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DAILY MOBILITY PRACTICES AND URBAN STRUCTURE IN THE PERI-URBAN ENVIRONMENT: [1]

LOMAS COLORADAS AND PORTAL DE SAN PEDRO, SAN PEDRO DE LA PAZ(CHILE)

PRÁCTICAS DE MOVILIDAD COTIDIANA Y ESTRUCTURA URBANA EN EL ENTORNO PERIURBANO: LOMAS COLORADAS Y PORTAL DE SAN PEDRO, SAN PEDRO DE LA PAZ(CHILE)

YABEL ARÉVALO MOLINA [2]
LEONEL PÉREZ BUSTAMANTE [3]
DANIELA VILLOUTA GUTIÉRREZ [4]

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2 Magíster en Procesos Urbanos Sostenibles
Universidad de Concepción, Concepción, Chile.
Colaborador Académico, Facultad de Arquitectura, Urbanismo y Geografía, Departamento de Geografía
https://orcid.org/0000-0003-0619-4611
yabel95@gmail.com

3 Doctor en Urbanismo
Universidad de Concepción, Concepción, Chile.
Profesor Titular, Facultad de Arquitectura, Urbanismo y Geografía, Departamento de Urbanismo
https://orcid.org/0000-0001-6661-6260
leperez@udec.cl

4 Magíster en Urbanismo
Universidad de Concepción, Concepción, Chile.
Doctora (c) en Arquitectura y Estudios Urbanos, Colaboradora Académica Posgrado, Facultad de Arquitectura, Urbanismo y Geografía, Departamento de Urbanismo
https://orcid.org/0000-0001-7706-5759
dvillouta@udec.cl

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Se propone comprender las prácticas de movilidad cotidiana en dos áreas residenciales periurbanas contiguas, pero que presentan características distintas en cuanto a origen histórico, diseño y trazado urbano, nivel socioeconómico y acceso a transporte público. El estudio se localiza en los sectores de Lomas Coloradas y Portal de San Pedro de la comuna de San Pedro de la Paz. A partir de un análisis cuantitativo, se analizó comparativamente el nivel de integración que permite la trama urbana usando el método Space Syntax (Hillier et al., 1987) mediante el software DephtmapX, para luego identificar la cantidad de equipamientos y la densidad poblacional en base a datos disponibles del censo 2017. Por último, el desarrollo de la movilidad se estudió desde la aplicación de encuestas semiestructuradas enfocadas desde el punto de vista de la oferta. Los resultados muestran que el tipo de trama urbana y su nivel de integración local pierden incidencia en las prácticas de movilidad cotidiana cuando se trata de desplazamientos a nivel intercomunal. Así, dentro de la oferta de transporte, satisfacer únicamente la oportunidad de acceso no asegura la disminución de desigualdad urbana observada desde la movilidad cotidiana de los individuos.

Palabras clave: movilidad cotidiana, periurbanización, sintaxis espacial, urbanizaciones cerradas.

The aim of this article is to comprehend daily mobility practices in contiguous peri-urban residential areas that have different characteristics in terms of their historical origin, urban design and layout, socioeconomic level, and access to public transportation, using the areas of Lomas Coloradas and Portal de San Pedro in the commune of San Pedro de la Paz. From a quantitative analysis, the level of integration allowed by the urban fabric was analyzed comparatively using the Space Syntax method (Hillier et al., 1987) through the depthMapX software, to then identify the number of facilities and population density based on data from the 2017 census. Finally, mobility was studied by applying semi-structured surveys focused on supply. The results show that the type of urban fabric and its level of local integration lose importance in daily mobility practices when it comes to intercommunal travel. Thus, within the transport offer, just satisfying access to these areas does not ensure the reduction of the urban inequality observed in the daily mobility of people.

Keywords: daily mobility, peri-urbanization, spatial syntax, gated communities.

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I. INTRODUCTION

There is consensus in the literature that the urban expansion of the contemporary city and its sprawl, are closely related to mobility systems (Galimberti, 2018; Jirón et al., 2010; Mawromatis, 2013). The creation of road infrastructures and the promotion of private vehicles, act as catalysts of urban sprawl, favoring the emergence of new urban developments outside consolidated areas. With this, they have significantly transformed the urban morphology of cities, increasing traffic problems and deepening inequalities in access to job opportunities and quality facilities and services (Tiznado-Aitken et al., 2019). This research argues the need to address the role of urban structure considering everyday mobility from its direct ties to unequal access and the forms of social exclusion in large urban areas (Jirón et al., 2010). In this aspect, the role of urban structure and public transport supply vis-a-vis mobility practices has seen less research for the peri-urban areas of medium-scale cities, specifically those with high levels of dependence on the regional capital. This article proposes addressing the case of two neighborhoods in the commune of San Pedro de la Paz as examples of accelerated urban development. Their growth has been fragmented, with a high degree of urban segregation and inequality (IDE, 2017), although with a diverse urban structure.

This research asks how the urban structure is related to daily mobility practices of peri-urban sector inhabitants with high levels of segregation and inequity. Starting from this basis, it lays down a hypothesis that the low integration of the urban fabric, with urban sprawl that has a low density and quality of public transport, are variables that intensify mobility practices and deepen existing inequalities in the peri-urban area. To investigate the characteristics of urban structure that affect mobility practices, it is proposed to comparatively analyze the daily mobility practices from the supply approach (Herce, 2009) using residents of different urban developments in the peri-urban San Pedro de la Paz, and their relationship with the levels of integration of the urban fabric (Hillier et al., 1987) and variables that shape the built environment. In this way, the implications of continuing to replicate the peripheral low-density sprawl model through gated communities are visualized. Regarding the methodology, first of all, 370 semi-structured surveys were applied to residents to understand mobility practices and the public transport supply. Secondly, to observe the urban structure and the built environment, the level of integration allowed by the urban fabric was analyzed following the Spatial Syntax theory. The results show that, in a context of urban sprawl lacking functional and historical centralities, the structure of residential areas and dependence on motorized transportation intensify high-cost daily mobility practices and travel times. However, the type of urban fabric and its level of local integration lose their impact when it comes to intercommunal commutes. Finally, the study helps to clarify the relationship between the built environment and urban mobility, while introducing a new methodology to make the forms of urban fragmentation in a medium-scale city visible.

II. THEORETICAL FRAMEWORK

Peri-urban environment, urban fabric, and daily mobility

From the general scope, Jacobs (1961), regarding spatial configuration and urban structure, states that each crossroads represents an additional opportunity where citizens can choose between different options of urban space, concluding that one way to value the potential quality of a route as support for urban life is from the density of intersections. Similarly, Lynch (1985) addresses the ease of recognition and organization between the different parts of the urban landscape under the concept of "legibility", emphasizing that in a legible city, the routes and districts are easily identifiable and grouped into a global pattern. Hillier et al. (1993) and Penn et al. (1998) also state that the way new housing developments are embedded in the street network can affect complex social processes by affecting movement patterns in the streets. These movement patterns affect the use of land and space; therefore, they are related to the construction of community networks, the development of commercial activity, and security levels, and with this, the satisfaction of the neighborhood. In this way, the public transport network is becoming vitally important both to expand and to restrict opportunities for meeting. Thus, "the public space has the potential to rebuild what society divides" (Hillier et al.,1987). This relationship is precisely the area that has been developed by The Bartlett School of Architecture through spatial syntax, particularly through the analysis of axial maps that represent all the public spaces and streets of the city. Through modeling, the entire fabric is covered with the minimum number of straight lines, as long as possible, measuring the average number of steps it takes to move from one node of the grid to another, or from one line to another within axial maps. In this way, "global integration" is understood as the variable that measures the position of each segment

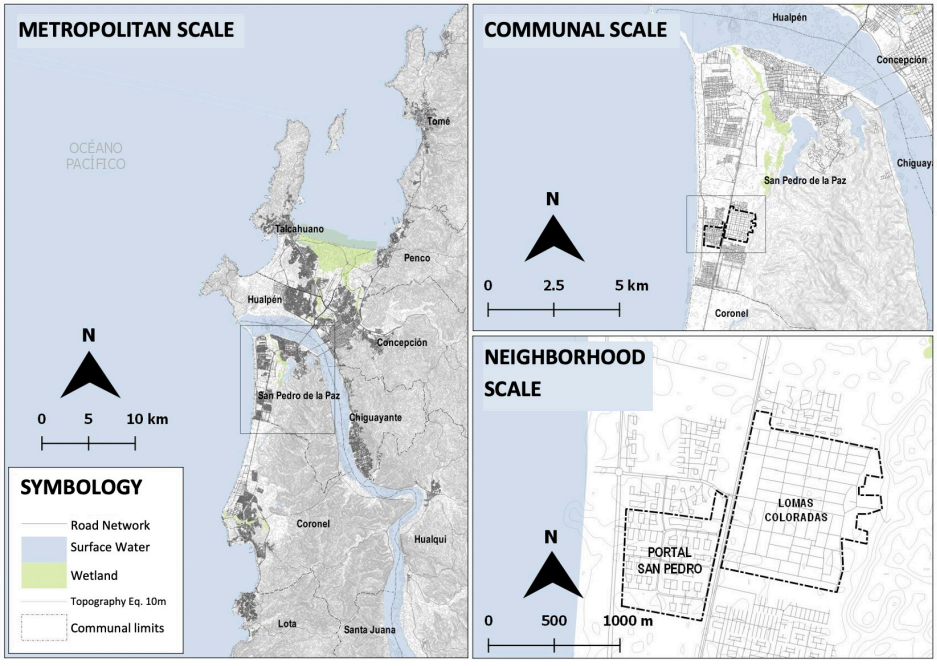

Figure 1. Localization of case studies at a metropolitan, communal, and neighborhood scale. Source: Preparation by the authors.

considering the entire system, and "local integration" as the variable that measures the position of each segment regarding its immediate surroundings (Hillier, 1996; Mora & Greene, 2008; Zumelzu et al., 2016).

In this same aspect, Marquet and Miralles (2014) propose that the observation of urban proximity phenomena, from the point of view of everyday mobility, allows analyzing not only what the city structure allows people to do, but also what they really do. From this, the concepts of "occupational mobility", referring to trips for mandatory reasons such as studies or work, and "personal mobility", understood as diverse activities such as shopping, leisure, and social life, are distinguished. Likewise, daily urban mobility is understood as "that social practice of daily displacement through urban time and space that allows access to activities, people, and places" (Jirón et al., 2010, p. 24). On the other hand, Herce (2009) proposes studying mobility with an alternative approach from the "supply", understood as the key factor to increasing users from the combination between coverage, frequency, and punctuality. Similarly, Cervero (2020) proposes an "adaptive transit" model that modifies traditional transit services to respond to low-density settlement patterns. To some extent, Cervero's (2020) model coincides with the aspects that Herce (2009) outlines as key in the analysis of mobility, adjusting urban settlement patterns, and the designs and technologies of transport services.

In particular, from a historical perspective, in the final decades of the twentieth century, the neoliberal reforms imposed by the South American dictatorships led to the dispersion of residences and later employment, being recognized, according to Napadensky and Orellana (2019), as a phenomenon of the global transformation of metropolitan areas. This would create new centralities outside of outdated foundational centers, intensifying intra- and inter-urban relations (Napadensky & Villouta, 2019). From the metropolitan level case study, the authors understood the Metropolitan Area of Concepción (AMC, in Spanish) as an intermediate highly-complex city undergoing a metropolization process, where, the more this process progresses, the greater the concentration of specialized services in the traditional center is, thereby increasing the dependence of the peripheral communes on the urban system. On the other hand, for Castro, González, and Múnevar (2018), the peri-urban area is a discontinuous space where, intermittently, there may be

5 AMC abbreviation

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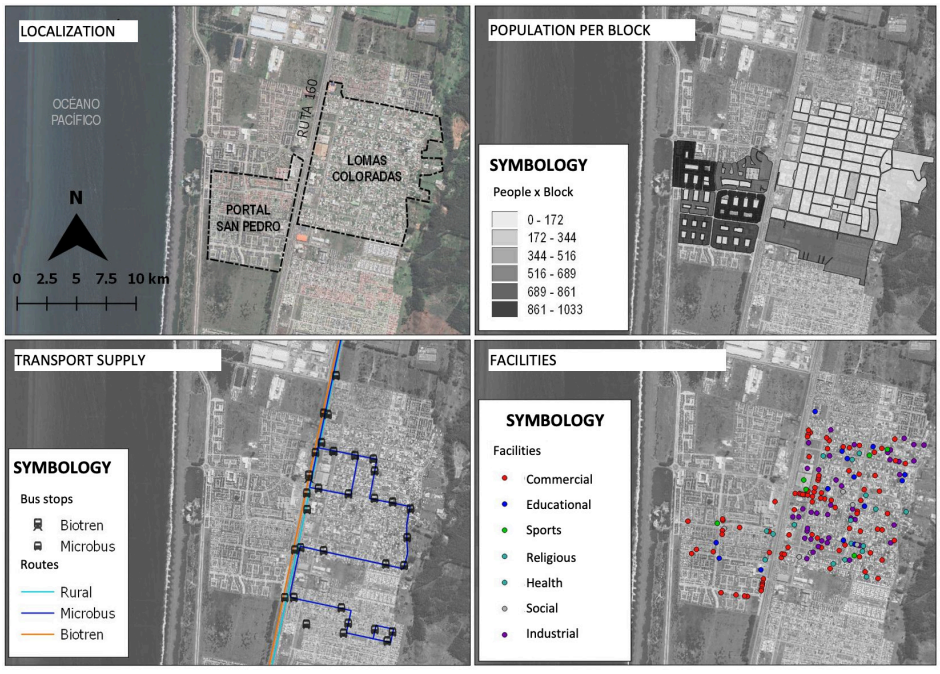

Figure 2. Built environment: density, transport, and facilities. Source: Preparation by the authors based on the 2017 Census (INE, 2018); GESITRAN cartography; SII digital cartography and field survey.

land destined for rural activity, along with a weak coverage of services and facilities.

From the local scope of the case study, the peri-urbanization process in San Pedro de la Paz mainly arose through private projects after the liberalization of the land market in Chile in 1979, which meant that land was no longer considered a scarce good. Alongside this, the approval of Decree in Law (DL) No. 3,516 of MINAGRI (1980) increased the building density on rural land[6], reducing the minimum property subdivision from 20 hectares set by DL N° 752, of 1974, to 0.5 hectares (Jiménez et al., 2018). These measures provided the regulatory framework for the expansion of the real estate market into rural areas, mostly using the gated communities model, defined as housing complexes with controlled access and sharing common spaces[7]. In this area, Stockins (2004) describes gated communities as "urban pieces" characterized by the dissolution of the block, the turning of complexes inwards, and the use of the ***cul-de-sac.*** For the most part, they emerge along main roads and are characterized by the prominence that the private car acquires in them (Galimberti, 2018), which implies a greater consumption of resources for a smaller number of inhabitants, thus promoting an unsustainable city model (Jiménez et al., 2018).

Characterization of the case studies: Lomas Coloradas and Portal de San Pedro

San Pedro de la Paz is a commune of the province of Concepción located on the coastal edge of the Bio-Bio Region (Figure 1). From the physical geography, its main units are the Pacific Ocean, the Bio-Bio River, the coastal plain, the Nahuelbuta Mountain range, Los Batros Wetland, and the Grande, Chica, and La Posada lagoons. These geographical and morphological units have been influential in the settlement, configuration, and growth processes of their urban centers (Salinas & Pérez, 2014). Thus, urban growth has developed in a fragmented way, without a spatial or functional center.

Over the past few decades, the real estate expansion process in San Pedro de la Paz has spread toward the peripheries, having as foci, route 160 along the coastal

6 The rural properties are understood as agricultural, livestock, or forestry properties located outside the urban limits.
7 The concept of "condominium" is understood generically as referring to housing complexes with controlled access that share common spaces.

Figure 3. Elevation of the built environment; Portal San Pedro (above) and Lomas Coloradas (below). Source: Preparation by the authors.

plain towards Coronel and the Andalué sector on the Nahuelbuta Mountain Range (Salinas & Pérez, 2014), where vehicle congestion has been one of the most obvious effects of urban sprawl in terms of everyday mobility. That is why, given the context of peripheral expansion and its relationship with the development of everyday mobility, it is necessary to observe the adjoining peri-urban neighborhoods of Lomas Coloradas and Portal San Pedro, which have different urban morphologies (Figure 2 and Figure 3).

Lomas Coloradas is located east of Route 160 and is a traditional neighborhood built in the 1970s after the construction of the Socoagro slaughterhouse. Its layout is orthogonal with open passageways. Self-built housing predominates, and it has a population density of 43.3 inhab/ha (INE, 2018) and diverse types of facilities covering 25% of its land.

Meanwhile, Portal San Pedro is located to the west of Route 160. The building works started in 2003, with a residential complex of gated communities arranged in a tree-like layout with detached 2-floor houses. Its population density is 110.9 inhab/ha (INE, 2018) and 9% of its land has facilities. This becomes relevant when mobility practices differ between two sectors that, despite being contiguous in the peri-urban area, are different in terms of urban morphology, densities, facilities, and the public transport supply (Figure 2 and Figure 3).

III. METHODOLOGY

This research is based on the question of how the urban structure is related to the daily mobility practices of peri-urban sector inhabitants with high levels of segregation and inequity. From this, the hypothesis is raised that, in the peri-urban setting, the structure of residential areas is related to everyday mobility practices in terms of the integration variables of the fabric and the public transport supply, intensifying mobility practices that deepen existing inequalities.

To investigate the characteristics of the urban structure that affect mobility practices, the daily mobility practices among residents of condominiums and lots in the peri-urban area of San Pedro de la Paz and their relationship with the urban structure were analyzed comparatively. For this, a quantitative methodology with a descriptive scope was used with two levels of analysis.

At the first level, the calculation of the urban fabric's global and local integration levels was considered to study the urban structure by making a planimetric survey in AutoCAD 2015. Secondly, to process the relationship between each segment, the DepthMapX software was used (Figueroa et al., 2018). Finally, to expand upon understanding at a spatial level, this was complemented with a survey of the facilities, population, and housing density (Table 1). In the second level of analysis, the variables that Herce (2009) proposes from supply were observed to understand the mobility practices, namely: coverage, security, frequency, and punctuality, which was complemented with cartographic surveys of the transport supply. To do this, 370 origin-destination and semi-structured surveys were made to residents using a "door-to-door" system in February and March 2019, with 95% reliability and a sampling error of 5%, which were then processed with descriptive statistics of SPSS. The target population was 9,964 people and was defined according to the total inhabitants of each block in both case studies, using geo-referenced data from the 2017 Census. The following expression was used to calculate the sample (Suárez, 2004):

Sample Size = Z2 *(p)* (1-p) / c2
where Z = Confidence level (95%); p = 0.5; c = Margin of error (0.05 = ±5)

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Specific Objectives	Variables	Sources of Information	Processing
Analyzing the characteristics of the built environment and the location of urban uses that generate mobility.	Facilities Population Density	Primary: Planimetric survey Secondary: Georeferenced map of the 2017 Census	AutoCAD 2015 ArcGIS, ESRI
	Global Integration Local Integration	Primary: Spatial syntax	DepthMapX
Understanding the mobility practices in the peri-urban setting from a multiscale analysis with a supply approach.	Public transport supply Urban scale	Secondary: Integrated map - SECPLA GESITRAN Cartography	ArcGIS, ESRI
	Coverage Frequency Punctuality Security	Primary: Survey of the perception and mobility practices of a representative sample	IBM SPSS Statistics 25

Table 1. Synthesis of the methodological processes. Source: Preparation by the authors.

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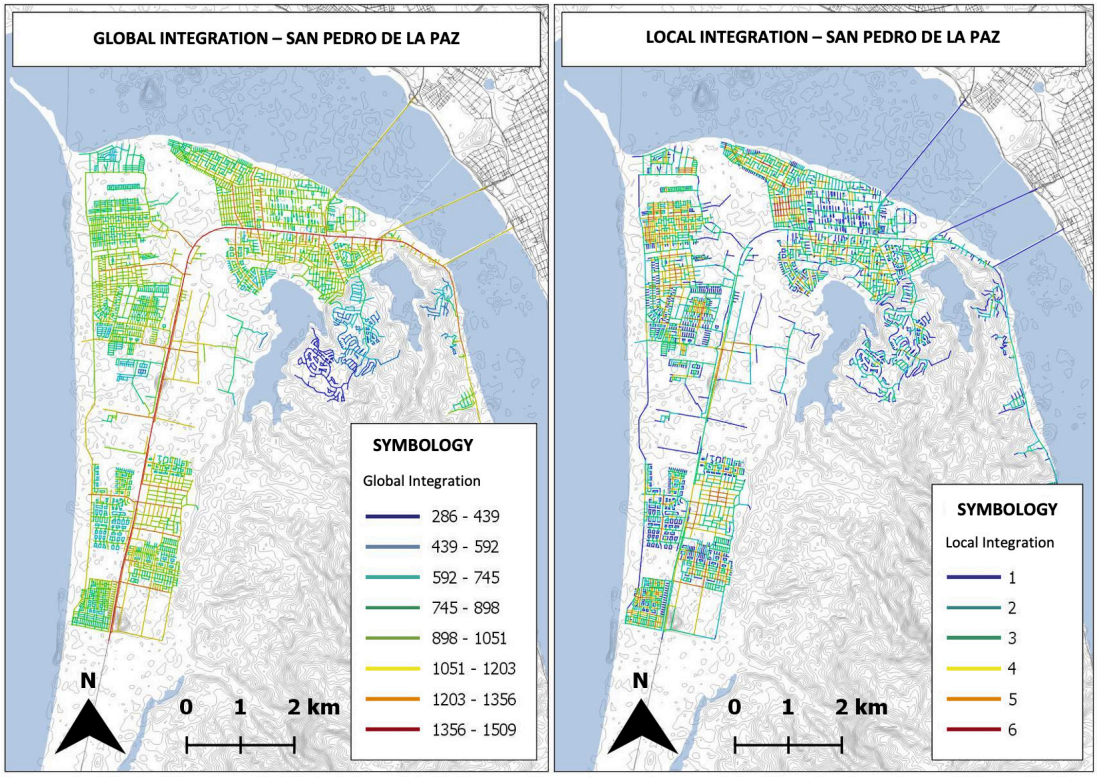

Figure 4. Global and local integration - San Pedro de la Paz. High values in red. Source: Preparation by the authors.

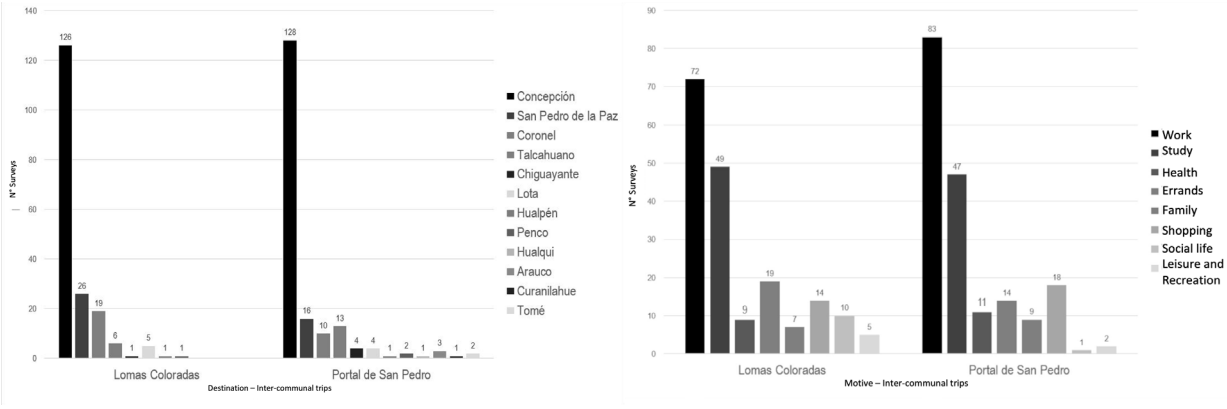

Figure 5. Commune destination on everyday trips.Source: Preparation by the authors.
Figure 6. Reason for travel for inter-communal mobility. Source: Preparation by the authors.

IV. RESULTS

Local and global integration conferred by the urban fabric in San Pedro de la Paz

The results indicate that at a communal level, the highest "global integration" values are found along Route 160, the main road that connects the interior fabrics of San Pedro de la Paz with the communes of Coronel to the south and Concepción to the north (Figure 4). Currently, the urban sprawl around Route 160 is characterized by real estate projects with low global integration, whose structure contributes to the loss of compactness and urban continuity.

In the "local integration" variable at a communal scale, the highest levels are seen in the neighborhoods of Candelaria, Michaihue, Lomas Coloradas, and part of Villa San Pedro, all consolidated residential sectors, structured based on regular orthogonal grids. While the lowest levels of local integration were recorded in the Andalué, El Venado, Portal San Pedro, San Pedro del Valle, and Huertos Familiares sectors, recent residential areas with arborescent plots, where the ***cul-de-sac*** predominates.

At a neighborhood level, the sectors studied have very different levels of global and local integration (Figure 4). The low levels of global integration in Portal San Pedro are explained by only having 2 roads that connect to Route 160, unlike the 6 roads that the Lomas Coloradas sector has. While the disparity in the levels of local integration arises due to the type of fabric used and the number of intersections that these allow. High values of local integration are identified in 42% of the segments of Lomas Coloradas and 4% of Portal San Pedro, and low values of local integration in 5% of Lomas Coloradas' segments and 45% of Portal San Pedro's.

Intercommunal Mobility in San Pedro de la Paz

Regarding the analysis of the resident's mobility practices, the destination commune that concentrated the most displacements was Concepción with 70%, followed by San Pedro de la Paz with 9% (Figure 5). Of these trips, it was observed that 88.7% were for work purposes (Figure 6). As for the choice of modes of transport, 34% used buses, 26% Biotren (the train), and 39%, a private car (Figure 7), meaning that 24.8% spent over $50,000 per month on transportation (Figure 8). Considering this, the sector with the lowest overall integration into the urban fabric and the public transport network increases automotive dependence and with it, monthly expenditure for transport.

Intercommunal Mobility in Lomas Coloradas

Similar to the previous case, the communes that had the most displacements were Concepción and San Pedro de la Paz with 68% and 14% respectively (Figure 5), where work reasons accounted for 84.4% (Figure 6). Regarding the mode of transport used, the use of the bus predominates in 65% of the surveys, followed by the private car and the Biotren, with 23% and 8% respectively. The percentage of expenses over $50,000 per month decreases to 7.6% of the sample (Figure 8). In this way, the sector with greater global integration into the urban fabric and greater public transport supply decreases vehicle dependence and, in turn, monthly spending on transport.

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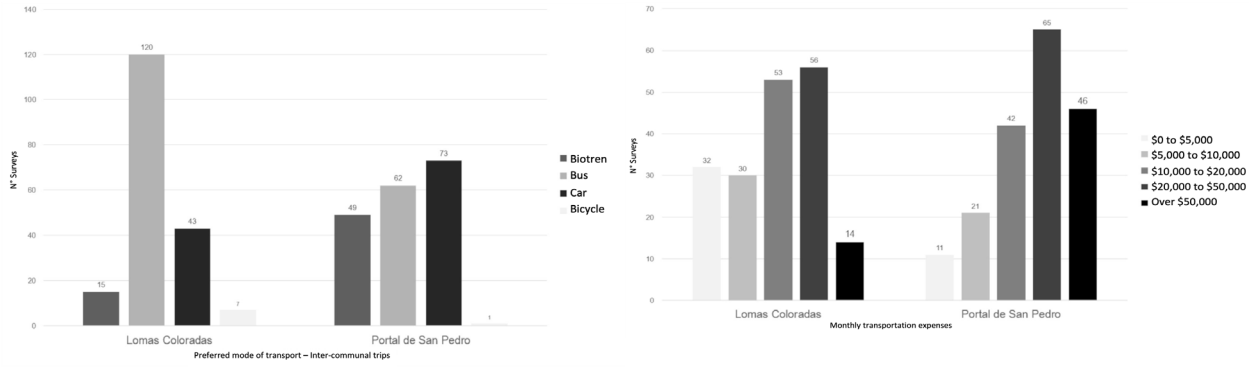

Figure 7. Preferred mode of transport on inter-communal trips. Source: Preparation by the authors.
Figure 8. Monthly expenses for transportation. Source: Preparation by the authors.

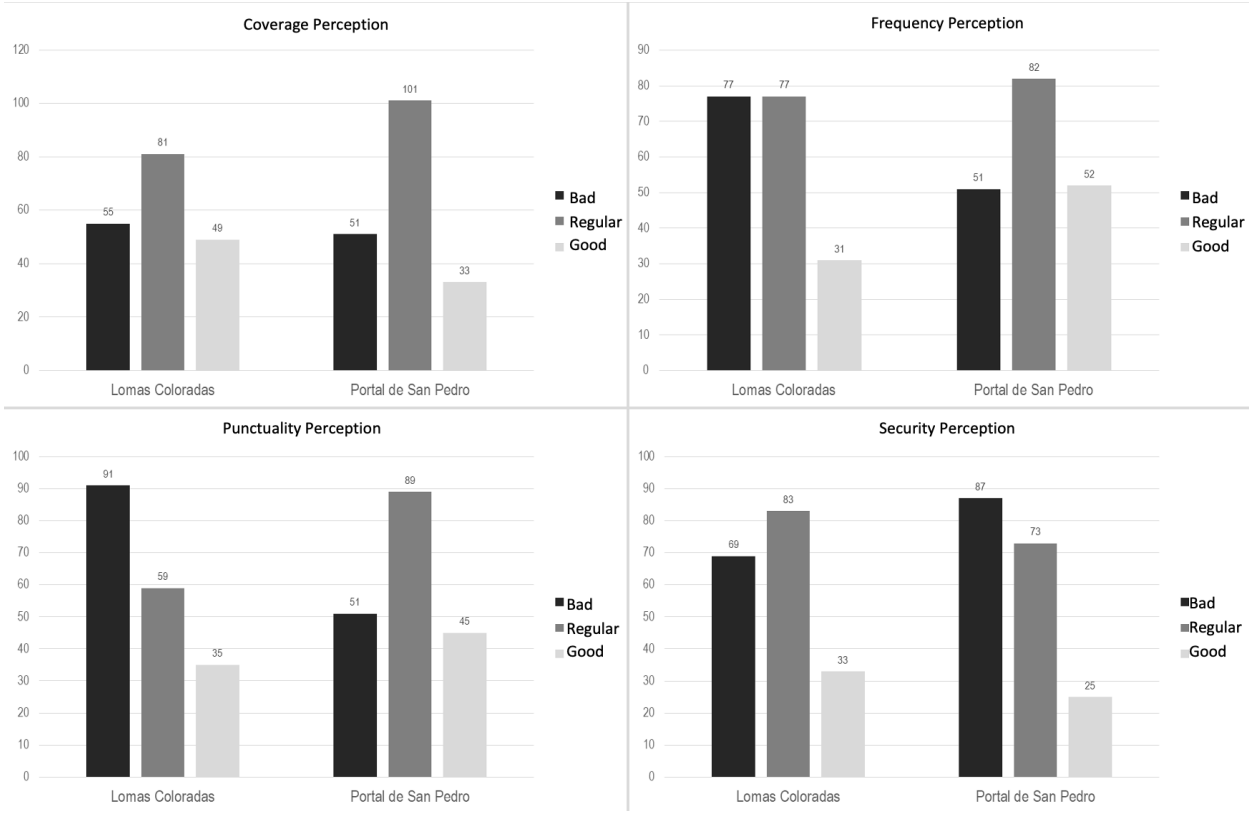

Figure 9. Public perception of the public transport offer. Source: Preparation by the authors.

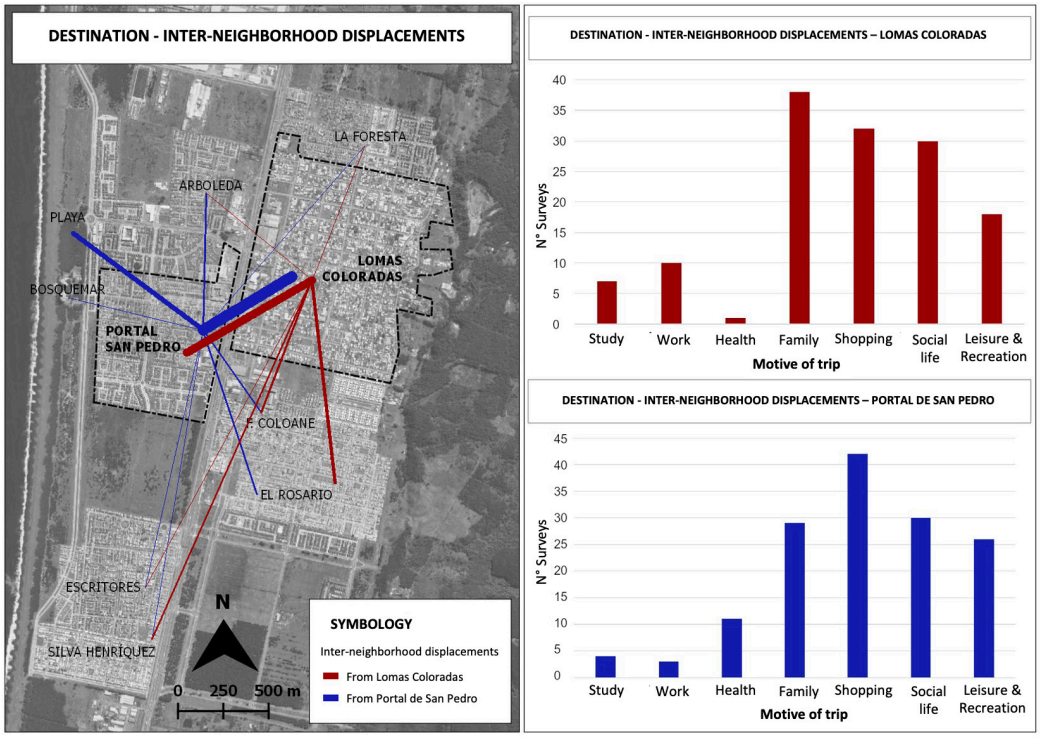

Figure 10. Inter-neighborhood displacements. Source: Preparation by the authors.

Public perception of the public transport supply

After obtaining background information on the urban fabric, location of facilities, and population density in each sector, the next step was to compare the daily mobility practices in a multiscale, communal, and inter-neighborhood way, to know from a citizen's perspective the quality of the supply in the means of transport used (Figure 9).

For the "coverage" and "frequency" variables, both sectors differ in walkable access to public transport. Even though the data indicate that for Lomas Coloradas the perception of access to public transport at walking distance is worse than Portal San Pedro (30% and 27% respectively), the frequency is better valued for the latter (28% "bad" for Portal San Pedro, 41% "bad" for Lomas Coloradas).

For "punctuality", the method used in the round trips is affected. The buses are affected by daily traffic jams, while the Biotrén runs every 15 minutes. 37% of the surveys evaluate "security" as "bad" and 45% as "regular", a figure that in Portal San Pedro increases to 47% for "bad" and 39% for "regular". Therefore, public transport in the neighborhood with better punctuality is perceived as more unsafe, coinciding with higher expenditure on transport (24.8% over $50,000) and the predominance of the car. And on the other hand, the sector with the best public transport coverage is perceived as safer, regardless of the punctuality variable. The latter case is the Lomas Coloradas sector which has a 65% use of the bus in the surveys for work reasons, with lower expenditure on transport.

Inter-neighborhood mobility

The reasons for inter-neighborhood travel coincide in both peri-urban sectors with different local integration, except for the "occupational" reasons of health and work. This is explained because the only healthcare facility is located in Lomas Coloradas (Figure 2) and because part of the surveyed population resided in Lomas Coloradas, but worked in Portal San Pedro. In another aspect, the results vary in terms of the displacement destination, where the sector with the lowest population density shows a greater spread outside its neighborhood of origin, hence, the higher the density, the greater the use of the immediate neighborhood is (Figure 10).

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V. DISCUSSION

Mora & Greene (2008) propose that the greater the integration of the fabric, the greater the flow of movement is, where it is the structure of the space and not the land use that fosters meeting between inhabitants. In this way, the spatial configuration first probabilistically conditions and then is conditioned by the land use patterns and the distribution of activities (Mora & Greene, 2008). This is consistent with the low levels of global and local integration of new tree-type gated communities and ***cul-de-sacs*** identified in the Portal San Pedro sector, which promote the intensive use of cars over public transport, regardless of the punctuality variable that the Biotren system may have. In addition to this, the excessive prominence of the control, regulation, and security variables in gated communities (Svampa, 2001), as in the case of Portal San Pedro, decreases the possibility of social meetings between different social groups in the public space (Stockins, 2004). The mobility practices of residents of neighborhoods with low integration have led to a low intensity of spatial co-presence, preventing the natural materialization of encounters and interaction patterns between different social groups, which coincides with the perception of insecurity in the case of Portal San Pedro.

On the levels of local and global integration, despite achieving significantly different values in both sectors, the fabric by itself does not achieve a greater impact on the reasons for intercommunal travel. However, other aspects are affected by the context of urban sprawl and fragmentation, namely what was proposed by Mawromatis (2013), where, in a sector with less integration into the urban fabric and less access to the public transport network, vehicle dependence increases and, with it, monthly spending on transport.

"Personal" motives predominate in neighborhood-scale displacements, agreeing with Marquet & Miralles (2014) that proximity is much more related to personal activities than to occupational ones, even though both cases have different global and local integration values. However, the results vary in terms of the destination, where the less dense sector shows a greater spread of trips outside its neighborhood of origin, demonstrating that the higher the density, the greater the use of the immediate neighborhood. Faced with these cases, Marquet and Miralles (2014) argue that the increase in displacement time is offset by an increase in leisure or shopping activities in the immediate surroundings of residences.

VI. CONCLUSIONS

This research starts with the question of how the urban structure is related to the daily mobility practices of inhabitants in a peri-urban sector with high levels of segregation and inequity. From here it is confirmed that in the analyzed peri-urban neighborhoods of San Pedro de la Paz, the spatial configuration of the environment and the structure of the residential areas intensify high-cost mobility practices, with long commute times and a preference for motorized means. The urban structure variables that intensify the mobility practices corroborated by this research are due to low global integration of the fabric, the low-density extension of the built environment, and a deficient public transport supply (unsafe and low coverage). According to Mora and Greene (2008), this implies a lower possibility of inhabitants meeting in the space with different motives and from different social groups. These variables reduce the conditions that favor the generation of commercial nuclei, foreseeing homogeneous and segregated environments. However, there are certain singularities that the proposed hypothesis specified where the low integration of the urban fabric, the low-density urban sprawl, and the low quality of the public transport supply are variables that intensify mobility practices. First, in a context of urban sprawl and fragmentation in a medium-scale city, lacking functional and historical centralities as is the case of San Pedro de la Paz, the type of layout and its level of local integration lose their impact on daily mobility practices when it comes to intercommunal displacements, due to the peri-urban location of both case studies with respect to the AMC.

Secondly, intermodal development is insufficient for the most densely populated sector, conditioning dependence on the private car over other modes of transport and, with this, increasing the saturation of the road infrastructure. In addition to this, the public transport supply and its relationship with the reason for intercommunal travel directly affects monthly transport spending, causing limitations on the opportunity to access urban activities for certain strata, and in turn, generating exclusive territories fostered by planning that increases existing inequalities.

Thirdly, the land liberalization and peri-urbanization processes, and their interrelation with the road infrastructure, where tree-growing typologies predominate at a residential level, promote an unsustainable diffuse model that demands more resources without satisfying a high density of inhabitants. This research gives rise to future studies that consider the pedestrian fabric in the integration calculation, the analysis of space visibility, and complement with disaggregated variables at the socioeconomic level of the neighborhoods. In this way, in the future the results can be implemented for the formulation of urban public policies, integrating the role of the built environment in the formation of integrated neighborhoods from a dynamic approach based on mobility.

VII. REFERENCIAS BIBLIOGRÁFICAS

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