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Spatial analysis for prioritizing areas for urban renewal projects in the city of Cali in Colombia

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ABSTRACT

Most traditional downtown areas in large Latin American cities are undergoing processes of physical deterioration and population decline; thus, alternative urban planning solutions are required to address these issues, including urban renewal as a means to enhance, valorize, improve, and integrate consolidated areas of the city through a change in patterns, with a view to promoting mixed-use development and prevent urban sprawl. This paper proposes a spatial analysis methodology for prioritizing areas for urban renewal projects (AEPRU) in the downtown area of Cali, Colombia, using indicators supported by current urban regulations and fieldwork in the selected study area. The results are reported through tables and thematic cartography produced with Geographic Information Systems (GIS) tools.

KEYWORDS: Urban renewal. Spatial analysis. GIS.

1 INTRODUCTION

Most traditional downtown areas in Latin America have been experiencing a decline in population over time, as land use purposes have shifted from residential to commercial and service-oriented ones. Additionally, previous commercial activities and even factories located in these areas have gradually been relocated to other neighborhoods or to the outskirts of cities. This urban phenomenon of desolation and depopulation poses several socio-economic challenges that need to be addressed and resolved by decision-makers through public policies and territorial planning.

As an alternative to reverse this situation, urban renewal can recover and revitalize underutilized areas that have a consolidated urban infrastructure and a strategic geographic location in the downtown area. Managing urban renewal projects, as a public policy, allows for the development of more inclusive cities that can provide better accessibility to general services, which include public spaces, urban mobility, employment opportunities, sanitation systems, infrastructure and public services, among others.

Urban renewal is understood as a process of reusing and occupying land with the aim of improving and enhancing existing urban services in consolidated areas of the city, creating new mixed-use spaces where residential and non-residential uses converge. It is a technique for transforming the existing urban pattern within a particular sector, leveraging the benefits of its location and inherent centralities. Furthermore, it is a method for compacting the city and avoiding urban sprawl (MENDES, 2013, p. 35).

For allocation of Government funds to these urban renewal projects, one needs to recognize the potential of the above-mentioned areas, particularly by identifying those that should be prioritized, not only to balance socio-spatial public interests but also attract real estate investments for the sake of revitalization. Therefore, the objective of this study is to devise a spatial analysis methodology for identifying and prioritizing areas with the highest potential for implementation of urban renewal projects within a central sector of the city of Cali, Colombia.

As part of the methodological procedures, advanced geographic information systems (GIS) technology was used for geographic demarcation and location of the selected areas for the purpose of designing thematic maps that spatially summarize the methodological exercise proposed in this study. These maps can serve as valuable guides for urban planning, as they provide a visual representation of the priority areas and support informed decision-making processes.

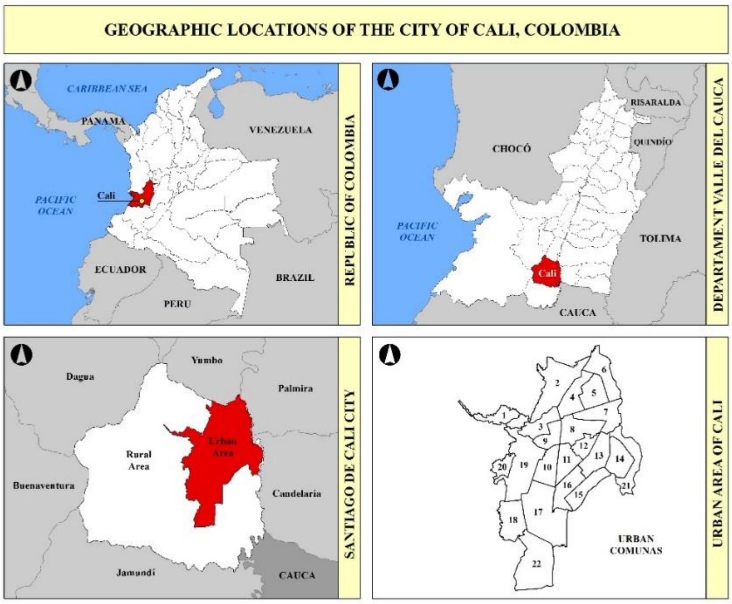
2 THE CITY OF CALI IN COLOMBIA AND ITS URBAN RENEWAL AREAS

The city of Santiago de Cali was officially designated as a Special District for Sports, Culture, Tourism, Business and Services in 2018 (LEY 1933 DE 2018). The current District is the third-largest city in Colombia, forming a triangle, along with Bogotá and Medellín, which concentrates a significant portion of the country's population and economic production. According to DANE (2018), the estimated population for the year 2021 is approximately 2,280,907 inhabitants, with 54% of females and 46% of males. Only 1.5% of the population resides in rural areas while 98.5% lives in urban areas.

Cali is the capital of the Valle del Cauca department and the most important city in the southwest of Colombia; it is located in the geographical valley of the Cauca River (Figure 1), bordered by the Western and Central mountain ranges of the Andes. It has an altitude ranging between 990 and 1,000 meters above sea level and an average temperature of 24°C throughout the year. It is the only major city in Colombia with quick access to the Pacific Ocean, situated 114 km away from Buenaventura, the country's main port (FAJARDO, 2011, p. 27).

Its total surface area is 564 km², 120 km² of which are dedicated to the urban area, accounting for 21% of the territory. The urban area is divided into 249 neighborhoods and 91 urbanizations spread across 22 comunas[1], while the rural area is organized into 15 corregimientos[2].

Figure 1 – Geographic locations of the city of Cali, Colombia



Source: Authors' own data based on POT Cali, 2014

[1] A comuna is the administrative entity of a medium-sized or major city in the country that groups together specific sectors or neighborhoods (DANE, 2018).

[2] A corregimiento is a division of the rural area of a municipality, which includes a population center (DANE, 2018).

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In addition to these divisions, the urban regulations of the city, as outlined in article 301 of the "Plan de Ordenamiento Territorial" (POT) of 2014, define and delimit areas that have similar physical and socioeconomic characteristics. Each area has urban regulations that require differentiated management for different sectors of urban land and urban sprawl. These areas are referred to as *"urban treatments"* and are categorized into four classes: conservation, consolidation, urban renewal, and development (ACUERDO 0373 DE 2014).

Urban renewal projects are exclusively developed within the boundaries defined in the urban renewal treatment 3 (TRU3), as established in the partial plans included in the POT. They are regulatory instruments for intervention in territories where there is a need for a radical change in the occupancy pattern, with a view to interrupting and reversing the process of physical and environmental deterioration of a given area. This way, one can ensure the continued presence of current residents and the participation of property owners, as well as improve and intensively utilize the existing infrastructure or generate new centers of development through public investment and encouragement of private investment (ACUERDO 0373 DE 2014).

Figure 2 shows the areas within the city of Cali where urban renewal projects could potentially be carried out through a partial plan, in accordance with the current regulations.

Figure 2 – Urban renewal treatment area 3 in Cali, Colombia

Source: Authors' own data based on POT Cali, 2014

3 QUALIQUANTITATIVE METHOD FOR STUDYING RELATIONSHIPS BETWEEN URBAN VARIABLES

The methodology proposed in the present study involves the identification, systematization, georeferencing and classification of qualitative and quantitative urban

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variables associated with urban renewal processes in the city of Cali, Colombia. This is achieved through a spatial analysis approach that involves weighted overlay.

The unit of study is the urban lot. Taken together, urban lots constitute the areas selected for implementing urban renewal projects according to the current regulations of the city of Cali in Colombia, particularly the POT of 2014 (ACUERDO 0373 DE 2014).

The TRU3 areas, as established in the urban regulations, cover a large expanse; therefore, the proposed methodology was applied within a previously selected polygon. To conduct this study, a range of GIS tools were employed to spatially represent the various attributes that are used for defining the study area. The use of GIS is an integral part of all methodological stages, as it enables the systematic organization and graphical representation of information through cartography.

The next step is to cluster quantitative and qualitative urban variables into three categories associated with urban renewal processes. After identifying the urban variables, the subsequent phase involves organizing and synthesizing primary and secondary information at the lot level, and then georeference the data using GIS tools. At this point, each urban variable can be spatially represented and visualized through different thematic maps.

Based on the procedures described in the previous paragraph, indicators are created for urban renewal projects. For each variable, a score ranging from 0 to 100 is assigned, allowing for measurement and classification of the analysis criteria.

The urban renewal indicators are selected and grouped within the categories of land management, building capacity, and urban conditions, aiming to generate a classification based on interval scales in the context of urban renewal. These results can be achieved by calculating a weighted average of the indicators that are associated with each category, which are then ordered from the lowest to the highest qualification, based on Jenks Natural Breaks Classification.

To conclude, the values of the three categories are related through a weighted average and classified using the Jenks Natural Breaks method. This last operation results in a spatial analysis for prioritizing areas for urban renewal projects (AEPRU), which is visually represented through thematic cartography. This proposed methodology is applied within a selected TRU3 area in the city of Cali, Colombia, and can serve as a reference for urban planning in other large Latin American cities. Figure 3 shows the steps of the method, their sequences, and interrelationships that have ultimately generated the study AEPRU.

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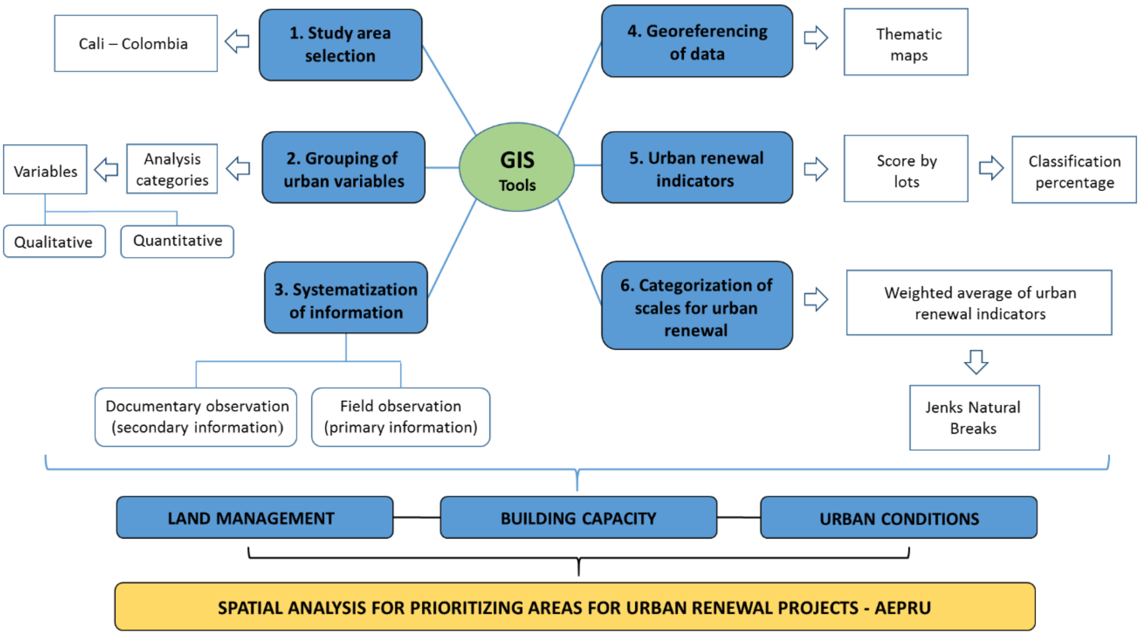
Figure 3 – Qualiquantitative method for studying relationships between urban variables



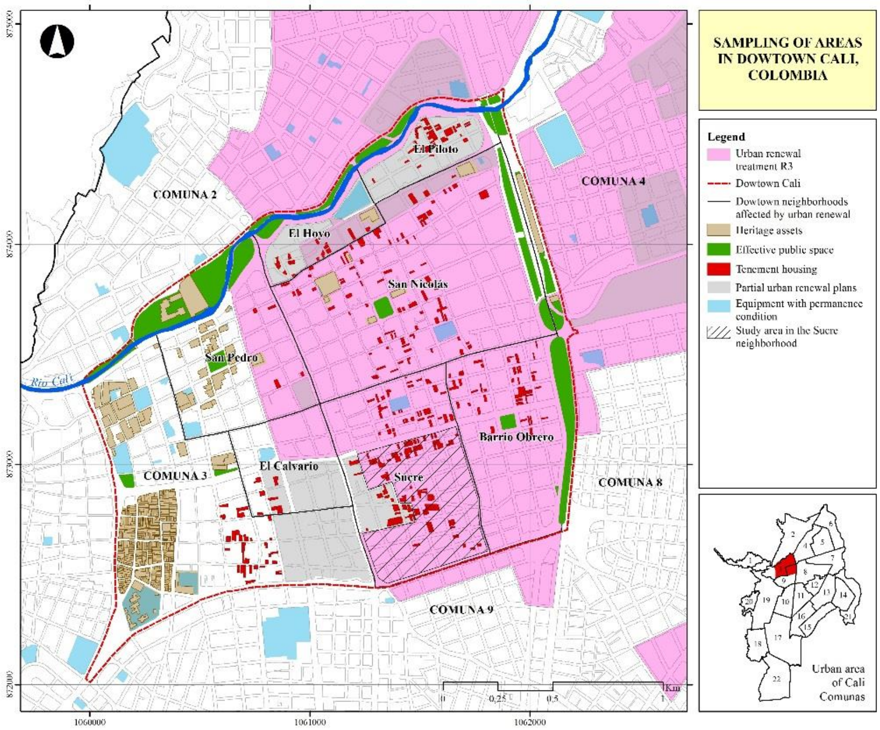
Source: Authors' own data

3.1 Selection of study area

The city of Cali has large areas designated for urban renewal interventions (Figure 2). However, certain sectors within these areas may present urban elements that pose challenges to the established operations according to the current urban regulations. To avoid potential conflicts in planning and to direct public and private investments more efficiently, one needs to identify sectors within these larger areas where urban planning instruments can be implemented with minimal risk to the execution of urban renewal projects.

To select the study polygon, the areas or surfaces were sampled, following the method proposed by Ander-Egg (1972, p. 85). This procedure involved geographic stratification sampling, specifically based on the territory. The method consisted in using a map of the area of interest and dividing it according to the characteristics proposed for analysis. In this exercise, particular factors were taken into consideration within the limits of TRU3, for example, proximity to the historical and traditional downtown Cali, presence of tenement housing, permanent urban equipment, partial urban renewal plans approved previously, heritage assets, and effective public spaces (Figure 4).

Figure 4 – Sampling of areas in downtown Cali, Colombia



Source: Authors' own data based on POT Cali, 2014 and Plan del Centro Global de Cali - USB; Univalle, 2010

The result of the geographic sampling is a heterogeneous polygon within the Sucre neighborhood in Comuna 9, located in the northern part along Carrera 10 (K, KR). It is bordered to the west by the Ciudad Paraíso urban renewal project and Calle 15 (C, CL), to the east by Calle 21, and to the south, by Carrera 15, also known as Avenida 3 de Julio (Figure 5). The study area covers an approximate surface of 26 hectares (260.000 m²), 44 blocks and 1,095 lots.

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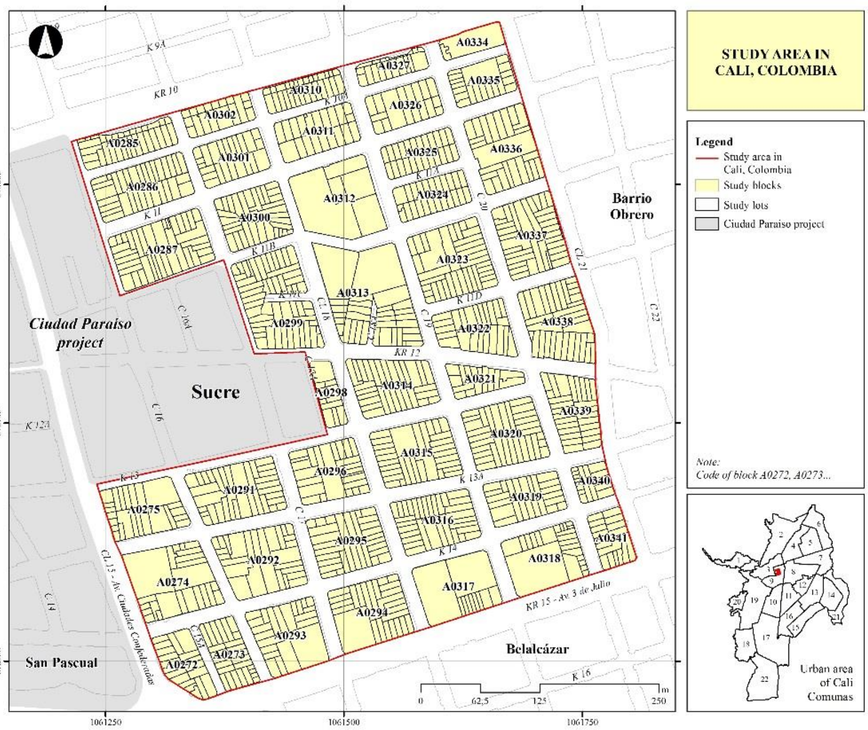
Figure 5 – Study area in Cali, Colombia



Source: Authors' own data based on POT Cali, 2014

3.2 Grouping of urban variables by analysis categories

The grouping technique is a statistical tool that allows for the classification of different units of analysis into clusters, based on the processing of numerous variables that describe the state of these units. This technique allows urban variables with similar characteristics to be associated within a common cluster. It is a diagnostic tool used for exploring different choices when constructing a composite indicator (SCHUSCHNY; SOTO, 2009, p. 46-47).

The methodological proposal in this study uses a total of 15 qualitative and quantitative urban variables that impact urban renewal processes and projects. These variables are grouped into three categories of analysis which, together, enable a method for territorial planning of AEPRU, as shown in Table 1.

Table 1 – Categories of analysis and urban variables

Categories of analysis	Urban variables	Data type	Information
1. Land management	1. Condominium	Qualitative	Secondary
	2. State of conservation of the building	Qualitative	Primary
	3. Subdivided lot units	Quantitative	Secondary
	4. Land uses	Qualitative	Primary
	5. Land price	Quantitative	Secondary
2. Building capacity	6. Building height	Quantitative	Primary
	7. Heritage assets	Qualitative	Secondary
	8. Centrality	Qualitative	Secondary
	9. Coefficient of use of constructive potential	Quantitative	Secondary
	10. Activity zoning	Qualitative	Secondary
3. Urban conditions	11. Informal settlement	Qualitative	Primary
	12. Urban structuring axes	Qualitative	Secondary
	13. Equipment	Qualitative	Secondary
	14. Effective public spaces	Qualitative	Secondary
	15. Road hierarchy	Qualitative	Secondary

Source: Authors' own data

3.2.1 Land management

Land management can be interpreted as the set of interventions by the public administration in the land market, aimed at accomplishing the ethical and political objectives embraced by the community in the processes of transformation, occupation, and conservation of a territory. It can also be defined as the actions that establish the rules of the game for land use for the distribution of rights between landowners and the community (MALDONADO et al., 2016, p. 77-78).

The most common problem in the development of urban intervention projects, both public and private ones, is the high cost of land, which hinders the location of social housing on affordable and suitable plots. Perhaps the main challenge in simultaneously undertaking the densification and renewal of important sectors of the city is how to manage this land, ensuring that entire strategic areas can be subject to coordinated urban interventions that are able to transform socio-economic dynamics and the built environment while accommodating the densification of additional public infrastructure (EMRU, 2016, p. 74).

3.2.2 Building capacity

Building capacity, expressed as land utilization, refers to the number of square meters that can be constructed for a specific use, as authorized by urban regulations on a given plot of land. In other words, it represents the percentage of the total area that can be built upon (EMRU, 2016, p. 47).

3.2.3 Urban conditions

The urban conditions identified in this study, as well as the projects established by the legal framework (POT), will determine the level of attraction for promoters and developers in specific zones of the city that can accommodate their projects. These conditions refer to the existing or projected quality of life in terms of urban standards: green and recreational areas, presence of equipment, mobility and general accessibility conditions, public initiatives, presence of tenement housing, among others.

3.3 Systematization of information

Information was systematized through a compilation of qualitative and quantitative data from the selected urban variables. Secondary information was collected from the official geoportal of the Municipality of Cali through IDESC[3]. Primary data, on the other hand, was gathered from observations during field visits to the study territory. All data from secondary and primary sources were applied at the level of the individual lot and were consulted and collected during the year 2022.

The detailed unit of information for the study is the individual lots that make up the study area. The data was input into Microsoft Excel® spreadsheets and then imported into the QGIS software for creating a spatial database with the categories of analysis and variables for selection of urban renewal projects.

3.4 Georeferencing of data

The concept of georeferencing means locating a specific point in a known coordinate reference system; it is a data identification process based on geographic location (latitude and longitude) that enables the graphical or digital representation of a particular phenomenon of feature in a given territory through geoprocessing tools while maintaining its precise and accurate location (TALASKA; ETEGES, 2012, p. 3).

GIS tools were utilized to georeference all the urban variables and perform various spatial analyses for each lot in the study area. A GIS can be defined as a computerized system that enables the collection, input, storage, manipulation, analysis, representation, and output of spatial and non-spatial data according to specifications and requirements defined by users in a decision-making context (IGAC, 1998, p. 194-195).

3.5 Urban renewal indicators

At this stage of the methodology, the urban variables have been grouped and georeferenced with their respective data. The next step is to transform the systematized information into indicators that allow for the measurement and qualification of the variables related to the implementation of urban renewal projects.

According to DANE (2012, p. 13-14), an indicator is a qualitative or quantitative expression that allows describing characteristics, behaviors, or phenomena of reality through the evolution of a variable or by establishing a relationship between variables. Indicators are used to compare previous periods, similar products or a target or commitment, enabling the evaluation of performance and its evolution over time.

The 15 indicators proposed in this study are both qualitative and quantitative in nature, ranging in nominal and ordinal values and weights from 0 to 100. This allows for the

[3] Infraestructura de Datos Espaciales de Santiago de Cali: https://idesc.cali.gov.co/geovisor.php

classification, ordering and determination of results (SCHUSCNHY; SOTO, 2009, p. 55-58). The urban renewal indicators in the selected study area have a time frame of the year 2022 and are measured for each lot according to the proposed classification. The results are expressed as percentages, as shown in Table 2.

Table 2 – Urban renewal indicators in Cali, Colombia – 2022

Indicator	Category	Classification	Weight	Lot	%
Condominium	Land management	Does not apply – Buildings with > 10 stories	-	0	0
		Condominium with 8 to 10 stories	0	0	0
		Condominium with 5 to 7 stories	10	1	0.1
		Condominium with 2 to 4 stories	20	14	1.3
		Buildings that are not condominiums	70	1,080	98.6
		Total	**100**	**1,095**	**100%**
State of conservation of the building	Land management	New	0	3	0.3
		Good	10	269	24.6
		Regular	20	475	43.4
		Bad	30	335	30.6
		Very bad	40	13	1.2
		Total	**100**	**1,095**	**100%**
Subdivided lot units in the Sucre neighborhood in Cali, Colombia	Land management	9 m^2 - 100 m^2	0	254	23.2
		101 m^2 - 200 m^2	5	697	63.7
		201 m^2 - 400 m^2	10	108	9.9
		401 m^2 - 900 m^2	15	22	2
		901 m^2 - 1,800 m^2	30	8	0.7
		1,801 m^2 - 3,339 m^2	40	6	0.5
		Total	**100**	**1,095**	**100%**
Land uses	Land management	Residential	0	291	26.6
		Mixed	10	266	24.3
		Institutional	10	4	0.4
		Services	15	30	2.7
		Commercial	15	382	34.9
		Industrial	20	73	6.7
		Unused	30	49	4.5
		Total	**100**	**1,095**	**100%**
Land price per m^2 in the Sucre neighborhood in Cali, Colombia	Land management	1,000,001 COP – 1,350,000 COP	0	90	8.2
		750,001 COP – 1,000,000 COP	5	48	4.4
		600,001 COP – 750,000 COP	10	19	1.7
		300,001 COP – 600,000 COP	15	62	5.7
		200,001 COP – 300,000 COP	30	875	79.9
		100,000 COP – 200,000 COP	40	1	0.1
		Total	**100**	**1,095**	**100%**
Building height in the Sucre neighborhood in Cali, Colombia	Building capacity	5-story buildings	0	3	0.3
		4-story buildings	5	40	3.7
		3-story buildings	10	153	14
		2-story buildings	20	227	20.7
		1-story buildings	30	666	60.8
		Empty lots	35	6	0.5
		Total	**100**	**1,095**	**100%**
Heritage assets	Building capacity	Direct influence of heritage assets (100 m around)	0	-	-
		No direct influence of heritage assets	100	-	-
		Total	**100**	**0**	**-**
Centrality	Building capacity	Buildings without centrality	0	999	91.2
		Industrial centrality	5	-	-
		Centrality of industrial services	5	-	-
		Supply centrality	10	-	-

		Automotive service centrality	10	96	8.8
		Centrality of large equipment	15	-	-
		Business centrality	25	-	-
		Centrality with uses associated with housing	30	-	-
		Total	**100**	**1,095**	**100%**
Coefficient of use of constructive potential	Building capacity	2 – 2,5	0	-	-
		2.6 – 3.5	5	-	-
		3.6 – 4.5	10	999	91.2
		4.6 – 5.5	15	-	-
		5.6 – 6.5	20	96	8.8
		6.6 – 7.5	30	-	-
		Total	**100**	**1,095**	**100%**
Activity zoning	Building capacity	Public spaces	0	-	-
		Equipment	0	-	-
		Exclusively residential	10	-	-
		Predominantly residential	20	926	84.6
		Industrial	30	-	-
		Mixed	40	169	15.4
		Total	**100**	**1,095**	**100%**
Informal settlement	Urban conditions	Buildings without informal settlement	0	1.031	94.2
		Tenement housing	40	57	5.2
		Trespassing on property	60	7	0.6
		Total	**100**	**1,095**	**100%**
Urban structuring axes	Urban conditions	Buildings without an urban structuring axis	0	954	87.1
		Buildings within the urban structuring axis	100	141	12.9
		Total	**100**	**1,095**	**100%**
Equipment	Urban conditions	Equipment	0	4	0.4
		No direct influence of equipment	40	1.060	96.8
		Direct influence of equipment (surrounding 100 m)	60	31	2.8
		Total	**100**	**1,095**	**100%**
Effective public spaces	Urban conditions	Effective public spaces	0	-	-
		No direct influence of public spaces	30	-	-
		Direct influence of public spaces (surrounding 100 m)	60	-	-
		Total	**100**	**0**	**-**
Road hierarchy	Urban conditions	Local road	10	757	69.1
		Collector road	20	157	14.3
		Minor arterial road	30	107	9.8
		Major arterial road	40	74	6.8
		Total	**100**	**1,095**	**100%**

Source: Authors' own data

3.6 Categorization of scales for urban renewal

To categorize scales for urban renewal, the values of each indicator were associated with their category of analysis in a methodological procedure for data cross-referencing widely accepted in spatial analyses, also known as decision tree or hierarchical analysis of weights (MOURA, 2007, p. 2901).

The classification of the categories of analysis, which is also applied to the final result, is based on the methodology for urban scale categorization proposed by Ferreira et al. (2022, p. 8). This approach considers a degree of relevance with 6 levels grouped by the weighted average of the indicators, ordered from the lowest to the highest score (Table 3).

Table 3 – Categorization of urban scales

Classification
1. Irrelevant
2. Very low
3. Low
4. Medium
5. High
6. Very high

Source: Authors' own data based on information from Ferreira et al., 2022

The values are classified through urban scale categorization, using the statistical method of Jenks Natural Breaks. This method is based on inherent natural grouping within the data: similar values are clustered together while maximizing the differences between classes. It calculates the differences between ordered statistical values in an ascending manner and establishes a threshold to separate the groups where the differences in values are significant (ESRI, 2022).

Finally, the statistical grouping method was applied to each urban renewal category corresponding to land management, building capacity and urban conditions. Measurement is based on the number of lots within the study area for the year 2022. Upon completing this step, a combined process is performed with these categories to present the research results; this operation is described and explained in the next chapter.

4 RESULTS

According to Buzai and Baxendale (2010, p. 7), spatial analysis consists of a series of techniques and mathematical and statistical models applied to data that are distributed in geographic space. To obtain results, one needs to formulate hypotheses or draw conclusions about the data that describe spatial relationships or spatial interactions between cases.

Spatial analysis establishes the connection between the essentially cartographic domain and the areas of applied analysis, statistics, and modelling, allowing researchers to combine georeferenced variables and use them to create and analyze new variables. It consists of the extrapolation and creation of new information capable of achieving a better understanding of a specific phenomenon from an isolated or integrated perspective (ROSA, 2011, p. 276).

To obtain an AEPRU value, one needs to calculate the weighted average of the three categories of analysis (see formula after the paragraph), and then classify the lots by the Jenks natural break clustering method into six levels that range between irrelevant, very low, low, medium, high, and very high. The last two are the those with the best conditions to intervene in the territory. The data are grouped according to their classification, that is, the ones with the highest amount are classified as very high and high, in the same way that those with the lowest weight are classified within the range of irrelevant, very low and low.

$$AEPRU = \frac{\text{Land management} + \text{Building capacity} + \text{Urban conditions}}{3}$$

The results are spatially represented in thematic maps created with GIS by overlaying layers of indicators according to the categories of urban renewal for each lot. This process leads to the spatial identification of contiguous areas with better aptitudes, based on the methodology proposed for the inclusion of urban renewal projects in the study area. Similarly, it can be used to recognize a single preferred option, as well as multiples options depending on the specific needs of each case.

On the other hand, a set of lots will not be considered in the application of spatial analysis because they present specific conditions that hinder the execution of urban renewal projects. These include: heritage assets, permanent urban equipment, building with 10 or more stories, and large industrial and/or commercial areas with legally operational economic activities.

4.1 Priority areas for urban renewal projects

After applying the methodological process in the area selected in the Sucre neighborhood in the city of Cali, Colombia, as shown in the thematic map (Figure 6), a continuous subarea comprising 7 blocks (A0272, A0273, A0293, A0294, A0317, A0318 and A0341) stands out. This subarea contains the lots with higher scores (high and very high) for inclusion in urban renewal projects. This specific area consists of 141 lots, equivalent to 13% of the total lots within the selected polygon, and it covers a surface area of 4 hectares, accounting for 15% of the total area of the study site.

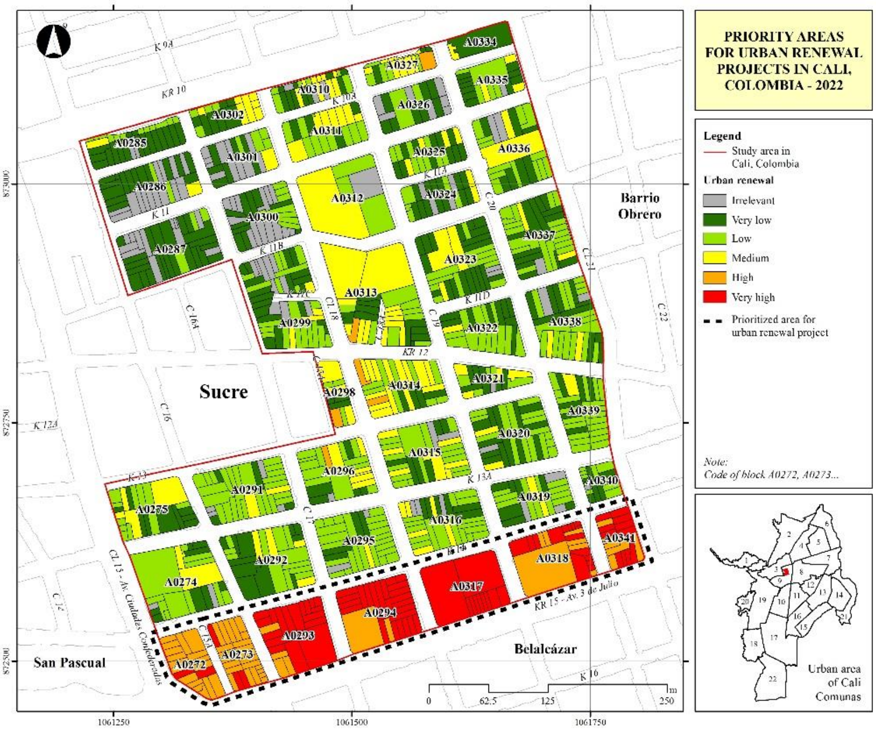
According to Colombian urban regulations, the final selected area can be prioritized for renewal planning along with the inclusion of an urban renewal partial plan. Table 4 shows the classification of AEPRU for each study lot.

Table 4 – Classification of lots by priority area for urban renewal projects in Cali, Colombia 2022

Classification	Lots	Participation percentage
Irrelevant	108	10%
Very low	327	30%
Low	379	35%
Medium	134	12%
High	65	6%
Very high	82	7%

Source: Authors' own data

Figure 6 – Priority areas for urban renewal projects in Cali, Colombia – 2022



Source: Authors' own data

5 CONCLUSIONS

The processes of physical deterioration and depopulation of traditional downtown areas in large cities of Latin America are a recurrent urban phenomenon that requires comprehensive interventions in territorial planning. Urban renewal emerges as an alternative to reverse this issue through structural changes in consolidated areas of the city, thereby enhancing existing urban services.

The spatial analysis methodology, combined with the use of GIS tools, allows the creation of options to identify and prioritize areas for implementation of urban renewal projects. This paper reported a theoretical-practical exercise in cartography and territorial planning developed in the city of Cali, which can serve as a reference for other cities in Colombia and even in the wider context of Latin American cities.

It should be noted that the AEPRU in the Sucre neighborhood in the city of Cali, in Colombia, is valid for data for the year 2022, as it must be taken into account that the results may vary over time, owing to the dynamic and frequent changes occurring in large cities.

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