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Empty Urban Spaces and Socioeconomic Inequality: Issues That Converge on the Northern Border of Mexico

Vacíos urbanos y desigualdad socioeconómica: temas que convergen en la frontera norte de México

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ABSTRACT

Urban empty spaces can be understood as those vacant lands waiting to be built. In legal terms, its regime can vary between public and private. This article analyzes the nature of their geospatial distribution, examining the correlation between this urban phenomenon and the socioeconomic inequality of the population of three border cities in northern Mexico (Mexicali, San Luis Río Colorado, and Nuevo Laredo). A descriptive-comparative methodology was implemented based on statistical techniques and digital and physical surveys of the vacant lands in these cities. The results indicate that poverty levels and the number of empty urban spaces are directly related (positively correlated). In conclusion, a comparative discussion between the three cities is presented. Also, the main differences and coincidences identified are pointed out.

Keywords: 1. empty urban spaces, 2. socio-spatial segregation, 3. geospatial analysis, 4. poverty, 5. border cities.

RESUMEN

Los vacíos urbanos pueden ser entendidos como terrenos baldíos que se encuentran a la espera de ser edificados. En términos legales, su régimen puede variar entre público o privado. Este artículo analiza la naturaleza de su distribución geoespacial, examinando particularmente la correlación que existe entre este fenómeno urbano y la desigualdad socioeconómica de la población de tres ciudades fronterizas localizadas en el norte de México (Mexicali, San Luis Río Colorado y Nuevo Laredo). Se implementó una metodología descriptiva-comparativa basada en técnicas estadísticas, así como en levantamientos digitales y físicos de los terrenos baldíos de estas ciudades. Los resultados indican que el nivel de pobreza y la cantidad de vacíos urbanos se relacionan en sentido directo (correlacionados positivamente). Como conclusión se presenta una discusión comparativa entre las tres ciudades y se señalan las principales diferencias y coincidencias detectadas.

Palabras clave: 1. vacíos urbanos, 2. segregación socioespacial, 3. análisis geoespacial, 4. pobreza, 5. ciudades fronterizas.

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INTRODUCTION

Human beings' social and cognitive evolution has entailed an increasingly complex diversification of economic activities, which is reflected as a metamorphosis of the morphology of a large part of contemporary cities. In specific terms, some of the most significant urban changes over the XX century had to do mainly with the evolution of the means of transport and "the new ways of commercial interchanges that were introduced as industrialization arrived, in parallel a specifically industrial bourgeoisie appeared" (Lefebvre, 1975, p. 18).

Hence, economic interests have always been intimately linked to the development and typology of cities and in this way, the relocation of economic activities has changed their physiognomy (Pérez-Campuzano, 2011).

From the early XXI century, a clear prevalence of economic interests is noticed, which to a large extent is fostered by the political environment that has become a fundamental direction as regards territorial order and, therefore, urban morphology.

In this respect, Kozak (2011) points out that out of global liberalism, humankind has been driven by the endeavor of maximizing the environment, which has been reflected in the transformation that urban structures are experiencing; coincidentally, Brenner and Theodore (2002) point out that cities have become incubators of many of the main political and ideological strategies that support the dominance of neoliberalism.

If it is taken as a fact that the local and the global mutually constitute one another, two asseverations by Massey (2004, p. 82) come from such premise, on the one side, "local places are neither merely products nor victims of globalization", while on the other, "each place has a different mixture, an interweave of social relationships wherein a place may have a dominant position, whereas in others, it holds more or less subordinated places".

In this way, the analysis of economic and urban links has been usually studied by Urban Economy and from this standpoint, various authors have specifically reflected on the spatial location of areas with heavier poverty density in the cities. For example, Thomas (1990) specifically links poverty to the localization of urban edges; concurringly, Toro Vasco, Velasco Bernal and Niño Soto (2005) point out that relationships in chains of power perpetuate poverty in the periphery as well as underdevelopment.

Furthermore, there are also stances that oppose these asseverations; for instance, Martínez Chapa and Mazar (2007) mention that city centers have an increasing percentage of poor and elderly people as well as newcomers, most of which are immigrants from the countryside or localities where socioeconomic disadvantages prevail.

By and large, in this sort of theoretical-empirical analyses on urban morphology and urban economy there is usually a tendency to study the phenomenon from the standpoint of the behavior of the existing built environment. However, this has been negligible for few studies that focus on understanding the behavior of urban structures from the analysis of the

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empty space, free from buildings. In this regard, Kociatkiewicz (1999, p. 49) points out "emptiness is infinite as a form of time and as a form of space. It is not defined by any objective point, cognitive structures, habits, expectations. It is everywhere and nowhere".

There are many questions regarding the empty urban space in the cities. For instance, in the theoretical sphere there has been little reflection on the main reasons for an urban space to remain empty. At once, the magnitude of this urban topic is unknown in qualitative terms; that is to say, what is the density index of this sort of undeveloped plots in a city? What is their individual and total surface extension? Are these cases as a set related to the scale of the city? What is more, there is neither knowledge about the way they distribute and relate in the cities; do they have defined agglomeration patterns? Or else, do they merely distribute randomly across the urban environment?

It is worth mentioning few have been the studies in which the topic of empty urban spaces is addressed from a qualitative standpoint; some examples can be found in Bowman and Pagano (2000) and Gunwoo, Miller and Nowak (2018), who carried out various empirical analyses with a view to quantifying the individual and total surface in a number of American cities. Nevertheless, these works' analyses were only descriptive and statistical, without linking any social variable.

The present article has as a goal to provide some questions regarding the aforementioned urban geography with answers. In particular, the methodologic design tried to address the hypothesis stated in relation to ascertain whether the poverty ranges of the population can be considered a (qualitatively and spatially) factor linked to the number of empty urban places located in the following cities: Mexicali, Baja California; Nuevo Laredo, in Tamaulipas; and San Luis Río Colorado, Sonora, all of them in Mexico.

The results from the statistical techniques applied were the product of two sorts of analyses. On the one side, the spatial distribution of empty urban spaces and the sectors with the highest poverty index in each of the selected cities were studied (intraurban analysis); secondly, a debate was prompted with a view to comparing the similarities and discrepancies detected in the three cities (interurban analysis).

SOCIAL, ECONOMIC AND URBAN PARTICULARITIES OF BORDER CITIES

To understand the morphology of border cities in northern Mexico it is necessary to bear in mind that they started their urban development process by the end of the XIX century and the early XX, which is a significant chronologic lag if it is historically compared with cities in central and southern Mexico, where these experienced profound changes in their architecture and urban geography in the XVI and XVII centuries. Basically, a political, economic, and social model was imposed on the latter; this model's spatial dimension was

directly influenced by the urban layout guidelines of the Spanish conquest. This did not take place in the cities of northern Mexico; in words by Rajchenberg and Héau-Lambert (2007):

> […] the northern Mexican region was not immediately incorporated as a part of the territorial representations of the nation over the formative years of the State; on the contrary, such territory was called a desert, symbolized by cacti and full of legends about the untamed ferocity of the indigenous population (Rajchenberg & Héau-Lambert, 2007, p. 39).

This historic delay may help understand that presently the northern cities in Mexico have an architecture and urban morphology that is actually different from the usually observed in other Mexican cities, even Latin American. In this sense, Méndez, Rodríguez and López (2005) describe Mexican border cities as urban spaces where various urbanistic models concur; they are the result of a hybrid configuration of two different national models, one Mexican and another American.[3]

The authors above also underscore three characteristic elements present in each border city in northern Mexico: the international border line, a railroad, and a bridge or gate to enter into the United States. The urban layout of such cities is thus ruled by these three elements, composed of a center next to the border and the checkpoint, and on the basis of this, the urban layout is organized from concentric road patterns. In this manner, the urban morphology usually resembles a horseshoe or half a circle interrupted by the border line.

Nowadays, speaking of the border cities in northern Mexico means referring to various cities as a set, among which distinguishable are Tijuana and Mexicali, Baja California; San Luis Río Colorado and Nogales, Sonora; Ciudad Juárez, Chihuahua; Piedras Negras, Coahuila; and, Laredo, Reynosa and Matamoros, Tamaulipas.

In demographic terms, it is estimated that seven million people live in this group of cities at present (see table 1). In words by Díaz-Bautista (2003, p. 1091), "Mexico's northern border is a mix of economic, social and cultural realities comprised in several regions along 3200 kilometers of border line with the US".

In social terms, "not only does the concept of border entail the idea of separation, as it defines the limits proper to individuals and societies, but also the contrary, that is to say, the idea of relationship, for it links people and societies with particular historic and mental structures" (Lara Cisneros, 2011, p. 9). Recurrently, this sort of border cities "unify uneven and asymmetric realities generating new forms of labor, commercial or recreational articulation" (Valenzuela, 2014, p. 20).

An instance of this relationship is in the mobility of the labor force that everyday commutes to either side of the border, where it is common to notice there are people who

[3] The urban and architectural influence from the United States has been mainly linked to cities such as San Diego and Los Angeles, California; Tucson, Arizona; and El Paso, Laredo and San Antonio, Texas.

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sleep on the Mexican side and everyday go to work in American cities. This is usual, for example, between Tijuana and San Diego, Baja California and California; Ciudad Juárez and El Paso, Chihuahua and Texas; and also, between Nuevo Laredo and Laredo, Tamaulipas and Texas. This is a characteristic that normally leads to call these cities mirror or twin cities.

In this sense, Tambi (2016) describes this sort of border cities as those whose adjoining condition exposes them to integration, with steady bilateral ties; this way, they can develop a common agenda. Owing to this, Iglesias (2014) mentions the existence of a large amount of transborder processes that have generated an incredible interdependence level, in spite of the increasingly sophisticated control and militarization processes unfolded in recent decades.

It is necessary to recognize the existence of other sort of socioeconomic interactions in cities with no immediate neighbor with which they are able to properly emulate the bilateral dynamic of mirror cities; for example, perhaps in Mexicali the link with its closest cities, Calexico and El Centro, California, is not so clearly noticed. San Diego and Los Angeles are presently the largest attraction hubs in terms of employment. In parallel, in San Luis Río Colorado, this socioeconomic interaction mainly takes place with the city of Yuma, Arizona.

As a consequence, migration and transborder mobility are daily noticed the modification of social-spatial relationships; they have transformed the urban landscape, for after visiting the urban structures of the main border cities, a series of diverse unused spaces is commonly observed, be them empty urban spaces, derelict spaces and urban remnants. In this sort of cities it is common to notice there is a "spatial history of fragmentation, abandonment and lack of meaning; moreover, this complex process entails a sentiment of passivity and inactivity from the city dwellers. Throughout the urban layout there are large plots calling for recovery and meaning of existence" (Ceniceros, 2016, p. 19).

As regards the economic sphere, it is important to remark that in national terms, the GDP of the six Mexican northern border states accounted for 23.5 percent of the national total (INEGI, 2016), which makes their great economic importance evident. In this context, it is necessary to emphasize the role of the North America Free Trade Agreement (NAFTA) enacted on January 1st, 1994. This event was a milestone that boosted a transformation in the local economies of border cities to varying extents and even the development of urban structures:

> Such commercial agreement was an important stage in the consolidation and integration of the Mexican economy into the North American market and its insertion in the globalization process, creating comparative advantages in finance, trade, technology and manufacturing (Coubés, 2003, p. 8).

In this way, the economic vocation of the region has been transforming in a more significant manner over the last three decades. It is also worth clarifying there are standpoints that put forward that the benefits of NAFTA have not been homogeneous for all the border cities.

In this sense, Coubés (2003) points out that large cities such as Tijuana and Ciudad Juárez are on the benefitted side, in terms of economic growth and employment generation; whereas medium-sized localities such as Nuevo Laredo and Matamoros might be, by the same standards, the least benefitted. It is worth clarifying that this asymmetry between border cities must not be considered a direct consequence of NAFTA; it is also necessary to pinpoint that such differences are not only noticeable in economic terms, but also in the various poverty degrees observed in border cities (see table 1).

Table 1. Statistical demographic information and poverty ranges

Border city	Population (2020 projection)	Poverty range (%) 2015
Demographic scale: more than 1 000 000 inhabitants		
1. Tijuana, Baja California	1 789 531	29.50 %
2. Ciudad Juárez, Chihuahua	1 464 930	26.40 %
3. Mexicali, Baja California	1 087 478	25.70 %
Demographic scale: 400 000–1 000 000 inhabitants		
4. Reynosa, Tamaulipas	686 670	34.80 %
5. Matamoros, Tamaulipas	546 115	39.70 %
6. Nuevo Laredo, Tamaulipas	421 295	35.50 %
Demographic scale: fewer than 400 000 inhabitants		
7. Nogales, Sonora	268 801	23.90 %
8. San Luis Río Colorado, Sonora	226 478	40.30 %
9. Piedras Negras, Coahuila	177 255	28.40 %

Source: own elaboration from CONAPO (2020) and CONEVAL (2018).

The border cities with the lowest poverty rates are Nogales, Mexicali and Ciudad Juárez, whereas those with the highest were San Luis Río Colorado, Matamoros and Nuevo Laredo. These stats concur with the affirmations by Pick, Viswanathan and Hettrick (2001), Anderson and Gerber (2007), and Garza-Rodríguez (2016) that poverty at both sides of the border is much higher on the east than in the west (the exception is San Luis Río Colorado); this is noticed in Tamaulipas being the border state with the most poverty, while Baja California cities have lower levels of poverty.

DEFINITION AND THEORETICAL STANCES ON EMPTY URBAN SPACES

Speaking of empty urban spaces takes us to reflect on those undeveloped lands we daily observe in the urban landscape, on spaces still waiting to be given a formal use. In physical and practical terms, this would be to build in them or else, in the feasible cases, integrate them into the public life of the cities by turning them into green areas or spaces for coexistence. In order to grasp the urban landscape, it is vitally important to analyze the behavior between the spaces with constructions and those without. In words by Contreras

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(2005, p. 59): "landscape is not the result of spontaneous generation, not even of a single evolution process, therefore, studying the landscape disregarding its background is to condemn the study to immediately restricting its actual understanding".

The topic of empty urban spaces has been occasionally approached from the urbanistic standpoint as a manifestation of the antiurban space (Curzio, 2021; Doron, 2006; Maciocco, 2008; Trancik, 1986) for despite they are undeveloped plots that frequently seem to be forgotten by the urban imaginary and public policies, they are still urban spaces, that have no use and have become leftover spaces (Hasan, Rahman, Islam and Siddika, 2018).

In this sense, it is necessary to point out that terminology has to be carefully used in non-utilized urban spaces, for as Nefs (2006, p. 49) comments "in the case of built assets, vacant refers to abandoned buildings. Conversely, vacant lands have never had any form of occupation; in short, they are neither occupied by people, construction nor infrastructure".

One of the most complete definitions of empty urban spaces is to be found in Urbina (2002, p. 27), who points out that they are "objects with neither definition nor pre-established purpose, they are the residue, the negative; the undefined space in and in-between the limits and downtowns and their areas of influence, and whose functional composition does not take part in any of them". For its part, the American Planning Association defines empty urban spaces as "undeveloped plots that are not actively used for any purpose" (Davidson and Fay, 2004, p. 244). To reach a better understanding of the appearance of empty urban spaces, it is suggested observing image 1.

Image 1. Example of empty urban land, case A-MX-3510 in the city of Mexicali, Baja California, Mexico

Source: own image.

The specific study of empty urban spaces began formalizing after the second half of the XX century, particularly by Northam (1971). This author was one of the earliest to make theoretical contributions on this topic; in particular, he proposed a classification in which five different sorts of empty urban spaces were identified:

> (1) remnant plots, typically small in size and often with an irregular contour, thus far undeveloped; (2) plots with physical limitations such as steep slopes or at risk of flooding, and so not suitable for building; (3) private lands of corporative reservations usually kept for future expansions or relocations; (4) plots for real-estate speculation, frequently located in transition areas; and, (5) governmental plots reserved by public agencies for future developments, given the necessity and funding (Northam, 1971, p. 345).

Studies on empty urban spaces have been diverse in nature and from varied standpoints, maybe the analysis of their impact on urban image has been the most resorted approach. In this regard, Ceniceros (2016) emphasizes that the existence of empty spaces in the physical layout of the cities may make the urban image crack due to a lack continuity and fluid structure; this way, the image of the city these spaces produce is unconcluded and diffuse.

In line with the above in the sphere of urban landscape, Díaz Cruz (2015) proposes the concept of residual landscape; whereas Peimbert (2016) defines a parallel concept called interstitial landscape; while Riesco Chueca (2020) exposes the concept of distal landscape, which is characterized by lack of identity and inefficacy to link individuals.

The debate on empty urban spaces has also taken place regarding urban morphology and geography relating to the determination of their main distribution patterns. In this regard, Berruete (2017, p. 122) points out that empty urban spaces are defined as “spaces linked to the periphery of cities, places separated by urban dynamics”.

Even if it is true that usually empty urban spaces may be located at the fringes of urban structures, reality shows us there are some cases as well in which various sorts of undeveloped plots are usually in intermediate zones for the expansion of the urban fabric; indeed, this sort cases are the most attractive from the standpoint of real-estate commercial speculation. In this way, empty urban spaces are not something exclusive to periphery, but they can indistinctly appear in various city zones, even in city centers (Urbina, 2002).

Finally, there are theoretical contributions on specific topics related to empty urban spaces. For example, Pareja Lozano (2016) approaches the topic from the governmental standpoint, exposing, for example, various regulatory and juridical considerations; while Smith (2008), and Németh and Langhorst (2014) reflect on the possibility of integrating and harnessing this sort of undeveloped plots in the public life of cities. In Berruete’s words (2015, p. 32) these spaces might be seen as well as “transforming elements because from a negative standpoint these are areas which have not been integrated into the city yet. On the other side, from a positive perspective, they are places with chances to boost the reformation of depressed areas”.

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To sum up, empty urban spaces lack a shape; their surface may be polygonal, with a regular (e.g., rectangular) or a capricious morphology, i.e., irregular in geometric terms. Basically, they are vacant plots of varying dimensions; in legal terms, its ownership may be public or private. However, the common denominator is that these spaces are located in the urban structure and still waiting to be built upon, thereby, they are hollow, undeveloped, empty in the sense of not performing a function in social-spatial terms.

METHODOLOGY

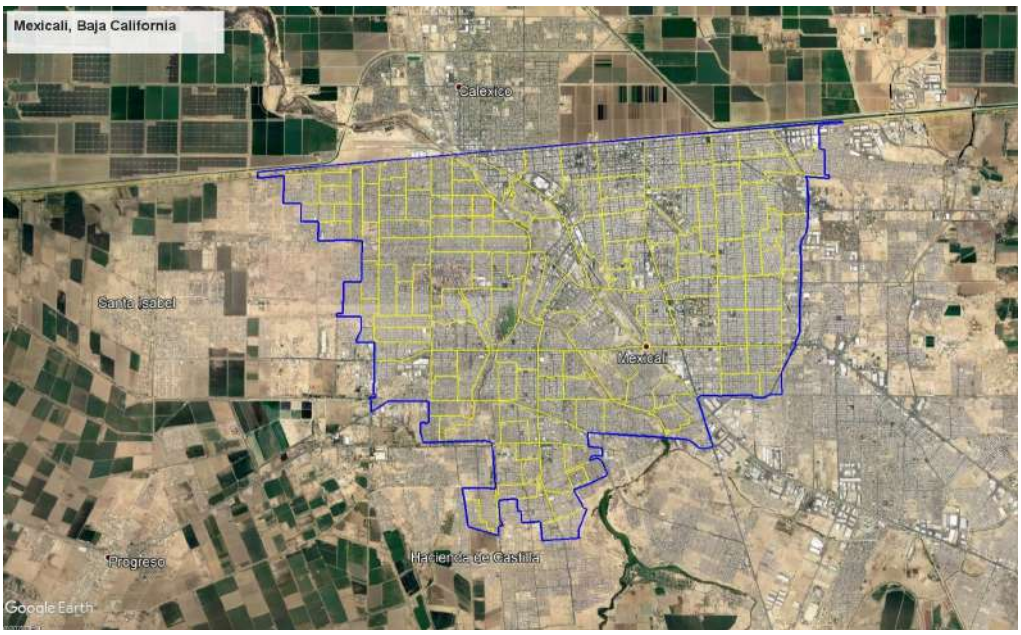
General description

The methodologic design is based on a correlational study of descriptive-comparative character; therefore, it has a selective nature. Likewise, it is worth pointing out that the research carried out was transversal as it is a practical case study undertaken within specific time frames. Information gathering was from November 2019 to February 2020.

For the purpose of the practical exercise hereby exposed, three cities were selected, which in addition to being at the border, have the singularity of having different demographic scales (see table 1). The above for the purpose that the analyses at geospatial and correlational levels manage to comparatively contrast the way empty urban spaces relate to poverty indexes in function of the demographic size of the selected cities.

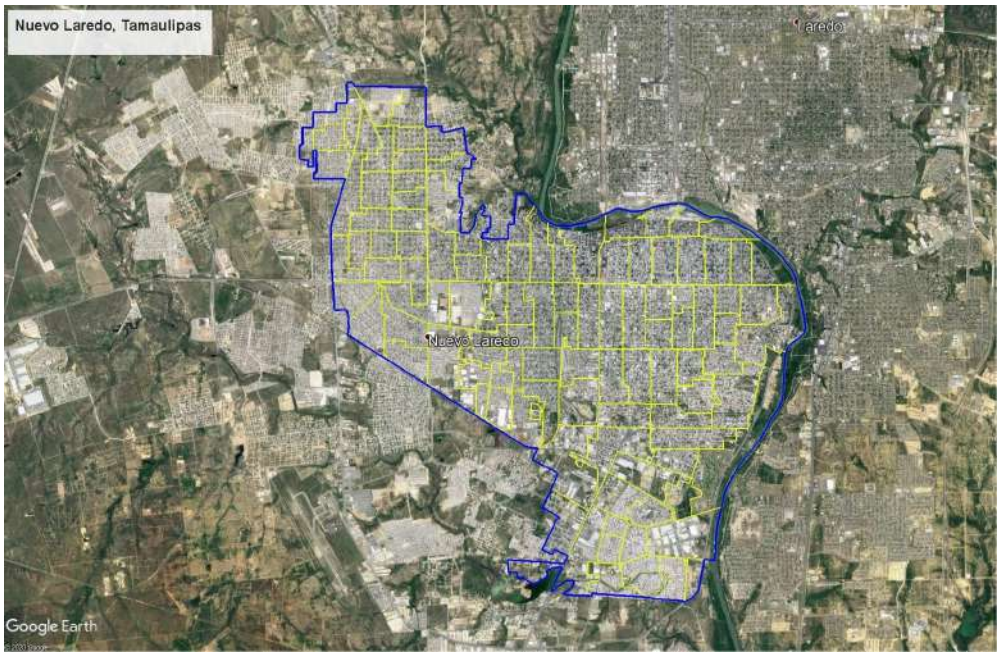
Firstly, Mexicali was chosen; located in the state of Baja California, it has a population estimated to be about 1 087 478 inhabitants (CONAPO, 2020). Nuevo Laredo was chosen next; located in Tamaulipas, it has a population of 421 295 inhabitants (CONAPO, 2020). Finally, the third city is San Luis Río Colorado, Sonora, with an estimated population of 226 4278 inhabitants (CONAPO, 2020). Later on, in each of the cities a set of Basic Geostatistical Areas (BGAs) was selected and integrated. In this way, a large polygon was produced to account for the geographic area under study in each of the cities (see images 2, 3 and 4).

Image 2. Limits of the study area in Mexicali, Baja California



Source: own elaboration based on information from INEGI (2016).

Image 3. Limits of the study area in Nuevo Laredo, Tamaulipas



Source: own elaboration based on information from INEGI (2016).

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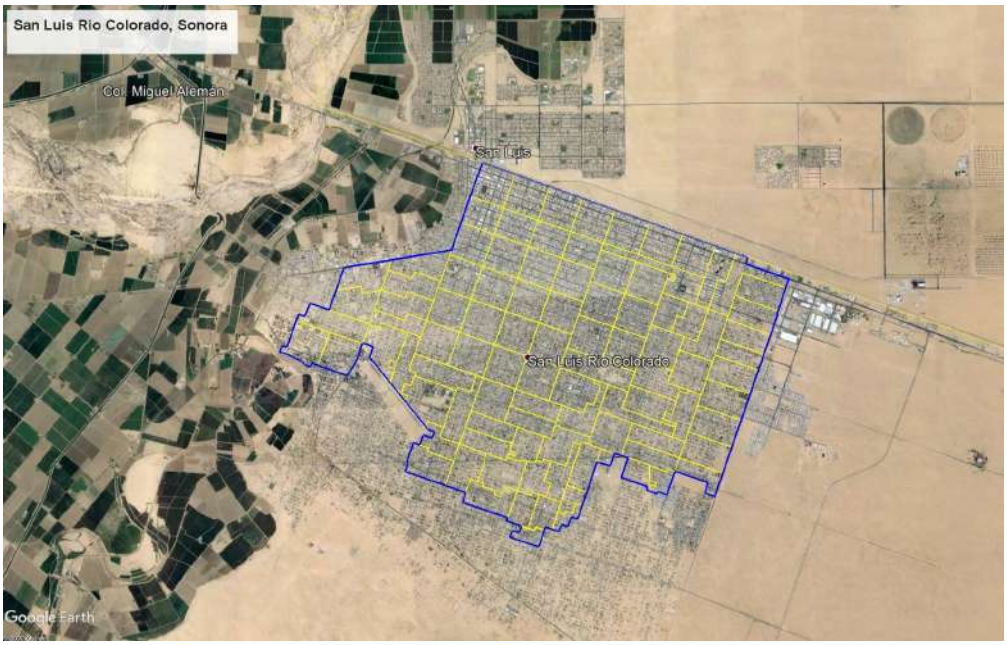
Image 4. Limits of the study area in San Luis Río Colorado, Sonora



Source: own elaboration based on information from INEGI (2016).

In this way, by means of interpreting orthogonal aerial photographs a digital surveying was carried out for each city, pinpointing specific cases, and outlining the perimeter of empty urban spaces detected. At once, four visits to each city were made for the purpose of verifying or discarding the information previously obtained from the digital surveying, and also including new cases found in the fieldtrips.

The information was integrated resorting to a computing program specialized in geographic information systems (QGIS 3.4.5) with a view to generating the maps. An independent database was built for each of the cities under study, which included the individual surface of each of the empty urban spaces. Each case study was classified on the basis of its dimensions; that is to say, empty urban spaces with a surface under 200 m^2 were considered *small scale*, while those between 200 m^2 and 500 m^2, *intermediate scale*; and spaces with a surface larger than 500 m^2 were classified as *large scale*.

By means of analyzing and interpreting the information in the databases above, statistics were generated in relation to the proportional percentages for the surface of each empty urban space and the surface of each BGA. As well, the density indexes of each BGA were calculated; that is to say, it was ascertained how many empty urban spaces there were per hectare in each of the study areas (expressed as empty spaces/hectare). This information was

analyzed and contrasted in a correlational manner with the poverty ranges expressed in the poverty report for Mexican municipalities in 2015 (CONEVAL, 2018). As a result of such study, *Consejo Nacional de Evaluación de la Política Social*, CONEVAL [National Council for Social Policy Assessment] publicly shared a comprehensive database with national results at the level of BGA, with a total count of 51 034 BGAs.

The aforementioned report on poverty bases on a methodology that retakes the modified vision of unmet basic needs and its relation to income; it is also substantiated by Gordon's (2002) proposal for poverty measuring in the United Kingdom. The methodologic design of such author had as a goal to identify the condition of poverty fundamentally based on two basic spheres exposed firstly by Sen (1976): on the one side, the problem of identification, and on the other, aggregation or measurement.

In order to solve the problem related to identifying the population in poverty situation, the methodology proposed approaching this sphere from two different dimensions: 1) the dimension associated to the sphere of economic welfare, which is operatively measured by the per capita current income indicator; and, 2) the dimensions associated to social rights such as education, health, social security, food, housing and related services (CONEVAL, 2010).

It is worth mentioning that owing to confidentiality, the poverty index calculated by CONEVAL is only provided in an aggregated manner; that is to say, only the poverty ranges by BGA are given.

Emphasizing on the BGAs with a poverty range over 50 percent, the behavior of the density indexes of the most impoverished areas of the analyzed cities was acknowledged. This parameter was chosen because in 2015, CONEVAL detected that 35.19 percent of BGAs had a poverty index over 50 percent and in those cases, more than a half of such population was in multidimensional poverty.

To decide on the appropriate statistical technique to run the correlational analysis between the density index and poverty ranges calculated by CONEVAL, firstly, the distribution of probability followed by the density index at the level of study and global area was studied by means of the Kolmogorov-Smirnov test. From this test, it was concluded that the density index did not follow any Gaussian distribution (also known as normal distribution) for any of the four scenarios (the three cities and a global analysis), therefore, the nonparametric Kruskal-Wallis test was resorted to. Later on, the post-hoc Dunn test was applied for multiple comparisons between the poverty ranges observed in the cities and at global level. The P-values obtained from these statistical tests were contrasted with a significance level $\alpha = 0.05$.

Criteria to select and classify empty urban spaces

It is worth pointing out that as commented by Nefs (2006), the main characteristic of empty urban spaces is that it is free from buildings, though the urban reality shows some specific

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cases that may account for a complex representation for they can hold some constructions oftentimes abandoned, ruins or rubble. In the face of this situation, the proposal by Northam (1971) was taken as a parameter, specifically for the purpose of researching empty urban spaces, those with up to 10 percent of any sort of derelict construction or ruins were considered (if the percentage surpassed 10 percent, they were no longer considered empty urban spaces, instead they were considered abandoned spaces).

As regards their use, these spaces are noticeable for not having a specific assigned use, though urban reality has demonstrated that undeveloped plots are given certain temporary uses by the population, for instance as venues for sports events, fairs, circuses, or expositions. However, after these events take place, the plots are left again. For further details on the sort of temporary uses, see Pareja Lozano (2016).

Furthermore, it is also necessary to mention the reflections by Smith (2008), which clearly refer the existence of empty and permanent spaces in zones where construction is forbidden; or else, that they may be temporary and the unwanted result of destruction, cleaning and abandonment processes. In this sense, it is worth underscoring that indubitably there will always be specific zones where there exists a legal regulation that forbids construction, for example in archeological sites, forest reserves and urban protected areas, in general. These areas were not considered empty urban spaces because they are not spaces waiting to have a use, at once, because this sort of protected areas does fulfill an established role in a city, this way they are not unused spaces.

RESULTS

Intraurban analysis of Mexicali

In the city of Mexicali, a study area that comprised 151 BGAs was defined. In terms of territory, it accounts for 7,435.83 hectares. A total of 6 282 empty spaces were located and recorded; they account for a density index of 0.84 cases per hectare. This way, it was also possible to ascertain the addition of all the individual surfaces of all the abandoned spaces, totaling 477.78 hectares, i.e., 6.43 percent of the analyzed area.

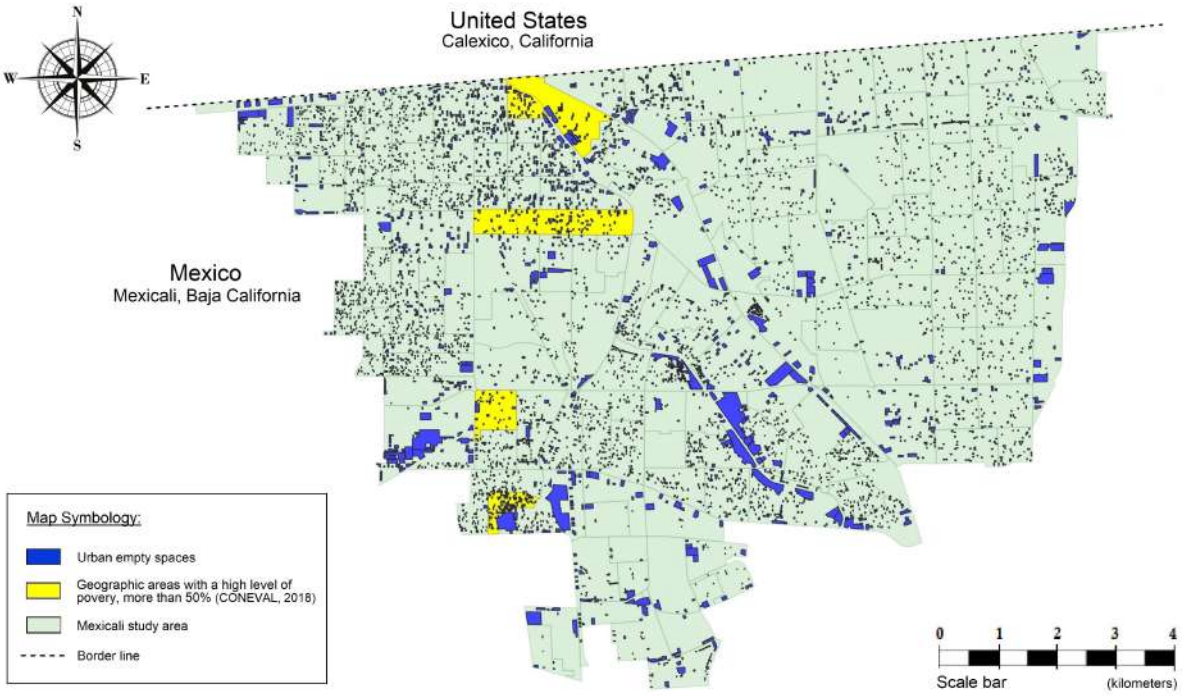
At the time of analyzing the scale of each of these empty urban spaces, it was determined that the average surface in Mexicali is 760.55 m^2; likewise, it was possible to identify that 1,324 cases (21.08%) were small scale, for their surface was under 200 m^2, while 3,494 cases (55.62%) were considered intermediate as they were between 200 m^2 and 500 m^2; finally, only 1,464 cases (23.30%) were large scale, that is to say, larger than 500 m^2.

As regards poverty, considering the ranges established by CONEVAL (2018), in each of the 151 BGAs it was possible to ascertain there is an average poverty range of 21.58 percent in the study area, and six BGAs had a poverty index over 50 percent (see areas in yellow in map 1). Although 319 empty urban spaces are located in areas with greater marginalization, they only accounted for 5.08 percent of the cases. In the six BGAs with a poverty range over

50 percent, the density index of empty urban spaces is 1.42 per hectare. Conversely, 4,702 cases were found in the 124 BGAs that were classified with the least poverty range (under 26%), which is 74.85 percent of the total cases. Nevertheless, in these BGAs, the density index was 0.75 empty urban spaces per hectare.

For its part, it was noticed that the spatial distribution of empty urban spaces across the city of Mexicali responds to fully defined agglomeration patterns; specifically, there is noticeable concentration on the northwest city, very close to the main border cross to Calexico, specifically in neighborhoods *Pueblo Nuevo*, *Santa Clara*, *Lucerna* and *Revolución*. With lighter intensity, in the southern part of the city, there are some agglomerations of empty urban spaces as well, in the neighborhoods *Hidalgo* and *Xochimilco*; by contrast, it is also visually noticed that the eastern part of the city clearly has a totally different distribution pattern than that of the western zone, for it is possible to notice fewer cases. For further reference see map 1.

Map 1. Distribution of empty urban spaces in Mexicali



NB: the representation of the spatial model shows the distribution of the 6,282 empty urban spaces in Mexicali. BGAs in yellow are the ones with the highest poverty range (over 50%).

Source: own elaboration based on information from INEGI (2016).

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Intraurban analysis of Nuevo Laredo

In this city, a study area that comprised 110 BGAs was defined, which in terms of territory was 4,597.87 hectares. Particularly, a total of 3,836 empty urban spaces were located and recorded, which means a density index of 0.83 cases per hectare; whereas the addition of the individual surfaces of all the empty spaces was 453.25 hectares, that is to say, 9.86 percent of the area under study.

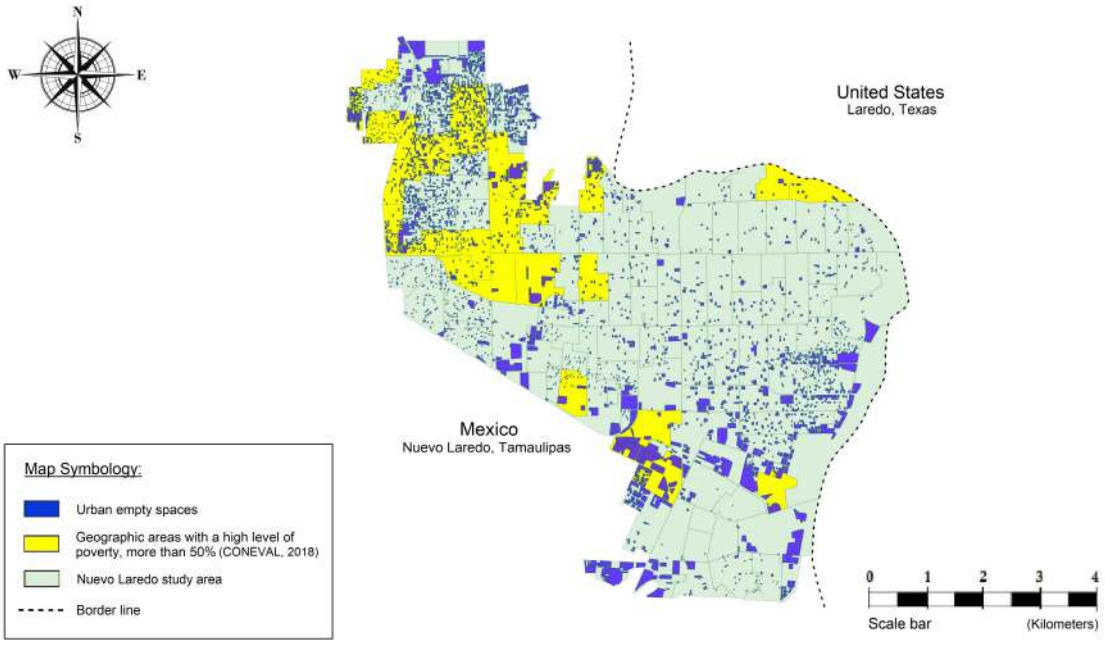
Taking the addition of each individual surface and dividing it between the total cases, the average surface extension in Nuevo Laredo was calculated as 1,181.57 m^2. It was possible to identify those 837 cases (21.82%) are small scale, that is to say smaller than 200 m^2; while 1,569 cases (40.90%) were intermediate (between 200 m^2 and 500 m^2). Finally, 1,430 cases (37.28%) were large scale (surfaces larger than 500 m^2).

As regards poverty, taking the ranges CONEVAL established for each of BGA as a basis, it was possible to ascertain that in the area there was an average poverty range of 34.22 percent; in particular, 22 BGAs have a poverty range over 50 percent (see yellow areas in map 2), and a total of 1,092 empty urban spaces were located in areas of greater marginalization.

As a percentage this is 28.47 of the total cases. In like manner, in such BGAs there is a density index of 1.22 empty spaces per hectare. Conversely, 1 564 cases were located in the 57 BGAs with the lowest poverty range (below the range of 26%), which as a percentage is 40.77 of the study cases; in such BGAs there was only a density index of 0.58 cases per hectare.

The distribution of empty urban spaces in Nuevo Laredo shows there were well-defined agglomeration patterns, particularly, a clear concentration in the northwest city, specifically in the neighborhoods *Bellavista*, *Bertha del Arellano*, *Buenavista*, *Voluntad y Trabajo*, *Los Garza* and *La Joya*. Conversely, it is also visually noticed that the areas closest to the border were those with the least cases. For further reference see map 2.

Map 2. Distribution of empty urban spaces in Nuevo Laredo



NB: the representation of the spatial model shows the distribution of the 3,836 empty urban spaces in Nuevo Laredo. BGAs in yellow are the ones with the highest poverty range (over 50%).
Source: own elaboration based on information from INEGI (2016).

Intraurban analysis of San Luis Río Colorado

In the city of San Luis Río Colorado, Sonora, a study area that comprises 97 BGAs was defined, which in terms of territory is 3,686.47 hectares. Within the study area, 3 686 empty urban spaces were located and recorded, this is an incidence rate of 1.00 empty urban space per hectare. The addition of the individual surfaces of the empty spaces accounted for 240.15 hectares, which is 6.51 percent of the analyzed study area.

Taking as a base the individual addition of each surface and dividing it between the total cases, it was defined that in San Luis Río Colorado the average surface was 651.51 m^2. It was possible to identify that only 44 cases (1.19%) are small scale; while 2,277 cases (61.77%), intermediate; finally, 1,365 cases (37.03%) were large scale.

In the sphere of poverty, after analyzing the ranges defined by CONEVAL (2018) for each of the 97 BGAs that composed the total study area, it was possible to ascertain there was a poverty range of 38.40 percent (see areas in yellow in map 3) and a total of 702 empty spaces were located in these areas of greater marginalization, in terms of percentage it is

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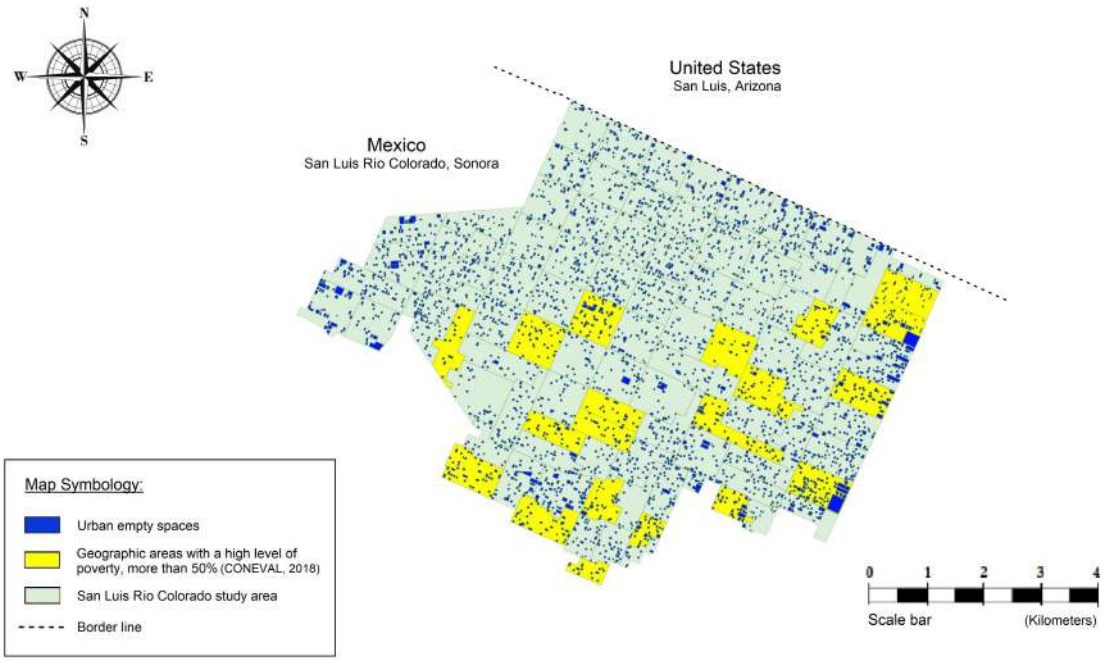
19.05. Likewise, in such BGAs there was density index of 1.03 empty urban spaces per hectare; on the contrary, 1 616 cases were located in the 39 BGAs with the lowest poverty range (under the range of 26%), which as a percentage is 43.84 of all the cases; concurringly, these BGAs had the same density index, i.e., 1.03 empty urban spaces per hectare.

As regards the spatial analysis of the distribution of the study cases in San Luis Río Colorado, it is possible to visually identify that no significant tendencies are noticed in relation to agglomeration patterns, though conversely, there is a random independent dispersion. Some light tendencies are noticeable on the western part of the city, where there seems to be a lower intensity of cases; on the contrary, toward the east it increases, specifically this trend is noticed in barrios *Campestre*, *Altar* and *Progreso*. It also noticed that in the areas closer to the border there was a lower intensity in the amount of abandoned spaces. For further reference see map 3.

Map 3. Distribution of empty urban spaces in San Luis Río Colorado



NB: the representation of the spatial model shows the distribution of the 3,686 empty urban spaces in San Luis Río Colorado. BGAs in yellow are the ones with the highest poverty range (over 50%).

Source: own elaboration based on information from INEGI (2016).

Comparative analysis at interurban level

After describing the individual results in each of the three cities, following an analysis aimed to describe the differences detected in the cities is presented taking as a ruling principle for the discussion the geospatial distribution of the empty urban spaces and their links with poverty index. To simplify this task, the appendix below that integrates such results is presented (See table 2).

Table 2. Appendix with the integration of results

		Mexicali	Nuevo Laredo	San Luis Río Colorado
Information on study area	Number of BGAs	151	110	97
	Total surface	7,435.83	4,597.87	3,686.47
	Poverty range (CONEVAL, 2018)	21.58%	34.22%	38.40%
Descriptive results of the empty urban spaces	Total cases located	6,282	3,836	3,686
	Density index (cases per hectare)	0.84	0.83	1.00
	Addition of individual surfaces (hectares)	477.78	453.25	240.15
	Percentage regarding the study area	6.43%	9.86%	6.51%
	Average size (hectares)	760.55	1,181.57	651.51
Information from poverty-related variables	Empty urban spaces in BGAs with high poverty ranges (over 50%)	319	1,092	702
	Percentage regarding the total cases	5.08%	28.47%	19.05%
	Empty urban spaces in BGAs with low poverty indexes (under 26%)	4,702	1,564	1,616
	Percentage regarding the total cases	74.85%	40.77%	43.84%
	Density index in BGAs with high poverty ranges (over 50%)	1.42	1.22	1.03
	Density index in BGAs low poverty indexes (under 26%)	0.75	0.58	1.03
	Difference between both incidence rates	+0.67	+0.64	0.00

Source: own elaboration based on the obtained results.

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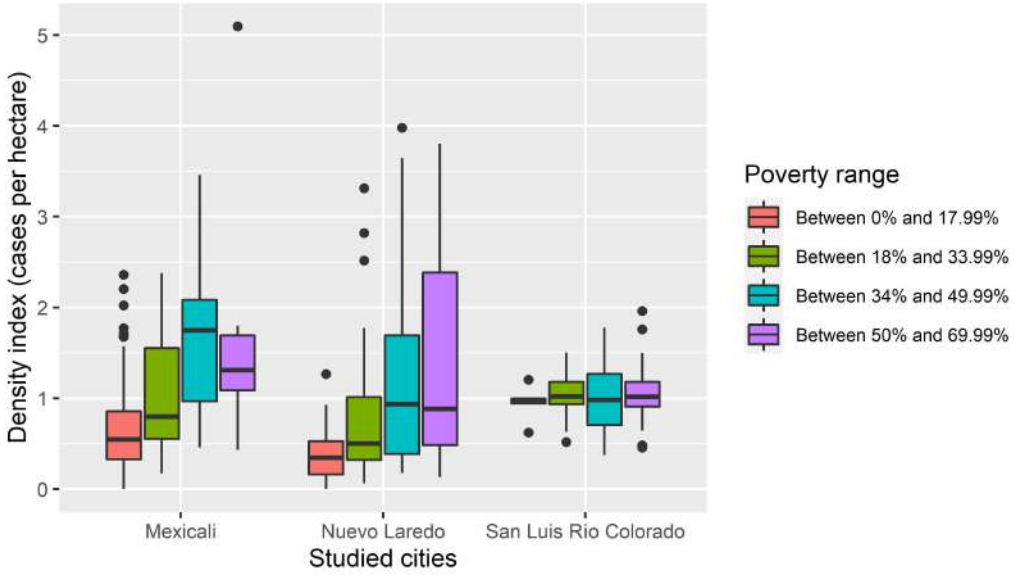
Taking the information above as a basis, it was possible to generate two graphs where the dispersion and symmetry of the obtained results is described. In graph 1, a comparison between density and empty urban spaces indexes (considering BGA as a measurement unit) contrasted against the poverty ranges defined by CONEVAL (2018) is observed. Such analysis is individually exposed for each of the three areas of study.

Graph 1. Comparison between the density indexes of empty urban spaces and poverty ranges

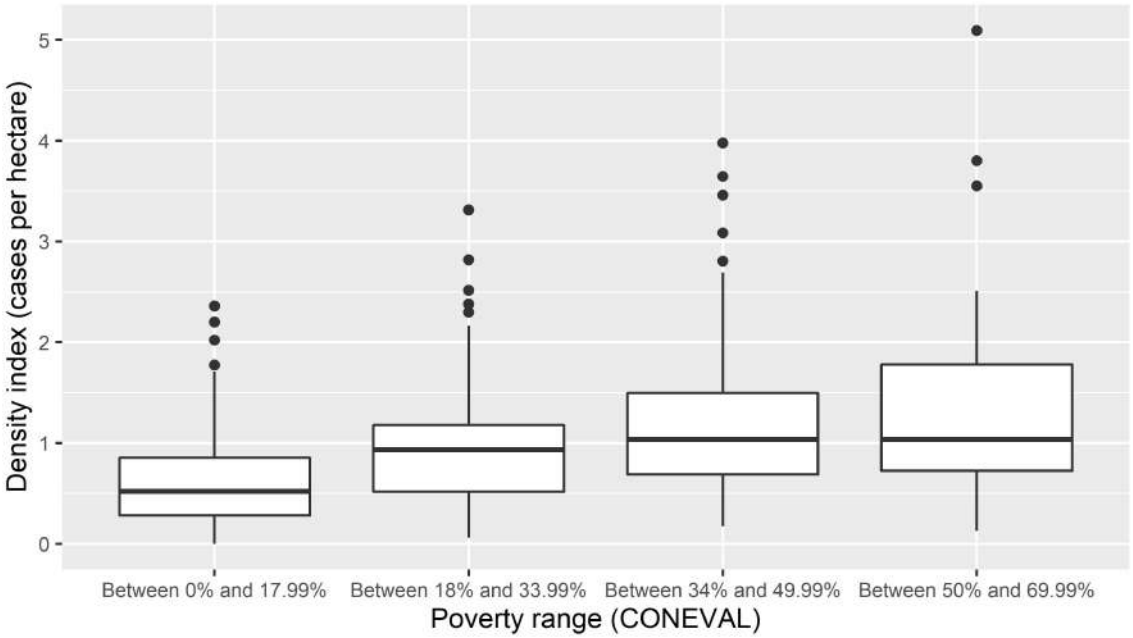


Source: own elaboration based on the obtained results.

Furthermore, it is also interesting to study globally and simultaneously the relationship between density index and poverty range in the three cities to understand the phenomenon in a more general manner. For such purpose, a box-and-whisker graph was produced (graph 2), which shows the analysis results for the 358 BGAs[4] in the three cities. In this graph, it is noticed that as the poverty range increases in the studied BGAs, the density index also does.

[4] When graphing the results, it was decided not to include BGA no. 2802700010192 for according to CONEVAL it is the only whose poverty range was between 70 and 100 percent.

Graph 2. Global comparison contrasting the density indexes of empty urban spaces and poverty ranges



Source: own elaboration based on the obtained results.

To ascertain if the increments observed in graphs 1 and 2 are statistically significant at individual and global level per city, the information was analyzed by means of a nonparametric test called Kruskall-Wallis. As a result of the application of this test, the values exposed in table 3 were obtained. In this table, it is noticed there is a difference between the density index per poverty range for Mexicali and Nuevo Laredo and the global average of the three cities. However, this was not the case for San Luis Río Colorado.

Table 3. Results of Kruskal-Wallis test

	Kruskal-Wallis Value	Degrees of freedom	P-value
Global (three cities)	50.352	3	~0.0000
Mexicali	34.199	3	~0.0000
Nuevo Laredo	16.041	3	~0.0011
San Luis Río Colorado	1.0867	3	~0.7803

Source: own elaboration based on the obtained results.

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After the application of Kruskall-Wallis test, the post-hoc Dunn test was also applied for multiple comparisons by pairs of poverty range groups. The results of these tests are shown in table 4.

Table 4. Results of the post-hoc Dunn test

	Comparison of poverty ranges	Z value	P value	Result
Global (Three cities)	From 0% to 17.99% vs 18% to 33.99%	-4.5996	0.0000	Different
	From 0% to 17.99% vs 34% to 49.99%	-6.3007	0.0000	Different
	From 18% to 33.99% vs 34% and 49.99%	-2.1542	0.0468	Different
	From 0% to 17.99% vs 50% to 69.99%	-5.4040	0.0000	Different
	From 18% to 33.99% vs 50% to 69.99%	-1.9594	0.0401	Different
	From 34% to 49.99% vs 50% to 69.99%	-0.2009	0.8407	Nondifferent
Mexicali	From 0% to 17.99% vs 18% to 33.99%	-3.3479	0.0024	Different
	From 0% to 17.99% vs 34% to 49.99%	-5.2960	0.0000	Different
	From 18% to 33.99% vs 34% and 49.99%	-2.7450	0.0121	Different
	From 0% to 17.99% vs 50% to 69.99%	-2.6602	0.0117	Different
	From 18% to 33.99% vs 50% to 69.99%	-1.2148	0.2693	Nondifferent
	From 34% to 49.99% vs 50% to 69.99%	0.3987	0.6901	Nondifferent
Nuevo Laredo	From 0% to 17.99% vs 18% to 33.99%	-1.8997	0.0862	Nondifferent
	From 0% to 17.99% vs 34% to 49.99%	-3.3211	0.0027	Different
	From 18% to 33.99% vs 34% and 49.99%	-1.6914	0.1089	Nondifferent
	From 0% to 17.99% vs 50% to 69.99%	-3.5109	0.0027	Different
	From 18% to 33.99% vs 50% to 69.99%	-2.0286	0.0850	Nondifferent
	From 34% to 49.99% vs 50% to 69.99%	-0.4882	0.6254	Nondifferent
San Luis Río Colorado	From 0% to 17.99% vs 18% to 33.99%	-0.7003	1.0000	Nondifferent
	From 0% to 17.99% vs 34% to 49.99%	-0.2496	0.8029	Nondifferent
	From 18% to 33.99% vs 34% and 49.99%	0.9180	1.0000	Nondifferent
	From 0% to 17.99% vs 50% to 69.99%	-0.4761	1.0000	Nondifferent
	From 18% to 33.99% vs 50% to 69.99%	0.3456	0.8756	Nondifferent
	From 34% to 49.99% vs 50% to 69.99%	-0.4319	0.9988	Nondifferent

Source: own elaboration based on the obtained results.

Observing the post-hoc tests at global level, it is noticed that only two groups of ranges with higher poverty levels have about the same density index value. All the other pairs of poverty level groups show significant differences in the density index. This hints that poverty is indeed related to density index, though the BGAs where poverty surpasses 34 percent have approximately the same indexes.

In Mexicali, only two pairs of groups displayed similarities in their density index level. On the one side, the group from 18 to 34 percent with the group from 50 to 70 percent; on the other, the group from 34 to 80 percent with the group from 50 to 70 percent. This indicates that poverty relates with the density index, while BGAs where poverty surpasses 18 percent have about the same density indexes.

In relation to Nuevo Laredo, only two pairs out of the groups of poverty showed differences in their density index level: on one side, the group that takes from 0 to 18 percent with the group from 34 to 50 percent; on the other, the group from 0 to 18 percent with the group from 50 to 70 percent. In the case of this city, it is observed that with a moderate increase in poverty –this is, it only increases within an observed range– there are no significant differences in density level. By contrast, when noncontinuous groups are analyzed, for example, groups from 0 to 18 percent and from 34 to 50 percent, there are noticeable differences. The above indicates that there is indeed a relationship between poverty level and density index, though such relation may be considered moderate.

Finally, no differences were observed between the pairs of groups of poverty in San Luis Río Colorado, which indicates that for this city in particular, no relationship was observed between density index and the poverty ranges observed in BGAs.

CONCLUSIONS

In its theoretical section, the present article contributes to produce a more complete vision about the meaning and main characteristics of the set of analyzed undeveloped plots, which are usually called empty urban spaces. Studying the nature of the spatial distribution of empty urban spaces contributed to offer another approach to the symbiosis between built and unbuilt environments. Particularly, it was verified that in the case of Mexicali and Nuevo Laredo the distribution of empty urban spaces does not show a homogeneous condition but on the contrary, in the urban sprawl of such cities there were very specific agglomeration patterns, where most of the cases concentrate.

Conversely, there are other areas of the city where the number of cases is negligible. However, in San Luis Río Colorado, there exists a very different spatial behavior, as the distribution of cases took place quite homogenously. The answer to this difference is closely linked to the scale of the city. In larger cities such as Mexicali and Nuevo Laredo, there is a wider variety of productive sectors in which housing and trade concentrate, which generally leads the population to inhabit such areas of the city, consequently, a difference in the urban

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morphology appears between the build environment and that which is not. Conversely, San Luis Río Colorado is a city with a smaller demographic scale, where there is not really a variety of productive sectors, thereby class segregation according to socioeconomic sector is not so noticeable. This situation is witnessed in the fact that population distributes more homogeneously across the city, in this way, the most marginalized sectors do not concentrate within specific areas.

Moreover, as a result of the geospatial analysis it was possible to notice the existence of a lower number of abandoned spaces in the areas close to the border. The answer to this phenomenon is that there is generally a higher capital gain in the areas close to the border strip. That is to say, this sort of plots has become more desirable to live and mainly establish businesses; in this way, they become high-gain areas, which are not usually overlooked by private capitals and under this logic it is understandable that there are few vacant lands.

It is worth pointing out there was an exception in neighborhood *Pueblo Nuevo*, located in Mexicali border strip. In this case, the high index of empty urban spaces may have a meaning owing to the migratory flows and depopulation that were vigorously fostered with the Bracero Program (1942 to 1964), which had as a goal to encourage Mexican labor force to cross the border in order to work legally in the US, mainly in productive agricultural activities (Vizcarra, 2019).

Furthermore, the results that come from the empirical exercise also demonstrated that in Mexicali and Nuevo Laredo there is a spatial correlation between empty urban spaces because it was possible to observe statistically significant differences in the density indexes between low and high poverty ranges (see table 4 and graph 1), which indicates that the areas with the most poverty are also those with a heavier concentration of empty urban spaces.

However, in the case of San Luis Río Colorado such indexes were exactly the same (1.03); this may be explained because in this city the study cases had an utterly different spatial distribution in comparison with the other cities. In San Luis Río Colorado no defined agglomeration patterns were observed; that is to say, empty urban spaces are distributed homogeneously, consequently, poverty also expresses this way, as the BGAs with higher poverty ranges also distributed randomly in the city. At global level, analyzing the three cities as a set, a spatial and statistical coincidence was found between these phenomena (if the density index of empty urban spaces increases, it is expected that the BGA poverty range also does). Such relationship was observed up to the range of poverty that reaches 34 percent; once surpassed no increment took place.

To sum up, the present article puts forward a specialized methodological design to try to understand the nature of the geographic distribution that empty urban spaces exhibit and the way they can be analyzed from various social variables. In this case, the analysis was carried out specifically on poverty, though there might exist future research lines related to other socioeconomic aspects of the population.

Translation: Luis Cejudo-Espinosa

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