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RESIDENTIAL SEGREGATION IN TWO CITIES IN PERU'S SOUTHERN MACRO-REGION [1]

SEGREGACIÓN RESIDENCIAL EN DOS CIUDADES DE LA MACRO REGIÓN SUR DEL PERÚ

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Los estudios sobre segregación residencial en el Perú han privilegiado el estudio de la ciudad capital, en desmedro de ciudades con otras escalas y contextos. En este artículo analizamos los niveles y patrones de segregación residencial en dos ciudades del Perú, ubicadas en la macro región sur: Arequipa y Tacna. A partir de los datos proporcionados por los censos de los años 2007 y 2017, se analizaron indicadores sintéticos y espaciales de segregación en ambas ciudades, tomando como referencia el nivel educativo del jefe de hogar y calculando los datos para las escalas de manzana, área censal y distrito. Los resultados muestran que se mantienen patrones de segregación heredados, al mismo tiempo que los crecientes estratos medios son incluidos en los asentamientos populares más consolidados. Además, se identificaron procesos que refuerzan la segregación, como la modificación de la función de las áreas centrales, producción de suelo urbano para estratos altos y homogeneidad de desventajas en nuevas áreas de expansión urbana, las que están vinculadas particularmente en la ciudad de Arequipa en la ocupación sobre áreas de riesgo. El estudio sugiere que estos procesos dan forma a un patrón de segregación urbana de baja escala o fragmentación en ambas ciudades que coexisten con los patrones heredados.

Palabras clave: segregación residencial, patrones de segregación, urbanización, crecimiento urbano.

Studies on residential segregation in Peru have privileged the study of the capital city, to the detriment of cities with other scales and contexts. This article analyzes the residential segregation levels and patterns in two Peruvian cities in the southern macro-region: Arequipa and Tacna. Based on data provided by the 2007 and 2017 censuses, synthetic and spatial segregation indicators were analyzed in both cities, taking as reference the educational level of the head of household and calculating the data on the block, census area, and district scales. The results show that inherited segregation patterns are maintained, while at the same time, the growing middle-class sectors are included in the more consolidated working-class settlements. In addition, processes that reinforce segregation were identified, such as the modification of the role of central areas, urban land production for the upper-class areas, and homogeneity of disadvantages in new areas of urban expansion, which are linked, particularly in the city of Arequipa, to the occupation of risk areas. The study suggests that these processes shape a low-scale urban segregation or fragmentation pattern in both cities, which coexists with inherited patterns.

Keywords: residential segregation, segregation patterns, urbanization, urban growth.

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I. INTRODUCTION

Residential segregation (RS, from now on) - understood as the distribution and concentration patterns of the population in the region - is one of the most important fields of analysis in urban studies. RS patterns are based on socio-economic, demographic, and/or ethnic criteria to configure opportunity structures that impact the quality of life. The production of urban space and the levels of segregation do not depend exclusively on individual decisions but on the institutional arrangements of the land and real estate markets, the location of public investment policies, and the contextual conditions of each urban agglomeration. RS "is a multiscale process driven by diverse systemic mechanisms and contextual factors, their legacies and transformation, and not by inevitable global forces, individual behavior, or pure market logic" (Arbaci, 2019, p5). It depends on each city's historical trajectory, multiple dimensions, and institutional arrangements (Maloutas, 2012). In operational terms, RS refers to the degree of separation of two or more groups in the same area (Massey & Denton, 1988).

RS is a field that is not without controversies. Debates have been identified around whether contemporary territorial transformations generate conditions for the increase of RS, large-scale segregation patterns, or small-scale segregation and socio-spatial fragmentation (Borsdorf & Hidalgo, 2010; Janoscka, 2002; Prévot Schapira, 2001; Sabatini et al., 2001), or the relationship between segregation and inequalities (Ruiz-Tagle & López, 2014; Sabatini et al., 2020). In methodological terms, discussions arise on synthetic (such as the dissimilarity index) and spatial indices (Sánchez & Gómez, 2021), operationalization (Massey & Denton, 1998), and the impact of the analysis scale on the results (Marengo & Elorza, 2014; Sabatini et al., 2001), the use of census tracts or other delimitations. In addition, whether the RS patterns are similar when comparing cities of different scales and sizes has recently been discussed (Garreton et al., 2020; Krupka, 2007; Mayorga, 2021; Monkkonen, 2012).

The following article contributes to these debates by comparing two regional cities in Peru's southern macro-region. The starting point is moving away from the country's metropolitan area and capital, Lima, and its almost 10 million inhabitants, to analyze Tacna and Arequipa, with populations of around 300,000 and 1 million, respectively (INEI, 2017). These cities were chosen for the following three reasons: a) Both belong to the same southern macro-region; b) Arequipa is the second most populous city in the country; and c) Both cities have population growth rates higher than the country's capital and a significant recent regional growth. The dimensions are the distribution and homogeneity/heterogeneity, analyzed from the socioeconomic variable, taking as a reference the level of education achieved by the head of household. The analysis uses spatial and non-spatial indexes with information from the 2007 and 2017 censuses, and three scales of analysis were incorporated: block, census area, and district.

The article identifies various debates about RS in urban studies to delimit its working premises. Subsequently, the socio-spatial context of the analyzed cities and the results of the spatial and non-spatial indices are described. Finally, the article marks the coexistence of both cities' large- and small-scale segregation dynamics as relevant.

II. THEORETICAL FRAMEWORK.

Segregation: debates and scales

RS is one of the central topics in urban studies. In particular, it is a crucial analytical input to understanding growth models, location patterns, relationships between social inequalities and urban form, and the role of the land and housing market, among other things. In the United States, the racial, sociocultural, and socioeconomic ethnic components have been discussed from different angles (Massey & Denton, 1998). On the other hand, various adaptations and uses of the analysis models were made in Latin America to understand Residential Segregation (Sabatini, Cáceres & Cerda, 2001) from critical readings (Ruiz Tagle & López, 2014). RS is associated with multiple processes (de Queiroz, 2017). Among the main topics, the following stand out: link with "urban informality" (Clichevsky, 2000), public policies, housing, and land markets (Águila & Prada, 2020; Prada-Trigo & Andrade, 2022), and the effects of migration. At the same time, RS is a structure of opportunities (Katzman, 2001) associated with dynamics of labor insertion (Niembro et al., 2019), income generation (Gomes & de Queiroz, 2021), territorial stigmas (Elorza, 2019), citizen security (Arriagada & Morales, 2006), access to the labor market (Niembro et al., 2019) and can influence - albeit ambiguously - social networks (Marques, 2015) and their resources (Otero et al., 2021).

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Different debates regarding the analyzed literature can be highlighted. Faced with the question about the particularity of the RS patterns in Latin American cities (Rodríguez & Arriagada, 2004), an argument was made in favor of a large-scale pattern as a result of the characteristics of the massive urbanization process of the 20th century, the barriers of access to housing in the formal markets, and the processes of irregular access and self-construction. On the other hand, the move to smaller-scale segregation, or fragmentation, was proposed (Borsdorf & Hidalgo, 2010; Prévot Schapira, 2000). An intermediate line shows that the RS patterns are explained by the forms of measurement and work scale or by their coexistence (Aguilar & Mateos, 2021).

A second debate is about the relationship between segregation, extension, population, and metropolization, which were extended to comparative studies that identified general characteristics of RS patterns between cities of different sizes, with or without metropolitan conditions. Garreton et al. (2020) proposed an analysis model where a correlation between size and level of segregation was demonstrated for Chile. According to Krupta (2007), size and segregation have no significant differences. Monkkonen (2012) analyzed more than 100 urban areas in Mexico and concluded the following: "The historical urban development processes are more important in determining segregation patterns than the universal land market factors" (p. 143). The contexts are specific configurations of historical, territorial, and institutional processes to understand the RS patterns (Theodore et al., 2009). Namely, segregation is a concept linked to the context (Maloutas, 2012), where people are more inclined towards cities other than the capitals.

In the case of intermediate cities, Toro and Orozco (2018) discussed the particularities of segregation patterns in intermediate cities, highlighting the possibility of different processes - such as forms of negotiation and tolerance of proximity between social groups. Paying particular attention to real estate growth, for their part, Águila and Prada (2020) identified in the city of Valdivia, Chile, a "segregation marked by opposite poles, i.e., there is a voluntarily segregated group, which is a high socioeconomic class [...] and a peripheral cordon" (p.39). For the case of intermediate cities in Mexico, Ruiz et al. (2021) concluded that the growth of intermediate cities follows a periphery pattern, with homogeneous old areas, indigenous populations in dispersed localities, and swaths of "newcomer" populations in disadvantaged situations.

III. CASE STUDY

Cities of Peru's Southern Macro-region

Similar to regional trends (Cebrián et al., 2023), Peru's urban growth in the 20th and 21st centuries was mainly defined by the sustained increase in urban population, which rose from 35.4% in 1940 to 82.4% in 2017. The urban primacy, with a third of the national population residing in the capital (Lima), forms part of the centralism and weaknesses of networks of cities integrated into the national territory (Espinoza et al., 2022; Galarza, 2011).

The country's System of Cities and Population Centers revealed that the cities with the highest demographic growth between 2007 and 2017 are not the capital. The population growth rates of intermediate major cities and regional metropolises are higher than those of national metropolises (Table 1). Metropolitan Lima saw the most significant growth in the 20th century, with intercensal growth rates of 5.2 (1940-1961), 5.7 (1961-1972), 3.7 (1972-1981), 2.7 (1981-1993), and 2.0 (1993-2007). This meant rising from about 500,000 inhabitants in 1940 to almost 10 million in 2017. Although the growth rate has decreased, it is still the country's most important urban area.

The predominance of Lima is also reflected in urban studies, which presented excessive attention to this to the detriment of other processes at a national level (Calderón & Vega-Centeno, 2016). Studies focusing on the capital usually argue that this case is representative of the rest of the country's urban processes. This sometimes leads to the reproduction of what Vergara and Salazar (2021) mention, namely studying cities of different scales as if they were "mini-metropolises." There are important exceptions, such as territorial studies (Vilela, 2023), debates on the role of intermediation of intermediate cities (Canziani & Schejtman, 2013), and the possibilities they offer for decentralized economic development (Espinoza et al., 2022), as well as efforts to analyze territorial and environmental conditions in Arequipa (Zevallos, 2020), the water distribution system also in Arequipa (Zapana et al., 2021), and the role of the state in the production of land and housing in Tacna (Abanto, 2017), among others.

According to Law No. 31313, "Sustainable Urban Development Law" (2021), it is mentioned that Peru's national territory is subdivided into urban macrosystems. Due to its economic and demographic importance, the southern macrosystem has Arequipa as a dynamic city (regional metropolis). Tacna (a major city) is located in this same macro system. Both cities have a smaller population than the capital, even though Arequipa has

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Department capital	2007	2017	City typology	Growth rate
Puerto Maldonado	57,035	85,024	Main intermediate city	4.1
Ayacucho	151,019	216,444	Major City	3.7
Abancay	51,462	72,277	Main intermediate city	3.5
Chachapoyas	23,202	32,026	Intermediate city	3.3
Moquegua	50,799	69,882	Main intermediate city	3.2
Huánuco	148,665	196,627	Major City	2.8
Moyobamba	39,250	50,073	Main intermediate city	2.5
Arequipa	806,782	1,008,290	Southern Macrosystem Regional Metropolis	2.3
Piura	377,896	473,025	Northern Macrosystem Regional Metropolis	2.3
Cajamarca	161,215	201,329	Major City	2.2
Huancavelica	40,004	49,570	Intermediate city	2.2
Cusco	348,935	428,450	Central Southern Macrosystem Regional Metropolis	2.1
Ica	232,054	282,407	Main Major City	2.0
Trujillo	766,082	919,899	Northern Macrosystem Regional Metropolis	1.8
Huancayo	382,478	456,250	Central Macrosystem Regional Metropolis	1.8
Pucallpa	272,251	326,040	Central Macrosystem Regional Metropolis	1.8
Huaraz	99,462	118,836	Major City	1.8
Tacna	242,670	286,240	Main Major City	1.7
Metropolitan Lima	8,472,092	9,562,280	National Metropolis	1.2
Puno	119,116	128,637	Major City	0.8
Tumbes	91,365	96,946	Main intermediate city	0.6
Chiclayo	527,250	552,508	Northern Macrosystem Regional Metropolis	0.5
Iquitos	367,153	377,609	Northern Macrosystem Regional Metropolis	0.3
Cerro de Pasco	61,046	58,899	Main intermediate city	-0.4

Table 1. Growth rate and population in department capitals**4**. Source: MVCS (2016); INEI (2017)

one million inhabitants and Tacna has less than 300,000. Therefore, the population and territorial extension had considerable growth in both cases. Between 1984 and 2017, the built-up area of Arequipa grew more than threefold (Figure 1), especially in recently urbanized areas on land classified as a non-mitigable risk zone (Arequipa Provincial Municipality, 2015). In the case of Tacna, the built-up area has grown sixfold (Figure 2). However, due to the growth of the urban area, these areas are exposed to more significant anthropogenic hazards that limit their habitability (quarries, pig farms, sanitary landfills, among others) (Tacna Provincial Municipality, 2013).

IV. METHODOLOGY

The microdata of the 2007 and 2017 Population and Housing Censuses (CPV, in Spanish) were used, which were processed in a Geographic Information System

4 According to the national regulations, there are 8 classification ranges of urban agglomerations, the main ones being: 1) National metropolis (Lima) (10 million inhabitants); 2); regional metropolis (500,001 or more); major city (100,000 to 500,000); intermediate city (20,000 to 100,000); and minor city (5001 to 20,000).

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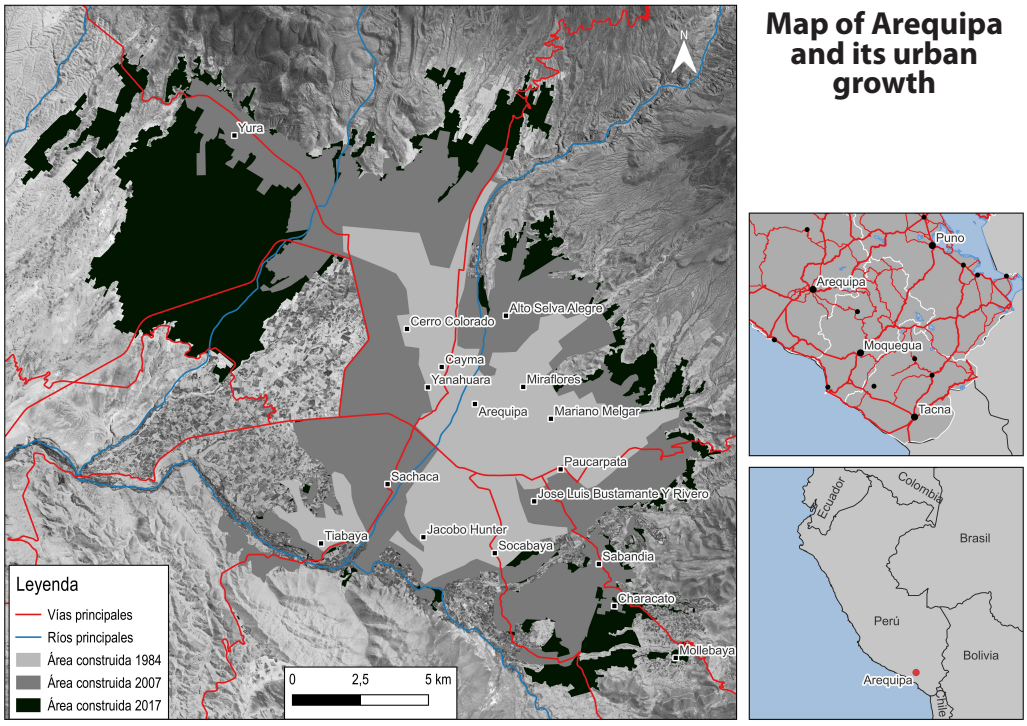

Figure 1. Map of location and urban growth of Arequipa. Source: Population and Housing Census (CPV) 2007 and 2017 (INEI), Google Earth

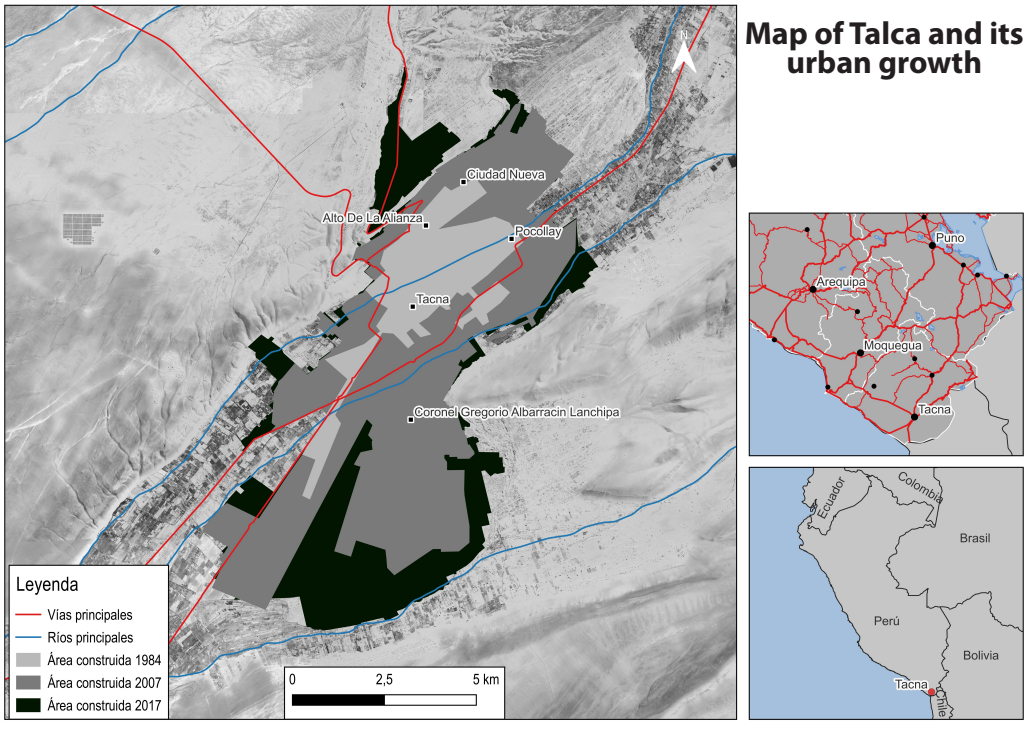

Figure 2. Map of location and urban growth of Tacna. Source: CPV 2007 and 2017 (INEI), Google Earth

IV. METHODOLOGY

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Arequipa				
	2007	2017	Absolute	Relative
Low	41 522	46 923	5 401	13,01%
	19,49%	15,64%		
Medium	64 452	110 849	46 397	71,99%
	30,26%	36,96%		
Higj	107 039	142 152	35 113	32,80%
	50,25%	47,40%		
Tacna				
	2007	2017	Absolute	Relative
Low	15 591	16 918	1 327	8,51%
	22,56%	19,22%		
Medium	25 841	38 526	12 685	49,09%
	37,40%	43,76%		
Higj	27 668	32 598	4 930	17,82%
	40,04%	37,03%		

Table 2. Absolute and relative intercensal variation of the head of household educational level in Arequipa (2007 – 2017). Source: CPV 2007 and 2017 (INEI)

(GIS) environment, Quantum GIS software (QGIS), GeoSegregation Analyzer, and Geode. For the data's georeferencing, the scope was calculated by dividing the number of blocks by the data extracted from the blocks of the National Institute of Statistics and Informatics (INEI, in Spanish) cartographic database[5]. Once georeferenced in blocks, the data were added at the census area level (delimitation of the INEI that houses an average of 63 blocks).

After the exploratory analysis, the head of household's educational level was determined as an analysis parameter, given the available data, the explanatory capacity, and the revised bibliography. Similarly, Rodríguez and Arriagada (2004) and Marengo and Elorza (2014) included heads of households under 25 due to their small proportion in the analyzed cases[6]. The educational level achieved variable was categorized into low, medium, and high. The low group includes the elementary or primary level of education (no level, initial, primary, and special primary); the middle group includes secondary education; and the high group for complete or incomplete technical, university, and postgraduate education.

To evaluate the complementarity of spatial and non-spatial indices, two standard indices in RS analysis were chosen as synthetic indices: the Duncan dissimilarity index (DI) (Equation 1) and the segregation index (SI) (Equation 2) (Aparicio et al., 2013).

Equation 1

$$ID = \frac{1}{2}\sum_{i=1}^{n}\left|\frac{x_i}{X} - \frac{y_i}{Y}\right|$$

Equation 2

$$IS = \frac{1}{2}\sum_{i=1}^{n}\left|\frac{x_i}{X} - \frac{t_i - x_i}{T - X}\right|$$

For the spatial indices, the standard deviation of the socio-educational groups in each census area was used, defined as the average of the differences between each data and the arithmetic mean of the set according to each census area (Toro & Orozco, 2018). In addition, the Morán local spatial association index (LISA) was used to locate sector groupings.

V. RESULTS

The intercensal analysis allowed for identifying variations in the composition of socio-educational groups (Table 2). In both cities,

5 A scope of 82.3% was obtained in Arequipa and 85.9% in Tacna in 2007.
6 In Arequipa, in 2017, heads of household under the age of 25 accounted for 6% of the total.

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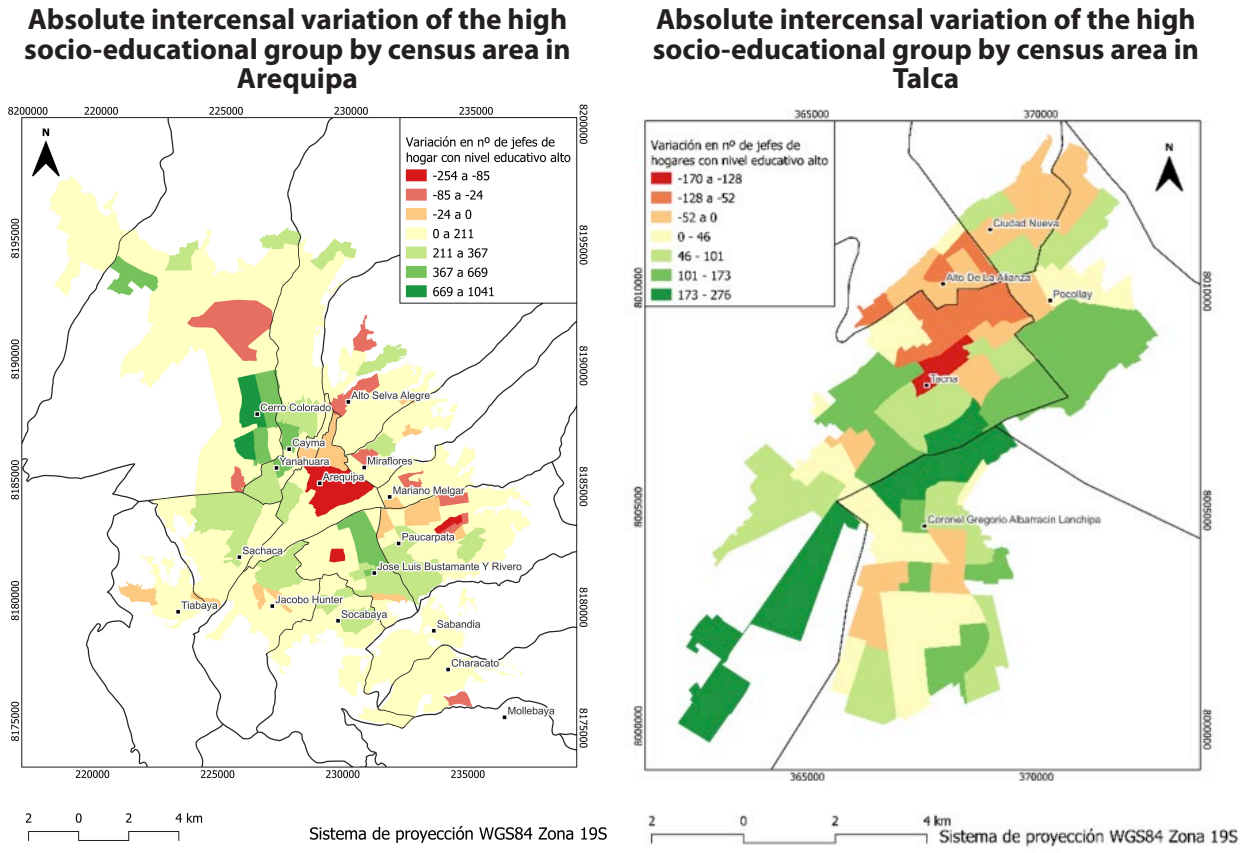

Figure 3. Intercensal variation according to census area in both cities. Source: CPV 2007 and 2017 (INEI).

the middle group had the highest growth, and the low and high groups declined in absolute and relative terms. In the city of Arequipa, the high group remained the most predominant, while in Tacna, the middle group displaced the high group.

In the case of the high socio-educational group, the analysis of the intercensal variation at the census area level shows patterns in both cases. In both cities, the most significant reduction of heads with a high educational level occurs in census areas near the historic center, followed by the decrease of this group in areas of urban expansion associated with forms of working-class urbanization. In addition, a growth of the group of heads of households with a high educational level was observed in the sectors characterized as rural areas and rustic islands according to the regulatory plans: Cerro Colorado in Arequipa and the district boundary of Tacna and Gregorio Albarracín (Figure 3).

Although the intercensal variation provides information on the changes in the group structure in each city, synthetic segregation indices characterize the segregation distribution dimension. For Arequipa, the dissimilarity index shows that segregation increased between the high and medium groups and decreased between the medium and low groups (Table 3). Similarly, in Tacna, segregation increased between the high and medium groups and decreased between the medium and low groups (Table 4).

Results similar to the previous ones were obtained when analyzing the Segregation Index (SI) (Table 5). Segregation increased in both cities' upper and middle groups at the census area level. On the contrary, segregation would have been reduced on a block scale in both cases. This shows that measuring segregation with non-spatial indices is susceptible to the scale and confirms the increase in segregation between the middle and upper groups in both cities.

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Arequipa (2007)			
Group	Low	Medium	High
Low		14,27	38,20
Medium	14,27		27,82
High	38,20	27,82	
Arequipa (2017)			
Group	Low	Medium	High
Low		11,12	38,80
Medium	11,12		32,17
High	38,80	32,17	

Table 3. Index of dissimilarity of socio-educational groups in Arequipa, according to census area (2007 - 2017). Source: CPV 2007 and 2017 (INEI)

Tacna (2007)			
Group	Low	Medium	High
Low		13,50	35,37
Medium	13,50		29,35
High	35,37	29,35	
Tacna (2017)			
Group	Low	Medium	High
Low		13,90	34,52
Medium	13,90		31,81
High	34,52	31,81	

Table 4. Dissimilarity index of socio-educational groups in Tacna, by census area (2007 - 2017). Source: CPV 2007 and 2017 (INEI)

The variation compared to the mean or standard deviation of the different socio-educational groups was analyzed to explore the spatial dimension of segregation. Following Toro and Orozco (2018), the following figures compared the measures of social homogeneity and the predominant socio-educational group in each city. In Arequipa, the socio-spatial transition pattern includes a sector close to the historical center where a homogeneous high group predominates, followed by an intermediate cordon where the high group predominates in a more heterogeneous way, and finally, a peripheral cordon of medium and low groups, which is very heterogeneous (Figure 4). For 2017 (Figure 5), the central, high, and homogeneous sector is expanding due to real estate projects for the middle class (for example, in Cerro Colorado). The area of the historical center remains less homogeneous, which is associated with the intercensal variation described above. Likewise, the average socio-educational group increase is expressed in the higher frequency and increased heterogeneity observed in the intermediate and peripheral cordon. However, sectors of very heterogeneous middle and lower groups persist in the peripheries and areas of urban expansion. Sectors located in peripheral districts and working-class settlements are also related to the agglomerations of vulnerable groups in the city (Figure 6).

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Arequipa			
		2007	2017
Low	Block	42,93	39,64
	Census area	28,40	25,15
Medium	Block	34,91	32,50
	Census area	17,94	22,81
High	Block	44,13	41,19
	Census area	31,53	34,01
Tacna			
		2007	2017
Low	Block	37,32	33,92
	Census area	22,05	19,56
Medium	Block	31,53	29,85
	Census area	17,95	21,01
High	Block	42,27	39,21
	Census area	31,34	33,16

Table 5. Segregation index in Arequipa and Tacna 2007 – 2017. Source: CPV 2007 and 2017 (INEI)

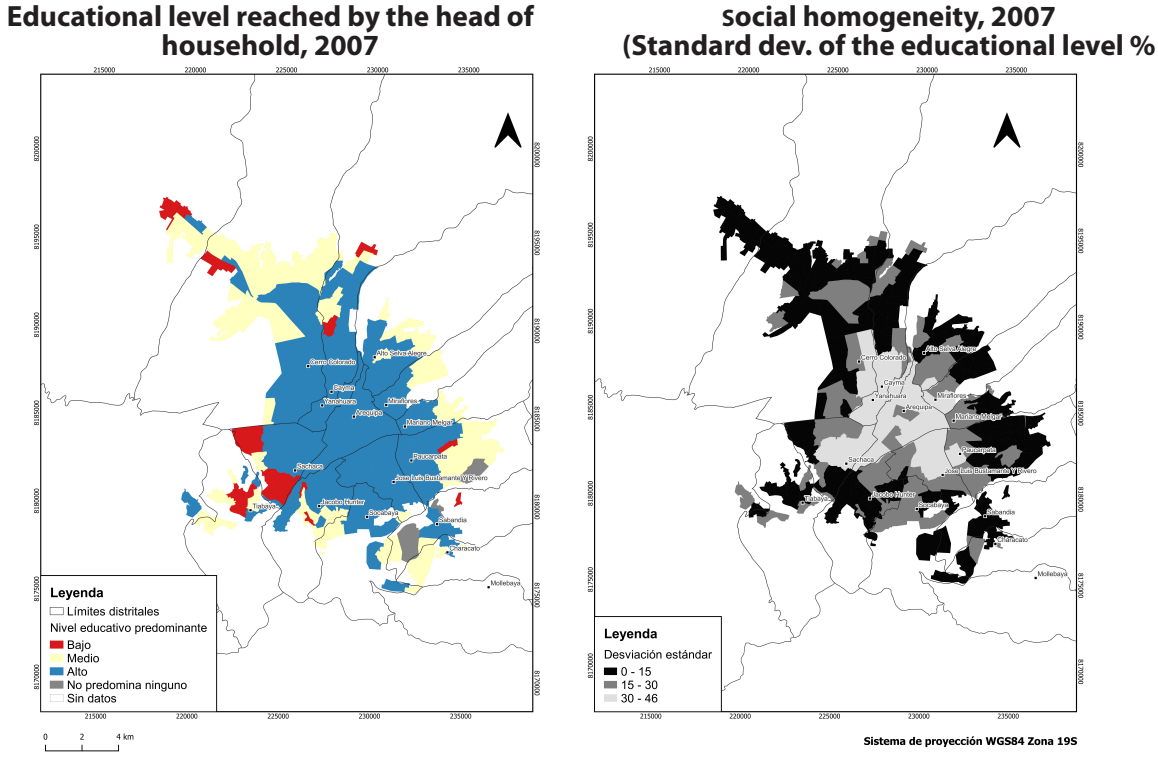

Figure 4. Predominant socio-educational group and social homogeneity in Arequipa, 2007. Source: CPV 2007 (INEI).

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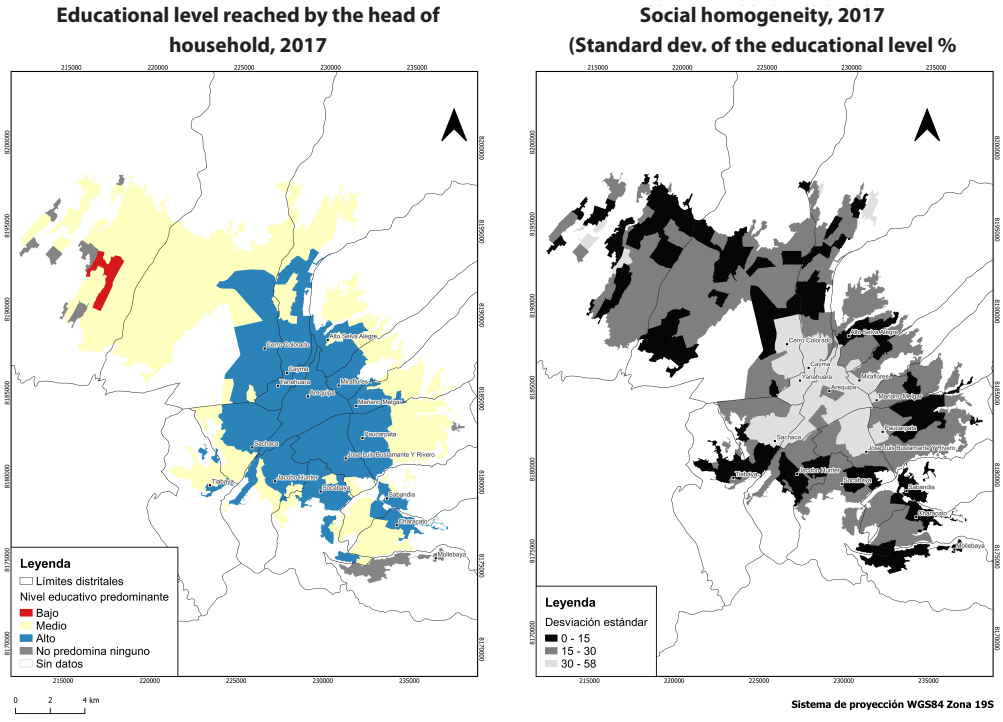

Figure 5. Predominant socio-educational group and social homogeneity in Arequipa, 2017. Source: CPV 2017 (INEI).

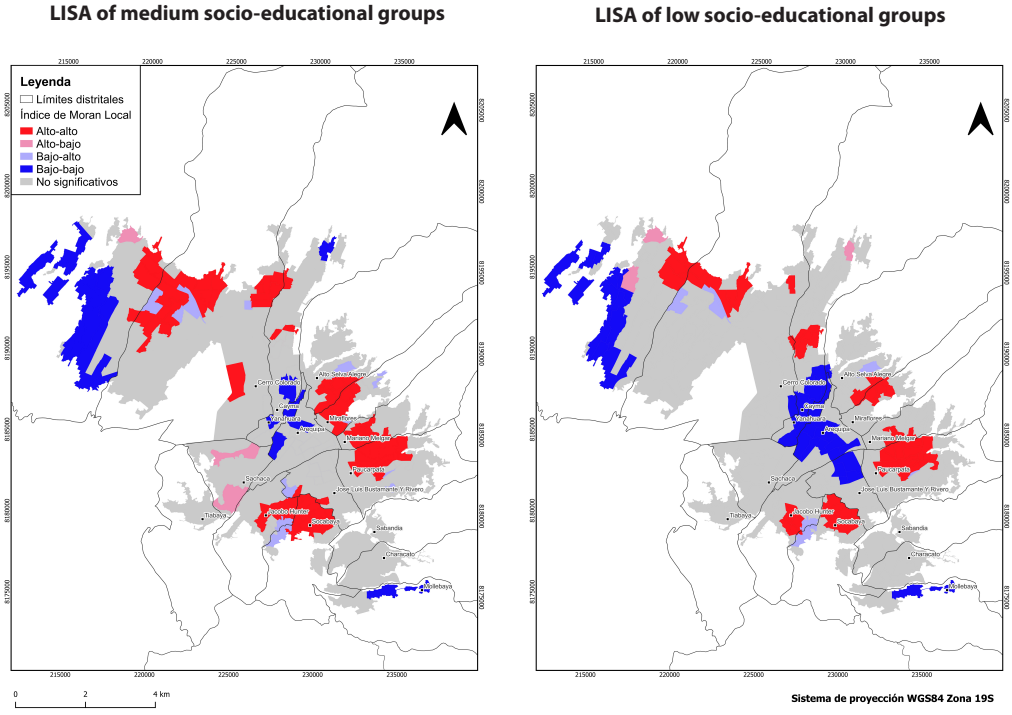

Figure 6. Agglomeration of middle and lower socio-educational groups in Arequipa, 2017. Source: CPV 2017 (INEI).

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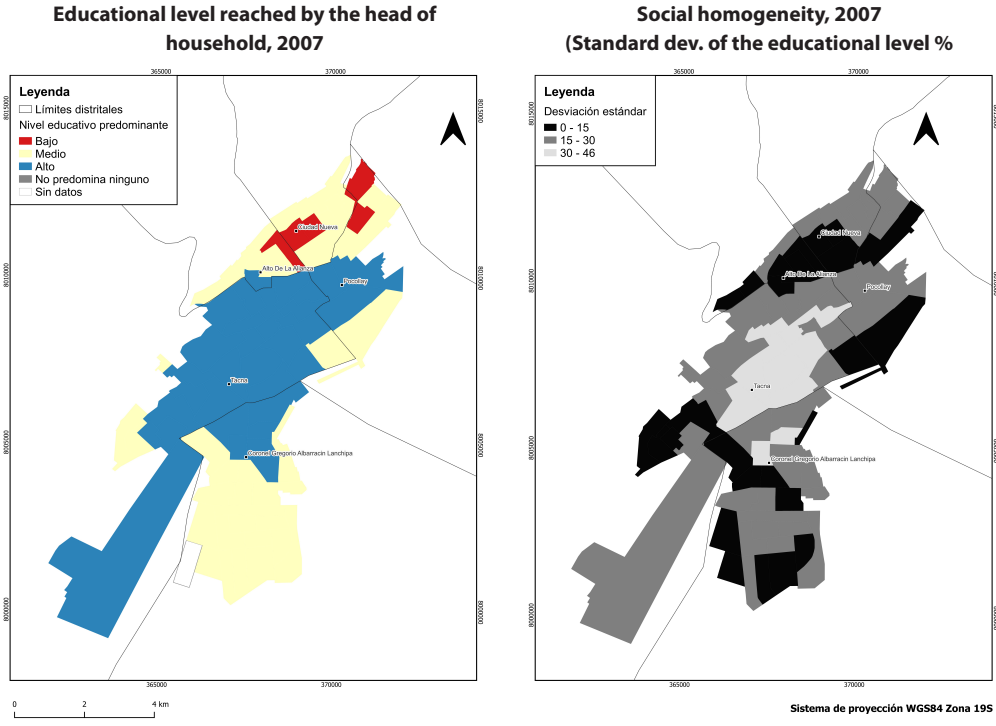

Figure 7. Predominant socio-educational group and social homogeneity in Tacna, 2007. Source: CPV 2007 (INEI).

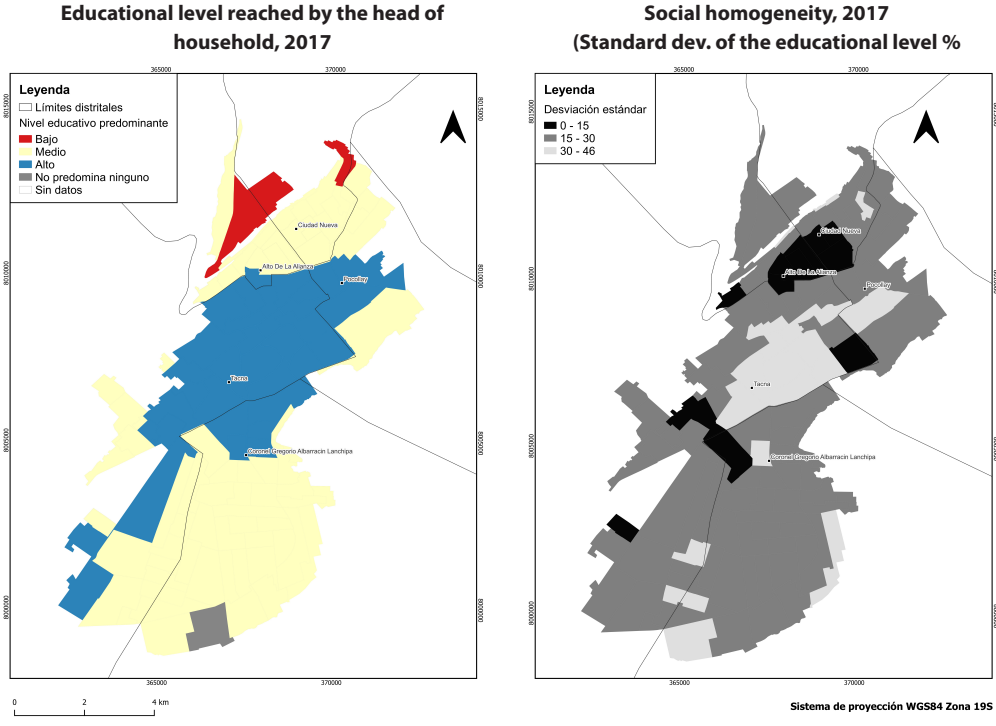

Figure 8. Predominant socio-educational group and social homogeneity in Tacna, 2017. Source: CPV 2017 (INEI).

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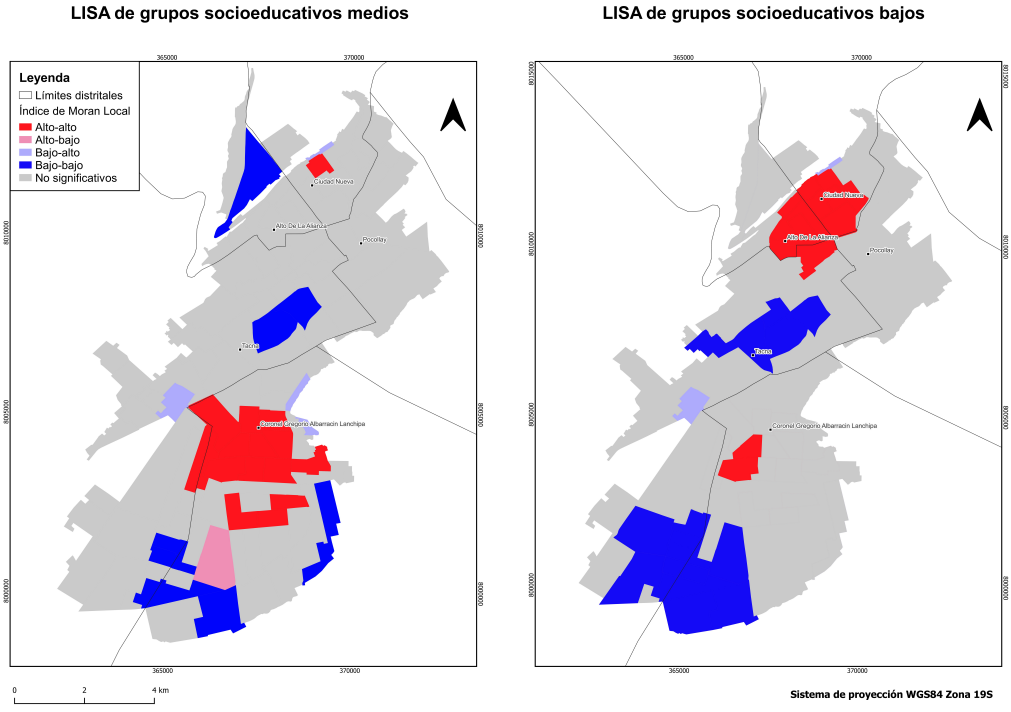

Figure 9. Agglomeration of medium and low socio-educational groups in Tacna, 2017. Source: CPV 2017 (INEI).

A similar spatial pattern was identified in the case of the cities of Tacna and Arequipa (Figure 7). By 2017, the high and homogeneous central sector expanded to the southeast (Cercado de Tacna) and the northwest (Pocollay) due to the real estate development of gated condominiums. On the other hand, the increase of the middle group was expressed in the frequency and more significant heterogeneity in the intermediate and peripheral cordon, with greater incidence in the south of the city (the district of Coronel Gregorio Albarracín). Likewise, sectors with very heterogeneous medium and low groups persist in the city's northern districts (Alto de la Alianza, Ciudad Nueva) (Figure 8). This pattern is confirmed by the results of the agglomeration nuclei of the medium and low groups located in the south and north, respectively (Figure 9).

VI. DISCUSSION

Unlike other studies, the results of the synthetic and spatial indices were complementary, demonstrating the importance of looking closer at using different types of indices to understand RS (Sánchez & Gómez, 2021). As well as in studies on non-metropolitan cities (Águila & Prada, 2020; Ruiz et al., 2021) and in metropolitan areas, such as Lima (Fernández de Córdova, Moschella & Fernández-Maldonado 2020), it was found that the RS follows an urban pattern of periphery where central sectors of upper classes and heterogeneous peripheral cordons are differentiated.

The cases of Arequipa and Tacna show how historical, institutional, and contextual factors define the urban pattern of urban segregation. In Arequipa, the historic center and its surroundings continue to undergo an urban transformation from a residence space to a space for commerce and tourism services (Meza & Condori, 2018). In addition, the results show that the number of upper-class residents decreased in the central area and increased in the agricultural land area due to real estate developments. On the other hand, the peripheral cordons diversify and include the growing middle class and the agglomeration nuclei of the lower class. It should be noted that the recent urban expansion occurs in sectors of non-mitigable risk and is characterized by rapid growth and low population density. On the other hand, Tacna shares the dynamics described previously, although it has variations according to its context. In particular, in the 21st century, the most

significant expansion occurred in the south of the city, which includes the growing middle class to a greater extent. In contrast, the north of the city widely concentrates the most vulnerable population and is exposed to dangers of natural and anthropogenic origin.

VII. CONCLUSIONS

It is concluded that RS patterns are associated with the production processes of working-class urban settlements in the 20th century. This is evident by the permanence of a large-scale urban pattern of segregation in both cities. However, the shift towards the service economic sector, particularly tourism, and the production of urban land for upper classes in rural areas close to urban centers give way to low-scale segregation. In this sense, the coexistence of two types of segregation in both cities is shown to be associated with contextual and territorial factors. This result was possible because a methodology that combines synthetic and spatial indices for RS analysis was applied. In the same way, the use of GIS allowed the identification that the recent urban expansions are taking place on risky land that cannot be developed, adding complexity to the management of this urban problem.

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