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EDITORIAL Editorial

ANA ZAZO MORATALLA 1

El cambio climático y la planificación urbano-territorial chilena

En el ámbito internacional, el primer documento que reconoce por primera vez la existencia del cambio climático (CC) fue la Convención Marco de las Naciones Unidas sobre el Cambio Climático (CMNUCC) de 1992. Su objetivo era el de estabilizar las concentraciones de gases de efecto invernadero (GEI) a un nivel que impidiera interferencias antrópicas peligrosas en el sistema climático, lo que implicaba evitar que la producción de alimentos no se viera amenazada y que el desarrollo económico pudiera ser sostenible. El Protocolo de Kyoto (1997) puso en funcionamiento la CMNUCC comprometiendo a los países industrializados a limitar y reducir las emisiones de gases de efecto invernadero en conformidad a metas individuales comprometidas. Los objetivos impuestos suponían una reducción media de las emisiones del 5 % en comparación con los niveles de 1990 en el quinquenio 2008-2012. Actualmente, la comunidad internacional se rige bajo el Acuerdo de París (2015) que es jurídicamente vinculante y su objetivo es limitar el calentamiento mundial a 1,5°C en comparación con los niveles preindustriales. En el año 2020, todos los países comprometidos presentaron sus planes de acción climática conocidos como Contribuciones Determinadas a Nivel Nacional (CDN), entre los que se encuentra Chile.

En el marco chileno y con anterioridad a la presentación de la CDN, desde el ámbito del medio ambiente, y promovido desde el Ministerio de Medio Ambiente y más concretamente desde su División de Cambio Climático, ya se habían desplegado varios instrumentos estratégicos y normativos enmarcados en los acuerdos internacionales de CC. Ya en la década de 2000, Chile puso en marcha su primera Estrategia Nacional de CC (2006-2010) y su respectivo Plan de Acción Nacional de CC (2008-2012) que se centraban en abordar la mitigación de los GEI. En 2015, en paralelo a la ratificación del Acuerdo de París, Chile aprueba el Plan Nacional de Adaptación al CC que es la actualización de los planes de la década anterior. Este plan ya incorpora criterios de adaptación junto a los de mitigación y se concretan en el Plan de Acción Nacional de CC (2017-2022). Del Plan Nacional derivan diversos planes sectoriales, entre los que se encuentra uno de especial interés para el urbanismo: el Plan de Adaptación al Cambio Climático para Ciudades desarrollados entre en Ministerio de Vivienda y Urbanismo y el Ministerio de Medio Ambiente (2018). Este documento identifica las ciudades como parte del problema de las emisiones GEI a nivel global, pero también como parte de la solución, debiendo compatibilizar el fortalecimiento de las capacidades de adaptación con el de mitigación.

La gobernanza institucional vinculada al Cambio Climático se encuentra muy estructurada en el ámbito nacional. Existe un Equipo Técnico Interministerial de Cambio Climático (ETICC), constituido por los puntos focales de CC de diversos ministerios, y responde ante el Consejo de Ministros para la Sustentabilidad y el Cambio Climático. Finalmente, en el año 2022 se aprobó la Ley Marco de Cambio Climático, cuyo objetivo fue la de regularizar y ordenar las acciones e instrumentos normativos vinculados con el Cambio Climático. Esta ley reconoció y perfiló la estructura general normativa y de gobernanza preestablecida durante los 7 años anteriores.

Los documentos vinculados con el Cambio Climático derivados de este ámbito medio ambiental proponen la bajada de sus lineamientos y propuestas a la escala regional a través de Planes de Acción Regionales de Cambio Climático (PARCC) que deben adecuarse a las realidades regionales, así como la incorporación transversal de sus principios tanto en las Estrategias de Desarrollo Regional (ERD) como en los Planes Regionales de Ordenación del Territorio (PROT), instrumentos de desarrollo y planificación regional, respectivamente. A esta escala, también

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Figura 1, 2 Rampa Cuauhtémoc. Fotógrafa @maidaleon_photos

se propone la creación de Consejo Regional de Cambio Climático (CORECC) como espacio de gobernanza para la acción climática. Hoy en día, todas las regiones tienen los CORECC activos, cuatro regiones chilenas cuentan con Plan Regional de Cambio Climático y otras ocho los tienen en elaboración.

A escala comunal, se propone la bajada de las directrices del Plan Regional de Cambio Climático de forma transversal en los Planes de Desarrollo Comunal (PLADECO), dejando fuera los instrumentos de planificación locales como el Plan Regulador Comunal (PRC). Además, en concreto, propone el desarrollo de Planes de Acción Comunal de Cambio Climático (PACCC) que aborden las problemáticas locales y afronten los retos regionales y nacionales. El proceso vertical de bajada de estos instrumentos hasta la escala local ha sido lento, debido al tiempo de desarrollo que requieren los planes. Sin embargo, existen determinadas comunas que en el periodo 2015-2020 ya habían desarrollado este tipo de planes con el apoyo de la Red Adapt Chile y la Red Chilena de Municipios por el Cambio Climático, que canalizaron la participación en varios proyectos de la Unión Europea. A día de hoy, más de 100 municipios chilenos se han unido al Pacto Global de Alcaldes por el Clima y la Energía y buscan medidas urgentes para contrarrestar los efectos del Cambio Climático. La Asociación Chilena de municipalidades es la encargada de desarrollar la Estrategia Nacional de Acción Climática Local de Chile, que incluye medidas para apoyar a las ciudades miembros del Pacto para la realización de acciones climáticas concretas que apunten al cumplimiento del Acuerdo de París.

En el ámbito del urbanismo, la Politica Nacional de Desarrollo Urbano de 2016 (PNDU) aún vigente, a pesar de apuntar a cumplir el ODS 11 de ciudades inclusivas, seguras, resilientes y sostenibles, no incorpora criterios específicos de mitigación o adaptación al CC. El primer instrumento nacional de urbanismo que los incorpora es el Plan Nacional de Desarrollo Urbano (PNOT) de 2019, que plantea la necesidad del desarrollo de capacidades de resiliencia y adaptación de los asentamientos humanos y la infraestructura estratégica ante el riesgo de desastres y la adaptación al cambio climático, así como la incorporación de las funciones de los sistemas naturales como herramienta de mitigación ante amenazas y adaptación al CC y reducción del RDN. El PNOT orienta las políticas e instrumentos nacionales entre los que destacan aquellos con impacto directo en las ciudades como la Política Nacional de Desarrollo Urbano (PNDU) y el Plan de Acción Nacional de Cambio Climático (PANCC), así como el Plan de adaptación al CC para ciudades. Esto implica que en futuras versiones de PNDU deberán ser incorporados criterios de mitigación y adaptación al CC. En términos de su bajada a la escala regional, sus lineamientos deben incorporarse en las Estrategias de Desarrollo Regional (ERD), en los Planes Regionales de Ordenación del Territorio (PROT) y en los Planes Reguladores Intercomunales o Metropolitanos (PRI-PRM). En la escala local deben ser incorporados en los Planes de Desarrollo Comunal (PLADECO) y los Planes Reguladores Comunales (PRC).

Con el objetivo de impulsar la carbono-neutralidad de las ciudades, el Consejo Nacional de Desarrollo Urbano (actualmente CND Territorial) publicó en 2021 un documento titulado *Propuestas para avanzar a ciudades carbono neutrales y resilientes al cambio climático* que posiciona las ciudades como actor clave en la acción climática para alcanzar una convergencia y coordinación entre las diversas políticas públicas y sistemas de gobernanza. Sus dos metas apuntan a: (1) ciudades resilientes y adaptables al año 2050, y (2) ciudades carbono neutrales al año 2050, es decir, adaptación y mitigación. Para orientar la acción climática de las ciudades, este documento pone en el centro a la ciudadanía seguido por la gobernanza y la planificación. Posteriormente, en anillos concéntricos exteriores se identifican los campos desde los cuales enfrentar estas dos metas: resiliencia, infraestructura y ecosistema, adaptación, energía, movilidad sustentable, mitigación o gestión de riesgo de desastres. Las acciones para enfrentar los efectos adversos en las ciudades son muy heterogéneas y requieren de la coordinación de instrumentos e instituciones muy diversos.

Por ello, los gobiernos locales deben hacer uso y coordinar todos los instrumentos de escala local para poder alcanzar la mayor efectividad en la acción por el clima. Desde el ámbito del desarrollo y los planes sectoriales de CC, estos tienen la capacidad abordar muchas temáticas como la movilidad sostenible, la gestión residuos, o resiliencia alimentaria que hoy los instrumentos de planificación, por lo limitado de sus facultades, no pueden abordar. Estas líneas y acciones consiguen una efectividad medible a corto plazo y pueden alinearse con proyectos a otras escalas (regional, nacional o incluso internacional) para conseguir financiación. Por otra parte, a pesar de las limitaciones de las competencias de los PRC, estos han ido incorporando facultades en los últimos años a través de incentivos para incorporar materias vinculadas con la sustentabilidad, medio ambiente y cambio climático. Desde la perspectiva climática, el PRC regula ámbitos estructurales como las edificaciones, las áreas de riesgo, las medidas de mitigación, la infraestructura verde o las islas de calor, cuya efectividad es sólo medible en el medio y largo plazo. En ese sentido, resulta relevante identificar ambos tipos de instrumentos como complementarios en la acción por el clima local, tanto en términos de los niveles de actuación que pueden afrontar, como en términos de los plazos en los que se perciben sus resultados.

Finalmente, es importante resaltar que, además de aportar orientaciones sobre el tipo de lineamientos y acciones que las ciudades deben abordar para enfrentar los efectos adversos del cambio climático, el estado desde sus múltiples escalas y áreas de actuación debe asegurar el fortalecimiento de capacidades de los municipios en términos de mitigación y adaptación al cambio climático, así como apoyar o canalizar la financiación para poner en práctica políticas y acciones derivados de la planificación sectorial, de desarrollo o urbana.



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s SPATIAL-TEMPORAL ANAL OF HEAT ISLANDS APPLIED THE COASTAL CITY OF SAN FRANCISCO DE CAMPECH MEXICO¹

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La urbanización de la ciudad de San Francisco de Campeche influye en la formación de isla de calor urbano debido a materiales de construcción, edificios y estructuras, actividades humanas, falta de vegetación, e infraestructura de transporte. Las islas de calor tienen consecuencias negativas como aumento en el consumo de energía y un mayor estrés térmico en la población. Además, contribuyen al cambio climático debido al aumento de emisiones de gases de efecto invernadero, causadas por la demanda adicional de energía. Ciudades como Sídney, Beijing, Nanjing, Moscú y Hong Kong están implementando estrategias de planificación urbana que promueven la vegetación urbana, el uso de materiales de construcción reflectantes, la mejora del transporte público y la promoción de la eficiencia energética en edificios. Con el fin de identificar islas de calor se utilizaron imágenes satelitales Landsat. Se analizó el crecimiento de la población y la mancha urbana realizando un análisis de índice de vegetación. En relación con los análisis realizados, se identificó que la temperatura ha aumentado aproximadamente 6°C entre los años 1990 y 2022; así como ha disminuido la vegetación ante el crecimiento de la mancha urbana y las viviendas, cuadruplicando el Índice de Vegetación de Diferencia Normalizada (NDVI) en la clase 0-0.25. Finalmente, se proponen medidas de mitigación para contrarrestar los efectos que causan las islas de calor en la ciudad.

Palabras clave: islas, calor, ciudad, costa

The urbanization of the city of San Francisco de Campeche influences the formation of urban heat islands due to construction materials, buildings and structures, human activities, lack of vegetation, and transportation infrastructure. Heat islands have negative consequences such as increased energy consumption and heat stress for the population, contributing to climate change due to increased greenhouse gas emissions caused by additional energy demand. Cities such as Sydney, Beijing, Nanjing, Moscow, and Hong Kong are implementing urban planning strategies that promote urban vegetation, the use of reflective building materials, the improvement of public transport, and the promotion of energy efficiency in buildings. Landsat satellite images were used to analyze population growth and urban sprawl to identify heat islands, and a vegetation index analysis was also made. Regarding the analyses, it was recognized that the temperature increased by approximately 6°C between 1990 and 2022. There has also been a decrease in vegetation due to the urban sprawl and housing growth, quadrupling the Normalized Difference Vegetation Index (NDVI) in the 0-0.25 class for the same period. Finally, mitigation measures are proposed to counteract the effects caused by heat islands in the city.

Keywords: islands, heat, city, coastline

I. INTRODUCTION

Urbanization is one of the human processes with the most significant environmental and climate impact. 55% of the world's population lives in cities, which is expected to increase to 68% by 2050 (Ma et al., 2023). Harmful agents for health are emitted, which affect local meteorology. At the same time, urban growth, economic development, and changes in land use are also a threat to humans and the ecosystem (Xu et al., 2021), as cities contribute to global warming, mainly due to the effect of Urban Heat Islands or UHI.

For example, in the coastal regions of the world, the effect of the UHI is extreme, changing the regional meteorology with extreme heat waves and floods, and the phenomenon is expected to intensify (Qiu et al., 2023). In these regions, the complexity increases as a result of the sea breeze that leads the UHI several kilometers inland until its dissipation (Yun et al., 2020). It is necessary to understand the phenomenology to allow the formulation of policies supporting decisionmaking and scenario planning that consider: a) Analysis of the time scale; b) Inclusion of landscape and urban form, proportion of green and blue areas, improvement of the albedo, modal distribution of transport; c) Passive technologies in the building envelope; d) Active technologies considering artificial climate control; and e) Public health and citizen participation (Degirmenci et al., 2021). Therefore, focusing on urban decentralization, expansion control, green coverage rate, and building density will improve the thermal environment and air pollution (Luo & He, 2021).

Currently, there is a lack of knowledge about the spatio-temporal variation of the intensity of daytime and nighttime surface UHI. Similarly, resources still need to be improved to cope with the rapid impacts of urbanization. In recent years, satellite images have been used as an alternative to detect UHIs due to their availability, free access, and extensive registration history. San Francisco de Campeche is an essential region because it belongs to the World Heritage list and is located in a coastal area with rapid urbanization, so conducting a study focused on the UHI, using satellite images from the period 1990 – 2020, will quantify the historical changes in surface and atmospheric temperature, as well as changes in vegetation cover, to identify and characterize the UHI. It is also hypothesized that the results of this study will reveal the areas with the most significant changes in temperature and vegetation cover, thus providing a basis for proposing actions to mitigate the effects of UHI in San Francisco de Campeche.

II. THEORETICAL FRAMEWORK

Urban Heat Islands (UHI)

UHI are thermal anomalies resulting from the temperature difference between a surrounding urban and rural area, where the additional heat emitted increases the atmospheric temperature (Ortiz Porangaba et al., 2021). These increase summer cooling loads and consequent energy consumption, which leads to higher greenhouse gas emissions (Khare et al., 2021). This thermal process affects the population by increasing the local temperature and by releasing pollutants into the atmosphere and air pollution. Therefore, it is vital to understand how the components of cities relate to UHIs to establish improvement measures in the urban thermal environment and to reduce air pollution (Kim & Brown, 2021; Liang et al., 2021). With the rapid spread of urbanization worldwide, the urban heat island effect substantially and adversely impacts cities, including energy, environment, and health conditions. Unfortunately, constructive geometry and human activities severely intensify the phenomenon of UHIs (Xu et al., 2021).

It has also been observed that UHIs and air pollution are responsible for significant health impacts. According to a World Health Organization (WHO) report, indoor air pollution caused approximately 3.8 million deaths in 2016, and about 4.2 million deaths were attributed to air pollution in the same year. In addition, it is estimated that 91% of the population lives where the air quality index exceeds the limits of the WHO guidelines. Therefore, regarding the figures provided by the WHO, regulating urbanization could have two-way benefits (Singh et al., 2020). Urbanization coincides with notable environmental changes, including vegetation, soil, and climate (Vasenev et al., 2021). Therefore, understanding how the components of cities affect UHIs has become a great challenge for societies that seek to improve the quality of life through the implementation of urban planning criteria (Hidalgo García & Arco Díaz, 2021).

The selection of urban planning indicators such as building density, built area, and green coverage rate, among others, during the preparation phase for urban planning, can regulate the intensity of urban development and the configuration of the urban thermal environment after the application of the planning proposal (Luo & He, 2021). This understanding of the relationship between urban planning indicators and the formation of the term environment allows addressing, in greater detail, the thermal aspect in the planning stage, which helps optimize the urban



Figure 1. Location of the city of SFC, Mexico. Source: Preparation by the authors.

planning proposal to mitigate the effects of UHIs (Luo & He, 2021).

Even though urban areas face multiple environmental challenges interacting with climate change, including the UHI effect, vegetation can be a nature-based solution for UHI mitigation (Tan et al., 2021). The interaction of UHI in a coastal tropical city may be different from that of cities in temperate climate zone, affecting it severely. However, there is a lack of UHI studies focused on coastal tropical cities (Chew et al., 2021).

Internationally, some studies have been carried out worldwide in coastal cities such as those of Greece (Giannaros & Melas, 2012), Oman (Charabi and Bakhit, 2011), in the Caspian Sea (Firozjaei et al., 2023), Istanbul (Dihkan et al., 2015), China (X. Xu et al., 2023) and in the Mediterranean Sea (Kassomenos et al., 2022). However, studies are still emerging in Mexico and the Gulf of Mexico.

III. CASE STUDY

Case study: Campeche, Mexico

The study was conducted in San Francisco de Campeche (SFC) (19°50'41'N and 90°32'23'W), the State Capital of Campeche, Mexico, which is located on the Yucatan Peninsula, on the shores of the Gulf of Mexico (Figure 1). San Francisco de Campeche is a fortified historical city and one of the few walled cities in America. Its historic center and old neighborhoods have buildings dating from the sixteenth to the nineteenth centuries, including military, civil, and religious architecture. Given its historical and commercial context, the homogeneity of its architecture was declared an Area of Historical Monuments in 1986, and in 1999, it was included in the list of World Heritage of Humanity of the United Nations Educational, Scientific, and Cultural Organization (UNESCO).

It has an area of 3,410.64 km² with an average altitude of 5 meters above sea level (Figure 1). It is mainly characterized by a warm-humid climate with summer rains, which are distributed in three seasons: "Rains" (June-September), "Norths" (October-January), and "Dry" (February-May). The city's average annual temperature is 27°C, with maximum summer averages of 29°C and a historical maximum temperature of 43°C (INEGI, 2022).

Demographically, it has 294,077 inhabitants, 32% of the State's inhabitants, with a population increase of 25% in the last ten years (INEGI, 2020). This has led to unplanned urbanization, which originated from transforming land into housing areas, thus reducing the green areas within the city. These areas are identified as having UHI potential, generating an urban increase in the use of air conditioning, energy demand, and air pollution.

This type of urban growth pattern in San Francisco de Campeche is primarily associated with high energy consumption, which is why this city is considered a case study whose analysis will help generate a methodology that allows detecting and proposing exportable improvements to other cities with similar characteristics, such as addressing public health problems, improving energy efficiency, protecting the environment, and adapting to climate change.

IV. METHODOLOGY

To identify and characterize UHIs from a temporal perspective and to contrast them with population growth, it is proposed to break down the analysis into four phases: (1) Analyze the population growth of the city of SFC; (2) Quantify the historical temperature changes (surface and atmospheric); (3) Quantify the changes in vegetation cover; and (4) Identify the areas with the most significant changes in temperature, vegetation cover and the relationship between them. Therefore, the methodology analyzes four temporal elements: the Land Surface Temperature or LST, Normalized Difference Vegetation Index or NDVI, historical population growth, and analysis of the local temperature history, the latter to reinforce the analysis of temperature changes.

The historical climate analysis used data from the ERA5 model generated by the European Center for Mediumterm Weather Prediction and local weather stations. The population analysis is based on the region's demographic records.

Landsat satellite images, represented in spectral bands, were used to calculate the LST and NDVI. Due to the scarce information available and the precarious monitoring and observation systems of local environmental changes, these images are essential for analyzing and addressing environmental problems in Latin American cities. Landsat-5TM, Landsat-7TM, Landsat-80LI, and Landsat-90LI images were examined. They were obtained from the databases of the United States Geological Survey (USGS, no date). The study analyzed images between 1990 and 2020 in 5-year intervals associated with April to characterize the dry season, which is the hottest in the region.

Historical growth of the population of the urban conurbation area

Data were collected from population growth and its relationship with the urbanized area. These were collected from local records, such as the Municipal Urban Development Program of Campeche 2020-2040 (SEDATU, 2020), the Campeche Urban Development Director Program 2008-2033 (PDU, in Spanish), and the Municipal Program of Territorial Ecological Management (PMOET, in Spanish).

Earth's surface temperature

To obtain this data, images of band 6 were used for Landsat-5TM and Landsat-7TM, and band 10 for Landsat-8OLI and Landsat-9OLI. The calculation consists of 4 steps (X. Li et al., 2016) :

1. Spectral radiance $(L_A, W/(m^2 sr * \mu m))$ for TM images is obtained with Eq.1, where is the digital value of the pixel in a range of 0-255, and , the maximum and minimum values of the pixels in the thermal band, and and , the scaled maximum and minimum spectral radiances. For the OLI images, this was calculated from Eq.2 (considering radiation at the top of the atmosphere or TOA radiance), where was the correction for band 10, and *ML* and *AL* represented multiplicative and additive factors for the reheating of the radiance to a certain band.

$$L_{\lambda} = \left(\frac{L_{max,\lambda} - L_{min,\lambda}}{Q_{cal,max} - Q_{cal,min}}\right) * \left(Q_{cal} - Q_{cal,min}\right) + L_{min,\lambda}$$
(1)

$$L_{\lambda} = ML * Q_{cal} + AL - O_i \tag{2}$$

 Luminous intensity temperature or Bright Temperature (BT) Eq.3, where K1 and K2 are thermal conversion constants associated with the type of satellite image (TM or OLI).

$$BT = \frac{K2}{ln\left(\frac{K1}{L_{\lambda}} + 1\right)} - 273.15^{\circ}C \tag{3}$$

3. Land Surface Emissivity (LSE) Eq.4, indicates the average emissivity of an element on the land surface from the NDVI, where and are the maximum and minimum of the NDVI.

$$LSE = 0.004 * \left(\frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}}\right)^2 + 0.986$$
(4)

 Estimation of the LST, given by Eq.5, where is the wavelength of the emitted radiance (μm), h=; s is Boltzman's constant, and c is the speed of light.

$$LST = \frac{BT}{\left(1 + \left(\lambda * \frac{BT}{h * c/s}\right) * \ln(LSE)\right)}$$
(5)

Surface temperature time series

For this analysis, the temperature record from 1940 to 2023 was used, obtained from two sources:

From 1940-2022, from the ERA5 model (https://cds. climate.copernicus.eu), for air temperature records at 2 m above the Earth's surface to identify increases in the city over time. This value is calculated in one-hour intervals by interpolating between the lowest level of the model and the land surface. 2022-2023, from a multifunctional wireless weather station located within the city at the coordinates 19.85°N
– 90.50°W. The temperature data series was collected from October 2022 to April 2023, recording every 10 minutes.

Normalized difference vegetation index

1. This indicator checks the condition of vegetation from near-infrared (NIR) and red (R) bands from the Landsat images. Its estimation was made through the following formula Eq. 6 (H. Li et al., 2018):

$$NDVI = (NIR - R)/(NIR + R)$$
(6)

For the Landsat-5TM and Landsat-7TM images, spectral bands 4 and 3 were used for the NIR and R values, while for Landsat-8OLI and Landsat-9OLI, bands 5 and 6 apply. The NDVI values range between \pm 1.0, while green vegetation is between the values of 0.2-0.8 (Wang et al., 2020).

V. RESULTS

Analysis of historical population growth

Figure 2 presents the historical demographic growth, built housing, and impact on urban fragmentation in the city from 1950 to 2019 (last census). Figure 2 contrasts the city's population growth concerning built-up housing. Over the 70 years, the state's population has grown by 87%, with the highest increases occurring in 1970 and 2019. A third of the increase has happened in the last ten years. On the other hand, the number of housing units has grown even faster, increasing by 91% since 1980. In particular, real estate expansion has grown by 38% since 2000, which is associated with demographic growth. These results are linked to the increase in urban sprawl (Figure 2), a product of urban expansion to the south and east of the city. In the eighties and nineties, housing growth was concentrated in the southern and southeastern areas. Changes in land use are directly associated with the increase in land temperature.

Land surface temperature (LST)

Figure 3 compiles the LST maps from 1990 to 2020 in five-year intervals, cataloging the surface temperature in 5 color ranges: Blue (< 20°C), light blue (20-25°C), green (25-30°C), yellow (30-35°C), orange (35-40°C), and red (>40°C). During the nineties, the city did not exceed 25°C at a land level at the hottest time of the year, with the oldest and most central neighborhoods having higher temperatures,



Figure 2. a) Housing behavior and urban sprawl in Campeche (above), b) Housing behavior compared to the population of Campeche (below). Source: Preparation by the authors.

a product of the reduced urban sprawl. In later decades (2000-2020), the LST exceeded 30°C due to urban expansion to the city's surrounding areas. This is consistent with the emergence of housing neighborhoods in the east and west, which caused an expansion of 37% on forest land.

In the areas of the historical center and the east, an increase in temperature caused by deforestation was observed, exceeding 35°C. In addition, the tendency to generate zones that reach or exceed 40°C is interesting. This indicates that, in 30 years, a coastal city with a small population, such as the case study, has increased the land-level temperature by approximately 10°C.

To visualize the behavior of the temperature at ground level, information was extracted from 24 points identified with more significant change throughout the city for each of the



Figure 3. Land temperature maps for the case study: a)1990; b)1995; c)2000; d)2015; e)2020. Source: Preparation by the authors.



Figure 4. Information extraction points and Series for points 1 and 12. Source: Preparation by the authors.

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ANÁLISIS ESPACIOTEMPORAL DE ISLAS DE CALOR APLICADO EN LA CIUDAD COSTERA DE SAN FRANCISCO DE CAMPECHE, MÉXICO ROMÁN CANUL-TURRIZA, KARIANNA AKÉ-TURRIZA, OSCAR MAY-TZUC, MARIO JIMÉNEZ-TORRES REVISTA URBANO Nº 49 / MAYO 2024 - OCTUBRE 2024 PÁG. 8 - 23 ISSN 0717 - 3997 / 0718 - 3607



Figure 5. NDVI maps for the case study: a)1990; b) 1995; c)2000; d)2020; e)2022. Source: Preparation by the authors.

analyzed images (Figure 4). The graph shows the changes in temperature for points 1 and 12, with an average increase of 6°C from 1990 to 2020.

Vegetation analysis

The NDVI values were grouped into five vegetation classes: Very scarce (<0), scarce (0-0.25), reduced (0.25-0.50), acceptable (0.50-0.75), and abundant (>0.75), as can be seen in Figure 5. Figure 4 shows that, in 1990, the urban area was reduced and concentrated in the city center, with sparse vegetation dominating. However, a significant portion of what at that time represented the city's periphery (currently the southern and eastern areas) retained acceptable levels of vegetation. Five years later, a reduction in vegetation is visible in the east of the city, coinciding with the demographic increase and the number of buildings. In 2020, the reduction of vegetation extended to the south and southeast of the city, where more than 90% of the urban core is in the category of scarce vegetation, contributing to the rise in temperature.

Table 1 compiles the evolution of the NDVI in the last 20 years. The least frequent category that has been reduced the most is "very scarce vegetation," which has gone from 16.38ha to 0.38ha. On the other hand, the "scarce" category has been the most representative and the only one that has grown, while the extensions in the "abundant" vegetation category are almost imperceptible. During these two decades, there has been a tendency to reduce urban vegetation, putting the population at risk from the tropical climate heat waves without green areas or urban vegetation to cushion them. ANÁLISIS ESPACIOTEMPORAL DE ISLAS DE CALOR APLICADO EN LA CIUDAD COSTERA DE SAN FRANCISCO DE CAMPECHE, MÉXICO ROMÁN CANUL-TURRIZA, KARIANNA AKÉ-TURRIZA, OSCAR MAY-TZUC, MARIO JIMÉNIZ-TORRES REVISTA URBANO Nº 49 / MAYO 2024 - OCTUBRE 2024 PÁG. 8 - 23 ISSN 0717 - 3997 / 0718 - 3607

Classes			Area in Hecta	ares		
	1990	1995	2000	2015	2020	2022
<0	116.45	16.52	579.16	0.32	0.14	0.38
0-0.25	181.75	386.60	54.27	410.3	515.75	433.59
0.25-0.5	371.60	230.85	1.76	224.4	119.29	200.94
0.5-0.75	65.36	1.22	0	0.17	0.01	0.27
>0.75	0	0	0	0	0	0

Table 1. Details of the normalized difference vegetation index from 1990 to 2022. Source: Preparation by the authors.



Figure 6. Relationship between NDVI and LST for the case study in the years: a) 1990; b) 1995; c) 2000; d) 2015; e) 2020; f) 2022. Source: Preparation by the authors.



Figure 7. Temperature behavior in SFC in the different decades of study. Source: Preparation by the authors



Figure 8. Hourly temperature data series in the period January 1940 - December 2022. b) Series of annual maximum temperature values between 1940 and 2022. Source: Preparation by the authors.

When vegetation affects the distribution of the LST, a reasonable approach to determine the spatiotemporal changes is to identify the relationships between the LST and the NDVI. Figure 6 illustrates the negative relationship between the NDVI and LST values. Between

1990 and 1995, the LST values did not exceed 35°C, while the NDVI was distributed between 0.8 and -0.1 on average. This results in negative and very steep regression slopes, suggesting vegetation softened the thermal effect. The correlations tend to be more horizontal from



Figure 9. Data record of the climatological season; the date format is month/day/year. Source: Preparation by the authors.

2000 due to an increase in temperature values, which reach 40°C, and a decrease in noticeable vegetation, which acquires an average maximum NDVI between 0.4 and a minimum of up to -0.4. From 2015 to 2020, the NDVI values are grouped in intervals of 0 and 0.4, with some minimum values reaching -0.2 or 0.5. The temperature remains close to 40°C; in 2020, it even approaches 50°C. For 2022, the trend of the NDVI values is maintained, and a reduction in the (surface) temperature values is observed, reaching values close to 35°C. This reduction of the NDVI is indicative of deforestation due to the urban area's expansion and the temperature increases, which indicate the presence of UHIs in the city.

Surface temperature time series

The temperature data were acquired at a location in the coastal zone 15 km away from the city, derived from the resolution of the meshing of the ERAS model, corresponding to 0.25°C, at intervals of 28km. Figure 7 shows the temperature behavior from the annual perspective and the analysis in four specific decades (1950, 1970, 1990, and 2010). There has been a gradual increase in temperature since 1970, an increase in maximum temperatures in recent decades, and a decrease in minimum temperatures due to thermal warming in the region.

Figure 8 above shows the temperature series with an average value of 26.21 °C, a minimum of 14.01 °C, and a maximum of 36.95 °C, reached in 2020. According to the graph below, the maximum recorded value was 33.66°C in 1940, while in 2020, it was 35.83°C. Likewise, the series' trend line indicates that the temperature has increased by 1.30°C and reached highs of 34.66°C.

Figure 9 presents the data for October 2022 to May 31st, 2023, recording a minimum temperature of 16°C, a maximum of 40°C, and an average of 27.3°C. An upward trend is observed that begins in April and extends until the middle of May when the values reach 40 °C

VI. DISCUSSION

The results for the case study exhibit an interrelation between the lack of urban design and planning, which, together with the UHIs, results in high thermal retention of solar radiation impacting buildings, pavements, materials, and surfaces, a situation very similar to that reported by Tian et al. (2021). This also coincides with what was reported by Han et al. (2022), who find that coastal cities experience the most changes because emerging cities experience growth without policies or planning, causing rapid expansions in proportion, density, and regularity. This is contrary to cities with planned development, where more natural areas such as green surfaces and urban parks are built to improve the environment and reduce thermal stress. This supports the hypothesis that the analysis of population growth contributes to identifying the UHIs.

In the case study, the effect of UHIs is increased due to the relative humidity typical of coastal cities, which can vary from 60% to 100% throughout the day. For the case of Singapore, Chew et al. (2021) mention that relative humidity, being related to temperature increases during the day and night, indicates a daily variation of up to 3°C they also use data measured in the field with stations.

The use of images to identify the UHIs is widespread. For example, in the city of Thessaloniki, Greece (Giannaros & Melas, 2012), images were used to identify the UHIs. They also used temperature data measured at stations. However, Giannaros and Melas (2012) incorporated wind speed and thermal comfort into their analysis, finding variations of up to 4 °C.

On the other hand, the Landsat imaging application in the study conducted in Istanbul by Dihkan et al. (2015) stands out since they analyze the 1984 – 2011 period to find the LST, identifying the land uses/cover (LULC) and its temporal and spatial changes, finding a relationship between LST and LULC, which originate the HUS with temperatures close to 50°C. In the city of Muscat, Oman, the authors Charabi and Bakhit (2011) use meteorological observations to infer the spatio-temporal changes analyzed during one year. These studies support the hypothesis that

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satellite images can successfully quantify historical surface temperature and vegetation coverage changes.

The phenomenon of UHIs has adverse effects on the socialurban ecosystem, such as an increase in the electricity consumption in buildings, a reduction of thermal comfort, and a decrease in air quality, affecting the health of residents and leading to higher mortality. A recent study in the metropolitan city of Bangkok (Thailand) on physical factors driving the urban heat island found that the average annual temperature of a city with more than one million inhabitants is between 1K and 3K higher than that of the surrounding rural areas (Khamchiangta & Dhakal, 2019).

When the intensification of UHIs occurs, there is an increase in the mortality of children and older adults, as well as in respiratory and cardiovascular diseases and even cancer (Hidalgo García & Arco Díaz, 2021; Hidalgo-García & Arco-Díaz, 2023; Yao et al., 2022). Changes in land use patterns, combined with population growth and the heat generated by human activity, drastically alter the climate as Ullah et al. (2019) have evidenced. This situation is analogous to that observed in SFC, where land use changes, population and urban growth have changed the city's temperature.

The studies examined on UHIs agree that urbanization causes changes in the physical characteristics of the natural landscape and urban land use, resulting in the disappearance of large areas of vegetation and modifying the local climate (Zhao et al., 2011). In the San Francisco de Campeche case study, the NDVI allowed seeing the areas with the most changes, finding a relationship between the LST and vegetation coverage, similar to that of Hidalgo García & Arco Díaz (2021) and Hu et al. (2020), who associated NDVI with LST, finding a negative correlation; i.e., there is a reduction in NDVI values as LST values increase. This confirms the hypothesis that changes in vegetation cover will facilitate the identification of UHI areas.

In SFC, it is seen that the reduction in NDVI values is due to the construction of housing units. This can be compared with what is documented by Ciacci et al. (2022) that, in cities, the changes generated by the construction sector represent 27% of global greenhouse gas emissions. Therefore, diverse mitigation strategies have been proposed and applied to reduce the risk of UHIs. The ones that stand out are urban green spaces, green roofs, vertical greening or green walls, water bodies, cold materials, and changes in urban geometry (Ciacci et al., 2022). Planning and design that modify the characteristics of the surrounding environment could reduce the UHIs. Replacing trees and vegetation with less permeable material surfaces minimizes the natural effects of shading, water evaporation from the soil, and leaf evapotranspiration, so the reverse process would maximize them.

Studies have been conducted to maximize the natural effects of shading strategies, focusing on UHI mitigation measures and their impact on building energy consumption and outdoor thermal comfort (Tian et al., 2021). The implementation of sustainable urban infrastructure, sustainable rain management, and reduction of anthropogenic heat have been proposed, as well as the implementation of mitigation measures in construction, such as protection from solar radiation, minimization of heat infiltration, maintenance of thermal comfort, and the planning of urban areas together with urban development measures such as reforestation, green infrastructure, and reduction of anthropogenic heat (Leal Filho et al., 2017). In addition, it can influence public policies, certifications, and regulations, which allow, as well as the methodology applied in Europe on optimal profitability (European Parliament, 2010), outlining the most cost-effective measures to rebuild buildings, focusing on economic aspects or interventions to achieve an NZEB (Nearly zero-energy buildings) standard, or energy and environmental certifications in the urban environment. An example of them is the Italian regulations, which regulate the development of the urban environment to comply with the Kyoto Protocols, highlighting the role of trees (Ciacci et al., 2022). However, this lacks strategies, methodologies, regulations, and public policies that reduce the effects of UHIs.

In the last three decades, San Francisco de Campeche has experienced an increase in its temperature, which has resulted in a 40% increase in electricity consumption, as reported by SENER (2023), coinciding with what was pointed out by Tian et al. (2021) who indicate that, in countries with warm climates, every 1°C increase leads to a 1.66% increase in electricity consumption. Implementing any of the strategies above in the case study could substantially impact the thermal-urban environment if used primarily in the project's design stage.

Although no strategy for UHI reduction is applied in this research, some implemented in other regions that, due to SFC's characteristics, could be practical and replicable are proposed. An example of this is that urban greening can purify the air, regulate the temperature, and improve the urban ecosystem. On the other hand, urban green space lowers the air temperature, mitigates pollution, and reduces the energy used for cooling. The use of green roofs can influence the urban environment since they represent between 20% and 25% of a city's surface (Besir & Cuce, 2018). They can also reduce indoor temperatures on the top floor by up to 3.4°C (Tam et al., 2016).

In Hong Kong, a study on urban heat island mitigation strategies showed that with 60% green cover, the air



Figure 10. Intervention proposals. a) Before, b) Reforestation, c) Before, d) Green wall placement. Source: Preparation by the authors.

temperature could be reduced between 0.65°C-1.45°C and the annual energy savings were estimated at 3.4x10⁷kWh and 7.6x10⁷kWh, respectively (Peng & Jim, 2015). In the same way, green walls are smaller in size, have high aesthetic value, and can mitigate UHIs by reducing the wall's temperature to save energy, with thermal insulation provided by vegetation, cooling evapotranspiration, and screening against the wind. Pan and Chu (2016) showed that a green wall can save 16% of a building's energy consumption.

Figure 10 shows a before-and-after of a proposal to reforest an urban sector and the proposal to place a green wall in a house. The sector is on 59th Street, located in the historic center. This street connects the Puerta de Mar with the Puerta de Tierra of the walled city, becoming the city's most popular and crowded meeting point, the so-called "heart of the Historic Center of Campeche." The Figure's house represents the modern constructions in San Francisco de Campeche.

Finally, urban planning can improve the urban climate by meeting the needs of residents (Zhao et al., 2011). Together with urban design, this has a realistic environmental meaning and can mitigate the effect of UHIs in some urban regions by optimizing urban morphology (Q. Hu et al., 2016).

The size, geometric shape, and vegetation cover are the urban morphology factors that impact the thermal stress of the city (Liang et al., 2021)Given this, SFC requires urban planning that allows it to develop and decrease UHIs. The results of this study provide a watershed that will enable deepening the analysis of UHIs, from their origin to reduction strategies. This will be useful for urban planners (engineers, architects, among others), public health officials, and government actors.

VII. CONCLUSIONS

The UHI analysis has been consolidated as an indispensable component in understanding the current urban climate. This research reveals the importance of complementing traditional climate and weather studies, such as the agricultural calendar and rainfall periods, among others, with historical temperature analyses and satellite images. These provide a crucial perspective on addressing the challenges of unplanned urban growth. Integrating data on UHIs with urban planning and design observations is presented as a comprehensive approach to mitigating the adverse effects of disorganized urban development.

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The UHIs identified in the city of SFC focus on areas with a high density of urban infrastructure, where the presence of buildings is predominant and vegetation is scarce. This urban concentration has been associated with a significant increase in surface temperature, with a rise of 6°C recorded from 1990 to 2022. At the same time, a marked decrease in vegetation cover has been observed, quadrupling the values of the Normalized Difference Vegetation Index in the 0 – 0.25 class in the same period. These findings reflect an increasing trend in temperature, especially evidenced by the series of annual maximum values of the period.

The UHI in SFC is due to environmental degradation that currently disturbs the population's comfort, mainly in April. This increase in temperature causes an increase in electricity consumption to maintain thermal comfort, in addition to generating adverse effects on public health.

Additional variables that may influence the formation and intensity of UHIs are suggested. Relative humidity and wind speed are important factors that can modulate the effects of UHIs and should be considered in future studies. In addition, a detailed thermal comfort analysis provides a more complete understanding of how climatic conditions affect the subjective perception of temperature and human well-being. Identifying the periods of greatest discomfort and comparing these parameters during the day and night generates a more accurate assessment of the risks associated with UHIs and guides adaptation and mitigation strategies.

Ultimately, to effectively address the challenges caused by UHIs and to improve the quality of urban habitat, it is necessary to implement various political strategies, leading to the modification of public policies based on urban planning results, which considers short-term actions such as revegetation with local vegetation and the creation of green spaces, in addition to the incorporation of innovative interventions such as the development of green infrastructures and walls. By promoting urban vegetation and improving vegetation cover, air temperatures can be reduced, UHI's effects can be mitigated, and profitable and sustainable environments for urban dwellers can be generated. These interventions reduce energy consumption, improve urban biodiversity, and create recreational and functional public spaces.

In this way, UHI analysis emerges as a crucial research area to address the different challenges of disorganized urban growth. By integrating data on UHI with urban planning and design considerations, progress is demonstrated toward sustainable, resilient, and livable cities capable of mitigating the adverse impacts of urban development without control for present and future generations.

VIII. REFERENCES

Besir, A. B., & Cuce, E. (2018). Green roofs and facades: A comprehensive review. *Renewable and Sustainable Energy Reviews*, *82*, 915–939. https://doi. org/10.1016/j.rser.2017.09.106

Charabi, Y., & Bakhit, A. (2011). Assessment of the canopy urban heat island of a coastal arid tropical city: The case of Muscat, Oman. *Atmospheric Research*, *101*(1), 215–227. https://doi.org/https://doi.org/10.1016/j. atmosres.2011.02.010

Chew, L. W., Liu, X., Li, X.-X., & Norford, L. K. (2021). Interaction between heat wave and urban heat island: A case study in a tropical coastal city, Singapore. *Atmospheric Research, 247*, 105134. https://doi.org/https://doi.org/10.1016/j.atmosres.2020.105134

Ciacci, C., Banti, N., Di Naso, V., Montechiaro, R., & Bazzocchi, F. (2022). Experimentation of Mitigation Strategies to Contrast the Urban Heat Island Effect: A Case Study of an Industrial District in Italy to Implement Environmental Codes. *Atmosphere*, *13*(11), 1808. https://doi.org/10.3390/ atmos13111808

Degirmenci, K., Desouza, K. C., Fieuw, W., Watson, R. T., & Yigitcanlar, T. (2021). Understanding policy and technology responses in mitigating urban heat islands: A literature review and directions for future research. *Sustainable Cities and Society*, *70*, 102873. https://doi.org/10.1016/j. scs.2021.102873

Dihkan, M., Karsli, F., Guneroglu, A., & Guneroglu, N. (2015). Evaluation of surface urban heat island (SUHI) effect on coastal zone: The case of Istanbul Megacity. *Ocean & Coastal Management, 118*, 309–316. https://doi. org/ 10.1016/j.ocecoaman.2015.03.008

Firozjaei, M. K., Sedighi, A., Mijani, N., Kazemi, Y., & Amiraslani, F. (2023). Seasonal and daily effects of the sea on the surface urban heat island intensity: A case study of cities in the Caspian Sea Plain. *Urban Climate*, *51*, 101603. https://doi.org/https://doi.org/10.1016/j.uclim.2023.101603

Giannaros, T. M., & Melas, D. (2012). Study of the urban heat island in a coastal Mediterranean City: The case study of Thessaloniki, Greece. *Atmospheric Research*, *118*, 103–120. https://doi.org/https://doi.org/10.1016/j.atmosres.2012.06.006

Han, W., Tao, Z., Li, Z., Cheng, M., Fan, H., Cribb, M., & Wang, Q. (2022). Effect of Urban Built-Up Area Expansion on the Urban Heat Islands in Different Seasons in 34 Metropolitan Regions across China. *Remote Sensing*, *15*(1), 248. https://doi.org/10.3390/rs15010248

Hidalgo García, D., & Arco Díaz, J. (2021a). Modeling of the Urban Heat Island on local climatic zones of a city using Sentinel 3 images: Urban determining factors. *Urban Climate, 37.* https://doi.org/https://doi.org/10.1016/j.uclim.2021.100840

Hidalgo-García, D., & Arco-Díaz, J. (2023). Spatiotemporal analysis of the surface urban heat island (SUHI), air pollution and disease pattern: an applied study on the city of Granada (Spain). *Environmental Science and Pollution Research*, *30*(20), 57617–57637. https://doi.org/10.1007/s11356-023-26564-7

Hu, Q., Zhang, R., & Zhou, Y. (2016). Transfer learning for short-term wind speed prediction with deep neural networks. *Renewable Energy*, *85*, 83–95. https://doi.org/10.1016/j.renene.2015.06.034

Hu, Y., Dai, Z., & Guldmann, J.-M. (2020). Modeling the impact of 2D/3D urban indicators on the urban heat island over different seasons: A boosted regression tree approach. *Journal of Environmental Management, 266*, 110424. https://doi.org/10.1016/j.jenvman.2020.110424

INEGI. (2020). Panorama sociodemográfico de México 2020: Campeche.

INEGI. (2022). Aspectos Geográficos: Campeche 2021.

Kassomenos, P., Kissas, G., Petrou, I., Begou, P., Khan, H. S., & Santamouris, M. (2022). The influence of daily weather types on the development and intensity of the urban heat island in two Mediterranean coastal metropolises. *Science of The Total Environment*, *819*, https://doi.org/https://doi.org/10.1016/j. scitotenv.2022.153071

Khamchiangta, D., & Dhakal, S. (2019). Physical and non-physical factors driving urban heat island: Case of Bangkok Metropolitan Administration, Thailand. *Journal of Environmental Management, 248*. https://doi.org/10.1016/j. jenvman.2019.109285

Khare, V. R., Vajpai, A., & Gupta, D. (2021). A big picture of urban heat island mitigation strategies and recommendation for India. *Urban Climate*, *37*. https://doi.org/https://doi.org/10.1016/j.uclim.2021.100845

Kim, S. W., & Brown, R. D. (2021). Urban heat island (UHI) intensity and magnitude estimations: A systematic literature review. *Science of The Total Environment*, 779. https://doi.org/10.1016/j.scitotenv.2021.146389

Leal Filho, W., Echevarria Icaza, L., Emanche, V., & Quasem Al-Amin, A. (2017). An Evidence-Based Review of Impacts, Strategies and Tools to Mitigate Urban Heat Islands. *International Journal of Environmental Research and Public Health*, *14*(12), 1600. https://doi.org/10.3390/ijerph14121600

Li, H., Meier, F., Lee, X., Chakraborty, T., Liu, J., Schaap, M., & Sodoudi, S. (2018). Interaction between urban heat island and urban pollution island during summer in Berlin. *Science of The Total Environment, 636*, 818–828. https://doi. org/10.1016/j.scitotenv.2018.04.254

Li, X., Li, W., Middel, A., Harlan, S. L., Brazel, A. J., & Turner, B. L. (2016). Remote sensing of the surface urban heat island and land architecture in Phoenix, Arizona: Combined effects of land composition and configuration and cadastral–demographic–economic factors. *Remote Sensing of Environment*, *174*, 233–243. https://doi.org/10.1016/j.rse.2015.12.022

Liang, Z., Huang, J., Wang, Y., Wei, F., Wu, S., Jiang, H., Zhang, X., & Li, S. (2021). The mediating effect of air pollution in the impacts of urban form on nighttime urban heat island intensity. *Sustainable Cities and Society*, 74. https://doi.org/10.1016/j.scs.2021.102985

Luo, Y., & He, J. (2021). Evaluating the heat island effect in a planned residential area using planning indicators. *Journal of Building Engineering, 43*, https://doi. org/10.1016/j.jobe.2021.102473

Ma, Y., Lauwaet, D., Kouti, A., & Verbeke, S. (2023). A toolchain to evaluate the impact of urban heat island and climate change on summer overheating at district level. *Urban Climate*, *51*, 2. https://doi.org/10.1016/j.uclim.2023.101602

Ortiz Porangaba, G. F., Teixeira, D. C. F., Amorim, M. C. de C. T., Silva, M. H. S. & Dubreuil, V. (2021). Modeling the urban heat island at a winter event in Três Lagoas, Brazil. *Urban Climate*, *37*. https://doi.org/10.1016/j.uclim.2021.100853

Pan, L., & Chu, L. M. (2016). Energy saving potential and life cycle environmental impacts of a vertical greenery system in Hong Kong: A case study. *Building and Environment*, *96*, 293–300. https://doi.org/https://doi.org/10.1016/j. buildenv.2015.06.033

Parlamento Europeo (2010). European Parliament and Council of the European Union - Directive 2010/31/EU. Unión Europea.

Peng, L. L. H., & Jim, C. Y. (2015). Economic evaluation of green-roof environmental benefits in the context of climate change: The case of Hong Kong. *Urban Forestry & Urban Greening*, *14*(3), 554–561. https:// doi.org/https://doi.org/10.1016/j.ufug.2015.05.006

Qiu, J., Li, X., & Qian, W. (2023). Optimizing the spatial pattern of the cold island to mitigate the urban heat island effect. *Ecological Indicators*, *154*. https://doi.org/10.1016/j.ecolind.2023.110550

SEDATU (2020). Programa municipal para el desarrollo urbano: Campeche 2020-2040. Secretaría de Desarrollo Agrario, Rural y Urbano.

SENER (2023). Sistema de Información Energética. Secretaría de Energía. https://sie.energia.gob.mx/bdiController. do?action=cuadro&subAction=applyOptions

Singh, N., Singh, S., & Mall, R. K. (2020). Urban ecology and human health: implications of urban heat island, air pollution and climate change nexus. In *Urban Ecology* (pp. 317–334). Elsevier Inc. https://doi. orq/10.1016/b978-0-12-820730-7.00017-3

Tam, V. W. Y., Wang, J., & Le, K. N. (2016). Thermal insulation and cost effectiveness of green-roof systems: An empirical study in Hong Kong. *Building and Environment*, *110*, 46–54. https://doi.org/https://doi.org/10.1016/j.buildenv.2016.09.032

Tan, J. K. N., Belcher, R. N., Tan, H. T. W., Menz, S., & Schroepfer, T. (2021). The urban heat island mitigation potential of vegetation depends on local surface type and shade. *Urban Forestry & Urban Greening*, *62*, 127128. https://doi.org/https://doi.org/10.1016/j.ufug.2021.127128

Tian, L., Li, Y., Lu, J., & Wang, J. (2021). Review on Urban Heat Island in China: Methods, Its Impact on Buildings Energy Demand and Mitigation Strategies. *Sustainability*, *13*(2), 762. https://doi. org/10.3390/su13020762

Ullah, S., You, Q., Ullah, W., Hagan, D. F. T., Ali, A., Ali, G., Zhang, Y., Jan, M. A., Bhatti, A. S., & Xie, W. (2019). Daytime and nighttime heat wave characteristics based on multiple indices over the China–Pakistan economic corridor. *Climate Dynamics*, *53*(9), 6329–6349. https://doi. org/10.1007/s00382-019-04934-7

United States Geological Survey. (n.d.). http://earthexplorer.usgs.gov/

Vasenev, V., Varentsov, M., Konstantinov, P., Romzaykina, O., Kanareykina, I., Dvornikov, Y., y Manukyan, V. (2021). Projecting urban heat island effect on the spatial-temporal variation of microbial respiration in urban soils of Moscow megalopolis. *Science of The Total Environment*, 786. https://doi.org/https://doi.org/10.1016/j. scitotenv.2021.147457

Wang, R., Hou, H., Murayama, Y., & Derdouri, A. (2020). Spatiotemporal Analysis of Land Use/Cover Patterns and Their Relationship with Land Surface Temperature in Nanjing, China. *Remote Sensing*, *12*(3), 440. https://doi.org/10.3390/rs12030440

Xu, L., Wang, J., Xiao, F., El-Badawy, S., & Awed, A. (2021a). Potential strategies to mitigate the heat island impacts of highway pavement on megacities with considerations of energy uses. *Applied Energy*, 281. https://doi.org/10.1016/j.apenergy.2020.116077

Xu, X., Pei, H., Wang, C., Xu, Q., Xie, H., Jin, Y., Feng, Y., Tong, X., & Xiao, C. (2023). Long-term analysis of the urban heat island effect using multisource Landsat images considering inter-class differences in land surface temperature products. *Science of The Total Environment*, 858. https://doi.org/1btps://doi.org/10.1016/j.scitotenv.2022.159777

Yao, L., Sun, S., Song, C., Wang, Y., & Xu, Y. (2022). Recognizing surface urban heat 'island' effect and its urbanization association in terms of intensity, footprint, and capacity: A case study with multi-dimensional analysis in Northern China. *Journal of Cleaner Production*, *372*. https://doi.org/https://doi.org/10.1016/j.jclepro.2022.133720

Yun, G. Y., Ngarambe, J., Duhirwe, P. N., Ulpiani, G., Paolini, R., Haddad, S., Vasilakopoulou, K., & Santamouris, M. (2020). Predicting the magnitude and the characteristics of the urban heat island in coastal cities in the proximity of desert landforms. The case of Sydney. *Science of The Total Environment*, *709*. https://doi.org/10.1016/j.scitotenv.2019.136068

Zhao, C., Fu, G., Liu, X., & Fu, F. (2011). Urban planning indicators, morphology and climate indicators: A case study for a north-south transect of Beijing, China. *Building and Environment*, *46*(5), 1174–1183. https://doi.org/https://doi.org/10.1016/j.buildenv.2010.12.00

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PITRUFQUÉN, CHILE: THE CITY AS A STRATEGY FOR TERRITORIAL OCCUPATION¹

PITRUFQUÉN, CHILE: LA CIUDAD COMO ESTRATEGIA DE OCUPACIÓN TERRITORIAL

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El presente trabajo analiza el desarrollo de la ciudad de Pitrufquén (ubicada en la Región de La Araucanía, Chile, fundada en 1897) desde el punto de vista histórico, territorial, urbano y arquitectónico. Se plantea que el devenir de la ciudad se enmarca en un nuevo momento en que el Estado chileno abandona criterios militares y asume factores económico-territoriales donde la presencia del ferrocarril es determinante. La selección del lugar, su particular trazado, así como el desarrollo de su arquitectura, son evidencias de este cambio. Desde el punto de vista histórico, se analiza cómo en el sitio de Pitrufquén, la sociedad mapuche desarrolló la ganadería como actividad económica principal, al contar con praderas para alimentar el ganado, la tierra era apropiada para los cultivos agrícolas y se encontraba allí un importante vado para cruzar el río Toltén. La situación de punto estratégico, se mantuvo y acentuó con la fundación de la ciudad y la llegada de la vía férrea hacia el año 1898, convirtiéndose el poblado en punta de riel, en el avance hacia el sur del país. En el caso de la traza urbana, se abordó su peculiaridad ya que, junto a Lonquimay, constituyen en la región de La Araucanía las únicas tramas ordenadas en base a una elipse que, además en el caso de Pitrufquén, convive con una traza de damero. En el estudio se analizaron sus plazas, avenidas diagonales y la vía de circunvalación perimetral. En el plano arquitectónico, el artículo analiza las tres capas o aspectos de la ciudad: el primero, estudia una de arquitectura en madera con obras de fines del siglo XIX y comienzos del XX; el segundo se refiere a la arquitectura pública, representada por edificios como, la municipalidad, los servicios públicos, el correo y otros, y el tercero capa corresponde a la arquitectura moderna, como vivienda y comercio del período comprendido entre los años 1940 y1960.

Palabras clave: territorio, historia urbana, trama urbana, arquitectura en madera, arquitectura moderna, ciudades.

This paper analyzes the development of Pitrufquén (located in the Araucanía Region, Chile, and founded in 1897) from a historical, territorial, urban, and architectural point of view. It is proposed that the city's development is framed in a new moment, where the Chilean State abandons military criteria and assumes economic-territorial factors where the railroad's presence is a determining factor. The choice of the site, its particular layout, and the development of its architecture are evidence of this change. From the historical point of view, it is analyzed how, in Pitrufquén, the Mapuche society had cattle raising as the main economic activity, as it had pastures to feed the cattle, the land was suitable for crops, and there was a vital ford to cross the Toltén River. This strategic location was maintained and accentuated by the city's founding and the railroad's arrival in 1898, turning the town into a railhead for progress towards the south of the country. In the case of the urban layout, its peculiarity was addressed since, together with Lonquimay, these are the only sections in the La Araucanía region organized based on an ellipse, which, in the case of Pitrufquén, also coexists with a checkerboard layout. The study analyzed its squares, diagonal avenues, and the perimeter ring road. At an architectural level, the article explores the three layers or aspects of the city: The first one studies the wooden architecture with works from the late 19th and early 20th centuries; the second refers to public architecture, represented by buildings such as the municipality, public services, the post office, and others; and a third layer addresses the modern architecture, such as housing and stores from the period between 1940 and 1960.

Keywords: territory, urban history, urban fabric, wood architecture, modern architecture, cities.

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I. INTRODUCTION

During the second half of the 19th century, the Chilean State's occupation of the Araucanía was marked by military, economic, social, and urban aspects. These were mainly materialized by military fortifications, especially between 1862 and 1883. After that, one of the determining factors for the foundation and development of urban centers was marked by economic-territorial arguments, which were consolidated by the arrival of the railway and its expansion to the south of the country. In this context, Pitrufquén was founded in 1897, a stateplanned city in the heart of the Mapuche territory. This article seeks to address Araucania's urban development by studying this city, its strategic location before and after the occupation, and the imprint of its layout and architectural development in the 20th century.



Figure 1. Map of Chile with the location of Pitrufquén. Source: Bárbara Sáez Orrego 2023.

Figure 2. Map of Pitrufquén in the Araucanía, Chile, 1897. Source: Chilean Memory. "The state and municipal buildings plan"; 43 for the "Police station"; 47 for the "garrison"; 115 for the "hospital"; 1 for the "slaughterhouse"; 119 for a "lazaretto" or quarantine station, as well as part of the blocks 144 and 145, were declared "state properties" without defining their use; in a significant space of the town was the railway station.

As Wladimir Antivil (2017) has pointed out, in the Araucanía, it is possible to see three determining factors in its configuration and development: The installation of several lines of fortifications, the construction of the railway, and the division of rural land. "These can be defined as the built physical acts that largely determined the shape and physiognomy of Araucanía" (Antivil, 2017, p. 9), noting that "the lines of the forts and the railway stand out because these structures established most cities... the railway generating a new north-south vertical trunk, consolidating urban settlements" (Antivil, 2017, p. 9). The case of Pitrufquén fell into this logic, hence its interest as a case study.

It was hypothesized that Pitrufquén shows a new moment where a State and bureaucracy with greater capacity to intervene with an urban project in a recently incorporated territory is observed. This is expressed in the choice of where to install the "city" that, far from the military criteria typical of the late 19th century, privileged its strategic location for the development and economic articulation of the railway. This strong State can also be glimpsed in the type of urban layout. Unlike the traditional colonial checkerboard cities, a radial urban model was used that sought to establish its presence and consolidate the occupation of Mapuche space through a new order that was planned, with limited borders and a defined figure, establishing a new way of city-making in the Frontier or the Araucania territory (Figure 1 and Figure 2).

II.THEORETICAL FRAMEWORK

The State, the territory, and the city

From a theoretical point of view and the perspective that the research is addressed, at least four concepts were considered fundamental for a thorough understanding of the phenomenon under study: Geographical space, territory, State, and modern project.

Geographical space is not immutable (Craib, 2004) but rather a social construct resulting from the historical processes in which internal and external elements act as articulators and disarticulators. For Santos (1990), space constitutes a field of forces of unequal acceleration that particularizes places, changing with historical processes. Therefore, it can be assumed that "space is a social act, a social factor and a social instance" (Santos, 1990, p. 146). This long-term dimension of the territory, "overloaded as it is with numerous fingerprints and past readings," makes it seem more like a "palimpsest" (Corboz, 2004). The capitalist mode of production uses the existing space (waterways, sea, land, railways, air), disintegrates it, and restructuring the previous organization creates a new space, a produced space (Lefebvre, 2013). The meaning of territory is the space given by the people who exercise sovereignty over it. It is possible to think that this does not constitute a fixed fact. History leaves its mark on the territory, and in the case of the Araucanía, the city constituted one of the most remarkable marks, product and producer of a profound State-led territorial transformation from the second half of the 19th century.

Charles Tilly (1990) suggests that the association between State and city constitutes a binomial present throughout, at least, the last millennium in Western history, in such a way that it is possible to think that the establishment of urban centers in the Araucanía is directly linked to the need to establish "State" or that the installation of the Chilean State is consubstantial to the foundation of cities in that territory. In this sense, the foundation of cities is an expression and concretization of the idea that "the State is made by doing" (Bourdieu, 2014, p. 175), making it possible to increase statehood, that is, the State's ability to be a State (Oszlak, 2012).

In the Araucanía, "the city, as the materialization of the modern project, is the space where the political power and the commercialization and production centers are established territorially" (Alvarado, 2015, p. 111). Alvarado conceptualizes these specific urban formations as "colonial cities" where "colonial relations based on economic, political, cultural, class and socio-racial hierarchies operate" (Alvarado, 2015, p. 114).

During the second half of the 19th century, the Frontier, as the Araucanía is also called, underwent intense transformations that substantially modified the physical, political, social, and economic landscape (Pinto, 2021; Correa, 2021; Marimán, 2019; Flores, 2013). By 1900, the change in understanding the Mapuche territory and space was remarkable, accentuated further during the 20th century. The Chilean nation-state deployed different devices and tools on the territory that made this mutation possible. Religious missions, military expeditions, transport and communication routes, the arrival of the "new inhabitants," the arrival of national institutions and officials, and the foundation of cities also had an impact. This task of building a national territory led to the need to incorporate indigenous spaces into this new logic. A process that, at the same time, dismantled the existing "Mapuche territoriality" and sought to build the new "Chilean territoriality" where cities were decisive (Alvarado, 2015; Flores, 2019; Escalona & Olea-Peñaloza, 2022).

The Mapuches resisted the state's presence, materialized in forts and missions. However, the indigenous military defeat between 1881 and 1883 left fewer obstacles to establishing and developing urban centers, which were decisive in developing an agricultural economy. This dynamic of occupation and transformation demanded appropriate

III. CASE STUDY

The study analyzes the case of Pitrufquén, founded in 1897 in the Araucanía Region, Chile. This city demonstrates the relevance of the economic logic that displaced the military one, manifested in the absence of barracks, a moat, or another defensive measure, and its acquired relevance as a railway precinct.

communication and transport routes for the new requirements.

The city of Pitrufquén has an oval urban design. This elliptical city represents a unique setup in Chile, as cities mostly follow the Spanish orthogonal grid model in checkerboard format. implemented in other cities of the Araucanía region.

IV. METHODOLOGY

The methodology used in this study has a combination of historical and urban-architectural research methods. That is to say, from a historical perspective, a heuristic methodology was used for the location, collection, and analysis of primary and secondary documentary sources, in addition to a critical reading of the consulted bibliography. From an urban-architectural point of view, the historical and current planimetry available was analyzed: Pitrufquén, its urban conditioning factors, location, placement, and morphology, analyzing its architecture in different periods, the materiality of the work, and the diverse expressions of the city.

The resources used in the study are planimetry, photos, and sketches.

V. RESULTS

Pitrufquén and the Mapuche territory

During the colonial era, Mapuche society had livestock farming as its leading economic activity. The military malones5 on the Spanish forts gave way to attacks for economic purposes, resulting in raids on the ranches, where cattle were sought as booty. From the middle of the 17th century until the second half of the 19th century, this practice marked the economy, society,

and territorial logic of the Mapuches in the Wallmapu6. This dynamic led to a substantial expansion towards the Puelmapu, first in search of bighorn cattle. When this was exhausted, the destination of the attacks was the ranches of the Buenos Aires, Mendoza, and Córdoba provinces, from where many horses and cattle were driven.

The knowledge of geography, the control of the Pampas watering holes, the Andes Mountain Range openings, the fords, and the prairies in the Araucanía became a central aspect. In this context, Pitrufquén was a strategic site because it had meadows to feed livestock, fertile agricultural land, and a location alongside the main ford to cross the mighty Toltén River. Indeed, this was why Pinolef, son of the cacique Paillaguñ, who controlled the Pucón mountain range gap, moved to Pitrufquén and became a wealthy farmer and rancher (Guevara, 1912). In 1860, Pitrufquén was visited by the German traveler Paul Treutler, who highlighted the fertility of the valley: "Where beans, corn, wheat, and other grains are produced in abundance, quite a few animals are fattened and where important establishments could be raised" (Treutler, 1958, p. 167).

Highlighting its strategic location, he points out that "this reservation is, without dispute, the most suitable point for trading speculation between the Calle-Calle and Toltén rivers" (Treutler, 1958, p. 167). Pitrufquén was a strategic point for the State in controlling and dismantling the Mapuche territory in re-articulating and designing the new Chilean territoriality, which had founding towns and railway development as its fundamental pillars.

Pitrufquén and the foundation of the town

Assuming that a town is born when the State officially approves its plan makes it impossible to specify the date of its foundation. Treutler (1958) visited the place in 1860, noting that "Pitrufguén was one of the most important villages in the Araucanía, and had about four hundred souls" (Treutler, 1958, p. 387). Its cacique (leader) was Felipe Paillalef, who, in his *rucahue*, next to the *rukas* (houses) built in the traditional indigenous style, had a house built "entirely in the European way, with doors and windows, it had been made by two Chilean carpenters and a blacksmith" (Treutler, 1958, p. 393).

In 1896, the railway line was being laid. They were busily working on clearing forests and constructing embankments and stations. This task was intensified the following year when the work on the bridge over the Toltén began. By that date, in Pitrufquén, there was already "an inn

5 Malón was a surprise Mapuche attack on a fort or a ranch.

6 Wallmapu refers to the entire Mapuche territory comprising the Gulumapu or Western lands, including the Araucanía and the Puelmapu, and the Eastern lands on the other side of the Andes Mountain Range.

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Figure 3. Pitrufquén railway station, c.1900. Source: Images of Chile from 1900 (n.d.).

and granary" (Verniory, 2005, p. 444). The Toltén Bridge was a significant engineering project. At 450 meters in length, it comprised nine 50-meter metal sections resting on two abutments and eight pillars. As for the Malleco viaduct and the Quillem, Cautín, and Quepe bridges, Creusot was the engineer in charge of the final assembly. In October 1898, the Toltén Bridge was completed and delivered. The Temuco-Pitrufquén line was inaugurated by the President of the Republic, Federico Errázuriz, on November 13th that year (Verniory, 2005, p. 483). With these milestones, Pitrufquén was united to the North with the rest of the country and was the railhead for the progress to the South (Figure 3).

When reconstituting the dynamics of the urban population of Pitrufquén from 1895 to 2017, the results are as follows (Table 1). The figures in Table 1 show that the 1895 census identifies a "village" with 2,376 inhabitants. This data is associated with the bridge's construction over the Toltén River and the extension of the railway line to the south.

In the first half of the 20th century, the urban population experienced an initial growth that can be associated with the installation of state institutions and bureaucracy, private institutions linked to religious orders, or a migratory process attracted by the area's incipient agricultural and forestry activity, which found in this town a center for provisions, and a place to store and transfer its production using the railway. In 1952, the fall in population compared to the previous census is attributed to the vitality acquired

Census	Urban population of Pitrufquén
1895	2.376
1907	3.271 (Lisperguer)
1920	4.038
1930	4.024
1940	5.193
1952	4.533
1960	6.472
1970	7.770
1982	9.437
1992	10.491
2002	13.420
2017	16.531

Table 1. The population of Chile's towns, 1875-1992. Source:National Statistics Institute [INE], Central Statistical Office (1904),INE (1992), INE (2019).

by other urban centers in the region, such as Temuco to the north, the consolidation of Gorbea to the south, and the dynamism acquired by Villarrica, due to the promotion of tourist activity and administrative autonomy in the 1930s. However, the data in Table 1 show how the city of Pitrufquén consolidated significantly from the 1960s.



Figure 4. Traditional checkerboard patterns observed in the cities of Angol, Lautaro, Traiguén, and Temuco, compared to those of Pitrufquén and Lonquimay, unique radial patterns existing today. Source: Chilean Memory (n.d.).

The urban plot of Pitrufquén

The towns founded in the Araucanía replicated the checkerboard layout in other Chilean cities (Guarda, 1978).

However, three cities escaped this rule: Villa Queule, whose plan dates from 1914; Villa Portales in 1898; and Lisperguer in 1897, which later changed its name to Pitrufquén (Figure 4)

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Figure 5. Pitrufquén today: 1) Plaza Pedro Montt; 2) Plaza Los Héroes; 3) Avda. Francisco Bilbao; 4) Avda. de Circunvalación Pedro León Gallo; 5) Railway premises; 6) Railway track and railway bridge; 7) Pan-American Highway and road bridge; 8) Municipality, Post Office and Public Services; 9) Fire station and cinema; 10) Old railway station (demolished); 11) College of the Dominican Mothers; 12) Casa de altos (Figure 7); 13) Wooden housing (Figure 8); 14) Robin's Hardware Store (Figure 10); 15) CORVI complex for police officers. Source: Bárbara Sáez Orrego, 2023.

In the Araucanía region, cities "were transformed, to a greater or lesser extent, into the figuration of colonial power and administration, which through capitalist and bureaucrat actors - under the European imaginary of material and spiritual progress - modified the topography, the circuits of connectivity, the hierarchies of power, and the representations of the occupied territory" (Alvarado, 2015, p. 107). In Pitrufquén, the State marked presence through its institutions, bureaucracy, and the urban and architectural materiality that this entailed. The urban center was the place par excellence where it was materialized to increase the levels of statehood over the population and the territory. There were schools, a civil registry, a court, land and colonization offices, police, notaries, and departmental and municipal offices, among others. There were also fire stations, sports and social clubs, political parties, cinemas and theaters, newspapers, and everything typical of urban life (Figure 5).

The urban plot of Pitrufquén is particular because it is a planned city using a radial model rarely used in the south of the country. It is organized around an oval intersected by two diagonal avenues, in the center of which the main square is located. The urban presence of the railway and its station, which crosses the city's elliptical plot in one of its thirds, is of particular interest, configuring a second square in front of it.

The oval perimeter avenue configures a poignant and clear edge of the city, especially towards the southern sector. Even if its layout is irregular in certain sections, the idea of forming a landscaped and wooded avenue prevails, a public promenade located initially at two points with the railway. This intersection was widened with the subsequent construction of the Pan-American highway that crosses the city on the north-south axis. .

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Figure 6. Pitrufquén Main Square. Source: Gonzalo Cerda Brintrup, personal files, 2023.

The incorporation of two diagonal avenues at the intersection of the city's central square should be understood as an idea of order that characterizes the plot. The diagonal avenues hierarchize the central square, providing unusual perspectives for a Chilean city, organized from the colonial idea in orthogonal checkerboard plots (Figure 6). However, incorporating an oval edge and diagonals does not mean leaving behind the checkerboard's reticular weave. This persists in the city's design, making the grid layout, diagonals, and perimeter oval, compatible.

Incorporating the railway into the city's layout brought other urban phenomena. The presence of the railway station and its depots strained the commercial growth of the city center, which entailed the city's development from the center to the station, called the "Station neighborhood." In the case of Pitrufquén, the formation of the "Ultra station neighborhood" defined the sector that goes beyond the station and that had its own characteristics.

The location of railway stations in most of the cities of the Araucanía produced a phenomenon: the transformation of the line that connects the central square and the train station into the city's most important commercial street. In the case of Pitrufquén, it is Francisco Bilbao Street around which the so-called "casas de alto" grew, a typology that incorporated commerce on the first level and housing on the second. That is to say, the city's commercial life was associated with central living, something that can be observed to this day. The commercial houses were inscribed in a continuous facade, with which the central plot of the city was spatially conformed. It is essential to highlight that the "casa de altos" typology produced a frequented and active city, even on weekends, when commerce does not work, enhancing family life on the upper floors. This urban quality is still maintained in Pitrufquén (Figure 7).



Figure 7. Casa de altos in Pitrufquén: first-level store; second-level housing. Source: Gonzalo Cerda Brintrup, personal files, 2023.

In the peri-urban center, remnants of rural life can be found towards the interior of the plot, with houses with significant yards, orchards, front yards, and even small agricultural facilities such as chicken coops, pigsties, wheat granaries, and other agricultural products that consider the rural occupation around the city.

The "Station Neighborhood" has, in the case of Pitrufquén, a recognized center, the station's square, called "Plaza Los Héroes." This was the city's public reception space when the railway was still running. Today, this space has changed, but its importance has not decreased. Nowadays, the spatial and commercial tension between Station Square and Central Square, or Manuel Montt Square, vitalizes the economic and urban life of the city.

On the other side of the railway line, the "Ultra station" neighborhood traditionally housed industrial and semiindustrial activities associated with the railway. Warehouses, workshops of various kinds, small agricultural facilities, housing, and neighborhood stores continue to operate, although much less than compared to the railroad boom from the beginning of the 20th century to the 1970s. The city's urban growth also shifted towards the "Ultra station" neighborhood, with important State-built housing complexes (Housing Corporation, CORVI) for police officers built in the 1950s and that are currently in full use (Vergara et al., 2021).

Architectural heritage of Pitrufquén

The radial urban model applied in Pitrufquén has a correlate. On the one hand, with the wooden construction tradition of the architecture of southern Chile, and on the other, with the emergence of modern architecture and new materials such as reinforced masonry and concrete, both by individuals and the State. This is predominantly expressed in buildings for institutions. In this way, its urban layout is being completed



Figure 8. Wooden architecture in Pitrufquén. Source: Gonzalo Cerda Brintrup, personal files, 2023.

with architecture, first in wood and then in modern materials, many of which constitute today part of the country's southern architectural heritage.

In the city of Pitrufquén, at least three layers of architectural heritage are noticeable: its wooden architecture, in particular, housing and its insertion into the so-called "wood culture" in southern Chile; public architecture represented by buildings such as the municipality, the post office, the fire station, and the cinema; and modern architecture with notable examples of commercial buildings and housing from the 1940-1960 period.

Wooden Architecture

The so-called "wood culture" was used in the south of Chile from the mid-19th century, especially with the migrations of Chileans and foreigners. Pitrufquén is an area abundant with countless native species, such as oak, larch, luma, and mañío, among others. In this environment, it was natural that intensive use of this material arose to produce housing, religious, industrial, school, and institutional buildings and develop everyday items such as household utensils and boats of all sizes. This material penetrated the daily and constructive culture of the south of the country to the point that it is possible to state that, in southern Chile, wood, more than a constructive material, is a cultural material (Cerda, 2022a) (Figure 8).

The architectural development of the Araucanía, particularly that of Pitrufquén, is inscribed in this environment. Thus, in this material, it is possible to find countless examples of housing, public buildings, shops, and agricultural and industrial architecture in the city. The wooden reinterpretation of the European reference models that guide the city's architectural production is of interest. Thus, supported by catalogs, photographs, and construction manuals, the local carpenters reproduced,


Figure 9. Public Services Building and Municipality of Pitrufquén. 1974. Source: Gonzalo Cerda Brintrup, personal files, 2023.

in their way, the models contributed by the migrant population. The result is sober, austere wooden architecture, which has the first purpose of setting oneself up in the territory and constitutes an important architectural heritage of the country.

Public architecture

The state and the public-private development of institutions resort to modern architecture. Between the 1940s and 1970s, schools were built, such as the Dominican Sister's School, the Fire Service building that included a cinema, and the town hall building - the municipality which also incorporated other public services.

The Public Services building symbolized the State's presence in the city and became one of the most significant works of countless cities and towns in the Araucanía (Parraguez & Escobar, 2022).

These works, for the most part, are located in front of the main square and unite several organizations such as the General Treasury of the Republic, Internal Revenue Service, Chilean Mail Service, and the Illustrious Municipality with its different departments. The constructions represent the modernizing action and presence of the State in the country. It is common for its architecture to be ascribed to the Modern Movement in its different periods. The hypothesis is that modern architecture represents a modernizing state that seeks to reach the whole population with its institutions and services (Figure 9).

Modern architecture

In the decades of 1940-1950, a repertoire of works that could be classified as modern architecture emerged in the city. This was architecture assimilable to the so-called "first modernity," which emerged strongly in Chile from the 1940s and in the south of the country was marked by the 1939 PITRUFQUÊN, CHILE: LA CIUDAD COMO ESTRATEGIA DE OCUPACIÓN TERRITORIAL GONZALO CERDA-BRINTRUP, JAIME FLORES-CHÁVEZ, PABLO FUENTES-HERNÁNDEZ REVISTA URBANO Nº 49 / MAYO 2024 - OCUBRE 2024 REVISTA URBANO Nº 49 / MAYO 2024 - OCUPARE 2024 36



Figure 10. Modern architecture in Pitrufquén. Robin's Hardware Store. Source: Gonzalo Cerda Brintrup, personal files, 2023.

Chillán (8.0°R) and the 1960 Valdivia (9.5°R) earthquakes (Cerda, 2022b). This architecture was mainly used to build stores, housing, and institutional works. The production of modern "high-rise houses" is particularly interesting. This combines commercial and housing programs the city had developed for the central plot, initially in wood.

This architecture is inserted in the pre-existing plot and a continuous facade, contributing to the conformation of well-configured edges and a continuous urban space (Figure 10).

VI. DISCUSSION

In the second half of the 19th century, the Chilean state began occupying and transforming Araucania's indigenous territory. In this strategy, the cities constituted ideological and material support for the state's arrival in the territory. If, at first, the military criteria were predominant in determining the location of urban centers, after 1883, it gave space to those linked to economic reasons, the case where the foundation of the town of Pitrufquén was inserted into. However, it was already a strategic point in the Mapuche territorial logic previously due to its ford and the geomorphological and soil quality characteristics of the plain on the southern bank, which had led important caciques to settle there (Guevara, 1912; Antivil, 2017; and Flores, 2023).

By the end of the 19th century, those who designed the railway route identified Pitrufquén as the most suitable place to bypass the Toltén River using a bridge and in the plain to trace a town that did not contemplate a military enclosure or a moat, but did have blocks and sites for the installation of a series of state institutions. A territory as a palimpsest, a historical process, with old and new vestiges that imprint the places, singularizing them (Corboz, 2004). The reading of the written and cartographic sources confirms that Pitrufquén, unlike other Araucania towns, was not configured as a military fort, but was the result of a new stage of state action, where the railway marked the hierarchization of space and its stations constituted the gateway of the towns.

It is essential to point out that the installation of towns and cities in the Araucanía represented a territorial occupation strategy different from that developed by the original Mapuche people, characterized by the installation of dispersed housing in the territory, mainly following the river (Antivil, 2017; Flores, 2021). On the contrary, the Chilean occupation was carried out through cities that followed the railway line, first in a north-south direction and later in the opposite direction along branch lines. This established a different occupation logic from the pre-existing one that, in some cases, was resisted by members of the Mapuche community. However, it was also positively valued, given the railway's modern communication and transport facilities**7**.

Regarding the study and analysis made, it is argued that urban centers in the Araucanía constitute one of the clearest expressions of the state action, of the need to increase the levels of statehood, the spatiality of colonialism, and a manifestation of the interdependence of the State and the city that was projected until today. Thus, the city, as a state artifact, not only accounts for the emergence of the urban phenomenon but also constitutes one of the fundamental aspects in the redesign of the ancient indigenous territory (Alvarado, 2015; Escalona & Olea-Peñaloza, 2022; Flores, 2012; Flores 2020 and Flores 2023).

In the case of Pitrufquén, as is also the case of Lonquimay, the use of a radial model for the urban plan can be associated with the search for an idea of order, the establishment of a well-defined plan, of known edges that clearly define what is city and what is countryside.

Without there being a specific document that explains the reason for the implementation of the radial model in the city's fabric, the case of Pitrufquén may correspond to a current in vogue towards the end of the 19th and the beginning of the 20th century, based on European reference models, both for the city and its urban plots, as for architecture. These models are reworked, reinterpreted, and adapted to the local reality. It has been stated that in the configuration of cities in "Latin America, since its inception, there is a symbiosis and superposition of cultures, the abrupt transplantation, the chronological mismatch, the more or less slow adaptation to imported ideas, of new solutions full of spontaneity and inventiveness..." there being "the common thread in the effects of European urban culture on Latin American societies (Andreatta, 2007, p.14).

It is possible to hypothesize that Haussmann's ideas for 19th-century Paris, which influenced the development and renovation of European cities such as Vienna, Brussels, or Florence and even North American cities such as Chicago through the City Beautiful movement, may have been an antecedent of the radial outline of a new-plan city such as Pitrufquén in southern Chile.

VII. CONCLUSIONS

It is concluded that Pitrufquén constitutes a significant example of the Chilean nation-state's occupation and transformation process of the indigenous territory of the Araucanía. In this sense, the city and the State consider each other indispensable in dominating and controlling a border area. That is why Pitrufquén is the symbolic, material, and cultural expression of an urban society of the late 19th century that moves on indigenous lands.

Regarding the territory, the city represents the new territorial logic implemented by the Chilean State that differs from the one that the Mapuches had elaborated, a territory without cities. The choice of the city's location was strategic. The ford allowed crossing the mighty Toltén River, the intersection point of the main indigenous roads that crossed the Araucanía from north to south and east to west. In this sense, new technologies such as the railway are present in the origin and development of the city through the railway bridge, the station, and the economic dynamics of the city and the rural environment.

Regarding the urban plot, the configuration of the elliptical outline of the city, the presence of diagonal avenues, the incorporation of squares, the checkerboard layout inserted in the ellipse, and the presence of the railway are especially notable. The urban layout is peculiar in developing cities in Chile and the Araucanía, representing one of the few examples that advance from the traditional checkerboard pattern to other more complex urban layouts.

7 this positive assessment on the part of the Mapuches on the arrival of the railway to La Araucanía was expressed by Wladimir Antivil during the presentation of his paper "The construction of the territory between Malleco and Cautín during the advance of the State in La Araucanía: reflections on four cartographies (1869-1888)". 2nd Seminar Territory, City, and Architecture in the Araucanía 19th – 20th Centuries. University of Bío Bío, Concepción, November 6th and 7th, 2023.

Regarding architectural development, at least three architectural layers are evident in the city: wooden architecture, with notable examples of homes and commercial buildings that are part of southern Chile's so-called "wood culture"; public architecture, represented by buildings such as the municipality and public services; and modern architecture, with notable examples of modern "high-rise houses" where commercial and housing programs are combined.

For these reasons, Pitrufquén represents a paradigmatic settlement of insertion and territorial occupation according to the State logic in the Araucanía towards the end of the 19th century, testing a configuration and peculiar elliptical radial urban plot that characterizes it compared to other cities and towns in the south of Chile.

VIII. REFERENCES

Alvarado, C. (2015). La emergencia de la Ciudad Colonial en Ngulu Mapu: Control Social, Desposesión e Imaginarios Urbanos en E. Antileo; L. Cárcamo-Huechante; M. Calfío y H. Huinca-Piutrin (Eds.), Awükan Ka Kuxankan Zugu Wajmapu Mew: Violencias Coloniales en Wajmapu, (pp. 107 - 140). Ediciones Comunidad de Historia Mapuche. https://www. comunidadhistoriamapuche.cl/wp-content/uploads/2017/05/530100_a0eb c11c30e8433e828df3145bcc4d68.pdf

Andreatta, V. (2007). *Ciudades cuadradas, paraísos circulares*. [Tesisesis de Doctorado Universidad Politécnica de Cataluña, España]. https://upcommons.upc.edu/handle/2117/94284

Antivil, W.(2023). "La construcción del territorio entre Malleco y Cautín durante el avance del Estado en la Araucanía: reflexiones en torno a cuatro cartografías (1869-1888)". 2º Seminario Territorio, Ciudad y Arquitectura en la Araucanía Siglos XIX – XX. Universidad del Bío-Bío, Concepción, 6 y 7 de noviembre. https://farcodi.ubiobio.cl/agenda/evento/2-seminario-territorio-ciudad-en-la-araucania-siglo-xix-xx/

Antivil, W. (2017). Una mirada a la Araucanía. Construcciones territoriales en la colonización chilena en el siglo XIX. *Revista Urbano, 20(35)*, 6 - 17. https://doi. org/10.22320/07183607.2017.20.35.01

Bourdieu, P. (2014). Sobre el Estado. *Curso en el Collège de France (1989-1992)*. Editorial Anagrama. https://www.anagrama-ed.es/libro/argumentos/sobreel-estado/9788433963697/A_466

Cerda, G. (2022a). Arquitectura en madera en el sur de Chile: 1740-1940. Ediciones Universidad del Bío-Bío. http://edicionesubiobio.cl/#Catalogo_por_Ano.112

Cerda, G. (2022b). Arquitectura moderna en madera en el sur de Chile: 1940-1970. Ediciones Universidad del Bío-Bío. http://edicionesubiobio.cl/#Catalogo_ por_Ano.113

Corboz, A. (2004). El territorio como palimpsesto en Martín Ángel (ed.), Lo urbano en 20 autores contemporáneos. Ediciones UPC. https://es.scribd.com/ document/377660961/El-territorio-como-Palimpsesto-Andre-Corboz

Correa, M. (2021). La historia del despojo. El origen de la propiedad particular en el territorio mapuche. Pehuén/CEIBO. https://tienda.pehuen.cl/products/lahistoria-del-despojo

Craib, R. (2004). Cartographic Mexico: A History of State Fixations and Fugitive Landscapes. University Press. https://www.dukeupress.edu/cartographicmexico Escalona, M. & Olea-Peñaloza, J. (2022). Colonialismo y despojo en Wallmapu, sur de Chile: expansión territorial y capitalismo en la segunda mitad del siglo XIX. *Tempo*, 1(28), 239 - 259. https://repositoriodigital.uct.cl/ items/f91e37ae-a085-4a90-b1f7-137cfffcc9be

Flores, J. (2012). La Araucanía y la construcción del Sur de Chile, 1880-1950. Turismo y vías de Transporte. *Revista Scripta Nova*, 418(12), 1 - 21. https:// www.ub.edu/geocrit/sn/sn-418/sn-418-12.htm

Flores, J. (2013). La Ocupación de la Araucanía y la pérdida de la platería en manos mapuche. Finales del siglo XIX y primeras décadas del XX. *Revista de Indias*, 73(259), 825 - 854. https://revistadeindias.revistas.csic.es/index.php/revistadeindias/article/view/944/1017

Flores, J. (2019). La construcción del Estado chileno en la Araucanía a través de los papeles del Fondo de Intendencia de Cautín, 1887-1914. Bajo la Lupa, Subdirección de Investigación, Servicio Nacional del Patrimonio Cultural, Archivo Nacional de Chile. https://www.archivonacional.gob.cl/sites/www. archivonacional.gob.cl/files/images/articles-93488 archivo PDF.pdf

Flores, J. (2020). Procesos de significación y resignificación de una ciudad, Temuco 1881-2019. *Arquitecturas del Sur*, 38(58), 24 - 43. https://doi.org/10.22 320/07196466.2020.38.058.02

Flores, J. (2021). Cautín e Imperial. Arterias del Ngulumapu, en C. Aldunate y H. Rodríguez (Ed.), *Caminos de Agua en Los Ríos de Chile* (pp. 256 - 261). Ograma Impresores. https://es.scribd.com/document/694291099/ CAMINOS-DE-AGUA-2

Flores, J. y Araya, R. (2023). La Fundación de un fuerte en la Araucanía: Toltén en 1867 o la derrota de las serpientes. *En III Jornadas de Antropología Histórica de Araucanía, Pamapas y Patagonia*, (pp. 181 - 191). Universidad de Buenos Aires. http://eventosacademicos.filo.uba.ar/index.php/ensenanzafilosofia/ index/search/authors/view?firstName=RobertoymiddleName=ylastName =Araya%20Navarroyaffiliation=ycountry=

Guarda, G. (1978). *Historia urbana del Reino de Chile*. Editorial Andrés Bello. https://www.memoriachilena.gob.cl/602/w3-article-94093.html

Guevara, T. (1912). Las últimas familias i costumbres araucanas. [Archivo PDF]. https://anales.uchile.cl/index.php/ANUC/article/view/25576/28094

IMÁGENES DE CHILE DEL 1900. (s.f.). http://chiledel1900.blogspot. com/2013/11/carahue-saavedra-y-pitrufquen.html

Instituto Nacional de Estadísticas - INE. (1904). Oficina Central de Estadística, "Séptimo censo jeneral de la población de Chile levantado el 28 de noviembre de 1895". Tomo IV, Santiago de Chile, Imprenta Universitaria de S. A. García Valenzuela.

Instituto Nacional de Estadísticas – INE. (1992). Población de los centros poblados de Chile, 1875-1992. Santiago de Chile.

Instituto Nacional de Estadísticas – INE. (2019). Síntesis de resultados del censo 2017 Región de La Araucanía, informe comparativo censos 2002 – 2017. Instituto Nacional de Estadística. https://regiones.ine.cl/documentos/ default-source/region-ix/estadisticas-r9/publicaciones-anuales-enfoquesy-minutas/ediciones-especiales/2019/s%C3%ADntesis-de-resultados-2017-la-araucan%C3%ADa.pdf?sfvrsn=40bae9b8_6

Lefebvre, H. (2013). *La Producción del Espacio*. Capitán Swing Libros. https://istoriamundial.wordpress.com/wp-content/uploads/2016/06/ henri-lefebvre-la-produccion-del-espacio.pdf

Marimán, P., Nahuelquir, F., Millalen, J., Calfio, M. & Levil, R. (2019). *jAllkütunge, wingka! jka kiñechi! Ensayos sobre historias mapuche.* Ediciones Comunidad de Historia Mapuche. https://www.comunidadhistoriamapuche.cl/libro-allkutunge-wingkaka-kinechi-2019/

Memoria Chilena. (s.f.). Biblioteca Nacional Digital de Chile. https://www. memoriachilena.gob.cl/602/w3-channel.html

38

0718 - 3607

0717 - 3997

SSN

Oszlak, O. (2012). La formación del Estado argentino. Orden, progreso y organización social. Ariel. https://isp-sal.infd.edu.ar/sitio/wp-content/ uploads/2020/03/015-Oszlak.pdf

Pinto, J. (2021). La Araucanía. Cinco siglos de historia y conflictos no resueltos. Pehuén. https://tienda.pehuen.cl/products/araucania-cinco-siglos

Parraguez, M. & Escobar, N. (15 de mayo de 2022). *Municipalidades de La Frontera: la expresión del Estado en las comunas 1925-1975*. [Discurso principal] Seminario de título, Concepción, Universidad del Bío-Bío, Chile.

Santos, M. (1990). Por una geografía nueva. Espasa-Universidad. https://www. academia.edu/12471249/Por_una_geografia_nueva_Milton_Santos

Tilly, Ch. (1990). Coerción, capital y los estados europeos, 990-1990. Alianza.

Treutler, P. (1958). Andanzas de un alemán en Chile, 1851-1863. Editorial del Pacífico, S. A. https://www.memoriachilena.gob.cl/602/w3-article-8041.html

Vergara, J., Álvarez, D., Asenjo, D. & Dintrans, D. (2021). Practicidad y comunicación de lo técnico en las tipologías de vivienda CORVI. *Revista INVI*, 36(103), 323 – 348. https://revistainvi.uchile.cl/index.php/INVI/article/ view/63417

Verniory, G. (2005). *Diez años en Araucanía, 1889-1899*. Pehuén. https://tienda. pehuen.cl/products/diez-anos-en-araucania

MOVILIDAD DEL CUIDADO ALREDEDOR DE UN CENTRO DE DESARROLLO INFANTIL MUNICIPAL EN CUENCA, ECUADOR ANA CRISTINA ULLAURI-UGALDE, ANA SOFIA IDROVO-SOLIZ, CARLA HERMIDA-PALACIOS REVISTA URBANO Nº 49 / MAYO 2024 - OCTUBRE 2024 PÁG. 40 - 51 ISSN 0717 - 3997 / 0718 - 3607

MOBILITY OF CARE AROUND A MUNICIPAL DAILY CARE CENTER IN CUENCA, ECUADOR¹

MOVILIDAD DEL CUIDADO ALREDEDOR DE UN CENTRO DE DESARROLLO INFANTIL MUNICIPAL EN CUENCA, ECUADOR

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Históricamente, ha existido una desigualdad en las condiciones de movilidad entre hombres y mujeres que derivan principalmente de los roles de género que ejercen en la sociedad. Generalmente, son las mujeres las responsables de realizar las actividades del cuidado, tales como encargarse de los infantes. En este contexto, resulta importante estudiar la movilidad del cuidado en diferentes ámbitos. Para reflexionar sobre esta temática, se tomó como caso de estudio los alrededores del Centro de Desarrollo Infantil Municipal 27 Febrero en la ciudad de Cuenca-Ecuador. Se aplicaron cuatro instrumentos: encuestas caso-tipo a padres/madres de familia, herramienta de código abierto para la evaluación en microescala de entornos eMAPS, observación directa no participante y entrevistas semiestructuradas. Se encontró que, si bien la calidad del entorno urbano influye en las condiciones de movilidad del cuidado, en los desplazamientos desde y hacia el centro educativo existen otros factores que resultan más relevantes como el modo de transporte utilizado y la seguridad personal.

Palabras clave: espacio público, movilidad, género, rol del cuidado

Historically, there has been an inequality in mobility conditions between men and women, which derives mainly from their gender roles in society. Generally, women are responsible for caregiving activities, such as caring for children. In this context, studying the mobility of care in different areas is vital. To reflect on this issue, the environment around the 27 Febrero Municipal Child Development Center in the city of Cuenca-Ecuador was used as a case study. Four instruments were applied: Case-type surveys to parents, open-source tools for the micro-scale evaluation of eMAPS environments, non-participant direct observation, and semi-structured interviews. It was found that, although the quality of the urban environment influences the mobility conditions for caregiving when traveling to and from the educational center, other factors are more relevant, such as the means of transportation used and personal safety.

Keywords: public space, mobility, gender, role of caregiver

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I. INTRODUCTION

In their Sustainable Development Goals, SDGs, the United Nations established the need to ensure more equitable and accessible mobility for all people, recognizing inequalities, including those caused by gender. However, there is evidence that shows, on the one hand, that women and men have different mobility patterns (Gutiérrez & Reyes, 2017). On the other, women's mobility is conditioned by factors, especially safety, which forces them to use particular strategies to get around, such as being accompanied by a family member, investing more in safer transport systems (García, 2022), or traveling greater distances to avoid places considered as dangerous (Figueroa & Waintrub, 2015), among others. That is why it is essential to study the relationship between gender and mobility to have evidence that supports public policy regarding urban design and planning of school zones.

According to González-Alvo and Czytajlo (2022), the incorporation of mobility studies with a gender perspective in Latin America arose from the inequalities that characterize the social structure of cities. These inequalities show the differences in mobility patterns between men and women, which arise mainly from the gender roles imposed by society. Men have had paid jobs to support the household, i.e., productive work, and women, on the other hand, have been engaged in household care and reproductive tasks (Montoya-Robledo et al., 2020; González-Alvo & Czytajlo, 2022).

Montoya-Robledo et al. (2020) show that women perform 75% of household or care tasks. According to Heather et al. (2019), society still depends on women as the primary family caregivers in the Ecuadorian case. While women perform 40 hours of unpaid work, men contribute approximately 10 hours. The authors point out that, according to data from 2014, it is women in Latin America who work more than men, and in the case of Ecuador specifically, there is a ratio of 61 hours of total work, paid and unpaid, for women, versus approximately 54 hours for men.

Care activities also involve particular conditions in the daily movements of those who carry them out, primarily women. Studies on the mobility of care in Latin America reveal interesting data which confirm this. For example, Chaves et al. (2017) in Buenos Aires detected that women with small children face mobility challenges, from the "lockdown in motion" because they cannot leave their homes to the "work in motion," organizing routines for all their responsibilities. The phenomenon is also intersectional. Namely, those who have the least resources face the worst conditions. Gutiérrez and Reyes (2017) state that, in poor neighborhoods of Buenos Aires, women carry the burden of care and lack time for other activities. Similar findings were observed in the poorer neighborhoods of Santiago de Chile, where women feel trapped between the responsibilities of home, work, and raising children (Jirón, 2007).

Trips to drop off and pick up children from educational institutions are a fundamental phenomenon when studying the mobility of care. In this context, this article aims to identify the factors that affect the mobility of care conditions in the surroundings of a Municipal Child Development Center located within Mercado 27 Febrero in Cuenca, Ecuador.

The study is structured in five parts: first, it comments on the concept of mobility in general and care in particular. Secondly, the case study and the methodology used to collect the information are detailed. Thirdly, the results obtained from applying four instruments are presented: case-type surveys, an open-source tool for the microscale evaluation of eMAPS environments, non-participant direct observation, and semi-structured interviews. Fourth, the data obtained are triangulated to establish the main findings. Finally, the conclusions and recommendations are presented.

II. THEORETICAL FRAMEWORK

Mobility, gender, and care

The concept of mobility includes the characteristics of supply (mode of transport, infrastructure) and those of demand (age, gender, distance, economic possibilities, and physical conditions) (Miralles Guasch, 2002). The term mobility replaced transport because it considers the population's needs to move from one place to another, not only the capacity of the means of transport (Herce, 2009). That is why it can be said that there is an inequality in mobility between different population groups, as some have more facilities to access specific modes of transport, which allow them to reach their destinations in better conditions and in less time. Therefore, they have more opportunities compared to more vulnerable groups such as children, older adults, disabled people, women, and people with limited resources, among others (Miralles Guasch, 2002).

In the case of historical inequalities caused by gender, some concepts emerged that allowed us to look closer at them regarding the use and appropriation of public space. Such is the case of "feminist geography,"

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which arises in the field of urbanism and spatiality to address the problem of women's invisibility in the configuration of spaces. This approach recognizes and questions the absence of the role played by women in the organization and design of urban environments (Soto Villagrán, 2018). Similarly, urbanism with a gender perspective implies "giving a place to women's participation in decision-making processes, as well as making inequalities visible in different dimensions (political and symbolic material) both in the city and urban planning processes or management" (Gonzalez-Alvo & Czytajlo, 2022, p. 37).

The differences caused by gender roles, particularized to everyday mobility, have been studied from the concept of "the mobility of care." That is the one that relates care activities to daily trips (Sánchez de Madariaga & Zucchini, 2019), trips related to the care of children, older adults, and disabled people, as well as errands and purchases and that, therefore, involve nonpendular trips, with multiple destinations, organization of routines, among other conditioning factors. By way of example, in the Latin American case, the study by Heather et al. (2019) on the use of public transport by women in Quito, Santiago, and Buenos Aires found that trips for care made in this mode of transport, amount to 47% during the week and 64% on the weekend. This represents the second most cited reason for travel, so transport planning should not ignore these daily needs. This type of travel is greatly affected by the dispersed growth of cities since the distances between facilities are increasing. Adding to the lack of adequate public or private transport, this can generate significant limitations in people's access to their destinations or use services (Sánchez de Madariaga & Zucchini, 2019; Jirón & Gómez, 2018).

III. CASE STUDY

The Municipal Child Development Centers (CDI, in Spanish) in Cuenca are free facilities for comprehensive child development, initial education, and pedagogical



Figure 1. Location of Municipal DCIs in Cuenca - Ecuador Source: Preparation by the authors.



Figure 2. 27 Febrero Child Development Center. Source: Pablo Sebastián Rodas (2018).

support (Cuenca Mayor's Office, n.d.). The municipal CDIs arose out of a concern for working mothers who had no one to care for their children or where to leave them during their working hours.

This research used the CDI inside the 27 de Febrero Market in the city's south (Figure 1). It has 43 children and an approximate surface area of 500 m². This sector was chosen because it was one of the centers with the lowest score when performing a weighted assessment matrix that used indicators obtained from the Institute for Transportation & Development Policy -ITDP (2020), cited in Torres Maldonado's research (2022). The criteria for each CDI were services or amenities, public transport, public space, and road conditions. In the market, an inter-parish terminal connects the southern rural area with the urban one.

Although the urban environment around the 27 Febrero Market has shortcomings, it is located in El Ejido, which is considered a modern city, where two important avenues cross. In its surroundings, the constructions are mostly less than four floors, and the use is mainly residential (Figure 2).



Figure 3. Isochrone for eMAPS application. Source: Preparation by the authors.



Figure 4. An example of a sketch made as part of the non-participant observation. Source: Preparation by the authors.

IV. METHODOLOGY

Four instruments were applied to explore the factors that affect the mobility of care conditions around the CDI of the 27 Febrero Market:

Case-type survey: This method was used to determine who takes children to and from the CDI and in which mode of transport. Twenty-five surveys were conducted at the front door of the CDI inside the 27 Febrero Market.

eMaps: This is an open-source tool for the microscale evaluation of walkability in urban environments (LlactaLAB, 2020). As a first step, an isochron was created (Figure 3). This was determined based on the location of the bus stops closest to the CDI and its immediate surroundings. The street segments and lots were validated using QGIS to generate the maps used for the field study evaluation. Once all the forms of each of the 19 segments had been answered, rating them as positive and negative, depending on their impact on walkability, began.

Non-participant direct observation: This consisted of collecting data by observing the mobility of care in different spaces and mapping activities to explore the phenomenon through feminist geography. The three main accesses of the CDI and the bus stops were taken as the starting point. For the information processing, the maps made in the field study were analyzed in detail (Figure 4), and analysis variables classified the information.

Semi-structured interview: This technique was applied to seven CDI parents. With this instrument, we sought to understand the dynamics in the mobility of care to and from the CDI. The processing used tables, where the answers were classified according to analysis categories. Table 1 shows the characteristics of the participants.

Interviewees	Date	Gender	Age	Kinship	Transport	Special conditions
Interviewee N°1	April 6th, 2023	Female	41 years old	Mother	On foot	Disability conditions.
Interviewee N°2	April 6th, 2023	Male	40 years old	Father	Private vehicle	Husband of a market worker.
Interviewee N°3	April 6th, 2023	Female	33 years old	Mother	Private vehicle	Market worker
Interviewee N°4	April 11th, 2023	Female	30 years old	Mother	On foot / public transport (bus)	Does not work in the market
Interviewee N°5	April 11th, 2023	Female	24 years old	Mother	Public transport (bus)	Mother of three young children, only one attends the CDI Febrero 27.
Interviewee N°6	April 11th, 2023	Male	38 years old	Father	Private vehicle	Does not work in the market
Interviewee N°7	April 11th, 2023	Female	44 years old	Mother	On foot / public transport (bus)	Market worker

Table 1. Description of the interviewees. Source: Preparation by the authors.



Figure 5. Results of the case-type survey. Source: Preparation by the authors.

V. RESULTS

Results of the case-type survey

The research shows that the female gender predominates in the question of who accompanies the child on their journeys to the CDI. As for whether the subjects worked in the 27 Febrero Market, 13 interviewees did not work in this space, and 12 did. On the other hand, it is most usual for children to arrive holding an adult's hand. However, it was interesting that no child came in a stroller. Finally, regarding the mode of transport they use to get to the CDI, the most frequent is public transport, in this case, the bus. 11 of the 25 people consulted use this means, with walking in second place in third and last place taxi and motorcycle options (Figure 5).

eMaps Results

The levels of walkability in the previously established area of influence were evaluated. It is interesting to see how the rating can vary significantly from one section to another. For example, the market's surroundings obtained low ratings, reflected in yellow, orange, and red (Figure 6), indicating that walkability in this area is not in the optimal



Figure 6. Result of eMAPS walkability evaluation. Source: Preparation by the authors.

conditions to guarantee accessibility. However, Avenida Fray Vicente Solano and the corridor towards the Virgen de Bronce were evaluated as the most suitable areas for good walkability, obtaining the highest scores.

Results of non-participant direct observation

It was evident that women usually accompany their children to and from the CDI. They are also the ones who mostly attend the market to make their daily purchases or attend to their stalls (Figure 7). In addition, it was possible to detect that parents usually take their infants holding their hand, information coinciding with the results obtained in the survey. On the other hand, the presence of people under the influence of alcohol was observed in the surroundings of the market, mainly on the corner of Belisario Andrade and Adolfo Torres Streets.

The observation at the selected entrance showed the citizen guard **5** hovering around the market, creating a sense of security (Figure 8). As for the observation at the selected bus stops, it was found that many people do not cross the zebra crossings or those set up to cross safely. It was also observed that women generally have difficulties getting on and off the bus when



Figure 7. Women do the shopping. Source: Preparation by the authors.



Figure 8. Presence of the citizen guard. Source: Preparation by the authors.

5 Guardia Ciudadana is "a Municipal-run public institution that controls the public space, reinforces security together with the police and citizen security in the Cuenca district" (Guardia Ciudadana, n.d., s.p.).

accompanied by children and even more so when carrying shopping bags. Finally, one of the four bus stops analyzed does not have the necessary infrastructure because there is only one vertical "Bus Stop" sign (Figure 9).

Results of the interview

The interviewees stated that the CDI's location within the market facilitates the daily lives of those who care for children since it has several activities in the same place, such as work, education, and shopping. It is important to emphasize that, for five of the seven people interviewed, one of the main reasons they chose to enroll their children in the CDI analyzed is their daily work in the stalls within the market or its vicinity. However, three interviewees mentioned the lack of green areas near the 27 Febrero CDI. An example is interviewee N°2, who stated, "There are no parks for market children who need to be distracted."

Another interesting topic related to the mobility of care was waiting for the bus with the infants. Interviewee N°7 mentioned certain difficulties, such as, "We have to be careful as parents because sometimes, because they are little, they run, and since the bus stop is very close, it is of concern to us." Of the three interviewees who use the bus, two women mentioned that the bus stops do not have the necessary infrastructure, there are no roofs to cover themselves from the rain, and, in some cases, they only have a vertical sign.

In the interviews, three women who travel on foot commented that their daily environment has some obstacles. Interviewee N°1 is a person with a disability who has to take her daughter, mentioning that the market sidewalks are very high, hindering her mobility. Sometimes, the child's grandmother takes her to the CDI, and on two occasions, she has suffered falls due to obstacles while walking through the area. On the other hand, regarding personal safety when walking, interviewee N°7 says, "Sometimes the pedestrian sidewalk to go out to the Bronze Madonna, that one is a little dark, nothing has happened to me, but they have commented that young people appear who want to steal things." Most of the women who walk, 3 of the 5 interviewees, to come to or from the CDI, in the streets around the market, use pedestrian crossings, but in some cases, they consider them unsafe, as evidenced by interviewee N°1 "cars come from everywhere," interviewee N°7 mentions that there is no respect for the pedestrian by drivers at crossings without traffic lights.

Regarding the interviews conducted, certain factors that generate insecurity around the market are identified. The most worrying cause is the presence of people who are intoxicated, especially on weekends, as well as the existence of street vendors outside the market and debt collectors inside it. Interviewee N°1 reported, "Sometimes, I don't open for fear of them, that they will take my things..." She feels



Figure 9. Bus stop on Av. Fray Vicente Solano. Source: Preparation by the authors.

insecure about the collectors' presence. They offer a very high interest rate; if the payment due is not paid, the borrowers are threatened with taking, sometimes forcefully, supplies from the kiosks inside the market. Five interviewees mentioned the presence of the citizen guard and the social cohesion between neighbors as factors that improve security.

Regarding the sample obtained, the difference in the conditions of mobility of care is marked by the intersectionality approach; that is, inequalities are further accentuated by race, socioeconomic status, or origin issues. An example is the inequalities produced between urban and rural inhabitants, which is evident in the interviews conducted. Interviewee N°4 is a resident of the urban area, and she mentions that it takes about 10 minutes to get to the CDI, an assertion opposed to the opinion delivered by interviewee N°5, who mentions, "Quingeo is an hour away from here, I leave at 6:10 and arrive

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at 7:10. I get up at 5:30 in the morning." Both interviewees travel by public transport and do not have another means of transport to get to the CDI, but they have different travel conditions due to their place of residence. This differentiation causes other consequences, including children arriving late for classes, the bus being late, and the bus being full, which has the consequence of not stopping at the bus stop.

VLDISCUSSION

This research sought to identify the factors that affect the mobility of care conditions around the 27 Febrero Child Development Center. The main issue is identifying and categorizing crucial concepts based on feminist geography or urbanism with a gender perspective. The study also emphasizes the critical role of women in the configuration of urban spaces and how this affects mobility dynamics. The study focuses primarily on transferring children to and from the CID nursery.

The mobility of care involves multiple factors. There is evidence, reflected in the literature, that demonstrates the dependence of women as the main ones responsible for performing the tasks of care and the inequality of conditions in their daily mobility (Motoya Robledo et al., 2020; Sánchez de Madariaga & Zucchini, 2019). Authors such as Heather et al. (2019) and González-Alvo and Czytajlo (2022) emphasize that inadequate public transport, low-quality infrastructures, and the perception of constant insecurity condition the mobility of care. This research explored this phenomenon in a particular case: the CDI within the 27 Febrero Market in Cuenca-Ecuador. The analyzed case study corroborates that although some men are responsible for taking and picking up children, women are mainly responsible; in our case study, 72% were women, according to case-type surveys applied at work.

The main findings highlight that the mode of transport and the perception of safety influence the mobility of care quality. The case-type surveys of 25 people in the studied sector found that 16% of respondents use a private vehicle for comfort and independence versus 84% of individuals who move on foot or by bus. However, the conditions of these modes of transport for the inhabitants in Latin America are not always the best (Figueroa & Waintrub, 2015; García, 2022). Public authorities must provide suitable conditions for all modes of travel. The pyramid of mobility, where pedestrians and cyclists are prioritized, followed by public transport users, should be the action guide of municipalities worldwide. Similarly, it is crucial to consider the different experiences, daily lives, and needs of vulnerable population groups when designing and planning mobility infrastructures.

The analysis of the results of the eMAPS indicate low walkability in the surroundings of the CDI, which primarily affects those who are in charge of moving children and people with disabilities (llárraz, 2006) since cities do not usually meet the needs of women, children, people with disabilities, and older adults, among others. Another shortcoming identified regarding the urban environment is the existence, quality, and/or location of zebra crossings. This leads parents to jaywalk (through the middle of the street) with their children, risking their safety.

The bus is the most used means of transport by the people surveyed and interviewed from the case study. The nonparticipant observation and interviews showed the poor condition of specific stops; 1 of the 4 stops analyzed only had a vertical sign and no protection from the weather or benches. Sometimes, vehicles are parked at the stops, hindering the route and making it difficult for passengers to board and disembark. These data coincide with those provided by Ilárraz (2006), who talks about physical accessibility, which is the ease or difficulty of accessing stations or stops, as well as getting on or off the transport itself, and that, due to all the conditions of mobility of care, it is women who have the least possibilities of accessibility to means of transport, which leads to an exclusion in terms of travel.

In all the interviews, personal safety was mentioned. A noteworthy fact was that the two men interviewed talked about insecurity in the city, while the five women detailed the causes of their feeling of insecurity. The main reason was the presence of people under the influence of alcohol hanging around the market and the existence of street vendors and debt collectors for the market workers. These groups, defined as "unwanted," mostly comprised adult men (Gargiulo et al., 2020; Mugan, 2018). The presence of these groups sometimes forces women to take other routes, even if they are longer and less efficient (Figueroa & Waintrub, 2015). The concept of personal safety and lack of lighting was relevant even though the schedules for arrival and departure from the CDI are in the day.

The quantity and quality of lighting affected the eMAPS scores. It was identified that the lighting and urban design are crucial for crime prevention and citizen security. Welldesigned spaces with good visibility, lighting, accessibility, and signage can improve women's perception of safety (Jirón & Gómez, 2018; Ilárraz, 2006; Park & García, 2020).

It was recorded that the mobility of care conditions is crossed by intersectionality, where women have disadvantages in using and appropriating public space, even more so if they have few resources (Reves-Muñoz, 2023; Alcántar & Velentim, 2023). It was found that those who

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take their children by public transport have disadvantages compared to those who travel by private transport. They have to move to and from rural areas, investing a lot of time in their journeys (Gutiérrez & Reyes, 2017), hindering the possibility of dedicating their time to study, recreation, or socialization.

VII. CONCLUSIONS

In this case study, it is corroborated that women are primarily responsible for accompanying their children on their journeys to and from the 27 Febrero Child Development Center and that, in addition, the mode of transportation and the perception of safety are determinants in the mobility of care conditions. Likewise, it is verified that these are crossed by intersectionality, both by socio-economic level and place of residence (urban or rural).

These data demonstrate the importance of adopting a gender perspective in urban planning and in implementing concrete actions to promote equity, safety, and efficiency in women's movements or those who perform care work, thus contributing to constructing more inclusive and just cities.

The research allows for comparing results with CDIs in vulnerable and rural neighborhoods or identifying the differences between private kindergartens attended by children of a higher socioeconomic level in the future.

Finally, the study contributes to the knowledge and discussion of how mobility, associated with caregiving tasks, impacts the daily lives of people, especially women, who devote a significant amount of time to this often unpaid work.

VIII. REFERENCES

Alcaldía de Cuenca (s.f.). Centros de Desarrollo Infantil. GAD Municipal de Cuenca. https://www.cuenca.gob.ec/content/centros-de-desarrollo-infantil

Alcántara, J. & Valentim, J. (2023). Gender-based Disinformation: A scoping review of the literature, 2013-2023. *Ex aequo*, (48), 125-145. https://doi. org/10.22355/exaequo.2023.48.09

Chaves, M., Segura, R., Speroni, M., & Cingolani, J. (2017). Interdependencias múltiples y asimetrías entre géneros en experiencias de movilidad cotidiana en el corredor sur de la Región Metropolitana de Buenos Aires (Argentina). *Revista Transporte y territorio*, (16), 41-67. https://doi. org/10.34096/rtt.i16.3602

Figueroa, C. & Waintrub, N. (2015). Movilidad femenina en Santiago de Chile: reproducción de inequidades en la metrópolis, el barrio y el espacio público. Urbe. *Revista Brasileira de Gestão Urbana*, 7, 48-61. https://doi. org/10.1590/2175-3369.007.001.AO03

García, F. (2022). " Los piratas son los que nos salvan": informalidad, ritmos espacio temporales y normatividad práctica en la (in) movilidad cotidiana de Cali. *Revista Colombiana de Antropología*, 58(1), 283-303. https://doi. org/10.22380/2539472X.1534j

Gargiulo, I., García, X., Benages-Albert, M., Martínez, J., Pfeffer, K., & Vall-Casas, P. (2020). Women 's safety perception assessment in an urban stream corridor: Developing a safety map based on qualitative GIS. *Landscape and Urban Planning*, 198. https://doi.org/10.1016/j.landurbplan.2020.103779

González-Alvo, I., & Czytajlo, N. (2022). Movilidad y género en contextos de vulnerabilidad el caso del Sistema Metropolitano de Tucumán. *lconos*, 26(73), 35-56. https://iconos.flacsoandes.edu.ec/index.php/iconos/article/ view/5232

Guardia Ciudadana. (s.f.). Misión. http://www.guardiaciudadanacuenca. gob.ec/?q=content/misi%C3%B3n

Gutiérrez, A., & Reyes, M. L. (2017). Mujeres entre la libertad y la obligación. Prácticas de movilidad cotidiana en el Gran Buenos Aires. *Transporte y territorio*, (16), 147-166. https://doi.org/10.34096/rtt.i16.3607

Heather A., Cárdenas, G., Pereyra, L. & Sagaris, L. (2019). *Ella se mueve segura*. Un estudio sobre la seguridad personal de las mujeres y el transporte público en tres ciudades de América Latina. Caracas: CAF y FIA Foundation. https://scioteca.caf.com/handle/123456789/1405

Herce, M. (2009). Sobre la movilidad en la ciudad: propuestas para recuperar un derecho ciudadano. Editorial Reverte. https://cafedelasciudades.com.ar/ imagenes%20131/Indice_prologos_movilidad.pdf

llárraz, l. (2006). Movilidad sostenible y equidad de género. *Revista de servicios sociales*, (40), 61-66. https://www.zerbitzuan.net/documentos/ zerbitzuan/Movilidad%20sostenible%20y%20equidad%20de%20genero. pdf

Jirón, P. (2007). Implicancias de género en las experiencias de movilidad cotidiana urbana en Santiago de Chile. *Revista Venezolana de Estudios de la Mujer*, 12(29), 173-197. http://ve.scielo.org/scielo.php?script=sci_arttextypid=S1316-37012007000200011ylng=esytlng=es.

Jirón, P., & Gómez, J. (2018). Interdependencia, cuidado y género desde las estrategias de movilidad en la ciudad de Santiago. *Tempo Social, revista de sociología da USP*, 30(2), 55-72. https://doi.org/10.11606/0103-2070. ts.2018.142245

LLACTALAB (2020). eMAPS. Github. https://emaps.readthedocs.io/es/latest/

Miralles Guasch, C. (2002). *Ciudad y transporte: el binomio imperfecto.* Planeta Publishing Corporation. https://books.google.com.cu/ books?id=qR8wFfHovsYCyprintsec=copyright#v=onepageyqyf=false

Montoya-Robledo, V., Montes Calero, L., Bernal Carvajal, V., Galarza Molina, D. C., Pipicano, W., Peña, A. J., Pipicano, C., López Valderrama, J. S., Fernández, M. A., Porras, I., Arias, N., & Miranda, L. (2020). Gender stereotypes affecting active mobility of care in Bogotá. Transportation research part D: *transport* and environment, 86, 102470. https://doi.org/10.1016/j.trd.2020.102470

Mugan, G. (2018). The Role of Space and Time Use Behaviors in Shaping the Incivility Experience of Young People. *MEGARON*, 13(2), 182-191. https://doi.org/10.5505/MEGARON.2018.83997

Park, Y., & García, M. (2020). Pedestrian safety perception and urban street settings. International Journal of Sustainable Transportation, 14(11), 860-871. https://doi.org/10.1080/15568318.2019.1641577

Reyes-Muñoz, V. (2023). Aproximaciones desde la Interseccionalidad Situada a las violencias experimentadas por mujeres migrantes afrodescendientes en el espacio público, Santiago de Chile. *Revista Punto Género*, (19). https://doi.org/10.5354/2735-7473.2023.71217

Sánchez De Madariaga, I., & Zucchini, E. (2019). "Movilidad del cuidado" en Madrid: nuevos criterios para las políticas de transporte. Ciudad y territorio - *Estudios Territoriales*, 52(203), 89–102. https://doi.org/10.37230/CyTET.2020.203.08

Soto Villagrán, P. (2018). Hacia la construcción de unas geografías de género de la ciudad. Formas plurales de habitar y significar los espacios urbanos en Latinoamérica. *Perspectiva Geográfica*, 23(2). https://doi.org/10.19053/01233769.7382

Torres Maldonado, A. (2022). Movilidad Segura en centros de desarrollo infantil municipal. [Tesis de Maestría, Universidad Oberta de Catalunya]. Repositorio institucional.

52 MISMA LUCHA, DISTINTOS OBJETIVOS: ESTRATEGIAS TERRITORIALES POR EL DERECHO A LA CIUDAD EN DOS CAMPAMENTOS DE TEMUCO, CHILE IGNACIO BONDIS-LUNA, FÉLIX ROJO-MENDZA, MIGUEL ESCALONA ULLOA REVISTA URBANO Nº 49 / MAYO 2024 - OCTUBRE 2024 PÁG. 52 - 61 ISSN 0717 - 3997 / 0718 - 3697 / 0718 - 3607

SAME STRUGGLE, DIFFERENT GOALS: TERRITORIAL STRATEGIES FOR THE RIGHT TO THE CITY IN TWO ENCAMPMENTS IN TEMUCO, CHILE¹

MISMA LUCHA, DISTINTOS OBJETIVOS: ESTRATEGIAS TERRITORIALES POR EL DERECHO A LA CIUDAD EN DOS CAMPAMENTOS DE TEMUCO, CHILE

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Los campamentos habitacionales en Chile representan la marginación urbana en el país. Debido a las limitadas opciones que el Estado ofrece en términos de vivienda, estos asentamientos históricamente han desarrollado formas de organización y lucha en busca de su derecho a la ciudad. En esencia, estas acciones se centran en la autogestión para obtener un lugar donde vivir. Sin embargo, a pesar de compartir necesidades similares, estos grupos muestran diversas formas de lucha. En el contexto actual, con una creciente demanda de viviendas en el país se pueden observar variadas estrategias adoptadas por estos grupos para integrarse en la ciudad. Este artículo se enfoca en analizar las estrategias de ocupación y gobernanza espacial implementadas en dos campamentos ubicados en la ciudad de Temuco (Chile), Los PInos y Los Ripieros. Se utiliza un enfoque cualitativo que se basa en la aplicación de una cartografía social a los líderes de ambos asentamientos y la exploración de las narrativas relacionadas con la gobernanza espacial pasada y futura. Se identificaron diferencias entre estos dos campamentos, a pesar que comparten una ubicación física contigua y surgieron al mismo tiempo. Los resultados revelan que, a pesar de similitudes iniciales en términos del desarrollo urbanístico, existen diferencias en cuanto a las motivaciones que quían sus acciones futuras. Mientras que Los Ripieros busca activamente influir en la obtención de una solución habitacional permanente en otros sectores de la ciudad, Los Pinos opta por involucrarse en el marco de las normativas urbanas vigentes para asegurar una solución habitacional en el mismo lugar. Estos hallazgos enriquecen la discusión sobre la marginalidad urbana, al mostrar que las luchas por el espacio de grupos excluidos se centran en el equilibrio entre el arraigo y la obtención de vivienda. Esto último debe ser considerado por el estado, al momento de diseñar políticas urbanas.

Palabras clave: marginalidad urbana, asentamientos informales, cartografía social, planificación territorial, políticas públicas.

The housing encampments in Chile represent urban marginalization in the country. Due to the limited housing options the State provides, these settlements have historically developed forms of organization and struggle in search of their right to the city. Essentially, these actions focus on self-management to obtain a place to live. However, despite sharing similar needs, these groups show diverse forms of struggle. In the current context, with a growing demand for housing in the country, various strategies these groups adopt to integrate into the city can be observed. This article focuses on analyzing the occupation and spatial governance strategies implemented in two encampments located in the city of Temuco, Chile: Los Pinos and Los Ripieros, through a qualitative approach based on the application of a social mapping to the leaders of both settlements and the exploration of narratives related to past and future spatial governance. Differences were identified between these two encampments. Although they share a contiguous physical location and emerged at the same time, the results reveal that, despite initial similarities in urban development, there are differences in the motivations guiding their future actions. While Los Ripieros actively seeks to influence obtaining a permanent housing solution in other sectors of the city. Los Pinos chooses to get involved within the framework of existing urban regulations to secure a housing solution in the same place. These findings enrich the discussion on urban marginality by showing that the struggles for space of excluded groups are centered on the balance between rootedness and obtaining housing. The latter is vital for the state to consider when designing urban policies.

Keywords: urban marginality, informal settlements, social mapping, territorial planning, public policies.

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I. INTRODUCTION

The concept of urban marginalization appears due to a systematic relegation or exclusion of certain groups or communities outside what is known as the urban center. In this context, historical spatial marginalization has negatively impacted the urban social fabric, precipitating territorial stigmatization (Abufhele, 2019). This phenomenon is derived from not only the accumulation of poverty but also the presence of a punishing and absent State (Wacquant, 2015; Perlman & Delgadillo, 2019), exacerbated by the negative perception of these sectors transmitted by the media and academia (Ruiz-Tagle, Álvarez & Labbé, 2023).

However, its residents build alternative narratives and meanings about the city (Pérez, 2019) by establishing, among other things, informal economies to meet their needs (Aceska et al., 2019) and self-management to mitigate their marginalized situation (Pino & Ojeda, 2013; Cortés, 2014; Castañeda & Hernández, 2021; Moreno, 2021). In this sense, the active participation of residents in urbanization and the defense of their rights have promoted legitimate and participatory territorial governance models (Wigle, 2014), where the informal habitat they occupy represents a variant to build the city (Pino & Ojeda, 2013).

In this context, although irregular encampments, or informal settlements comprising precarious housing and without essential services, represent a spatial expression of urban marginalization in Chile, they have a rich history of organizing and fighting for the right to the city (Moreno, 2021). In this line, some studies mention that the residents of these spaces act as active agents in the transformation of their territories to be part of the city despite the emerging vulnerabilities, job insecurity, and personal and family challenges they face (Castillo, 2014; Imilán et al., 2020). However, the political strategies employed by the irregular occupants of diverse urban spaces vary considerably, adapting to each group's particular circumstances and objectives.

This article examines the occupation and spatial governance strategies used in two camps in Temuco, Chile, using the social cartography technique applied to leaders of irregular occupations. Although these encampments or camps are located contiguously and emerged during the same period (2019-2020), each exhibits a unique and differentiated self-management policy in addressing the central challenges they face regarding housing and the right to the city. According to Lefebvre (1969), the latter is understood as the right to participate democratically in the production and administration of urban spaces, allowing a deeper exploration of how these communities actively seek to get involved and exert influence over their urban and housing environments. With this in mind, the article aims to contribute to the discussion on urban marginality, considering the reflections, strategies, and projections used by the "excluded" to win the right to live in the city.

II. THEORETICAL FRAMEWORK

Encampments in Chile and State Action

The Chilean State has designed different strategies to address irregular settlements, which paradoxically have often intensified the original challenge. The first effort was the Workers' Housing Law of 1906, which aimed to stimulate the construction of affordable and healthy housing. However, this law ended up encouraging the illegal occupation of land in the urban peripheries due to the chronic inability to cover the demand for housing (Hidalgo, 2010).

During Pinochet's military regime (1973-1990), housing policies adopted a neoliberal orientation, marked by the elimination of taxes and the liberalization of urban land. The market was considered the optimal agent for allocating urban uses (Sabatini, 2000). This increased land value in the consolidated central areas, making the periphery a viable option for low-income families and housing policies seeking more affordable land (Ducci, 1997).

With the return to democracy in 1990, Chile's housing policies maintained their neoliberal nature, but focused on reducing the housing deficit and irregular settlements. Despite a notable decrease in the deficit and an increase in homeownership, the preference for quantity over quality resulted in the construction of lowquality housing in peripheral areas with limited access to services and employment. This situation motivated the initial beneficiaries of these policies to leave their homes, generating two patterns of displacement: towards areas with cheaper land and leases (Tant, 2017; Fuster-Farfán et al., 2023) and better-located areas in the city, in search of personal and family progress, which rejects the stigmatization that living in social housing often entails (Brain et al., 2010).

However, despite the Chilean State's efforts to reduce the housing deficit and avoid the presence of encampments in different cities, the emergence of irregular occupations remains a reality. Although policies are associated with the camps, they still focus mainly on providing housing, neglecting the dynamics of the social construction of the space (Matus et al., 2019). This is essential to address, for



Figure 1. Location of both encampments in the city of Temuco. Source: Preparation by the authors.

example, the self-management of vulnerability scenarios in which some populations are (Carrasco & Dangol, 2019).

Today, there are 1,091 housing encampments in Chile (MINVU, 2022). This figure exceeds the 971 that existed in 1996, which was the critical year in this area and led the government of Eduardo Frei Ruiz-Tagle to intensify the urban policy associated with the increase in the production and delivery of own housing. In the same vein, the city of Temuco registered a sustained increase in housing encampments, reaching 34 that were home to 1,040 families (MINVU, 2022; TECHO, 2021).

The marginalized and the possible planning in the cities

In Chile, residents have acquired skills related to constructing and consolidating new neighborhoods, allowing them to create residential spaces outside the guidelines established by traditional planning. This experience made them stop being passive actors in their relationship with housing policies and become active protagonists (Fernández, 2023; Castillo, 2014). Relevant examples of this type of organization are the La Victoria and La Toma de Peñalolén neighborhoods, both in the Metropolitan region, and the Manuel Bustos camp in the Valparaíso region (Sepúlveda, 2019). All have shown that, through collective action and negotiation with state entities, the old encampments can be incorporated into the city (Cortés, 2014; Zenteno et al., 2020).

Since the 1990s, this dynamic has challenged the traditional vision of urban planning, as it transcended mere regulations and technical and architectural decisions by encouraging greater diversity and participation in the city's configuration. In this period, more inclusive and collaborative planning emerged, where the inhabitants began to play a fundamental role in building and developing the urban environment. This supports the notion of subaltern urbanism as an

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MISMA LUCHA, DISTINTOS OBJETIVOS: ESTRATEGIAS TERRITORIALES POR EL DERECHO A LA CIUDAD EN DOS CAMPAMENTOS DE TEMUCO, CHILE IGNACIO BONDIS-LUNA, FÉLIX ROJO-MENDOZA, MIGUEL ESCALONA ULLOA REVISTA URBANO N° 49 / MAYO 2024 - OCTUBRE 2024 PÁG. 52 - 61 ISSN 0717 - 3997 / 0718 - 3607 alternative that has shaped and continues to adapt the construction of cities in the Chilean context. Subaltern urbanism implies recognizing that self-construction goes far beyond being just informality, marginality, or a response to housing problems. This urbanism implies understanding the efforts of the inhabitants to coordinate and organize the work that transforms territories into habitable places, which also constitutes political actions (Magliano & Perissinotti, 2020).

In this sense, it is crucial to recognize and assess the existing practices in the territories, regardless of whether they come from the State or the market, to reveal what is called "insurgent planning" (Miraftab, 2018). This approach implies recognizing citizens as empowered actors who seek self-determination and challenge the dynamics of global capitalism, as well as the representations that specialists and politicians make of inhabited territories (Regitz, 2019).

III. METHODOLOGY

The methodological approach used in this research is based on a qualitative and exploratory perspective. The territorial scope addressed includes the Los Ripieros and Los Pinos encampments, established during 2019-2020 and located in a macro zone of Temuco called San Ramón (Figure 1). The selection of these camps considered two crucial criteria for the research: a) their recent emergence in the urban context of the city and b) their mutual proximity, a relevant factor to contemplate the logic of spatial governance in groups with the same housing needs.

A participatory methodology was adopted to address the study objective, distinguished by its close collaboration with the communities involved in these urban issues. This research design is based on the dialectical interaction between the most representative members of the community and the participating researchers (Pájaro & Tello, 2014). Regarding this approach, social cartography, which involves creating maps that reflect the interrelation between the spatial environment and people (Pájaro & Tello, 2014), was used. An essential element of social cartography is that it transcends the mere representation of a given time and space, aspiring to harmonize the perspectives of various social agents (Gil & Gómez, 2019).

In the observed camps, the implementation of social mapping followed two lines of inquiry. First, the narratives related to the planning and self-construction processes

of the camps were explored. Secondly, projective spatial governance was established, which allowed an understanding of the relationship between the current organization's past, present, and future. The three leaders of each participating camp were asked to discuss and capture the highlights of the inhabited space following the research lines. It should be noted that, in preparing these cartographies, made in September 2022, general questions were used that encouraged discussion and design in paleographers. The resulting maps, retrospective and prospective scenarios created by the leaders, were validated and discussed by the group that made them.

As an information analysis strategy, the social maps created by the participants were first described, highlighting the spatiotemporal dimensions and changes in the environment. This made it possible to visualize the occupation strategies of both camps. Later, the representative leaders evaluated and discussed the details of the spatial governance established in their territories, highlighting the differences and similarities in occupying the territory.

To record the information, the discussions related to the preparation of the maps were recorded with audio and then analyzed following the qualitative classification layout proposed by the Grounded Theory (Strauss & Corbin, 2002).

IV. RESULTS

The two encampments studied**5** are located on vacant lots in Temuco, along the banks of the Cautín River (Figure 1). Historically, these were the points of settlement for rural migrants during the first decades of the 19th century, when they faced rapid urban consolidation and could not find space in the city (Rojo-Mendoza & Hidalgo, 2021).

To revitalize the area defined as wasteland and future settlement space of the two camps studied, the municipality of Temuco established a beach-like spa called "Los Pinos" in the 1990s. Despite its initial success, its condition worsened over time, degenerating into a wasteland full of micro-dumps and with a notable incidence of criminal acts. Subsequently, this area was also exploited for the extraction of aggregates. In this way, the lands on which the Los Pinos and Los Ripieros camps were located reflect an urban space degraded over time, something not very different from the lands used for land grabs in Chile (Imilán et al., 2020).

Similar origins: who can and what is needed

The Los Ripieros camp has 36 families, and its leadership comprises women between 20 and 40 years old. Before this, none of the leaders had experience participating in organizations or leading community projects. However, they occasionally get advice from relatives or acquaintances with experience in these fields. On the other hand, the Los Pinos camp comprises 154 families, and its leadership is led by men between 25 and 50 years of age who already have experience in camps and community organizations. Migrants from Haiti, Venezuela, Colombia, Ecuador, and Bolivia also reside in this camp (López et al., 2018).

Both encampments implemented an initial territorial strategy based on three interconnected actions: cleaning the area, creating a meeting point for constant reorganization, and having essential services for the community. In this context, and regardless of the final meaning of the camp, the initiatives and the types of organizations that are discussed, and the orientations that each actor wants to give to the settlements, there are concrete actions that ensure the survival of the encampments in the cities, which is called the *formalization of urban informality*. It should be noted that this formalization seeks, in essence, to address the material and institutional marginality of the first-time installation (lack of state presence).

"The neighborhood's meeting room is the main thing. It was our beginning; we used to get together here... Here we joined together, here we shared as a community" (Los Ripieros Camp Leader, September 2022).

"The issue of electricity, we said we need electricity; where do we get it? And the closest thing we had was the state neighborhood, or there in Los Pinos. We worked, through installments ..., we made contact with an engineer, then another electrician who worked at another camp, to make a quote on how much it would cost us to put electricity here" (Camp Leader Los Pinos, September 2022).

When the land occupation began, the Los Ripieros camp established a selection process to determine which families would be part of the community. According to the camp leaders, coexistence and harmony are essential to consolidate the community project. The initial population of 92 families was reduced to 30 through the mechanism used, a figure that later increased to 36. In addition, the leadership held conversations with selected individuals who were potentially perceived as conflictive to prevent future issues.

"They had problems with other neighbors; we left the ones who did not cause trouble. Or they

didn't help in absolutely anything and wanted to receive everything... They thought that if they did not have a plot, they couldn't participate, but then they didn't come to the meetings, and if you notice that they don't come to the meetings, to the activities, it's because they're not interested in working with you for the same purpose" (Camp Leader Los Ripieros, September 2022).

In the Los Pinos camp, the selection process was less rigorous. It was based primarily on the land's capacity and the two founding families' previous knowledge of the space. Quickly, and because the information circulated mainly among acquaintances and relatives, this number increased to 77 families in a matter of weeks. Although the initial occupation in Los Pinos is broader and less structured than in the Los Ripieros camp, certain criteria were established to prevent conflicts. For example, to prevent the formation of ghettos and promote coexistence and tolerance, it was stipulated that migrant families should not be grouped by nationality in the same sector.

> The land determined the number of neighbors, then no one else entered" (Camp Los Pinos Leader, September 2022).

Despite the discrepancies in the criteria for incorporating families between the two camps, both share a common origin: the aspiration and strengthening of a residential area in a given area in the city of Temuco.

In this way, the sense of marginality refers not only to the spatial exclusion that people experience when they are deprived of residing in consolidated urban areas, but also, considering these two cases, to the meaning of the first occupation actions that seek to claim the right to participate in the life of the city.

Differences begin: Governing informality

Within the organization of the camps, the leadership plays a key role in guiding the progress and advancement of the project and resolving conflicts in daily life. On the one hand, the most experienced residents of Los Ripieros proposed the election of a board responsible for organizing and leading future actions. The board's experience, composed only of women, cemented social cohesion and opened up new competencies and leadership skills. With this organizational background, the first list of families was made to start with the procedures of the housing committee and plan the space for housing construction. The construction location inside the camp was agreed upon based on being next to related people or relatives. "...it was a very pleasant consensus because no one later complained or said anything. The land size is the same for everyone" (Camp Leader Los Ripieros, September 2022).

On the other hand, in the Los Pinos camp, the first board had the experience of living in an old camp called Avenida Ferrea. They were in charge of organizing the camp, enrolling the families, and designating the location and size of the sites. For this, each family had to delimit the place according to the homogeneous meters:

> "...we were going to the person, and we were saying Ok, that place is going to be yours, so 10 (meters) this way and 15 (meters) that way, those were like the specifications. Then, after, he corroborated (Camp Leader Los Pinos, September 2022).

However, the differences in the governance of both camps arise from the characteristics related to urban infrastructure. The Los Pinos camp adopted professional management to ensure the permanence of the settlement in its current location, a common practice in informal settlements since the 1960s and 1970s, according to Cortes (2014). On the other hand, Los Ripieros actively seek to influence the obtaining of a permanent housing solution, which includes the possibility of integrating into different areas of the city.

To achieve its objectives, Los Pinos entered the game of the current urban regulations, trying to formalize informality. To do this, electrical and architectural plans for the camp's housing complex were prepared and presented to state agencies to guarantee the proper use of space and the request for urbanization. In October 2022, they were formed as a neighborhood board, which was the foundation stone in the search for the ownership of the land currently used. In this sense, political action in Los Pinos is characterized by the creative use of laws, regulations, and citizen participation mechanisms to achieve a negotiating position with the ability to influence, in a binding way, what we could call a territorial formalization strategy. This type of strategy used by marginal populations to stay in the same places has been observed in populations that also experience risks associated with their lives (Addo & Danso, 2017; Carrasco & Dangol, 2019).

On the other hand, beyond the efforts to legitimize the space they occupy, Los Ripieros have focused their pressure on obtaining a definitive housing solution instead of staying in the current settlement, thereby establishing an *extensive territorial formalization strategy*. This means that they are implicitly open to relocating to a social housing project in other areas of the city as long as a move of the entire community without exceptions is guaranteed. To this end, the committee is responsible for keeping the list of members updated and managing the application for the housing subsidies offered by the state. However, while waiting for a permanent home, they plan to improve the camp's infrastructure to prevent fires and create recreational spaces for children.

V. DISCUSSION

In the historical panorama of urbanization in Latin America, marginalized populations' occupation of vacant and peripheral lands evolved since the 19th century. Initially, the tendency was to occupy and reside in available areas, distant from urban productive centers. However, this occupation transcends the simple residential need and has been transformed into a concrete political strategy. This strategy seeks to influence government planning policies significantly. This includes obtaining property titles to strengthen the neighborhood project and forming territorial organizations, such as the Los Pinos Neighborhood Board, to dispute spaces of political power. This represents a paradigm shift in the relationship between informal settlements and the state.

Traditional planning, closely linked to state policies, often fails to recognize the camps' inhabitants as key actors in the production and transformation of the city. This vision considers them more as a problem than as active participants, which is why state initiatives are more concerned with the housing solution of these populations than with the principle of living that mobilizes these groups (Matus et al., 2019; Carrasco & Dangol, 2019; Addo & Danso, 2017). In response, contemporary approaches, such as insurgent planning (Miraftab, 2018), seek to recognize and value these groups' self-management capacity in their residential habitability processes.

In this sense, even though the two camps analyzed emerged under similar circumstances, with similar initial strategies in the space's occupation and development and the professionalization of their irregular establishment, marked discrepancies are evident in their visions of the future. These relate precisely to projective forms of spatial governance. On the one hand, the Los Pinos camp emphasizes the importance of the place, considering the land as the central axis of its claims and dialogs with the State to consolidate a permanent residence in that location. On the other hand, for Los Ripieros, housing is the focus of their struggle, a priority



<image>

Figure 2. The boundary between the two camps (wooden fence). Source: Photograph of the authors taken from the Los Ripieros camp.

that could encourage them to move to other city areas. These divergences reflect, in part, the historical influence of the Chilean State on the valuation of housing ownership since the 20th century (Hidalgo, 2010), an influence that continues to affect current residential aspirations, even within the most disadvantaged sectors of society (Rojo-Mendoza et al., 2023).

The dissimilarity in objectives of the studied camps shows that, although both camps originated in the same temporal and geographical context, substantial discrepancies predominate between them in terms of the organizational tactics they adopt. An example is the creation of physical boundaries between settlements (Figure 2). According to community leaders, this strategy helps preserve the identity of each group's project. However, these limits have different roles in each camp. For Los Ripieros, it safeguards the social essence of their project, while for Los Pinos, it is a challenge to overcome in the search for the consolidation of their community.

VI. CONCLUSIONS

Self-management in informal access to urban space is a process fed by urban imaginaries that guide from the initial taking of land to the consolidation of a camp in a particular space. These imaginaries, rooted in both the leaders and the families that make up the Los Pinos and Los Ripieros settlements, are fundamental since it is through their social practices and skills that they shape their daily lives and interaction with the urban environment.

However, although self-management is a shared trait in self-built settlements, each human group has distinctive urban imaginaries. This is evident in settlements such as Los Pinos and Los Ripieros, which clearly define their boundaries despite sharing the same terrain. These delimitations arise from the need to differentiate themselves and the intention to develop unique projects that affect their way of living and their daily life. In ISSN

The diversity of strategies used by irregular settlements contrasts sharply with the homogeneous and static vision that state agencies usually have of the camps, revealing instead a phenomenon that is particular to each context, time, and place and eminently dynamic.

In the social network of Los Ripieros, a vital community cohesion stands out, where the ties of kinship and mutual knowledge among its members allow it to weave a network that is closed to new members. Such a perception is a key deterrent that promotes deliberate distancing from the adjoining camp. For its part, Los Pinos pursues expansion beyond the established boundary with the neighboring camp. This effort is due to a strategic plan to recover spaces for new housing development. The political vision of Los Pinos is based on the conviction that the numerical strength of its members is a fundamental pillar for negotiation and adequate pressure on the State to guarantee a future transfer of ownership of the land.

The analysis of these camps highlights their residents' resilience and self-management capacity, challenging traditional notions of marginalization and turning them into active agents in the construction and transformation of their urban environments. This leads to a rethinking of state intervention in irregular urban settlements, stating that the response is not limited to the simple formalization and urbanization of the same area, but also contemplates the political and social instrumentalization of the camp as a dynamic and constantly evolving phenomenon in the urban fabric of Chile and Latin America.

VII. REFERENCES

Abufhele, V. (2019). La política de la pobreza y el gobierno de los asentamientos informales en Chile. *Revista EURE - Revista de Estudios Urbano Regionales,* 45(135), 49–69. http://www.eure.cl/index.php/eure/article/view/2898/1172

Aceska, A., Heer, B. & Kaiser-Grolimnd, A. (2019). Doing the City from the Margins: Critical Perspectives on Urban Marginality. *Anthropological Forum*, 29(1) 1-11. https://doi.org/10.1080/00664677.2019.1588100

Addo, I. & Danso, S. (2017). Sociocultural factors and perceptions associated with voluntary and permanent relocation of flood victims: A case study of Sekondi-Takoradi Metropolis in Ghana. *Jàmbá: Journal of Disaster Risk Studies, 9(1)*, 1-10. https://dx.doi.org/10.4102/jamba.v9i1.303

Brain, I., Prieto, J., & Sabatini, F. (2010). Vivir en Campamentos: ¿Camino hacia la vivienda formal o estrategia de localización para enfrentar la vulnerabilidad? *Revista EURE - Revista de Estudios Urbano Regionales, 36*(109), 111–141. http://dx.doi.org/10.4067/S0250-71612010000300005

Carrasco, S. & Dangol, N. (2019). Citizen-government negotiation: Cases of in riverside informal settlements at flood risk. *International journal of disaster risk reduction*, 38. https://doi.org/10.1016/j.ijdrr.2019.101195

Castañeda, Y. & Hernández, A. (2021). Ciudad informal, territorialidades de producción social del espacio urbano en asentamientos humanos. *Ciudad y Territorio Estudios Territoriales, 53*(207), 141–152. https://doi.org/10.37230/CyTET.2021.207.08

Castillo, M. (2014). Competencias de los pobladores: Potencial de innovación para la política habitacional chilena. *Revista INVI – Instituto de la Vivienda, 29(81), 79-112*. http://dx.doi.org/10.4067/S0718-83582014000200003

Cortés, A. (2014). El movimiento de pobladores chilenos y la población La Victoria: ejemplaridad, movimientos sociales y el derecho a la ciudad. *Revista EURE - Revista de Estudios Urbano Regionales, 40*(119), 239–260. https://doi.org/10.7764/366

Ducci, M. (1997). Chile: el lado obscuro de una política de vivienda exitosa. *Revista EURE - Revista de Estudios Urbano Regionales, 23(69). 99–115.* https:// doi.org/10.7764/1164

Fernández, J. (2023). Estigma y resistencia: acción institucional y autogestión comunitaria en Alto Hospicio, Chile. *Convergencia*, 30, 1-28. https://doi.org/10.29101/crcs.v30i0.20354

FUNDACIÓN TECHO. (2021). Catastro Nacional de campamentos 2020–2021. Centro de Estudios Socioterritoriales (CES). https://ceschile.org/catastro/

Fuster-Farfán, X., Ruiz, J.I., & Henry, L. (2023). Las periferias de la periferia: producción de ciudad y política habitacional en Chile. *Territorios*, 49 (1), 1-27. https://doi.org/10.12804/revistas.urosario.edu.co/territorios/a.12404

Gil, N. & Gómez, J. (2019). La cartografía participativa como herramienta para la acción política, dos estudios de caso en espacios rurales y urbanos en Colombia. *Cardinalis*, (12), 290–316. https://revistas.unc.edu.ar/index. php/cardi/article/view/24984

Hidalgo, R. (2010). El papel de las leyes de fomento de la edificación obrera y la caja de habitación en la política de vivienda social en Chile 1931-1952. *Revista INVI*, 15(39), 92-120. https://doi.org/10.5354/0718-8358.2000.62105

Imilán, W., Osterling, E., Mansilla, P., & Jirón, P. (2020). El campamento en relación con la ciudad: informalidad y movilidades residenciales de habitantes de Alto Hospicio. *Revista INVI – Instituto de la Vivienda, 35*(99), 57–80. https://revistas.uchile.cl/index.php/INVI/article/view/63167

Lefebvre, H. (1969). El Derecho a la Ciudad. Editorial Península.

López, E., Flores, P., & Orozco, H. (2018). Inmigrantes en campamentos en Chile: ¿mecanismo de integración o efecto de exclusión?. *Revista INVI* – *Instituto de la Vivienda*, *33*(94), 161-187. https://dx.doi.org/10.4067/S0718-83582018000300161

Magliano, M, & Perissinotti, M. (2020). La periferia autoconstruida: migraciones, informalidad y segregación urbana en Argentina. *Revista EURE - Revista de Estudios Urbano Regionales*, *46*(138), 5-23. https://dx.doi. org/10.4067/S0250-7161202000200005

Matus, C., Ramoneda, A. & Valenzuela, F. (2019). La integración social como desafío: análisis del programa de campamentos en Chile (2011-2018). *Revista INVI*, 34(97), 49-78. https://dx.doi.org/10.4067/S0718-83582019000300049

MINISTERIO DE VIVIENDA Y URBANISMO. (2022). Catastro Nacional de Campamentos 2022. Recuperado el 05 de enero de 2023 de https://www. minvu.gob.cl/noticia/noticias/minvu-presenta-el-catastro-nacional-decampamentos-2022/

Miraftab, F. (2018). Insurgencia, planificación y la perspectiva de un urbanismo humano. *Territorios. (38).* 215–233. https://doi.org/10.12804/revistas.urosario.edu.co/territorios/a.6507

Moreno, J. (2021). ¿Al lado del camino? Inventariando estrategias de autogestión del hábitat en Chile. *Revista INVI, 36*(102), 279 – 301. https://revistainvi.uchile.cl/index.php/INVI/article/view/63360

Pájaro, D. & Tello, E. (2014). Fundamentos epistemológicos para la cartografía participativa. Etnoecológica, 10(1), 1 – 20. https://www.researchgate. net/publication/296665874_Fundamentos_epistemologicos_para_la_ cartografia_participativa

Pérez, M. (2019). Uno tiene que tener casa donde nació. Ciudadanía y derecho a la ciudad en Santiago. EURE 45 (135), 71-90. http://dx.doi.org/10.4067/ S0250-71612019000200071

Perlman, J. & Delgadillo, V. (2019). Ciudades sin tugurios, ciudades sin alma. Repensando los conceptos y las consecuencias de la marginalidad en las favelas de Río de Janeiro. Andamios, 16(39), 207 - 233. https://doi. org/10.29092/uacm.v16i39.680

Pino, A. & Ojeda, L. (2013). Ciudad y hábitat informal: las tomas de terreno y la autoconstrucción en las quebradas de Valparaíso. Revista INVI -Instituto de la Vivienda, 28(78), 109 – 140. http://dx.doi.org/10.4067/S0718-83582013000200004

Regitz, M. (2019). De la planificación insurgente a la praxis del circuito inferior: ¿una articulación posible?. Estudios Socioterritoriales. Revista De Geografía, (26), e038. https://doi.org/10.37838/unicen/est.26-038

Rojo-Mendoza, F. e Hidalgo Dattwyler, R. (2021). Las clases sociales y el modelamiento socioespacial de Temuco, Chile, a finales del siglo XX. Estudios Demográficos y Urbanos, 36(3), 825-863. https://doi.org/10.24201/ edu.v36i3.1919

Rojo-Mendoza, F., Mercado-Cerroni, C. & Alvarado-Peterson, V. (2023). Residential Expectations in a Neoliberal Perspective: A Sociological View of Social Classes and the Right to Housing. In: Navarro-Jurado, E., Larrubia Vargas, R., Almeida-García, F., Natera Rivas, J.J. (eds) Urban Dynamics in the Post-pandemic Period. The Urban Book Series. Springer, Cham.

https://link.springer.com/content/pdf/10.1007/978-3-031-36017-6_18. pdf?pdf=inline+link

Ruiz-Tagle, J., Alvarez, M. & Labbé, G. (2023). Urban marginality and institutional effects: Disinvestment, inefficacy, and stigmatization in Santiago de Chile. Journal of Urban Affairs. https://doi.org/10.1080/0735216 6.2022.2150198

Sabatini, F. (2000). Reforma de los mercados de suelo en Santiago, Chile: efectos sobre los precios de la tierra y la segregación residencial. Revista EURE - Revista de Estudios Urbano Regionales, 26(77), 49 - 80. https://dx.doi. org/10.4067/S0250-71612000007700003

Sepúlveda, K. (2019). Experiencias de urbanización: El caso del campamento Manuel Bustos (Viña del Mar, Chile). Revista Faro, 2(30), 6 - 19. https://www. revistafaro.cl/index.php/Faro/article/view/604

Strauss, A. & Corbin, C. (2002). Bases de la investigación cualitativa: técnicas y procedimientos para desarrollar la Teoría Fundamentada. Universidad de Antioquia. https://www.academia.edu/29601295/Bases_de_la_ investigaci%C3%B3n_cualitativa_T%C3%A9cnicas_y_procedimientos_ para_desarrollar_la_teor%C3%ADa_fundamentada

Tant, E. (2017). El desplazamiento y la expulsión urbana en Chile: Dos estudios de casos. ÉnfaCIS, Centro de Investigación Social, TECHO, (11). 1 – 15. https:// ceschile.org/wp-content/uploads/2020/11/5_enfacis11.pdf

Wacquant, L. (2015). Las cárceles de la miseria. Ed. Manantial.

Wigle, J. (2014). The 'Graying' of 'Green' Zones: Spatial Governance and Irregular Settlement in Xochimilco, Mexico City. International Journal of Urban and Regional Research, 38 (2): 573-89. https://doi.org/10.1111/1468-2427.12019

Zenteno, E., Sepúlveda, K., Ahumada, J. & Díaz, J. (2020). De ciudadanías insurgentes a planificadores, urbanos. Organización social en la urbanización del campamento Manuel Bustos de Viña del Mar. Revista de geografía Norte Grande, (77), 157 - 172. https://dx.doi.org/10.4067/S0718-34022020000300157

VIII. ACKNOWLEDGMENTS

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RESIDENTIAL SEGREGATION IN TWO CITIES IN PERU'S SOUTHERN MACRO-REGION¹

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.

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; Janoschka, 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 nonspatial 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 nonspatial 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, 2001). 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., 2022), 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

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
lca	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 capitals4. 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).



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	F 401	13,01%		
	19,49%	15,64%	5 401			
Medium	64 452	110 849	46 207	71,99%		
	30,26%	36,96%	40 597			
Higj	107 039	142 152	2E 112	32,80%		
	50,25%	47,40%	22 11 22			
Таспа						
	2007	2017	Absolute	Relative		
Low	15 591	16 918	1 2 2 7	8,51%		
	22,56%	19,22%	1 527			
Medium	25 841	38 526	10.605	49,09%		
	37,40%	43,76%	12 000			
Higj	27 668	32 598	4 0 2 0	17,82%		
	40,04%	37,03%	4 950			

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 socioeducational 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.







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 workingclass 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. 9

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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).
Arequipa			
		2007	2017
Low	Block	42,93	39,64
LOW	Census area	28,40	25,15
Modium	Block	34,91	32,50
Medium	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)



Educational level reached by the head of household, 2007

social homogeneity, 2007 (Standard dev. of the educational level %



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



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



LISA of medium socio-educational groups

LISA of low socio-educational groups

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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).



Social homogeneity, 2017

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

LISA de grupos socioeducativos medios

LISA de grupos socioeducativos bajos



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 applomeration 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 2021), 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

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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.

VIII. REFERENCES

Abanto, E. (2017). Cuando el Estado construye la barriada. [Tesis para optar al grado de Magíster en Desarrollo Urbano]. Universidad Católica de Chile.

Águila, M. J., & Prada, J. (2020). Crecimiento urbano y segregación socioespacial en Valdivia. *Urbano*, 23(42), 32-43. https://dx.doi.org/10.22320/07183607.2020. 23.42.03

Apparicio, P., Fournier, E., & Apparicio, D. (2013). Geo-Segregation Analyzer: a multiplaform application (version 1.1). Montreal, Spatial Analysis and Regional Economics Laboratory (SAREL), INRS Urbanisation Culture Société.

Arbaci, S. (2019). Paradoxes of Segregation: Housing Systems, Welfare Regimes and Ethnic Residential Change in Southern European Cities. NY: Wiley.

Arriagada, C., & Morales, N. (2006). Ciudad y seguridad ciudadana en Chile: Revisión del rol de la segregación sobre la exposición al delito en grandes urbes. *EURE*, 32(97), 37-48. https://dx.doi.org/10.4067/S0250-71612006000300003

Borsdorf, A., & Hidalgo, R. (2010). From Polarization to Fragmentation. Recent Changes in Latin American Urbanization en P. Lindert y O. Verkoren (Eds.) *Decentralized Development in Latin America* (pp. 23-34). Heidelberg: Springer.

Calderón, J., & Vega Centeno, P. (2016). La cuestión urbana en Perú: balances y perspectivas para el siglo XXI en P. Metzger, et al. (Eds). La cuestión urbana en la región andina (pp.175-222). Quito: PUCE.

Canziani, J. & Schejtman, A. (2013) (Eds.). Ciudades intermedias y desarrollo territorial. Lima: PUCP.

Cebrián, F., Beltrão Sposito, M. & Dammert-Guardia, M. (2022). Urban Growth, Metropolization, and Growth Management in Latin America and the Caribbean en J. Gonzales, C. Irazábal y R. Lois.González. (Eds.). *The Routledge Handbook of Urban Studies in Latin America and the Caribbean* (pp. 35-53). NY: Routledge. Clichevsky, N. (2000). Informalidad y segregación urbana en América Latina: Una aproximación. Santiago: CEPAL. https://fcp.uncuyo.edu.ar/ upload/clichevsky-2000.PDF

De Queiroz Ribeiro, L. (Ed.). (2017). Urban Transformations in Rio de Janeiro: Development, Segregation, and Governance. Springer.

Elorza, A. (2019). Segregación residencial y estigmatización territorial. Representaciones y prácticas de los habitantes de territorios segregados. *EURE, 45(135), 91-110.* http://dx.doi.org/10.4067/S0250-71612019000200091

Espinoza, A., Fort, R. & Espinoza, M. (2022). Reorganizar el Perú: ciudades intermedias y desarrollo en M. Balarin, S. Cueto y R. Fort. (Eds). *El Perú pendiente: ensayos para un desarrollo con bienestar* (pp. 287-310). Lima: GRADE.

Fernández de Córdova, G., Moschella, P. & Fernández-Maldonado, A. (2021) Changes in Spatial Inequality and Residential Segregation in Metropolitan Lima en M. van Ham, T. Tammaru, R. Ubarevičienė, H. Janssen. (Eds.). *Urban Socio-Economic Segregation and Income Inequality:* A *Global Perspective* (pp. 471 – 490). Springer. https://link.springer.com/ chapter/10.1007/978-3-030-64569-4_24

Galarza, L. (2011). Visión de futuro territorial. Documentos de trabajo # 14. CEPLAN. https://www.ceplan.gob.pe/documentos_/documento-detrabajo-14-vision-de-futuro-del-desarrollo-territorial/

Garreton, M., Basauri, A., & Valenzuela, L. (2020). Exploring the correlation between city size and residential segregation: Comparing Chilean cities with spatially unbiased indexes. *Environment and Urbanization*, *32(2)*, *569-588*. https://doi.org/10.1177/0956247820918983

Gomes, M. & De Queiroz, L. (2021). Segregación socioespacial y desigualdades de ingreso de la clase popular en la región metropolitana de Río de Janeiro, Brasil. *EURE*, 47(142), 17-48. https://doi.org/10.7764/EURE.47.142.02

INEI (2017). Perú: Perfil Sociodemográfico. https://www.inei.gob.pe/ media/MenuRecursivo/publicaciones_digitales/Est/Lib1539/

Janoschka, M. (2002). El nuevo modelo de la ciudad latinoamericana: fragmentación y privatización. *EURE*, 28(85), 11-20. https://dx.doi. org/10.4067/S0250-71612002008500002

Kaztman, R. (2001). Seducidos y abandonados: el aislamiento social de los pobres urbanos. *Revista de la CEPAL*, 75, 171-189. https://dialnet.unirioja.es/ servlet/articulo?codigo=1237690

Krupka, D. (2007). Are big cities more segregated? Neighborhood scale and the measurement of segregation. *Urban Studies*, 44(1), 187-197. https://doi.org/10.1080/00420980601023828

Maloutas, T. (2012). Introduction: Residential Segregation in Context en T. Maloutas y K. Fujita. (Eds.) Residential segregation in comparative perspective: Making sense of contextual diversity. Ashgate.

Marengo, C. & Elorza, A. (2014) Tendencias de segregación residencial socioeconómica: El caso de Córdoba (Argentina) en el período 2001-2008. *EURE*, 40(120), 111-133. https://www.redalyc.org/pdf/196/19630362001.pdf

Marques, E. (2015). Urban Poverty, Segregation and Social Networks in São Paulo and Salvador. *International Journal of Urban and Regional Research*, 39(6), 1067-1083. https://doi.org/10.1111/1468-2427.12300

Massey, D. & Denton, N. (1998). The Dimensions of Residential Segregation. *Social Forces*, 67(2), 281-315. http://www.jstor.org/stable/2579183

Mayorga, J. M. (2021). Comparación de los patrones espaciales e incidencia de la segregación residencial en las principales ciudades de Colombia. *Investigaciones Geográficas (España)*, (75), 267-294. https://doi. org/10.14198/INGEO.17548

Meza, M. & Condori, V. (2018). *Historia mínima de Arequipa: desde los primeros pobladores hasta el presente*. Instituto de Estudios Peruanos.

Ministerio de Vivienda, Construcción y Saneamiento. (2016). Decreto Supremo que aprueba el Reglamento de Acondicionamiento Territorial y Desarrollo Urbano Sustentable. https://busquedas.elperuano.pe/ dispositivo/NL/1466636-3 21/05/24

Municipalidad Provincial de Arequipa. (2015). Memoria del PDM Arequipa. Plan de Desarrollo Metropolitano de Arequipa 2016-2025. Región y Provincia de Arequipa. https://impla.gob.pe/publicaciones/pdm-2016-2025/

Municipalidad Provincial de Tacna. (2013). Plan de Desarrollo Urbano de la ciudad de Tacna 2014-2023.

Monkkonen, P. (2012). La segregación residencial en el México urbano: Niveles y patrones. *EURE, 38(114), 125-146*. http://dx.doi.org/10.4067/S0250-71612012000200005

Niembro, A., Guevara, T., & Cavanagh, E. (2019). Segregación residencial socioeconómica e inserción laboral: El caso de San Carlos de Bariloche, Argentina. *INVI*, 34(97), 129-154. http://dx.doi.org/10.4067/S0718-83582019000300129

Otero, G., Volker, B., & Rozer, J. (2021). Space and social capital: Social contacts in a segregated city. Urban Geography, 43(127), 1-24. https://doi. org/10.1080/02723638.2021.1950982

Prada-Trigo, J., & Andrade, P. (2022). Segregación y vulnerabilidad como efecto de las políticas públicas en Chile. El caso de Alerce, Puerto Montt. *Cuadernos Geográficos*, 61(2), 247-268. https://doi.org/10.30827/cuadgeo. v61i2.21989

Prévot Schapira, M. (2001). Fragmentación espacial y social: conceptos y realidades. Perfiles latinoamericanos, 9(19), 33-56. https://perfilesla.flacso. edu.mx/index.php/perfilesla/article/view/315/269

Rodríguez, J., & Arriagada, C. (2004). Segregación Residencial en la Ciudad Latinoamericana. *EURE, 30(89), 5-24.* http://dx.doi.org/10.4067/S0250-71612004008900001

Ruiz, C., Vieyra, A., & Méndez-Lemus, Y. (2021). Segregación espacial en Tarímbaro, municipio periurbano de la zona metropolitana de Morelia, Michoacán. *Revista de geografía Norte Grande*, 78, 237-257. http://dx.doi. org/10.4067/S0718-34022021000100237

Ruiz-Tagle, J. & López, E. (2014). El estudio de la segregación residencial en Santiago de Chile: Revisión crítica de algunos problemas metodológicos y conceptuales. *EURE*, *40(119)*, *25-48*. http://dx.doi.org/10.4067/S0250-71612014000100002

Sabatini, F., Cáceres, G., & Cerda, J. (2001). Segregación residencial en las principales ciudades chilenas: Tendencias de las tres últimas décadas y posibles cursos de acción. *EURE, 27(82), 21-42*. http://dx.doi.org/10.4067/ S0250-71612001008200002

Sabatini, F. R., Rasse, A., Trebilcock, M., & Greene, R. (2020). Ciudad y segregación vapuleadas por el capitalismo. Crítica de los enfoques idealistas. *Urbano, 23(42), 08-17.* https://doi.org/10.22320/07183607.2020.2 3.42.01

Sánchez, M. & Gómez, R. (2021). Indicadores espaciales y no espaciales: un enfoque complementario para el análisis cuantitativo de la segregación residencial en la ciudad de Managua. *Urbano*, 24(43),52-61. https://dx.doi. org/10.22320/07183607.2021.24.43.05

Theodore, N., Peck, J., & Brenner, N. (2009). Urbanismo neoliberal: la ciudad y el imperio de los mercados. *Temas sociales, 66(10), 1-11.* https://www.researchgate.net/publication/277955552_Urbanismo_neoliberal_la_ciudad_y_el_imperio_de_los_mercados

Toro, F., & Orozco, H. (2018). Concentración y homogeneidad socioeconómica: Representación de la segregación urbana en seis ciudades intermedias de Chile. *Revista de Urbanismo, 38, 1.* https://doi. org/10.5354/0717-5051.2018.48834

Vergara, L., & Salazar, G. (2021). Non-metropolitan cities in Latin American urban studies: Between 'trickle-down urban theory' and 'singularisation theory'. *International Development Planning Review*, 43(3), 321-344. https://doi.org/10.3828/idpr.2020.18

Vilela, M. (2023). Relaciones espaciales en la dispersión poblacional y estructura territorial. Valle Sondondo. *Territorios, 48(5).* https://doi. orq/10.12804/revistas.urosario.edu.co/territorios/a.12230

Zapana, L., March, H., & Sauri, D. (2021). Las desigualdades en el acceso al agua en ciudades latinoamericanas de rápido crecimiento: El caso de Arequipa, Perú. *Revista de geografía Norte Grande, 80, 369-389.* https:// revistaingenieriaconstruccion.uc.cl/index.php/RGNG/article/view/18193 /36391

SEGREGACIÓN RESIDENCIAL EN DOS CIUDADES DE LA MACRO REGIÓN SUR DEL PERÚ MANUEL DAMMERT-GUARDIA, LUIS RIVERA-SEGURA REVISTA URBANO Nº 49 / MAYO 2024 - OCTUBRE 2024 PÁG. 62 - 77 ISSN 0717 - 3997 / 0718 - 3607 PRODUCIENDO PERIFERIAS: MORFOLOGÍA Y HABITABILIDAD EN LAS CONURBACIONES DE CUENCA, ECUADOR MICHELLE ESTEFANÍA PEGÁNTEZ-YÉPEZ, NATASHA EULALIA CABRERA-JARA REVISTA URBANO Nº 49 / MAYO 2024 - OCTUBRE 2024 PÁG, 62 - 77 ISSN 0717 - 3997 / 0718 - 3607

PRODUCING PERIPHERIES: MORPHOLOGY AND HABITABILITY IN THE CONURBATIONS OF CUENCA, ECUADOR¹

PRODUCIENDO PERIFERIAS: MORFOLOGÍA Y HABITABILIDAD EN LAS CONURBACIONES DE CUENCA, ECUADOR

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La expansión de las ciudades intermedias latinoamericanas ha dejado patrones de ocupación irregulares y discontinuos sobre sus territorios periféricos. En apariencia, las configuraciones urbanas de los bordes no difieren de manera relevante, sin embargo, cada estructura morfológica es heterogénea, posee conductas propias, diferentes motivaciones de ocupación y resulta en diversos modelos consolidados. En Cuenca, Ecuador, estas zonas difusas entre el límite urbano y rural están marcadas a su vez por dinámicas de segregación y dependencia al centro consolidado y en ellas se registran los índices de calidad de vida más bajos de la ciudad. En este contexto, el objetivo de la investigación fue encontrar una posible relación entre los tipos de morfologías periféricas y los niveles de habitabilidad urbana de cuatro núcleos urbanos de la ciudad. Se usó un diseño metodológico cuantitativo de alcance correlacional de dos etapas. Inicialmente, se clasificaron las morfologías urbanas y se calificaron los niveles de habitabilidad por separado, aplicando instrumentos independientes. Posteriormente se cruzaron los resultados para describir posibles vínculos entre variables. Los hallazgos resaltan disparidades significativas de habitabilidad entre conurbaciones y se define una aparente correlación directa entre ambas dimensiones de análisis.

Palabras clave: morfología urbana, habitabilidad, periferia, dispersión urbana, ciudad intermedia.

The expansion of Latin American intermediate cities has left irregular and discontinuous occupation patterns in their peripheral territories. In appearance, the configurations of the urban edges do not have relevant differences. In fact, each morphological structure is heterogeneous and has its own behaviors, different occupation motivations, and diverse resulting consolidated models. In Cuenca, Ecuador, these diffuse zones between the urban and rural limits are marked by segregation dynamics and dependence on the consolidated center and have the lowest quality-of-life indexes in the city. In this context, the objective of the research was to find a possible relationship between the types of peripheral morphologies and the levels of urban habitability of four city urban centers, using a quantitative methodological design with a two-stage correlational scope. Initially, urban morphologies were classified, and the habitability levels were rated separately, applying independent instruments. Then, the results were cross-checked to describe possible links between variables. The findings highlight significant disparities in habitability between conurbations and define an apparent direct correlation between the two dimensions of analysis.

Keywords: urban morphology, habitability, periphery, urban sprawl, intermediate city.

I. INTRODUCTION

The growth of cities towards their peripheries has been constant throughout history since the formation of new communities alongside old cities that exceeded their natural boundaries (Mumford et al., 2014) through the accelerated expansion during the Industrial Revolution, which transformed urban morphology and lifestyles, giving rise to the phenomenon of the peri-urban (Bruegmann, 2005). This expansive process has been associated with the appearance of marginal and disorganized areas, linked to socioeconomic gaps and lack of planning (Freidberger, 2000), which has generated criticism of the 'dispersed city' model due to its negative impact on the quality of urban life and its surrounding rural environment (Hermida et al., 2015; Cabrera, 2016). Nowadays, urban edges are conceived as passive support of what the center rejects or cannot contain (Villamizar, 2014). Martins and Pereira (2022) mention that their uncontrolled growth will fragment the territory, decreasing the levels of habitability on the city's margins.

Particularly in Latin America, the most significant transformation of its territorial structure took place during the second half of the last century (Montero & García, 2017), moving from a rural predominance to an urban profile where the population of cities increased from 33% to 74% between 1940 and 1995 (Gilbert, 1997). This change was accompanied by a decrease in population density (Hermida et al., 2023), deepening the already entrenched segregation processes and transforming the region into one of the most urbanized in the world (ECLAC, 2020).

In Latin American cities, expansive dynamics result in specific morphologies linked to social and economic conflicts (Díaz & Medina, 2019; Ruiz & Romano, 2019; Segarra, 2021). The urban edge territories have been transforming into scenarios of shortcomings, which demand a broader reading, associated not only with their physical dimension but also social and political. The link between these dimensions is evident in several urban texts (Abdelrashid, 2023; Alexander, 1977; Gehl, 2010) and is addressed in this article by studying four peripheral neighborhoods of the intermediate city of Cuenca in Ecuador.

The main objective was to identify and describe the relationship between the types of peripheral morphologies and the habitability levels in the selected cases. The article is based on a literature review where it studies, on the one hand, morphology understood as the physical layout of the built area in a fabric that confers shape and structure to the urban environment and, on the other, habitability as the set of urban conditions that make a place suitable and

comfortable to live (Mouratidis, 2018). A methodological design of a correlational scope quantitative approach, conducted in two stages, is used to achieve the objective. In the first, the morphological typologies of each neighborhood are defined using Spacematrix, while the habitability levels are evaluated on a table of indicators scored on the Likert scale. In the second stage, the results are correlated by comparing them with the literature. Finally, a discussion based on the comparison of analyzed data is raised.

II. THEORETICAL FRAMEWORK

Conceptual delimitation of periphery, morphology, and habitability

When addressing the relationship between morphology and habitability in peripheral neighborhoods, it becomes imperative to specify these concepts, which constitute the central line of this research. Firstly, the definition of 'periphery' refers to those areas named by the literature as edge, urban-rural interface, or peri-urban (Hermida et al., 2023) that are formed on the margin of cities, that "are cataloged or not as expansion and live permanent urbanization processes" (Toro et al., 2005, p.57) and are characterized by a dispersed, disjointed and unplanned growth model (Díaz & Medina, 2019).

On the other hand, 'morphology' is understood as the physical layout of the built area in a fabric that confers shape and structure to the urban environment (Pesántez & Cabrera, 2023). This configuration can be analyzed from various theoretical perspectives, including the historicalgeographical approach that studies three fundamental elements: plot, building, and land use (Rocca et al., 2013); and the typological-project style approach, oriented to the interpretation of the territorial form and its building patterns (Oliveira, 2017). For Prieto et al. (2018), on the other hand, the approaches to urban morphology study are related to three major schools: the Anglo-Saxon, the Italian, and the French. The Anglo-Saxon emphasizes the study of roads, parceling, and land use, considering parcel dynamics as a product of social transformations. The Italian school emphasizes the formative aspects of building typology, where the most repetitive architecture becomes a decisive element of the urban form. Meanwhile, the French school presents the block as the unit of analysis that helps explain the city's structure and the urban project.

Finally, 'habitability' is defined as the conditions that make a place suitable and comfortable (Mouratidis, 2018), recognizing two interrelated aspects: the architectural

and the urban. This variable faces the phenomenon of "inhabiting", which acquires different approaches in each country, so establishing its meaning is complex (Rodas, 2019). The most basic definition speaks of minimum sanitation standards in housing (Moreno, 2008), but the concept of habitability can transcend the urban environment. The first refers to the internal characteristics of homes, such as ventilation, lighting, and thermal comfort, while urban habitability deals with the ability of cities to meet the essential needs of their inhabitants, such as accessibility to services and equipment (Rodas, 2019).

Relationship between morphology and habitability

A growing focus of study in urban research has been the link between morphology and habitability from different methodological and thematic approaches. Among them, it is vital to highlight the repeated mention of urban compactness that underlines the importance of built density and land use efficiency in the configuration of habitable urban environments (Ananda, 2014; Hermida et al., 2015; Mouratidis, 2018; Pan et al., 2017; Zhang & Zhang, 2015). Ananda (2014) and Dave (2011) highlight how housing density, influenced by compactness, can directly impact the provision of public infrastructure and services as key elements for the quality of urban life. Another relevant aspect of these investigations is the inclusion of variables such as walkability and cyclability (Berghauser & Haupt, 2021; Ewing et al., 2016; Hermida et al., 2015; Lin & Yang, 2009). These indicators of adequate public transport and human-oriented urban design reflect a growing trend towards urban sustainability and reducing dependence on private transport (Houston et al., 2015; Zhang & Zhang, 2015).

The variability in the areas of habitability addressed is remarkable; while some studies focus on basic infrastructure and services, others extend their analyses to urban green and sociability (Dempsey et al., 2012), components that are increasingly recognized for their impact on the psychosocial well-being and health of residents. This analysis highlights approaches that prioritize efficiency and land use over those that integrate quality of life and sustainability. This change is fundamental to face the contemporary challenges of urbanization, especially for Latin American cities experiencing a rapid expansion and diversification of their peripheries (Hermida et al., 2023).

In the Latin American case, Marchant et al. (2023) examined how the spatial configurations of peri-urban areas, characterized by disorganized developments and horizontal expansion, directly impact the living conditions of their inhabitants. For example, the irregular distribution of housing and the lack of adequate infrastructure limit access to essential services such as drinking water, sanitation, and public transport, exacerbating social and economic vulnerability conditions. In addition, Flores et al's (2021) research has shown that spatial fragmentation and lack of planning result in low connectivity and accessibility, affecting the residents' social integration and economic opportunities. These reflections underline the importance of understanding urban morphology not only as the physical layout, but as a crucial determinant of the quality of life and social inclusion in the peri-urban contexts of Latin America that integrates psycho-social, physical-spatial and environmental aspects (Espinoza & Gómez, 2010)

Proposed approach

This research is based on a new approach to morphological study (Kropf, 2009), consisting of a series of mathematical techniques "whose purpose is to decipher shapes, patterns, and tendential behaviors" (Oliveira, 2017, p. 66), using calculations that are easy to replicate (García, 2016). Thanks to this method, it has been possible to triangulate guantitative data on density and compactness by analyzing spatial conditions, which determine certain perceptions of habitability. Alexander et al. (1988) distinguished three approaches to this type of quantitative data on morphology referring to the perceived, the physical, and the measured (García, 2016). For example, the perceived density depends on how each individual recognizes their environment; the physical density concentrates on the tangible and objective characteristics of the built environment, while the set of quantitative aspects forms the so-called measurable density. The latter represents the relationship between an area and the number of contained elements. This approach to urban morphology turns its components into indicators of spatial and perceptual qualities (Pesántez & Cabrera, 2023). The methodological item presented analyzes the morphology using quantitative indicators, focused on the measurable physical characteristics of urban tissues.

This research focuses on urban habitability due to its direct relationship with morphology. It approaches it as a condition where housing is physically integrated into the city, has accessibility to services and equipment, and has characteristics that decrease in marginal and difficult-to-access areas (Alcalá, 2007). Pérez (1999) explores these conditions from an objective-oriented approach, which includes physical characteristics such as infrastructure, transport, and location. On the other hand, Rodas (2019) proposes a more subjective approach that considers aspects such as comfort, security, social cohesion, and privacy. Urban habitability depends on the city model, which affects different variables such as the environment, infrastructure, mobility, and sociability (Pesántez & Cabrera, 2023). It is observed that a compact urban fabric encourages the use of public transport and sustainable modes of transportation, such as walking and cycling. However, it should be considered that the relationship between density and mobility is not linear. These dense urban areas generally





Figure 1. Growth Corridors, Living Conditions Index, and case studies: Sayausí, Chiquintad, Nulti, and Baños. Source: Cabrera, 2016; Orellana & Osorio, 2014.

have greater accessibility to public and private services, which benefits the economy and reduces dependence on commuting to other equipped centers, encouraging more frequent social interactions. On the other hand, compact cities tend to reduce greenhouse gas emissions and energy consumption (Hermida et al., 2015). In conclusion, the morphology of an urban fabric affects its environment, infrastructure, mobility, sociability, and health of its inhabitants.

III. CASE STUDY

Like other Latin American countries, Ecuador experienced economic and political phenomena that transformed the shape and density of its cities. The change of its economic model towards a neoliberal one expanded the dimensions of the real estate market's intervention and, with the increase of private motorization, promoted an unprecedented expansion in the country's central municipalities. This study was carried out in four areas of the periphery of Cuenca. This Ecuadorian intermediate city is the one that has the greatest expansion record in recent decades, having grown ninefold since 1950 in a dispersed and atomized pattern with an urban footprint difficult to delimit (Hermida et al., 2015).

During the selection of cases, it was found that the expansion of the periphery of Cuenca is marked by physical and service dependence between its rural parish capitals and the consolidated city (Hermida et al., 2015). This periphery visibly accentuates growth around the road corridors connecting the urban area with the city's



Figure 2. Orthophotos of the selected case studies: Sayausí, Chiquintad, Nulti, and Baños. Source: Preparation by the authors, 2024

populated centers (Cabrera, 2016) (Figure 1). Additionally, the sectors with the lowest Living Conditions Index (LCI) are located in the peripheries, except the Nulti conurbation, where the LCI is one of the highest in the city (Orellana & Osorio, 2014) (Figure 1).

Under these considerations, it was established as sample inclusion criteria that the conurbations should: (1) be part of the edge of the city, cataloged in the ordinance as an urban area in the process of consolidation; (2) be adjacent to a main rural parish, and (3) have developed around a road corridor or primary urban expander. The conurbations chosen were Sayausí, Chiquintad, Nulti, and Baños (Figure 2).

IV. METHODOLOGY

The methodological approach used is quantitative with a correlational scope. The urban morphologies classification was carried out in *Spacematrix* (Berghauser & Haupt, 2021), while the urban habitability evaluation is presented in

a parametric rating table on A Likert scale (Berghauser et al., 2021; Rodas, 2019; Segarra, 2021; Moreno, 2008). Finally, the morphological typologies were associated with the habitability levels analyzed in the discussion, which coincided with other systematized studies in the literature review.

Classification of morphologies

The morphologies were classified BY their level of built dispersion. *Spacematrix*, an empirical tool with a quantitative approach, was used to typify urban configurations based on a survey of four metric indicators: built intensity (FSI), built compactness (GSI), height (H), and amplitude (OSR) (Berghauser & Haupt, 2021). The indicators were calculated using the same data series: study area by block, built area, and unbuilt area, which required obtaining dimensions from cartographic data, aerial photographs, and field visits. According to the tool, the compactness (GSI: *Ground Space Index*) is calculated by dividing the constructed area on the ground floor for the study area by block, equivalent to the GOS (Ground Occupancy Coefficient) in Ecuador according to current regulations.



GSI=Área construida en planta / Área de estudio (por manzana)

FSI

FSI=Área construida total / Área de estudio (por manzana)

L L= FSI / GSI

OSR

OSR= (1 - GSI) / FSI





Figure 3. Outline for the calculation of the four indicators to classify morphologies. Source: Berghauser & Haupt, 2021.



Punto o par ordenado (manzana)

Clústers de acumulación de puntos (define la tipología según Berghauser y Haupt)

Tipologías propuestas

- 1. Disperso con construcciones aisladas de baja altura
- 2. Disperso con construcciones aisladas de media altura
- 3. Disperso con construcciones aisladas de gran altura
- 4. Compacidad media con construcciones adosadas de baja altura
- 5. Compacidad media con construcciones adosadas de media altura
- 6. Compacidad media con construcciones adosadas de gran altura
- 7. Compacto con construcciones en bloque de baja altura
- 8. Compacto con construcciones en bloque de media altura
- 9. Compacto con construcciones en bloque de gran altura

Figure 4. Diagram of interpretation of results and classification of morphological typologies. Source: Berghauser & Haupt, 2021.

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The intensity (FSI: *Floor Space Index*) is calculated by dividing the total built-up area for the study area by block, being, instead, equivalent to the LUC (Land Use Coefficient). The height (H) is calculated by dividing FSI over GSI, or, in other words, the area built in height over that built on the ground floor. Finally, the open space relation (OSR), which indicates the relationship between the unbuilt space and the built-up area in each block, is calculated by subtracting GSI from the study area and dividing the resulting value for FSI (Berghauser & Haupt, 2021) (Figure 3).

Once the indicators are raised, these four datasets become a point on the Cartesian plane. The values calculated in each block determine the ordered pair (x,y), and the morphologies are classified under the clusters formed by points (blocks) in certain areas of the plane, using the criteria defined by Berghauser and Haupt (2021) (Figure 4).

Habitability assessment

Urban habitability was evaluated using a table of indicators adapted and scored on the Likert Scale

according to standards established by related methodologies (Moreno, 2008; Rodas, 2019; Segarra, 2021). The table covers four general rating parameters: access to infrastructure, sustainable mobility, sociability potential, and preservation of urban green. These criteria were identified as recurrent in previous studies in the region, supporting their relevance and applicability in this context (Moreno, 2008).

Specific indicators were defined within each parameter and adapted to the particular characteristics of the peripheral neighborhoods to ensure their relevance. Each indicator was evaluated on a scale of 1 to 5, where 1 represents the worst rating, and 5 is the best. Subsequently, an equitable weighting of the results of each parameter was carried out to calculate a final score out of 100 points. Each contributed 25% of this score, recognizing that each equally influences the built-up neighborhoods' urban habitability level. That is, regardless of the number of initiators, each of the four parameters is equivalent to 25% of the final score (Table 1, Table 2, and Table 3)

Access to infrastructure				
Aspect	Indicators	Source		
Public infrastructure	Access to water and sanitation	5. The drinking water service is regular every day of the week. 1. There is no drinking water service.	ETAPA EP (Public Telecommunications, Drinking Water and Sewerage Company of Cuenca).	
	Access to electricity	5. The electricity service is regular every day of the week. 1. There is no electricity service.	ETAPA EP (Public Telecommunications, Drinking Water and Sewerage Company of Cuenca).	
	Access to telecommunications service	5. Telephone and internet services are regular every day of the week. 1. There is no telephone or internet service.	ETAPA EP (Public Telecommunications, Drinking Water and Sewerage Company of Cuenca).	
Service infrastructure	Intensity of mixed uses	5. There are 5 or more types of uses in most sections. 1. There is only 1 type of use in most stretches.	Land Use and Management Ordinance. Google Earth. Onsite revision	
	Distance to health and/or education services	 Maximum walking distance of 200 meters to a health and/or education infrastructure. More than 1 km away from a health and/or education infrastructure. 	Google Earth. Onsite revision	
	Distance to commercial supply services	 Maximum walking distance of 200 meters to a commercial supply infrastructure. More than 1 km away from a commercial supply infrastructure. 	Google Earth. Onsite revision	

Access to infrastructure				
Aspect	Aspect Indicators Major (5) and minor (1) qualification standards			
Green	Public green area per inhabitant	5. The public green area per inhabitant equals or exceeds 9 m ² . 1. The public green area per inhabitant is less than 3 m ² .	Google Earth. Geoportal of the Municipal GAD of Cuenca.	
infrastructure	Ratio between permeable and impermeable surface	 The ratio between impermeable and permeable surfaces is 2:1. The ratio between impermeable and permeable surfaces is 8:1 or higher. 	Onsite revision	
Pocroational	Effective public area per inhabitant	 The area of effective public space per inhabitant is equal to or greater than 4.5 m². The effective area of public space per inhabitant is zero. 	Google Earth. Geoportal of the Municipal GAD of Cuenca.	
infrastructure	Number of services in the public space	 5. There are 5 or more types of use in most public spaces, including essential services. 1. There is only 1 type of use in most public spaces without essential services. 	Onsite revision	

Table 1. Aspects, indicators, qualification standards, and sources to assess access to infrastructure. Source: Preparation by the authors, 2024

Sustainable mobility				
Aspect	Indicators	Major (5) and minor (1) qualification standards	Source	
Walkability	Size of the sidewalk	5. The minimum sidewalks are 1.80 meters wide or more. 1. The minimum sidewalks are less than 1.20 meters wide.	Onsite revision	
	Continuity of sidewalk	5. The sidewalks are linear throughout the section, and their continuity is not interrupted.1. There is no linearity in the sidewalks, or there is no sidewalk.	Onsite revision	
	Conditions of the sidewalk	 5. There are no holes, steps, or unevenness. 1. More than 50% of the area contains holes, steps or unevenness. 	Onsite revision	
	Accessibility to bike paths	 5. The streets have lanes for cyclists, segregated from the flow of motorized transportation. 1. There is no infrastructure for bicycles. 	Onsite revision	
Cyclability	Lane size	 The cycle lanes are 2 meters wide or more. The cycle lanes are less than 1.20 meters wide. 	Onsite revision	
	Lane continuity	 5. Cycle lanes have continuity throughout the city. 1. The cycle lanes have no continuity. 	Google Earth. Onsite revision	
Public transport	Distance to public transport stops	 Maximum walking distance of 200 meters to a public transport station (metro, train or bus). More than 1 km away from a public transport station. 	Google Earth. Moovit app.	
	Number and frequency of trips	5. Constant trips every 10 minutes throughout the day. Trips every 20 minutes or more from morning to afternoon.	Moovit app.	
Private transportation	Average number of cars per family	5. Less than one car per family. 1. More than two cars per family,	INEC(2014) (National Institute of Statistics and Censuses). EMOV EP (Public Mobility Company of Cuenca).	
	Distance and travel time	 5. Daily car trips of a maximum of 15 minutes. 1. Daily car trips of more than 30 minutes. 	Google Earth. Moovit app.	

Table 2. Aspects, indicators, qualification standards, and sources for assessing sustainable mobility. Source: Preparation by the authors, 2024

Potential for sociability				
Aspect	Indicators	Major (5) and minor (1) qualification standards	Source	
Channelizers	Amount of furniture for resting	5. There is more than one possibility to sit on the public furniture in most sections.1. No furniture or structure offers the opportunity to sit and rest	Onsite revision	
interaction	Number of places of shade and shelter	 walking under a shelter for rain and sun is possible along most sections. No structure provides shade or shelter. 	Onsite revision	
Safety enhancers	Amount of public lighting5. Public lighting is directed to the sidewalk and/or the crossings in most sections. There is no public lighting on the road.		Onsite revision	
	Number of blind facades	5. There are no blind facades that block the visibility of the private space in most sections.1. More than 50% of the extension of most sections is composed of blind facades.	Onsite revision	
Preservation of urban greenery				
Aspect	Indicators	Major (5) and minor (1) qualification standards	Source	
Lost green area	Amount of green area lost in the expansion	5. 5% of the green area of the selected area has been lost in the last 5 years.1. It has lost more than 50% of the green area of the selected area in the last 5 years.	Geoportal of the Municipal GAD of Cuenca. PDOTs 2015 and 2022.	

Table 3. Aspects, indicators, qualification standards, and sources to evaluate the potential of sociability and the preservation of urban green. Source: Preparation by the authors, 2024

V. RESULTS

Identified urban morphologies

From the application of *Spacematrix* in the four conurbations, the results revealed a distinctive typification for each periphery, depending on its degree of dispersion. When locating the collected data, the points accumulated in the Cartesian plane corroborated that the Sayausí conurbation is of type 4, of medium compactness with low-rise terraced buildings; Nulti of type 1, scattered with isolated low-rise buildings; Chiquintad, of type 2 or scattered with isolated mid-rise buildings and Baños, of type 5 or medium compactness with mid-rise terraced buildings (Figure 5). In other words, the findings describe Sayausí and Baños as more compact conurbations than Chiquintad and Nulti, which are significantly diffuse.

The scattered typologies 1 and 2 have low constructed intensity indices (FSI) and low constructed coverage indices (GSI). The difference between the two lies in the height of their buildings

(H) and the area of retreats, or non-built areas per block (OSR). In morphological typology 1 of Nulti, a larger area of retreats was measured, generally on the four fronts of the houses, and the constructions are lower than in Chiquintad of morphological typology 2. In the same way, this happens with the typologies of medium compactness 4 and 5, Sayausí and Baños, where the one with the highest height (L) and the lowest open space (OSR) is that of morphologies type 5 of Baños.

Urban habitability levels

The findings of the urban habitability assessment pointed out deficiencies in access to infrastructure, sustainable mobility, sociability potential, and preservation of urban green in the four peri-urban neighborhoods. After evaluating each indicator on the Likert Scale of the proposed table, it was obtained globally that the Sayausí conurbation reached 51 out of 100 points, Chiquintad 28, Nulti 38.75 and Baños 54.5 (Figure 6).

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Fotografia del barrio

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Figure 5. Results of the classification of morphologies of the studied conurbations. Source: Preparation by the authors, 2024

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RESULTADOS DE HABITABILIDAD URBANA POR INDICADOR EN CADA CONURBACIÓN



Figure 6. Results of the evaluation of urban habitability of the studied conurbations. Source: Preparation by the authors, 2024

Concerning infrastructure, the conurbations of Sayausí and Baños stood out for their accessibility to public services, diversity of uses, and presence of equipment, while Nulti and Chiquintad present more restrictions. In evaluating sustainable mobility, it was evident that all conurbations have difficulties accessing passive transport. The conurbations most dependent on private cars are Nulti and Chiquintad, while Sayausí and Baños showed less dependence due to access to more frequent and effective public transport lines.

None of the conurbations has adequate rest places, parks, or squares that encourage social interaction. However, the Sayausí conurbation obtained the best score in this parameter thanks to the permeability and versatility of its facades, which provide opportunities for neighborhood

meetings. Finally, when evaluating the preservation of postexpansion natural areas, the Sayausí, Baños, and Chiquintad conurbations almost doubled their occupation area in the last decade. At the same time, Nulti grew by about 30% in the same period.

As can be seen in Figures 5 and 6, the more compact morphologies exhibit better urban habitability conditions. The typologies of medium compactness, represented in red, obtained more than 50% of the habitability rating, although they are still considerably low. Among these two, the morphology of medium compactness with medium height constructions (type 5) in Baños obtained the best rating. On the contrary, the scattered morphologies obtained the lowest habitability ratings, although the height difference did not indicate the same relationship between these two.

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VI. DISCUSSION

Firstly, it was found that the scattered morphologies, characterized by isolated constructions, effectively face difficulties accessing public infrastructures and are far from essential services such as hospitals and schools. In addition, the recreational infrastructure is insufficient. According to the literature, the relationship between compact morphologies and the efficient provision of infrastructure is positive regarding technical sustainability and energy efficiency, as Schiller (2007) points out in his work "Urban Infrastructure: Challenges for Resource Efficiency." This is due to the noticeable increase in the use and waste of material and economic resources in providing and maintaining services in scattered morphologies. In contrast, in compact neighborhoods, these services are generally more diverse and efficient (Dempsey et al., 2012).

On the other hand, there is also a theoretical consensus stating that higher occupancy densities contribute to the increase in the use of public transport and active modes of transport while reducing the use of cars and the distances traveled (Hermida et al., 2015; Ingvardson & Nielsen, 2018; Pan et al., 2017; Zhang & Zhang, 2015). In theory, urban transport modes are classified into public transport, active transport (walking or cycling), and private motorized transport (Ewing et al., 2016; Houston et al., 2015; Kim, Park, and Hong, 2018; Lin & Yang, 2009); and all of them are crossed by urban morphological conditions that determine the behavior of the trip, the distance and the choice of the modality. This research indicated that mobility to and from the conurbations is conflicting for the four neighborhoods studied. However, it was evidenced that the bus lines are less efficient for type 1 and 2 conurbations in Nulti and Chiguintad. Stops are generally scarce within these conurbations, and the travel time is more than 20 minutes. Baños and Sayausí, probably due to the influx of people, have more transport lines connected to important points of the urban area, and the routes are made more frequently. The walkability and other passive modes of transport are very difficult to realize due to the urban configuration of the conurbations. However, the more scattered morphologies are more dependent on the use of the car, particularly Nulti, whose economic conditions also favor the choice of this mode of transfer.

According to related studies, compactness and high density also positively affect the opportunities to meet people and favor, for example, the frequency with which people interact with their immediate neighbors (Berghauser & Haupt, 2021; Mouratidis, 2018). However, Bramley and Power (2009) add that this relationship is not always linear and that social interaction tends to improve as density increases only up to a healthy level, to then decrease drastically. In this study, the sociability potential obtained the most contrasting results when comparing the scores of the scattered and medium compactness morphologies. Morphologies 1 and 2, with scattered characteristics, obtained the lowest results because the city in these neighborhoods does not offer safe spaces to stay and does not favor community life or neighborhood encounters. The most problematic conurbation was Chiguintad, which, in addition, is beginning to be populated with closed condominiums en masse and isolated housing that harm urban life (Gehl, 2010; Dave, 2011). On the contrary, it was found that the morphologies of medium compactness offer opportunities for community encounters, and Sayausí particularly enjoys living spaces, shade, and permeability, which gave it the highest rating of this criterion.

Finally, it was found that, regardless of their morphological typology, the four conurbations have grown without any concern for preserving the natural and rural green space. There are still places for cultivation, livestock farming, and new subdivisions for city residents. In this sense, Ávila (2008) identifies the phenomenon of "deruralization" as the result of the drastic changes that the rural territory has suffered physically and socially due to accelerated growth, and suggests a change of perspective. The urban edge, discontinuity, and fragmentation studies must also be seen from a territorial perspective, which implies expanding the planning scale from urban to regional (Ballén, 2014, cited by Cabrera, 2016). On the urban scale, borders are growth scenarios that must conform to internal norms (Salazar & Zuleta, 2014). A purely urban approach would exclude the dynamics, uses, and inhabitants of the rural environment and open up the perspective and elucidation of the conflict faced by natural habitats and their primary uses in the face of expansion (Ruiz & Romano, 2019; Cabrera, 2016).

Despite the results, which suggest a positive correlation between variables, it is essential to clarify that habitability is also influenced by economic, social, and political factors that were not addressed in this study but are understood as fundamental to achieving a comprehensive vision of the reality of the peripheries of Cuenca. Although the quantitative approach of correlational scope and the tools used (Spacematrix and parametric rating on the Likert scale) provide quantifiable and comparative information, they do not entirely address the complexity and multidimensionality of the phenomena studied. Therefore, the results and conclusions cannot be generalized, although they show a trend that could be repeated with the corresponding differences in similar environments. In future research, addressing these limitations through methodological triangulation approaches that integrate

quantitative and qualitative methods and the active participation of residents and other key players in the research process would be beneficial. Having said that, the relationship between urban habitability and morphology in terms of dispersion is supported by the theory (Ananda, 2014; Hermida et al., 2015; Mouratidis, 2018; Pan et al., 2017; Zhang & Zhang, 2015) and is ratified in this study. Being the most scattered conurbations, those with the lowest habitability, and those with medium compactness, those with the highest habitability.

VII. CONCLUSIONS

The results obtained from this study in four peripheral areas of Cuenca, in Ecuador, show a correlation between the morphological typology and the levels of habitability in the studied conurbations, with the most compact tending to better urban habitability conditions, compared to those more scattered, with which the central research objective, consisting of identifying and describing these relationships in the selected cases, is fulfilled. It was observed that scattered morphologies face more significant difficulties in access to public infrastructures and a greater dependence on private transport, which does not contribute to sustainable mobility. In addition, these areas lack adequate public spaces that encourage social interaction, which can negatively affect community cohesion and the well-being of residents.

On the other hand, the compact morphologies presented a greater diversity of land uses, better accessibility to public services, and less dependence on private transport, offering more opportunities for social and community interaction, which could contribute to a greater sense of belonging and quality of life for residents. However, it is essential to highlight that urban habitability is influenced by various economic, social, and political factors not addressed in this study. Therefore, to understand the reality of the Latin American peripheries, it is necessary to consider these aspects in future research and integrate qualitative and participatory methods to deepen urban margins' territorial dynamics and livability narratives.

The relationship between morphology and habitability in the Latin American peripheries is a topic of great relevance and complexity, and the management of both is decisive for the quality of life of cities. This implies implementing policies to ensure compact growth models that favor social, economic, and environmental sustainability in urban edges. The findings of this study support the importance of considering urban morphology when designing urban development policies and strategies in the Latin American peripheries, promoting compaction and diversification of land uses. Finally, it highlights the importance of comprehensive urban planning that addresses morphology and habitability to improve the population's living conditions. Finally, the lack of density and green spaces in the peripheral territories highlights the urgency of addressing these challenges coherently and systematically to move towards more sustainable and inclusive cities.

VIII. REFERENCES

Abdelrashid, D., Khalifa, A., Serag, Y., & El Fayoumi, M. (2023). Investigating The Common Perceptual Qualities of Urban Morphology and Subjective Wellbeing Scales for Urban Mobility Studies: A Literature Review. *Future Engineering Journal*, 1(4), 1-14. https://digitalcommons.aaru.edu.jo/fej/

Alcalá, L. (2007). Dimensiones urbanas del problema habitacional. El caso de la ciudad de Resistencia, Argentina. *Revista INVI, 22*(59) 35-68. https://doi. org/10.5354/0718-8358.2007.62133

Alexander, C. (1977). A pattern language: Towns, Buildings, Constructions. *Oxford University Press*. https://www.patternlanguage.com

Alexander, E. R., Rees, K. D., & Murphy, P. Y. (1988). Density measures and their relation to urban form. Center for Architecture and Urban Planning. http:// dc.uwm.edu/caupr_mono/37 12/1/2024

Ávila, H. (2008). Enfoques geográficos en torno a la nueva ruralidad en E. Pérez, M, Farah y H. Cartón de Grammont. *La nueva ruralidad en América Latina. Avances teóricos y evidencias empíricas* (1ª Ed., pp. 103-132). *Pontificia Universidad Javeriana*. https://www.flacsoandes.edu.ec/sites/default/files/ agora/files/1254927167.luciano_martinez_la_descentralizacion_0.pdf

Ananda, J. (2014). Evaluating the Performance of Urban Water Utilities: Robust Nonparametric Approach? *Journal of Water Resources Planning and Management, 9*(140) 40-54. https://doi.org/10.1061/(ASCE)WR.1943-5452.0000387

Berghauser, M., & Haupt, P. (2021). SPACEMATRIX Space, Density and Urban Form. *Nai Publishers Netherlands*. https://www.researchgate.net/publication/351049141_Spacematrix_-_Space_Density_and_Urban_Form

Berghauser, M., Haupt, P., Berg, P., Alstäde, V., & Heyman, A. (2021). Systematic review and comparison of densification effects and planning motivations. *Buildings and Cities*, *2*(1), 378-401. https://journal-buildingscities.org/articles/10.5334/bc.125

Bramley, G., & Power, S. (2009). Urban form and social sustainability: the role of density and housing type. *Environment and Planning B: Planning and Design*, *36*(1), 30-48. https://journals.sagepub.com/doi/abs/10.1068/b33129

Bruegmann, R. (2005). Sprawl: a compact history. *The University of Chicago Press*. https://press.uchicago.edu/ucp/books/book/chicago/S/bo3614185. html

Cabrera, N. (2016). Metodología para el diagnóstico y la ordenación de los corredores de crecimiento de ciudades intermedias ecuatorianas: Cuenca como caso de estudio [Tesis de magíster, Universidad de Cuenca]. http:// dspace.ucuenca.edu.ec/handle/123456789/25256

CEPAL. (2020). Panorama Social de América Latina. CEPAL. https://repositorio. cepal.org/entities/publication/61652648-a144-413a-bab4-1eae639b3ecf

Dempsey, N., Brown, C., & Bramley, G. (2012). The key to sustainable urban development in UK cities? The influence of density on social sustainability. *Progress in planning 77*(3), 89-141. https://www.sciencedirect.com/journal/progress-in-planning/vol/77/issue/3

Dave, S. (2011). Neighborhood Density and Social Sustainability in Cities of Developing Countries. *Sustainable Development, 19*(3), 189-205. https://doi. org/10.1002/sd.433

Dempsey, N., Brown, C., & Bramley, G. (2012). The Key to Sustainable Urban Development in UK cities? The Influence of Density on Social Sustainability. *Progress in Planning*, 77, 89-141. 10.1016/j.progress.2012.01.001

Díaz, M., & Medina, M. (2019). Concepto de Compacidad urbana en el contexto de borde urbano en D. A. Arias-Caicedo, J. J. Castiblanco-Prieto, M. Castillo-de Herrera, M. S. Díaz-Osorio, I. F. Medina-Arboleda, M. Medina-Ruiz, . . . A. Y. Vallejo-Rivas. El borde urbano como territorio complejo. Reflexiones para su ocupación (1a ed., pág. 24). Bogotá: Universidad Católica de Colombia. https://hdl.handle.net/10983/26147

Espinoza, A., & Gómez, G. (2010) Hacia una concepción socio-física de la habitabilidad: espacialidad, sustentabilidad y sociedad. *Palapa*, *5*(1) 59-69. https://www.redalyc.org/pdf/948/94820714006.pdf

Ewing, R., Hajrasouliha, A., Neckerman, K., Purciel, M., & Greene, W. (2016). Streetscape Features Related to Pedestrian Activity. *Journal of Planning Education and Research, 36*(1), 5-15. https://doi. org/10.1177/0739456X15591585

Freidberger, M. (2000). The rural-urban fringe in the late twentieth century. *Agricultural History*, 74(2), 502-514. https://doi.org/10.1215/00021482-74.2.502

García, F. (6 y 7 de junio del año 2016). Morfología urbana en la periferia del siglo XX de Murcia: compacidad y densidad de los tejidos urbanos. [Discurso principal]. VIII Seminario Internacional de Investigación en Urbanismo. Barcelona, España. https://doi.org/10.5821/siiu.6264

Gehl, J. (2010). Cities for People. Island Press.

Gilbert, A. (1997). *La ciudad latinoamericana*. Siglo XXI. https://www.redalyc. org/articulo.oa?id=67601722

Hermida, M., Hermida, C., Cabrera, N., & Calle, C. (2015). La densidad urbana como variable de análisis de la ciudad. El caso de Cuenca, Ecuador. *Revista Eure*, 41(124), 25-44. http://dx.doi.org/10.4067/S0250-71612015000400002

Hermida, M., Cabrera, N., & Durán, M. (2023). Crecimiento y urbanización en L. Fuentes, M. Greene, R. Mora (Eds.) *Dinámicas urbanas*(1a ed., Vol. 1, pp. 12-31). Pontificia Universidad Católica de Chile. https://www.researchgate. net/publication/376112098_Crecimiento_y_Urbanizacion

Houston, D., Boarnet, M. G., Ferguson, G., & Spears, S. (2015). Can Compact Rail Transit Corridors Transform the Automobile City? Planning for More Sustainable Travel in Los Angeles. *Urban Studies, 52*(5), 938-959. https:// www.jstor.org/stable/26146022

INEC (Instituto Ecuatoriano de Estadísticas y Censos). (2014). Estadísticas. http://www.inec.gob.ec/estadísticas/

Ingvardson, J., & Nielsen, O. (2018). Effects of new bus and rail rapid transit systems – an international review. Transport Reviews, *38*, 96-116. https://www.worldtransitresearch.info/research/6699/

Kim, D., Park, J., & Hong, A. (2018). The Role of Destination's Built Environment on Nonmotorized Travel Behavior: A Case of Long Beach, California. *Journal of Planning Education and Research*, *38*(2), 152-166. https://doi.org/10.1177/0739456X16688765

Kropf, K. (2009). Aspects of Urban Form. *Urban Morphology*, 13(2), 105–120. https://doi.org/10.51347/jum.v13i2.3949

Lin, J., & Yang, A. (2009). Structural Analysis of How Urban Form Impacts Travel Demand: Evidence from Taipei. *Urban Studies*, 9(46), 51-67. https:// doi.org/10.1177/0042098009106017

Marchant, C., Riesco, M., & Monje, Y. (2023). Crecimiento y fragmentación del periurbano valdiviano. Efectos del urbanismo neoliberal en una ciudad intermedia del sur de Chile. *EURE, 49*(147), 1-25. http://dx.doi.org/10.7764/eure.49.147.09

Martins, F. & Pereira, G. (2022). Produção imobiliária de habitação em Curitiba na década de 2010: algumas reflexões. *Cadernos Metrópole*, 24(53), 311-336. https://doi.org/10.1590/2236-9996.2022-5312

Montero, L., & García, J. (2017). Panorama multidimensional del desarrollo urbano en América Latina y el Caribe. *CEPAL*. https://repositorio.cepal.org/ entities/publication/f5b33bfe-0c64-4f2f-88a0-0e53b0639727

Moreno, S. (2008). La habitabilidad urbana como condición de calidad de vida. Palapa, 11(7), 47-54. https://www.redalyc.org/pdf/948/94814774007.pdf

Mouratidis, K. (2018). Built Environment and Social Well-being: How does urban form affect social life and personal relationships? *Cities*, 74, 7-20. https://doi.org/10.1016/j.cities.2017.10.020

Mumford, L. (2014). La ciudad en la historia: sus orígenes, transformaciones y perspectivas. Logroño: Pepitas de calabaza. Sociología histórica. https://revistas.um.es/sh/article/view/246771/186591

Oliveira, V. M. (2017). Morfologia urbana: diferentes abordagens. *Revista De Morfologia Urbana*, 4(2), 65–84. https://doi.org/10.47235/rmu.v4i2.7

Orellana, D., & Osorio, P. (2014). Segregación socio-espacial urbana en Cuenca, Ecuador. *Analítika: revista de análisis estadístico*, 8, 27-38. https://dialnet.unirioja. es/servlet/articulo?codigo=5004620

Pan, H., Li, J., Shen, Q., & Shi, C. (2017). What Determines Rail Transit Passenger Volume? Implications for Transit-Oriented Development Planning. *Transportation Research Part D: Transport and Environment, 57*, 52-63. http:// www.sciencedirect.com/science/journal/13619209

Pesántez, M., & Cabrera, N. (2023). Morfología y habitabilidad urbana en el borde de una ciudad intermedia. Caso de estudio Cuenca, Ecuador [*Tesis de magister. Universidad del Azuay*]. http://dspace.uazuay.edu.ec/handle/ datos/13224

Pérez, A. (1999). "La construcción de indicadores Bio-Ecológicos para medir la calidad del ambiente natural urbano". Documento de investigación del Grupo de Calidad Ambiental Urbana. Mérida: Facultad de Arquitectura y Arte de la Universidad de Los Andes. https://docplayer.es/15445317-La-construccionde-indicadores-bio-ecologicos-para-medir-la-calidad-del-ambiente-naturalurbano.html

Prieto, P., Romero, V., Moyano, A., Solís, E., & Coronado, J. (2018). Identificación, clasificación y análisis de las formas urbanas en ciudades medias: aplicación a las capitales provinciales de Castilla-La Mancha. *Anales de Geografía de la Universidad Complutense*, *38*(1), 87-112. https://dialnet.unirioja.es/servlet/ articulo?codigo=6484433

Rocca, M., Lancioni, A., Rios, L., Dellachaux, A., & Sgroi, A. (2013). *Expansión urbana en municipios de la provincia de Buenos Aires: avances del proceso y vinculos con las politicas territoriales. Mundo Urbano, 41.* http://www.mundourb ano.unq.edu.ar/index.php/ano-2013/75-numero-41/243-expansion-urbana-enmunicipios-de-la-provincia-de-buenosaires-avances-del-proceso-y-vinculoscon-las-politicas-territoriales

Rodas, A. (2019). La vida social en la vivienda. Fenomenología de la habitabilidad programa habitacional socio vivienda, Guayaquil-Ecuador [*Tesis de doctorado. Universidad de Morelos].* http://riaa.uaem.mx/handle/20.500.12055/1173

Ruiz, J., & Romano, S. (2019). Mezcla social e integración urbana: aproximaciones teóricas y discusión del caso chileno. *Revista INVI*, 34(95), 45–69. https://revistainvi.uchile.cl/index.php/INVI/article/view/63073

Salazar, C., & Zuleta, B. (2014). La noción de borde en la narrativa urbana. Estudio de caso: Medellín, Colombia. Revista Bitácora Urbano Territorial, 24(2), 31-39.

Schiller, G. (2007). Urban infrastructure: challenges for resource efficiency in the building stock. *Building Research y Information*, 35(4), 399-411. https://doi. org/10.1080/09613210701217171

Segarra, G. (2021). Narrativas en la periferia de la ciudad intermedia. El caso de Loja-Ecuador. *Revista Eidos*, 17, 75–85. https://dialnet.unirioja.es/servlet/articulo?codigo=8489524

Toro, C., Velasco, V., & Niño, A. (2005). El borde como espacio articulador de la ciudad actual y su entorno. *Revista Ingenierías Universidad de Medellín, 4*(7), 55-65. https://www.redalyc.org/pdf/750/75004705.pdf

Villamizar, N. (2014). Bordes urbanos: teorías, políticas y prácticas para la construcción de territorios de diálogo. *Bitácora Urbano Territorial*, 2(24), 31-33. https://issuu.com/bitacoraurbanoterritorial/docs/bit__cora_24_v2_/1

Zhang, W., & Zhang, M. (2015). Short- and Long-Term Effects of Land Use on Reducing Personal Vehicle Miles of Travel: Longitudinal Multilevel Analysis in Austin, Texas. *Transportation Research Record, 2500*, 102-109. https://doi. org/10.3141/2500-12

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URBAN GROWTH AND VULNERABILITY TO CLIMATE CHANGE OF CALDERÓN IN THE METROPOLITAN DISTRICT OF QUITO, ECUARDOR¹

CRECIMIENTO URBANO Y VULNERABILIDAD AL CAMBIO CLIMÁTICO DE CALDERÓN EN EL DISTRITO METROPOLITANO DE QUITO, ECUADOR

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La parroquia Calderón, ubicada en el Distrito Metropolitano de la ciudad de Quito, presenta una dinámica espacial característica de los procesos de expansión con un crecimiento poblacional notable, pérdida de suelo agrícola y asentamientos en áreas vulnerables. Esta investigación tuvo como objetivo identificar la vulnerabilidad al cambio climático mediante análisis del crecimiento urbano de la parroquia Calderón para definir medidas de adaptación al mismo. Se utilizó la metodología de enfoque mixto a través de tres etapas: análisis histórico y espacial del crecimiento urbano, relación entre el crecimiento urbano y vulnerabilidad al cambio climático y medidas de adaptación al cambio climático en la parroquia Calderón. Los trece indicadores analizados demuestran en sus componentes de exposición y sensibilidad un nivel medio bajo de riesgo, sin embargo, sucede lo contrario en el componente de capacidad adaptativa donde la vulnerabilidad es alta. La relación entre el crecimiento urbano de la parroquia y la vulnerabilidad al cambio climático no es directa. Por una parte, los procesos de expansión afectan al territorio y a la población, originando conflictos ambientales y sociales y, por otra, se evidencian factores que están inmersos en la propia dinámica espacial de la expansión urbana.

Palabras clave: cambio climático, crecimiento urbano, exposición, sensibilidad, vulnerabilidad

The parish of Calderón, located in the Metropolitan District of Quito, has a spatial dynamic characteristic of the expansion processes, with notable population growth, loss of agricultural land, and settlements in vulnerable areas. This research aimed to identify the vulnerability to climate change by analyzing urban growth in this parish to define measures for its climate change adaptation. A three-stage mixed approach methodology was used: the historical and spatial analysis of urban growth, the relationship between urban growth and vulnerability to climate change, and climate change adaptation measures in the parish of Calderón. The thirteen indicators analyzed show a medium-low risk level in their exposure and sensitivity components. However, the opposite is true for the adaptive capacity component, where vulnerability is high. The relationship between the parish's urban growth and vulnerability to climate change is not direct. On the one hand, the expansion processes affect the territory and the population, causing environmental and social conflicts. On the other hand, factors immersed in urban expansion's spatial dynamics are revealed.

Keywords: Climate change, urban growth, exposure, sensitivity, vulnerability.

I. INTRODUCTION

In Latin America, urban growth occurs in an accelerated and disorderly way, reflecting "deep causes of an economic and social origin, along with a lack of adequate urban planning" (Herrera & Pecht, 1976, p. 18). Consequently, problems such as regional and urban network imbalance, marginality, unemployment, absence of essential services, and increased urbanization in the peripheries are revealed (Vilela & Moschella, 2017). However, climate change has become one of the current narratives that influence the political, economic, territorial, and cultural spheres, and this, accompanied by accelerated urbanization processes, is a significant challenge. Firstly, urbanization in developing countries is related to being less prepared for environmental challenges. Secondly, large cities are vulnerable to climate change risks such as losing natural resources or even natural disasters. Thirdly, cities produce the highest level of greenhouse gases and energy consumption (Duque & Montoya, 2021). Similarly, urban expansion causes variations in air temperature that can affect the residents' well-being (Ferrelli et al., 2016).

According to the UN (2011), understanding urban area growth is essential to mitigating climate change. These areas have obvious risks from weather patterns that have become the daily realities of the most vulnerable population. The analysis of climate and environmental change in the context of Latin America and the Caribbean is particularly relevant, given that it is a primarily urban region. Cities are home to more than 80% of the population and most economic activities, which generates a high demand for land, public services, drinking water, and energy. This, in turn, seriously impacts air quality and greenhouse gas emissions (Duque & Montoya, 2021). Therefore, urban growth has replaced forests, wetlands, and agricultural fields, as can be seen in the study by Mendes et al. (2020), who note that "the homogeneity of hot and humid areas eliminates the thermal contrasts needed to generate local breezes and winds" (p. 192), which explains the high levels of pollution in mediumsized and large cities.

In this context, the studies reviewed on urban expansion in Calderón confirm the parish's situation in terms of territorial and environmental conflicts. For example, Altamirano's (2016) research shows that urban expansion is related to the environment. He points out that demographic growth has been generated by diverse factors such as the location of residential, industrial, and equipment areas. This presents an environmental impact due to high levels of pollution as a result of the increase in population, industries, and automobile fleet, among other

aspects. Another study by Vásquez (2007) mentions that population growth and the need for territory to urbanize the land with an agricultural vocation have disappeared. Therefore, urban development affects protection and conservation areas. It should be noted that no research has been carried out regarding the relationship of urban growth with climate change in the studied territory beyond the environmental issue, reorganization, and proposal of urban models for the parish. Therefore, analyzing this case is relevant to understanding how unplanned urban expansion and territorial conflicts exacerbate the parish's vulnerability to the adverse effects of climate change, such as temperature increases, extreme weather events, and the alteration of rainfall patterns. These effects threaten the natural environment and the quality of life of its inhabitants.

In this way, it is proposed to identify the vulnerability of Calderón parish, considering that accelerated growth has affected it socially, economically, and environmentally. In this sense, the general objective of this work is to identify the vulnerability to climate change by analyzing the urban growth of Calderón to define climate change adaptation measures. Three specific objectives were raised: analyzing urban growth historically and spatially, determining the relationship between urban growth and vulnerability, and establishing climate change adaptation measures. The research was based on a mixed approach study, combining quantitative, qualitative, and spatial methods over three stages: 1) historical and spatial analysis of urban growth, 2) evaluation of the relationship between urban growth and vulnerability to climate change, and 3) proposals for adaptation measures. For this, thirteen indicators were used to measure exposure, sensitivity, and adaptive capacity. This paper proposes guidelines on climate change based on the governance and absence of adaptation measures in the Territorial Organization and Development Plans (PDOT, in Spanish) and the recent Climate Change Adaptation Plan (2023).

II. THEORETICAL FRAMEWORK

The research is carried out in three categories: urban growth, climate change, and vulnerability. Urban growth is understood from three processes: expansion, consolidation, and densification. The term *expansion* "refers to the change of land use, i.e., when spaces used for rural activities are used in city-related activities" (Ramírez & Pértile, 2013, p. 196). On the other hand, *consolidation* is related to the set of services, infrastructure, and densification. It includes the increase in population and housing per unit area. Small cities have a concentric urban expansion trend. However, there is gradual demographic growth with a change in the development



Figure 1. Location of the parish of Calderón. Source: Preparation by the authors based on information from the Military Geographical Institute.

model, which implies urbanization processes. Therefore, city expansion begins to be evident in the peripheries and rural areas. (Bazant, 2008).

Thus, urbanization processes alter the climate at local and regional levels, and urban areas tend to have higher temperatures and more precipitation than rural ones. Urbanization influences the climate because it hinders the flow of winds, causing a hotter and less ventilated environment. Automobiles, industries, and human activity generate heat emissions, and pavements retain heat, contributing to an increase in urban temperature (Vásquez, 2007). Therefore, urbanization processes are a fundamental part and consequence of urban growth, directly related to climate change and its challenges. Developing countries are the most exposed to climate threats and other environmental challenges, where net CO₂ emissions come from using and changing land use (IPCC, 2020). The IPCC (2019) defines climate change as the "variation of the climate's state identifiable in the variations of the average value (...), which persists for prolonged periods, usually decades or longer, and that climate change may be due to internal natural processes or external ones" (p. 75).

It is also essential to introduce the concept of *vulnerability* and the situations and effects of climate change to which informal settlements are exposed. *Vulnerability* is the "propensity or predisposition to be negatively affected. Vulnerability comprises a variety of concepts, including sensitivity or susceptibility to harm and lack of responsiveness and adaptation" (IPCC, 2019, p. 92). Meanwhile, *exposure* is "the presence of people, livelihoods, species or ecosystems, environmental functions, services and resources, infrastructure, or economic, social or cultural assets in places and environments that could be negatively affected" (IPPC, 2019, p. 11). *Sensitivity* is the "degree to which a system is affected, positively or negatively, by climate variability or change. The effects can be direct (...) or indirect" (IPCC, 2007, p. 113), and the *adaptive capacity* is the "ability of systems, institutions, human beings, and other organisms to adapt to potential damage, to take advantage of opportunities or cope with the consequences" (IPCC, 2019, p. 76).

III. CASE STUDY

The parish of Calderón is located 15 km northeast of the Quito Metropolitan District (QMD). It sits on the Guangüiltagua plateau and has an area of 79.17 Km². It is one of 33 rural parishes (Figure 1). It is bordered to the north by the parish of San Antonio, to the South by Llano Chico, to the East by Guayllabamba, and to the West by Pomasqui (GAD Calderón, 2023). Calderón has been part of the expansion process that the QMD has experienced (Farinango, 2017) through four mechanisms, as pointed out by Loachamín (2017): "socio-economic and residential segregation, migration, economic crisis, and land speculation" (p. 5).

Historical-spatial analysis of the urban growth of the Calderón parish

Calderón has seen an urban growth model starting from land subdivision and the start of agricultural activities in the 1960s and 1970s. The population settled in the consolidated area, and households with family incomes below the minimum wage did so in the periphery, forming new nuclei in the parish. The division of haciendas and land donation was the starting point for "building amenities and population 3997 / 0718 -

Year	1950	1962	1974	1982	1990	2001	2010	2020
Inhab.	6.931	8.854	13.358	18.059	36.297	84.848	152.242	243.587

Table 1. Evolution of the population in the parish of Calderón. Source: Prepared by the authors based on historical data from the National Institute of Statistics and Censuses (INEC).



Figure 2. Variation of the urban sprawl in Calderón parish (2000-2021). Source: Preparation by the authors based on GIS (2016) files of UN Habitat, NYU, and Lincoln Institute of Land Policy (2016).

increase, which drove the growth and development of the parish" (Ron, 2017, p. 79). In addition, real estate companies were interested in large plots for building closed housing complexes or for industrial use.

As a result of population growth, the peri-urbanization processes have shaped Calderón spatially with greater emphasis after the 1990s (Álvarez, 2021; Farinango, 2017). This was because "the excessive rise in population in a very short period drastically impacted how the space was used" (Álvarez, 2021, p. 105). If the growth of Calderón is considered in terms of migratory processes and increased commercial activity due to its spatial location (Farinango, 2017), it is necessary to point out that population growth was evidenced from the first national census in 1950. The growth up to 1982 was in line with that of a rural parish; however, between 1950 and 1974, it doubled (Farinango, 2017; Ron, 2017), and between 1974 and 1990, it tripled (Table 1). The population growth rate from 1982 to 1990 was 7.76%, 7.72% from 1990 to 2001, and 6.50% from 2001 to 2010 (Loachamín, 2017; GAD Calderón, 2023). Calderón is also considered the parish with the highest population density since, according to the 2010 census, it reaches a density of 1.9245 hab/Km², the highest among other rural parishes of the QMD (GAD Calderón, 2023; Farinango, 2017).

The urban sprawl of Quito spread to the periphery, and one of the most affected areas was the northeast after 2000 (Figure 2). The consolidated land, as stated by Farinango (2017), increased from 3.79% in 1996 to 35% in 2010, denoting that growth "has occupied all the flat spaces for development and has started to occupy irregular topographic spaces" (p. 22). Therefore, with urban growth and environmental and social conditions, the land use in the parish has changed. Between 2005 and 2015, there was evidence of a decrease in residential and agricultural use and ecological protection and an increase in industrial and residential surface use (Loachamín, 2017).

The following aspects were considered to analyze the exposure, sensitivity, and adaptability variables: Calderón is located in the Esmeraldas River basin and the Guayllabamba River sub-basin, consisting of six microbasins and six gorges, the most extensive being the Tumahuco gorge with 24.69 km² (Mora, 2017; Loachamín, 2017; GAD Calderón, 2023). It is located in the plains of a valley and has slopes of less than 25% in the urban area. Conversely, where the slope is more significant, this area has been destined for residential and protective agricultural use (Loachamín, 2017). The Calderón parish has a warm mesothermal dry climate (Loachamín, 2017),

Variable	Indicator	Source
	Flood risk in urban habitat	
Exposure	Risk of heat waves in urban habitat	QMD Municipality Geoportal
	Risk due to landslides in urban habitat	
	Wildfires hazard	
	Population density	
Sensitivity	Access to basic services	Military Geographical Institute
	Socioeconomic level	Geoportal
	Conflict over land use in the Expansion area	
	Plant cover	
	Level of education	Military Geographical Institute Geoportal
Ability to adapt	Access to IESS Social Security	Population and Housing Census 2010
	Actions and projects on climate change	
	Local plans for climate change and disaster risk management	QMD Council

Table 2. Variables analysis model. Source: Preparation by the authors.

with an average annual rainfall of 519.0 mm between February and April with intense rains (Mora, 2017). The average temperature varies from 14 to 18°C; however, temperatures of 13 to 15°C predominate in the consolidated area (GAD Calderón, 2023).

IV. METHODOLOGY

The following research was based on a study with an experimental design and mixed approach (quantitative, qualitative, and spatial). A deductive method was used to obtain guidelines and propose adaptation measures. An in-depth applied and exploratory research was carried out since the relationship between urban growth and vulnerability to climate change in Calderón parish was analyzed through two stages.

Stage 1: Relationship between urban growth and vulnerability to climate change

A documentary review of secondary information on climate change and vulnerability in previous studies, plans, and reports, among other sources, was proposed as a research technique for which an information matrix was used. The spatial analysis was performed with GIS software to make thematic vulnerability maps. The operationalization of this component was worked out using an analysis model (Table 2) that collected three variables and thirteen indicators.

The thirteen indicators were chosen based on the proposals of three research projects: the vulnerability index to climate change and adaptation plan for the city of Loja (FIC and Universidad Técnica Particular de Loja, 2021), The book of vulnerability. Concept and guidelines for standardized vulnerability assessment (GIZ, 2017) and Vulnerability and adaptation to climate change in Guayaguil (CAF, 2018). A comparative matrix was made for their analysis, and each variable was represented; in addition, the availability of information regarding the Geoportals of the Municipality of the QMD and the Military Geographical Institute was considered. Each of the indicators had a scale of 1 to 5, and three had to be modified to adapt to this scale: the conflict for land use in the expansion zone, because they were classified as adequate use, over light, over moderate, over severe, underutilized, and the non-expansion area does not apply. The plant cover indicator was classified into agricultural, mixed agricultural, anthropic, conservation and production, conservation and protection, and extraction of non-renewable natural resources, with livestock, protection or production, and unproductive lands not applicable. These were grouped to represent the scale, assigning level 5 to conservation coverage. As for the indicator of access to IESS Social Security, the data were grouped into five levels according to access. For the result of the vulnerability scale, the ratio of total hectares and hectares with a high or low level was considered depending on the indicator. Finally, for the indicators of actions and projects on climate change and local plans, a search was made for actions and

Indicator	Total Inhab.	High/low value	Scale
Exposure			
Flood risk in urban habitat	3136.53	11.12	0.35
Risk of heat waves in urban habitat	3132.91	111.74	3.57
Risk due to landslides in urban habitat	3127.71	782.98	25.03
Wildfires hazard	7919.63	1453.79	18.36
Sensitivity		·	
Population density	6225.33	52.95	0.85
Access to services	6225.33	177.88	2.86
Socioeconomic level	6225.33	1749.09	28.05
Conflict over land use in expansion areas	6241.02	275.24	4.41
Plant cover for conservation and protection	6241.02	1137.69	18.23
Ability to adapt		·	
Level of education	6225.39	5285.33	
Population enrolled in Social Security	7919.69	4693.16	59.26
Departments/heads that include climate change (municipality)			75.00
Actions/projects on climate change			

Table 3. Vulnerability results, scale from 0 to 100%. Source: Preparation by the authors.



Figure 3. a) Flood risk. (b) landslides in urban habitats. Source: Preparation by the authors based on data in the shape format of 2020 of the QMD Municipality Geoportal (2023).



Figure 4. a) Risk of heat waves in urban habitat. b) Wildfires. Source: Preparation by the authors based on data on the shape format of 2020 from the QMD Municipal Geoportal (2023).

projects implemented by the municipality and the Calderón Zonal Administration, as well as the availability of local plans concerning climate change and disaster risk management. Therefore, instruments such as the 2022 Accountability and the 2022 Annual Operating Plan were analyzed. Thus, 25 departments/heads at the municipal level who work on climate change were determined, and 20 actions were developed on this topic; a difference ratio was made with 100% for managing the vulnerability scale in these two indicators.

Stage 2: Adaptation measures to climate change in Calderón Parish

In the second stage of the research, the bibliographic review technique of regulatory documents in force in the country and the QMD, as well as international parameters on adaptation measures, was used. The municipality has 25 areas that work on environmental issues, including climate change, within the projects and 20 actions that include the QMD PDOT. In this case, this was subtracted from 100% to determine the vulnerability regarding the absence.

V. RESULTS

Vulnerability analysis

According to the Ministry of the Environment, Water and Ecological Transition, Calderón has a vulnerability index to

climate change of 90.48%, a high value on the proposed measurement scale (Ministry of the Environment, Water and Ecological Transition, 2023). According to the research results, the parish's vulnerability is low to medium (0-60%) concerning the first nine indicators (Table 3). However, the adaptive capacity of the parish has high levels of vulnerability (60-100%). In this context, implementing planning instruments regarding climate change can improve adaptation capacity and allow it to face its negative impacts.

Exposure

Figure 3a shows the flood risk in 5 levels. It is observed that the South-west has a high level of risk, covering an area of 11.12 ha, and an average level, on the other hand, is evident in the North and South with an area of 1121.81 ha exposed to floods, representing 35.70% of the urban surface area. On the other hand, the urban area is located on a semi-flat relief with low slopes, as indicated in Figure 3b, where the risk of landslides is high (111.75 ha). Only in the eastern sector of the parish is the risk medium-high, where the transition from the natural to the urban area occurs and where the slopes are greater than 40% (GAD Calderón, 2023). It can be seen that the low level corresponds to 63.27% of the urban area.

Figure 4a shows a high level of risk in the North and Northeast sectors in an area of 782.92 ha, close to natural

and protection areas, representing 24.95% of the urban area. Very high temperatures produce droughts, which increases the events related to wildfires. The North Eastern sector is next to ecological protection areas; the conservation and protection ground cover predominates with forest, shrub, herbaceous vegetation, grasslands, and paramo. Figure 4b indicates the very high level of wildfire danger that is spread throughout the territory. The average level, equivalent to 2506.3 ha, occupies a large continuous area on the East side.

Sensitivity

The expansion sectors close to protection and conservation areas had low densities, unlike those in the southwest of the parish, where high densities are seen in an area of 52.96 ha and high averages of 56.19 ha, as evidenced in Figure 5a. On the other hand, Figure 5b shows that the parish has a high level of access to essential services (drinking water, sewerage, and garbage collection), that is, 2882.80 ha, representing 46.31% of the surface, as opposed to 177.88 ha that have a low level in the Northern sector.

The socioeconomic level indicator (Figure 5c) considered high to low socioeconomic level values, obtaining that the high socioeconomic level covers only 58.83 ha, with low and medium-low levels predominating with 1746.09 ha and 2580.21 ha, respectively.

Regarding the conflict indicator of land use in the expansion zone (Figure 6a), 275.24 ha belong to the highest level; there is a conflict concerning underutilization "where the demand or requirement of the activity exceeded the supply provided by the land" (CIIFEN, 2012, p. 22). In addition, the land cover was analyzed (Figure 6b), and the presence of conservation and protection land in the parish was highlighted. Therefore, 1137.69 ha are from the use of conservation and protection. It should be considered that this use is essential because anthropic activities reduce the sensitivity of these areas and the population (CAF Development Bank of Latin America, 2018).

Ability to adapt

Calderón reveals a low average level of education (Figure 7a), with an area of 5285.33 ha. In the access to social security indicator, information from the Population and Housing Census 2010 (INEC, 2010) was used to obtain five population ranges of access to social security from the IESS, which, in this case, represents 473,086 inhabitants. The low level corresponds to 4693.16 ha (Figure 7b). This zone considers the expansion areas, use of ecological protection, and those scattered in the consolidated area. The high level represents only 115.38 ha of the entire territory.



Figure 5. a) Population density (inhab/ha). b) Access to essential services. c) Socio-economic level. Source: Preparation by the authors based on data in the shape format of 2019 from the Military Geographical Institute Geoportal (2019).



Figure 6. a) Conflict over land use in expansion areas. b) Plant cover. Source: Preparation by the authors based on data in the shape format of 2019 from the Military Geographical Institute Geoportal (2019).



Figure 7. a) Education level. b) Access to IESS social security. Source: Preparation by the authors based on data in the shape format of 2019 of the Military Geographical Institute Geoportal (2019) and the Population and Housing Census (INEC 2010).

Action	Plans	
Recovery of plant cover	5 ha of plant cover with collective reforestation actions in ecological protection areas and ravines	Territorial Organization and Development Plan GAD Calderón 2021 (update 2023)
Revision of 100% of the risk analysis reports	22 reports to locate anthropogenic activities that cause risk	Metropolitan Organization and Development Plan 2021-2033
Implementation of 22 actions to mitigate minor risks	15 collective actions for disaster risk mitigation 6 training processes on risk issues in neighborhoods	Quito PACQ 2020 Climate Change Action Plan

Table 4. Actions and projects implemented, and plans related to climate change and risk management. Source: Preparation by authors based on secondary information matrices and Municipality of Quito (2022).

Also, in this component, the adaptive capacity was assessed using two factors (Table 4): actions and projects implemented by the municipality and the Calderón Zonal Administration and the availability of local plans related to climate change and disaster risk management.

Climate change adaptation measures

Factors such as vulnerability and exposure were considered for climate threats. In this sense, it is vital that the PDOT management model establishes mechanisms to implement climate adaptation measures. This considers the key players, current mechanisms, engagement times, and whether a unit within each GADM is responsible for monitoring and execution. In this context, implementing climate change planning instruments can improve adaptation capacity and face the negative impacts that lead to climate change.

For its part, the Quito PACQ 2020 Climate Action Plan (Secretary of Environment of the Metropolitan District of Quito and C40, 2020), in its adaptation component, prioritized some dimensions that facilitated the design of actions with the identification of the most significant territorial impact and benefits. This PACQ highlights some actions: (1) the proposal of climate compatible planning standards using guidelines for climate change adaptation in urban expansion and agricultural areas, which includes the zoning and standards for land conservation area; (2) the land occupation conditions for climate neutrality, which involved areas that contribute to the land bank to reduce the risk, provided that there is available land to cover the lack of green areas, public space and housing; (3) early warning water adaptive management to reduce flood risks, i.e., the implementation of extreme rainfall event notifications; (4) a sustainable urban drainage infrastructure proposal that controls surface runoff in urban areas, to increase the resilience to climate change; (5) training and capacity building regarding wildfires to reduce the impact of fire by human causes; and finally, (6) to engage in sustainable and climate compatible agriculture, through sustainable agriculture land use management, which contributes to food security and sovereignty (Secretariat of Environment of the Metropolitan District of Quito and C40, 2020).

VI. DISCUSSION

The UN (2011) notes that the combustion of flammable fossil elements, extensive industrial pollution, the destruction of forests, and changes in land use have led to an accumulation of greenhouse gases in the atmosphere, decreasing the ability of oceans and vegetation to absorb these gases, which has caused temperatures changes in cities. Understanding urban growth becomes crucial for mitigating climate change, especially in Latin America and the Caribbean, where most of the population resides in urban areas and economic activities are concentrated in cities. This concentration generates a high demand for resources and services, contributing to environmental pollution. In addition, the transformation of the urban landscape, with the replacement of natural areas by infrastructures, alters local weather patterns, exacerbating city pollution levels (Duque & Montoya, 2021).

In this way, the research findings on Calderón Parish highlight the interconnection between urban growth, climate change, and vulnerability. Historically, population growth has driven urban expansion, especially towards peripheral areas, significantly increasing housing density. This uncontrolled growth exacerbated climate risks such as landslides, floods, and heat waves, unevenly affecting the territory and population and creating environmental and social conflicts. This relationship aligns with the theoretical framework, which describes how urban expansion alters the local and regional climate, contributing to a hotter and less ventilated environment due to heat retention on urban surfaces. Vulnerability, defined as the predisposition to be negatively affected by climate change, manifests itself in peripheral urban areas where exposure to climate risks is combined with an increasing sensitivity and a limited adaptive capacity. Taken together, these findings underscore the importance of sustainably addressing urban growth and implementing climate change adaptation measures to reduce the vulnerability of urban communities to emerging environmental challenges.

Consequently, "the urban growth model effectively represents a factor of vulnerability to the effects of climate change" (Cerda, 2020, p. 48). Climatic, social, and environmental factors have become a fundamental focus for the population's vulnerability; i.e., an urban growth model can reduce ecosystem resources, increasing vulnerability (Cerda, 2020). Thus, "the urbanization process, understood as a concentration of inhabitants, expansion of urban limits or creation of new cities, has a high impact on the environment and social dynamics" (Rosales, 2013, p. 1).

VII. CONCLUSIONS

This research proposes to identify the vulnerability to climate change by analyzing the urban growth of the Calderón parish to define climate change adaptation measures. To do this, thirteen indicators were used to determine the vulnerability conditions in the parish and develop the exposure, sensitivity, and adaptive capacity variables in the territory.

Population growth in the Calderón parish has been one of the main factors in the expansion process. It has led to the implementation of new residential, industrial, and commercial areas. However, this area has unfavorable geomorphological and geological conditions and is prone to natural hazards such as floods, landslides, and ash falls, with a high risk in the East of the parish. In the adaptive capacity variable, a high vulnerability is observed due to the few actions and projects aimed directly at climate change adaptation by the Municipality of the QMD and the Calderón Parish GAD. The lack of legal instruments prevents climate-related actions from being coordinated, as well as the lack of initiatives to engage with the private sector and develop actions that start from research and innovation towards the advancement of mechanisms that ensure efficient measures in the face of climate change vulnerability.

In conclusion, the research reveals the intimate relationship between uncontrolled growth and its vulnerability to climate change. The population increase has driven the expansion of residential, industrial, and commercial areas, which has exposed the parish to natural hazards such as floods and landslides, especially in the Eastern area. The municipal and parish authorities' lack of specific actions and projects to adapt to climate change has left the community vulnerable. The research highlights the urgency of integrating adaptation measures into Territorial Organization and Development Plans (PDOT) with the participation of key actors and the need to have risk management units in each municipality. The action proposals presented are based on existing instruments, such as the Quito 2020 Climate Action Plan, which offers a framework for effectively addressing climate vulnerability in Calderón Parish.

VIII. REFERENCES

Álvarez, J. (2021). Barreras invisibles del territorio: segregación residencial socioespacial multitemporal de la parroquia Calderón. *EÍDOS*, 97-107. https://revistas.ute.edu.ec/index.php/eidos/article/ view/992

Altamirano, E. (2016). *Expansión urbana y justicia ambiental: el caso de la Parroquia Calderón – DMQ*. [Tesis pregrado Ingeniero Geógrafo en Planificación Territorial. Pontificia Universidad Católica del Ecuador] https://repositorioslatinoamericanos.uchile.cl/handle/2250/2967186

Bazant, J. (2008). Procesos de expansión y consolidación urbana de bajos ingresos en las periferias. *Bitácora* 13(2), 117-132. https://revistas. unal.edu.co/index.php/bitacora/article/view/18527

CAF (Banco De Desarrollo De América Latina). (2018). Vulnerabilidad y adaptación al cambio climático en Guayaquil. [Archivo PDF] https:// scioteca.caf.com/handle/123456789/1276

Cerda, S. (2020). Aproximación a la relación entre la vulnerabilidad a los efectos del Cambio Climático y el modelo del crecimiento urbano en la Parroquia Limoncocha del Cantón Shushufindi. [Tesina Flacso, Ecuador] https://repositorio.flacsoandes.edu.ec/xmlui/handle/10469/17280

Centro Internacional para la Investigación del fenómeno de El Niño, CIIFEN. (2012). Estrategia provincial de cambio climático. Fase l: Diagnóstico Vulnerabilidad sectorial de la provincia del GUAYAS frente al cambio climático y la variabilidad climática. [Archivo PDF] https://www. researchgate.net/publication/306107811_Estrategia_Provincial_de_ Cambio_Climático_del_Guayas Duque, I. & Montoya, J. (2021). Cambio climático y urbanización. *Revista Cuadernos de Geografía*. 30(2), 274-279. http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S0121-215X2021000200274

Farinango, F. (2017). Segregación e informalidad de los espacios periurbanos de Calderón. El rol de las políticas públicas de planificación. https://repositorio.puce.edu.ec/items/9b01cc38-268d-4ea9-8612-7bbadc7f61b2

Ferrelli, F., Luján, M. & Piccolo, M. (2016). La expansión urbana y sus impactos sobre el clima y la sociedad de la ciudad de Bahía Blanca. *Revista Estudios Geográficos*, 77(281), 469-489. https://www.researchgate.net/publication/312356005_La_expansion_urbana_y_sus_impactos_sobre_el_clima_y_la_sociedad_de_la_ciudad_de_Bahia_Blanca_Argentina/fulltext/587dee0908aed3826af3c03a/La-expansion_urbana-y-sus-impactos-sobre-el-clima-y-la-sociedad-de-la-ciudad-de-Bahia-Blanca-Argentina.pdf

FIC (Fundación para la Investigación del Clima) y Universidad Técnica Particular de Loja. (2021). Índice de Vulnerabilidad al Cambio Climático y Plan de Adaptación para la ciudad de Loja, Ecuador. Resumen ejecutivo. Caracas: CAF [Archivo PDF] https://scioteca.caf.com/ handle/123456789/1812

GAD Calderón. (2023). *Plan de Desarrollo y Ordenamiento Territorial* [Archivo PDF] https://gobierno.gadcalderon.gob.ec/wp-content/ uploads/2021/09/PDOT-FINAL-PROPUESTA-2021.pdf

GIS Atlas of Urban Expansion (2016). Volume I: Areas and Densities [Archivo PDF] https://www.lincolninst.edu/es/publications/other/ atlas-urban-expansion-2016-edition

GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit). (2017). El libro de la vulnerabilidad. Concepto y lineamientos para la evaluación estandarizada de la vulnerabilidad. Ministerio Federal de Cooperación Económica y Desarrollo.

Herrera, L., & Pecht, W. (1976). *Crecimiento urbano de América Latina*. Banco Interamericano de Desarrollo. [Archivo PDF] https://www.ipcc. ch/site/assets/uploads/sites/4/2020/06/SRCCL_SPM_es.pdf

Instituto Geográfico Militar. (2019). *Catálogo de Datos Geográficos.* https://www.geoportaligm.gob.ec/geonetwork/srv/spa/catalog. search#/home

INEC (Instituto Nacional de Estadísticas y Censos). (2010). Censo Nacional de Población y Vivienda 2010. https://www.ecuadorencifras. gob.ec/informacion-censal-cantonal/

IPCC (Grupo Intergubernamental de Expertos Sobre el Cambio Climático) (2007). Cambio Climático 20027. Impacto, adaptación y vulnerabilidad. [Archivo PDF]. https://www.ipcc.ch/site/assets/ uploads/2020/02/ar4-wg2-sum-vol-sp.pdf

IPCC Grupo Intergubernamental De Expertos Sobre El Cambio Climático, (2019). Calentamiento global de 1.5C. [Archivo PDF]. https:// www.ipcc.ch/site/assets/uploads/sites/2/2019/09/IPCC-Special-Report-1.5-SPM_es.pdf

IPCC (Grupo Intergubernamental de Expertos Sobre el Cambio Climático) (2020). El cambio climático y la tierra. [Archivo PDF]. https:// www.ipcc.ch/site/assets/uploads/sites/2/2019/09/IPCC-Special-Report-1.5-SPM_es.pdf\ Loachamín, A. (2017). Análisis del cambio de uso de suelo de la parroquia rural Calderón del Distrito Metropolitano de Quito entre los años 2005 y 2015 como aporte a la actualización del PDOT de Calderón [Tesis para la obtención del Título de Ingeniería en Ciencias Geográficas y Planificaicón Territorial. Pontificia Universidad Católica del Ecuador]. http://repositorio.puce.edu.ec/handle/22000/13262

Mendes, F., Romero, H., & Ferreira da Silva, D. (2020). Cambio Climático adverso provocado por la urbanización sin planificación ni evaluación ambiental en Santiago de Chile. *Revista Geografía Norte Grande*, 77, 191-210. https://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0718-34022020000300191

Ministerio del Ambiente, Agua y Transición Ecológica. (2023). Sistema de información de Proyecciones y Riesgo Climático, Medidas de Adaptación al Cambio Climático e Indicador de Vulnerabilidad del Ecuador (SPRACC). http://spracc.ambiente.gob.ec/geovisor-web-s-pracc/frontend/

Mora, T. (2017). Vulnerabilidad social frente amenazas sísmicas en la Parroquia Calderón. [Tesis de pregrado Ingeniería en Ciencias Geográficas y Planificación Territorial. Pontificia Universidad Católica del Ecuador]. http://repositorio.puce.edu.ec/handle/22000/13235

Municipio de Quito. (2022). Informe de rendición de cuentas. Administración Zonal Calderón. https://www.quito.gob.ec/index.php/ rendicion-de-cuentas/2022

Municipio del Dmq. (2023). *Geoportal Quito*. Secretaría General de Planificación. https://geoportal.guito.gob.ec/visor/

ONU (Organización de las Naciones Unidas). (2011). Informe Mundial sobre Asentamientos Humanos 2011. Las ciudades y el cambio climático: Orientaciones para políticas [Archivo PDF]https://unhabitat.org/sites/ default/files/download-manager-files/Las%20Ciudades%20Y%20 El%20Cambio%20Clim%C3%A1tico%20Orientaciones%20Para%20 Pol%C3%ADticas.pdf

Ramírez, L., & Pértile, V. (2013). Cambio de uso de suelo y tendencias de la expansión urbana entre 1990 y 2030 en Juan José Castelli y Villa Ángela, Chaco, Argentina, Universidad de Luján. Extraído el 25/06/2023 de *Geografía y Sistemas de Información Geográfica*, 5(12), 194-216. https://ri.conicet.gov.ar/handle/11336/8572

Ron, K. (2017). La producción social del espacio en el periurbano del Distrito Metropolitano de Quito: Calderón de los rural a lo urbano [Tesis maestría en Estudios Urbanos. Facultad Latinoamericana de Ciencias Sociales. Flacso Ecuador] https://repositorio.flacsoandes.edu.ec/ handle/10469/11882

Rosales, E. (2013). Estudio prospectivo de la expansión del límite urbano del Distrito Metropolitano de Quito para las Parroquias Orientales de Calderón, Puembo y Tababela y su interrelación con la dinámica urbana de centralidades [Tesis pregrado Ingeniero Geógrafo en Planificación Territorial. Pontificia Universidad Católica del Ecuador] http:// repositorio.puce.edu.ec/handle/22000/11043

Secretaria De Ambiente Del Distrito Metropolitano De Quito Y C40. (2020). Plan de Acción de Cambio Climático de Quito, PACQ, [Archivo PDF]. https://www.fondoambientalquito.gob.ec/wp-content/ uploads/2022/10/Quito_CAP_2020.pdf

ONU Habitat, NYU, Lincoln Institute of Land Policy. (2016). Atlas of Urban Expansion. Recuperado el 04/04/2023, de The 2016 Edition. Volume 1: Areas and Densities. http://www.atlasofurbanexpansion.org/data
Vásquez, J. (2007). Afectación socio-ambiental por procesos de urbanización en la parroquia de Calderón [Tesis pregrado Ingeniería Geográfica y del Medio Ambiente. Universidad de las Fuerzas Armadas]. https://repositorio.espe.edu.ec/xmlui/handle/21000/2339?localeattribute=en

Vilela, M., & Moschella, P. (2017). Paisaje y expansión urbana sobre espacios naturales en ciudades intermedias. El caso de Purrumpampa en Huamachuco La Libertad, Perú. *Bulletin de Institut francais d'études andines* 46(3), 1- 146. https://doi.org/10.4000/bifea.8515

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FRAGMENTED OR DISINTEGRATED CITY? URBAN MODELS APPLIED TO INTERMEDIATE MEXICAN CITIES FROM THE PERSPECTIVE OF GEODEMOGRAPHY¹

¿CIUDAD FRAGMENTADA O DESINTEGRADA? LOS MODELOS URBANOS APLICADOS A LAS CIUDADES INTERMEDIAS EN MÉXICO DESDE LA GEODEMOGRAFÍA

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- 1 This work is part of the Research Project, registered with the Research and Postgraduate Secretariat of the National Polytechnic Institute: 20230596, called: "Residential segregation in the Context of Polycentrism and Urban Dispersion in Mexican Cities
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Los modelos urbanos son fundamentales en la discusiones teóricas y empíricas de las ciudades. Sin embargo, los modelos de la ciudad latinoamericana propuestos por geógrafos alemanes no han sido muy cuestionados a pesar de su empleo y, por otra parte, existen pocos estudios fuera de las grandes áreas metropolitanas de Latinoamérica. Por ello, se busca identificar si existe un patrón de la estructura residencial de las *ciudades intermedias* del Sistema Urbano Nacional de México por medio de la geodemografía. Esta propuesta metodológica busca traer nuevas herramientas de los métodos de análisis espacial, enfocados en estilos de vida, y centrase en el estudio de una de las grandes capas que tienen los modelos urbanos, la de su estructura residencial. Los resultados muestran en primer lugar que, utilizando los modelos y sus temporalidades como caleidoscopio, se pueden identificar los múltiples patrones de las ciudades, y no un único modelo. En segundo lugar, aparece un nuevo patrón desintegrado donde no son reconocibles los modelos clásicos de la Escuela de Chicago y donde la ciudad fragmentada quedó desintegrada.

Palabras clave: ciudades utópicas, ciudades intermedias, análisis de datos, segregación residencial, modelos urbanos.

Urban models are fundamental in the theoretical and empirical discussions about cities. However, the Latin American city models proposed by German geographers have not been questioned much despite their use, and there are few studies outside the large metropolitan areas. Therefore, this article, using geodemography, seeks to identify whether there is a residential structure pattern in the intermediate cities of Mexico's National Urban System. This methodological proposal looks to use new spatial analysis tools focused on lifestyles and the study of one of the great layers that urban models have: their residential structure. The results show that, firstly, using the models and their temporalities as a kaleidoscope, it is possible to identify the multiple patterns of cities and not just a single model. Secondly, a new disintegrated pattern appears where the classical models of the Chicago School are unrecognizable, and the fragmented city is left disintegrated.

Keywords: Utopian cities, intermediate cities, data analysis, residential segregation, urban modeling.

I. INTRODUCTION

Urban models were fundamental elements in both theoretical and empirical discussions in the 20th century (Szupiany, 2018, p: 102). These had three fundamental connotations, according to Janoschka (2005): a *constructive utopia*, such as the *garden city*; others generated by *deductive logic*, such as those of Christaller or von Thünen; and the models that emerged from the simplification of complex realities, known as city structural models. The latter are mainly associated with the work the Chicago School of Human Ecology carried out in the 1920s: the concentric ring model, the sector model, and the multi-core model (Linares, 2012, p:16).

At the end of the 20th century, emerging models were called into question due to the crisis of modernity. However, Borsdorf (2003) affirmed their methodological validity, defending their usefulness to the specificities of the Latin American city. At the beginning of the 21st century, some urban models applied to Latin American cities were developed, in particular, proposed by researchers from other latitudes who used these cities as analysis (Borsdorf, 2003; Borsdorf et al., 2002; Ford, 1996; Janoschka, 2002). Sometime later, some urban researchers became concerned about adopting these models. From Mexico, Álvarez (2010) guestions the applicability of the theoretical currents based on the study of cities in North America, Europe, and Oceania to the context of Mexican cities. This approach coincides with the perspective of Delgadillo (2019), who argues that "the adoption of concepts and theories developed by researchers studying different urban realities and in other linguistic contexts can provide a limited understanding of local urban processes" (p.62).

In particular, on the models developed by German geographers in Latin America, Orellana (2020) points out that there is no further analysis despite being a widely used reference by urban studies. Therefore, the author argues that it is essential to question and refute its applicability, for example, in intermediate urban systems. In the same sense, Álvarez (2010) points out that studies tend to focus on metropolitan areas, with limited attention to medium-sized cities.

In this context, this research aims to identify whether there is a pattern of the residential structure of the Intermediate Cities of the national urban system of Mexico through geodemography. This methodological proposal seeks new tools to "analyze people according to the place where they live" (Harris et al., 2005, p. 2). In this way, with the data sources of the National Institute of Statistics and Geography (INEGI) of 2020, and together with the spatial analysis methods focused on lifestyles, it is sought to have a sound methodology for the study of one of the great layers that urban models have, that of their residential structure.

II. THEORETICAL FRAMEWORK

The models of the Latin American city are up for debate

The urban models applied to Latin America at the end of the 20th century and the beginning of the 21st century were developed by researchers from other latitudes, who used these cities as analysis (Ford, 1996; Borsdorf, 2003; Janoschka, 2002). The first was Ford (1996), who presented an urban model at the end of the 20th century that retains the basic structure of rings and sectors of the Chicago School models but introduces six significant modifications. The second model is the joint proposal of Borsdorf et al. (2002), which Borsdorf (2003) presents as the historical development of Latin American cities up to the fragmented city. However, the model that had the most significant impact on academia was that of Janoschka (2002), highlighting the emergence of insular urban forms that differ from traditional city models in the region (Figure 1).

After these publications, a large number of studies appeared that sought to find out if these proposed models followed the reality of Latin American cities in different geographies such as Chile (Valdebenito, 2014; Orellana, 2020), Argentina (Linares, 2012; Buzai, 2014; Buzai & Montes (2020) or Mexico (Alvares, 2010; Göbel, 2015; Aguilar & Mateos, 2011). Other studies only mentioned them to frame their conclusions about the transformation of the Latin American city without any robust analysis or questioning the interpretative delimitation of these models.

In particular, in Mexico, a study of 32 cities developed based on three indicators found that these cities do not entirely conform to the theoretical models of a monocentric urban structure and, in addition, over time, cities tend to be less concentric and develop another type of spatial organization (Álvarez, 2010). Another study in Mexico notes that "the Latin American city model by Bähr, Borsdorf and Mertins describes many development trends that occur in the process of the metropolization of the urban agglomeration of Querétaro" (Göbel, 2015, p. 59). However, Querétaro today represents a typical city where tradition, modernity, and poverty are directly confronted (Göbel, 2015). Another study that related urban models and residential segregation sought to identify demographic differentiation in the Metropolitan Area of Mexico City. It found that they followed the



Figure 1. Theories of the internal structure of the Latin American city. Source: Author's elaboration based on Ford (1996), Borsdorf (2003), and Janoschka (2002).

traditional residential segregation model regarding the spatial distribution of socioeconomic groups (Aguilar & Mateos, 2011). However, there are indications of a more recent model of urban dispersion and fragmentation of space, with the presence of socio-economic groups such as the peripheral proletariat and the marginal urban-rural periphery. In addition, office workers in housing units tend to be located in interstitial areas and along main road accesses (Aguilar & Mateos, 2011). This analysis generated locations similar to those found in the study associated with the pattern of residential segregation in Latin American cities (Gómez-Maturano & Kunz, 2020)

As for the validity of the models of German geographers, some authors find many trends that occur in the city's metropolization process (Göbel, 2015; Aguilar & Mateos, 2011). Other researchers, in addition to the signs of the German models, identify that the structural elements are synthesized together with other models and that they sometimes represent a historical evolution of city organization (Linares,

- OCTUBRE 2024 PÁG. 108 - 121 97 / 0718 - 3607 ciudad Fragmentada o desintegrada? Los modelos urbanos aplicados a las ciudades intermedias en méxico desde la geodemografíao johanna RICARDO GÓMEZ-MATURANO PÁG. 108 - 1 - 3997 / 0718 - 36 REVISTA URBANO Nº 49 / MAYO 2024 -

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Figure 2. Intermediate Mexican cities. Source: Prepared by the author based on the United Nations list of cities (2018).

2012; Buzai & Montes, 2020). Ultimately, with a more critical perspective, it is concluded that the models of German geographers do not explain the entire Latin American city (Valdebenito, 2014) since cities do not entirely conform to the theoretical models of a specific urban structure (Alvarez, 2010). This is because there may be particularities in cities, such as political and social processes and even urban phenomena, such as conurbation, that modify them (Orellana, 2020).

IV. METHODOLOGY

The object of study is the *intermediate cities* of Mexico, considering what has been pointed out by authors such as Alzate (2023), that its conceptualization is under construction. In this sense, the characterization of a study by Navarro et al. (2023) is returned to, where intermediate cities in Mexico are defined as "those included in the metropolitan context, with a population range between 500,000 and one million inhabitants, that are not part of a higher-ranking metropolitan system" (p. 8). These cities coincide in their characteristics with the UN list of cities (2019), where Mexican cities are classified into three groups: large metropolitan areas, metropolitan areas, and medium urban areas (Table 1) (Figure 2). In this case, the so-called metropolitan areas are considered *intermediate cities* in this study.

754.000 Culiacán 719.000 Xalapa 655.000 Oaxaca de Juárez Celaya 640.000 Durango 573.000 Pachuca de Soto 570.000 Ciudad Juárez 1.423.000 La Laguna 1.313.000 Querétaro 1.214.000 San Luis Potosí 1.126.000 Mérida 1.064.000 Mexicali 1.026.000 Aguascalientes 1.017.000 Cuernavaca 998.000 Chihuahua 950.000 Tampico 928.000 Acapulco de Juárez 920.000 Saltillo 901.000 Morelia 888.000 Veracruz 864.000 Villahermosa 825.000 Reynosa 810.000 802.000 Cancún 789.000 Hermosillo Tuxtla Gutiérrez 763.000

2015 Population

Table 1. List of intermediate Mexican cities. Source: Prepared by the author based on the United Nations list of cities (2018).

which is the "analysis of people according to the place where they live" (Harris et al., 2005, p. 2), i.e., knowing where someone lives provides valuable information about how that person lives. This spatial analysis method has the following structure. First, data from the 2020 Population and Housing Census (INEGI, 2020) were collected and input, from which the analysis variables were selected, which refer to the people and places where they live. Secondly, regarding the statistical techniques, a Principal Components Analysis (PCA) was performed, the primary objective of which was to reduce the dimensions and synthesize the data input information into the procedure. Along with this analysis, a correlation analysis was performed to reduce the database's dimensions, which comprised 61 variables (Table 2).

Short name of Variable	Description of the Variable
GRAPROES	Average level of schooling
HOGJEF_F	Census households with female reference.
HOGJEF_M	Census households with a male reference.
OCUPVIVPAR	Occupants in inhabited private dwellings.
REL_H_M	Male-female ratio
P12YM_SEPA	Population aged 12 and over who were married or cohabiting.
P12YM_CASA	Population aged 12 and over who are married or cohabiting
P12YM_SOLT	Population aged 12 and over who are single or never cohabited.
P18YM_PB	Population aged 18 and over with secondary education and above
P3YM_HLI	Female population aged 3 years and over, who speak an indigenous language.
PAFIL_IPRIV	Population affiliated with private health services.
PAFIL_OTRAI	Population affiliated with another institution.
PAFIL_PDOM	Population affiliated in PEMEX, Defense, or Navy
PCON_DISC	Population with disabilities
PDER_IMSS	Population affiliated with the IMSS.
PDER_ISTE	Population affiliated with the ISSSTE.
PDER_SEGP	Population affiliated with the Health and Welfare Institute.
PEA	Population aged 12 and more who are economically active.
PNACENT	Population born in the entity.
PNACOE	Population born in another entity.
POB0_14	Population from 0 to 14 years.
POB15_64	Population from 15 to 64 years old.
POB65_MAS	Population aged 15 to 64
POBTOT	Total population.
POCUPADA	Population aged 12 and over who are employed.
PRES2015	Population aged 5 and over residing in the entity in March 2015
PRESOE15	Population aged 5 and over residing in another entity in March 2015
PROM_OCUP	Average number of occupants in dwellings
PSINDER	Population without affiliation with health services
PROM_HNV	Average number of children born alive
TVIVHAB	Total number of inhabited dwellings
TVIVPAR	Total number of private dwellings
VIVPAR_DES	Uninhabited private homes.
VIVTOT	Total number of dwellings
VPH_1CUART	Private dwellings inhabited with only one room
VPH_1DOR	Houses with one-bedroom
VPH_2CUART	Houses with two bedrooms.
VPH_2YMASD	Houses with two or more bedrooms.
VPH_3YMASC	Houses with three or more bedrooms.
VPH_AGUADV	Homes that have piped water in the housing area.

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Short name of Variable	Description of the Variable
VPH_BICI	Homes with a bicycle as a means of transport.
VPH_C_ELEC	Homes with electricity.
VPH_CEL	Homes with cell phone
VPH_CISTER	Homes with a cistern or tank
VPH_CVJ	Homes with video game consoles.
VPH_DRENAJ	Houses with drainage.
VPH_EXCSA	Housing with toilet.
VPH_INTER	Homes with Internet.
VPH_NDACMM	Homes with a car or van, not a motorcycle or scooter.
VPH_PC	Homes with a computer, laptop, or tablet.
VPH_PISODT	Houses with floors made of materials other than earth.
VPH_SINCINT	Homes without a computer or Internet
VPH_SINTIC	"Housing without information and communication technologies (ICT)"
VPH_SNBIEN	Houses without any assets
VPH_SPMVPI	Homes with paid movie, music, or video streaming service
VPH_STVP	Homes that have to pay for TV service.
VPH_TELEF	Homes with a landline.
VPH_TINACO	Houses with water tank.
VPH_TV	Homes with TV
VPH_SINRTV	Homes without radio or television
VPH_SINLTC	Homes without a landline or a cell phone

Table 2. List of the variables selected for cluster analysis. Source: Prepared by the author based on the 2020 Population and Housing Census (INEGI, 2020), some names were abbreviated.

The second statistical process was the cluster analysis, which aims to group individuals with similar characteristics and is assisted by a dendrogram. Thus, in addition to creating groups, this analysis sought to hierarchize the datasets to have a predetermined order in which similar observations are grouped using the spatial analysis units called Basic Geostatistical Areas (BGA), the census areas in Mexico.

Finally, in conceptual terms, this study will refer to geodemographic groups as the groups that, in the classical models, were called the upper, middle, and lower classes.

V. RESULTS

Who are the geodemographic groups, and how do they live?

The cluster analysis and the dendrogram based on Harris et al. (2005) showed three groups in almost all cities as the fewest groupings. Each group has specific characteristics in their housing, such as the degree of urbanization, the satisfaction with housing, certain types of people from the educational point of view, family status, life cycle, socioeconomic characteristics, access to health, and migration. In particular, clusters one and three are opposite in their characteristics, and cluster two is a mixture of both. In some cases, the difference between the two main groupings is not very high, for example, in Cancun, Merida, Aguascalientes, Oaxaca, Acapulco, and Cuernavaca. However, in another, it shows considerable differences, as is the case of Culiacán, Saltillo, Durango, Mexicali, Xalapa, Morelia, and Pachuca (Figure 3).

As for the characteristics of the housing, cluster three has more private homes; in general, they have more rooms, they have a floor that is not the earth, toilets, and a water tank; on the contrary, those in cluster one are not private homes, in general, they have fewer rooms, there are more unoccupied homes, and they have less infrastructure. As for the degree of consolidation of urbanization, number three has drainage, water, and electricity; on the contrary, number one has a lower degree of consolidated urbanization.

In addition, regarding the satisfiers of everyday life, cluster three mostly has the internet, computers, laptops or tablets, video game consoles, landlines, paid TV services, and paid-for movie, music, or video streaming services. On the contrary, cluster one is characterized by not having these satisfiers of everyday life. Finally, regarding mobility, cluster three has a car, van, motorcycle, or scooter, while cluster one uses bicycles more as a means of transport.



Figuea 3. Radar graph of clusters 1 (blue line) and 3 (orange line) of the Intermediate Cities of Mexico with selected variables. Source: Preparation of the authors based on the geodemography methodology described in Harris et al. (2005).



Figure 4. The geodemographic pattern of concentric circles. Source: Author's elaboration.

Cluster three is characterized, from an educational point of view, by having a higher preparation; that is, they have at least high school studies; cluster one generally has a lower education. In terms of household types, cluster three has more married people, with more male heads of household, and they are larger families; cluster one has fewer married people, more separated people, and more female heads of household. For the life cycle, cluster three has a mixture of children, young people, adults, and older adults, and the one has a more young and adult population than children and older people.

In the socio-economic category, Cluster Three has a higher economically active population and a higher employed population, while Cluster One is less connected to the labor market. In health, cluster three, in general, is more affiliated with health services; on the contrary, those in cluster one are not affiliated with these health services but are more affiliated with the Health Welfare Institute (social health model); therefore, they are characterized by being a population with more people with some disability. As for

migration, cluster three has a larger population born in the entity; on the contrary, cluster one is characterized by having a migrant population.

Some cities do not necessarily respond to these characteristics from a demographic point of view. However, in some specific cases, there are differences, such as tourist cities, and others are considered typical cities in their characteristics.

The geodemographic patterns of Mexican intermediate cities.

From the spatial point of view, the intermediate cities of Mexico were classified into different geodemographic patterns. The first is the pattern of concentric circles; examples are Pachuca, Morelia, Tampico, Cancun, and Xalapa. In these cities, the high geodemographic group is characterized by having better housing, living in spaces with a better degree of urbanization, and more satisfactory

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Figure 5. The geodemographic pattern of concentric circles and sectors and the polarized pattern in concentric circles and fragmented sectors. Source: Preparation by the Author.

housing (cluster three). They are located in the center, and their presence decreases as one moves away from the center. The middle geodemographic group, characterized by a mixture (cluster two), occupies the second ring, and the lowest is located in peripheral sectors (cluster one). On the other hand, another city in concentric circles, but where the low geodemographic group is located in the center of the city, is Tuxtla in Chiapas, where the middle groups are located in the second ring and the high ones on the periphery. Interestingly, most of these cities are in central and southern Mexico (Figure 4).

The second pattern is concentric circles and sectors in San Luis, Celaya, and Mexicali. In this, it can be seen that the highest income geodemographic groups (cluster 3) are located in the third ring on the periphery but grouped into sectors in the city. Those with low incomes (cluster 1) are located both on the peripheries and in the central part of the city in small fragmented sectors. Finally, the middle occupies the second ring, sharing space with the upper class in some cases (Figure 5). The third geodemographic pattern is that of fragmented sectors in La Laguna, Durango, and Juárez. In this case, the geodemographic groups with the highest incomes are located in the so-called high-income cone, but in a fragmented way, mixing with the middle and lower classes. On the other hand, the lower income groups are scattered throughout the city, mainly in the center, in the second contour, and on the periphery, but with emphasis on one sector of the city. On the other hand, the middle groups are found as the space that brings the city together (Figure 5).

The fourth pattern is the city fragmented into concentric circles, represented by Chihuahua, Saltillo, Merida, Aguascalientes, Culiacán, and Hermosillo. In this case, the geodemographic groups with the highest incomes are located mainly on the periphery of cities in the form of concentric circles but in a fragmented way without generating sectors. In the second contour, the middle class is present, which allows for the location of many fragments of low and high groups. Generally, the sectors 3997 / 0718



Figure 6. The geodemographic pattern fragmented into concentric circles. Source: Preparation by the author.

with the lowest incomes are located in a fragmented way in the center, in the second contour, and on the periphery of the city (Figure 6).

The fifth geodemographic pattern is the disintegrated one, where the large sectors referred to in the fragmented city models are not identified; this pattern seems pulverized. Examples are the cities of Querétaro, Villahermosa, Oaxaca, Acapulco, Cuernavaca, and Veracruz. These cities are determined by having multiple nuclei, not sectors, similar to the different socio-demographic groups, high, medium, and low (Figure 7).

VI. DISCUSSION

The results show that the city models of German geographers do not explain all Latin American cities from the geodemographic point of view, which is evidenced by the first patterns identified in concentric circles and sectors. These cities are related to the model of Burgess, Hoyt of the Chicago School, and Ford (1996). However, in these cities, except for Tuxtla, the central parts are still used by the urban elites, as was identified by Borsdorf et al. (2002), but for the colonial city that they called compact, from 1550 to 1810, and the city of the first phase of urbanization until 1920, which they called a sectoral city.

The patterns where the affinity with the current models begins to be identified are the so-called fragmented sector and the fragmented pattern in concentric circles. In these, it is possible to identify that pointed out by Linares (2012) and Buzai and Montes (2020), who synthesize patterns together, as these cities are a mixture of Burgess' concentric circles' models, the sectors of Hoyt, that of Ford (1996) and the so-called polarized city identified by Borsdorf et al., (2002), for the seventies, where the groups are located in opposite sectors of the city, but in this case in a fragmented way as was identified in the models of

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Figure 7. The disintegrated geodemographic pattern. Source: Preparation by the Author.

German geographers (Borsdorf et al., 2002; Janoschka, 2002; and Borsdorf, 2003).

Finally, in the disintegrated pattern, the sectors and concentric circles that are still identified in the Ford (1996), Borsdorf (2003), and Janoschka (2002) models no longer appear. This pattern seems closer to the new Urban Sprawl models in studies worldwide (Seevarethnam et al., 2021) and in Latin America (Silva & Vergara-Perucich, 2021). This could be explained by the conurbation phenomenon identified by Orellana (2020) or because the city grew dispersed along the main roads. Therefore, sectors that gather social groups are not identified but appear fractured throughout the territory. In these cities, the fragmented city seemed disintegrated; this new pattern needs to be analyzed in greater depth in future studies.

The study carried out had limitations in proposing an urban model. On the one hand, only one of the layers of the urban structure was worked with, the residential structure that allowed identification of the geodemography, which left aside other factors, such as the road network, the location of industry, commercial activities, centralities, the existence of closed neighborhoods, degradation processes, informality, and gentrification. On the other hand, the previous models are based on the analysis of the evolution of large cities, so it refers to the processes.

This study considered only the situation in 2020. Therefore, intermediate cities and the possibility of proposing some models could be considered future lines of research. Finally, the applied methodology allowed us to identify how they live and who, in the classical models, are generically called upper, middle, and lower class. The high-income geodemographic group lives in their own homes, they have more rooms for family members, and generally, they will have their housing finished with all the necessary additions. They live in the consolidated areas of the city, and in those newly created with all the urban services, they have most of the satisfactory ones, from the typical ones

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like pay television to having all the ICTs; their mobility is supported with automotive means. These people generally have university studies, live in nuclear families, where men exercise greater domination, in diverse spaces in the life cycle, have greater integration into work, have health services, and are generally a native population. The lowincome geodemographic group often presents a duality of these characteristics.

VII. CONCLUSIONS

The results show that no urban model explains all the geodemographic patterns without considering a unique pattern in the intermediate cities in Mexico. However, as a whole, all the models allow us to understand complex cities, combining patterns and temporalities and perhaps identifying a pattern in that kaleidoscope that allows us to understand the cities. This is in order not only to identify the model to which a city belongs, but to the city that would be transformed in the future: a polarized city, a city segregated into sectors, a fragmented city, a scattered city, or that new pattern that seems to be emerging from the disintegrated city.

This is not the diffuse city or the Urban Sprawl that was looking for a new, less hierarchical spatial organization. Nor is it a fragmented city, since it is not only broken and separated, but the disintegrated city seems to be the dissolution and decomposition of the city, losing spatial unity and social cohesion that could have severe consequences for the quality of life for people by dismembering community relations, replacing them with highly individualized spaces where the weakening of the community is appreciated. At the moment, these data provide a basis for future research. However, it is essential to explore this new vein to increase knowledge about the urban and metropolitan phenomenon in Mexico.

VIII. REFERENCES

Aguilar, A. G., & Mateos, P. (2011). Diferenciación sociodemográfica del espacio urbano de la Ciudad de México. *Eure*, 37(110), 5-30. http://dx.doi. org/10.4067/S0250-71612011000100001

Álvarez, (2010). El crecimiento urbano y estructura urbana en las ciudades medias mexicanas. Quivera. *Revista de Estudios Territoriales*, 12(2), 94-114. https://www.redalyc.org/pdf/401/40115676006.pdf

Alzate, J. G. V. (2023). Consideraciones teórico-metodológicas para el estudio de ciudades intermedias en sus atributos socioespaciales. *Jangwa Pana: Revista de Ciencias Sociales y Humanas*, 22(1), 1. https://doi. org/10.21676/16574923.4736

Borsdorf, A. (2003). Cómo modelar el desarrollo y la dinámica de la ciudad latinoamericana. *Eure*, 29(86), 37-49. http://dx.doi.org/10.4067/S0250-71612003008600002

Borsdorf, A., Bähr, J., & Janoschka, M. (2002). Die Dynamik stadtstrukturellen Wandels in Lateinamerika im Modell der lateinamerikanischen Stadt. *Geographica Helvetica*, 57(4), 300-310. https://gh.copernicus.org/ articles/57/300/2002/

Buzai G. & Montes G. (2020). El mapa social de la ciudad de Córdoba (Argentina). *Cuadernos Geográficos*, 59(1), 299-315. http://dx.doi.org/10.3082

Buzai, G. (2014). El mapa social de la ciudad de Luján, 2010. Modelo socioespacial basado en Linkage Analysis. https://ri.conicet.gov.ar/handle/11336/105072

Delgadillo, V. (2019). Metáforas de las ciudades latinoamericanas ¿Conceptos y adjetivaciones importadas, neutras y despolitizadas?. *Revistarquis*, 8(2), 49-65. https://revistas.ucr.ac.cr/index.php/revistarquis/article/view/37924

Ford, L. (1996), "A New and Improved Model of Latin American City Structure", The Geographical Review (3° ed., Vol. 86) American Geographical Society. https://www.jstor.org/stable/215506

Göbel, C. (2015). Una visión alemana de los modelos de ciudad. El caso de Querétaro. *Revista Gremium*, 2(4), 47-60. https://doi.org/10.56039/rgn04a06

Gómez Maturano, R., & Kunz Bolaños, I. (2020). Tipología de barrios para un aporte metodológico desde la segregación residencial en Zona Metropolitana del Valle de México (ZMVM). *Revista de urbanismo*, (42), 72-87. http://dx.doi. org/10.5354/0717-5051.2020.54781

Harris, R., Sleight, P. & Webber, R. (2005). *Geodemographics: neighbourhood targeting and GIS*. (pp. 1-289) John Wiley and Sons.

Instituto Nacional de Estadística y Geografía (INEGI). (2020). Censo de Población y Vivienda 2020. https://www.inegi.org.mx/programas/ccpv/2020/

Janoschka, M. (2002). El nuevo modelo de la ciudad latinoamericana: fragmentación y privatización. *Eure*, 28(85), 11-20. http://dx.doi.org/10.4067/ S0250-71612002008500002

Janoschka, M. (2005). El modelo de ciudad latinoamericana. Privatización y fragmentación del espacio urbano de Buenos Aires: el caso Nordelta: En, M. Welch (Ed.). *Buenos Aires a la deriva. Transformaciones urbanas recientes* (pp. 96-131). Editorial Biblos.

Linares, S. (2012). Aportes de la ecología urbana y modelos neoclásicos para analizar la diferenciación socioespacial en ciudades medias bonaerenses. Pergamino, Olavarría y Tandil (2001). *Revista Huellas,* (16), 13-35. https://repo. unlpam.edu.ar/handle/unlpam/2782

ONU (Organización de las Naciones Unidas). (2019). World Urbanization Prospects: 2018 Revision, File 12: Population of Urban Agglomerations with 300 000 Inhabitants or More in 2018, by Country, 1950-2035 (thousands), Department of Economic and Social Affairs, Population Division. https://esa.un.org/unpd/ wup/Download/7/cuadgeo.v59i1.8643

Navarro, J., Muñiz, I., & Gómez-Maturano, R. (2023). El policentrismo se impone a la dispersión en el proceso de descentralización del empleo de las ciudades intermedias mexicanas. *Eure*, 49(148). http://dx.doi.org/10.7764/eure.49.148.05

Orellana, A. (2020). Conformación metropolitana desde la fragmentación. El proceso de conurbación del Gran La Serena. *Urbano*, 23(41), 58-83. http:// dx.doi.org/10.22320/07183607.2020.23.41.04

Seevarethnam, M., Rusli, N., Ling, G. H. T., & Said, I. (2021). A geo-spatial analysis for characterising urban sprawl patterns in the Batticaloa Municipal Council, Sri Lanka. *Land*, 10(6), 636. https://doi.org/10.3390/land10060636

Silva, C., & Vergara-Perucich, F. (2021). Determinants of urban sprawl in Latin America: evidence from Santiago de Chile. *SN Social Sciences*, 1(8), 202. https://doi.org/10.1007/s43545-021-00197-4

Szupiany, E. (2018). La ciudad fragmentada: una lectura de sus diversas expresiones para la caracterización del modelo latinoamericano. *Revista de Estudios Sociales Contemporáneos*, 19, 99-116. https://ri.conicet.gov.ar/handle/11336/89153

Valdebenito, C. E. (2014). La huella socioeconómica y demográfica en la estructura residencial de las ciudades medias de Latinoamérica: el caso de Viña del Mar–Chile en la década 1992-2002. *Revista Electrónica de Geografía y Ciencias Sociales*, 18. https://revistes.ub.edu/index.php/ScriptaNova/article/ view/15078

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