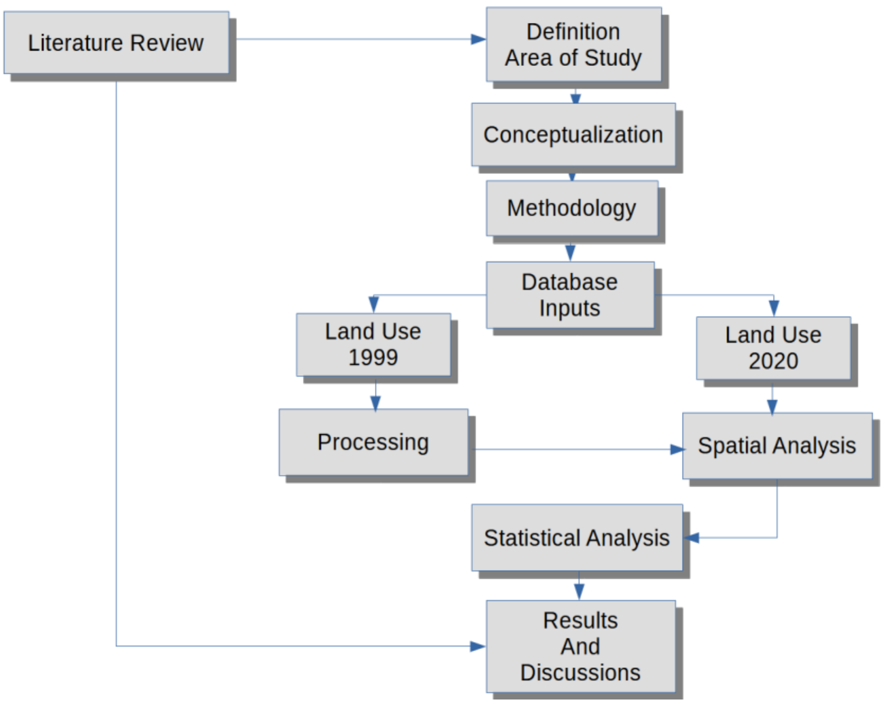
The axis network, the basis of the cartographic generalization of the district under study, followed the structure shown in Figure 3, based on block faces. The structure of the axes has a paramount importance for this type of analysis in which all iterations take place on it. The disconnection among pseudo nodes can compute erroneous values in the analyses about the axes. Thus, this construction received special attention so that the main objective of the study could be achieved.

Figure 1 - Location of the Laranjal district, in the southeast region of the municipality of Pelotas, RS



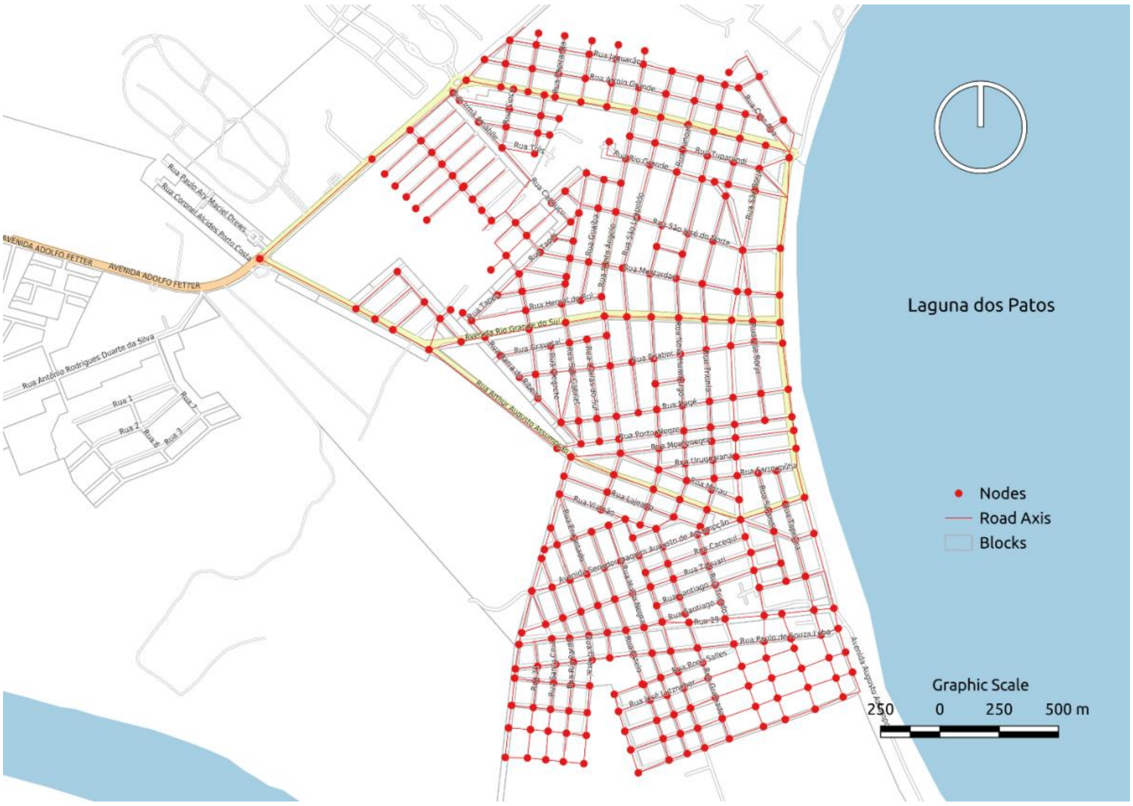
Source: The Authors, based on maps Brazilian Institute of Geography and Statistic (IBGE) 2022.

Figure 2 - Flowchart with the main steps developed throughout the work



Source: The Authors, 2022.

Figure 3 - Map of road axes based on block faces, Laranjal/Pelotas/RS



Source: The Authors, 2022, based on the basic urban map of Pelotas City Hall.

For the purpose of differentiation and hierarchy of the road system, in order to obtain better coherence with the constructed reality, we assigned impedance values that could differentiate during the processing the main avenues of access to the neighborhood, as well as the beach avenue and the internal paved avenues, since most of the internal roads of the neighborhood are only paved with gravel. The impedances assigned to the road system, for the purpose of differentiating the roads, followed the distribution shown in Figure 4. The values "1" were distributed on the main access road to the district and on the beachside avenue for its natural attractiveness. Values of "5" were assigned to the secondary accesses to the district and also to an internal road in the southern portion since it is an asphalt avenue that provides a direct connection between the main access and this region of the district. Other routes received a value of “10” among all of them, as they are mostly secondary and not structuring within the district.

With these criterions of spatial representation, the model was loaded with two basic information: population (demands) and land use (offers).

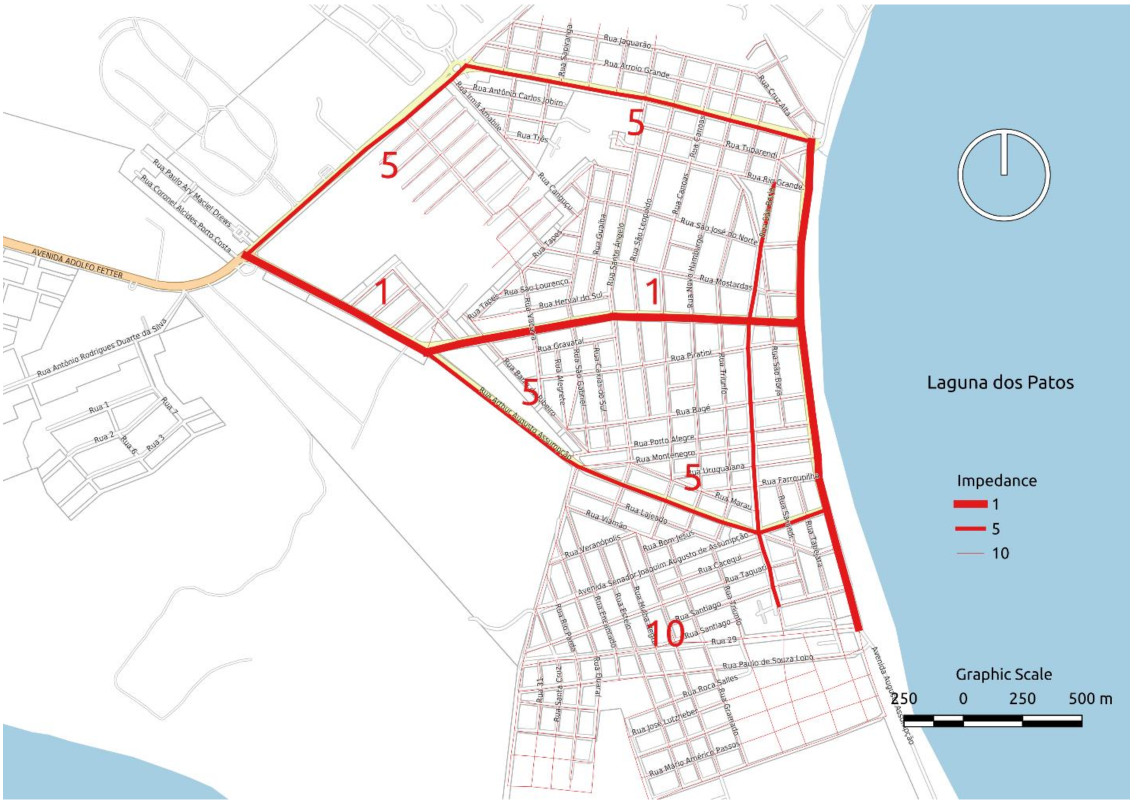
Population

In the IBGE (Brazilian Institute of Geography and Statistics) census data for the district appears within a single sector. Due to the highly homogeneous occupation characteristics, a uniformity in demographic density was considered in the distribution and loading of demands in the modeling process, with each residential lot corresponding to the loading of 2.9 people per unit, supported by data from the National Household Sample Survey (PNAD) referring to the average number of inhabitants per residence in Brazil (IBGE, 2022).

Land use

The land use data for the year 1999 was retrieved from a previous study conducted at the Urbanism Laboratory of Faculty of Architecture and Urbanism of Federal University of Pelotas. The land uses in each lot were collected in loco, and they are part of the research report called "Urban Convergence: An Alternative for Managing Land Use", which was supported by FAPERGS. In that study, businesses and services were understood as any and all activities that generate offers that provide assistance to basic daily needs. Thus, for our model, all existing uses of this type were grouped during the processing into a single generic category established as "offers", with no distinction among them. The original data was reviewed and spatialized in a GIS environment (QGIS) with precise locations to the street sections, based on faces of city blocks.

Figure 4 - Impedance distribution on the street network, Laranjal/Pelotas/RS



Source: The Authors, 2022, based on the basic urban map of Pelotas City Hall.

The land use data for the year of 2020 was obtained from PM Pelotas/SGCMU (City Management and Urban Mobility). All land uses were grouped into a single generic category established as "offers", and also reviewed and spatialized in a GIS environment to the street sections.

The neighborhood in 1999 had 3565 housing units and 95 activities of businesses and services. In 2020, there were 4104 housing units and 144 uses for businesses and services. Over the course of 21 years, the neighborhood had a growth of 539 new homes and 49 new uses for businesses and services. In total, there was a 15.12% growth in housing and a 51.58% increase in businesses and services.

Uploading of population and land use to the spatial representation

One of the principles of the probabilistic model used in this study is based on the connectivity of the urban network, in which the iterations between demands and offers are processed. For a coherent result, it is necessary to have a topologically consistent and uniformly concatenated mesh. For this purpose, network construction and topology tools were used in QGIS with consecutive tests in order to obtain a fully integrated network without connection errors.

In the data loading step, the pre-established uses were associated to the segments of public spaces through geoprocessing techniques in Python language *scripts* processed in the QGIS *software*. These data aggregations were later exported in *shape* file format (native extension of GIS software) for the *Urban Metrics* software in order to generate the results of Potentiality.

Conceptualization of the model for estimating potentialities

The simulation of flows between spaces with demands (residential units) and spaces with offers (commerce and services) in the urban environment, in the model proposed by Krafta (1996), generates Potentiality as one of its results. Potentiality is the indicator of spaces that have a privileged location in flows between the demands and the offers, without providing offers (Polidori, Peres, Tomielo, 2016), and is established by the following formula:

Pot Ii = (Pd.Qo) . {[min] dt PQ} -1 ∀I ⊄ Offer=Offer i

Which reads that the Potentiality of entity I in the interaction i (Pot Ii) is equal to the product of the loading of the demands of entity P by the loading of the offer of entity Q multiplied by the inverse of the distance between entities P and Q, for every entity I that does not contain an offer equal to some offer of entity.

In our experiment we considered the global radius in computing the measure of potential, as the neighborhood is quite walkable and easily traveled by bike and thus, the access to any offers is quite feasible.

Data Correlations

The proposed statistical method to determine the correlation of data is the *Chi-Squared* test (Pearson, 1900), which consists of quantitatively evaluating the relation between the result of an experiment and the expected distribution for the phenomenon. It is used to compare two categorical variables and verify if they are homogeneous. The test was based on the 144 points of existing businesses/services in the study area and executed in the RStudio application.

RESULTS AND DISCUSSIONS

The input data for processing purposes had the following parameters of distribution of demands and offers in the year 1999 (Figure 5). The visual analysis of distribution for commercial and service establishments shows a greater concentration in the central/northern region and on the beachfront. It is highly noticeable the existence of seven large lots occupied entirely by businesses and services scattered in the central/northern region. It is also possible to identify that in 1999 there were no activities of offers in the initial portion of the main access roads to the district.

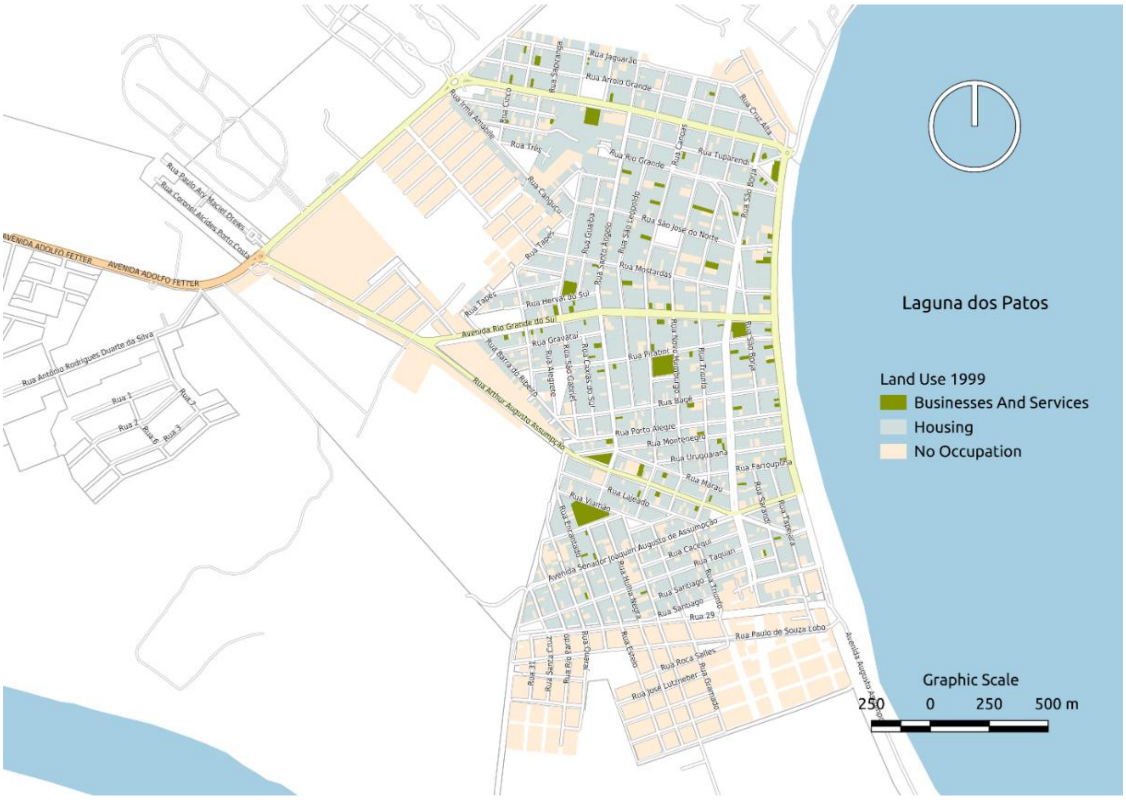
The Potential measure was calculated for the data collected in 1999 on the segmented representation of streets with global radius and the impedances previously described. Results obtained for the Potential measure can be seen in Figure 6.

The visual analysis of the measure shows clearly the highest values of Potentialities on the main avenues of access to the neighborhood and then penetrating the urban structure until reaching the beachfront avenue. On these street segments obtained values ranging from 6352 to 16588. Median values are spread perpendicularly from these routes into the central areas. Values on these street segments rang mostly between 2541 and 6352. It is on these street segments assigned with higher values that major transformations in land use are expected.

In the subsequent spatial analysis, land use data from 2020 was loaded together with the results of the Potentiality measure of the 1999 network (Figure 7). In the GIS environment was possible to create a link between both data for subsequent statistical analysis. Thereby, it was possible to study if there were correlations between the potentiality measure for 1999 and land use locations in 2020.

Changes in the location of the offers are easily observed in some areas. We can see the existence of new economic activities in the main access road to the district, which did not exist in 1999 and which had obtained a high Potential value. In a visual interpretation, we can observe the general adherence of new activities to locations with high to medium values obtained with the Potential measure. However, there are two situations where the Potential measure was incapable to explain land use distribution in 2020. The first situation is a specific section with a high Potential value on the intermediate access axis to the southern part of the district, which connects the main entrance of the district to this region. On this street segment, there is still no occupation on the side due to the fact that there is a marsh on both sides of the road which makes activities on this route impossible. The second situation refers to some street segments with median to low values of Potential that nonetheless, had the presence of new businesses and services in the year of 2020.

Figure 5 - Land Use in 1999, Laranjal/Pelotas. RS



Source: The Authors, 2022, based on the basic urban map of Pelotas city hall and Urbanism Laboratory of Faculty of Architecture and Urbanism of Federal University of Pelotas.

To investigate this second situation an additional spatial analysis was performed with Krafta's measure of Urban Convergence. This measure evaluates which offer locations are highly central to all points of demand in the network. The results of this measure can be seen in Figure 8, along with land use location for 2020. Interestingly, the streets segments with higher values of Urban Convergence are locations that already had commerce and services in 1999 and also gained new activities in 2020. Thus, it is possible to explain this preference in location due to two factors: the easiness of access in the network to all probable consumers; and the presence of activities that generate an attractive location for new activities in its surroundings.

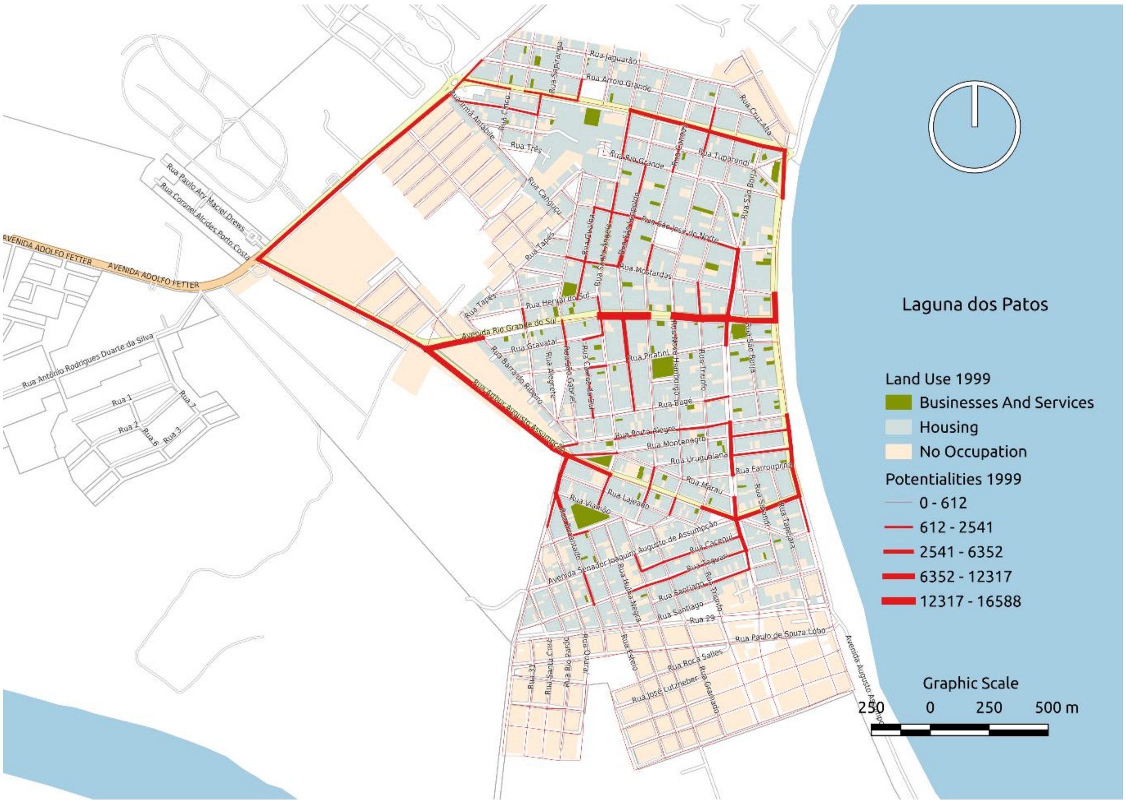
The present results suggest that a combined measure with both Potential and Urban Convergence may account for better prediction in new activity locations.

In addition, the analyzes were superimposed on the results of the Potentiality measurement with income, population density and spatial distribution of offers. Income data show a heterogeneous dispersion throughout the urban space without evidence of concentration or clusters that justify a prioritization of the spatial distribution of offers for these socioeconomic profiles (figure 9). In the same sense, crossing data with population density revealed the same situation (figure 10). What is noticeable is a diffuse distribution of offers throughout the urban fabric. Therefore, it can be assumed that the distribution of offers is more associated with internal flows between demands and offers and the road hierarchy.

The visual inspection of the spatial analysis suggests a good explanatory capability for the Potential measure, even though there were situations where the results indicated the need for further explanations. In order to better delineate the correlations between the Potential measure and the location preferences for businesses and services the generated data was statistically investigated. In Table 1 we present the number of businesses and services about street segments and the corresponding average Potential of these segments. We also evaluated the corresponding average Urban Convergence measure to see if it could account statistically for the situations detected in the visual analysis.

Furthermore, the network connectivity map shows that there is no relation with the most connected axes and location of offers. This reinforces the thesis of the relation between flows among demands and offers and the hierarchy of the road system (Figure 11).

Figure 6 - Result of the Potentiality measure and land use for the year 1999, Laranjal/Pelotas, RS



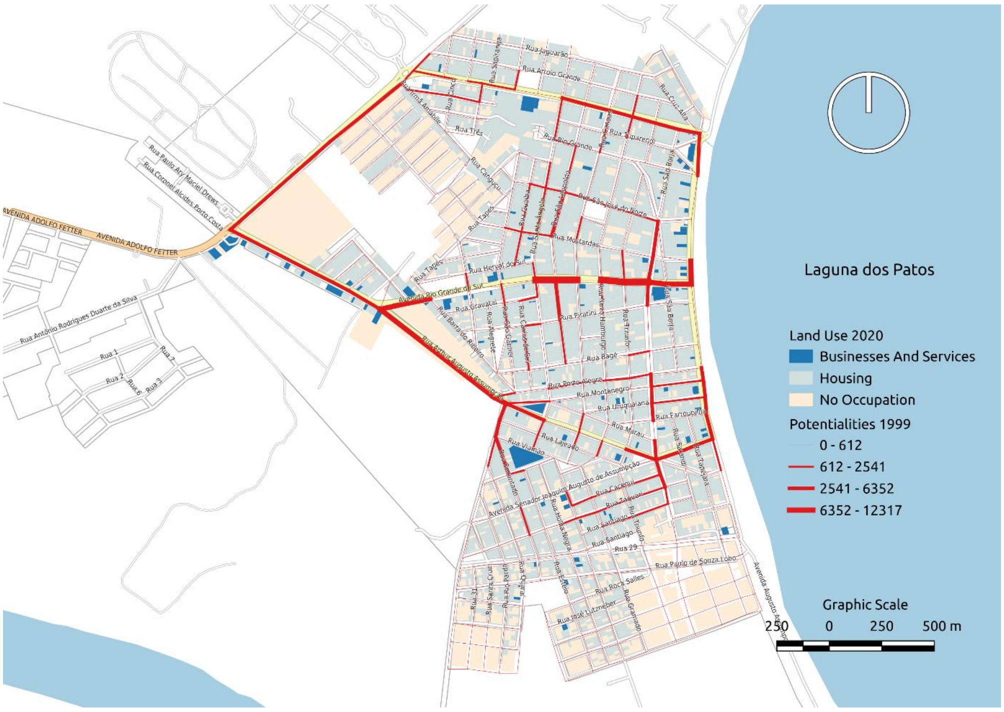
Source: The Authors, 2022, based on the basic urban map of Pelotas City Hall and modelling process.

Table 1 - Description of the average Potentiality value and occurrences of businesses and services

Number of businesses and services in 2020	Average Potentiality	Average Urban Convergence	Frequency
0	592	196	580
1	1106	945	54
2	1502	1538	20
3	0	2281	4
4	356	5449	4
5	3744	0	2
12	3744	0	1
			Total = 665

Source: The authors, 2022.

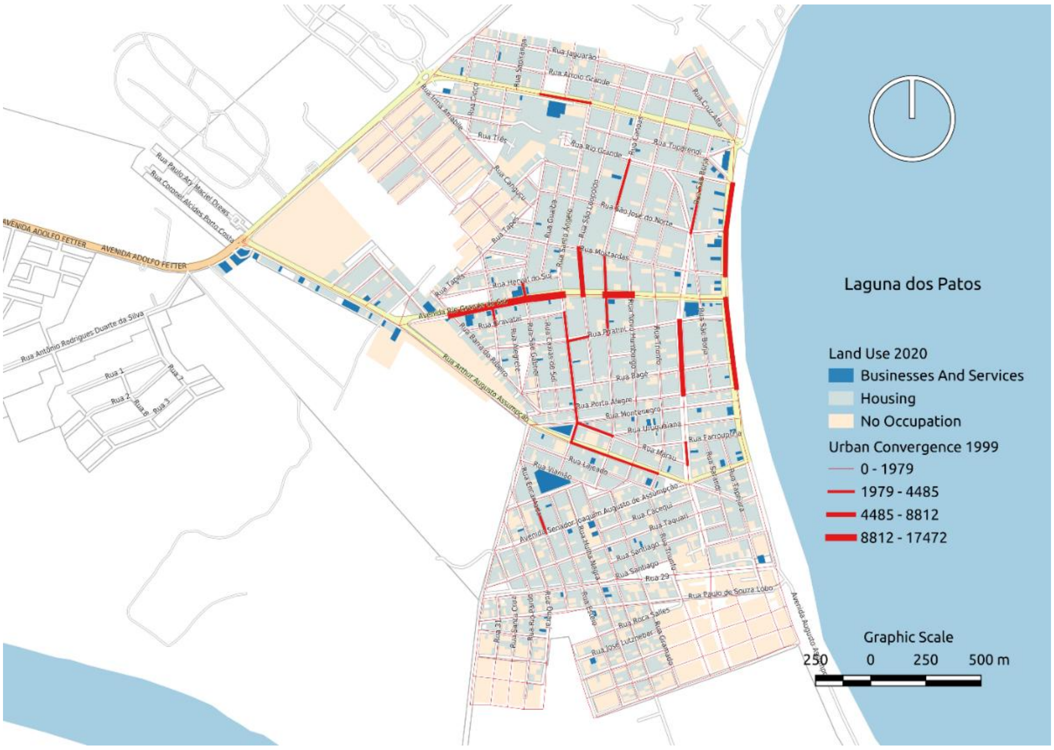
Figure 7 - Land use in 2020 and the result of the Potentiality measure in 1999, Laranjal/Pelotas, RS



Source: The Authors, 2022, based on the basic urban map of Pelotas City Hall and modelling process.

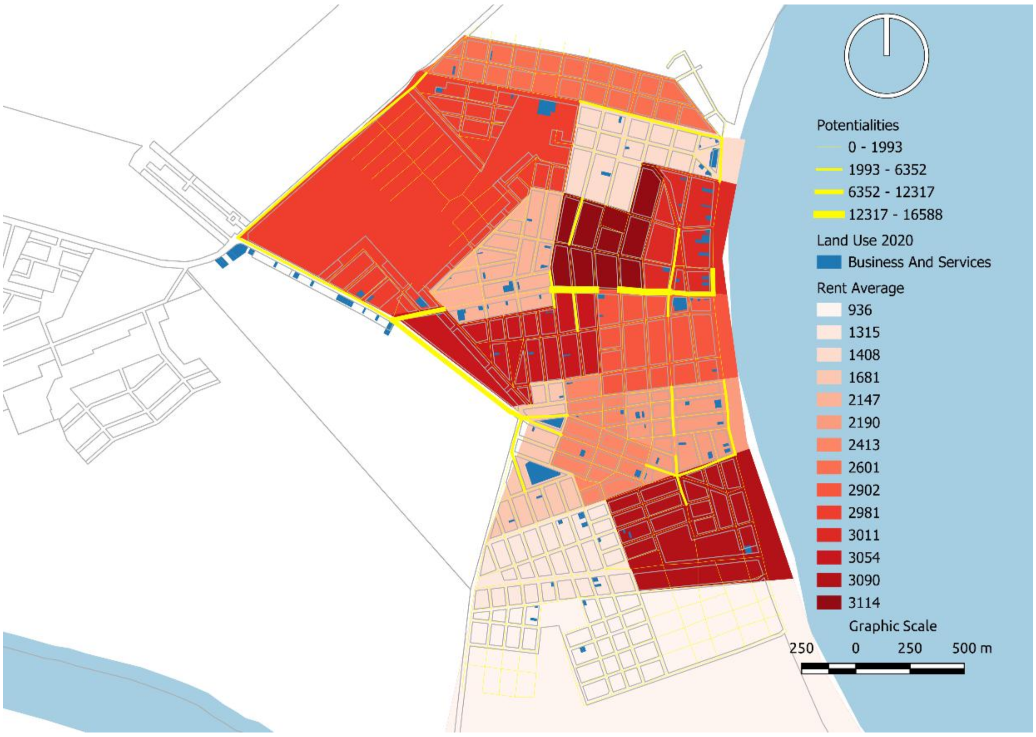
Statistical analysis

Figure 8 - Result of Urban Convergence for the year of 1999 and location of businesses and services land uses for 2020, Laranjal/Pelotas, RS.



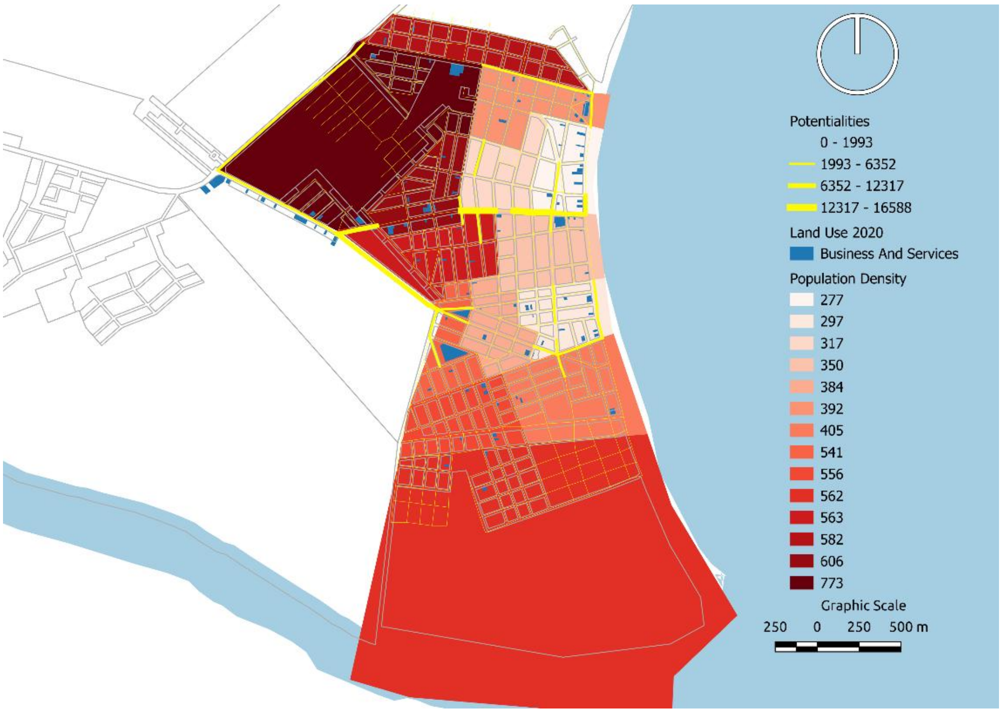
Source: The Authors, 2022, based on the basic urban map of Pelotas city hall and modelling process.

Figure 9 - Result of Potentialities, rent average and location of businesses and services land uses for 2020, Laranjal/Pelotas, RS



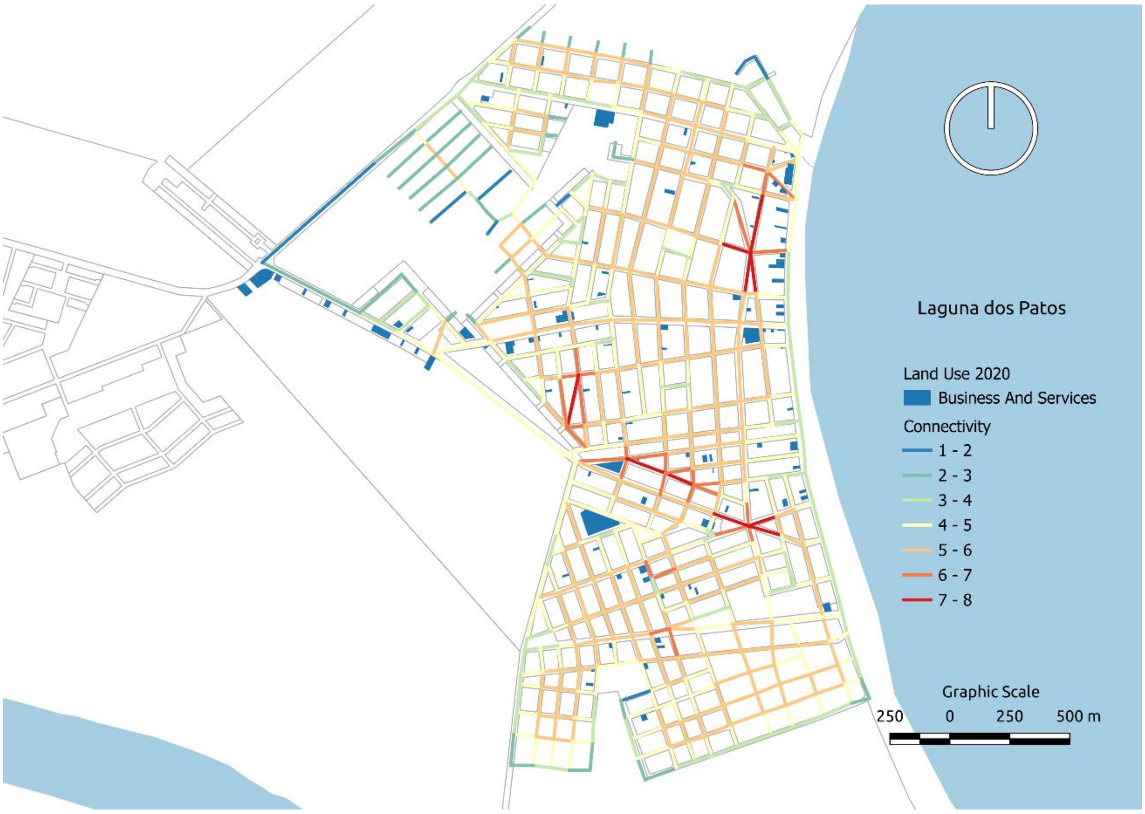
Source: The Authors, 2022, based on the basic urban map of Pelotas city hall, modelling process and census data of Brazilian Institute of Geography and Statistic (IBGE).

Figure 10 - Result of Potentialities, population density and location of businesses and services land uses for 2020, Laranjal/Pelotas, RS



Source: The Authors, 2022, based on the basic urban map of Pelotas city hall, modelling process and census data of Brazilian Institute of Geography and Statistic (IBGE).

Figure 11 - Road system connectivity and location of businesses and services land uses for 2020, Laranjal/Pelotas, RS



Source: The Authors, 2022, based on the basic urban map of Pelotas city hall and modelling process.

Observing the number of business and services per street segment, and comparing them to the average value of the Potential measure, it is possible to see that even though higher averages are seen related to the presence of more business and services, it is not a total match. On street segments with low concentration of activities there are some discrepancies. The Potential measure seems to give a better explanation for locations with higher concentrations of activities. On the other hand, the Urban Convergence measure has a very good correlation to the lower and medium activity concentrations, but is incapable to detect the higher concentrations.

The observed results confirm that both measures account for different aspects involved in location decisions. The combination of the two measures seems promising, but there is a need for more case studies to determine if the pattern is sustained and evaluate the non-linear relation among measures.

The data suggests the need to perform a statistical test to prove whether or not there is a valid association between the Potential measure and the overall presence of businesses and services on the street segments. By grouping street segments by their Potential values in three classes (high, medium and low) and comparing them to the average number of business and services on these street segments, it is possible to observe a positive relation between variables (Table 2). Analyzing the average, we can see a clear relation between the Potentiality and the amount of new activities that where created. When evaluating the standard deviation of businesses/services created by groups, we notice that the high value group of Potentialities has the greatest variation in relation to the average, with the presence of segments with 5 and 12 businesses/services.

Table 2 - Potentialities, Average Frequency of Businesses and Services and Standard Deviation

Potentiality Group	Average Businesses and Services 2020	Standard Deviation Businesses and Services 2020
1 to 500	1,49	0,80
506 to 1048	1,82	1,11
1062 to 6000	2,09	2,39

Source: The authors, 2022.

Finally, to prove the association between these variables, we had a *Chi-Squared* test with a p-value of 0.08358, which indicates the rejection of the null hypothesis of the test that states there is no association between the variables. As the hypothesis is rejected, we can state with 91.64% confidence level that there is an association between the Potentiality and the number of businesses/services generated in the analyzed road segments.

The results obtained attest the capability of Krafta's proposed model and measures, confirming the results of other application studies (GONÇALVES, 2011; SOUZA, MARASCHIN, 2021; DALCIN, 2022). However, in our study the results indicate that probably a non-linear combination of both the Potential and the Urban Convergence measures may contemplate better predictions for new activity locations.

CONCLUSIONS

Mathematical models with the function of experimenting and describing specific aspects of cities have been consolidated in the field of urbanism. They have evolved considerably with the increase of new variables and description methods. In particular, the model of "Urban Convergence" with its group of configurational measures, proposed by Krafta (1996), has contributed to a more precise representation of urban phenomena, increasing the descriptive capacity of network measures for the realm of urban systems. The subject of investigation by the present authors attest the coherence of the metrics in the model proposed by Krafta to explain and predict with good level of accuracy the dynamic processes of activity location observed in the built environment. The instruments were able to generate *insights* about the function of the urban environment and seem adept to guide decision-making by public policies to control and foresee the general tendencies of allocation of new activities in the urban structure.

The present exploratory study analyzed changes in the expansion of businesses and service activities in the 21-years interval in the district of Laranjal/Pelotas, RS, correlated with results of the Potential measure. The adopted modeling process with street segments and impedance to simulate the street quality, together with considering global radius to compute the Potential measure for land use distribution generated consistent results of potentialities for the locations of new activities in the year of 2020. Thus, a detailed representation of urban structure and the consideration of a wide radius for mobility within the neighborhood seem to be a suitable option for modeling small urban areas.

From the statistical point of view, the values of Potentialities obtained a significant positive correlation to the existence of businesses and services. However, this relation was found not to be straightforward, there were other factors that also influenced location decisions. It was found that the presence of existing concentrations of businesses and services and highly central locations also accounted for the location of new activities. These factors were found to be easily explained by the Urban Convergence measure. As a result, the exploratory study indicates that better explanations can be attained using both Potential and Urban Convergence measures in a combined formulation. This is a new result and indicates that further investigations and a new measure formulation are required in the future research development.

In the same sense, further refinement of the input data about demands is necessary since the demographic data in this study was approached in a homogeneous way due to the peculiar characteristics of the sample space. Furthermore, for a temporal analysis it is necessary to obtain land use data on a historical scale.

Although the sample space in our study is representative for a large part of Brazilian municipalities, it is necessary to expand this type of study to analysis of larger cities in order to determine whether the correlation is confirmed for larger environments. It is known that most Brazilian cities lack urban cartographic bases and, above all, control over the management of land use in a georeferenced way, which could be an obstacle to expanding analyzes and correlations in future studies. It is also necessary to consider other locations outside Brazil with different consumption behaviors and other urban configurations. Other analytical methods and composite metrics can also be used to investigate whether the correlation is confirmed in addition to other sample spaces and urban realities.

Finally, we should be mindful that urban dynamics can be explained by other methods and approaches. Still, from the point of view of the methodology adopted here, the Potential measure has demonstrated good predictability for land use changes with very simple procedures, and thus suitable for public municipality agencies.

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