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Proposal for Urban Sub-centers identification based on the Spatial Distribution of Functions. Case of Maputo City – Mozambique

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Abstract

This study presents a methodological proposal for identification of new urban functional centralities based on data from the points of interest of Open Street Map platform. On the other hand, data collected through fieldwork interviews were also used for the study and complemented with Google Earth imagery. Points of interest data were classified according to pre-defined criteria representing urban features. Each criterion was assigned a weight. The criteria weights were calculated based on the Analytical Hierarchical Process (AHP) method. For this purpose, interviews were carried out with specialists and individuals with greater experience of living in the study area, based on their perception regarding to the distribution of urban functionalities. The results of interviews were introduced in matrices that allowed the calculation of weights for each criterion. In addition, points of interest data were edited and processed through ArcGis application, in which a map was produced showing the spatial distribution of the points of interest and the respective levels of centrality. Therefore, it was possible to identify from this study some points of concentration outside the historic center of the Maputo city, which show evidence of emergence of new functional centralities as a result of implementation of new urban infrastructure in the non-central area, mainly related to commerce and services provision.

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INTRODUCTION

Studies on the distribution of urban centralities are of great importance in urban planning, especially in urban mobility. The location of the distribution of urban centers plays an important role as far as it reduces distribution costs, environmental impacts and traffic congestion in cities (SOPHA et al., 2016). Cities are living systems, made, transformed and experienced by people (CASTELLS, 1983). Looking at the inner space of the city, it should be noted that studies on its structure and functions are extremely important because they allow for better planning and management of urban space.

Urban space is characterized by a central place where most people converge, concentrating most of the goods and services in relation to the rest of the area. Center is the place where the main commercial activities, services, public and private management, transport terminals are concentrated and characterized by an intense vertical construction (CASTELLS, 1983). What defines a centrality is the movement along the roads, that is, the continuous circulation of

consumers, workers, automobiles, goods, information and ideas (MILANI AND SILVA, 2009). There should be stressed the importance of realizing that the intensity of that movement or flow depends on the importance of a given location and its ability to attract more people. Hence, it makes sense to analyze the centrality from the point of view of the functions of these places.

One of the most important steps to be taken into account in the analysis of urban spatial structure is the identification of its centralities (YU et al., 2020). The identification of centralities has been addressed in several studies. In a first phase, such studies used mainly population and employment data and, over time, studies on centralities incorporated several other elements.

It should be noted that the process of the emergence of new centralities in the urban space is a consequence of the growth of the city, both in demographic and spatial terms. In this process, new dynamics are promoted, such as the emergence of large commercial and service areas in the non-central areas (FERREIRA, 2018).

Several studies on the identification of new centralities have been conducted using different methodologies and data (chart 1).

Chart 1 - Studies conducted on urban centrality

Authors	Description
Borgatti (2005)	Centrality study considering the categories of trajectories that traffic can follow and the propagation method.
Hellrvik et al. (2019)	Proposal for a methodology that integrates activities, attraction and accessibility, which was called preferential centrality.
Porta et al. (2006)	Methodology for the analysis of geographic networks based on the assessment of multiple centrality on the basis of street graphs, with a metric and non-topological structure, investigating the plurality of centrality indexes between peers.
Santos et al. (2019)	Use of Delphi, AHP technique with the application of the gravitational model to identify likely new centers through a multi-criteria analysis in Rio Grande do Sul, Brazil.
Sevtsuk e Mekonnen (2012)	Analysis of an open source urban network for ArcGis, which calculates five centrality measures, namely, the range, severity index, entanglement, proximity and straightness.
Siqueira (2014)	Identification of sub-centers based on the establishment of cut-off values, econometric estimates and exploratory analysis of spatial data where two parameters are used, namely, the total number of workers and the density of employment.
Yu (2020)	Analysis of the centrality from the point of view of distribution of the urban function having used three layers, namely: data of points of interest, distance, functions and the spatial distribution of urban centers.
Zong et al. (2015)	Identification of changes in the spatial structure of cities, for the development and validation of appropriate planning strategies, where they propose a simple centrality index that can be applied on a large scale on human activities, identifying centers, establishing functional links in space and identifying structural changes in the urban space based on information about human activities.

Source: The Author

As can be seen, studies on urban centralities present several methodologies, with its strengths and weaknesses. In general, one of the greatest challenges in this type of study is the availability of data, mainly in developing countries which still do not have institutions dedicated to collection and structured storage of this type of data.

The present study is a proposal to identify new possible centralities in Maputo city, Mozambique, within the constraints of data availability. For this purpose, it is adopted a methodology that uses the data provided by the Open Street Maps platform as an information base. This platform provides a valuable raw geospatial database from collective sources for the construction of models of urban street networks for scientific analysis. Note that this platform also offers data on points of interest and their features, road network and features in their surroundings, as well as buildings and features (BOEING, 2019).

On this platform, it must be recognized that there are still doubts about its validity. Although there are problems of validity and reliability of information from points of interest, road network and buildings obtained by voluntary geographic information, these data are useful in studies on land use (JIANG et al., 2015). According to these authors, the coverage and accuracy of this information depends heavily on public online sources. In this way, information about the points of interest was considered, as it reflects the actual use of each location. Data on points of interest have information in the level of subplots, available from online suppliers, with almost global coverage, with high spatial resolutions and in most cases available free of charge (LONG AND LIU, 2015).

However, in studies of urban centralities using points of interest, it is important that elements that perform different urban functions be assigned different weights, taking into account that they attract people with distinct intensities. Unweighted representations in urban networks strictly limit the analysis, ignoring all information about the activities carried out at points of interest (SEVTSUK and MEKONNEN, 2012).

For the assignment of weights to different functionalities of the points of interest, the multi-criteria method and hierarchical analysis process were applied. It is one of the most inclusive systems considered to make decisions with several criteria and assumes a problem in a hierarchical

way (TAHERDOOST, 2017). This method made it possible to compare the decision factors in a paired way, which culminated in the allocation of the weights of each type of urban functionality.

STUDY AREA

Maputo city, before known as Lourenço Marques, is the capital of the Republic of Mozambique and the largest city of the country, located in its extreme south, at 25 ° 58 'S 32 ° 35' E, on the bank of Maputo Bay. It borders the district of Marracuene to the north, the municipality of Matola to the west and northwest, the district of Boane to the west, the Indian Ocean to the east and the district of Matutuine to the south. The city, over time, went through a process of expansion of the urban spot, originating processes of urban conurbation with the municipality of Matola to the west and the district of Marracuene to the north. However, for the present study, a cut was made (figure 1) representing the study area that represents the main and continuous region of the city.

The city has a total area of 346 km² and is located in a southern temperate zone between the tropic of Capricorn and the Antarctic polar circle. Due to its location, it suffers from the effects of sea currents, causing rains to occur with good regularity, during all months of the year. It is located in a coastal position and at the bottom of an estuary on the western bank of Maputo Bay, a privileged position for trade, transport, fishing and leisure. The urban site has a relief that varies from a coastal plain to the east, at low altitude, ending in steep forms that develop in the north-south direction leading to a higher plain, culminating in a promontory.

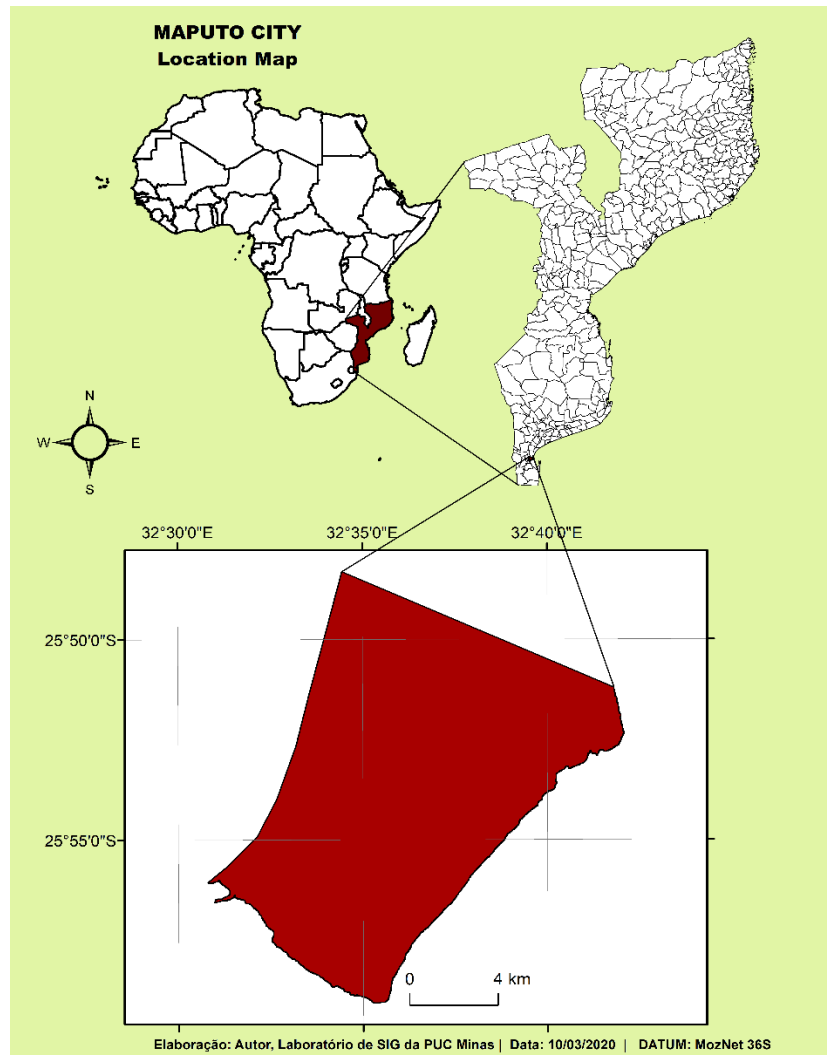
Historically, Mozambican urbanization emerged within the colonial matrix, that is, with access to resources and ports for export. Thus, there is a long history of urban settlement with coastal villages developed by Arabs, Indians and, later, Portuguese traders, who exported mainly gold, ivory and slaves.

Likewise, the origin of the Maputo city is associated with a port area that served as a point of disposal of natural resources and connection with the hinterland. This role is still notorious today within the network of cities in the Southern

African region, serving as an outlet for cities in South Africa and Swaziland. This area is going through a process of centralization of the central area, characterized by the construction of large shopping centers, public and private buildings for

the provision of services, commerce and housing. It is the area of greater daytime concentration of people with a wide vertical scale.

Figure 1 - Study area



Source: The Author

The history of occupation of the city of Maputo can be analyzed in two moments, namely, its genesis in 1781 in the colonial period with the creation of a prison and the period after the country's independence. The city under the Portuguese colonization was constituted as an administrative center with a centrality that sustained the conquest and territorial control in function of the domination strategies that aimed at guaranteeing capital accumulation by the metropolis, within the framework of a mercantile

economy, but with a racial component based on the exclusion of the African population and served as a place of production and export of raw material to the colonizing countries (BAIA, 2001).

The urban pattern is characterized by:

[...] A regular geometric layout adapted to the topography, but not rationalized; the urban prominence of the street, in which the widest main roads are located parallel to the coast, drawing a structure of linear blocks, with a street on both sides, identical to those

of the medieval period; the existence of a structuring square of a more Renaissance nature, articulating the paths and the access of the sand tongue to the continental margin, where the priority equipment is located, presenting a constancy and spatial interaction; the hierarchical space and the morphological independence in relation to the walled siege” (ROSSA, 2002; TEIXEIRA AND VALLA, 1999 APUD MELO 2017).

Also, in the colonial period, when the city was considered the capital of the Overseas Province of Mozambique, urban development emerged through situations created by the industrial revolution with a strong urban growth generated by the large influx of population mostly from rural areas, the introduction of new functionalities and sanitation needs and the provision of adequate infrastructure (MELO, 2017).

In this period, the dynamics of land occupation followed a pattern of Portuguese urbanism in which urban functions were distributed in accordance with the elevation quotas. Regarding this dynamic (MELO, 2017) makes the following description:

Between 1900 and 1940, the city grows to the north and west in a phased manner, following several expansion projects that reflect the same urbanistic principles, the consolidation of public structures, purely residential areas, accentuating the separation between different land uses, which refers to another characteristic of Portuguese urbanism, namely a different occupation according to elevation levels: the upper, cooler and more airy city, destined to administrative buildings, to the main civic and religious institutions and to the residences of the upper classes; and the lower city, destined to maritime activities, services and commerce, as well as to the lower classes, next to the port and places of employment (MENDES, 1985; MORAIS, 2001; TEIXEIRA AND VALLA, 1999 APUD MELO, 2017).

In the post-colonial period, the occupation was marked by structural measures such as the participation of private investors, national and international, an increasing pressure on the urban center. This situation exerted an increasing real estate pressure on the closest semi-urbanized areas and also in the most remote ones with the construction of administrative buildings, residential services for the middle and upper classes, which may involve gentrification

processes, the construction of housing subsidized by the state, the formulation of urban projects, the implementation of large commercial areas, equipment and road infrastructures (MELO, 2017).

Currently, the historic center is characterized by the emergence of new private (headquarters of banking institutions, shopping centers) and public (ministerial and administration of justice) buildings. These buildings were generally set up in areas that had not been occupied in the colonial period, with greater declivity or with high water table. This process broke with the Portuguese urbanism principle of adaptation to the topography and respect for the natural conditions of each location (MELO, 2017).

Thus, the current situation of urbanization in Maputo city results from the sum of the urban and post-colonial colonial processes that make up multiple parts framed in an urban mosaic of intricate geometry that consists of two realities (“cement zone” and “cane zone”), which constitute two realities that tend to fade as they progress, overlapping and juxtaposing themselves with other realities that have been taking shape and expression in the urban space (MALOA AND NASCIMENTO JÚNIOR, 2018).

The denominations “cement zone” and “cane zone” are the terms used to refer to two areas that represent the dichotomy that characterizes urbanization in the Maputo city. The first that is also called urban area obeys an orthogonal plan with paved road network, basic sanitation services, water supply networks, electricity and telecommunications, vertical constructions, in general, concentration of trade, services and some industries (ARAÚJO, 2003). The second area called suburban is characterized by unplanned neighborhoods and undifferentiated or anarchic plant, high density of land occupation, circulation difficulty, lack of service area, horizontal construction, non-existent sanitation services, deficient water supply network, electricity and telecommunications.

METHODOLOGY

In general terms, the present study had as methodological basis, the bibliographic reading, the processing of data related to the points of interest provided by the Open Street Maps

platform, the analysis of Google Earth images and fieldwork.

For the proposed study, two data sources were used. One of secondary data obtained from a raster database obtained on the Open Street Map platform (2020) and another of primary data through a survey. Open Street Map is a free and editable platform from around the world that is being built by volunteers who collect information while driving, cycling or walking the streets and paths, and around the areas that record all their movements using Global Positioning System (GPS) receivers. This information is used to create a set of points and lines that can be transformed into maps or used for navigation. In the case of the present study, the data layer used was related to points of interest that have information on the spatial distribution of urban functions.

The results of the interviews served to assign relative importance to the criteria, which allowed us to calculate the weights for the factors used to

identify probable new functional centralities in the city.

The data related to the map of points of interest were pre-analyzed, enabling the correction and editing of missing information. Through the information collected in fieldwork it was possible to compare with the constant in the points of interest. In cases where this information was not included, the raster data was edited. It was necessary to edit the data of the layers in order to introduce the weight variable that was used for the preparation of the maps. However, the values of the weights for each criterion were calculated based on the AHP method, where the results of the interviews were used.

The implementation of the interviews followed an intentional sampling, as the choice of respondents depended on the researcher's judgment.

For the study, the following criteria were considered (chart 2) for the analysis of functional centrality in the area under study.

Chart 2 - Description of the criteria

Place	Description
Public Administration	Public departments and urban service provision equipment.
Commercial	Market, shopping center, store, services.
Educational	Universities, colleges, schools at different levels, research institutions.
Financial	Banks, exchange offices and ATMs.
Industrial	Industries, automakers.
Recreation	Stadium, swimming pool, museum, gym, church, zoo, cinema, squares, etc.
Residential	Places of residence.
Restauration	Restaurants, cafes, bars, etc.
Health	Hospitals and clinics.
Transportation	Railway station (subway station), stop for public passenger transport, airports and ports.

Source: The Author

Given the need to assign the level of importance to each criterion, scales were used according to chart 3.

Chart 3 - Description of the scales

Importance scale	Description
1	Both places concentrate people to the same extent.
3	One of the locations concentrates people a little more than the other.
5	One location moderately concentrates more people than the other.
7	One of the locations intensely concentrates people than the other.
9	One of the locations concentrates very intensely people than the other.

Source: Adapted from (Taherdoost, 2017)

After applying the AHP method, the weights of each criterion were found. The results are shown in table 1.

Table 1 - Weights and criterion

CRITERION	WEIGHT
Commerce	0.4253
Public Services	0.1948
Banking Services	0.1097
Education	0.0987
Health Services	0.0714
Restauration	0.0444
Recreation	0.0282
Residential	0.0275

Source: The Author

To calculate the consistency of the results of the weights found, the values of the random index were used according to table 2. According to the Saaty's scale, the maximum allowed inconsistency for the square matrix of order 8 is 1.41. This value is used to calculate the consistency, which in this case was less than 0.1, thus satisfying the consistency requirements.

Table 2 - AHP Average Random Index

Matrix order	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	0.12	1.24	1.32	1.41	1.45	1.49

Source: (SAATY, 1987).

The fieldwork (based on the author's experience in the study area) was important in order to confirm or identify and characterize some features in points of interest where this information is doubtful or non-existent. It also served as a basis for the theoretical approach on spatial processes and forms in the study area.

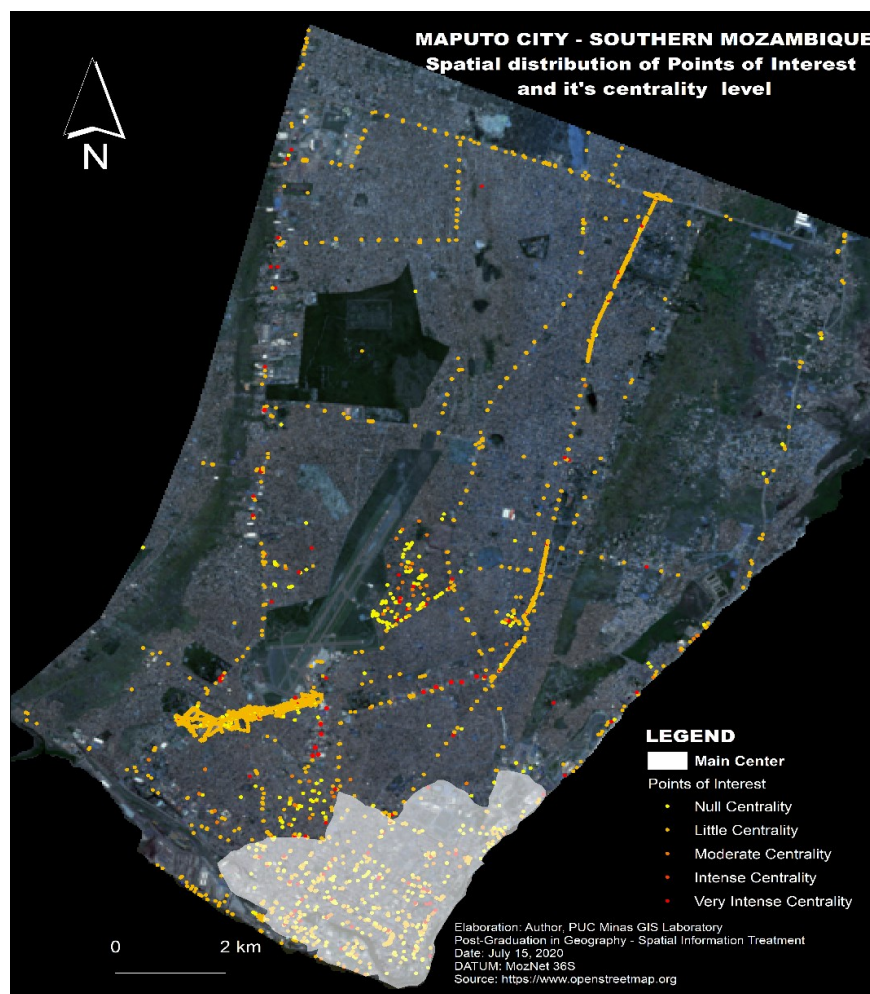
Therefore, the raster containing information about the points of interest was edited using the ArcGis tool in order to add a field that represents the weight of each criterion. After editing, the raster file was processed. The processing consisted of classifying the points of interest-based on the weights whose values were previously calculated (see table 1).

RESULTS AND DISCUSSION

The results to be discussed in the present study are related to the processing of data related to points of interest in the ArcGis application, fieldwork and observation of images via Google Earth.

Figure 2 illustrates the spatial distribution of the points of greater or lesser attraction in the study area. It is noted that trade, according to the results of the survey carried out, represents the highest level of attraction of people and consequently with the greatest weight. Therefore, on the map, the places that have the highest intensity of attraction should be understood as places where there is a greater concentration of commercial activities.

Figure 2 - Map of points of interest and their levels of centrality in the Maputo city



Source: The Author

The map shows yellowish dots that represent less concentration or zero and the red dots that represent areas of higher concentration according to the legend. It is possible to notice the appearance of places that concentrate more people outside the main center. However, the main central area remains the one that attracts the most people due to the greatest concentration of services and trade.

Some of these points of interest outside the main center represent areas made up of fuel stations, surrounded by convenience stores, service and commercial establishments. It is notorious the increasingly sharp movement of people in these areas who are benefiting from the services and products that were previously only available in the main center of the city. This phenomenon contributes to the decongestion of the city center and, consequently, the emergence of new functional centralities in the city, facilitating urban mobility.

Another important element that the map illustrates, is the fact that most points of greater concentration that appear on the periphery are

located along the main access roads. New infrastructures whose urban functions generate greater attraction are being set up along these avenues. Factors such as the difficulty of obtaining space in the main center and the existence of unoccupied land in the non-central zone are responsible for the decentralization of urban functionalities in Maputo city. However, trade and service provision are the functions that are registering the greatest decentralization. On the other hand, in recent years, there has been an increasing construction of public and private buildings in the main city center. It is an option that contributes to the greatest congestion in the main central area of the city and contributes negatively to urban mobility.

In the non-central area of Maputo city, there are some areas that play the role of attracting more people, also contributing to the decongestion of the main center. These areas are seen as functional nuclei located along some avenues within the city (figure 3). The main functionalities existing in these new centralities are commerce (retail or wholesale) and provision of services.

Figure 3 - Examples of functional nuclei.



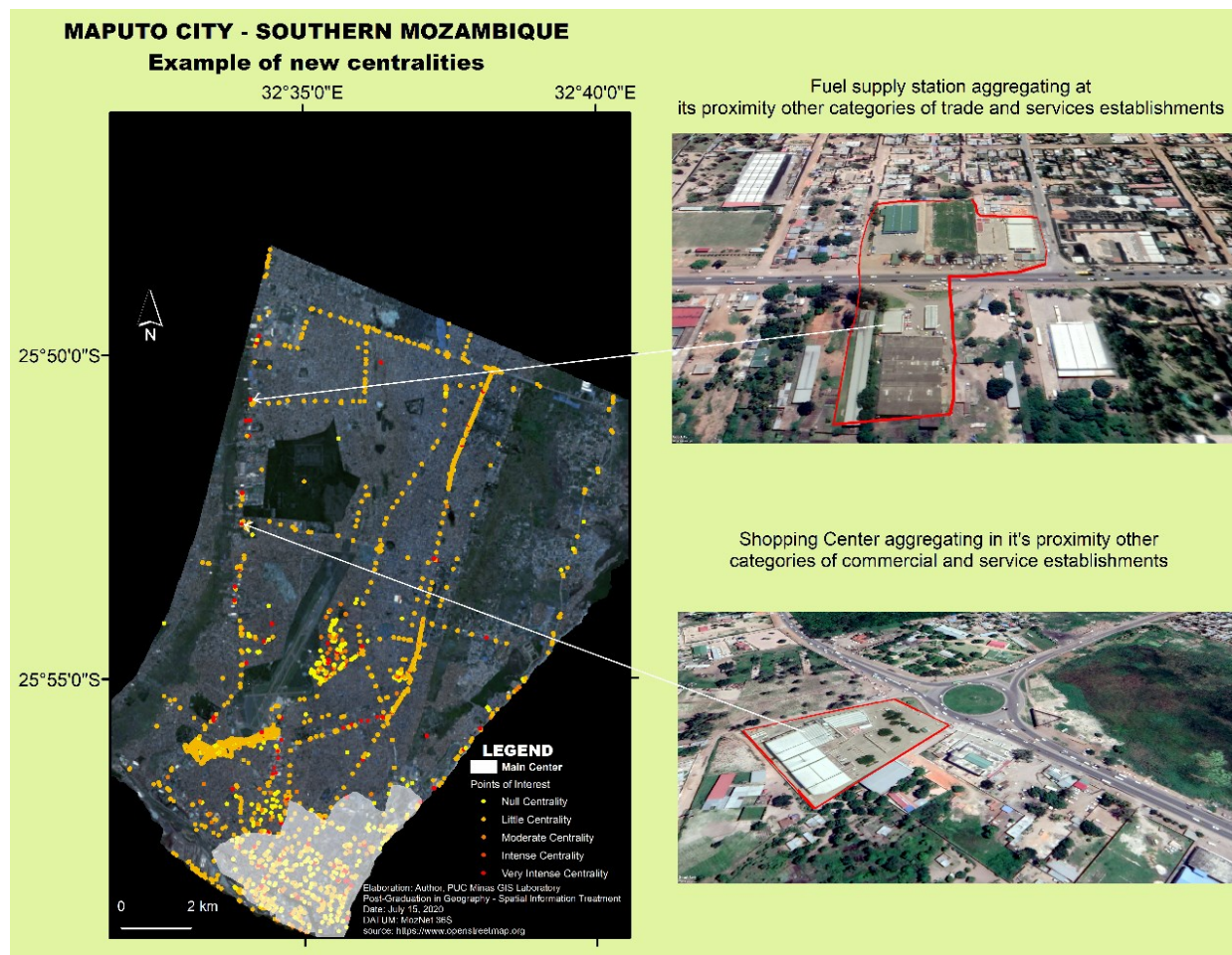
Source: The Author

These centers create a dynamic of concentration within the city, reducing the pressure on the main center as several services and products can already be found in them. This dynamic is called cohesion and the specialized areas (CORRÊA, 1995). For this author, this process is defined as that movement that leads the activities to be located together forming external economies of agglomeration. In this case, according to the author's approach, we are facing a dynamic of functionalities of a different and complementary nature consisting of shopping

centers, manufacturing units, insurance companies, banks, headquarters of industrial companies with links between them, both upstream and downstream, a reality that also contributes to the decongestion of the city center and the emergence of new centralities.

Another scenario that takes place in the city and contributes to the emergence of new centralities is the construction of new shopping centers outside the main center, which are represented by points of intense or very intense centrality as shown in figure 4.

Figure 4 - Example of new centralities



Source: The Author

These shopping centers add in their proximity other categories of commercial establishments and services with functions of a different nature, of the same line or even complementary such as banks, pharmacies, restaurants, pastry shops and other features.

The appearance of these concentration points in the peripheries of the center results mainly from the lack of space in the center, being that they usually occupy unoccupied spaces. It is a process that accompanies the urban implosion resulting from the urban reclassification by

decree, where rural areas have been added to the urban area, with the emergence of new neighborhoods. This decentralization makes the urban space more complex, with several secondary nuclei of activities, which generates savings in transport and for the consumer (CORREA, 1995).

CONCLUSION

One of the biggest challenges in studies of urban centralities is the provision of data that operationalize the proposed methodologies for this type of studies, mainly in developing countries such as Mozambique. This situation makes these types of study scarce or non-existent and, when they exist, are carried out with a limited set of data.

When working with data on urban functionalities, identifying their centralities is an extremely important task as it contributes to decision-making that allows the resolution of certain urban problems such as the high costs of distribution within the urban space and traffic jams.

Urban planning and management policies must take accessibility into account, as they shape the spatial distribution of urban functions. In this way, a balance in urban development is promoted. Thus, studies on urban functions and centralities are necessary to provide information that helps in making better decisions.

The present study analyzed the possible new functional centers that are creating a greater attraction of people based on the available data. The map results show some points of greater concentration in the non-central area, which tend to create new functional centralities within the urban space in the Maputo city.

Thus, the work sought to contribute to another methodological proposal in which it showed the possibility of using Open Street Maps platform data in urban functional centrality studies, as these data are increasingly reliable and comprehensive.

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AUTHORS' CONTRIBUTION

Tomé Francisco Chicombo conceived the study, collected, analyzed the data and wrote the text.



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