


# Geospatial analysis of tourism supply and flows in northeastern Brazil

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## **Keywords:**

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Spatial contiguity  
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## **Abstract**

Tourism has been established as a significant activity worldwide, especially in the economic aspect. As a multifaceted phenomenon, including its spatial component, the systemic perspective allows a fragmented or integrated study of its different parts. The geographic space encompasses fixed elements and tourist flows, which are dynamic according to the constitution of the space. In Northeastern Brazil, tourism is one of the activities that considerably move the economy and promote the consumption of places with the support of infrastructure and services. However, it is still a sector concentrated in the largest cities of the region, contributing to reinforcing intra-regional inequalities. Therefore, it is opportune to use geospatial analysis techniques to study tourism in order to identify and discuss the spatial distribution of tourism supply and possible tourist flows on two geographic scales: in Northeastern Brazil (NEB) and in the Immediate Geographic Region of Princesa Isabel (RGIPI). For this purpose, QGIS with R language was used to treat geographic, population, per capita income, and tourist businesses data and to calculate the spatial indices of autocorrelation and Moran's I contiguity on global and local scales, respectively. The outcomes revealed the spatial independence of tourist supply in the NEB, which is also seen on a local scale in the RGIPI. The analysis also revealed that the highest probabilities of tourist flow occur between the most populous, higher income, and more developed capitals. Therefore, geoprocessing plays a key role in the study of tourism as it materializes in geographical space and allows highlighting areas for tourism expansion in the interior of the NEB.

## INTRODUCTION

Tourism is a multi-sector human activity responsible for an ever-larger portion of the global economy. It is also a spatial phenomenon as the elements involved have a geographic location, whether static or flowing. It is about the consumption of places advertised and supported by an infrastructure capable of meeting tourist needs.

The northeast region of Brazil is nationally known to have many tourist attractions, especially along its coast, where the beaches are located, and part of the regional history is recorded. Its largest cities rely on this heritage wealth in order to boost tourist activities, historically favored by the occupation process of the region (ALVES; DANTAS, 2016) and the attention of the Brazilian State, especially after the 1980s (COSTA, 2012).

Tourism supply is successful when the place to be consumed is structured to receive visitors (host them, feed them, and offer products and services), as is the case of the capitals and metropolitan regions of Northeastern Brazil (SOUZA; SILVEIRA NETO, 2015).

Moreover, there are also potential tourist locations that fail to develop activities or integrate adjacent locations where tourism is a reality. Locations with tourism potential are characterized by unexplored tourist heritage or the existence of raw materials but no tourist activities, which is especially true in the interior of the Northeast region (GOMES, 2019).

From this perspective, this study aimed to analyze the spatial contiguity scenario of tourism supply and flows on two geographic scales: regional (Northeastern Brazil) and local (Immediate Geographic Region of Princesa Isabel, state of Paraíba).

## THEORETICAL BACKGROUND

Tourism is a multifaceted phenomenon streamlined in and by geographic space, with importance in several aspects of human life, including the economy, culture, and social relations. From this perspective, Beni (2006) addresses tourism as a systemic phenomenon composed of various subsystems that interact to reach an objective. This definition understands tourism as an activity with systemic properties that can be measured, manipulated, and controlled, such as performance, management, and resources.

Moreover, the geographic space is understood

in tourism as an object of consumption since it encompasses the activities that directly or indirectly modify tourism by inserting or removing functions and meanings through interactions between society and nature. These interactions can be investigated by geographic analyses that address the production of space as a consequence of locally developed relationships (MUNIZ; CASTRO, 2018).

The dynamics that tourism imprints on space include the exploitation of potentialities, which is increased or decreased with social demand and constitutes a changeable process of space and time production, which may either meet this demand or offer nothing – deflating the local attractiveness. Therefore, the elements that constitute the geographic space determine its production, creating tourism spaces in accordance with the existing material conditions (MUNIZ; CASTRO, 2018).

Thus, tourism development as a socio-economic-spatial-environmental activity is sought by social groups and individuals given the possibility of improving the quality of life of the population, either directly, through the increase in income, employment, and/or the provision of services, or indirectly, through the unfolding of direct means or the strengthening of local culture and environmental conservation (MEDEIROS *et al.*, 2015; CAMILO; BAHL, 2017).

Each place has vulnerabilities and potentialities under different social, cultural, political, environmental, and economic perspectives. For Cunha (2008), tourist attractions, such as waterfalls, beaches, museums, cultural groups, and typical foods, are elements that boost tourist visits. However, a driving agent is required to initiate the process of space production based on the local tourism potential.

In this article, tourism potential refers to the future perspective of a place offering activities based on its tourism resources. In turn, tourism resources are elements that can be exploited by tourism as raw materials. Once structured and ready for the development of activities, these resources become tourist attractions and are considered part of the supply (GOMES, 2019).

As a spatial phenomenon with geolocated elements, the behavior of tourism in the geographic space can be analyzed by geoprocessing techniques identified as geospatial analysis (FERREIRA, 2014). This quantitative approach of geographic research has increasingly provided a paradigm change in the study of geographic space due to the incorporation of new technologies (PAUL; JHA, 2021), also applied to tourism. Some of these

approaches are spatial autocorrelation, the contiguity index, spatial interaction probability, and spatial interpolation.

Spatial autocorrelation is a measure of spatial dependence of a geographic variable compared to itself. In the geographic space, phenomena are expected to be more similar the closer they are to each other (Tobler's Law). Therefore, the neighborhood relationship between geolocated elements is understood as a constituent element of this space.

A binary weighted connectivity matrix is used to calculate the spatial autocorrelation using Moran's I index, in which the adjacent municipalities with the occurrence of a variable receive weight 1, and neighboring municipalities without the variable receive weight 0. Therefore, the analysis always considers the relationship of the entity with its neighbors (BIVAND *et al.*, 2013; LUZARDO *et al.*, 2017).

A positive spatial correlation implies strong spatial organization or the existence of subspaces where similar values are clustered. In cases of negative spatial correlation, nearby points with very different values predominate. A null spatial correlation implies the absence of spatial dependence (FERREIRA, 2014). According to Rivero (2008), in tourism, a spatial correlation may indicate the diffusion or concentration of a tourist flow in the space and assist in tourism management and planning, especially to suggest possibilities for the geographic expansion of activities.

The p-value is calculated to identify the degree of statistical significance of Moran's I result. Therefore, when  $I > 0$  and the p-value  $< 0.05$  (or 95% significance), the contiguity hypothesis is accepted, and it can be said that there is locational dependence between the events (LUZARDO *et al.*, 2017).

In addition to spatial autocorrelation, which analyzes the behavior of the variable, the probability of spatial interaction is a technique used to model the dynamics between the variables that motivate an individual to move between places (FERREIRA, 2014). The probability of a spatial interaction occurring between two locations depends on geographic limitations or facilitating factors, which are intrinsic to the value of the variable.

In tourism, considering that attractions are the motivating elements for visits (CUNHA, 2008), the variables capable of describing the probability of spatial interaction should also include spatial elements, such as distances, spatial patterns, and geographic features.

## MATERIALS AND METHODS

### Study Area

The Brazilian Northeast region (NEB) is composed of nine federative units and 1,794 municipalities. According to Instituto Brasileiro de Geografia e Estatística (IBGE, 2017) - which is a federal public agency responsible for providing geographic and statistical information about Brazil -, the NEB population, estimated in 2020, consisted of 57,374,243 inhabitants; its five largest capitals, with populations larger than 1 million people, are Salvador, with 2,886,698 inhabitants; Fortaleza, with 2,686,612 inhabitants, Recife, with 1,653,461 inhabitants, São Luís, with 1.108.975 inhabitants; and Maceió, with 1.025.360 inhabitants. The human development index of the capitals in 2010, in descending order, was: Recife (0.772), Aracaju (0.770), São Luís (0.768), Natal (0.763), and João Pessoa (0.763) (PNUD Brasil; IPEA; FJP, 2020).

With regard to the Gross Domestic Product (GDP), the Northeast region produced, in 2018, approximately R\$ 1 trillion in wealth, corresponding to 14.3% of the total produced in the country (IBGE, 2018). As to tourism, the participation of this sector in the total national GDP in 2018 accounted for 8.1% and occupied 6.9 million jobs (BRASIL, 2019), placing tourism as an important component of the national economy.

Located in the state of Paraíba, the Immediate Geographic Region of Princesa Isabel (RGIPI) was used to apply the spatial autocorrelation index and the probability of interaction on a local scale by making a geographic section of a small and undeveloped region in the interior of Paraíba to analyze the tourist flow and tourism supply scenario in a specific geographic context.

The RGIPI is formed by the municipalities of Juru, Tavares, Princesa Isabel, São José de Princesa, and Manaíra, and its nucleus is Princesa Isabel, with approximately 23 thousand inhabitants and a Municipal Human Development Index (IDHM) of 0.606, which is considered average (IBGE, 2017; PNUD Brasil; IPEA; FJP, 2020).

The RGIPI was chosen due to its low overall development and because Princesa Isabel was the stage of a national historical movement (the Revolt of Princesa, in 1930) (PRINCESA, 2010). Moreover, the region is located in a mountain region characterized as an upland forest, with scenic landscapes - and yet showing incipient tourism - neighbor to the municipality of Triunfo

(PE), where tourism has well-established activities, although distant from the capitals and large northeastern cities.

### Materials

This study used secondary data to observe the spatial contiguity of tourism supply and the probability index of spatial interaction between visited locations, namely: the estimated population for 2020 (IBGE, c2017); the *per capita* income per municipality in 2010 (IBGE, 2010); collaborative data on the tourist attractions of NEB states, available on the TripAdvisor platform (c2021)- one of the most accessed by tourists in the world -, and the number of tourism enterprises (travel agencies, show houses, convention centers, tourism support, tour guides, vehicle rentals, lodging, event organizers, water parks, theme parks, providers specialized in tourist segments, feeding, and transporters) registered with Cadastur (BRASIL, s.d.), a federal government platform for the registration of tourism enterprises, referring to the fourth trimester of 2019, before the COVID-19 pandemic.

The software programs used in the study were: (1) the sheet editor WPS Office; (2) R language 4.0.3 (R CORE TEAM, 2009), using the software R Studio 1.4; and (3) the Geographic Information System (GIS) QGIS 3.10 (QGIS.org, 2020).

### Methods

In this quantitative and descriptive study, the first step corresponded to data preparation, such as joining the socioeconomic with geographic data in R 4.0.3 and calculating the Euclidean distances between all municipal headquarters in the NEB using QGIS 3.10.

In the processing step, spatial autocorrelation was calculated for a binary map, over polygons, using as input the data from tourism enterprises registered with Cadastur and validated by Pearson's correlation with the number of tourist attractions per state. The processing considered the neighborhood degree between features that showed a positive manifestation of the variable in question, along with the calculation of its covariance and variance. Global Moran's I index was used according to equation 1 (MORAN, 1948; 1950 cited by FERREIRA, 2014).

$$I = \frac{n}{2k} \left( \frac{\sum_{i=1}^n \sum_{j=1}^m \delta_{i,j} (z_i - \mu)(z_j - \mu)}{\sum_{i=1}^n (z_i - \mu)^2} \right) \quad (\text{Eq. 1})$$

Where:  $n$  = number of spatial units;  $k$  = number of possible joins;  $\mu$  = mean of binary events;  $\delta_{i,j}$  = binary connectivity between spatial units  $i$  and  $j$ ;  $z_i$  and  $z_j$  = number of occurrences of the variable in question in spatial units  $i$  and  $j$ .

The Global I index was calculated using the function *moran.test()* of package *spdep*, in R, and the function *poly2nb()* was used to calculate the neighbors of each polygon, generating a correlogram with the function *sp.correlogram()*. The objective was to assess the degree of spatial autocorrelation of tourism supply in the NEB.

On a local scale, in which the I index (Eq. 2) is calculated for each geographic unit of the map (municipality) in relation to its neighbors, the function *localmoran()* was used. As a result, statistical significance and Local I index maps were generated. It should be noted that both the Global I and Local I require the variable and a list of weights calculated for each neighbor of the geographic unit as input, obtained by the function *nb2listw()*.

$$I_i(d) = \frac{x_i - \mu}{\sum_i (x_i - \mu)^2} \sum_j w_{i,j}(d)(x_j - \mu) \quad (\text{Eq. 2})$$

Where:  $I_i$  = Moran's I Index in position  $i$ ;  $x_i$  = value of the variable in position  $i$ ;  $\mu$  = mean of the variable; and  $w_{i,j}$  = binary weighted spatial matrix.

The indicator of the probability of spatial interaction (Index "a") was obtained by the ratio between the number of tourism enterprises in the destination and the distances between the origin and destination locations, calculated in the GIS and weighted by the population and *per capita* income – adapted from Ferreira (2014) (Equation 3).

$$a_{i,j} = \frac{S_j}{d_{i,j}^\lambda} \quad (\text{Eq. 3})$$

Where:  $a_{i,j}$  = possibility of interaction between two locations  $i$  and  $j$ ;  $S_j$  = number of tourism enterprises in the destination location;  $d_{i,j}$  = distance between the origin location  $i$  and the destination  $j$ ;  $\lambda$  = weighting parameter (the higher it is, the more it mitigates the effect of the distance between locations  $i$  and  $j$  on the possibility of interaction) (Equation 4).

$$\lambda = \frac{1}{(r_i / P_i) + (r_j / P_j)} \times 100 \quad (\text{Eq. 4})$$

Where:  $r$  = *per capita* income; and  $P$  = population.

Subsequently, Inverse Distance Squared spatial interpolation (IDW) was applied according to Equation 5 (SILVA, 2018) to produce a continuous surface with the estimated values of index “ $a$ ” in the locations without sampled data in order to identify tourism supply zones and analyze tourist flows.

$$Z_0 = \frac{\sum_{i=1}^n (z_i / d_{ij}^2)}{\sum_{i=1}^n (1 / d_{ij}^2)} \quad (\text{Eq. 5})$$

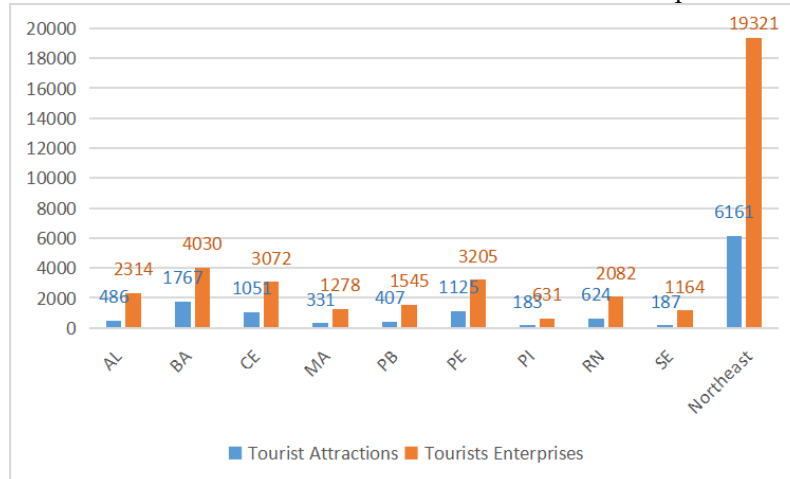
Where:  $Z_0$  = estimation of the  $Z$  value at point  $0$ , with location  $x, y$ ;  $z_i$  = sampled value of  $z$  at point  $i$ ;  $d_{ij}$  = Euclidean distance between point  $0$  (estimated) and point  $i$  (sampled).

## RESULTS AND DISCUSSION

### *Analysis of tourism supply in the NEB*

The data on tourism enterprises (Cadastur) were highly correlated with the collaborative data on tourist attractions (Tripadvisor) in the NEB states, reaching  $r = 0.9610$ , thus validating the use of official national Cadastur data in this analysis. Initially, 19,786 businesses and 6,161 attractions were counted and located in the federative units to which they are related (Figure 1). Of these, 465 were not related to a municipality.

Figure 1 – Occurrence of tourist attractions and tourism enterprises in the NEB.



Source: BRASIL (s.d.); Tripadvisor (c2021). Organized by the authors (2021).

The theme map of the spatial distribution of tourism enterprises across the NEB (Figure 2) reveals that the municipalities with more than 500 tourism businesses are located along the coast, which, by correlation, concentrates most of the offer of tourism activities (COSTA, 2012). Especially in their interior, the states of Bahia, Piauí, and Maranhão have the largest empty areas of registered tourism enterprises.

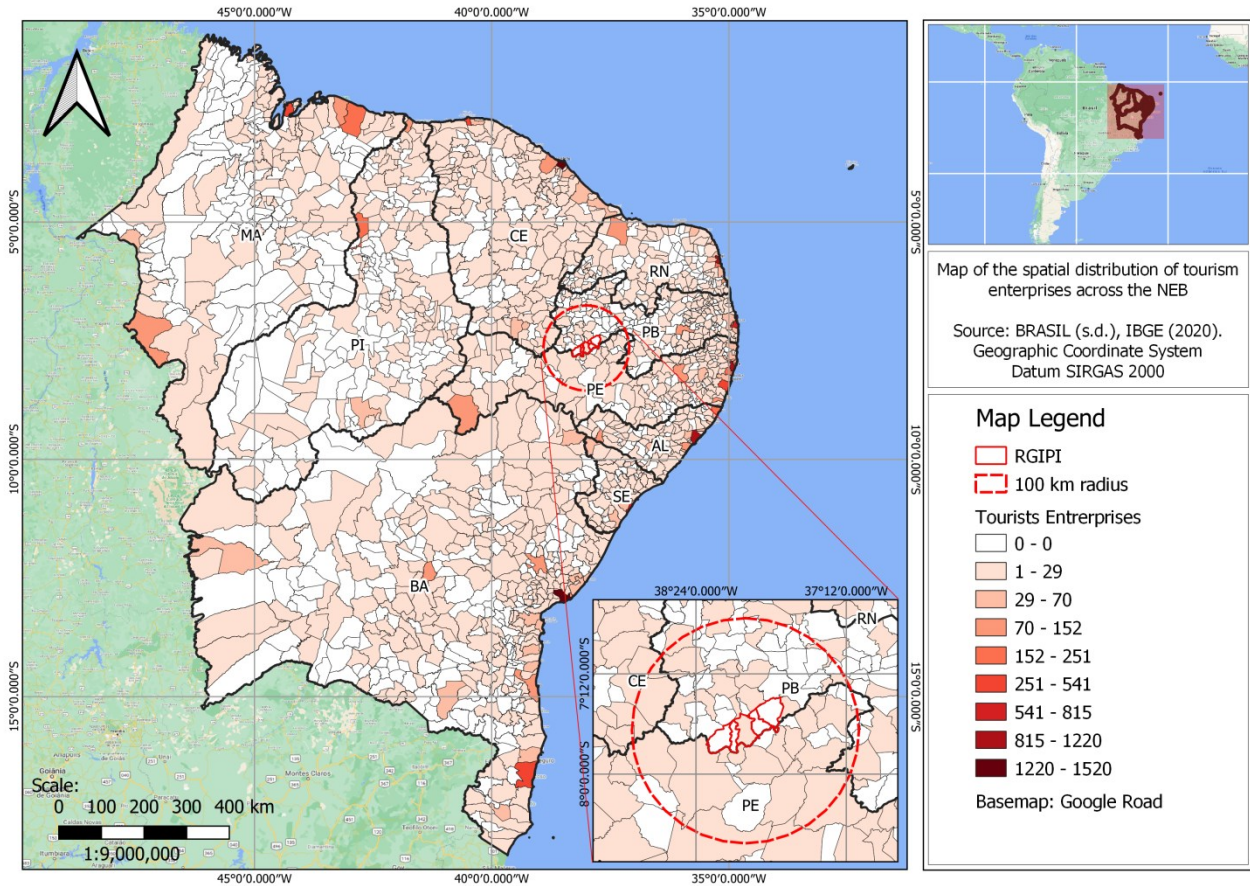
Also, Figure 2 highlights the predominance of ‘empty’ categories in the RGIPI and only one hosting business in Princesa Isabel,

underestimating the local tourism potential. This scenario makes evident the scarce support infrastructure and tourism services in the region.

Of the 1,794 northeastern municipalities, 774 do not have tourism businesses registered with Cadastur; 268 have only one; 182 have two; 85 have three; 78 have four, and 51 have five enterprises. These correspond to 37% of the total, implying many municipalities with little or no tourism activity under development.



Figure 2 - Distribution of tourism enterprises in the NEB and Immediate Geographic Region of Princesa Isabel.



Fonte: BRASIL (s.d.); IBGE (c2017); Organized by the authors (2021).

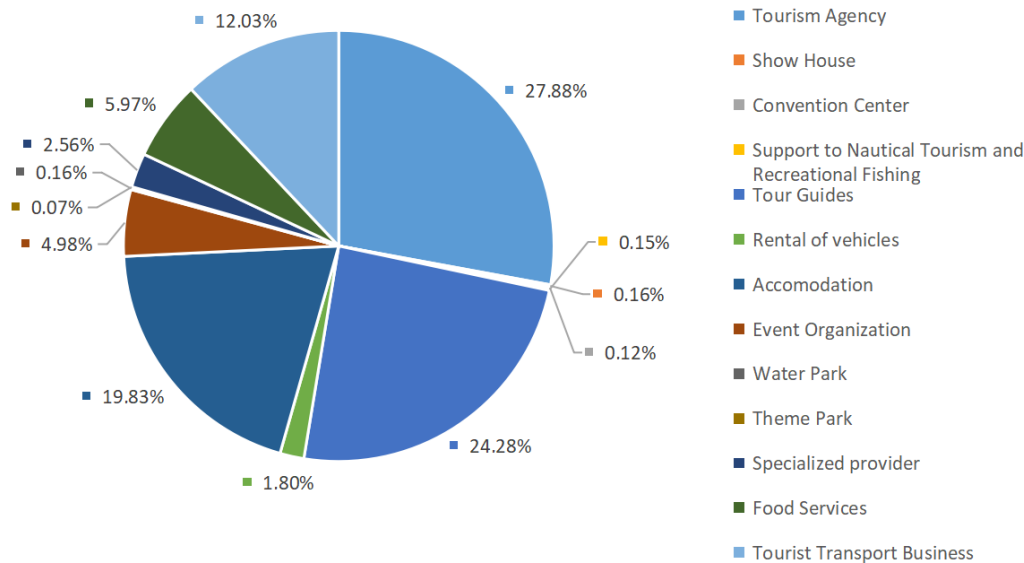
A total of 19,321 businesses associated with at least one northeastern municipality were identified, with an average of approximately 11 businesses per municipality and a standard deviation of 75.3 businesses, indicating a highly unequal spatial distribution of tourism activities across the NEB and, consequently, in the production of space. The capitals were the largest suppliers of tourism services, led by Fortaleza, with 1,520 businesses.

The state of Bahia encompasses 21% of these businesses, followed by Pernambuco (17%) and Ceará (16%). As to the mean of tourism

establishments, the states with the largest commercial support structures were Alagoas (22.7), Pernambuco (17.3), and Ceará (16.7). The standard deviation for these means also indicates an unequal spatial distribution in the states, concentrating in the capitals.

According to the occurrence of tourism services in the NEB (Figure 3), most services are offered by tourism agencies, tour guides, accommodation, and tourist transport businesses, meeting an elementary social demand for space consumption.

Figure 3 – Occurrence of tourism services offered in the NEB.



Source: BRASIL (s.d). Organized by the authors (2021).

There is also a diversity in tourism supply caused by local vocations, which, depending on the constitution of the space, require the existence of specific infrastructures, such as water parks and support to nautical tourism and recreational fishing in coastal municipalities or those with water resources used for these purposes.

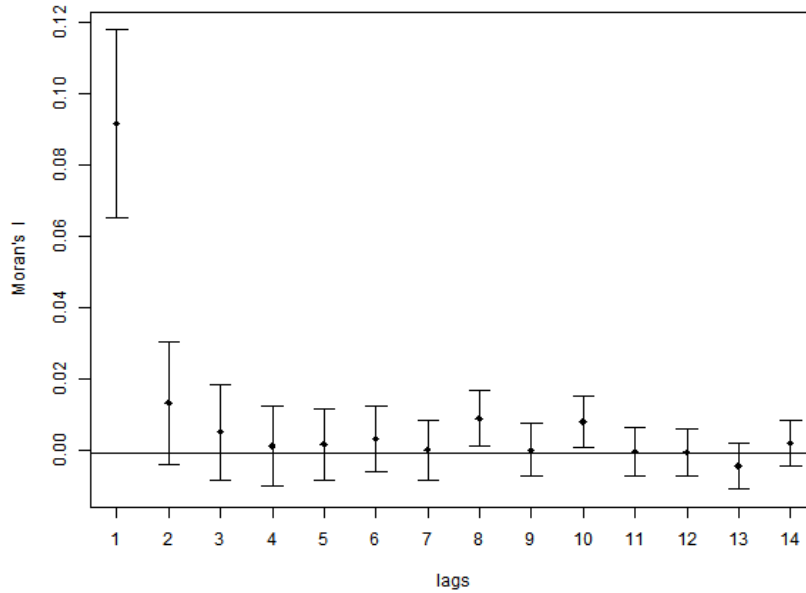
The graph shown in Figure 3 depicts tourism in the last trimester of 2019 in the NEB and summarizes the historical evolution of the construction of tourism spaces in the region. From this perspective, Muniz and Castro (2018) used the municipality of Carolina (MA) to demonstrate that the local historical context contains variables that allow understanding the timing and directions of space production. Under the dominant market logic, there is a provocation for socioeconomic movement and environmental exploitation – through the creation and maintenance of businesses, jobs, and income, and motivated by the competition in the offer but also by practical routes of natural tourism –, developing fixed elements and local flows and contributing, depending on their constitution, to tourism development in the space.

State support is also important in this process in order to boost the production of spaces, such as Prodetur/NE, a program that invests in the infrastructure, management promotion, advertising of locations, and environmental conservation, although developing the regions unevenly (ALMADA, 2020; SILVA *et al.*, 2021).

### *Spatial Autocorrelation and Contiguity of Tourism Enterprises in the NEB*

The spatial autocorrelation of tourism enterprises (Global I index) was  $I = 0.0916$  and  $p = 1.2e-12$ , suggesting the absence of contiguity in the tourism supply, confirmed by statistical significance. The correlogram of the variable *tourism businesses in the NEB* (Figure 4) highlighted that the Global I index values were close to 0 and were stationary from *lag 2*. *Lag 1* showed the highest spatial contiguity (which is already low), followed by a very close permanence around 0. That is, spatial independence stabilizes with increasing distance.

Figure 4 – Correlogram of officially registered tourism businesses.

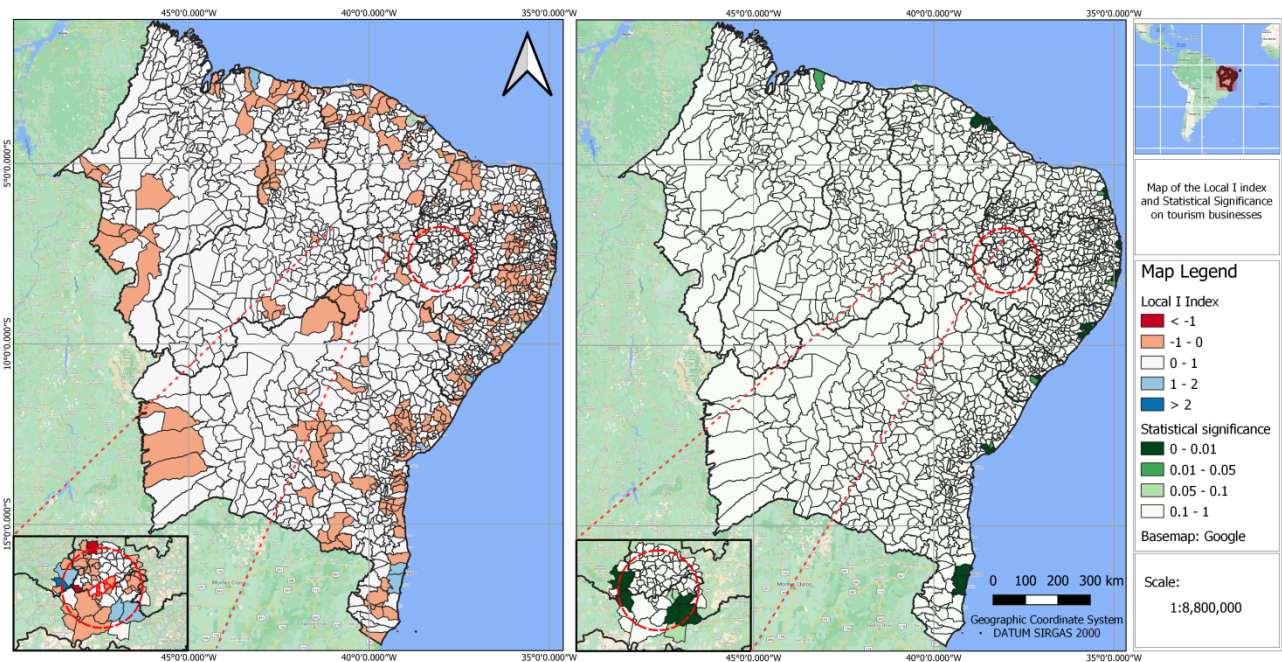


Source: The authors (2021).

In turn, Local Moran's I index in the entire NEB was between -1 and 0 in most NEB municipalities, or close to the spatial independence of tourism activities in relation to

their neighbors (FERREIRA, 2014). The highest Local I values, above 1 (contiguity of tourism supply), were located along the NEB coast and confirmed by the p-value (Figure 5).

Figure 5 – Map of the Local I index and Statistical Significance on tourism businesses in the NEB and RGIPI.



Source: The authors (2021).

In RGIPI, the Local I index highlights the existence of two clusters with spatial contiguity (blue colors), with relevant statistical significance (Figure 5). It is worth noting that this geographic section considered municipalities distant up to 100 km from the

RGIPI and produced a different result when all northeastern municipalities were included.

In most of the northeastern territory, especially in the interior and the RGIPI, there is no relevant continuous supply of tourism activities but rather a few and small spatial contiguity zones of that supply. This

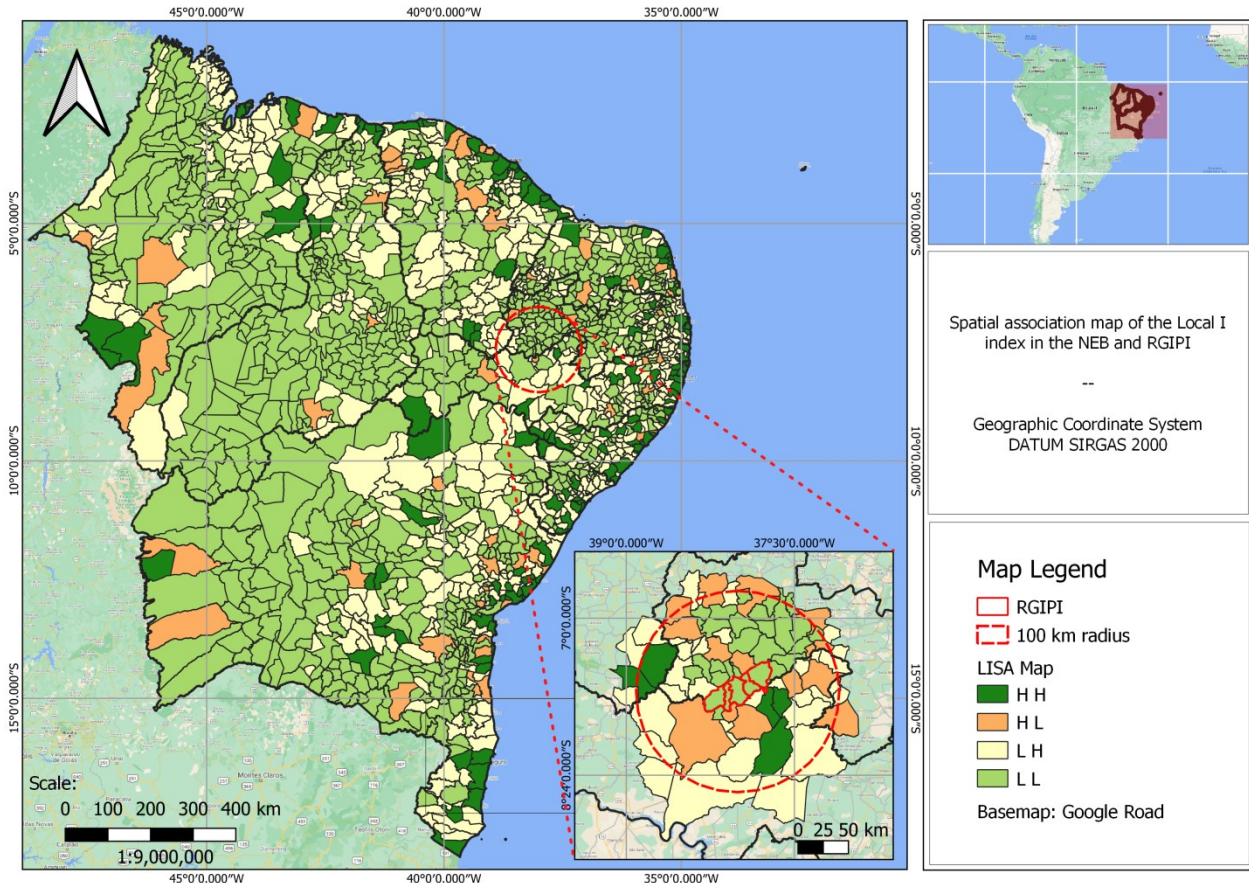


demonstrates that, although geographically dispersed, local tourism exists, suggesting zonal integration and tourism expansion possibilities into adjacent municipalities and highlighting the importance of analysis on global and local scales (RIVERO, 2008).

The spatial association map of the Local I index (LISA) on tourism businesses in the NEB

and RGIPI allowed identifying tourism clusters/zones where similarity indicator classes are shown for each municipality (*High-High*, HH; *High-Low*, HL; *Low-High*, LH; *Low-Low*, LL) (Figure 6).

Figure 6 – Spatial association map of the Local I index in the NEB and RGIPI.



Source: The authors (2021).

The LL indicator has perceptible clusters distributed in the interior of the NEB, implying similarity and contiguity for little or no tourism infrastructure. In these clusters, tourism infrastructure is small and lower than the global average.

By observing the RGIPI, the LL indicator highlights the clustering of 31 municipalities, while five municipalities form two zones of the HH indicator, precisely those with more tourist businesses than the global average, suggesting an expansion potential for tourism activities.

The occurrence of the HL and LH indicators implies the absence of contiguity, dissimilarity of values, and isolation or concentration of tourism activities in specific locations, without their propagation. In practice, it is a geographic

indicator of visitation restriction since there is no tourism offer in neighboring locations.

Despite this indication, the dissemination of tourism activities into neighboring municipalities strongly depends on public investments, especially to improve the physical infrastructure, the management for the promotion of tourism activities, and clear criteria for the spatial distribution of financial resources (SILVA *et al.*, 2021).

### Index “a” analysis

Based on the index “a”, a list with 16,146 interaction possibilities was produced by considering the capitals as the only tourist-issuing units. The index “a” highlighted the higher probability of tourist reception in the

capitals, more structured for tourism, more populous, and with higher *per capita* income, even surpassing the distance parameter between the destination and origin in many interactions.

The “*a*” index surely does not fulfill the highlighted probabilities, but it is an important

source of information for tourism planning in the destination. The ten highest values of *a* occurred between the municipalities listed in Table 1

**Table 1-** Probability of interaction index (*a*) between NEB municipalities.

| Origin (i)  | Destination (j) | $d_{i,j}$ (km) | $\lambda$ | “ <i>a</i> ” |
|-------------|-----------------|----------------|-----------|--------------|
| Recife      | Fortaleza       | 634.854409     | 0.000566  | 1514.456193  |
| Natal       | Fortaleza       | 434.706683     | 0.000636  | 1514.132011  |
| João Pessoa | Fortaleza       | 562.659225     | 0.000639  | 1513.854405  |
| Aracaju     | Fortaleza       | 817.867053     | 0.000617  | 1513.713823  |
| Salvador    | Fortaleza       | 1034.332610    | 0.000624  | 1513.429706  |
| Teresina    | Fortaleza       | 493.156586     | 0.000699  | 1513.416848  |
| São Luís    | Fortaleza       | 649.119053     | 0.000693  | 1513.188526  |
| Maceió      | Fortaleza       | 734.968633     | 0.000694  | 1513.052498  |
| Aracaju     | Salvador        | 284.137721     | 0.000573  | 1374.537068  |
| Recife      | Salvador        | 681.475369     | 0.000528  | 1374.249504  |

Source: The authors (2021).

The 20 municipalities most likely to receive tourists, starting with northeastern capitals, are: Fortaleza (CE), Salvador (BA), Maceió (AL), Recife (PE), Natal (RN), João Pessoa (PB), Aracaju (SE), Porto Seguro (BA), São Luís (MA), Jijoca de Jericoacoara (CE), Ipojuca (PE), Parnamirim (RN), Jaboatão dos Guararapes (PE), Teresina (PI), Olinda (PE), Maragogi (AL), Barreirinhas (MA), Campina Grande (PB), Feira de Santana (BA), and Santo Amaro do Maranhão (MA). Locations nationally known for their tourist attractiveness, such as Tibau do

Sul (RN), Lençóis (BA), Ilhéus (BA), Tamandaré (PE), and Marechal Deodoro (AL) ranked among the 30 municipalities most likely to receive tourists from the capitals.

When applying the case of the RGIPI to a 100 km radius from its surroundings – considering that longer distances would make the destination less attractive -, the highest probabilities of interaction occurred between nearby municipalities. A total of 340 results were obtained, of which the ten highest are shown in Table 2.

**Table 2 –** Ten highest probabilities of interaction from the RGIPI to other municipalities located up to 100 km away.

| Origin (i)           | Destination (j)       | $d_{i,j}$ (km) | $\Lambda$ | “ <i>a</i> ” |
|----------------------|-----------------------|----------------|-----------|--------------|
| Princesa Isabel      | Triunfo               | 16.612283      | 0.147630  | 9.906459     |
| Princesa Isabel      | Afogados da Ingazeira | 39.660159      | 0.152688  | 9.691682     |
| Tavares              | Afogados da Ingazeira | 29.603369      | 0.166386  | 9.674694     |
| Juru                 | Afogados da Ingazeira | 31.244166      | 0.167247  | 9.559873     |
| Manaíra              | Triunfo               | 14.959683      | 0.167999  | 9.521485     |
| São José de Princesa | Afogados da Ingazeira | 51.335010      | 0.170083  | 8.700344     |
| Tavares              | Triunfo               | 33.449423      | 0.160398  | 8.542422     |
| Manaíra              | Afogados da Ingazeira | 57.578772      | 0.174580  | 8.378035     |
| Juru                 | Triunfo               | 46.003548      | 0.161198  | 8.091911     |
| Princesa Isabel      | Serra Talhada         | 43.993334      | 0.149898  | 5.103889     |

Source: The authors (2021).

The municipality of Afogados da Ingazeira (PE) frequently appears in the list of the highest interactions even though it is neither the most populous municipality nor the one with the highest *per capita* income within the 100 km radius. However, it encompasses the highest number of tourism businesses, followed by Triunfo (PE) (the closest), Serra Talhada (PE)

(the most populous and with the highest *per capita* income), Mauriti (CE), and Itaporanga (PB).

When analyzing the  $\lambda$  parameter, whose lower values imply a greater weight for the tourist flow, it is seen that the Princesa Isabel-Triunfo, Princesa Isabel-Serra Talhada, and Princesa Isabel-Afogados da Ingazeira

interactions are the most likely for tourism. However, for non-tourism purposes (trade, search for medical services, and others), a spatial interaction constant between Princesa Isabel and Serra Talhada can be locally observed.

These results show considerable differences between the index “a” values for a region with undeveloped municipalities and the northeastern capitals. This fact is historically grounded on state interventions for tourism development in the Northeast region since the 1970s, particularly with polarization policies and tourism induction, which prioritized some zones to the detriment of others (DUDA; ARAUJO, 2014).

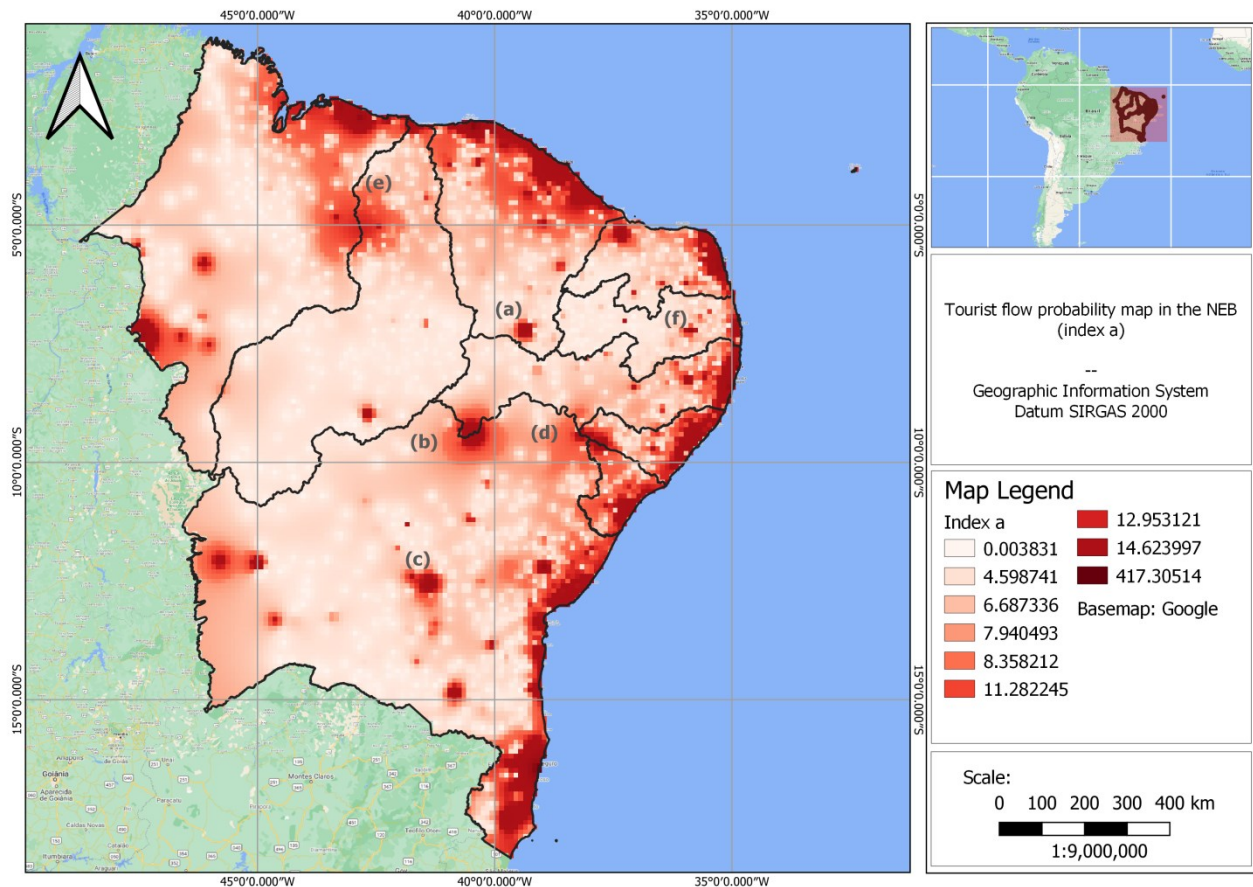
**Identification of tourism zones through the spatial interpolation of the Index “a”**

The tourist flow probability map in the NEB (Figure 7) was obtained by applying the IDW to the index “a” values, and its purpose was to represent the probability of a location receiving tourists. Thus, warm colors identify tourism zones in the NEB, corresponding to those that

actually exist and validating the index “a”, such as the coastal area of the NEB, historically favored by tourism development policies (DUDA; ARAUJO, 2014).

The highlights of the interior of the NEB are in the Cariri region of Ceará, encompassing the municipalities of Crato, Juazeiro do Norte, and Barbalha (Figure 7a); in Bahia, on the border with Pernambuco, where Juazeiro (BA) and Petrolina (PE) are located (Figure 7b), and also in the Chapada Diamantina region, highlighted by the municipality of Lençóis (Figure 7c). On the border between Alagoas and Sergipe, the municipality of Paulo Afonso (BA), cut by the São Francisco river and the location of one of the largest hydroelectric plants in the country is a well-established tourist destination, as well as Piranhas (AL) and Canindé do São Francisco (SE) (Figure 7d); in Piauí, it is the region around the capital, Teresina (Figure 7e); and in the Agreste region of Paraíba, it is the municipality of Campina Grande (Figure 7f), which hosts large Festas Juninas, wich are typical and traditional festivities occurring in the northeast region.

Figure 7 - Tourist flow probability map in the NEB (index “a”)



Source: The authors (2021).



The zones identified are dispersed in space (absence of spatial autocorrelation), except for the coastal strip, which is continuous. Moreover, there is only one zone in the interior of the continent connected to the coastal strip (Figure 7e), between Teresina and the coast of Maranhão, featuring as the only territorial extension of the NEB between the coast and the interior with a high tourist flow, which is little, given the vastness of the region, and highlighting the poor use of the tourist potential.

## FINAL CONSIDERATIONS

Geotechnologies play a key role in tourism, while a spatial phenomenon that encompasses society and environment and subsidizes decision-making. Geospatial analysis revealed spatial patterns that are intrinsic to tourism development.

The variables used in this study were sufficient to diagnose the status of tourism in the Northeast territory of Brazil, especially in the interior of the continent, revealing the lack of investments and the uneven tourist supply concentrated in the capitals.

Also, the geospatial tourism analysis of the NEB showed that there is space to mitigate severe regional inequality situations in tourism supply given the possibility for its expansion. However, it is necessary to reconfigure incentive policies as tourist flows converge to wealthier municipalities, historically favored by public policies.

Based on the scarcity of public actions and data, the lack of standardization for registration rules, and the inexistence of systematic tourism mapping, the deficiencies identified are due to the lack, in all spheres, of governmental support for developing tourism in municipalities with this potential and disseminating the tourism zones identified in this study. These factors hinder a detailed study, but the data and methods employed provided information of interest to local tourism development.

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## AUTHORS' CONTRIBUTION

Erickson Melo de Albuquerque guided the adopted methodology, idealizing the exploration of geospatial analysis techniques and tools, as well as collaborated in the writing and revision of the text. Eduardo Rodrigues Viana de Lima analyzed and selected the techniques and tools suitable for the study, acquired the data used and started writing the text.



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