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EDITORIAL
ANA ZAZO MORATALLA
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# EDITORIAL

Editorial

ANA ZAZO MORATALLA 1

**For the constitutional right to food for Chilean cities: healthy, sustainable and local. 2**

In May 2021, Chile democratically elected the people who will be part of the Constituent Assembly, whose mission is to write a new constitution. Over recent months, several issues have emerged as proposals from the candidates to be debated and introduced into the future Chilean Constitution. Among these, is the right to food, which is a human right found in article 12 of the Additional Protocol to the American Convention on Human Rights in matters of economic, social, and cultural rights, the "San Salvador Protocol", that indicates that not only does everyone have a right to suitable nutrition, but that the States "commit to perfecting the food production, supply and distribution methods, so that they commit to promote a greater international cooperation in support of the national policies on the matter". Chile signed up to the agreement, although it has still not been ratified in Congress. Its ratification or inclusion in the future constitution would make this right into an obligation of the State, one that is demandable, and thus, can be tried in court.

With the events that emerged from the social uprising and the Covid-19 pandemic, the Chilean society has been the spectator of how Chile passed from being openly recognized for its good performance in its development indicators, to being greatly criticized for basing its development on a neoliberal model that has abandoned the people, who were used for its operation. In food security and nutritional health, the latest report of the FAO and other international organizations indicate that more than 15% of the Chilean population are facing moderate to severe food insecurity, and that around 70% of the adult population is overweight or obese (FAO, IFAD, WHO, PMA, and UNICEF, 2020). In this framework, the inclusion of the right to food in the constitution seems to be not just necessary, but urgent.

What would having a constitutional right to food imply? In general terms, it would mean that the State would be in charge of providing food security, i.e. ensuring permanent physical, social, and economic access to safe nutritious food for everyone, to be able to lead an active and healthy life (FAO). But also, this incorporation should go slightly further and include the concept of food sovereignty, namely, giving people the right to define their food consumption, distribution, and production policies, recognizing the traditions, the local, geographical, and ethnic differences, prioritizing local production and promoting the decolonization of agriculture.

The right to food has become very relevant in Chilean cities, that concentrate 65% of the population, and at the same time, it has become a great challenge, due to the heterogeneity and spatial segregation of its socioeconomic fabric. The current distribution of fresh produce food supply points in the urban space is not homogeneous, which implies that in the urban space, food deserts can be found where the population does not have access to fresh and healthy food. Likewise, the main two urban food supply systems, street markets and supermarkets, have a spatial complementarity directly linked to the different socioeconomic segments, segregated in the urban space. Those places where it is not profitable to locate a supermarket, are replaced by street markets: ephemeral distribution systems, held weekly and vulnerable to weather conditions. Urban and metropolitan policies must return to the principles of the right to food

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Figure 1, 2 Felipe Soto,Concepción 2019

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and to ensure the social, economic, and spatial access to fresh and healthy food, so that they respond to the specific needs of every neighborhood. These premises lead to recovering the city and its infrastructure in food terms, like Paris was in the 19th Century and which, in the times of Covid-19, has been called "the 15-minute city", from a food perspective.

Additionally, to be able to guarantee right to food in the cities, it is necessary to look at them from another scale and understand them as a great metabolic entity that demands and "ingests" food resources, and that expels waste. In this sense, it is necessary to focus on three aspects of the food chain: origin, consumption, and waste. The first of these, origin, is related to the distance; traceability; the spatial, social and environmental (in)justice in the production space, with the decolonialization of the production. It is necessary to balance the proportion of food that could come from a local agrarian space, allowing cities obtain their supply locally. The second one, consumption, implies understanding that this is a political act where people choose the type of impact they wish to generate on the other side of the food chain, on deciding on the products to buy, or through which systems they do so. The third, waste, refers to how these may be reduced, reused, or recycled. Waste management can no longer be the sole responsibility of the consumer, so it is necessary to have urban policies that facilitate the separation, transportation, and transformation of materials, fostering their reintegration into the life cycle, to progress towards a most sustainable relationship with the immediate surroundings. Although each one of these three elements affect different people, policies, and regions, they are connected through food as part of the metabolic entity, which it is why a comprehensive view needs to be kept, that allows generating coherent policies at an urban, metropolitan, and regional scale.

Finally, it is necessary to ask how to achieve a the right to food in cities. In this direction, there are two parallel and complementary paths. On one hand, the top-down, which would introduce the right to food in the constitution, so that policies could be made and laws could be passed that would allow generating specific actions from the State. On the other, the bottom-up, which would imply setting off on the road alongside the local agents and councils that promote a real transition of the urban foodsheds and accessibility for all citizens to wholesome, safe, healthy, and local food. The purpose of this path would be generating governance models focused on developing local food policies, capable of being replicable in other cities, based on the local particularities, and that, little by little, could be scaled up to help to generate the policies and legal frameworks that allow applying this as the rule, and not the exception, in Chilean cities. However, the ideal scenario to fully develop the constitutional right to food in the cities would involve a complementary development of both paths, and would imply that these local models would fall within pertinent policies and regulations, suitable to the urban contexts that were covered under the right to food.

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# ASSESSMENT OF URBAN-TERRITORIAL INTEGRATION IN COLOMBIA[1]

## EVALUACIÓN DE LA INTEGRACIÓN URBANO-TERRITORIAL EN COLOMBIA

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El énfasis en lo urbano dado por la Nueva Agenda Urbana (NAU) se complementa con una apuesta por una integración entre las ciudades y su entorno que busca fomentar un desarrollo territorial equitativo y equilibrado, sin embargo, se ofrecen en ella pocos detalles sobre cómo puede llevarse a cabo dicha integración. Esta es una cuestión de especial relevancia en el contexto latinoamericano, donde la desigualdad territorial constituye un elemento central en cualquier discusión sobre el desarrollo. A partir de una revisión de las implicaciones teóricas de la equidad y el equilibrio planteados en la NAU y de su contraste con los distintos planteamientos teóricos y propuestas conceptuales sobre desarrollo territorial, se expone aquí un análisis del caso colombiano. En este estudio se emplean indicadores a escala municipal que muestran cómo la relación entre las grandes ciudades y su entorno no son tan unívocas como propone la NAU, y que la prosperidad urbana puede en muchas ocasiones generar desequilibrios territoriales que deben ser atendidos específicamente.

**Palabras clave:** política de desarrollo, urbanización, desequilibrio regional, migración rural, Colombia.

The urban emphasis given by the New Urban Agenda (NUA) is complemented by a commitmet to integrate cities and their hinterland, which seeks to promote an equitable and balanced regional development. However, in the former, there are few details on how such integration can be achieved. This is a matter of special relevance in Latin America, where regional inequality is a key element in any discussion on development. An analysis of the Colombian case is presented here, starting from a review of the theoretical implications on equity and balance stated in NUA, and their comparison with different theoretical approaches and conceptual proposals on regional development. In this study, municipal level indicators are used to show how the relationship between large cities and their hinterland is not as linear as the NUA suggests, and that urban prosperity can often generate regional imbalances that require specific consideration.

**Keywords:**development policy, urbanization, regional imbalances, rural migration, Colombia.

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# I. INTRODUCTION

For the first time in human history, more than half the world's population is living in urban areas (UN-DESA, 2018). The concentration of population within a tiny portion of the surface area (2-3%), who have the largest part of the wealth, consumption of resources, production of waste and environmental impact, leads to, by itself, an increase of inequality among regions. The center stage that the urban habitat has taken over the rural can also be seen by comparing the agendas that the general framework for public policy on housing and habitat have defined. The Habitat Agenda, approved in the II Habitat Conference in Istanbul (1996), without omitting the undeniable importance of urbanization, tried to maintain a balance between the urban and the rural. Twenty years later, the New Urban Agenda (NUA), approved in Habitat III in Quito (2016), is defined starting from the urban, as "a roadmap for the creation of cities that are places of prosperity, cultural centers, or of social wellbeing, while protecting the environment" (ECLAC, 2017, p. 10). Complementarily, the NUA faces the diversity of human settlements, proposing an "integration" of cities and regions that would allow generating beneficial synergies for society as a whole, and not just for the inhabitants of cities; an approach based on the premise that urban prosperity leads to the prosperity of the region, which would need to be empirically confirmed.

For decades now, the research agenda has been focused on ever more specific and local approaches, abandoning pretensions of systemic or structural analysis (Vázquez, 2010), a trend that has also permeated into urban research in the Latin American setting (Cuenya, 2001), and in particular, the Colombian one (Torres, 2009), with a clear bias towards large metropolitan areas (Duhau, 2013). From these approaches, analysis methods of urban problems have been developed that are not applicable to the study of another type of region, be these small cities or rural areas (Jiménez & Piaggio, 2020). In Colombia, the Cities System Mission (National Planning Department [DNP, in Spanish], 2014) shows said urban bias, while defining, in parallel, an analysis methodology that is difficult to apply beyond large urban centers. Alongside this, the Rural Mission (DNP, 2015), theoretically speaking, complements the diagnosis, but without a clear regional approach. In any way, the relative comprehensiveness of both analyses, does not go deep into the intertwined nature of both realities, and draws a polarized panorama that does not facilitate analysis of the complexity of urban-rural relations.

This work tries to evaluate whether, in the Colombian context, the association between urban and regional prosperity that the NUA supposed, is being fulfilled. Firstly, the text analyzes the statements of the NUA regarding urban-regional integration, as well as other theoretical visions on regional development, to then revise the state-of-the-art in the Latin American and Colombian context. Finally, a methodology based on specifically designed indicators is presented to try to overcome the epistemological separation between the urban and the rural, as well as the results produced in the Colombian case, that allow empirically comparing the assumptions of the NUA.

# II. THEORETICAL FRAMEWORK

### Outlines of the new urban agenda

The Habitat Agenda approved in Habitat II was outlined starting from an adversative: although a growingly urbanized world is accepted, it could not leave the non-urban world aside. Its discourse was based on that sustainability was only possible through the diversity of urban and rural settlements, and the links between them, that generated a mutual interdependence (UN, 1996; art. 10, 106 and 163) setting, as a goal, guaranteeing that all human settlements could offer the same development opportunities to their inhabitants (art. 101).

In the New Urban Agenda (NUA), the focus moves to urban settlements. The starting point is the idea that cities are the drivers of development and that, by solving their internal imbalances and improving their connection with the region, development can be fostered that also benefits the rest of the region. For this, the goal is set out to connect regions with urban hubs, fostering polycentrism and regional balance through integrated plans, in order to reduce inequalities between regions, and improve equality and spatial integration (UN-Habitat, 2017, art. 136).

In the regional dimension, a "balanced, sustainable and integrated" development is proposed, that promotes regional equality and integration. Leaving aside the concept of sustainability, which due to its transversality must permeate all other dimensions, the concepts of balance, equality and integration need to be clarified. In addition, the discussion about balance and equality requires a prior reflection about the latter, and the differences that appear for its application to people and to regions.

The notion of "equality" lies on a democratic ideal of western philosophy. Generalizing, the concept refers to the equal rights and obligations any person has regarding the community or society they are part of. To operationalize the concept, the notion of equality offers a more flexible vision adapted to the unequal circumstances of each context (Rosanvallon, 2015). The Habitat Agenda upholds that a balanced settlement is one that offers "the same access opportunities" (art. 27). The NUA speaks in similar, but not identical terms, of "guaranteeing equal rights and

opportunities, socioeconomic and cultural diversity, and the integration in the urban space" (art. 14a), where it is possible to see the coexistence of an equality and a positive difference (diversity).

The term "integration" is key in the NUA, but also polysemic and often ambiguous. In its article 14a, it refers to the "socioeconomic and cultural diversity" and "integration in the urban space", while in article 33, to the "socioeconomic and cultural integration". In both contexts, the concept can be interpreted as the participation of individuals, of communities, in a social or physical space, while the notion of diversity would introduce a descriptive nuance about the nature of said participation.

Ultimately, the "integration" between cities and regions is seen associated to several concepts -balance, sustainability, polycentrism, equality, system-, but in itself it remains undefined. In fact, the NUA does not explicitly specify the nature of integration that it appeals for, but it does mention the role of the cities as "centers and drivers of a balanced, sustainable urban and regional development, integrated at all levels" (art. 13e). This idea, where cities are not just becoming the dominant form of habitat, but also the drivers of human development as a whole, had already been presented years earlier under the concept of "urban prosperity" (UNHABITAT, 2012), and is being consolidated in different documents and a line of work within UN-Habitat, the Initiative for Urban Prosperity. Thus, positive changes in human societies currently emerge, according to UN-Habitat, from the cities, and benefitting from these changes requires in some way, being connected to them, so that the integration would imply a connection that allows the participation of the peripheral regions in the advantages emerging from the cities.

The proposal for the implementation of NUA in Latin America (ECLAC, 2017), allows observing a more operational development of these principles. It is confirmed that this is an action plan focused on cities, where the rest of the region only appears where required for the adaptation of urban policies. This Action Plan combines a generic vision on management, governance or financing issues, with a specifically urban vision in other more fundamental chapters. Mentions to non-urban regions are scarce. As a result, the goal of "integrated and balanced regional development" becomes operational by leveraging the potential of urban-rural ties with a better connection with rural zones from urban contexts.

The Action Plan, prepared by ECLAC, UN-Habitat, and the Chilean Minurvi, with the collaboration of hundreds of entities and professionals from across the continent, confirms that the "regional" dimension of the NUA is more an approach from which to set out urban policies, than a specific chapter to attend the needs of non-urban regions. The ambiguity associated to the permanent use of the terms "integration" and "regional" helps to obscure the fact that the NUA does not suggest a comprehensive strategy for regional policies, but that these are subject to the urban development strategy.



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## Regional development and balance

The globalization process promised to reduce regional inequalities, diminishing the relative importance of distance, but paradoxically, it has generated a growing differentiation regarding the performance of regions, with large cities turned into nodes that connect local and regional economies with the global exchange network. This situation has been described in terms of "archipelago economy" (Veltz,1996), alluding to large metropolis that have become islands, as similar to each other as they are dissimilar with their immediate surroundings, which questions the direct relationship between the development of a metropolis and that of its immediate surroundings.

Classic spatial economy has explained the different economic performance of regions from the notion of agglomeration and its associated advantages, without being able to explain the origin of the agglomeration itself. The neoclassical vision of development theorizes a progressive balancing of the levels of development without needing any type of intervention, aside from the opening up of local and regional economies for their insertion in global markets. ECLAC's theory of dependence, tried to explain the failure of policies based on these premises due to the asymmetry of relationships between central and peripheral countries, that tended to generate growing inequalities. Other theories, like the accumulative circular causation, the unbalanced growth or the growth nodes, shared similar conclusions: overcoming the inertia that digs deeper into the inequality between countries and regions would require some type of intervention (Moncayo, 2001, p. 1).

The Endogenous Growth Theory, formulated in the 1980s, restated some assumptions of the orthodox neoclassical theory: facing the decreasing performance, the perfect competition and the comparative advantage assumed by orthodox theory, it stated the possibility of growing performance thanks to innovation developed by local agents, and waived the premise of perfect competition. Models built on these theoretical bases have come to confirm the dependency theses: a tendency towards the growing inequality between regions, only reversible with a significant reduction of transportation costs.

The OECD attributes the economic success of a region to a virtuous combination of interconnected factors beyond the effect of agglomeration (Organization for Economic Cooperation and Development [OECD], 2009), while the World Bank proposes facilitating the mobility of resources,

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specifically internal migrations; promoting urbanization that generates externalities of agglomeration; and developing infrastructure that improves physical and virtual connectivity (World Bank, 2009). Both approaches maintain specialization as a goal, the World Bank being more explicit in the necessary complement of the integration in the markets. ECLAC suggests that the development differences between Latin American regions would be derived from the structural differences of productive systems, which the efforts for regional development should be focused towards, as such it proposes: transformation policies of productive structures to favor diversification; policies of regional retention, capture and redistribution of incomes; and strengthening of the social organization (ECLAC, 2015).

These proposals move in opposite ways insofar as they advocate specialization and diversification. ECLAC clearly bases these on the endogenous growth theories, advocating for growing performance that use friction of the distance to strengthen local structures, while the World Bank defends as a premise, the integration in global markets, and from these, a strategy of success within them. In all likelihood, regional development strategies should be as diverse as the regions are, but upon defining general strategies, approaches that are more appropriate for some regions may be being privileged over others. In this sense, it is worth asking whether the urban emphasis of the NUA and its regional integration approach, very similar to the integration in the markets that the World Bank proposes, really fosters balance and equality.

## Latin America, secular inequality

Regional imbalance and inequality are distinctive attributes of Latin America from the colonial period. The colonial logics of centralized control over an economy, focused on exports and subject to the economy of the European Metropolis, extended far beyond the independence processes. The substitution policies of imports, construction initiatives of economic sovereignty, did not modify the centralizing rationale, and continued privileging economic concentration. Finally, the new neoliberal approach, that has predominated in the region since the 1990s, has stopped most of the attempts to reduce inequalities within each country (Llungo, 2018: 14), opening up a new cycle of polarization (Moncayo, 2001, p. 10).

In the most recent scenario, the high concentration of production (ECLAC, 2015, p. 32) and the high internal productivity gaps have stood out, being four times higher in Latin American countries compared to OECD countries (ECLAC, 2015, p. 9). Recent behavior of this regional disparity is also heterogenous: the high levels of wealth and growth have mainly taken place in large metropolitan areas and important mining regions. Less developed regions, but with a greater economic dynamism, are located around large capitals, and in certain very specific regions of separated areas like the Amazonia, while the less developed regions with less dynamism are much more diverse, they would even seem to share "a condition of isolation that stops them from taking advantage of external factors that favor growth" (ECLAC, 2015, p. 12), also including metropolitan and mining areas with predominance of mature economic sectors.

The inequality or disparity among regions has been stated as a structural problem that affects economic efficiency (ECLAC, 2018). Several countries have acknowledged this problem and defined strategies and policies that differ however, in the starting arguments, focused on competitiveness and economic efficiency, on equality, democratic inclusion or social justice. However, the lack of continuity and the permanent change in approaches collide with the need for long-term outlines (Llungo, 2018).

## Regional inequality and imbalances in Colombia

For the case presented here, it has been stated that an "important part of the inequality among Colombians is expressed by inequality among regions" (Bonilla, 2008, p. 25). Barón (2002) defines in this framework, five economic regions in the country: the "elite", that groups regions that house the four main cities of the country; the coffee-growing region, diversified urban economies, alas not very large, combined with relatively modern farming production; the central region, that maintains farming as the main economic base; the Caribbean region, that has weaker economic indicators; and a peripheral region, that lags behind economically and socially speaking. Regarding the evolution of this inequality, it is possible to talk about a phase of regional convergence until 1960, followed by a growth polarization that continues until today (Bonet & Meisel, 2001; Galvis Aponte, Galvis Larios & Hahn de Castro, 2017), while the economic policies of the country did not consider this regional diversity (Galvis & Meisel, 2010), but only the displacement of the population towards more prosperous regions, that partly offset these growing inequalities (Peiró, Prieto & Tortosa, 2020).

The study of urban reality has been focused on the main cities, the regional capitals. An analysis made using the methodology of the Urban Prosperity Index, states that Colombia has "a relatively functional city structure" (UN-Habitat, 2015, pg. 24-25), highlighting the convergence of the values of prosperity and the reduction of inequalities, but exclusively within the universe of the system of cities, without considering the rest of the country's municipalities. From the rural perspective, it has been suggested that Colombia has "a development model that leads to the failure of the rural world" on fostering the extension of "the gaps between the urban and the rural" (United Nations

Development Programme [UNDP], 2011, p. 16). The lack of opportunities in the rural setting pushes people towards illegal activities, driving them towards the agricultural frontier, or displacing them towards cities. If cities are being thought of as drivers of a balanced regional development, this portion of the problem cannot be ignored.

## III. METHODOLOGY

The analysis of regional inequality in Colombia has generally taken place from macroeconomic indicators at a departmental scale. However, this scale of analysis does not allow observing the relationship between cities and their immediate surroundings. Although there already are economic indicators at a municipal scale, there is no historical timeline that allows analyzing convergence or divergence among municipalities. As an alternative, here it is proposed to use a series of socio-demographic indicators, built from the only two variables of the censuses of 1993, 2005 and 2018: the total population, and the percentage of the population with Unsatisfied Basic Needs (UBN).

In Colombia, it has been stated that internal migratory flows have traditionally been associated to economic opportunities (Galvis, 2002). The data from the 2005 census allowed confirming that large metropolitan areas and intermediate cities continued being the main recipients of those movements, while small municipalities were net emitters (Cuervo, Barbieri & Rangel, 2012), although new migratory flows have also been observed, associated to the appearance of new development hubs -mining, agroindustry or transborder trade- (Cuervo, Barbieri & Rangel, 2018). In this sense, migration from the poorest to the richest regions seem to be offsetting, in per capita terms, the growing economic gap between regions (Peiró et al., 2020). All this indicates that the demography can be considered as a suitable approximation to the prosperity of the regions.

For its part, the Unsatisfied Basic Needs (UBN) index is a direct measurement method of widespread poverty in Latin America, based on the determination of the percentage of families that lack any of their main needs -economic income, access to housing, education and healthcare services-, starting from census variables, that allows a high level of spatial desegregation (Feres & Mancero, 2001). Although the UBN method has been used in Colombia since 1978, from 2012 the multidimensional poverty index (MPI), based on the methodology of Alkire and Foster (2007) has become more important. This confirms a loss of validity of the UBN method, product of the social changes that have taken place in the country, and a greater flexibility of the MPI to characterize poverty (Angulo, Díaz & Pardo, 2011). Although the suitability of one indicator or the other is still under discussion to evaluate different social issues (Rodríguez, Moreno & Maldonado, 2016; Chaparro, 2017), the continuity of the UBN timeline throughout the censuses being analyzed is the conclusive argument to use it in this study.

To analyze the set of slightly over 1,100 municipalities, two urban and four rural categories have been used, which were defined using a cluster analysis from previous work. The following six reference indicators were used: population density; rural (disperse) population percentage; UBN; healthcare payment affiliation; aging index; and homicide index (Jiménez & Piaggio, 2020).

## IV. RESULTS

The 1993-2018 period represents a moderate phase of population growth, 33% in 25 years, and a significant improvement of living conditions, with an 18% decrease of the population with UBN, and a 51% increase in the population living without UBN. In the second inter-census period, 2005-2018, a slowdown of the demographic growth was produced, while the improvement in the UBN indicator sped up. Table 1 shows how the behaviors of each one of the town categories has differed.

A clear rural-urban gap can be seen in both the demographic growth and UBN data. The population growth is concentrated in urban municipalities, despite slowing down in large cities during the 2005-2018 period. Meanwhile, the rural municipalities have much lower growth rates, even negative ones, between 1993 and 2005, before slightly recovering in the second period. Finally, the gap in the UBN indicator continues to grow between urban and rural municipalities, except for the aging rural ones, where the reduction of the vulnerable population seems to go hand-in-hand with the reduction in population.

The urban-rural gap is shown again in the evolution of the population with UBN, although inverted, as in the rural municipalities, this population falls much more intensely than in urban ones, and especially in large cities. The rural municipalities with lower demographic growth, even those falling, are those which reduce the vulnerable population the most, while the cities with higher growth, are the ones that see a lesser reduction in population with UBN. This dynamic seems to indicate a net vulnerable population flow from the countryside to the cities.

Finally, the population growth without UBN is generally positive (+51.80%), especially in intermediate cities and in municipalities on the metropolitan periphery, which could be seen as a good indicator of "prosperity", under the terms



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| | Colombia | Large cities | Mid-sized cities and metropolitan peripheries | Rural municipalities | Vulnerable rural municipalities | Aging rural municipalities | Rural municipalities with high violence indices |
|---|---|---|---|---|---|---|---|
| Area | 1.139.818 | 2.947 | 121.848 | 192.016 | 562.816 | 39.028 | 221.161 |
| Towns | 1.118 | 7 | 176 | 354 | 257 | 210 | 114 |
| Population | | | | | | | |
| 2018 | 48.258.494 | 14.735.529 | 18.377.480 | 6.139.093 | 5.011.183 | 1.467.325 | 2.534.382 |
| 2005 | 42.077.064 | 13.388.229 | 15.058.232 | 5.500.650 | 4.462.553 | 1.471.786 | 2.201.594 |
| 1993 | 36.207.108 | 10.992.379 | 12.158.976 | 5.337.361 | 3.969.302 | 1.686.563 | 2.087.487 |
| Relative growth: population | | | | | | | |
| 1993-2018 | 33,28% | 34,05% | 51,14% | 15,02% | 26,25% | -13,00% | 21,41% |
| 2005-2018 | 14,69% | 10,06% | 22,04% | 11,61% | 12,29% | -0,30% | 15,12% |
| 1993-2005 | 16,21% | 21,80% | 23,84% | 3,06% | 12,43% | -12,73% | 5,47% |
| % Population with Unsatisfied Basic Needs (UBN) | | | | | | | |
| 1993-2018 | 14,13% | 4,51% | 10,06% | 19,90% | 46,49% | 14,76% | 27,32% |
| 2005-2018 | 28,49% | 11,31% | 22,45% | 40,79% | 72,31% | 42,23% | 45,40% |
| 1993-2005 | 37,34% | 18,74% | 30,30% | 51,40% | 76,99% | 52,14% | 56,34% |
| Relative growth: population with UBN | | | | | | | |
| 1993-2018 | -18,51% | -12,69% | -15,09% | -28,51% | -18,31% | -39,29% | -23,17% |
| 2005-2018 | -12,28% | -6,35% | -10,17% | -18,59% | -20,11% | -27,51% | -13,95% |
| 1993-2005 | -4,24% | -4,96% | -2,49% | -9,36% | 4,30% | -15,29% | -8,46% |
| Relative growth: population without UBN | | | | | | | |
| 1993-2018 | 51,80% | 46,74% | 66,23% | 43,53% | 44,55% | 26,29% | 44,57% |
| 2005-2018 | 26,97% | 16,41% | 32,21% | 30,19% | 32,40% | 27,20% | 29,06% |
| 1993-2005 | 20,45% | 26,76% | 26,34% | 12,42% | 8,12% | 2,55% | 13,92% |
| | | | | | | | |
| | Positive | Intermediate | Negative | Regarding the mean of the period | | | |

Table 1. Evolution of the multidimensionally defined classes (1993-2005).Source: Preparation by the Authors.

of the New Urban Agenda. However, each one of the inter-census periods shows significant differences: between 1993 and 2005, an urban-rural gap is clearly seen, while between 2005 and 2018, this is blurred on facing the mediocre behavior of large cities and a relative improvement of many of the rural municipalities.

The cartographic representation of the results (Figure 1) shows the spatial relationships that are established among the different categories. In Figure 1.A, the divergent behavior among the rural areas of the country is seen. In the center, they lose population in absolute terms, while in the periphery, the growth is relatively intense. Figures 1.B and 1.C complement and qualify this: the loss of population of central rural areas is accompanied by an intense drop in vulnerable population, but also a minimal increase of population without UBN. In the periphery, the opposite is seen: demographic growths with larger populations without UBN, and vice versa, which seems to indicate relatively intense migrations of vulnerable population in the marginal areas of the country.

To finish, Figure 2 is proposed as a summary where the six categories of municipalities have been defined from a cluster analysis on four variables -evolution of the total population, with UBN and without UBN, and UBN percentage in 2018-, which have been identified as expellers, stable or appealers -depending on their demographic evolution-, and as prosperous or vulnerable

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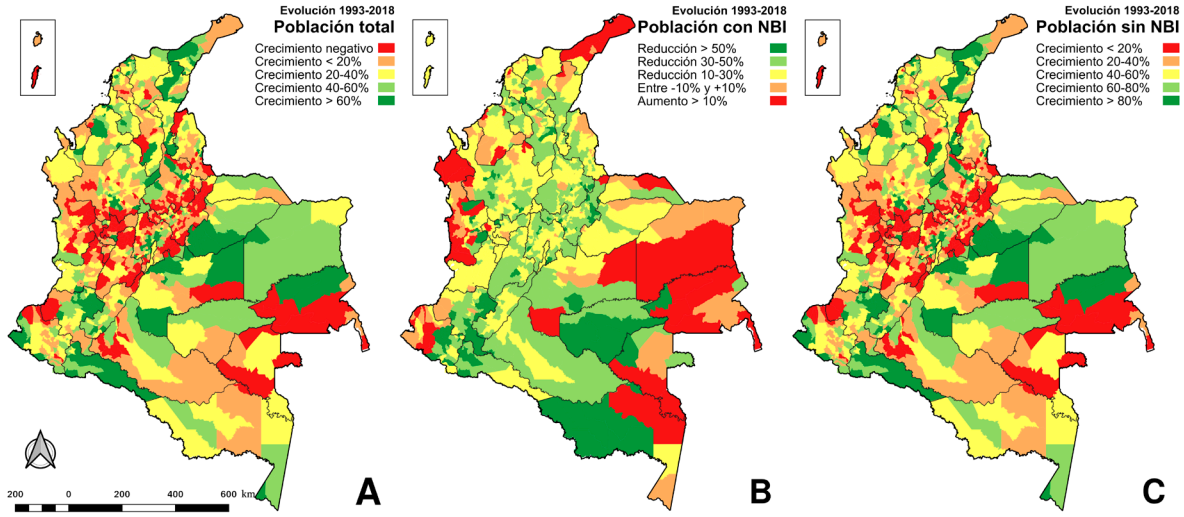


Figure 1. IPopulation indicators 1993-2018. Source: Preparation by the Authors.

-depending on the population percentage with UBN-. The result shows the contrast in prosperity of the center and the vulnerability of the periphery, but also between the dynamism of urban centers and given development lines facing the stagnation of most of the rural space.

## V. DISCUSSION

The period analyzed, 1993-2018, covers the stage when Colombia applied a clearly neoliberal approach in its regional development policies, that we can identify in the records of the World Bank (2009). During this time, a divergence is seen among regions on at least two scales: between the center and periphery, and between urban and rural areas. The global improvement in the indicators hides a growing inequality, already outlined at a department scale (Galvis et al., 2017), and confirmed here at a municipal scale, unveiling intra-department divergence phenomena, where urban prosperity should operate as a driver of regional development.

The behavior of Colombian cities reflects common trends within Latin American urbanization: a marked trend towards concentration; a migration of the vulnerable rural population towards the cities; and a more recent phenomenon of relative stagnation of large cities compared to more dynamic and complex metropolitan areas (Jordán, Riffo & Prado, 2017).

Rural areas show a more heterogeneous behavior: those better connected to the more prosperous cities, all of them in the Andean area, have a relative improvement of the poverty

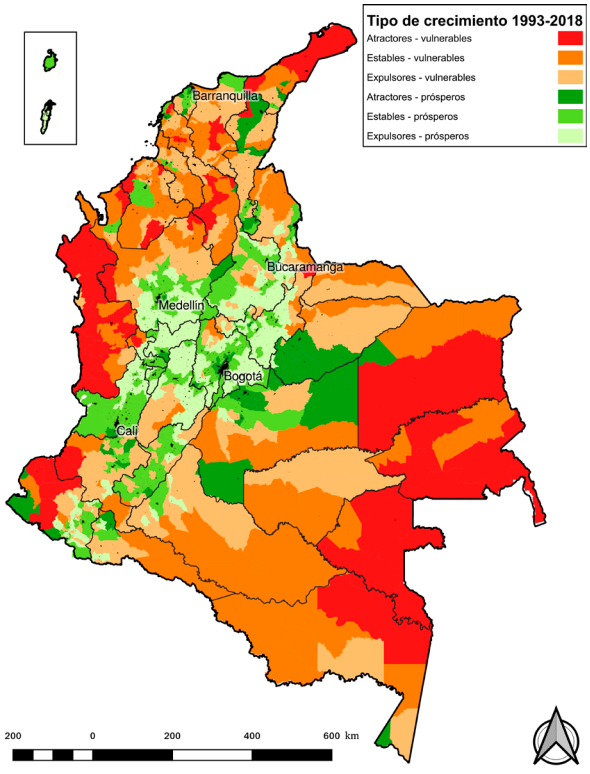


Figure 2. Typology of Municipalities. Source: Preparation by the Authors.

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indicators, but with a cost of a marked demographic decline and an intense aging of the population. Although this depopulation phenomenon was seen as a problem at the end of the 19th Century in Europe, and for decades in different Latin American countries, the most remarkable aspect of the Colombian case is that it is the regions closest and most integrated to the large urban hubs that suffer from this destructive phenomenon most. On the contrary, the regions that are farthest from the economic center of the country, show an important demographic dynamism, although quantitatively lower, led by the vulnerable population. All this implies a polarization, where the vulnerable population, which is also the youngest, abandons the intermediate spaces of the urban-rural continuum and moves either to big cities, or to the extreme opposite, to the margins of the country where there are opportunities associated to the expansion of the farming border, extraction activities, or illegal activities (PNUD, 2011; Cuervo et al., 2018).

In summary, considering the most prosperous urban areas of Colombia, an intense metropolitan expansion is seen, but also an intense decline in rural regions, which seems to contradict the assumptions of the New Urban Agenda, since urban prosperity seems to have contradictory effects on the area which it supposedly should benefit.

## VI. CONCLUSIONS

The Latin American context is quite conditioned by intense spatial inequalities, both on an urban and on a regional scale. If the goal of development is to improve the quality of life of all regions, in a balanced way, urban and regional policies must bear in mind the effects of divergence and even polarization that has been shown in the Colombian case, which shares many traits with most Latin American countries, like the extreme concentration of population and wealth, or the great inequalities in living conditions.

Although the New Urban Agenda (NUA) is built on a basically urban view, it does not forsake this to positively affect the rest of the region, conceptualized as a functional component of the urban. Starting from the results presented, the premise that urban development necessarily implies global benefits for the entire region, as NUA assumes, cannot be maintained. The regional balance then, must be placed at the heart of the debate on development and, because of this, it is essential to have detailed information of all municipalities, and not just of the urban centers of reference or the regional units, to understand the complex dynamics that are being produced in the interaction between the urban and the rural.

In this work, it has only been possible to present some of the results of the multidimensional analysis, which would require a greater understanding of the phenomena observed. The information of the 2018 census is only just starting to be processed and may lead to many other comparisons. The proposed methodology allows shedding light on changes in the mid-term, with a level of detail that has been understudied until now. Beyond this general approach, it is suggested, as a way to continue with the research, to narrow the focus, in order to observe, in greater detail, concrete phenomena in specific urban, suburban, or rural settings.

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LA VULNERABILIDAD ECOSISTÉMICA SEGÚN EL PLANEAMIENTO EN LA PROTECCIÓN DEL SUELO DE LA COMUNIDAD DE MADRID
RAFAEL CÓRDOBA HERNÁNDEZ
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# ECOSYSTEM VULNERABILITY ACCORDING

## TO THE LAND PROTECTION PLANNING OF THE COMMUNITY OF MADRID[1]

LA VULNERABILIDAD ECOSISTÉMICASEGÚN EL PLANEAMIENTO EN LA PROTECCIÓN DEL SUELO DE LA COMUNIDAD DE MADRID

RAFAEL CÓRDOBA HERNÁNDEZ 2

1 This article considers results of the doctoral thesis, “La estructura territorial resiliente: Análisis y formalización a través del Planeamiento Urbanístico” within the Doctorate on “Urban Regeneration and Sustainability, of the Universidad Politécnica de Madrid, Spain

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La *Vulnerabilidad Ecosistémica según el Planeamiento* (VEP) buscar valorar el papel de los servicios ecosistémicos para el mantenimiento y fortalecimiento de nuestras ciudades través de la identificación de los ecosistemas, su valoración y consideración desde la planificación. Esta investigación es una adaptación metodológica de un proyecto europeo que busca, a través de una propuesta de la Agencia Europea de Medioambiente, cartografiar sus ecosistemas y las presiones que reciben. Gracias a ello se deberían establecer políticas reductoras de estas presiones sobre el medio natural o evitar traspasar niveles críticos con el resultado de cambios en su nivel de resiliencia. La consideración del planeamiento como otro factor de presión supone la visibilización de un nuevo riesgo para estos ecosistemas que, si bien no había sido contemplada por el momento, tiene una gran relevancia en nuestro contexto. En ese sentido, es preciso aumentar la escala de trabajo y contar con las previsiones de crecimiento y protecciones de suelo existentes cuya información a nivel internacional sería muy difícil de homogenizar y obtener. Así, esta propuesta metodológica se centra concretamente en la Comunidad de Madrid (España) para identificar las presiones contempladas por la metodología europea y sumar una nueva variable que altera el riesgo de pérdida de estos sitios. El caso de estudio plantea desafíos importantes debido a la alta presión urbana presente, pero ejemplariza la problemática de los ecosistemas en el área analizada, identificando los espacios con menor resiliencia conjunta antes estos cambios, a razón de su predisposición a la urbanización.

**Palabras clave:** desarrollo sostenible, ecología, impacto ambiental, medio ambiente, planificación territorial

Ecosystem Vulnerability according to Planning (VEP, in Spanish) seeks to value the role of ecosystem services for the maintenance and strengthening of our cities through the identification of ecosystems, their valuation, and consideration from planning itself. This research is a methodological adaptation of a European project that seeks to map ecosystems and the pressures these receive, through a proposal from the European Environment Agency. Thanks to this, policies should be established to reduce these pressures on the natural environment or to avoid exceeding critical levels with resulting changes in its level of resilience. The consideration of planning as another pressure factor means seeing a new risk for these ecosystems that, although it had not been contemplated until now, is greatly relevant in our context. In this sense, it is necessary to increase the scale of work and to have the growth forecasts and existing land protections, whose information at an international level would be very difficult to homogenize and obtain. Thus, this methodological proposal focuses specifically on the Community of Madrid, Spain, to identify the pressures contemplated by the European methodology, and to add a new variable that alters the risk of losing these spaces. The case study poses important challenges due to the high urban pressure there is, but exemplifies the problems of ecosystems in the area analyzed, identifying the spaces with less joint resilience on facing these changes, due to their predisposition to urbanization.

**Keywords:** sustainable development, ecology, environmental impact, environment, regional planning

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# I. INTRODUCTION

The multitude of pressures and impacts that cities generate as a center for economic, social, and cultural attraction, has a dimension that clearly transcends their boundaries. These dynamics have an influence on the change of land use and, therefore, present challenges for planners, especially for the integration of environmental aspects in their projects (Hurlimann & March, 2012). One of the main challenges that the profession has in the planning, is incorporating the valuation of the state of ecosystems and their contributions for citizens. The composition of biological communities is altered by urbanization, through multiple activities that change both the properties of ecosystems and the services and goods they provide us and, as a result, the quality of life of the inhabitants who were previously supplied by these services (Gardi, Panagos, Van Liedekerke, Bosco & De Brogniez, 2015; Huemann *et al*., 2011; Koukoui, Gersonius, Schot & Van Herk, 2015). The protections of ecosystems that provide these goods is completely necessary and must be worked on comprehensively, establishing ties between the continental and local analysis scales (European Environment Agency, 2017). Given issues, like planning, have a local or regional character, in the Spanish case, and could barely be included at a national or European scale. However, the adoption of new sources of information and the urban perspectives there are on environmental information, can help to improve the interpretation of these spaces and to consider them in local resilience calculations (Hernández Aja *et al*., 2020).

The research starts with the hypothesis that the European ecosystem assessment methodology provides important keys to know the main pressures that act on ecosystems but that, on not contemplating urban planning, one of the fundamental causes of environmental damage, is being overlooked. For the introduction of this factor, it is necessary to adapt the information and scales typology of the European methodology to the region under analysis, and to consider planning. With this, a comparison is established between the protection derived from planning and the risk levels that emerge from the rest of the components involved.

With this purpose, the European project is analyzed and adapted to a given region, the Community of Madrid (Spain), to later incorporate the planning factor as a new anthropic pressure exercised on ecosystems. Despite this being a case study, the methodology developed has enough flexibility to adapt to different regions which, depending on the level of detail in the information they have, could work similarly to that outlined.

# II. THEORETICAL FRAMEWORK

Ecosystem services are understood as the benefits that human beings obtain from the environment (Millennium Ecosystem Assessment, 2014), and addressing them in cities requires a combination of socioeconomic and environmental monitoring tools where ecosystems can serve as a framework to achieve this combination (Maes *et al*., 2014). These ecosystems are formed by the interaction of communities of living organisms with abiotic surroundings, where biodiversity is the base behind them and allows them to be resilient in the face of global change ((Harrison *et al*., 2014; Linney, Henrys, Blackburn, Maskell & Harrison, 2020).

Despite the growing interest to use the concept of ecosystem services as a means to transfer knowledge of environmental science to decision makers and planners (Haase *et al*., 2014; Hassan, 2005; Kumar, 2012; United Nations, 2017), only initial steps have been taken in studies/plans to make integrated assessments about the ties between urban functionalities and environmental aspects (Guerry *et al*., 2015; Simón Rojo, Zazo Moratalla, Alonso & Jiménez, 2014), and the integration of this knowledge in the practice of planning continues to be a challenge, in particular in urban areas where sustainability related issues are not integrated into planning strategies (Artmann, 2014). In the meantime, the exhaustion of resources, both of energy and material nature, or the effects of extreme climate phenomena jeopardize our survival (Fernández Durán & González Reyes, 2014; Sala *et al*., 2000) and, although internationally there is a general acknowledgment about the importance of ecosystems and goods-services, outlining the problem of their management and degradation among the Sustainable Development Goals (Everard, Johnston, Santillo & Staddon, 2020; United Nations, 2018), great progress is not being made from the planning area.

### Anthropic impact on ecosystems and its effects on the service provision capacity

It is difficult to evaluate the different pressures, trends, and impacts corresponding to each ecosystem due to the lack of specific data. Because of this, these are associated and valued considering the five large groups of actions -habitat transformation, climate change, overexploitation of resources, introduction of invasive exotic species, and contamination and enrichment of nutrients- identified by the Millennium Ecosystem Assessment (2004). However, this methodology does not talk about urban pressure or the role of conservation that planning has.

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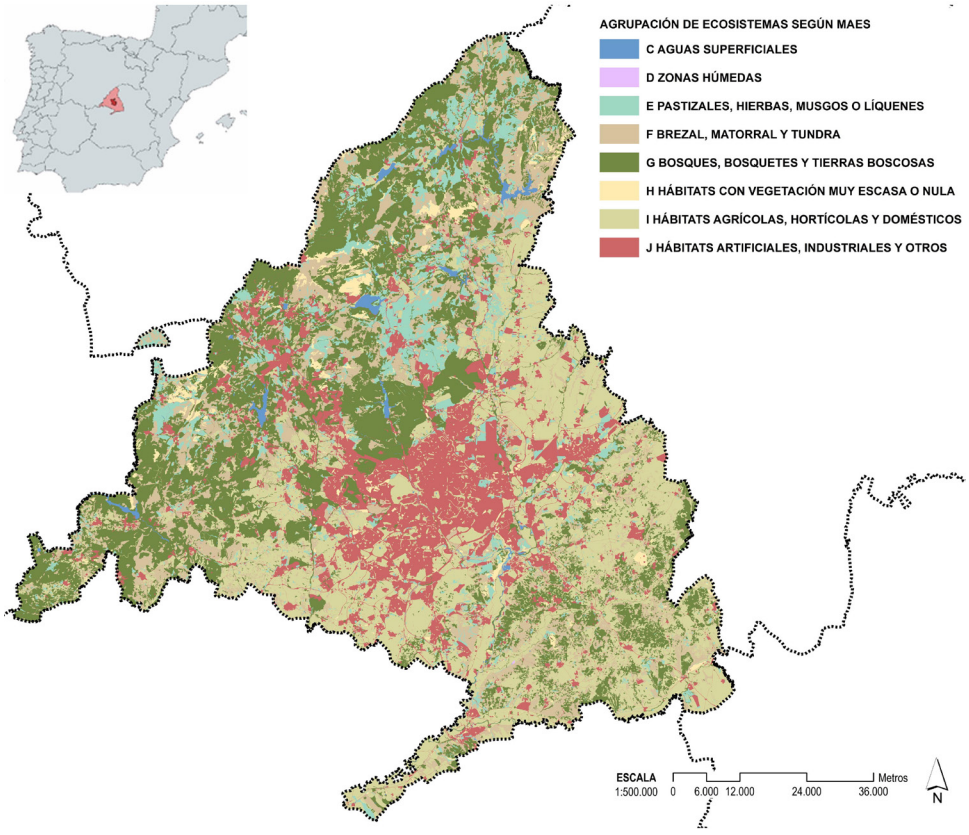


Figure 1. Identification of the Community of Madrid within Spain and its main ecosystems. Source: Preparation by the author based on data from the CORINE and EUNIS projects.

The pressures mentioned can help to assess the conditions of our ecosystems and the effects these have on their characteristics. It does not matter who we are or where we live, our wellbeing depends on the way in which the ecosystems work. The most obvious aspect is that ecosystems can provide us with material things that are essential for our lives, like food, water, or medicine. Although other benefits that we obtain from ecosystems are easily overlooked, they also play an important role in the regulation of where we live. These can help with climate regulation (Ghaley, Vesterdal & Porter, 2014), ensure the flow of clean water (Stürck Poortinga & Verburg, 2014), regulate the water cycle (McGrane, 2016), protect us from flooding (McGranahan, Balk & Anderson, 2007), and other hazards like soil erosion, landslides. and tsunamis (Gómez-Baggethun & Barton, 2013). In addition, they can contribute to our spiritual wellbeing, through their cultural importance or the opportunities they provide for leisure purposes or enjoying nature (Haines-Young & Potschin, 2012; Sandifer, Sutton-Grier & Ward, 2015). This information can be very useful to formulate specific urban policies, identifying for example, those areas that should be incorporated to the protection measures due to their ecosystem contributions or their greater vulnerability to change. Nevertheless, to suitably interpret the mapping of these issues, it is also necessary to incorporate possible future developments considered within the planning sphere.

## III. CASE STUDY

The Community of Madrid, Spain is defined, in urban terms, by the non-existence of comprehensive regional planning, the inadaptability of municipal planning to current legislation, and an environmental sectorial legislation that could be used to achieve greater regional sustainability (Córdoba Hernández & Morcillo Álvarez, 2020; Valenzuela Rubio, 2010). Currently, the main environmental problems come from the conflict between the population, their different activities, the region where these take place, and existing property pressure, especially in the

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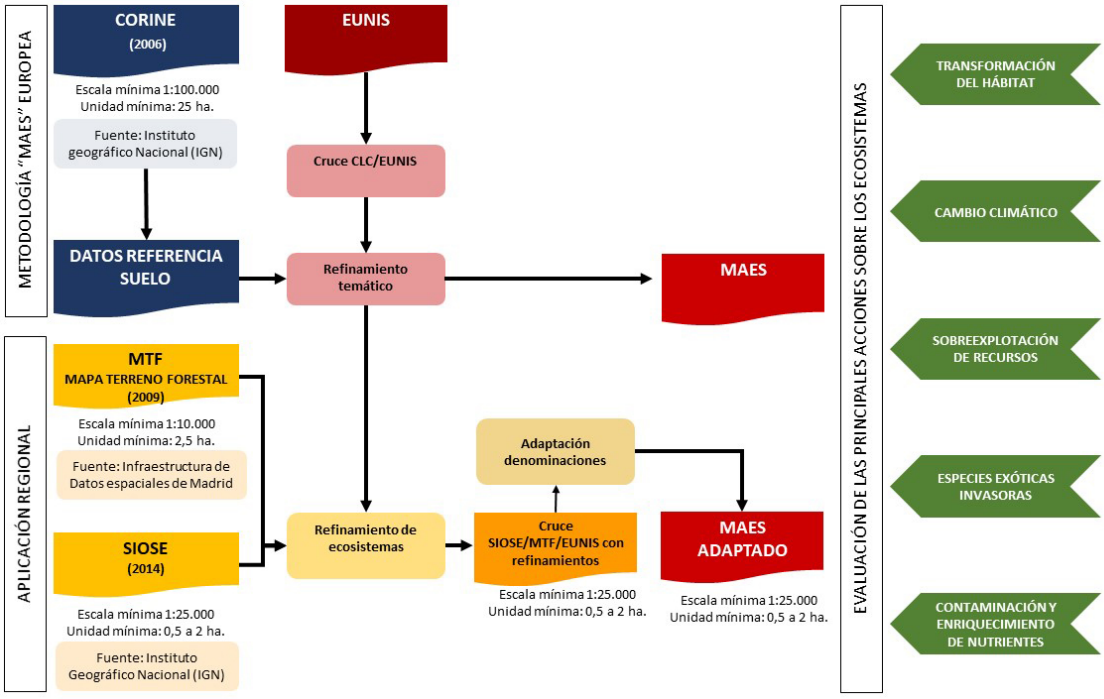


Figure 2. Comparison of the MAES methodological outline and its regionalized adaptation. Source: Preparation by the authors.

metropolitan area. The traditional way to try to alleviate this conflict, without leaving socioeconomic development or environmental protection aside, was through planning and environmental assessment. The main characteristics this case has and that favor its interpretation, are its provincial scale and suitable size (802,200 ha), the elevated population affected, 6.685 million to January 2020, the existence of 8 ecosystems according to the habitat groups of the European Nature Information System (EUNIS), and the absence of marine ecosystems, that are less developed by the European methodology, that is sought to be adapted (Figure 1).

## IV. METHODOLOGY

Consideration of planning as a complementary pressure factor on ecosystems leads to seeing a new risk, neglected until now by the methodology of the European Environment Agency (EEA) vis-a-vis this issue. In order to carry out this study and include this factor in the assessment, it is necessary to work at a scale where planning is governed by the same rules, and where information is accessible, as is the case of the Community of Madrid.

The first step is standardizing and complementing the European methodology to the national case with the necessary adaptation of the scale. For this, the information available from the National Geographical Institute and the services of the Madrid Spatial Data Infrastructure is used. Both provide open information that can be managed using Geographic Information Systems (GIS).

This process begins through the Mapping and Assessment of Ecosystems and their Services (MAES), which identifies 12 ecosystem types (Maes *et al*., 2014), and evaluates each action described by the EEA, aiming at analyzing the environmental problems and identifying measures to resolve them. These types are formed by ecosystem groupings considered in the European Nature Information System (EUNIS), whose classification seeks to identify all habitats, starting from the land use information provided by Corine Land Cover (CLC), and the maps of different habitats. The application of this analysis at a greater scale presents five problems: reference scale; minimum mappable unit; hierarchical simplification; lack of natural information at a regional scale; and free access only possible in raster format, which does not adapt to the detailed vectorial local map due to the size of the resolution cell.

So that the data available about ecosystem contributions and their comparison with urban protections have a greater

| | | | Reduction risk of ecosystem contributions due to the pressures detected by the Millennium Ecosystems Assessment | | | | |
|---|---|---|---|---|---|---|---|
| **MAES Ecosystem** | **Surf. (Ha)** | **% Total** | **Habitat transformation** | **Climate change** | **Overexploitation of resources** | **Invasive exotic species** | **Contamination and enrichment of Nutrients** |
| Urban | 120,885 | 15.07 | Very high | Moderate | Low | High | Very high |
| Agricultural lands | 222,907 | 27.79 | Very high | Moderate | High | Moderate | Very high |
| Pastures | 63,633 | 7.93 | High | Low | Moderate | Low | Low |
| Forests and Woods | 231,106 | 28.81 | High | Low | Moderate | Moderate | Moderate |
| Moors, bushes and land with scarce vegetation | 156,897 | 19.56 | Moderate | Moderate | Low | Moderate | Low |
| Wetlands | 62 | 0.01 | Very high | Moderate | High | Moderate | Very high |
| Rivers and lakes | 6,709 | 0.84 | Very high | Moderate | High | Moderate | Very high |
| **Total Community of Madrid** | **802,200** | **100.00** | | | | | |

Table 1. Reduction risk of ecosystem contributions due to the pressures detected by the Millennium Ecosystems Assessment, considering the MAES ecosystem classification Source: Preparation by the Authors.

reliability, it is suggested to adapt them to the information available in a specific region. In this way, the categories of the Spanish Land Occupation Information System (SIOSE, in Spanish) are reclassified, which helps to mark out the ecosystems and incorporates, with a better approximation, elements that divide habitats, such as communication or energy infrastructures, due to their scale.

In order to complete this map, the 46 land types identified by SIOSE are adapted to the 12 main ecosystems of the MAES project. The allocation is not direct, as CLC categories differ from those of SIOSE, and it is necessary to include information from the Community of Madrid Forestry Land Map (MFE, in Spanish) that details the ecosystems of agricultural lands, pastures, forests and woods, moors, and bushes (Figure 2). Once this process is done, a SIOSE map is obtained, where EUNIS ecosystem units can be assigned in greater detail than when they are crossed with the European CLC/EUNIS.

The following step is to measure the risk of reducing ecosystem contributions due to the pressure detected by the EEA (European Environment Agency, 2017) in the case under study. For this, the 44 covers identified by the SIOSE are grouped into 20 EUNIS ecosystems that are translated into 8 MAES ecosystem units. In this way, each ecosystem unit can be assessed considering the pressures exercised using the project's criteria and, given that the rest of the associated aspects are mapped, it is possible to regionalize the affectation (Table 1).

Alongside this, the autonomous planning is analyzed. This is characterized by three levels of formulation: regional planning; land conditioned by legislation; and municipal planning, where different councils have gone for a specific model of land protection and development in line with prevailing land legislation.

With this information, the fourth methodological step is made, which consists in comparing the risk levels of reducing ecosystem contributions with the urban planning of the Community of Madrid. From crossing the lands foreseen for the development not affected by any sectorial legislation that impedes their development, with the habitats most vulnerable to impacts, those lands that must be especially considered by municipal planning at the time of their revision emerge, given that maintaining their foreseen development would jeopardize the continuity of their ecosystem contributions.

The overlapping of these ecosystems with planning allows identifying Ecosystem Vulnerability according to Planning (VEP, in Spanish), which would be the last step of the methodology. These lands are defined as those which, on having a high or



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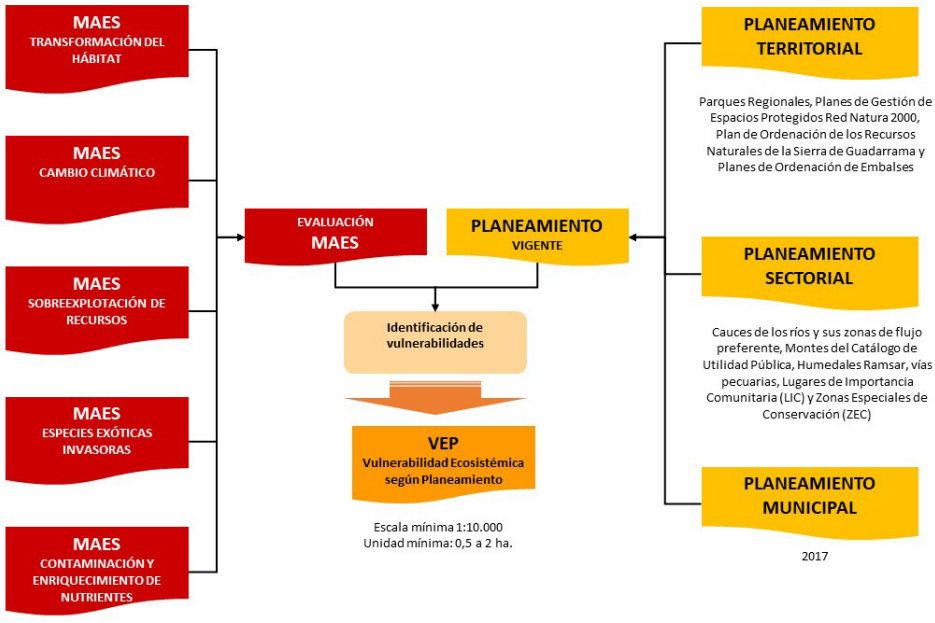
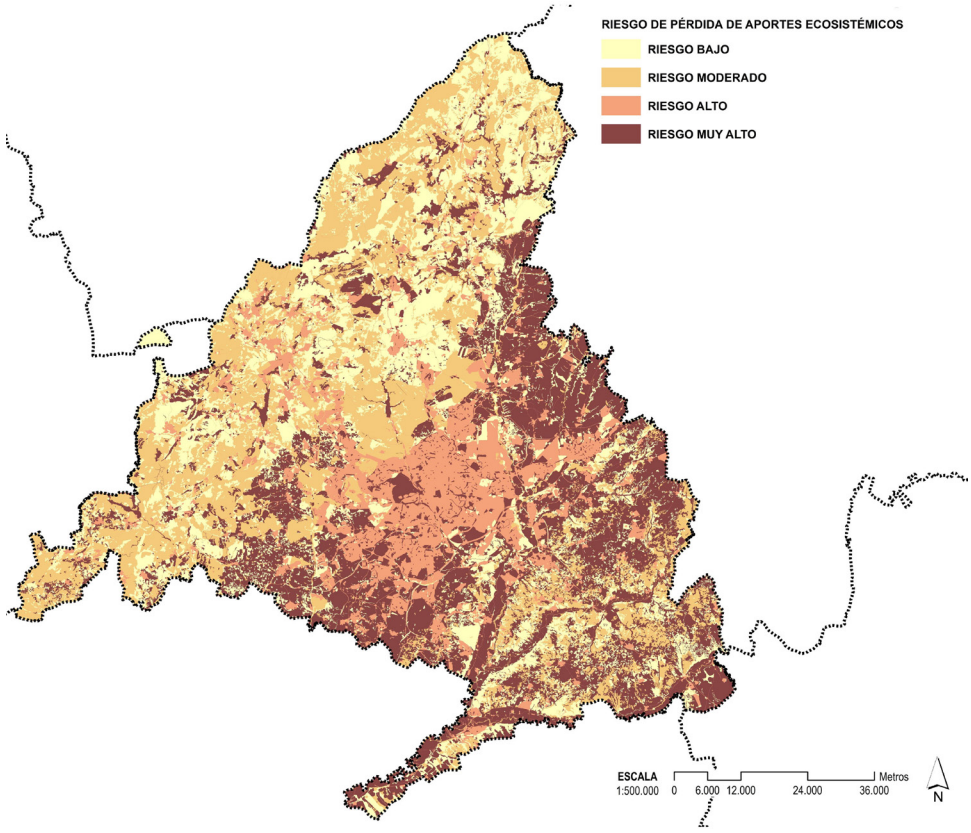



Figure 3. Integration of planning in the regionalized adaptation of the MAES methodology. Source: Preparation by the Authors.




Figur3 4. Regionalization of the impact of the actions detected by the Millennium Ecosystems through the adaptation of the MAES methodology. Source: Preparation by the Authors. Regionalization of the impact of the actions detected by the Millennium Ecosystems through the adaptation of

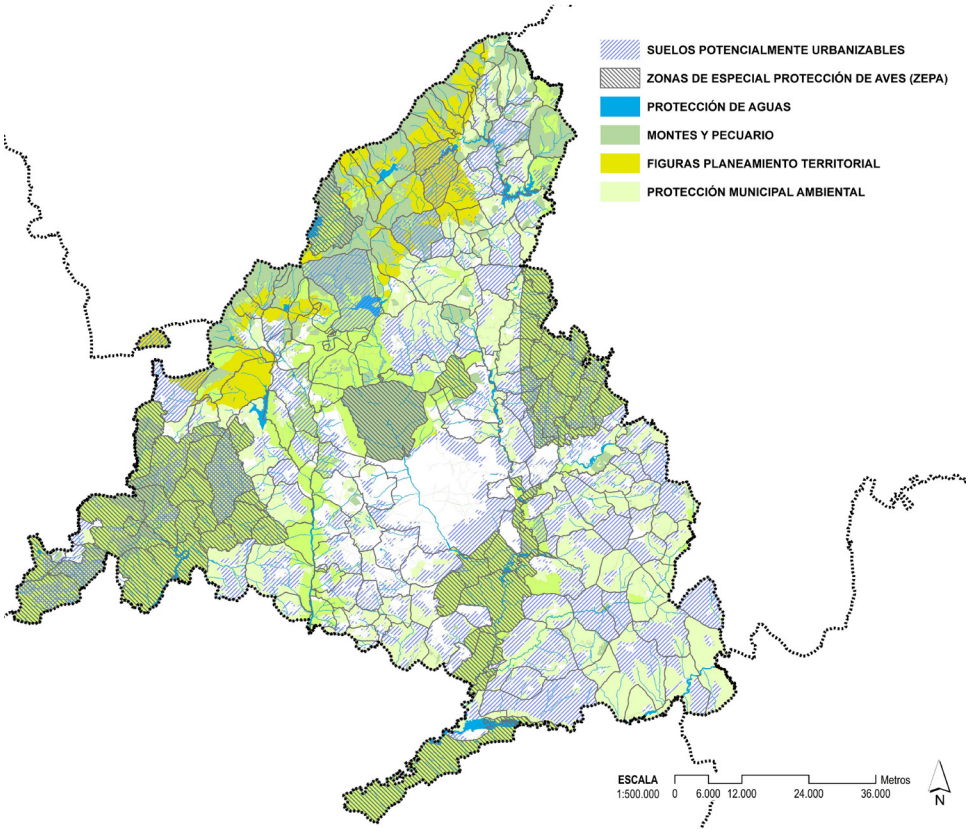



Figure 5. Regionalization of the sectorial protections and regional planning figures with environmental considerations.Source: Preparation by the Authors based on information from the Community of Madrid Regional Information System.

very high sensitivity to the effects of the actions suggested on biodiversity, also lack a suitable protection from urban regulation, permitting in these, uses that would harm this condition yet further (Figure 3).

## V. RESULTS

Starting from the results obtained, it is possible to indicate that the region whose ecosystems endure greater pressure coincides with urban ecosystems, agricultural land, wetlands, and rivers. According to the projection, the effects will mainly be noticeable in the central and southern part of the Community. The effects of climate change will be moderate or low, and the urbanized land, agricultural areas, wetlands and rivers, will be those that would suffer more temperature and rainfall flow changes, and extreme events and fires in the rural environment. The areas where overexploitation of resources could be most seen are those of agricultural areas, wetlands, lakes and rivers. where agricultural intensification through intensive agriculture and the overexploitation of crops and groundwater are already starting to manifest their first effects. Considering the potential risks that the introduction of exotic species would imply, the greatest danger lies in urban areas, while the effects of contamination and enrichment of nutrients would especially disturb the urban, agricultural, wetlands, lakes and rivers ecosystems. The simultaneity of these five actions allows grading the degree of vulnerability of these ecosystems in Figure 4.

On the other hand, the regionalization resulting from the different protections of sectorial legislation, the regional planning or municipal planning figures, can be seen in Figure 5. The general consideration of these matters, without delving deeper into their actual use, nor into valuing how suitable these are, would imply a high protection of the region, with 66.43% of the land with some type of protection. The main problem of regional planning figures is that, despite their denomination, they consider some inherited growth as occurs in the case of the PORN of Sierra de Guadarrama.

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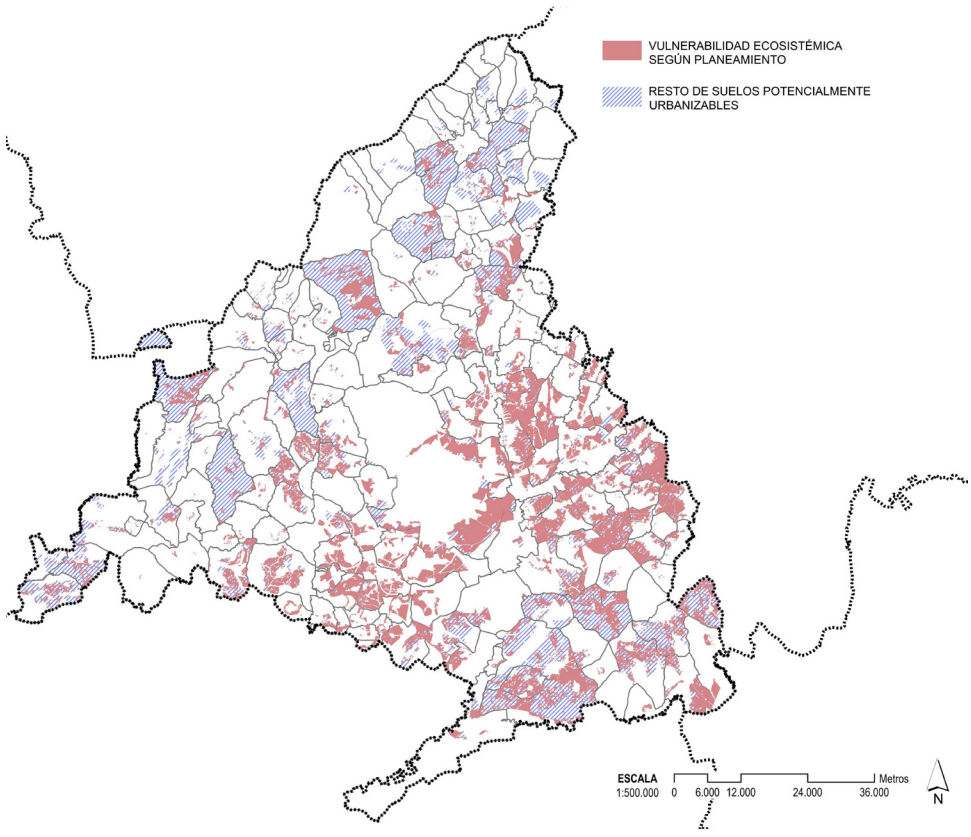


Figure 6. Ecosystem vulnerability according to planning. Source: Preparation by the Authors.

The consideration of the developments proposed to identify the VEP comes next. These have a size of 239,513 ha, equivalent to 29.86% of the region. From this surface, 62.61% would have a high or very high ecosystem vulnerability, according to the planning, and the contribution of their ecosystem resources would be jeopardized with its execution, harming the habitability not just of these future developments, but also of already urbanized land (Figure 6).

## VI. DISCUSSIONS

The consideration of both the adaptability capacity on the reduction of consumption needed to carry out an urban development, and to determine the protection needs of a given region, requires identifying the components of the regional model that determine its resilience capacity. Not doing so may jeopardize human wellbeing and maintaining the economic and social development of the region. This resilience could be defined as the capacity of a system to maintain itself, or to return to the functions desirable before a disturbance, to adapt to the change, and to transform the systems that limit current or future adaptation capacity (Meerow, Newell & Stults, 2016), and should form part, both of the urban planning and of the regional, urban and living policies of the coming years. But, for this, it is necessary to know the main problems that each region faces considering their physical and natural reality.

The trend towards global urbanization has caused a clear imbalance between the rural and urban worlds, a trend that continues to be encouraged by a lack of work, a new economic crisis or a growing lack of coverage of basic needs in some regions (Córdoba Hernández & García-Burgos Pérez, 2020; HIC-AL/ PSH Work group, 2017).

If these aspects condition, clearly and by themselves, the practice of planning, other less controllable vectors like the recent displacements derived from environmental problems and situations of risk caused by climate change (Oyedeji, 2017), increase the resilient factors to be assessed. These are not trivial matters, if consideration is paid to the forecasts that estimate

that more than 143 million people could be forced to move within their own countries to escape these threats (Rigaud *et al*., 2018).

The design and implementation of strategies and action plans for the preservation of ecosystems, the use of evidence-based planning tools to design conservation areas and networks and their connectivity, are essential for integrated natural environment management, as well as to increase the resilience of these regions against the adverse effects that may continue to arrive. In this sense, current land legislation should be in charge of regulating planning in this region, safeguarding the activities typical of urban land; those lands subject to special protection regimes, that are incompatible with their transformation following the regional planning, sectorial legislation, or their values.

For this, aiming for the construction of a coherent multiscale ecological network through the improvement and strengthening of European green infrastructure, directly considering the mandate of Objective 2 of the EU Strategy on Biodiversity for 2020 (European Union, 2011), focused on the improvement and upkeep of ecosystems, creating a transborder green infrastructure, may be a solution to the problems analyzed here. This network would be linked, at the same time, with the need of establishing ties at different scales: continental, national, regional, and local.

By the end of 2020, the State strategy for green infrastructure and connectivity and national ecological restoration (Ministry for Ecological Transition and Demographic Challenges, 2020) has been added to the aforementioned strategy. Its purpose is protecting nature, strengthening ecological resilience, promoting low carbon growth that uses resources efficiently, reducing threats for human health and wellbeing associated to contamination, chemical substances, and the impact of climate change, adhering to the VII General Action Program of the Union on matters of Environment, living well, within the limits of our planet (European Commission, 2013), and in line with the Sustainable Development Goals (United Nations, 2018).

According to the European Commission, green infrastructure is a strategically planned network of natural and semi-natural spaces and other environmental elements designed and managed to offer a broad range of ecosystem services, which the most vulnerable ecosystems identified with this methodology could perfectly be part of.

To carry out this task, it is necessary to reduce or not increase the detected vulnerability. This vulnerability should be considered in the environmental assessment procedures demanded by the regulations for land legislation.

From this perspective, having complete and reliable information about the status of ecosystems and their services, and delving deeper into the follow-up and monitoring of the changes that can happen, it becomes essential to know whether the goals of the strategic environmental assessment have been met or not, and if we are fulfilling our international commitments, not just referring to the mitigation and adaptation to climate change, but also to the preservation of the valuable natural environment that surrounds us.

Development in these aspects can contribute to supporting the implementation of environmental legislation, the integration of environmental conservation goals in the policies and development sector, and enacting all the changes needed to comply with these statements. In this context, conservation more than preservation should be targeted, despite being concepts that often used indistinctly. However, the difference is noticeable if we want to consider our future needs. In this way, while the first of the terms assumes the present and future defense, preservation only supposes a protection against what may happen in the future, but does not necessarily imply that a given action is done when that future arrives.

Looking further into this type of studies, the identification and mapping of ecosystems could be used to spatially define interactions between different spaces, prioritizing conservation and protection actions of our heritage or minimizing the compensations among ecosystem services.

## VII. CONCLUSIONS

This research shows the importance of mapping both the effects of given actions over ecosystems and of the planning itself and the different regional issues of sectorial legislation to diagnose the current situation, facing the challenges and uncertainty of their effects on urban planning in the current context. Although the European project handles the first of these matters to assess the ecosystem risk, it is also true that the urban pressure is difficult to integrate on this scale and it needs a national or autonomous context. The inclusion of planning in these valuations can be of great importance to suitably establish future uses of the region and their valuation, as well as the identification of the most vulnerable ecosystem lands, according to planning, to have a suitable conservation.

This mapping must identify and mark out the spatial extension of different ecosystems through the spatial integration of qualitative data on land cover and its environmental characteristics. In addition, in the search for a greater conservation of ecosystems, their state must be assessed, analyzing the main pressures, valuing the links between their conditions, quality and biodiversity, and establishing how this affects the capacity of the ecosystem to provide its services. Finally, it will be possible to rate the consequences for human beings and their wellbeing. The relevance of these questions is such, that planners cannot be left out and must take part,



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suitably regulating future uses of these lands, not just valuing them because of their natural or scenic values, but also considering the contribution of their goods-services.

Information on the pressure of given ecosystems can help to assess this service provision capacity. In this way, it is essential to inform about the policies to reduce these pressures, as well as to avoid exceeding critical pressure levels that are capable of causing a radical alteration in the ecosystem with the introduction and/or disappearance of species or a change in its resilience level. For this reason, before reaching this situation, work has to be done for the prevention and care of these areas using the suitable tools that each country or region provides. One of these tools is urban planning which, in the Spanish case, must seek efficiency of conservation and improvement measures for the natural environment, preserving land values whose transformation is unjustified to consider urban transformation needs or to minimize air, water or subsoil contamination, as its own legislation establishes. The inclusion of planning as such, must be a task performed by each one of the countries or regions, as the differentiations between these would complicate the task of homogenization at a European level greatly, running the risk of simplification. All in all, the methodology proposed opens new paths in this sense, being able to be adapted straightforwardly in other regional contexts, both autonomous and provincial in the Spanish case, as well as with other administrative figures at an international level.

Given the singularity of the planner's work, due to the implicit conditioning factors that the land classification itself implies, the greater definition of impacts the methodological change involves, should help Councils to suitably comply with these regulations. Ultimately, the analysis about the risk of reducing the contributions of ecosystems should be part of the Strategic Environmental Assessment of planning. With this, a strategic green network could be formed that would consider establishing points of control or follow-up indicators of their state and level of stress, all of which would allow having a more detailed analysis of the vulnerability situation of ecosystems.

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LA VULNERABILIDAD ECOSISTÉMICA SEGÚN EL PLANEAMIENTO EN LA PROTECCIÓN DEL SUELO DE LA COMUNIDAD DE MADRID
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# FINANCIALIZATION OF THE PHARMACEUTICAL INDUSTRY

## AND ITS IMPACT ON URBAN PERIPHERIES IN THE METROPOLITAN AREA OF THE VALLEY OF MEXICO [1]

FINANCIARIZACIÓN DE LA INDUSTRIA FARMACÉUTICA Y SU REPERCUSIÓN EN LAS PERIFERIAS URBANAS EN LA ZONA METROPOLITANA DEL VALLE DE MÉXICO

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El proceso de financiarización se encuentra presente en el ramo de la salud, de manera particular, en lo que se refiere a las grandes empresas farmacéuticas. Para el caso de México, se aprecia una expansión de las farmacias con consultorio derivado de los flujos de capital, pero, además, de la ausencia de un sistema de salud público de calidad. En el presente trabajo se analiza cómo los procesos contemporáneos de financiarización de empresas farmacéuticas han permitido la expansión del esquema de farmacias con consultorio y, en cierto grado, la "sustitución" de servicios de salud gestionados por autoridades públicas en las periferias urbanas de la Zona Metropolitana del Valle de México. Con base en información de Farmacias Benavides y Farmacias Guadalajara, emitida por la Bolsa Mexicana de Valores, sobre diversos indicadores sobre salud y farmacias en México, así como mediante la aplicación de entrevistas semiestructuradas a residentes de la periferia metropolitana, se argumenta que el crecimiento exponencial de las farmacias en las últimas dos décadas está articulado a la política de expansión y construcción de vivienda social. Estos proyectos de vivienda, en gran medida debido a los débiles controles regulatorios, no desarrollan una infraestructura sanitaria adecuada tanto en términos cualitativos como cuantitativos, favoreciendo así la apertura de instrumentos financieros que ha permitido que grandes empresas farmacéuticas se expandan en las últimas décadas.

**Palabras clave:** farmacias, urbanización, política de la salud, condiciones de vida, planificación urbana.

The process of financialization is present in the health sector, particularly in the case of large pharmaceutical companies. In the case of Mexico, there has been an expansion of pharmacies with medical offices as a result of capital flows, but also due to the absence of a quality public health system. This paper analyzes how the contemporary processes of pharmaceutical company financialization have allowed the expansion of the medical office-based pharmacy scheme and, to a certain extent, the "substitution" of health services managed by public authorities in the urban peripheries of the Metropolitan Zone of the Valley of Mexico. Based on information from Farmacias Benavides and Farmacias Guadalajara, issued by the Mexican Stock Exchange, on several indicators on health and pharmacies in Mexico, as well as semi-structured interviews with residents of the metropolitan periphery, it is argued that the exponential growth of pharmacies in the last two decades is linked to the policy of expansion and construction of social housing. These housing projects, largely due to weak regulatory controls, do not develop an adequate health infrastructure both in qualitative and quantitative terms, thus favoring the opening of financial instruments that have allowed large pharmaceutical companies to expand in recent decades.

**Keywords:** pharmacies, urbanization, health policy, living conditions, urban planning


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# I. INTRODUCTION

Critical urban studies have been emphatic in stating that neoliberal economic policies have not just transformed the real-estate market, but their scope has extended towards diverse spaces of social life. For the case of Mexico, this situation has been included in social studies, specifically those focused on complications within health service provision (López & Jarillo, 2017; Salgado & Guerra, 2014; Rabell, 2014; López & López, 2015).

As a result, different medium and large cities in Mexico have grown in recent decades through the formal housing market. However, this expansion of the urban periphery of the Valley of Mexico Metropolitan Zone (ZMVM in Spanish), has not been accompanied by the building of urban equipment and infrastructure (Céline, 2013; Montejano, Caudillo & Cervantes, 2018; Salinas & Pardo, 2020), and, in particular, by suitable health facilities (Cárdenas, 2014). Instead, a basic health attention model of pharmacies with doctor's offices has spread, administered by large private corporations, some of them with operations throughout Latin America. These are premises that originally only sold medication, that have since attached small doctor's offices, which generally attend medical emergencies that do not require specialized referrals to medical centers.

The accelerated growth of pharmacies with doctor's offices has been possible thanks to the financialization of the economy. This process is understood as the ever more important role of financial instruments, markets, players, and institutions in the running of domestic and international economies, and their impact on different scales, both in the production of the urban space and in daily life (Epstein, 2015; Aalbers, 2019). In this context, the financialization of the pharmaceutical industry represents a process of subordination of the companies' strategies to the accumulation of financial capital, mediated by the financial markets and guided by the ideology of value for the shareholder (Orhangazi, 2008), at the expense of the universal right to healthcare.

Some works in this regard focus on analyzing the global innovation networks of pharmaceutical consortiums (Rikap, 2019) and, in particular, in the innovation and development process of pharmaceutical products linked to speculation on the capital markets (Andersson, Gleadle, Haslam & Tsitsianis, 2010; Baranes, 2017). However, beyond analyzing the innovation process, the speculation of the capital market or the players involved, this work aims at contributing to the discussion on the injection of capital for the expansion of the pharmaceutical industry which, apart from the innovation and production of pharmaceuticals, enters into health service provision.

In light of the arguments outlined, the hypothesis is put forward that financialization, driven by the opening up of trade and the circulation of capital on different scales, has brought great amounts of capital from transnational companies into the pharmaceutical industry, leading to the expansion of pharmacies with doctor's offices, whose success lays in the reduction of the State's role in public healthcare. This situation has had an impact on the structure of the urban space, closely accompanying the recent urban sprawl into the peripheries of ZMVM.

As a result, the goal of this article is to analyze how contemporary financialization processes within the pharmaceutical industry have allowed the expansion of pharmacies with doctor's offices system and, to a certain extent, the "substitution" of health services managed by public authorities in the ZMVM periphery. Thus, it is argued, that this exponential growth of the last two decades, articulated to the social housing construction and expansion policy, one which has been mainly due to the weak regulatory controls, does not develop a suitable health infrastructure, either in qualitative or quantitative terms.

# II. THEORETICAL FRAMEWORK

In recent discussions on this issue, a first analytical level suggests that "financialization means an ever more important role of financial motivations, financial markets, financial players, and financial institutions in the operation of domestic and international economies" (Epstein, 2005, p. 3). This first level has a perspective that, starting from the political economy, places its attention on the dynamics of global circulation and production of value, emphasizing the operation of the securities and capital market. At a second analytical level, related to the dynamics of financialization, in terms of the unequal circulation of capital with the perspective of the production of urban space, Aalbers (2019) mentions that the existence of financialization necessarily occurs because of the particular ways in which this, on diverse scales, penetrates urban life and converts it into an asset that can be traded on the financial markets. The latter is very important to understand the financialization of the pharmaceutical industry, on one hand, starting from the financial processes that have allowed pharmacies with a doctor's office to expand and, on the other, on its repercussions on the production of the peripheries of ZMVM and, in this way, on the practices of the habitat.

The expansion of pharmacies and the structuring of a financialized market of pharmacies in Mexico, falls within the sustained reduction of state investment in social security provision (Díaz-Portillo et al., 2015; López & Aguilar,

2020). In this process, it is essential to place mediations or opportunities that leading economic entities have driven on focusing their investment in this sector in particular. In this way, the insufficient capacity of the health system and the growth of medium and large cities over recent decades, has been the context and opportunity to insert pharmacies within urban periphery spaces, where the already limited presence of public health institutions[4] has been supplanted by pharmacies with doctor's offices, which form the only option to attend low income population sectors (Galindo y Suárez, 2018), as will be seen later on in this article.

In recent specialized literature, some authors (Klinge, Fernández & Aalbers, 2020) confirm that the pharmaceutical sector is greatly dominated by large corporations known as "Big Pharma", which have changed the profitability strategy from one with a model focused on increasing production capacity, to one focused on the production of intangible assets (reflected in patents, copyrights, and a commercial base). These actions of Big Pharma are ever more similar to those of private capital funds which, obliged to generate revenues for their shareholders, find transactions in the stock markets as one of the quickest (riskiest) resources, to maintain their market share. This point opens up a space for articulation among the large pharmaceutical companies and the transnational conglomerates dedicated to the sale – and sometimes to the manufacturing – of pharmaceuticals.

Meanwhile, Rikap (2019) analyzes the technological competence in the transnational innovation networks of Big Pharma, especially, Roche, Novartis, and Pfizer, who outsource innovation at different stages to diverse institutions, to obtain higher profits. Andersson and his colleagues (2010) analyze the pharmaceutical industry as a business model that uses different speculative capital market instruments. Meanwhile, Baranes (2017) establishes that the financialization of the pharmaceutical industry maintains a growing importance of the profits via financial channels and the accumulation of intangible assets that generate profit to serve as the basis for the capitalization.

In the same vein as the work of Baranes, this article seeks to link this injection of assets behind the capitalization, with the expansion of the pharmacies in the periphery of ZMVM. At a time where the provision of health services and the sale of pharmaceutical products is progressively losing its connection with the purpose of reproduction of life -namely health as a right-, ground is paved so that investment funds, with holdings in different goods and services production sectors, broadens their field and scale of thinking. Thus, in an economy marked by a trend towards globalization, and, likewise, towards anchoring in fragmented urban spaces, the investment funds that have "Big Pharma" holdings, are also interested in broadening their portfolios to segments that guarantee high profitability rates. This is why they operate in global value chains where the financialized logic penetrates, in terms of a dialectic of equalization and differentiation (Smith, 2020), both in the sale of pharmaceuticals, and in the production of urban sprawl that has limited access to healthcare services.

To achieve this articulation, it was necessary that the state apparatus took on as a political goal, the imperative of reducing their role in the provision of health, urban, and housing services. Consensus on facing a slimmed-down State is achieved, both by means of the recommendations of multilateral financial entities, and by the path taken to increase the political lobbying of economic conglomerates that fight for regulatory frameworks favorable to their interests.

## III. METHODOLOGY

To revise the expansion dynamics of pharmacies with doctor's offices, the National Health and Nutrition Survey (ENSANUT, in Spanish) was used first. This was developed by the National Public Health Institute (INSP, in Spanish) in 2012 and 2018 with the goal of understanding their evolution in the national public healthcare system. Second, the public information of Farmacias Benavides and Farmacias Guadalajara (Corporativo Fragua), contained in the bulletins of the Mexican Stock Market (BMV, in Spanish) was consulted with, to see the makeup of the financialization mechanisms of this sector. These two cases were chosen, as they are an essential element of the analysis of financialization processes: namely that the companies take part in the capital market via issuing and placing shares (Sanfelici, 2016). This does not mean that these are the only pharmacies to have entered this business model, as Farmacias Similares, part of Grupo Por un País Mejor, even though it is not listed on the BMV exchange is, according to information from America-Retail, the company with the highest number of pharmacies with doctor's offices in the country. Finally, interviews were made to inhabitants from the housing complexes of Santa

4 According to the Health Secretariat, the number of physicians per 1,000 inhabitants in Zumpango and Huehuetoca is 1.2 and 1.0 respectively, below that of the State of Mexico (2.1) and the Republic (2.4), and all-in-all, below the average indicated by the OECD (3.5). With regard to the availability of beds per 1,000 inhabitants, the figures for the State of Mexico (1.0) are also below the federal average (1.4), and that stated by OECD (4.7).



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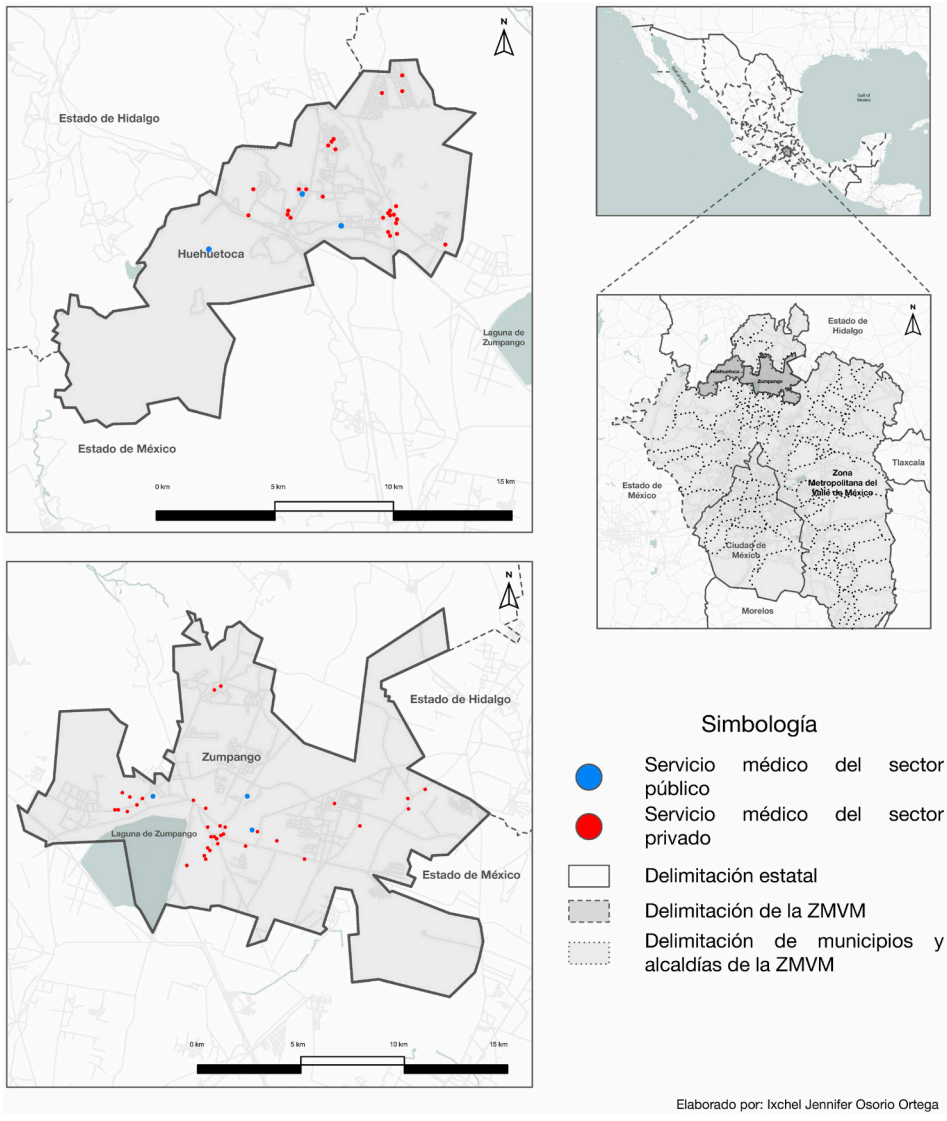


Figure 1. Distribution of public and private health services in the municipalities of Huehuetoca and Zumpango. Source: Prepared by Ixchel Jennifer Osorio Ortega with information from the National Economic Units Statistical Directory (DENUE, in Spanish), developed by the National Institute of Statistics and Geography (INEGI, 2021)

Teresa in Huehuetoca and Paseos de San Juan in Zumpango, both in the ZMVM periphery (Figure 1), as an example of places where inhabitants consider pharmacies with doctor's offices are their only close option.

## IV. RESULTS

According to the Federal Commission for the Protection against Health Risks (COFEPRIS, in Spanish) for 2015, out of the 28,000 pharmacies registered in the country, 13,000 (46%) operate under the pharmacies with doctor's office model, and from these, around 65% are in the ZMVM (COFEPRIS, 2015). Even though the pharmacies with doctor's offices do not offer specialized services, they become a quick resource to handle uncertainty, and because of this according to De Alba (2020), the vulnerability conditions of the patients are reproduced, since the goal of the pharmacies with doctor's offices is increasing the number of medical prescriptions that are sold in those facilities.

| Information | Company | | | |
|---|---|---|---|---|
| | Farmacias Guadalajara | | Farmacias Benavides | |
| Year of Foundation | 1943 | | 1971 | |
| City of Origin | Guadalajara, Jalisco | | Monterrey, Nuevo León | |
| Year of First Listing (BMV) | 1997 | | 1993 | |
| Expansion | Year<br>1997<br>2005<br>2012<br>2019* | Branches<br>73<br>416<br>1000<br>2043 | Year<br>1993<br>2005<br>2014<br>2019* | Branches<br>371<br>529<br>1023<br>1174 |

Table 1. General information about pharmacies Source: Preparation by the Authors with information from the Mexican Stock Exchange (Martínez, 2019).

The deregulation scenario of the health sector and the privatization dynamics have allowed companies, listed on the Mexican Stock Exchange, to expand, changing from solely being sellers of pharmaceuticals to ones partaking in the manufacturing-distribution business, and the provision of basic medical attention services (pharmacies with doctor's offices), as is the case of Farmacias Guadalajara and Farmacias Benavides. As a result of their listing on the Mexican Stock Exchange (BMV), and subsequent placing of 20% of their capital, Farmacias Guadalajara opened 343 new Super-pharmacies, rising from 73 in October 1997 to 416 in 2005, from being present in 19 cities to being in 110, which covered the 17 States of the Mexican Republic**5**. Meanwhile, Farmacias Benavides, which upon listing on the BMV with 24% of its capital, entered the pharmacy with doctor's offices segment in 2012 and ended that year with 772 pharmacies in operation, before reaching 1045 in 2015. In five years, they saw a significant expansion of 26%**6**. It is important to note that, as a result of an internationalization process in 2014, the latter's shareholding was transferred to the transnational Walgreens Alliance Boots (listed on the Dow Jones Index on the New York Stock Exchange since 2018), owner of pharmaceutical laboratories, and operator of 21,000 pharmacies around the world.

The financialization process that pharmacies with doctor's offices have followed, like that of Farmacias Guadalajara, Farmacias Benavides, Farmacias YZA, Farmacon, Farmacias Modernas (the last three owned by Grupo Fomento Económico Mexicano S.A.B. de C.V., known as Grupo Femsa, the main bottling plant of Coca-Cola in Latin America) and Farmacias Similares S.A. de C.V. (that, although not on the Stock Exchange, controlled 10.9% of pharmaceutical sales by 2019), has allowed them to spread in recent decades, taking advantage of urban expansion with insufficient public sector health facilities, and managing to convert this primary health attention model into an alternative for an important part of the population.

In 2010, the Agreement that provided the guidelines for the sale and dispensing of antibiotics came into force (Official Gazette of the Federation, 2010) **7**, and according to COFEPRIS data (2015), in the 2010-2015 period, an increase of 340% was seen in the number of pharmacies with doctor's offices, rising from 4,370 in 2010 to 15,000 in 2014. This increase is recorded in the ENSANUT, which indicates that: in 2006, the private sector attended 37.6% of all outpatient curative services (doctor's offices), while the public sector covered 61.4%. By 2012, two years after the Agreement came into force, the private sector had increased its share by 1.3%, reaching 38.9% versus 61.1% of the public sector. That year, ENSANUT provides broken down data of attention in private doctor's offices and indicates that, from all attending offices, 58.5% are independent doctor's offices and 41.5% pharmacies with doctor's offices.

In the same way, ENSANUT shows an increase from 38.9% in 2012 to 43.2% in 2018 in the number of people attended in private doctor's offices. However, in the broken down data from

5 Information obtained from the website of the Mexican Stock Exchange.

6 Information obtained from the website of the Mexican Stock Exchange.

7 Legal instrument that benefitted the growth of the pharmacies with doctor's offices, as in the framework of the health measures adopted in Mexico to face the AH1N1 pandemic in 2010, the sale of antibiotics without medical prescription was banned, which activated the generalized installation of doctor's offices, not just attached to pharmacies, but also managed by them (Osorio, 2019).



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2018, a reduction of consultations in pharmacies with doctor's offices is seen compared to those in independent doctor's offices, falling from 41.5% to 39.5%. This 2% reduction can be attributed to ENSANUT's sample model, as the reports of the companies running pharmacies with doctor's offices, show a sustained increase in the number of business units that came into operation between 2012-2018.

Now, considering this, there is an indicator contained in the ENSANUT that supports the increased participation of the pharmacies with doctor's offices. This is the percentage of prescriptions issued there. In 2012, pharmacies with doctor's offices reported 74.6% compared to a range of between 60-67% in public services, while in 2018, pharmacies with doctor's offices reported 81% of the prescriptions given for a range between 53-77% in public services. As can be seen, the pharmacies gained around 6% in prescriptions, leading to a corresponding increase in the total sales percentage, and although in the public case some services prescribed up to 77%, the lower limit fell considerably (6%), which demonstrates a deterioration in the provision of this service.

This expansion of the pharmacies with doctor's office segment is seen, not just in the increase of their market share, but also in the behavior of the shares of Farmacias Guadalajara and Benavides in the BMV. According to the former's annual reports, Farmacias Guadalajara has seen a 34.3% rise in their share price, from US$8.85 in 2011 to US$13.48 in 2021. This is why, in the 2018-2019 period, there has been a rise of around 2% in the number of branches, from 1,875 to 2,043. The performance of Farmacias Benavides, although it has remained constant compared to Farmacias Guadalajara (US$0.63 per share in 2011, and US$0.65 in 2021), it is noteworthy that it has not seen major falls over these 10 years. The number of branches in the latter did drop from 1,203 in 2018 to 1,174 in 2019, although the sales volume in this period increased by 2.7%. This was the result, on one hand, of a strong sales cost reduction program (Martínez, 2019), and on the other, by a greater integration to the global pharmaceutical manufacturing and distribution chains of the headquarters (Walgreens Alliance Boots).

## V. DISCUSSION

The exponential growth of pharmacies -with or without doctor's office-, that accompanies city expansion, is closely tied to the diversification of major domestic and international capital portfolios that have targeted the health system as an opportunity for appreciation through the financialization process. In this way, the colonization process by finance of the different dimensions of social life is seen both in the structuring of financial instruments, and in the issuing and placement of shares on the Mexican Stock Exchange by companies dedicated to the sale and manufacturing of pharmaceutical products.

In this way, and inasmuch as the financialization represents a deeply spatial phenomenon (French, Leyshon & Wainwright, 2011), the expansion of pharmaceutical companies' actions, can be seen in the framework of the search by financialized spatial-temporal solutions for the trends of the capitalism crisis. Alongside this, the scales and/or players like the State, the company-corporation, and the effects in daily life, stand out. However, in the relationships among said players, the production of space is the transversal axis of articulation.

State policies have built close ties between the growth of pharmacies with doctor's offices in spaces with recent urban expansion, starting from cheap dwellings with an absence of infrastructure, amenities and basic services. In Mexico, just like in different countries across Latin America, a housing production service based on granting subsidies to cover demand was installed, where the mass-scale production of cheap dwellings in urban peripheries and the fostering of private property has been privileged, a process that has generated serious social, economic, and spatial consequences (Graizbord & Acuña, 2007; Isunza, 2010a; Isunza, 2010b; Monkkonen, 2012; Monroy, 2015; Salinas, 2016).

The clear failures in federal government healthcare, have led state and local authorities to publicly argue that pharmacies with doctor's offices are a suitable mechanism to cover health demands. Under this scenario, the companies running the pharmacies with doctor's offices, owned by investment funds with interests in across Latin America, become an essential link in the chain of the neoliberal policies of healthcare commercialization.

In the municipalities where the interviews were held (Huehuetoca and Zumpango), there tend to be poor opinions about the State healthcare service: it is precisely there where the pharmacies gain sense. For example, on being asked about the medical services in her municipality, a woman living in a housing complex says:

> They are also deficient, we have nothing but pharmacies with a doctor, but these are not enough. Here people have died because they don't get seen by the doctor on time, because they can't be taken elsewhere, or because they can't get there quickly enough. They call an ambulance and it is very hard for them to get here, so yes, we have seen deaths. (Woman – 50 years old. Resident in the housing complex, Zumpango, State of Mexico).

The absence of quality medical services nearby can be seen. Location is also a factor that plays a key role. The income factor is also greatly in play in the healthcare decision:

> Just imagine, if you go to be seen in Cuautitlán (a town 10 km away), (…) go figure, if you have an emergency, where do you go? And if you have one? And if you don't? Now, for example, with a pregnant lady, who do you run to? Where do they go? Do you have the money to pay 9-10 thousand pesos to give birth, and is there a father, and if there isn't? I mean, if you get sick, there's no ER here, do you look for a doctor? There are none, not even private ones. (Woman – 42 years old, resident in the housing complex in Huehuetoca, State of Mexico).

In this way, Big Pharma investment, based on State policies that have encouraged the growth of pharmacies and the expansion of the periphery via cheap housing, has filled the space left by the State with its absence from the health sector. This is linked to localization, transportation and low income conditions, weaving a context of social precarity that is auspicious for the expansion of pharmacies with doctor's offices in the metropolitan periphery.

These elements are key for the discussion about the repercussions in urban peripheries of the financialization of the pharmaceutical industry, an issue which is actually one of the contributions of this article. Just as was reviewed in the theory section, the different projects refer to aspects like technological competence and the development of capital market financial instruments -to mention a few-, from where they derive their monopoly position. However, the empirical work allowed seeing, beyond these considerations, the role of capital accumulation, articulated with Big Pharma, in the expansion of pharmacies with doctor's offices, in a Latin American context marked by a deficient health coverage as a result of the expansion of neoliberal policies.

## VI. CONCLUSIONS

The financialization process has gained importance in recent times in urban studies, particularly those addressing the issue of housing. Now, this process has been linked to diverse economic sectors, including health services, in a context where commercialization plays a key role in the definition of a basic service as a logic of the reproduction of capital.

The financialization of the pharmaceutical industry has permitted the expansion of the pharmacy with doctor's office system. In fact, through the historic revision on the situation of Farmacias Guadalajara and Benavides, it has been possible to demonstrate that their listing on the Mexican Stock Market gave them a greater injection of capital, allowing them to open more branches. At the same time, this expansion led to them entering health services in a context of a deficient healthcare coverage by the public sector (Mejía, 2021).

Combined with this, the exponential growth seen in the last two decades, related to the social housing construction and expansion policy which, in a great extent is, the result of weak regulatory controls, does not develop a suitable health infrastructure either in qualitative or quantitative terms, which is why pharmacies with doctor's offices have positioned themselves as the option turned to most by low income population sectors. Likewise, the importance of the regional conditions stands out, which as "effects of place" (Bourdieu, 1999), operate as structural conditioning factors in the spread of pharmacies.

The theory and empirical discussion generated in recent years regarding financialization of the pharmaceutical industry (Big Pharma), fundamentally refers to capital accumulation mechanisms and their impact on developing countries. In addition, different works discuss the accumulation of intangible assets -patents and copyrights- and technological competence in transnational innovation networks, as a business model that uses speculative instruments in the capital markets. Meanwhile, the contribution of the work is given by the exploration of connections, often ignored in these works, within the expansion of pharmacies, promoted by the financing structure of pharmaceutical production and circulation, and the provision of low complexity health services – pharmacies with doctor's offices model -, which show, as has been discussed, that the transnational pharmaceutical industry does not just seek pharmaceutical production but rather progressively entering basic health systems, taking advantage of the reduction and, in some cases, absence of public health systems.

Finally, it is important to mention how, starting from the mobility of capital in the financialization process, it is Big Pharma who are taking a role in the different cities around the world, obtaining profits from dominating pharmaceutical distribution, as well as from the health services. This has been proved by two of the most important pharmacies in Mexico, Farmacias Benavides and Farmacias Guadalajara.

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FINANCIARIZACIÓN DE LA INDUSTRIA FARMACÉUTICA Y SU REPERCUSIÓN EN LAS PERIFERIAS URBANAS EN LA ZONA METROPOLITANA DEL VALLE DE MÉXICO
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# URBAN DETERMINING FACTORS OF HOUSING PRICES IN CHILE:

## A STATISTICAL EXPLORATION[1]

DETERMINANTES URBANOS DEL PRECIO DE LA VIVIENDA EN CHILE: UNA EXPLORACIÓN ESTADÍSTICA

JOSÉ FRANCISCO VERGARA-PERUCICH [2]



DETERMINANTES URBANOS DEL PRECIO DE LA VIVIENDA EN CHILE
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A partir de la implementación del Consejo Nacional de Desarrollo Urbano en Chile se ha puesto en marcha un Sistema de Indicadores y Estándares de Desarrollo Urbano. Uno de los principales problemas urbanos que enfrentan las ciudades chilenas es el aumento del precio de la vivienda. A raíz de ello, el presente estudio busca informar cómo los atributos urbanos influyen en los precios de las viviendas. Con tal fin, se catastran 2047 proyectos de vivienda para revisar cuáles indicadores de estándares de desarrollo urbano explican en mejor medida sus precios. Se aplica un análisis de componentes principales y regresiones lineales múltiples con las variables. Los resultados muestran una alta dependencia del precio sobre la autonomía financiera de las comunas e indican que la segregación residencial es incidental en cuanto a formación de valor de compra de viviendas.

**Palabras clave:** vivienda, precios, regresión, desarrollo urbano, evaluación económica

Starting from the implementation of the National Urban Development Council in Chile, an Urban Development Indicators and Standards System has been put in motion. One of the main urban problems faced by Chilean cities is the increase in housing prices. From this, the study looks to find how urban attributes influence housing prices. For this purpose, 2047 housing projects were surveyed to review which urban development standards indicators best explain their prices. An analysis of main components and multiple linear regressions are applied, together with the variables. The results show a high price dependence on the financial autonomy of the communes, and indicate that residential segregation is incidental to the formation of housing price value.

**Keywords:** housing, prices, regression, urban development, economic evaluation

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# I. INTRODUCTION

Housing prices in Chile are putting great pressure on household incomes (Vergara-Perucich & Boano, 2018). In 2019, the Chilean Chamber of Construction presented evidence to indicate that housing is becoming an unattainable asset for families (CNN Chile, May 10th, 2019). The lack of public housing provision systems, the increased role of financial entities in the real estate world, and the absence of price regulation systems, have allowed these values to exceed the payment capacity of an important part of households, generating a structural deficit that between 1998 and 2017 increased by 0.12%, despite that 498,444,111 UF being injected in the same period (Ministry of Housing and Urbanism [MINVU], 2021). Different approaches have presented findings about the way certain urban attributes explain part of house pricing. Cortés and Iturra (2019) state that facilities provided by the State tend to reduce the housing price, while those provided by the market tend to increase them. Encinas, Marmolejo-Duarte, Wagemann and Aguirre (2019) suggest meanwhile, that qualities related to sustainability are less relevant for consumers than the housing price, while the monopoly condition of the location allows explaining a large part of the sale price (Encinas, Aguirre, Truffelo & Hidalgo-Dattwyler, 2019). The commercial housing price in Chile is a critical aspect for households, but this is an issue that is lacking study. Specifically, this article explores housing prices considering the Urban Development and Standards Indicators System of the National Urban Development Council (SIEDU, in Spanish). Different studies have analyzed the makeup of Chilean house pricing using its built elements (Figueroa & Lever, 1992), typological qualities (Sagner, 2009), economic potential of the attributes (Iturra & Paredes, 2014; Quiroha, 2013), interest rates (Parrado, Cox & Fuenzalida, 2009), or the construction prices index (Silva & Vio, 2015). However, these works did not have access to the recently launched SIEDU, unlike what is expressed here, which mainly uses urbanistic elements. The findings of this research seek to complement previous approaches, privileging essential indicators for urban studies.

The purpose of this article lies in reporting the fundamental drivers of housing prices in Chile, starting from the urbanistic aspects reflected in the indicators for the 90 chosen communes. For this, 2047 new dwellings were recorded in Chilean cities with projects for sale in 2021. Complementarily, SIEDU indicators, which have data of the communes revised, were used to generate three approaches: a summary of variables with analysis of the main components, generated 11 synthetic components; a multiple linear regression to see which of the 11 components best explains the housing price; and a second regression with the 37 original variables. The results indicate that financial self-sufficiency of communes, residential segregation, and deficit are predominant factors that push the housing price up. These data can contribute to econometric studies that work with hedonic prices to theorize the fundamentals of each preparation, apart from giving information to other types of studies that explore the makeup of the new housing price in Chile.

# II. THEORETICAL FRAMEWORK

One of the most addressed topics in urban economics is the pricing of the property market. There are different approaches with different, though convergent, methodological emphasis (Evans, 1985). One of the precursors was Johann von Thünen, who set out the guidelines to understand the importance of location to define the value of a property (García Ramón, 1976), assumptions that would later be applied in the city and its centralities by William Alonso in ***Bid Rent Theory*** in 1964. These initial assumptions indicated that housing prices depend on demographic factors, like the purchasing power of the households (Taltavull, 2003). From a view that focuses on urbanistic factors, Berry and Garrison (1958) state that the attributes of each neighborhood contribute towards defining the value of properties. In a large part of the specialized literature, there is consensus about the link between housing price, location, and urban attributes (Fujita, Krugman & Venables, 1999).

Econometrics have allowed understanding the relationship between the produced space and the commercial value of the city. Said relationship can be virtuous when it influences developers to seek optimal urban designs. This was one of the contributions of Case and Shiller (1990), who demonstrated the spatial self-correlation between housing prices and urban qualities, linking the attributes of the housing with those of the neighborhood. The study of housing prices is nourished by the theory of consumption and the economics of behavior, starting from the contributions of Michael Ball (1973), who explains these values through "fundamental" traits, i.e., the attributes of each dwelling that determine their sale value. Later, Allen Goodman (1978) -inspired by the ideas of Sherwin Rosen (1974)- prepared a hedonic housing price index, demonstrating how the qualities of the neighborhoods explain a good part of the prices. Currently, this is the most used commonly method to explain housing prices (Sheppard, 1999; Yavuz Ozalp & Akinci, 2017). It is worth adding that Ball (1973) emphasizes the importance of generating broad statistical guidelines to carry out this type of studies, with

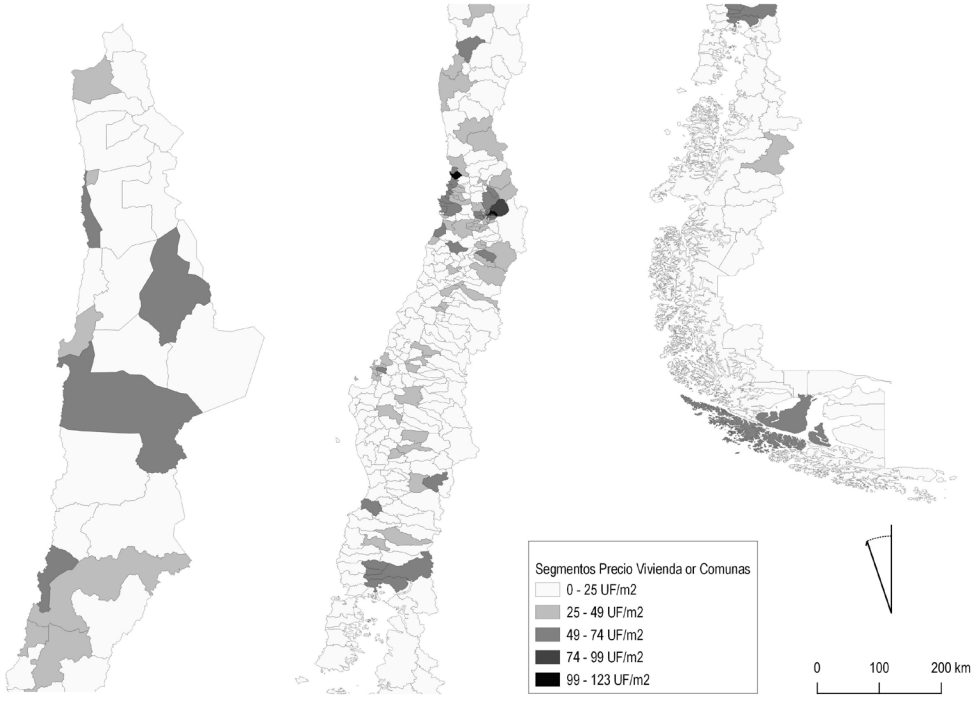


Figure 1. Price of new housing for Chilean communes, listed in UF/m2. Source: Preparation by the Author.

a sample representation that is statistically suitable for the tests, so that the conclusions generated are actually relevant in an issue as sensitive as housing.

In Chile, Figueroa and Lever (1992) propose as fundamental attributes in Santiago house pricing, the land surface, the presence of services and the socioeconomic level of the neighborhood, as well as the construction density. In 2009, Sagner identified the age of the dwelling and its surface area, as essential variables. Meanwhile, Paredes and Iturra (2014) say that this is about rental price, the number of bedrooms and bathrooms, the global housing quality index, the square meters, as well as the school level, age and gender of the dwelling's inhabitants (Iturra & Paredes, 2014). According to Quiroga (2013), there are less hierarchical variables of the dwelling, like the number of bathrooms or owners that live in their own home, which affect the price of a neighborhood. For Parrado et al (2009), the interest rates and the increased income of households are key, along with a good balance between supply and demand of housing units. In this same vein, Silva and Vio (2015) highlight the influence of macroeconomic variables like available rent, interest rates, and construction costs in the housing price.

The expectation of the future housing price is a vector for pricing, despite the fact that this phenomenon could leave room for future property bubbles if there are no suitable regulations in place (Cohen, Ioannides & Wirathip Thanapisitikul, 2016; Cohen & Zabel, 2020). Financial players have been taking a leading role in the land market, which may generate a problem of accessibility to housing (Gasic, 2018), since land value is a driver given their monopolistic condition (Encinas, Aguirre et al., 2019). The role of the subsidiary State in injecting resources to the property market more than participating in the system as a housing production player is added to this (Hidalgo, Dattwyler, Paulsen Bilbao & Santana Rivas, 2016; Razmilic, 2010).

The relationship between housing prices and urban variables, like those of the SIEDU, has not yet been explored. This becomes relevant when factors are added to housing pricing from urbanistic aspects, which is key to foresee how urban improvements with public funds increase prices, without capturing the gains (Vergara-Perucich & Aguirre-Núñez, 2020). Understanding housing pricing is, in fact, essential. Facing inequality of negotiation in free market economies, property prices



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| | | |
|---|---|---|
| Distance to public squares | Average important intersections every 1.44 km2 | Percentage of homes with family crowding situation |
| Public square surface area per inhabitant that complies with the distance standard (400 meters) | Number of casualties in traffic accidents per 100,000 inhabitants | Percentage of population in situation of poverty (income poverty -Ministry of Social Development (MDS)) |
| Distance to public Parks | Number of people injured in traffic accidents per 100,000 inhabitants | Percentage of population in situation of poverty (multidimensional poverty - MDS). |
| Percentage of population attended by public square system | Amount (kg) of final urban solid waste disposal per capita | Advanced human capital segregation index |
| Percentage of population attended by public parks system | Residential electricity consumption per capita | Number of crimes reported in the public space per 100 inhabitants |
| Public green areas surface per inhabitant | Non-residential electricity consumption per capita | Percentage of non-built surface area (barren sites) in urban areas |
| Distance to primary healthcare centers | Rate of fixed internet residential connections per 1,000 private homes | Difference between highest and lowest land value, in homogeneous (urban) areas defined by the Internal Revenue Service |
| Number of full shifts of primary healthcare physicians per 10,000 inhabitants | Unavailability of electricity supply – Annual SAIDI indicator | Percentage of domestic investment at a communal scale where the council takes part as contracting institution |
| Distance to primary education establishments | Percentage of blocks with paving in good condition | Updated communal regulatory plan |
| Ratio between effective availability of openings and potential demand for primary education. | Percentage of private homes that require improvements of materials and/or utilities | Participation of Municipal Common Fund (FCM, in Spanish) in the total municipal revenue (discounting transfers) |
| Distance to preschool education establishments | Requirement of new urban housing | Communal Regulatory Plan (PRC) acknowledges historic conservation properties and/or areas |
| At least 8 blocks from public transportation | Percentage of dwellings in an overcrowding situation | Percentage of participation in municipal elections, by commune |
| Percentage of public investment destined to projects that have heritage property restoration intervention processes over the total investment destined to projects with favorable recommendation | | |

Table 1. SIEDU indicators used for the study. Source: Preparation by the author based on CNDU (2020).



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will depend greatly on the class leadership financial players with great purchasing power transferred to property equity take, which will even be accepted by the market as a symptom of profitability, although it reduces access to houses for households with limited purchasing power (Harvey, 1985). An excellent way to identify speculation in the housing market is by measuring the distance between price and fundamental attributes (Coskun & Jadevicius, 2017; Dreger & Zhang, 2013; Gil-Alana, Dettoni, Costamagna & Valenzuela, 2019). With Chile being in a housing access crisis (CNN Chile, May 10th, 2019), acknowledging how separated its housing price is from its essential variables, requires identifying the factors that determine that relationship.

## III. CASE STUDY

The research focused on 90 communes where the average prices of new housing was recorded, for houses and apartments. The data was collected from the websites, TOCTOC.com, Portalinmobiliario.com and Pabellon.cl, between December 2020 and January 2021. 2047 offers were listed: 554 houses and 1493 apartments. The average

new housing price at a national level was 48.4 UF/m$^2$. The values at a communal level are summarized in Figure 1.

## IV. METHODOLOGY

To evaluate the urban drivers of housing prices, work has been done using the Urban Development Standards and Indicators System, SIEDU. These indicators emerge from an agreement between the National Urban Development Council (CNDU, in Spanish), the Ministry of Housing and Urbanism (MINVU, in Spanish) and the National Statistics Institute, to measure urban quality of life to reduce inequalities, as well as to monitor the effectiveness of urban and housing policies (Spatial Data Infrastructure [IDE], 2021).

SIEDU considers 76 indicators for 117 communes with more than 50,000 inhabitants (CNDU, 2020), but not all the communes register data for the 76 indicators, so the number of indicators being analyzed had to be reduced, to allow a higher number of communes to enter the study. As some communes did not have projects, the decision was made to work with the 90 that did allow completing the sample of the 37 indicators. Despite the reduction, the sample continues to be varied and offers richness for the analysis, which could be compared in the future with new studies, similar to that presented in this article, but that use updated versions for all communes and all the variables of the SIEDU. It was later determined to recalculate the "Segregation index of vulnerable population" indicator with census data, applying a dissimilarity index. SIEDU did not have complete information on public transportation, so the CASEN 2017 survey was used, through which the proportion of homes at least 8 blocks from bus stops was identified. Ultimately, the indicators used in the end, are shown in Table 1.

Once this is defined, the principal component analysis technique (PCA) was applied as well as multiple linear regression. PCA is a study of the variables, whose purpose is to verify which of these have least correlation, breaking down self-values into matrices (Lalloué et al., 2013). The resulting factors generate new groups of variables, reducing the sample size, to thus facilitate the regression study (Addendum 3). A multiple linear regression was made with the main components (Cai & Liu, 2015; Rebelo, 2009), testing the influence that components have on the average housing price by commune, using the following formula:

$$Y = (\beta_0 + \beta_1 X_{1i} + \beta_2 X_{1i} + \cdots + \beta_n X_{ni}) + e_i \qquad (1)$$

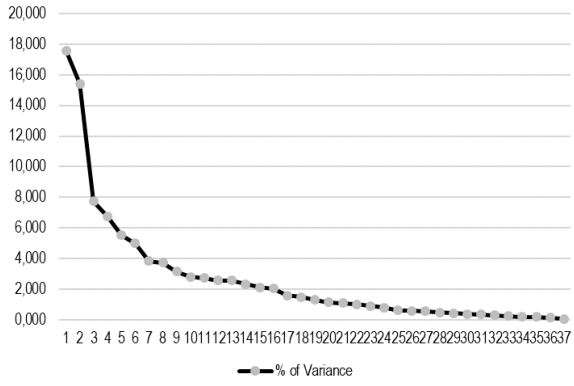


Figure 2. Variance percentage explained for each resulting component. Source: Preparation by the Author.

Where,
$\beta_0$: the value of variable Y when all predictors are 0
$\beta_i$: the weighted effect of the increase of a unit of variable Xi over variable Y
$e_i$: residual between the observed and estimated value of the model.

## V. RESULTS

The application of PCA generates 11 components that summarize 71.6% of the variables analyzed, which are represented in Figure 2. The Kaiser-Meyer-Olkin test on the sample is 0.67, which indicates a suitable composition.

Starting from these components (Table 2), a multiple linear regression is made (Table 3), that generates 10 different models, where the model with the best fit integrates 10 components and explains 76% of the variations of the new housing price. The most relevant component is the condition of self-sufficient commune -FAC4-: communes with maintained green areas; with educational establishments; and low dependence on the municipal common fund; with low number of people in situation of multidimensional poverty. This is an original finding for the Chilean case. The following component that is highlighted, is the socioeconomic homogeneity of low incomes -FAC3.- related to the reduction of the housing price, against the high socioeconomic homogeneity -FAC1-, associated to the increase of value. This indicates that segregation does have an impact on the housing price, result that



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| | |
|---|---|
| FAC1: High socioeconomic homogeneity of the neighborhood | Concentrates socioeconomic homogeneity indicators for high income classes |
| FAC2: Significant motorized private vehicle transit | Communes that have suburban areas and where the roads and vehicle transit is relevant |
| FAC3: Low socioeconomic homogeneity of the neighborhood | Concentrates socioeconomic homogeneity indicators for low income classes |
| FAC4: Self-sufficient communes | Communes with good municipal budget, homes with technology and with good access to public property |
| FAC5: Suitable public spaces | Good distribution of public properties and services |
| FAC6: Urban periphery border | Made up of spaces with barren sites within urbanizations, low access to electricity supply, segregation, and presence of precarious dwellings |
| FAC7: Urban governance | Communes with updated regional planning tools |
| FAC8: Public safety | High numbers of crime reports |
| FAC9: Heritage neighborhoods | Heritage management in central areas |
| FAC10: Zones under urban renewal | Heterogenous land value without historic property and with a social mix |
| FAC11: Moderate density | High housing demand, high production of solid waste, with family crowding and overcrowding situation |

Table 2. Main components of the study. Source: Preparation by the Author.

| Model and Components | | Non-standardized coefficients | | Typified coefficients | t | Sig. (<0.05)) | Collinearity | | R | R2 | R2 adjusted |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | B | Standard error | Beta | | | Tolerance | VIF | | | |
| 10 | (Constant) | 50,333 | 0,877 | - | 57,391 | 0,000 | | | 0,889j | 0,790 | 0,763 |
| | FAC4_1_Self-sufficient communes | 9,857 | 0,882 | 0,577 | 11,177 | 0,000 | 1,000 | 1,000 | | | |
| | FAC3_1_Low socio-economic homogeneity of the neighborhood | -7,222 | 0,882 | -0,423 | -8,189 | 0,000 | 1,000 | 1,000 | | | |
| | FAC1_1_High socioeconomic homogeneity of the neighborhood | 4,817 | 0,882 | 0,282 | 5,462 | 0,000 | 1,000 | 1,000 | | | |
| | FAC8_1_Public safety | 3,888 | 0,882 | 0,228 | 4,409 | 0,000 | 1,000 | 1,000 | | | |
| | FAC5_1_Availability of quality public spaces | 3,493 | 0,882 | 0,204 | 3,960 | 0,000 | 1,000 | 1,000 | | | |
| | FAC2_1_Significant motorized private vehicle transit | -3,174 | 0,882 | -0,186 | -3,599 | 0,001 | 1,000 | 1,000 | | | |
| | FAC6_1_Urban periphery border | -2,767 | 0,882 | -0,162 | -3,138 | 0,002 | 1,000 | 1,000 | | | |
| | FAC11_1_Shortage of affordable housing | 2,306 | 0,882 | 0,135 | 2,614 | 0,011 | 1,000 | 1,000 | | | |
| | FAC7_1_Urban governance | 2,020 | 0,882 | 0,118 | 2,290 | 0,025 | 1,000 | 1,000 | | | |
| | FAC9_1_Heritage neighborhoods | -1,898 | 0,882 | -0,111 | -2,152 | 0,034 | 1,000 | 1,000 | | | |

Table 3. Multiple linear regression results for model 10. Source: Preparation by the Author.



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| Model | Non-standardized coefficients | | Typified coefficients | t | Sig. (<0.05)) | Collinearity | | R | R2 | R2 adjusted |
|---|---|---|---|---|---|---|---|---|---|---|
| | B | Standard error | Beta | | | Tolerance | VIF | | | |
| (Constant) | 18,377 | 6,262 | | 2,934 | 0,004 | | | 0,919 | 0,920 | 0,834 |
| Residential electricity consumption per capita | 0,055 | 0,006 | 0,684 | 9,948 | 0,000 | 0,395 | 2,529 | | | |
| Average important intersections every 1.44 km2 | 0,132 | 0,041 | 0,193 | 3,253 | 0,002 | 0,531 | 1,883 | | | |
| Participation of the Municipal Common Fund (FCM) in the total municipal revenue (discounting transfers) | -0,133 | 0,055 | -0,155 | -2,400 | 0,019 | 0,451 | 2,219 | | | |
| Surface area of public squares per inhabitant that complies with distance standard (400 meters) | -0,885 | 0,321 | -0,162 | -2,760 | 0,007 | 0,540 | 1,851 | | | |
| Requirement of new urban housing | 0,001 | 0,000 | 0,156 | 2,992 | 0,004 | 0,692 | 1,446 | | | |
| Ratio between effective availability of openings and potential demand for primary education | -10,671 | 3,644 | -0,138 | -2,929 | 0,004 | 0,847 | 1,180 | | | |

Table 4. Sounder regression model. Source: Preparation by the Author.

| Regression Variables | B | Average | La Pintana | i. La Pintana with more public square surface area | ii. La Pintana with less dependence on the Municipal Common Fund | iii. La Pintana with more housing demand |
|---|---|---|---|---|---|---|
| (Constant) | 18,377 | 47,68 | 36,96 | 35,91 | 42,23 | 41,60 |
| Residential electricity consumption per capita | 0,055 | 751,000 | 567,02 | 567,02 | 567,02 | 567,02 |
| Average number of important intersections every 1.44 km$^2$ | 0,132 | 30,000 | 33,38 | 33,38 | 33,38 | 33,38 |
| Participation of the Municipal Common Fund (FCM) in the total municipal revenue (discounting transfers) | -0,133 | 39,17 | 79,48 | 79,48 | 39,74 | 79,48 |
| Public square surface area per inhabitant that complies with the distance standard (400 meters) | -0,885 | 4,86 | 2,81 | 4 | 2,81 | 2,81 |
| Requirement of new urban housing | 0,001 | 2459 | 4680 | 4680 | 4680 | 9360 |
| Razón entre disponibilidad efectiva de matrículas y demanda potencial por educación básica | -10,671 | 0,85 | 0,82 | 0,82 | 0,82 | 0,82 |

Table 5. Three urbanistic change hypotheses in La Pintana that would alter housing price. Source: Preparation by the Author.



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dialogs with the previous findings of Figueroa and Lever (1992), and with those of Sagner (2009). Another factor is the lack of affordable dwellings -FAC8-, from which an increase of value in those consolidated neighborhoods, with good quality public spaces -FAC5-, can be inferred. It is important to observe this result in light of the subsidiary logic of the State, as has already been said by Hidalgo Dattwyler et al. (2016) and by Razmilic (2010). Housing prices are linked to the reduction before dominant vehicle transit – FAC2-, periphery location -FAC6- and, to a lesser extent, to the presence of heritage neighborhoods -FAC9-. Finally, other elements linked to the price increase are the moderate density -FAC11- and a good system of urban governance -FAC7- with updated tools and public investment.

Complementarily, a multiple linear regression is made with the 37 SIEDU indicators. In this model (Table 4), the variables explain 83.4% of the price variance, although in this case, some of them are at the collinearity tolerance limit, i.e., the explicative arguments could repeat. Among the variables related to price increase, are the residential electricity consumption, the important road intersections for every 1.44 km$^2$, and the new housing demand in the commune. On the other hand, factors associated to reducing housing price, are the budgetary dependance on the Municipal Common Fund, the surface of public squares at 400 meters, and the availability of openings for primary education.

Finally, taking the commune of La Pintana as an example, starting from the model, a housing price of 36.9 UF/m$^2$ is projected, only 6% different from the market value. Using the regression formula, three hypotheses expressed in Table 5 are proposed.

In the first hypothesis (i), if La Pintana doubles public square areas, the housing price is reduced by 7%. To explain this counterintuitive result, it can be stated that the presence of public squares does not necessarily guarantee their upkeep by municipalities and that, as a result, the drop in price expressed is a reflection of the deterioration of the public space. In the second hypothesis (ii), if La Pintana reduces its dependence on the Municipal Common Fund by half, the housing price increases by 14%, which is the effect of the municipality's financial autonomy, as indicated in the regressions results. In the last hypothesis (iii), if the housing demand is doubled, the price increases by 13%, which is explained by the supply and demand dynamic (Nordhaus & Samuelson, 2006). It is worth mentioning that news on an extension of the Metro to La Pintana, would be accompanied by an increase in housing requirements, so it would be key to check whether the inhabitants of this commune could afford to stay there.

## VI. DISCUSSIONS

The results presented provide novel elements to progress in the understanding of the definition of housing prices, as well as the financial capacity of communes and their independence from the Municipal Common Fund. To illustrate this characteristic, it is necessary to mention that the communes with the highest values in FAC4 are Santo Domingo, Providencia, Santiago, Casablanca and Vitacura: wealthy municipalities that mark an increase in the values, starting from which, socioeconomic exclusion is generated. Likewise, it must be underlined that the housing price has a clear relationship with the socioeconomic homogeneity of the commune, a situation that reveals the importance of generating inclusive affordable housing mechanisms to break segregation. This is just as has been shown in other studies that have sought to explain this phenomenon from other approaches (Hidalgo Dattwyler et al., 2016).

In general, neighborhoods with easy access to goods and services, which are peri-central, socioeconomically homogeneous, pedestrian friendly, and in a resident renewal process, seem to be linked to an increase in housing prices. While spaces with a predominance of roads on the urban borders, or in abandoned centralities, are left linked to the reduction of said price. This ratifies an observation made by Encinas, Aguirre et al. (2019): the monopolistic condition of the land is key in the definition of housing prices. Based on these results, it is possible to detail the most profitable attributes of those locations, that are features from which capital gains could be a regional equality alternative to be explored (Vergara-Perucich & Aguirre-Núñez, 2020).

On the second regression, the statements of Cortes and Iturra (2019) on that the services provided by the State negatively affect housing prices compared to those provided by the market, match the results of this analysis, although this is not the same for all types of State services. It can be inferred that specific public services are linked to a lower housing price, which can refer to uses where the market has a lesser role, such as public schools or squares. However, there are more desirable public services, such as road quality and electricity.


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SIEDU must complete its variables with financialization and subsidiarity measures if it seeks that the diagnoses point to an inclusive and integrated city. In the theoretical framework presented here, it was indicated that previous studies considering macroeconomic data are fundamental to explain the housing price (Parrado et al., 2009; Silva & Vio, 2015). These aspects have a difficult material representation, but not because of this are they less urbanistic. On this point, the study has not been able to revise whether the financial entities with land ownership put pressure on housing prices, or if the presence of projects with subsidies reduces them. It is recommended to include in SIEDU, the outstanding payment rate, the local mortgage interest rate, the number of dwellings acquired with financial instruments, the local or regional CPI, and the concentration of ownership in people who do not live in the area, to monitor potential financial crises starting from urban processes (Gil-Alana et al., 2019). Likewise, it is necessary to include health and mortality factors from the Ministry of Health. The latter, is part of the lessons that the pandemic leaves behind: health problems are territorial (Mena et al., 2021; Vergara-Perucich, Correa-Parra & Aguirre-Núñez, 2020).

## VII. CONCLUSIONS

Chilean housing prices have been addressed from urban economics, but few studies have done so from urbanism. Nor has this been addressed in architecture schools. The price in housing design and planning must not be outside the knowledge of those working in the profession, even more so in cities segmented by purchasing power. Understanding how housing prices are determined, allows knowing how to add value to the habitat, considering that economic factors segregate the population. This work seeks in this context, to contribute with an urbanistic view focusing on linking the city with household budgets.

As main findings, self-sufficient communes, regarding the set of variables behind housing prices, indicate that a commune with resources is also a commune that tends to concentrate a high property value. On the contrary, the high motorization of neighborhoods tends to explain part of a lower housing price. It is confirmed that neighborhoods with low socioeconomic levels tend to have a lower housing price. On the other hand, it is interesting to see that electricity consumption is associated to a higher housing price, which can reveal greater access to technology or to neighborhoods with lower fuel use in daily life. Likewise, it is interesting how factors like the presence of public squares or communes where the educational offer does not cover the demand, i.e., there are more students per classroom, would explain a lower housing price. These findings allow dialoging with another kind of research that explores both the SIEDU, and the drivers of urban life quality in Chilean communes.

It is important to highlight that this is an exploratory study on existing variables that do not necessarily determine causality, but rather review whether the relationships between the SIEDU indicators and the housing price are consistent when it comes to providing useful reflections for urban economy studies, which they do. In this way, this work takes advantage of the SIEDU to take part in a key discussion on the affordable housing crisis, from an urbanistic approach, which rarely goes into the field of prices as a study problem.

Although the regressions results are conclusive, it is key to remember that housing prices can have multiple factors behind them, like the internal attributes, interest rates, or demographic, environmental or health variables. Possibly, many of these factors offer other explanations and, an inter-sectorial research would provide valuable findings. A qualitative research of the spatial characteristics of those communes with better explicative attributes of housing prices would also be valuable to review how this situation is represented in the built environment.

Just as was mentioned at the beginning, purchasing power and monopolistic land conditions have been relevant for the results presented here, but to understand how this affects the housing price, the recent contribution of SIEDU has been fundamental. This system of indicators must be complemented at some point with new data, where similar research to that presented here will provide new interpretations that complement these results.

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# SPATIAL AND ASPATIAL INDICATORS:

## A COMPLEMENTARY APPROACH TO THE QUANTITATIVE ANALYSIS OF RESIDENTIAL SEGREGATION IN MANAGUA[1]

INDICADORES ESPACIALES Y NO ESPACIALES: UN ENFOQUE COMPLEMENTARIO PARA EL ANÁLISIS CUANTITATIVO DE LA SEGREGACIÓN RESIDENCIAL EN LA CIUDAD DE MANAGUA

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El polimorfismo de su concepto y la complejidad de sus múltiples dimensiones espaciales, hacen de la medición de la segregación un tema desafiante. A través de los años se han desarrollado enfoques metodológicos que han producido diversos indicadores para cuantificar el fenómeno. Por un lado, se hallan los indicadores tradicionales, criticados por las fallas que se les aducen, entre las que destaca su incapacidad para revelar la forma en que se distribuye espacialmente el fenómeno. Y, por otro lado, se encuentran los indicadores espaciales, creados a partir del desarrollo de la estadística espacial y la disponibilidad de softwares de Sistemas de Información Geográfica (SIG), a los cuales se les adjudica superioridad conceptual y operacional. Esto ha empujado a algunos investigadores latinoamericanos a proponer el abandono del uso de los indicadores tradicionales y recurrir exclusivamente a los indicadores considerados espaciales. No obstante, a través de este artículo se muestra cómo, desde un enfoque complementario, los indicadores espaciales y no espaciales pueden articularse para revelar las distintas dimensiones espaciales de la segregación residencial, y así disminuir las arbitrariedades en su medición, representación e interpretación, a la vez que se atiende la limitada disponibilidad de datos espaciales individuales que caracteriza a Latinoamérica. Los resultados del estudio de la segregación residencial socioeconómica de la ciudad de Managua, a través del Índice de Disimilitud y el Índice de Moran Global, exhiben que Managua se caracteriza por una segregación a pequeña escala y que el grupo más segregado, en términos de concentración y agrupamiento, es la población con estudios universitarios completos. Asimismo, demuestran que, si bien los indicadores espaciales buscan capturar la naturaleza inherentemente geográfica de la segregación residencial, su exclusiva utilización falla en atender la multidimensionalidad espacial del fenómeno y puede conducir a vacíos en su cuantificación.

**Palabras clave:** análisis espacial, segregación social, inequidad urbana, asimilación espacial, estadística y datos numéricos




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The polymorphism of its concept, as well as the complexity of its multiple spatial dimensions, make the measurement of segregation a challenging subject. Which is why, over the years, methodological approaches have been developed, which have produced different indicators to quantify the phenomenon. On the one hand, there are the traditional indicators, which have been criticized for the flaws attributed to them, among which their inability to reveal the way in which the phenomenon is spatially distributed stands out. On the other hand, there are spatial indicators, created from the development of spatial statistics and the availability of Geographic Information System (GIS) software, which are believed to be conceptually and operationally superior. This has led some Latin American researchers to propose abandoning the use of traditional indicators altogether, and to exclusively use the indicators considered as spatial. However, this article shows how, from a complementary approach, spatial and aspatial indicators can be articulated to reveal the different spatial dimensions of residential segregation, and thus reduce arbitrariness in their measurement, representation, and interpretation. While, at the same time, it addresses the limited availability of individual spatial data that characterizes Latin America. The results of the study of socioeconomic residential segregation in Managua, through the Dissimilarity Index and the Global Moran´s Index, show that the city exhibits small-scale segregation, and that the most segregated group in terms of concentration and grouping is the population with a college degree. It also reveals that although spatial indicators seek to capture the inherently geographical nature of residential segregation, their exclusive use fails to address the spatial multidimensionality of the phenomenon and can lead to gaps in its quantification.

**Keywords:** spatial analysis, social segregation, urban inequality, spatial assimilation, statistics and numerical data

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# I. INTRODUCTION

In recent years, Latin America has seen a growing interest about conceptual and methodological issues related to the quantification of residential segregation. One of the most controversial statements has been the proposal to abandon the use of aspatial indicators because of their multiple flaws, and replace them with spatial indicators, given their estimated conceptual and operational superiority when it comes to measuring the phenomenon and its spatial patterns (Garrocho & Campos-Alanis, 2013). However, there have also been discussions about the urgency to introduce policy changes to manage census data in order to improve the quality of the studies in this and other fields, through instrumentation of a variety of simultaneous and non-exclusive solutions (Rodríguez, 2013); along with the need to address discrepancies that tend to appear in the analysis of the residential segregation dimensions, through complementary analytical approaches (Dominguez, 2017).

As a consequence, the purpose of this article is showing how spatial and aspatial indicators, from a complementary approach, can be articulated to reveal the different spatial dimensions of residential segregation, and thus reduce arbitrariness in the measurement, representation, and interpretation of the phenomenon, while addressing the Latin American reality regarding the management of individual spatial data and their limited availability.

For this purpose, the first step is to approach the challenges that the conceptualization and quantification of residential segregation present, and briefly introduce the city of Managua as a case study. Later, a methodological route is outlined which: i) uses information collected in the VIII Population and IV Housing Census of 2005; ii) considers the education variable broken down into two antagonistic social groups -illiterate population and population with completed tertiary education- as a single proxy variable of socioeconomic segmentation; and iii) proposes the use of two indicators -Global Moran's Index and Dissimilarity Index-, one spatial and another aspatial, to respectively study grouping and dissimilarity dimensions. In a third section, the results of the study are presented, which evidence that aspatial and spatial indicators reveal different results, as they show the different residential segregation spatial dimensions. However, they can be articulated to make progress towards a better understanding of the phenomenon. These results also allow detecting that this approach, due to its complementary nature, opens up the possibility not just to consider all residential segregation dimensions, but also to use the different available techniques and strategies, beyond those presented here. Finally, the main conclusions and bibliographical references of the literature consulted are presented.

# II. THEORETICAL FRAMEWORK

It is sufficient just to note the broad distribution of the term "segregation" in the political, media and scientific discourse, to show its polysemy and ambiguity, as well as the difficulties there are for its use and measurement (Link, Valenzuela & Fuentes, 2015; Madoré, 2005). Because of this, it is important to distinguish different but complementary ways that are used to approach the concept of segregation, among which the following stand out: i) those that refer to differences within a collective, and the separation of the subjects into categories with a certain degree of hierarchical distinction (Rodríguez, 2001, p. 14); ii) those which refer to a spatial relationship or regional separation or proximity among people belonging to a same social group (Sabatini & Sierralta, 2006, p. 4); and iii) those which associate the phenomenon with a high social homogeneity and spatial concentration, that lead to the isolation of a group and that, according to Marcuse -as was cited in Sabatini & Rasse (2017)-, always imply some degree of imposition.

The aforementioned notions allude to an approximation to the phenomenon that addresses it in spatial, descriptive, and quantitative terms, to study the five spatial dimensions identified by Massey and Denton (1988): dissimilarity, exposure, concentration, centralization, and grouping. This work addresses two of them. From this approach, researchers from different parts of the world have made progress in the design of quantification methodologies, knowledge about the levels, trends, and determination of the phenomenon's spatial patterns.

In this context, the traditional or aspatial measurements -Dissimilarity Index, Isolation Index, among others- used over the last two decades to quantify segregation, have been criticized on having a "simplifying" nature, and on ignoring the way the phenomenon is spatially distributed (Yao, Wong, Bailey & Minton, 2019). However, as of the 1990s, the development of spatial statistics, and the availability of GIS software, allowed using spatial segregation indicators -Global Moran's Index and Local Moran's Index-, as an alternative to the acknowledged limitations. In the United States, researchers like Brown and Chung (2006) and Reardon et al. (2008) have made the call to focus attention towards segregation measurements that are space and scale sensitive -Spatial Information Theory Index and Spatial Segregation Profile-, although these have not been widely used, especially in Latin America, where public access to microdata is limited.

It is actually in Latin America where a growing interest about the conceptual and methodological problems of residential segregation quantification has been seen. One of the approaches that has been the most controversial, proposes abandoning the use of aspatial indicators due to their flaws, and replacing them with spatial indicators, given their estimated conceptual and operational superiority

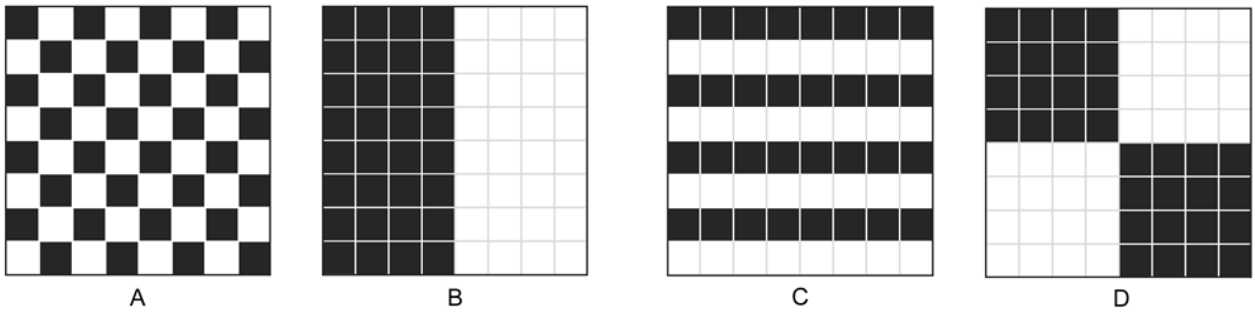


Figure 1. The chessboard problem. Source: Adapted from Garrocho & Campos-Alanis (2013, p. 276).

(Garrocho & Campos-Alanis, 2013). In addition, the urgency to introduce changes in census data management has been outlined, to improve the quality of the studies in this field, using the instrumentation of simultaneous and non-exclusive solutions (Rodríguez, 2013), and it has been proposed to address the discrepancies arising from the analysis of the residential segregation dimensions through complementarity focused analytical approaches (Domínguez, 2017; Linares, Velázquez, Mikkelsen & Celemin, 2016).

What is mentioned by Garrocho and Campos-Alanis (2013) and Ruiz-Tagle and López (2014) is interesting insomuch as they question the validity of approaches that are key in the debate, regarding the degree, the trends, and the pattern of Latin American segregation, whose base is the studies of Sabatini, Cáceres and Cerda (2001) for the main Chilean cities, which have echoed across the entire region. In particular, the former state that these approaches could be based on a measurement error associated to the use of aspatial indicators, and that the use of spatial indices would lead to different results.

It must be mentioned that, despite its limitations, and on there being other aspatial indicators, the Dissimilarity Index (DI) has become the main statistical measurement to quantify residential segregation. The first limitation is known as the "chessboard problem". Garrocho and Campos-Alanis (2013) exemplify it through a board where the squares represent spatial units as neighborhoods of a city, into which two population groups are distributed. On calculating the segregation indices using the classic board pattern (Figure 1, element A), certain results would be obtained. If the classic pattern were altered, moving all the black squares towards the middle of the board (Figure 1, element B), it would be expected to obtain different results that showed this new spatial distribution. However, on this being an aspatial indicator, it always generates the same results, without managing to distinguish between

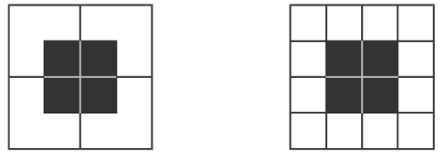


Figure 2. The modifiable areal unit problem. Source: Preparation by the Authors.

the classic pattern and any other spatial pattern (Figure 1, elements C and D) that may be formed (Garrocho & Campos-Alanis, 2013, p. 275-276).

The second limitation is known as the "modifiable areal unit problem" (MAUP). This was identified by White (1983), and consists of a variation of the DI, when the measurement area is modified. That is to say, that the smaller the measurement area is, the higher the index value. This problem is made evident in Figure 2: the spatial crowding of the homes represented by the black squares is strong at a microspatial level (Figure 2, element B), and weak if analyzed at a more aggregated level (Figure 2, element A). In this regard, Rodríguez (2013) indicates that the MAUP arises from the way census information is collected and published in spatial units whose limits are often non-existent in daily life.

Because of this, Garrocho and Campos-Alanis propose abandoning aspatial indicators and the absolute use of those they call genuinely spatial segregation indicators, like the Global Moran's Index (GMI), and the Local Moran's Index (LMI), which according to Ruiz-Tagle and López (2014), have shown "more reasonable results regarding the lack of spatiality of traditional indices" (p.34). Now, this proposal is

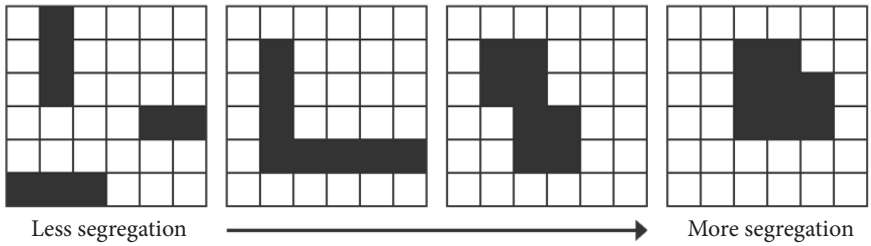


Figure 3. Segregation by grouping indices. Source: Ruiz-Tagle & López (2014, p. 34).

Figure 4. View of Managua from the Northern-Central Area. Source: Photograph by Álvaro Solis.

Figure 5. View of Xolotlán Lake from the Northern-Central Area of Managua. Source: Photograph by Álvaro Solis.



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subject to three aspects: i) it omits that spatial indicators solely measure grouping (Figure 3); ii) it disregards that the capacity to quantify residential segregation is limited by existing aggregation units in the censuses (Rodrígez, 2013; Molinatti, 2021), which are also commonly used when working with spatial indicators; and iii) it ignores that segregation measures have been developed for the last two decades, which are sensitive to space and scale, whose use in Latin America would imply enabling public access to microdata.

On facing this scenario, and as is shown in the following section, this article suggests a way of working that seeks to show how, from a complementary approach, spatial and aspatial indicators can be articulated to reveal the different spatial dimensions of residential segregation, and to reduce the arbitrariness in their measurement and interpretation, while approaching the Latin American reality regarding the limited availability of individual spatial data.

## III. METHODOLOGY

Although this article proposes, as has been said, a complementary approach to quantify residential segregation and its different spatial dimensions, which includes the use of aspatial and spatial indicators, the methodological path that is described below, only uses DI and GMI to study the grouping and dissimilarity dimensions, respectively. Despite this, it is suggested considering other residential segregation dimensions, as well as using the available techniques and strategies, such as: geographical information technologies for spatial analysis, graphical corrections, and spatial regressions among others.

The study was made in Managua, the Nicaraguan capital, inhabited by 28.9% of the population, which has a low density -38.51 inhabitants per hectare- compared to other Central American capital cities. It is characterized by a functional spread, the result of different factors, like the devastating earthquake of 1972, after which the State took control of property in the most affected area (historic hub), and opted to freeze its reconstruction. This led to a multiplying of neighborhoods around it and in the outskirts of the city, accentuating the disconnection of Xolotlán Lake with the rest of the city (Figure 5). Today Managua has a fragmented urban development, the result of flexible public management, where the actions of different real-estate and development agents have dominated (Figure 4).

To quantify socioeconomic residential segregation (SRS) in this case study, the information collected in the VIII Population and IV Housing Census carried out in 2005, was turned to, as this requires statistical representativity criteria. This shows a Managua that was divided into 5 district units (Figure 6), with a total extension of 267.17 km$^2$ and an estimated population of 937,489 inhabitants, spread over 618 neighborhoods and 23 districts. It is worth mentioning that, given the lack of census data referring to economic stratification, the SRS calculation was made using the census data available for public use. In this case, the education variable was used, broken down into two opposing social groups: the illiterate population and the population with complete tertiary education, as a single proxy variable of socioeconomic segmentation.

These decisions were based on the prevailing position in the residential segregation studies in the region, which usually use a single proxy variable of socioeconomic segmentation, such as poverty, education, or employment (Groisman & Suárez, 2010; Garín, Salvo & Bravo, 2009; Molinatti, Rojas & Peláez, 2016). At the same time, the great power of segmentation the education variable has in Latin American cities must be highlighted, inasmuch as it is capable of determining salary differentials and access to social protection, as well as linking it to the work division and the place occupied in the social structure (Molinatti ***et al***., 2016).

Meanwhile, the age of the census data can be considered as a methodological limitation, although this is common in Central America. El Salvador and Nicaragua are the countries with the oldest census data, from 2007 and 2005, respectively. However, it is essential to avoid methodological inhibition, which is like "a pronounced trend to confuse what one wishes to study with the series of methods suggested for this" (Mills, 1959, p. 69). In this sense, although there are no current data, those available are of a good quality and allow approaching the phenomenon being studied, through the indicators conceived for this purpose.

### Aspatial indices versus spatial indices

Despite its limitations, the Dissimilarity Index (DI) is the one used most for quantifying residential segregation. It seeks to measure the under or overrepresentation of a social group in the spatial units into which an urban area is divided (Apparicio, Martori & Fournier, 2014). It is considered that a social group is segregated the more unequal its distribution in space is. The index varies between 0 and 1, and tends towards this second value when the social group appears more strongly overrepresented in some areas and underrepresented in others. Its formula (equation 1) shows the segregation understood as dissimilarity.

$$D = \frac{1}{2}\sum \left| \frac{ai}{A} - \frac{bi}{B} \right| \qquad (1)$$



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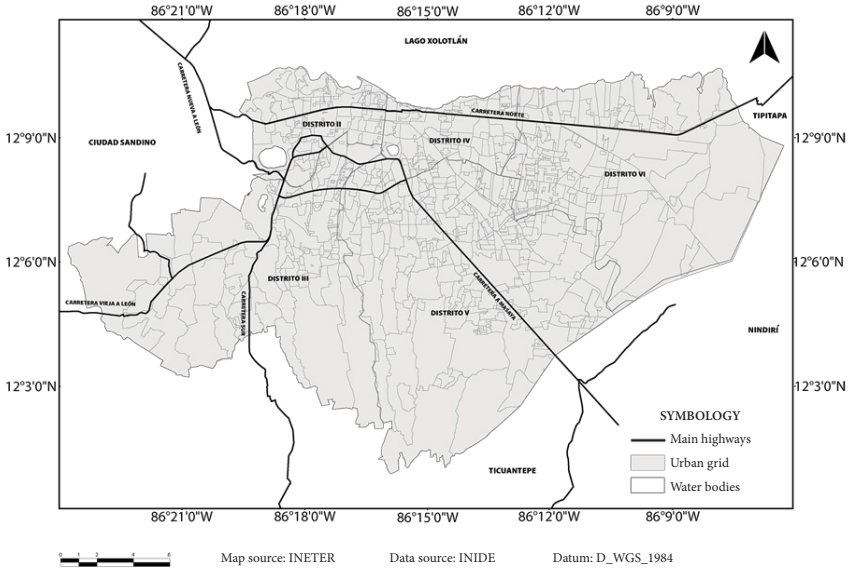


Figure 6. Outline of the study area. Source: Preparation by the Authors.





Where:
D: Dissimilarity Index
***ai***: Number of homes of a social group (illiterate population or with complete tertiary education) in area ***i*** (municipality, districts, and neighborhoods of Managua).
***A***: Total number of homes in the city of this social group.
***bi***: Number of homes not belonging to social group ***a*** in area ***i***.
***B***: Total number of homes not belonging to the social group ***a*** in the city.

Ultimately, to avoid MAUP, the phenomenon was measured on different scales of analysis, using a solution proposed by Molinatti (2013) that considers two strategies. First, the census data were processed for the available segregations (municipality, district, neighborhood), from biggest to smallest. Second, a methodological correction was applied in the graphical analysis of the Dissimilarity Index values, represented graphically through a "diagonal curve". This refers to the expected reduction of the index, when the measurement area increases, and allows distinguishing between the expected effect on facing the change of scale and the segregation effect itself. As a curve above the straight line would indicate macro-segregation, a curve below it would reveal micro-segregation or small-scale segregation.

The Global Moran's Index (GMI) was used to quantify residential segregation understood as grouping. According to Ramírez and Falcón (as cited in Siabato & Guzmán-Manrique, 2019), the GMI constitutes one of the most widespread calculations to globally measure spatial autocorrelation (SA), whose essence is analyzing how a phenomenon varies through the geographical space and thus be able to determine spatial patterns, describe their behaviors, and understand the type of association there is between neighboring spatial units. The SA applied to this study can lead to three results: 1) the social group tends to segregate and group in uniform areas, in clusters of rich or poor population, which evidences the existence of a positive correlation (Figure 7, element A); 2) the spatial units under analysis are contiguous to others of dissimilar characteristics and the social group tends to be disperse (Figure 7, element B), indicating that the spatial autocorrelation is negative; and 3) the location of the spatial units under study behaves randomly and it is not possible to identify a defined behavior, so there is no spatial autocorrelation (Figure 7, element C).

Regarding GMI, it must be said that this arises from directly comparing the values of each unit of analysis with the global mean of the phenomenon under study. As a result, it does not constitute a univocal universal measurement of the behavior of the analysis units, but rather that it depends on the neighborhood criterion that is chosen (Siabato & Guzmán-Manrique, 2019). In this case, spatial units within 500 meters, from 0 to 4000 meters are considered as neighbors, as the interaction between these is the one that best describes the phenomenon. At the same time, this criterion allows identifying whether this index has MAUP or not. The results of the GMI are interpreted as follows: a) a value of close or equal to 0 indicates a random pattern; b) values below 0 indicate a disperse pattern; c) values above 0 exhibit a cluster type

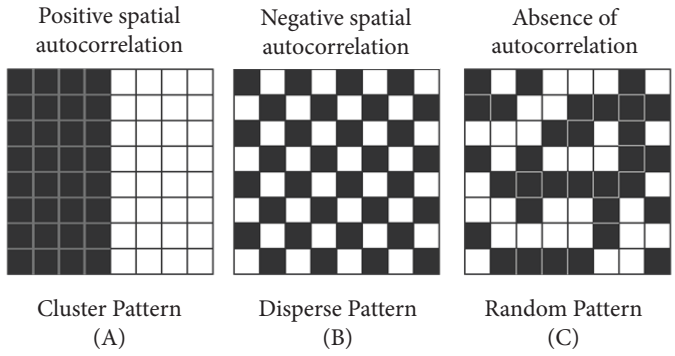


Figure 7. Spatial patterns and spatial autocorrelation. Source: Adapted from Siabato and Guzmán-Manrique (2019, p. 6).

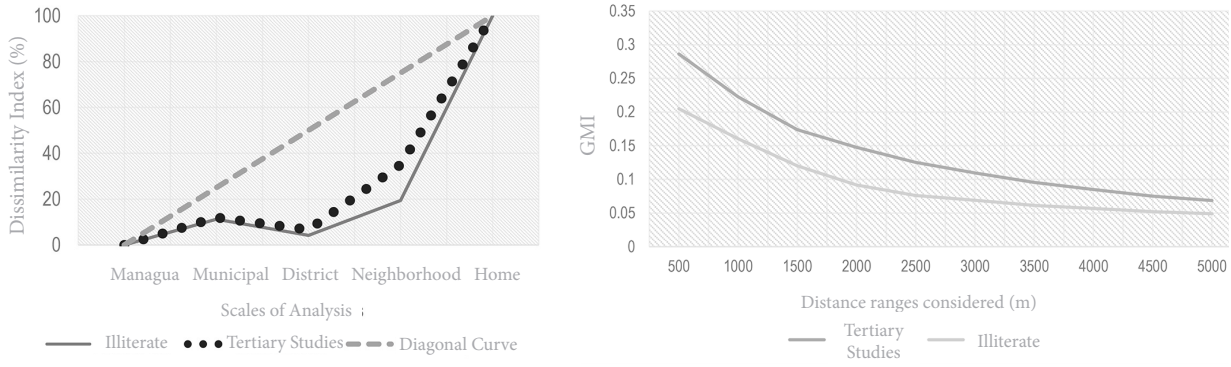


Figure 8. Comparison of DI with the methodological straight line, following scales of analysis for the city of Managua in 2005. Source: Preparation by the Authors.
Figure 9. Comparison of GMI for both social groups under study, following the distance ranges considered for Managua in 2005. Source: Preparation by the Authors.

pattern, which allows identifying whether there is a segregation pattern or not.

## IV. RESULTS

The results of the DI show important differences depending on the scales of analysis considered (Figure 8). On municipality and district scales, the segregation understood as dissimilarity does not have high values. However, on a neighborhood scale, this increases for both groups. It is seen that 35.01% of the population with complete tertiary education, and 19.44% of the illiterate population would have to change residence to reach a more balanced distribution in the city. That is to say, that 1 in 3 people from the highest economic stratums would have to change residence to reduce the dissimilarity of this group. This shows that Managua is characterized by a small-scale segregation.

The GMI presented the following results: 1) the illiterate population shows grouping, although it has a low spatial correlation at 500 meters, and lower still at 2000 meters until becoming negligible. 2) The most segregated group by grouping is the population with complete tertiary education, particularly at 500 and 1000 meters, although the correlation becomes negligible as of 3500 meters. In other words, the data show that the lowest economic stratums do not form large clusters of poverty, both rather are found spread in localized neighborhoods, presenting a low segregation by grouping. Meanwhile, the higher stratum neighborhoods are much more grouped in the city, even generating high salary cones that avoid proximity with neighborhoods of other social groups. Just like in the previous index, it is left clear that the population with complete tertiary education is segregated on a small scale (Figure 9).


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In summary, the results obtained show that: 1) Managua is characterized for having a small-scale segregation, as both social groups under study are more concentrated and grouped at a neighborhood scale. 2) The most segregated group in terms of dissimilarity and grouping is the population with complete tertiary education. This also shows that, in Managua, social homogeneity of the space dominates within the neighborhood or in the sum total of some neighborhoods, but contrasts with the social diversity on greater spatial scales like the district or municipality. This spatial arrangement detected by both indicators is known as "small-scale segregation", and accounts for the reduction of the geographical scale of the phenomenon, marking a break from traditional Latin American segregation patterns (Sabatini, 2015). In Managua, this situation is associated to a disperse urbanization process, as well as to the evolution of the operation of the land and housing markets.

## V. DISCUSSION

The results obtained allow, firstly, discussing about the limitations of aspatial indicators stated by Garrocho and Campos-Alanis (2013) and Ruiz-Tagle and López (214) as the main reasons to propose abandoning their use in the quantification of residential segregation.

In fact, the DI results show two empirical regularities of residential segregation studies: i) the population with complete tertiary education (highest economic stratum) is unequally distributed among the spatial units of the city and is concentrated more than the illiterate population in all scales of analysis; and, ii) the highest value of DI was obtained on the lowest scale of analysis considered (neighborhood), as the specialized literature describing the MAUP says (White, 1983). However, it must be mentioned that, both the DI and GMI results are revealing in this regard. In the case of the DI, the values did not fall on using a greater scale of analysis (Figure 8), which goes against the expected trend on the diagonal curve. While, on the contrary, the GMI did fall when the distance ranges considered for its analysis increased. This shows that regardless of the spatial pattern adopted, as the "chessboard problem" suggests, the intensity of segregation is different for DI and GMI. As can be seen, this result also questions the statements that assert the conceptual and operational superiority of the spatial indicators, and the advantages of their exclusive use for the quantification of the phenomenon (Garrocho & Campos-Alanis, 2013; Ruiz-Tagle & López, 2014).

Second, it is clear that spatial and aspatial indices measure different dimensions of the phenomenon, as the data show that the indices used coincide in one of the population groups under study, and differ in the other. This is why if, for example, the DI is compared for the population with complete tertiary education on a neighborhood scale (Figure 8) and the GMI at 500 meters (Figure 9), there will be a significant difference of more than 20 percent in the values obtained through the aspatial index that measures dissimilarity, compared to the spatial index used to measure the grouping. In this sense, it seems that empirically the same thing is not being quantified, because if this were true, the values obtained from the same indices would tend to be equal or similar, so the alternative proposed by Garrocho and Campos-Alanis (2013) and Ruiz-Tagle and López (2014), and the supposed advantage over the use of aspatial indicators, in reality is only another way of quantifying residential segregation, that fails to address the spatial multidimensionality of the phenomenon.

Finally, the results show the importance of opting for a complementary approach that considers the use of spatial and aspatial indicators as valid, and from which the results in this work would be read as follows: i) both social groups are concentrated and grouped with greater intensity on the neighborhood scale or at a homolog distance; ii) the illiterate population is concentrated and grouped with the same intensity; and, iii) the population with complete tertiary education is concentrated and grouped with greater intensity than the illiterate population on all the scales of analysis considered. Now, it is worth adding that this last group is concentrated more than it is grouped.

## VI. CONCLUSIONS

The research presented here allows concluding that in Central America, access to updated census data without spatial aggregation, that can make the quantification of residential segregation possible using spatial indicators, is still complicated. For this reason, the use of measures that are truly sensitive to the space and scale for the study of the phenomenon would still be limited. As a result, it is key to address the flaws attributed to these aspatial indicators by using correction strategies, like those used in this study or other available ones, and thus also find methodological alternatives that, despite the limitations there are, make possible the study of urban phenomena like socioeconomic residential segregation.

Likewise, it must be understood that, although spatial indicators seek to capture the inherently geographical nature of residential segregation, its exclusive use fails to address the spatial multidimensionality of the phenomenon. In this sense, considering the spatial indices as the only valid ones, can lead to gaps or bias in their quantification. Meanwhile, working with aspatial and spatial indices from a complementary approach, can more broadly show the characteristics of the phenomenon for different social groups, as well as to offer more comprehensive readings that reduce the differences that the analysis of the spatial dimensions of the phenomenon usually generate, from any of their analytical approaches.

Finally, it is key to understand that the quantification of residential segregation, through approaches like that proposed in this article, allows evaluating the effects of actions promoted



UN ENFOQUE COMPLEMENTARIO PARA EL ANÁLISIS CUANTITATIVO DE LA SEGREGACIÓN RESIDENCIAL EN LA CIUDAD DE MANAGUA
INDICADORES ESPACIALES Y NO ESPACIALES
PERLA MARÍA SÁNCHEZ URIARTE, RICARDO GÓMEZ MATURANO
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by the State through local governments and the institutions set up to address the challenges of urban and regional development, which have the potential to increase or reduce residential segregation. Within this framework, it is pertinent that the progress in the understanding of contemporary spatial patterns of the phenomenon under study, can outline the need to improve the spatial distribution of the lowest economic stratums, for the sake of guaranteeing a more balanced distribution of the resources, opportunities, and benefits that the city offers through its residential environments.

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# DIFFUSE URBAN SPRAWL IN INTERMEDIATE CITIES[1]

## SIMULATION OF THE EXPANSION PROCESS IN THE CITY OF TEMUCO, CHILE

CRECIMIENTO URBANO DIFUSO EN CIUDADES INTERMEDIAS SIMULANDO EL PROCESO DE EXPANSIÓN EN LA CIUDAD DE TEMUCO, CHILE

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La urbanización avanza de manera vertiginosa y sus impactos son visibles más allá de los espacios metropolitanos. En ese contexto, las metodologías de simulación del crecimiento urbano adquieren relevancia para comprender (y aportar a) futuros escenarios de crecimiento urbano. En concreto, aquí se analiza el caso de la ciudad de Temuco en la Región de La Araucanía empleando las siguientes herramientas: Cadenas de Markov, Autómata Celular, Evaluación Multicriterio-Multiobjetivo, como también de la determinación de usos/coberturas de suelo mediante Sistemas de Información Geográfica (SIG). Así, el trabajo determina el escenario urbano al año 2049 a partir de los patrones espaciales del área de estudio desde el año 1985. El modelo muestra la tendencia al crecimiento periférico y difuso hacia el norte de la ciudad y un fuerte desarrollo hacia el sector oeste en el barrio de Labranza, es decir, el primer sector se proyecta como un foco de posible expansión y el segundo, como uno de consolidación. Se concluye que ambas zonas requieren de instrumentos pertinentes y actualizados de planificación urbana, con los que la ciudad no ha contado hasta ahora.

**Palabras clave:** simulación, cadenas de markov, autómata celular, evaluación multicriterio-multiobjetivo, sistemas de información geográfica.



**Urbanization advances vertiginously and its impacts are visible beyond metropolitan spaces. In this context, urban sprawl simulation methodologies become relevant to understand and add to future urban growth scenarios. In this work, the case of the city of Temuco in the La Araucanía Region is analyzed, using the following tools: Markov chains; Cellular Automaton; Multicriteria-Multi-objective Assessment; and the determination of land usage/cover using Geographic Information Systems (GIS). Based on the above, the urban scenario was determined for 2049 from the spatial patterns of the area under study, since 1985. The model shows a trend to a peripheral and diffuse sprawl towards the north of the city and a strong development towards the western sector in the Labranza neighborhood. That is to say, the first sector is projected as a possible node of expansion, and the second, as one of consolidation. It is concluded that both zones require pertinent updated urban planning instruments, which the city has not had until now.**

**Keywords:** simulation, markov ahains, cellular automaton, multicriteria-multi-objective assessment, geographic information systems.


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# I. INTRODUCTION

According to a United Nations report from 2016, the impacts of urbanization can be seen in practically the entire planet and its regions, which, beyond their size, are facing noticeable mutations, whose configurations imply limits that are simple to perceive, but complex to set.

In this way, not just the metropolitan spaces have experienced constant modifications, but also other smaller sized cities have developed important mutations that affect and determine their spaces and surroundings. It is in this context that the mid-sized urban entities, or the so-called intermediate cities (Bellet & Sposito, 2009; Henríquez, 2014) emerge. These have ties with their rural spaces, forming different degrees of centrality in their respective regional spaces, and often becoming important political centers and/or as service providers, fostering social interaction, as they have a connection infrastructure of flows that allow bringing the decentralized State administration entities closer (Maturana & Rojas, 2015).

Intermediate cities, just as occurs with metropolitan spaces, have been subject to real estate pressure and provide evidence of similar complexities, both in terms of virtues -like greater access to specialized services or infrastructure, as a result of agglomeration economies-, and of problems -contamination, congestion, uncontrolled expansion, among others- (Bellet & Sposito, 2009). Because of this, it is relevant to study them using the models that urban science provides and contributes in urban planning or management processes.

"The new science of cities" appears in this sense, as a new example in the analysis and modeling capacities that can be applied in the city. This new approach, according to Batty (2013), provides a set of tools to represent, analyze, simulate, predict, and create urban structures. This, in the understanding that cities are defined as complex spatial objects, with different temporal and spatial scales that, despite their difficult characterization, present certain logics that allow analyzing them (Barthelemy, 2016).

In this scenario of changes and new possibilities of analysis, different Latin American countries are witnessing a powerful urbanization process and Chile is no different. Currently, over 87% of the population is urban (National Statistics Institute [INE, in Spanish], 2017), and the intermediate cities, regional capitals, have played an important role on being a space that catalyzes the needs of each one of their surrounding regions. In fact, according to information from the last population census in 2017, at the country's extremes, over 80% of the regional population is concentrated in these cities and, in the case of the more central regions, the trend rises to 43% in the Los Rios Region or to 32% in the O'Higgins Region, for example (INE, 2017).

Based on this, one of the interesting cases to analyze is the city of Temuco, due to its rapid metropolitanization process (Rojo, Alvarado, Olea & Salazar, 2020). It is located in the La Araucania Region, and practically concentrates 24% of the total regional population according to the latest census in 2017 (see location in Figure 2), quadrupling the next smallest city in the region in terms of population, and promoting a high dependence on services and facilities (Salazar, Irarrázaval & Fonck, 2017). Alongside this process, the city of Temuco has segregation phenomena with impoverished areas (Garín, Salvo & Bravo, 2009).

Temuco also has diverse planning complexities, where it has seen unsuccessful update processes both of the Communal Zoning Plan (PRC, in Spanish) and the Intercommunal Zoning Plan (PRIC, in Spanish). Both are Regional Planning Tools (IPT, in Spanish), implemented according to the scale, and constituted as the main directives that councils have to regulate their cities. In this framework, the main task of these tools is promoting, guiding, and regulating the harmonious development of the communal area, and particularly of its inhabited centers (Peña-Cortés, Pincheira, Rozas, Fernández & Ramírez, 2020), under the General Urbanism and Construction Law.

Enormous urban challenges are added to this regulatory and planning complexity, that could be portrayed in the dynamics of population and vehicle numbers. With regard to the former, in 1982 the city had 157,634 inhabitants and by 2017, it had 307,624, including the Temuco and Padre las Casas conurbation. That is to say, it has doubled its population over the last 35 years. And the figure is practically 360,000 people, when we talk about both communes. As for vehicle numbers, in 2001 Temuco had 42,548 vehicles, and by 2018, 98,430, i.e., doubling once more in less than 20 years. Both situations have raised challenges in terms of infrastructure, services, facilities, quality of life, and the environmental quality in the city.

Given this background, it is necessary and useful to reflect about the dynamics in the city, the not fully planned urban expansion it has seen, the urgent need for studies that make a better planning possible, and with them, a greater capacity of resilience and sustainability.

Consequently, the purpose of this article is exploring the change of land cover experienced in the city of Temuco, in order to generate a simulation of the built surface by



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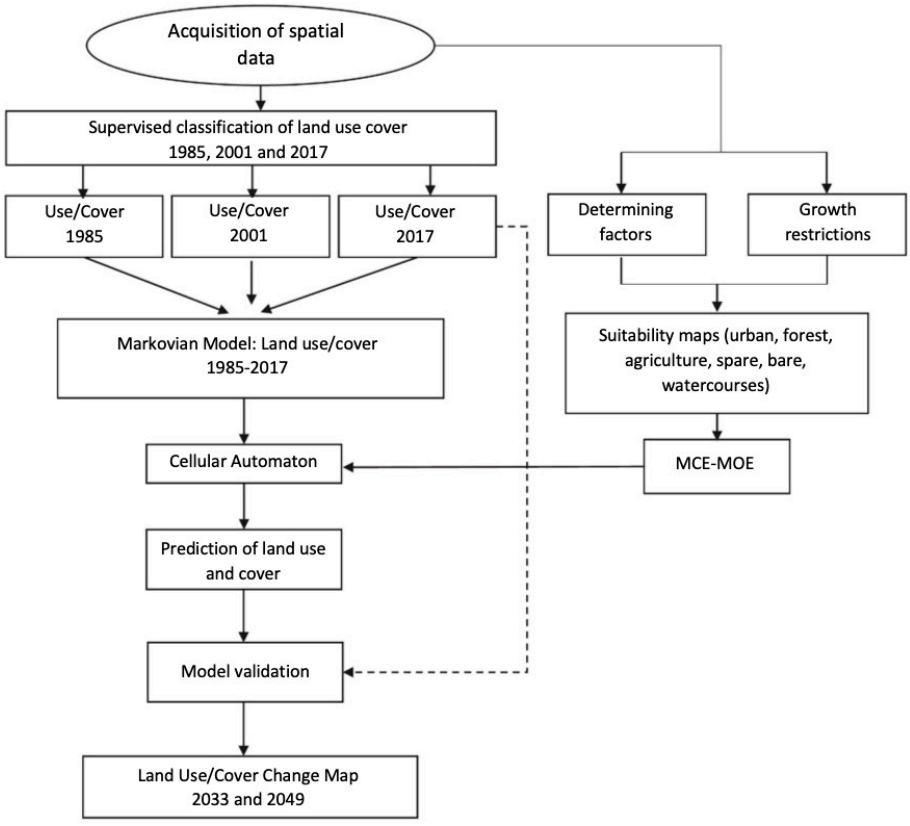


Figure 1. Methodological Model. Source: Preparation by the Authors, adapted from Morales & Maturana (2019).

2049, and thus contribute to the debate on the areas that should be incorporated in the city's future planning, at least in terms of urban boundaries. To carry out this process, a characterization of the land cover between 1985 and 2017 was made, and the model was validated to continue with a future urban growth simulation of the city between 2017 and 2049, analyzing both the resulting spatial patterns and the projected changes.

## II. METHODOLOGY

The study used satellite images to simulate the urban growth of Temuco and the area of Labranza by 2049, starting from 1985 and 2017. The images used came from the Landsat 5, 7 and 8 satellites for 1985, 2001 and 2017, respectively (United States Geological Service [USGS], 2019). The decision was made to start analysis from 1985, since its spectral bands allow correctly discriminating the land cover using image radiometry (Hernández, 2011).

The methodological steps in the simulation are summarized in Figure 1. First, the land cover was determined using the spectral classification of each image. These were also radiometrically corrected -radiometric calibration and atmospheric correction- to obtain reflectance values for each pixel.

In order to increase the limited spectral dimensionality of the 1985 Landsat image, and with this, improve its capacity to discriminate land coverage, this was subject to two transformations of the original reflectance curves of its pixels: (1) continuous removal and (2) first derivative (Entcheva-Campbell et al., 2004; Kokaly, 2001).

In this way, this part ended with the determination of the land uses and cover using the supervised classification method of urban use, forest cover, vegetation (dense and disperse), bare (sparse) land and watercourses for 1985, 2001, and 2017. The ENVI 5.0 program was used for this purpose.



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| Drivers of urban growth | Unit | Limitations | Surface Area | Source |
|---|---|---|---|---|
| Distances to the consolidated centers of Temuco (primary), Labranza (secondary) | Kilometers | Indigenous territories (granted lands) (IT) | km2 | CONADI – National Corporation for Indigenous Development (2018) |
| Structuring road network | Kilometers | Indigenous territories (granted lands) (IT) | km2 | CONADI (2018) and Ministry of Public Works |
| Suitability of susceptibility of land use/cover change | Kilometers | Watercourses | km2 | Preparation by the authors |
| | Kilometers | Urbanized land | km2 | Preparation by the Authors |

Table 1. Factors and limitations considered. Source: Preparation by the Authors.

The second step consisted in applying a Land Use/Cover Change Simulation Model (LUCCSM) between 1985 and 2017, to validate the model and then, determine through a new simulation, now from 2017 onwards, the future urban land.

In this way, the generated model collected retrospective results of urbanization between 1985 and 2017, as such the analysis focused on the spatial-temporal behavior of urban use. This model includes "Multi-Criteria-Multi-objective Evaluation", "Markov Chains" and "Cellular Automaton" techniques that were processed in the IDRISI Selva 17.0 program, which allowed applying these processes.

For the modeling, the Multi-Criteria-Multi-Objective Evaluation (MCE-MOE) technique was turned to, which uses layers as criteria to support the projection of urban growth in the city of Temuco. Within this, limiting factors of this urban increase were chosen as drivers (Table 1). Their use is due to key factors identified in other studies (Henríquez & Quense, 2010; Malczewski, 1999; Van der Merwe, 1997) that have an influence on urban expansion processes.

As can be seen, the first two limitations are relevant as they directly involve both the role of the State and of the Mapuche population in the area under study. The Indigenous Development Areas (ADI, in Spanish) are areas where indigenous development will be focused, as per Law 19.253 (Ministry of Planning, 2017), while the Indigenous Territories (IT) are protected areas where an indigenous person or community resides. Consequently, these are territories to be restricted. Obviously, the already urbanized land and watercourses were added to these.

As for drivers (Table 1), the urban suitability was assessed following a weighted linear sum, considering the factors proposed by Henriquez (2014). These factors were standardized between values of 0 (least suitability) and 255 (most suitability), and the weights of each of them were estimated through the Analytical Hierarchy Process (Kharat, Kamble, S.J, Raut, Kamble, S.S. and Dhume, 2016). This process is expressed in equation 1 below:

$$Aptitudurbana = \sum_{j=1}^{3} w_j e_{ij} \qquad (1)$$

Where,
wj = is the weight or criterion of each ***j*** factor, coming from the AHP (Saaty, 1980).
eij = value of each factor ***i*** for each one, or the criterion of ***j.***

Once the land coverage and MCE-MOE were determined, a probability matrix was generated, which makes the projection possible and implies considering at least two temporal measurements which, for this case, are in the range of 1985-2017 (Batty, 2013). With said scenario, the final change transition probability image in land cover was generated to be able to make the simulation up to 2049.

After this, the Markov Chains (MC) allowed projecting which spaces will change from an ***A*** cover state to a ***B*** cover scenario. The MC technique works considering that the spatial distribution of land cover is a direct result of the situation at a prior moment (t-1); therefore, this model supposes that a state is the linear result of its previous scenario (Batty, 2013).

The last technique of the modeling is Cellular Automaton (CA). This connects the previous state of the pixels with the state of the neighboring pixels, considering the transition rules of each land cover and use: starting from each pixel, these take a given future state using the land use/cover of the surrounding cells using their interactions, in this way being able to spatially locate the pixels with the highest probability of changing (Batty, 2005).



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An extremely important step to validate the simulation process carried out to 2049 is the validation of the model. With this goal, a simulation was made to 2017 considering the periods between 1985 and 2001. Once the calculation was obtained, the similarities between the real (2017 observed) and the simulated (2017 simulated) can be understood and evaluated using the Kappa index (Congalton, 1991), using equation 2 below:

$$índiceKappa = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}(x_i * x_{+1})}{N^2 - \sum_{i=1}^{r}(x_{ii} x_{+1})} \qquad (2)$$

Where,
r = number of rows and columns in the matrix.
N = total pixels in the matrix.
x ii = observations in row ***i*** and column ***i***.
xi = marginal total of row ***i.***
xi + 1 = marginal total of column ***i.***

In this way, the Kappa index allows estimating the adjustment of the proposed simulation model. When the value is above 0.5, it could be accepted that the model is validly predicting change (Morales & Maturana, 2019; Henríquez, 2014) and, therefore, its application to generate the simulation is possible. The Kappa index obtained and its soundness are detailed in the following paragraphs.

## III. RESULTS AND DISCUSSION

The analysis of Figures 2 and 4 express the urban expansion and land cover processes between 1985 and 2017. It can be seen that both the forest and urban surface saw their areas increased. However, the areas destined to vegetation, bare areas and also watercourses saw decreases in this sense (see values in Figure 3).

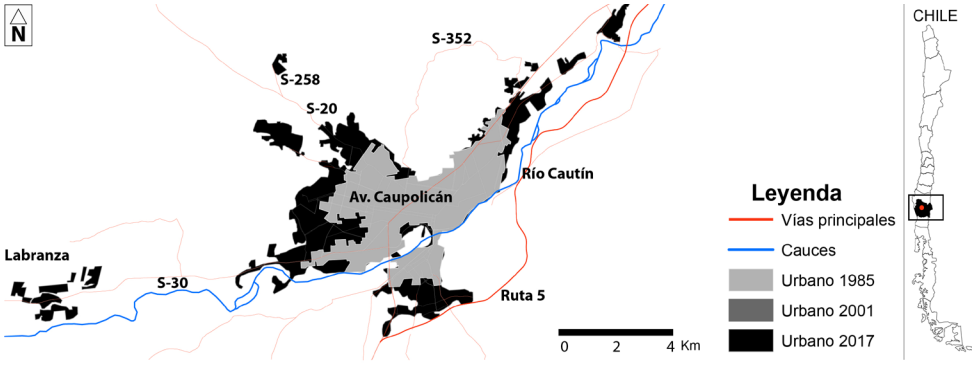


Figure 2. Area of study and urban growth between 1985 and 2017. Source: Preparation by the Authors.

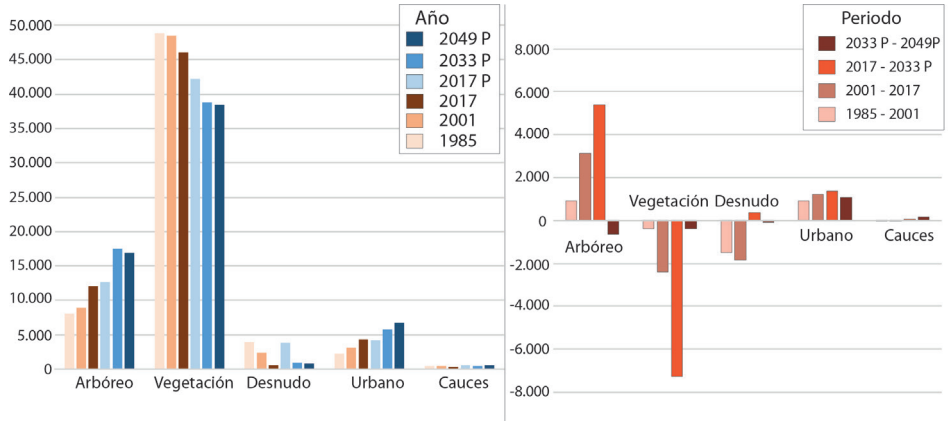


Figure 3. Real and simulated Land Use/Cover change values in Temuco (P: refers to the simulated or projected values). Source: Preparation by the Authors.



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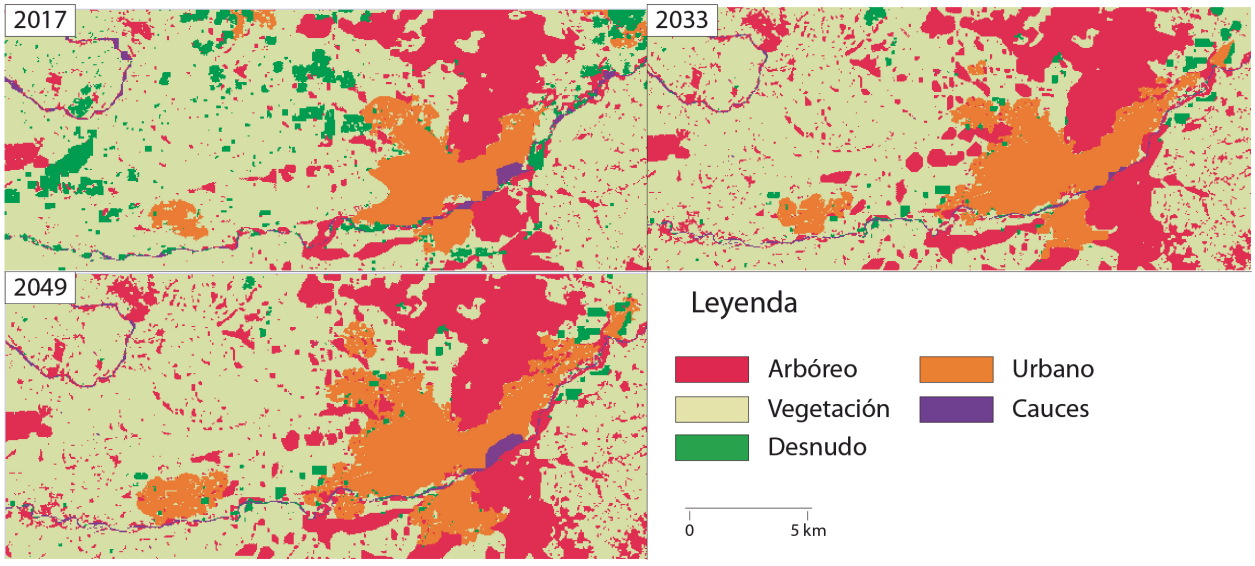


Figure 4. Scenarios simulated in 2017, 2033, and 2049. Source: Preparation by the Authors.

Regarding the categories that increased during the first period between 1985-2001, the most significant was the urban cover, which saw a growth of 918 ha, which translates to 41% of the land cover compared to 1985 (Figures 2 and 4). With forest cover, this increased by 11%. In addition, it is relevant to underline the emergence of Labranza (Figure 2) as an urban enclave, which, despite not adjoining Temuco, becomes a new spatial example nearby the city, something that did not occur in 1985. In regard to reductions, the bare land stands out, falling 39% in surface area compared to the initial year. Although the other two covers, vegetation and watercourses, saw declines, their changes were marginal at 0.8% and 1.8%, respectively.

During the 2001 and 2017 period (Figures 2, 3 and 4), the most relevant change is given by the drop in the urban land growth rate, although this is still important, and the rise in forest cover. The latter increased 35% compared to the first block, considering 3,148 new hectares, while urban cover did so at a pace of 39%, 2% less than the first block, increasing its spatial cover by 1,212 new hectares.

The same trend was seen regarding reduction, with lower values in the vegetation, bare land and watercourse cover. From these areas, the bare land saw its surface reduced most, falling at a pace of 77% compared to the first block. Meanwhile vegetation and watercourses fell 4.9% and 8%, respectively.

In summary, in the temporal evolution between 1985 and 2017, the change reflected for bare land stands out. This fell 86% in total from 1985 (3,360 ha), which beyond its disappearance in cover terms, indicates a strong dynamism regarding the change of one cover to another. This is contrasted to watercourses and vegetation, which do not reach 10% of change. Among the covers that increased, the urban one stands out, which almost doubled what it represented in 1985 -96% growth-, increasing by 2,130 hectares, which shows how spectacular the phenomenon is.

As for the urban land trend, this has 4,345 ha by 2017, exceeding the 2,215 ha of 1985, representing 51% of the most recent year. In addition, the case of forest cover can be highlighted, since it increased 4,403 ha compared to 1985, representing 67% of what exists by 2017.

It is relevant to point out the appearance of Labranza as a node of the urban framework without being a direct arm of it (Figure 2). This rose from 33 ha in 2001 to 204 ha in 2017, which shows the dynamism of the sector in just 16 years. However, this situation was foreseeable, mainly because of the construction of a dual-carriageway that began to be built in 2011. In fact, Labranza has been a center chosen for the location of social housing for populations that did not have a housing solution near to Temuco and, likewise has experienced actions of real estate players in recent



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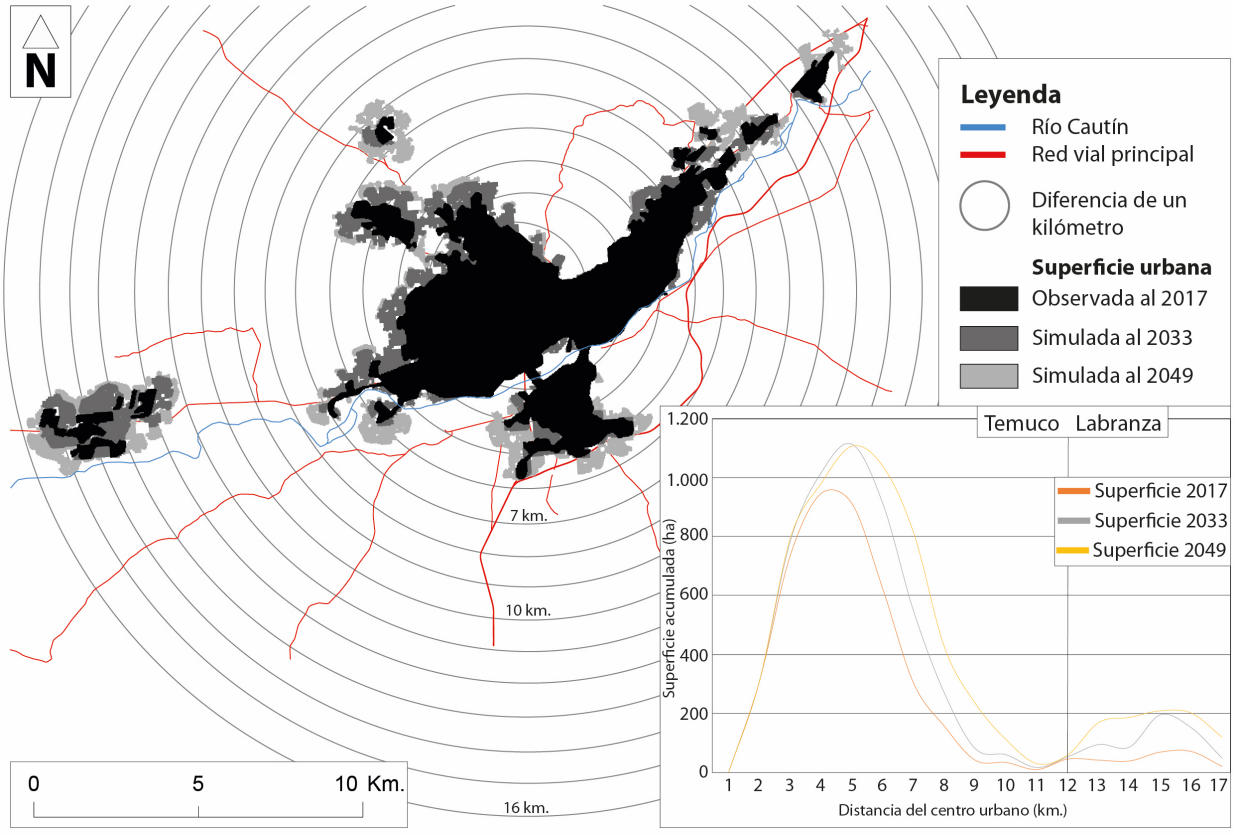


Figure 5. Simulation of the urban growth of Temuco in terms of distance. Source: Preparation by the Authors.

years, who have built a series of housing projects targeting the middle class, increasing pressure on this space further still.

With regard to the simulation process between 2017 and 2049, the spatial and validation results can be seen in Table 2. The categories are graphed both in Table 2, and in Figures 3 and 4.

Regarding the validation of the simulation process, the kappa values oscillate between 0 and 1. In the 0.2 and 0.4 interval, the match is acceptable; between 0.41 and 0.6 it is moderate; between 0.61 and 0.8 it is considerable, and it will be perfect the closer the value is to 1 (Morales & Maturana, 2019). In the case of Temuco, a value of 0.55 was obtained, which is considered acceptable for the purposes of this type of study and, in that sense, it would be validating the use of the model to simulate future growth that the city could experience by 2049.

| Index | Value |
|---|---|
| Kappa Index | 0.55 |
| Kstandard | 0.55 |
| Kno | 0.73 |
| Klocation | 0.63 |
| klocationStrata | 0.63 |
| Estimation by Category | |
| Forest | 0.637 |
| Vegetation | 0.615 |
| Bare | 0.007 |
| Urban | 0.655 |
| Watercourses | 0.300 |

Tabla 2. Kappa Validation Source: Preparation by the Authors.



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Considering the different scenarios, there is a match in terms of the estimated (simulated) and real surface of the urban cover, 4,230 and 4,345 ha, respectively, which expresses that the model is sound and that allows, as a result, carrying out the simulation between 2017 and 2049, whose results can be seen in Figures 4 and 5.

It is seen how, by 2049, urban cover would increase 2,437 hectares compared to 2017, which represents a 64% change rate, whose differential is 13.1% more than the growth rate observed between 1985 and 2017.

The proposed simulation model shows that urban growth will tend to be reinforced towards the periphery with an emphasis on the area of Labranza, which comes with the development of the dual-carriageway alongside Calle 1 Norte and the new Calle 1 Sur. In this way, a better connection will be generated between the regional capital and coastal sector of Temuco-Nueva Imperial-Carahue, where passing through Labranza will be obligatory and thus, making it one of the most positively and negatively affected by the traffic.

This phenomenon has not been random, given that, as has been indicated, there has been a major social housing construction policy in the area, while also bearing in mind, the new middle class property being developed. The dual-carriageway which will go beyond Labranza to Carahue, as indicated by the current authorities in the press, adds to this. This would also imply incorporating Nueva Imperial, thus annexing the two urban centers with high commuting processes to the city of Temuco. According to the 2002 and 2012 censuses, the latter unofficial, 16% of regional mobility towards Temuco came from these areas, a process that finds in the dual-carriageway, a solid basis to stimulate a greater diffuse and non-compact urban expansion.

Temuco by 2033 would grow by around 1,046 ha, sequentially in the simulated years, reaching a total of 5,721, of which 540 would correspond to Labranza, representing 9.4% of the total urban surface area (Figures 3, 4 and 5). Meanwhile, by 2049, the city system as a whole would increase by 2,437 ha, reaching a total of 6,782, of which 785 would correspond to Labranza, in that case, 12% of the total. These figures show how relevant, necessary, and urgent having urban space planning is. In fact, there have been considerations about the need to create a new commune, an aspect that has been considered from the political sphere with a requirement having been presented[6]. Since 2012, a social movement supporting the commune of Labranza has been formed, holding different activities to achieve an autonomous unit (Regional Planning Laboratory-UCT, 2013).
The importance assumed by Labranza is explained by its dynamic in the urban expansion process it would experience. If 2049 is taken as reference, the consolidated urban area of Temuco would have an expansion pace of around 1,854 ha, which is currently equivalent to 69% of what it would be by 2049 and therefore slower than Labranza. In fact, the latter will increase its surface area by approximately 4 times, so that in 2017, its population would be just 26% of what it would end up being in 2049, moment when the town could be formed as a compact unit. This would generate the reinforcement and extension of the mobility processes that are already occurring in this entire strip and also, an increased pressure on the land available for future property development projects.

A second sector that would experience relevant growth, is that of Mariposa Hill or the route to the "Chivilcan wetlands", located to the north of the city, close to Ñielol Hill. Currently there is a dynamic land market focused on smallholdings, but this would change in the future. In fact, if by 2033 it was only possible to consider Labranza as a non-adjoining node of the Temuco system, by 2049, new signs of urbanization will appear in the aforementioned areas, that would exercise pressure not just in terms of diffuse property development, but also in environmental terms, given that one of the city's main wetlands is located in this area; an area whose recognition has recently requested by the council in the framework of the Urban Wetlands Law[7].

It must be added that, continuing along route S-258, which is the extension of Pedro de Valdivia Av. (Figure 2), the social housing neighborhoods generated as a sort of archipelago, would also contribute to these dynamics. If the growth trend is projected as the model shows (Figure 5), it will be facing a scenario that will see Temuco grow ever more discontinuously, as an amoeba and not compactly, something already seen in

6 See "Region of La Araucanía…" (12th April, 2018).

7 Request of Temuco Council to the Environment Superintendence (https://www.temuco.cl/presentan-solicitud-para-declarar-humedal-urbano-a-las-vegas-de-chivilcan/).



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other intermediate cities in Chile (Morales & Maturana, 2019) and that, although expected, it goes against all the aspects associated to sustainability, indicated in the National Urban Development Policy presented in 2014.

To complement this analysis, further studies can be made in terms of the distances and growth that will be experienced, that can be seen in Figure 5. There it is noticeably reflected up to where Labranza and Temuco would have a surface impact. For Labranza, it would capture land up to 3 kilometers from its downtown: a clear presence in the first 2, with a slight increase towards the third and fifth or sixth kilometer. Meanwhile, Temuco, would have a presence up to approximately 14 kilometers from its downtown, extending both to the northern exit leading to the areas of Cajón and Vilcún, and to its conurbation with Padre las Casas and the urbanization modeled towards the north of the city, parallel to Ñielol Hill and the forest areas close to it. Now, due to its current setup, the greatest impact would be within the first 7 kilometers, growth that is no longer evidently rising (Figure 5).

On linking the dynamic described here with the state-of-the-art of the Planning Tools, it is seen that the Temuco Regulatory Plan has been in force since 2010, with an amendment in 2011, and modifications through a sectional plan for the Las Encinas sector in 2012. However, the region in question does not have a current Intercommunal Plan; just as occurs in Padre las Casas[8]. In this sense, it is important to mention that limiting factors like the presence of Land Grants - indigenous ownership-, have not been an obstacle for the expansion and projection simulated; on the contrary, as has been seen, the communities have remained in the middle of the urban expansion (Peña & Escalona, 2009), which also leaves enormous challenges for the future.

Notwithstanding this, from the results obtained, some weaknesses of the method should be considered, for example, the "speckle" or "salt and pepper" effect, emerging from the models. This is characterized by generating a series of patches that appear as part of the simulations distributed randomly or in a disorganized fashion when, in practice, they should be grouped. Although this was mainly seen in the base year projection (2017) and lessened in the following years. To face this complication, what is important is not to consider these effects within the analysis, as was done, as these are actually differentiated from the groups that the model does manage to determine, with the latter indicating spatial trends and relationships. Added to this, the diffuse plans of the growth nodes are linked to Mapuche reductions, which are indicated as a limitation in Table 1, on not being able to be annexed for their urban use. Bearing this in mind, the diffuse and on occasions discontinuous growth will probably be a tonic in the morphology that the city will be developing.

## IV. CONCLUSION

Modeling urban growth in intermediate cities contributes to preparing for possible scenarios, providing relevant tools in urban and regional planning, and considering the traits of the metropolitanization processes of these cities. From this point of view, the ministerial secretariats of the Ministry of Housing and Urbanism, along with the councils, are faced with the challenge of incorporating this type of analysis when making or updating regulatory planning tools, like the Communal or Intercommunal Regulatory Plans, which would allow them to have greater technical information for city planning.

As a result, it is key to act from public policies and to foster harmonious development, with regional planning logics, aiming at avoiding the problems of larger cities; although everything seems to indicate that the measures will be actually be focused on attenuating or modifying issues that seem to be ever growing. In fact, the city of Temuco is already seeing this type of problem, in terms of the diffuse land expansion, and projects a growth that lacks harmony in the next 30 years, in the context of a high presence of indigenous territories that have legal safeguards against interventions, which become priority in urban studies and public policies. Likewise, the need for evaluating new infrastructures and the role that public transportation will have in the mobility of the city's inhabitants is urgent, considering the polycentricity that the city will be acquiring in the future.

8 Urban Observatory of the Ministry of Housing and Urbanism and personal communication of Local Councils.



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The possibility of adding variables like the indigenous territories to the projection models, leaves within the ethical role, the possibilities of making the reality more complicated and not falling into reductions that do not necessarily involve a variety of players. Although this is just an approach to said reality, it is positive to safeguard these territories in the area under study.

Also, and despite that it is estimated that the results have been sound on incorporating a forest or agricultural space that a change towards the urban can present, the study does not value areas with ecological or agricultural production criteria, aspects that on being considered, could have contributed to generate a more in depth analysis in a theoretical simulation with or without their restrictions. Certainly, said valuation processes could make a paper by themselves, given the complexity involved.

Finally, and along this same line, other territories of the region close to the city and not addressed in this work should also be subject of urban studies, like those of Pitrufquén or Freire which, likewise, have been subject to property pressures and are immersed in the system of pendular movements with Temuco.



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# EFFECT OF PUBLIC INFRASTRUCTURE ON URBAN LAND PRICE

## CASE OF THE CITY OF CUENCA, ECUADOR[1]

EFECTO DE LA INFRAESTRUCTURA PÚBLICA EN EL PRECIO DEL SUELO URBANO
CASO DE LA CIUDAD DE CUENCA, ECUADOR

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1 This article forms part of the project “Aplicación de la teoría de la renta de la tierra en la valuación del suelo urbano con fines catastrales para la gestión de las municipalidades en el Ecuador” DIUC_XVIII_2019_74 and is financed by the Universidad de Cuenca, Ecuador

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En el presente documento se analiza el precio esperado de venta de predios urbanos versus el capital incorporado al suelo por infraestructura. Para esa tarea, se emplean los precios de oferta de mercado de 1,393 predios en la ciudad de Cuenca-Ecuador, obtenidos de anuncios en la web, inmobiliarias y letreros en sitio. Los resultados muestran que para el 95% de los predios, el capital incorporado por infraestructura representa hasta un 22.4% del precio solicitado, sin embargo, la ganancia esperada por los propietarios (precio solicitado menos capital incorporado) es alta, alcanzando como media 6.35 veces el costo de inversión. En base a la distribución espacial de los predios, se identificó que la zona del centro histórico y sus alrededores, constituye el sector donde se evidencian las mayores ganancias esperadas. Distinguir adecuadamente las áreas que captan dichas ganancias puede contribuir en la toma de decisión respecto a las políticas de recuperación de plusvalías generadas por la inversión pública.

**Palabras clave:** infraestructura urbana, mercado de suelo, política urbana, urbanización.



In this paper, the expected sale value of urban properties is analyzed compared to the capital incorporated to the land by infrastructure. For this task, the market prices of 1,393 properties in the city of Cuenca, Ecuador, were collected using different sources, including online ads, realtors, and for-sale signs. The analysis reveals that in 95% of the lots, the capital incorporated by infrastructure represents up to 22.4% of the asking price. However, the profit expected by the owners -expected price minus incorporated capital- is high, reaching an average of 6.35 times the investment cost. Based on the lot's spatial distribution, it was identified that the historic city center and its surroundings were areas where the highest expected profits are seen. Accurately distinguishing the areas that capture these profits can contribute in decision making regarding the capital gains recovery policies generated by public investment.

**Keywords:** urban infrastructure; land market; urban policy; urbanization

## I. INTRODUCTION

Infrastructures help cities to work well, as their material base and physical support, contribute towards minimizing poverty and socio-territorial inequality (Erazo Espinosa, 2013) and facilitate the production of goods and services, which is why they positively influence productivity (Barajas & Gutiérrez, 2012). However, infrastructures can also lead to significant rises in land prices, through the transfer of the value contained in public works to the private land (Jaramillo, 2009).

Two of the most important and urgent issues, that Latin American urban planners face, are: i) land speculation; and, ii) the lack of resources to provide a suitable infrastructure for the land that satisfies social needs (Smolka, 2013a). In Latin America, given accelerated urban growth, concentration of land ownership, and laws regulating its use, access to available land is very limited, which leads to price hikes and large speculative profits (Rojas & Smolka, 2013). The so-called speculative investments or speculative capitals can be seen in the cities, whose goal is capturing gains generated by the purchase-sale of properties, i.e., buying land with the expectation of an increased end price (Daher, 2015; Gasic, 2018).

Several authors, aiming at somewhat attenuating the effect of land speculation, have proposed different ways of recovering gains, considering that the benefits of investments in urban infrastructure are capitalized in the land value (Furtado & Acosta, 2013, Smolka, 2013a; Peterson, 2009). In this way, capital gains tax has been considered in different countries, adopting values that vary between 30% and 60% of the increased land value attached to infrastructure projects (Smolka, 2013b).

The recovery of capital gains can contribute towards a sustainable, efficient, and equalitarian urban development. However, the main problem is the difficulty of calculating the land value increase generated by infrastructure projects. This difficulty has led to other alternatives being looked into, including charging tax and charging to recover investments, are commonly found. This is the case of Ecuador, which has a dominant capitalist dependent economic model, oriented towards the external market, whose municipal governments have public policies and instruments to intervene in the land market. Some of their attributions, in this sense, are charging land tax, the regulation to capture capital gains (President of the Republic of Ecuador, 2010), and the implementation of instruments to regulate the land market (National Assembly of the Republic of Ecuador, 2016), but, for sociopolitical reasons, their application is often overlooked (Guamán & Vivanco, 2020).

In most towns, the base value of the tax determines the land valuation the market offers, making different discounts depending on the land's features. Nevertheless, it is common that the commercial value differs from municipal assessment. For example, in Cuenca (Ecuador), the market price is 2.27 times the assessment value and can even be 11 times this value (Bojorque, Chuquiguanga, Peralta & Flores, 2020), so it is necessary to properly make urban land valuation in order to not affect either the local government or the land owners.

The infrastructure there is increases land value in a complex way, insomuch that a suitable quantification of the capital incorporated by infrastructure would contribute to making the land value increases transparent. Given that infrastructure plays a very important role in land development and exercises an influence on productivity, both in cities and the countryside, also generating an increase in land price, the purpose of this document is to research into the relationships of the capital incorporated to the land through drinking water, sewerage, electricity, telephone networks, and road infrastructure, regarding the land price expected by the market offer in urban lots of the city of Cuenca, Ecuador.

In this way, an exploratory cross-sectional study is made to identify possible connections between infrastructure investment and expected land price. The spatial distribution of the relationship of the capital incorporated compared to the nominal asking price is also analyzed, with the intention of supporting decision-making when it comes to defining tax collection policies for improvement contributions.

In specific, the document is structured into five sections. The first establishes the theoretical framework, where different regional studies on the impact of infrastructure on land values are mentioned. The second section comprises the methodology that includes the analysis of the land prices, infrastructure data considered, and the determination of the profit expected by the owners. The third provides the main results, which are discussed in the following section. Finally, the conclusions of the study are presented.

## II. THEORETICAL FRAMEWORK

Analyses on land prices have emerged in different types of studies, like econometric ones that seek to identify the relationship of the land and/or rent price, with variables like the distance to centers of employment, public facilities or transport infrastructure, among others. This is the case of the work of Ipia Astudillo and Pacheco (2017)



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which shows spatial clusters in Cali, with a differentiated pattern in the center and some of the city's intersections, and with higher values compared to the periphery, starting from which a strong residential segregation is seen. Also, the study of López-Morales, Sanhueza, Espinoza and Órdenes (2019), made in Santiago de Chile, shows that proximity to the Metro increases the net profit of real estate developers by approximately 25.6%. These research projects that use regression models, show the spatial dependence between variables, although they point to the likelihood that the projected relations may be due to other factors that are not considered, like the socioeconomic composition. Beyond this, the need of having detailed information of several parameters has limited their use in certain practical applications.

Other studies refer to the analysis of specific variables in the configuration or impact on land price. In the work carried out by Serra, Dowall, Motta and Donovan (2005), it is reported that, for three Brazilian cities, the impact on the increase in land price is due to: provision of infrastructure; property ownership; lot size; and distance from the city center. It is established that the presence of infrastructure increases land value by 179% in Brasilia, 11% in Curitiba, and 89% in Recife. The authors estimate that, on average, investments in sewerage generated a land value increase equivalent to 3.03 times the investment cost. In the case of paved roads, it was 2.58, and for drinking water, 1.02.

According to Borrero (2013), in the Latin American peripheries, the cost of urbanizing one meter square varies between US$20 and $40. In an average city, considering a gross land cost of US$12/m$^2$ and an infrastructure investment of US$30/m$^2$, there is a total investment value of US$42/m$^2$. So it is worth asking, how can the land price sometimes reach US$2,000/m$^2$? And the answer lies in the speculative or intangible factor of the market. This is why Borrero finds, in analysis of different sectors, capital gain values of 172% (periphery sector), 789% (middle-class sector), 2,381% (commercial sector), and 4,700% (mall), which are extremely high and diverse.

Meanwhile, Ronconi, Casazza and Reese (2018) researched, among other aspects, the impact of different public service networks on the land price in two municipalities of Buenos Aires, Argentina. Based on a prototype urbanization project of 200 lots, they determined the costs of different infrastructure networks, obtaining values in USD/m$^2$ of 1.6 for water, 5.8 for sewerage, 9.8 for paving, 1.6 for lighting and electricity, and 2.0 for gas. It was calculated that the percentage difference between lots with and without infrastructure was 184% for sewers, 156% for gas, 136% for water, and 130% for paving. However, as the authors note, these direct differences hide other different attributes with respect to dissimilar lots. Ronconi et al. (2018), based on a multivariate analysis, identified that the infrastructure provision cost is substantially lower than the average increase in land price, outlining a 12% increase for paving, 184% for the gas network, 195% for sewerage, and 677% for drinking water.

In this context, this study looks to contribute in the analysis of the capital incorporated by public infrastructure compared to the expected urban land price. It is worth highlighting that the infrastructure does not only generate capital gains, as there are also differential attributes with respect to the lots that make their value higher in the market, aspects like distance to shopping centers, higher permitted density, availability of property ownership, lower flood risk, greater distance from landfills, and provision of other infrastructure services, to mention a few, which can have repercussions on the capital gains value (Serra et al., 2005; Jaramillo, 2009; Ronconi et al., 2018), despite these qualities not representing a direct capital investment.

## III. METHODOLOGY

The characteristics of the study area, the collection of land price information, and infrastructure costs are presented in this section, while the difference between the investment and the expected land price is determined.

### Land prices

The information on land prices was collected through extensive fieldwork and telephone calls to owners or realtors between October 2019 and March 2020. 1,393 records were collected in the urban areas of Cuenca, which addressed an area of approximately 74.33 km$^2$. Information was gathered for each site for: real estate tax code, lot's occupation condition (without building, with building or horizontal property), location within the block, land shape, lot's topography, construction area, and total cost. In addition, any comments on the lot were recorded.

Considering the type of occupation, there are 567 lots without buildings, 758 with buildings, and 68 horizontal properties. The spatial distribution of the information within the city of Cuenca, is presented in Figure 1.

Lots with and without buildings cover the entire area of interest, while horizontal property ones are absent in some



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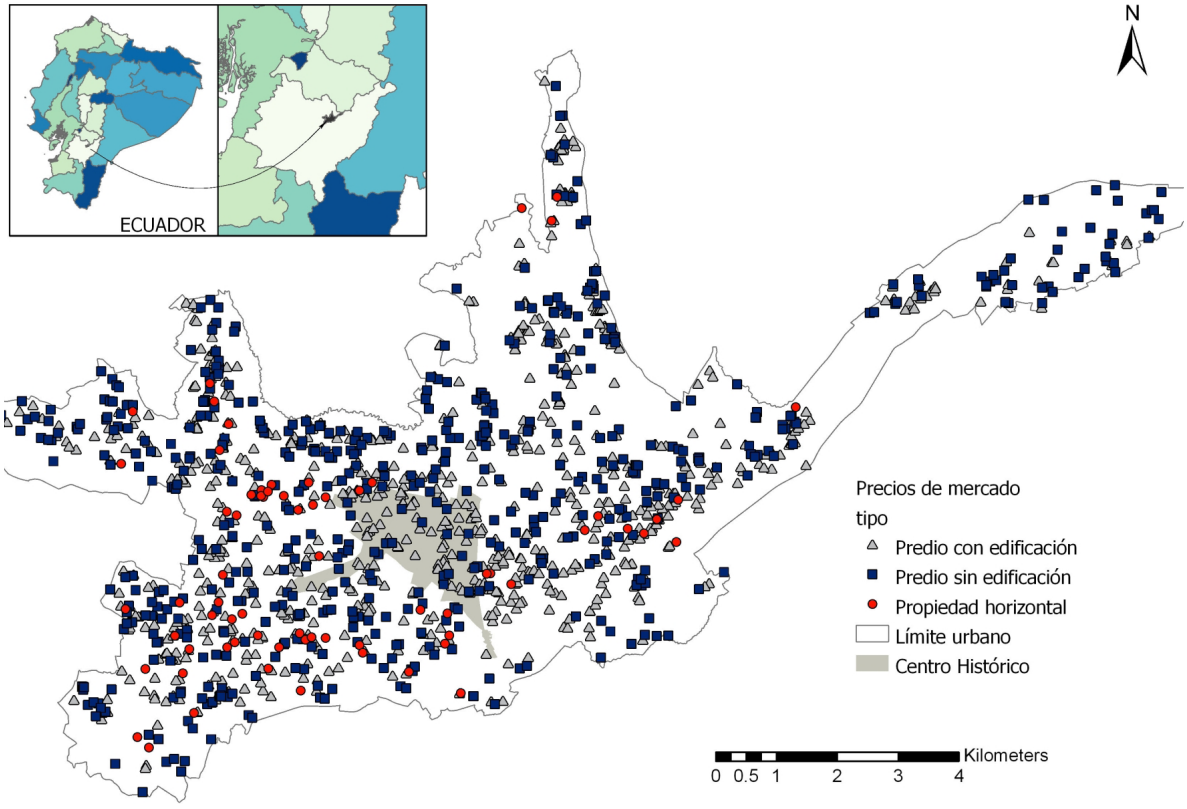


Figure 1. Geographical location and spatial distribution of the values collected considering the lot type: without building, with building, and horizontal property. Source: Preparation by the authors based on data collected between October 2019 and March 2020.



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areas, among other reasons, because of the regulation controlling land use and occupation in the city. The areas where there are no lots for sale, generally constitute sites destined to services like: airport, stabilization ponds, industrial parks, parks, military barracks, cemeteries, hospitals, among others.

To determine the gross price of the lot, i.e., excluding the building, the residential value process was considered, taking the year it was built, and the depreciation rate considering the construction material. The residual method consists in deducting from the property's total value, the costs attributable to the depreciated construction. This is how the land value is obtained (GAD Quito, 2019).

## Infrastructure information

In order to define the costs of different infrastructures, the GAD Municipal information of the Cuenca District, referring to the special contribution of improvements, was used. The basic infrastructure considered was: telephone, drinking water, and sewerage, performed by the company ETAPA; urban roads, which fell upon the Decentralized Autonomous Government of Cuenca; and the electricity network, managed by the company, Empresa Eléctrica Regional Centro Sur C.A.

The drinking water cost generated for a standard lot (140.5 $m^2$) was US$488.85, which represents a cost of US$3.48/$m^2$ for a 100 mm diameter pipe, 3.84 for 100-250 mm pipes, 4.12 for 250-450 mm, and 4.54 for pipes over 450 mm. The information on charges to pay for improvements for the sewerage and water sanitation areas was US$1,593.49, leaving a total of US$11.34/$m^2$.

With the purpose of assigning the capital incorporated to the lots by road infrastructure, the cost per linear meter of road, depending on its material, was determined. The cost generated was US$3,443.20, which represents a cost of US$24.51/$m^2$ for hydraulic concrete paving. The cost of rigid reinforced concrete and paving per meter in length and per meter was US$118.90. Based on the price analysis, the cost was calculated for other road structures: cobbles

| Statistics (USD/m2) | Lots without buildings | Lots with buildings | Horizontal property | All lots |
|---|---|---|---|---|
| Mean | 384.17 | 446.88 | 560.34 | 426.89 |
| Standard error | 8.95 | 8.40 | 29.03 | 6.12 |
| Median | 337.08 | 401.07 | 565.02 | 381.94 |
| Standard deviation | 213.10 | 231.4 | 251.85 | 229.49 |
| Minimum | 15.00 | 30.06 | 114.98 | 15.00 |
| Maximum | 1,319.63 | 1,839.95 | 1,289.50 | 1,839.95 |
| Number of lots | 567 | 758 | 68 | 1,393 |

Table 1. Statistical values of the different data groups related to the land price. Source: Preparation by the Authors.

in the historic hub (US$106.16), asphalt (US$84.93), cobbles and stones (treated material) (US$65.92), dirt tracks (US$4.25).

In the case of the electricity network, it was seen that some lots have an aerial network system and others, a buried one. To set the cost per meter squared, the information of charges to contribute to improvements with the electrical network areas was considered. For a site of 140.5 $m^2$, the generated cost was US$525.73, namely a value of US$3.74/$m^2$.

The telephone value generated was US$433.70, which means a cost of US$3.08/$m^2$. According to ETAPA, the entire city of Cuenca has this service. As such, on the entire urban area being covered, a uniform cost was considered for all the lots.

Based on the cost information of the different infrastructures and using GIS (Geographic Information System), a value was assigned to each lot, corresponding to infrastructure considered in the particular features of each system.

### Expected land gain

The discussion on the analysis of urban land prices begins by defining whether the land itself, has a price or not. In general, it is supposed that the gross land value -in the rural periphery- is the base price (Jaramillo, 2009). In the case under analysis, the base land value was the one the Municipality of Cuenca manages for land with no infrastructure, namely a price of US$20/$m^2$ (GAD Cuenca, 2019). The expected or potential gain will be considered as the difference of the value expected by the owners minus the capital incorporated and the base land value.

## IV. RESULTS

The main results obtained from the market price analysis are presented in this section. The incorporated capital for each lot and infrastructure is likewise determined, and the values are compared to analyze the expected gain. The results of the price statistics by lot type are expressed in Table 1.

From Table 1, it can be indicated that, for lots without buildings, the mean is US$384.17/$m^2$ and for lots with buildings, the mean is US$446.88/$m^2$, which represents an increase of 16.3%. In the case of horizontal property, the mean of 560.34 represents a 45.9% increase compared to lots without buildings. The mean land price, considered for all the lots, is US$426.89/$m^2$, a relatively high value, which limits access to urban land for the great majority of the population, encouraging them to search for lots in distant areas that have the same services, but that are far from the urban area.

Land price is very important, especially for housing production, as an increase therein, clearly brings with it, an increase in housing prices, so land policies must place emphasis on the regulation and control of land value to procure access to a "suitable dignified dwelling, regardless of social and economic situation", just as outlined in the Constitution of Ecuador (National Constituent Assembly of Ecuador, 2008).

### Capital incorporated by infrastructure

The contributions generated from the different infrastructures on the lots that form the urban area were determined. In Table 2, the costs are presented by



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| Systems (USD/m2) | Lots without buildings (P50/P95/P99) | Lots with buildings (P50/P95/P99) | Horizontal property (P50/P95/P99) | All the lots (P50/P95/P99) |
|---|---|---|---|---|
| Drinking Water | 3.3/3.7/3.8 | 3.5/3.7/3.8 | 3.4/3.7/3.7 | 3.4/3.7/3.8 |
| Electricity | 3.0/3.7/3.7 | 3.7/3.7/3.7 | 3.5/3.7/3.7 | 3.7/3.7/3.7 |
| Sewerage | 9.9/11.4/11.4 | 10.9/11.4/11.4 | 10.7/11.4/11.4 | 10.5/11.4/11.4 |
| Roads | 13.1/51.5/79.7 | 19.8/50.7/74.7 | 21.4/47.7/66.9 | 17.7/51.5/75.4 |
| All systems | 32.0/72.8/99.3 | 40.8/71.4/95.7 | 41.6/69.1/88.4 | 38.0/71.5/96.2 |

Table 2. Percentiles 50, 95 and 99 of the infrastructure costs considering the type of lot Source: Preparation by the Authors.

| Statistics | Lots without buildings | Lots with buildings | Horizontal property | All the lots |
|---|---|---|---|---|
| Mean | 5.96 | 6.48 | 8.20 | 6.35 |
| Standard error | 0.13 | 0.14 | 0.41 | 0.09 |
| Median | 5.48 | 5.77 | 8.16 | 5.71 |
| Standard deviation | 3.21 | 3.73 | 3.42 | 3.54 |
| Minimum | -0.44 | 0.01 | 2.06 | -0.44 |
| Maximum | 25.13 | 31.51 | 17.84 | 31.51 |
| Number of lots | 567 | 758 | 68 | 1,393 |

Table 3. Statistical values of the relationship of expected gain compared to the capital incorporated for basic infrastructure. Source: Preparation by the Authors.



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infrastructure, considering the 50, 95 and 99 percentiles, depending on the type of lot.

It is seen that road networks are the system that adds most to the price, with values that reach US$51.50/ $m^2$ in 95% of the lots. Sewerage comes next, whose contribution is US$11.40/$m^2$, then electricity and drinking water, with values of US$3.70/$m^2$, and telephone with a constant value of US$3.08/$m^2$.

On dividing the cost of each system for the expected sale price of each lot, the percentage of the capital incorporated to the sale price is obtained. Figure 2 shows the relative contribution of each one of the infrastructures compared to the expected price.

Considering the 95% percentile -1,323 lots of the 1,393-, it can be indicated that the contribution of the drinking water system to the expected lot price is 1.8% or lower; that of electricity is also 1.8% -figure superimposed with that of drinking water; telephone, 2.2%; sewerage, 5.6%; and road networks reach 13.0%. The total infrastructure

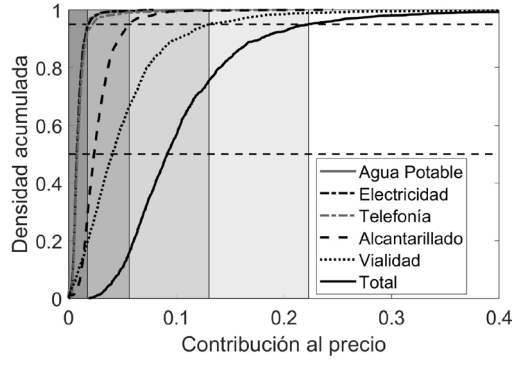


Figure 2. Percentage contribution of each infrastructure to the expected total price. Source: Preparation by the Authors.

contribution is 22.4% of the expected price, where road networks represent 53.2%; sewers, 23.0%; telephone, 9.1%; electricity 7.5%; and drinking water, 7.2%.

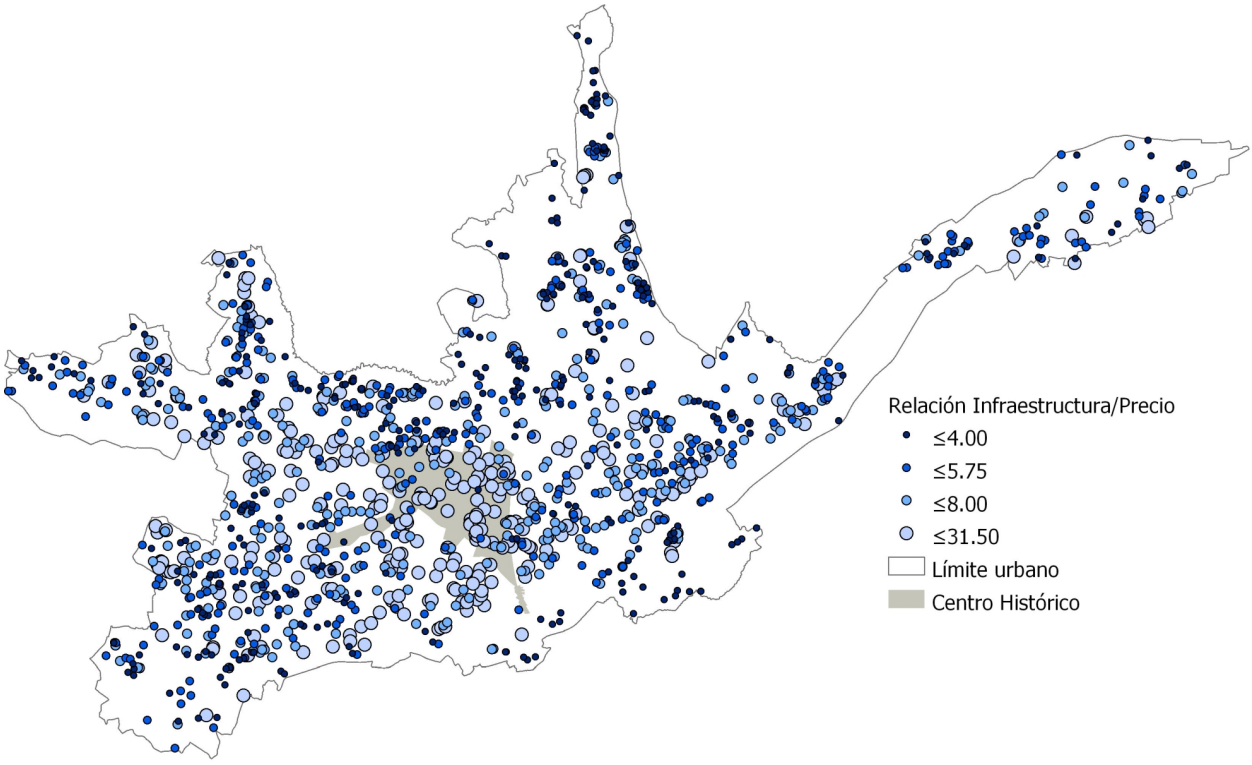


Figure 3. Spatial distribution of the relationship between the expected gain of lots and the capital incorporated in the infrastructure. Source: Preparation by the Authors.

### Capital incorporated in basic infrastructure compared to the expected gain

The expected gain was obtained from the price given by the offer minus the capital incorporated and the base land value. The statistics of the relationship between the expected gain against the capital incorporated are shown in Table 3.

In this way, the expected gain, on average, is 6.35 times more than the capital incorporated by infrastructure, which represents 635%. The maximum case identified had a figure of 3,151% of expected gain, which, without a doubt, reveals extremely high valuations. On the other hand, three lots were identified whose capital incorporated represents a higher value than the expected price, where the values of the relationship were negative. These lots correspond to ones without buildings and on sheer sites, that indicate a very high slope. These are sites that are not suitable for building, marking them out as marginal land.

Figure 3 presents the spatial distribution of the relationship between the expected gain and the capital incorporated in basic infrastructure. The categorization is based on data quartiles.

According to the image, it can be stated that, in general, a specific spatial pattern of the potential gain in the city is not evident: a heterogenous distribution is seen in the entire urban area. However, it is possible to appreciate that the highest number of relations is present in the historic hub of the city, before then falling back on approaching the peripheries.

## V. DISCUSSIONS

In Latin America, the impact of infrastructure works is more evident in the property value, due to the relative lack of lots with infrastructure, which implies an increase in the land price above the expense effectively made to provide services (Erba, 2007). From the results obtained here, it is seen that investment in infrastructure and the price expected by landowners, in several sectors of the city of Cuenca, show sizeable differences, namely, a very varied expected gain. In this way, it is determined that the values of the comparison between the expected gain and the capital incorporated by infrastructure is within the values reported by Borrero (2013), with higher expectations in commercial sectors, that reach values above 3,000%. Just like in the study of Ronconi et al. (2008), it is identified that the cost



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of providing infrastructure is substantially less than the average increase in the price expected by the owners. Even though the capital incorporated in services and land uses have an effect on the price, in this study, emphasis is only placed on the investment for infrastructure, considering that other external aspects are not direct investments made by the owner on the land. Likewise, certain services have a negative correlation compared to the sale price, for example, schools, supermarkets, pharmacies, among others (Aguirre-Núñez, Sandoval-Fernández & Alliende-Barberá, 2018).

In Cuenca, there is an important concentration of lots expecting very high values in the historic hub, possibly due to other factors involved, like land use, sociability, community, status, among others (Page, 2019), or the spatial (neighborhoods) or sectorial (specific elements) urban segregation, aspects which must be studied from a socioeconomic or cultural perspective to identify components related to materials and quality of life, just as Águila and Prada-Trigo (2020) suggest. In other sectors, there are high price lots, which can be attributed to their location vis-a-vis residential areas or commercial sectors. This information could lead to a future study to try to unravel the high asking prices, that are not solely attributable to investment for infrastructure. It is important to indicate that there is no direct explanation in most sectors about why adjoining lots have marked differences in the expected gains, which could constitute evidence of speculation, as there is no coherence between land prices, their infrastructure, and their location in the city. Sites with the same infrastructure (capital investment) are seen, although with totally different expected prices.

The disproportional increase of land price shows the need to prepare public policies in order to tax the undue transfer of wealth, through figures like the recovery of capital gains, as López Morales et al. (2019) also state, considering that property tax tends to regulate prices, as it looks to discourage speculation promoted by public works. In said sense, it would be positive that the local government undertook actions that directly impacted land speculation, like the regular publication of land value maps that reflect the reality of the market.

## VI. CONCLUSIONS

The construction of infrastructure in cities contributes to their development, but at the same time generates increases in land prices. Based on the market prices of 1,393 urban lots in Cuenca, Ecuador, and the basic infrastructure provision, this work identified the contrast between the capital incorporated in infrastructure and the gain expected by the owners.

The asking prices contained lots with and without buildings and of horizontal property. It was seen, in this context, that there is a difference between the mean prices which depends on the type of lot under consideration: for lots without buildings, the mean sales price was US$384.17/m$^2$; for lots with buildings, it was 446.88; and for horizontal property, 560.34. The mean corresponding to all the lots represents a value of US$426.89/m$^2$. These high prices, compared to the income of the Ecuadorian population, limit access to the lots on sale or even restrict access to housing, motivating the search for lots available at a lower cost outside the urban area.

Likewise, the capital incorporated in lots by each type of infrastructure -drinking water, sewerage, electricity, telephone and road networks- was determined, bearing in mind their areas of coverage and construction prices. For 95% of the lots, the basic infrastructure investment was US$71.5/m$^2$. Road networks have the highest percentage of the capital incorporated compared to other infrastructures, being followed by sewers, drinking water, electricity, and telephones.

Considering the asking price, it was determined that the capital incorporated in infrastructure represents 22.4% or less of the price for 95% of the lots. This shows that the expected gain is significant, reaching as a mean, a value that is 6.35 times the capital incorporated, and reaching extreme values of 31.51 times. Infrastructure investments made by the local government have an impact on the land value, which leads to its higher valuation. Said valuation ultimately benefits the owners or real estate developers, as these are the ones who receive said gains. Because of this, adequately identifying these capital gains can help in the decision-making regarding tax collection for contributions towards improvements.

Regarding the spatial distribution of the comparison between the expected gains of lots and the capital incorporated in infrastructure, this allowed identifying that asking prices as a result of the offer, have high expected gains, with the prices given by the land market defying logic, leaving it clear that the social behavior of the owners is strongly speculative, while the high expected price dynamic is also evident. In fact, lots with capital incorporated in infrastructure that are very similar in value are seen; however, the prices the owners ask are illogical.

It is necessary to add that, although market prices are the values expected by the owners, at the end of the deal, what was proposed initially could end up falling. However, it is seen that the prices in question are subject, without any control whatsoever, to supply and demand, and without considering the social use of urban land either. Here is where the importance lies in that the State generates policies to control the land market.



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## VII. ACKNOWLEDGMENTS

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# TRAIN STATIONS AS NODES AND PLACES:

## TRAIN STATIONS AS NODES AND PLACES: THE POTENTIAL OF TRAINS FOR TRANSIT-ORIENTED URBAN DEVELOPMENT IN SANTIAGO, CHILE[1]

ESTACIONES COMO NODOS Y LUGARES: EL POTENCIAL DEL TREN PARA EL DESARROLLO URBANO ORIENTADO AL TRANSPORTE EN SANTIAGO, CHILE

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En las últimas décadas, el tren ha jugado un rol poco relevante como elemento estructurante del desarrollo urbano en las ciudades de América Latina. Al igual que otros modos de transporte masivo, el ferrocarril puede ser objeto de estrategias que fomenten la integración del transporte público y del uso del suelo, para encauzar el desarrollo urbano hacia futuros más sustentables. Considerando que en Chile se están gradualmente reactivando servicios ferroviarios de cercanía alrededor de las principales ciudades, cabe preguntarse si el transporte ferroviario puede también aportar a formas de desarrollo urbano orientado al transporte en el contexto chileno. Así, este artículo explora precisamente el rol urbano de las estaciones y su potencial para opciones de desarrollo orientado al transporte. Enfocándose en el caso de Santiago, el trabajo analiza las estaciones a través del modelo node-place, que examina cada estación en base a su rol como nodo (es decir, a cuántos destinos permite alcanzar) y como lugar (considerando diversidad e intensidad de las actividades que se dan en sus inmediaciones). Los resultados muestran el limitado rol urbano que las estaciones ferroviarias cumplen en la capital chilena, evidenciando cierta homogeneidad respecto a los niveles de accesibilidad o a la atractividad de los entornos urbanos de cada estación. La aplicación del modelo nodo-lugar demuestra que el tren tiene un potencial no aprovechado para el desarrollo urbano de los entornos que atraviesa en Santiago y confirma el rol potencial de las estaciones como pequeñas polaridades a escala barrial y comunal.

**Palabras clave:** estaciones de ferrocarril, ferrocarriles, trenes, planificación urbana, transporte urbano

In Latin American cities, the train has played a less relevant role in recent decades as a structuring element of urban development. As with other means of mass transportation, railroads can be the object of strategies that foster the integration of public transport and land use, to guide urban development towards more sustainable futures. Considering that in Chile suburban rail services are gradually being reactivated around the main cities, it is worth asking whether rail transport can contribute to forms of transport-oriented urban development in the Chilean context as well. In this way, this article actually explores the urban role of train stations and their potential as options of transit-oriented development. Focusing on the case of Santiago, the article analyzes train stations by applying the node-place model, which examines each of them based on their role as a node (i.e., how many destinations they allow reaching) and as a place (considering the diversity and intensity of activities that take place in their vicinity). The results show the limited urban role that railway stations play in the context of Chilean capital, highlighting a certain homogeneity with respect to the levels of accessibility or the appeal of the urban environments of each station. The application of the node-place model shows that the train has an untapped potential for the urban development of the places it crosses throughout Santiago, and confirms the potential role of stations as small polarities at the neighborhood and municipal scale.

**Keywords:** railway stations, railways, trains, urban planning, urban transport

# I. INTRODUCTION

The integration of public transportation and land use is key for guiding urban development towards more sustainable futures. Strategies like transit-oriented urban development (TOD) promote the concentration of elevated densities in areas that are highly accessible when using public transportation, to guarantee a more efficient land use, allowing that the functions that generate more trips, concentrate nearby means of mass transportation, thus reducing dependence on the car (Jamme, Rodríguez, Bahl & Banerjee, 2019). Although Europe and North America have more experience in this sense (Newman & Kenworthy, 1996), the integrated planning of transportation and land use has also used in Latin American countries, for example, as a strategy to improve access to urban opportunities and to reduce existing socio-spatial inequalities (Cervero, 2013; Vecchio, Tiznado-Aitken & Hurtubia, 2020). All the current regulatory and normative frameworks do not always facilitate this integration (Suzuki, Cervero & Iuchi, 2013), some cities -Curitiba and, with less success, Bogotá- have promoted forms of transit-oriented urban development, concentrating building densities and mixed uses around new public transportation infrastructures like the bus rapid transit (BRT) corridors (Rabinovitch, 1996; Rodríguez, Vergel-Tovar & Gakenheimer, 2018).

In comparison with the BRT and unlike what has historically occurred in cities like London and Amsterdam (Haywood & Hebbert, 2008), in recent decades the train has played a less relevant role as a structuring element of urban development in Latin America. However, the train potentially has a key role in this sense, as shown in the case of Buenos Aires (Pucci, Vecchio, Bocchimuzzi & Lanza, 2019), and in some reactivation proposals, like that of San José (Pucci, Barboza & Vecchio, 2020). In Chile, rail services are in an apparently more favorable situation than in the past, and the number of passengers is increasing, especially thanks to the maintenance and the gradual reactivation of shuttle services around some large cities -Santiago, Concepción, Valparaíso and Temuco-. The suggested reintroduction of suburban type passenger services, for example, in the Santiago metropolitan area, and the promotion of existing services at a national level (Ministry of Transportation and Telecommunication [MTT], 2019), suggest that the importance of the train will increase in coming years. However, the possibility of planning the impact of rail lines in the region is affected by current planning limits, characterized by sectorial plans, non-binding between different scales, and fragmented by red tape (Katz et al., 2019).

Considering the role of railroad transportation at a metropolitan level, and the lack of integration between urban planning and mobility, it is worth asking whether the train can contribute to the forms of transit-orientated urban development in the Chilean context. This article explores the urban role of railway stations in Santiago, analyzing the relationship that active stations establish with the metropolitan mobility system, and with their immediate urban surroundings. The paper evaluates the Metrotren-Nos suburban train stations by applying the node-place model (Bertolini, 1999), that examines each one based on its role as a node -that is to say, how many destinations it can reach- and as a place -considering the diversity and intensity of activities that take place in its surroundings-. The focus on the urban stations of Santiago, subject of significant investment in recent years, allows analyzing the coordination between transportation and land uses in a scenario with limited integrated planning at a communal and metropolitan level (Vicuña del Rio, 2017). It is hypothesized that the stations of the Metrotren Nos service and some areas around the railroad still have an untapped development potential. After discussing the territorial role of railway stations, a first application of the node-place model is made in the context of Santiago, using its results to define transit-orientated urban development guidelines and thus provide an approach that is also valid for other Chilean railway lines.

# II. THEORETICAL FRAMEWORK

### THE STATION IN ITS AREA

From the perspective of transit-oriented development (TOD), stations contribute to the mobility system of an area and make its area of influence appealing, allowing increasing the number of public transport users and thus favoring the growth of new areas as well as the regeneration of existing urban ones (Cervero, Guerra & Al, 2017, cap. 7). The urban development setup around a station can take on different forms, depending on prevailing land uses, their density, and their scale of influence, which makes it possible to not just regenerate large central areas, but also reorganize low density suburban ones (Nigro, Bertolini & Moccia, 2019), or revitalize intermediate cities and reduce regional inequalities (Vickerman, 2015). However, in the Latin American context, the promotion of TOD around railway stations has been limited, being restricted to the reactivation of short railway lines such as trams -in Mendoza and in Bogota, among other cities- (Dejtiar, 2017; Quintero González, 2017).



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The double role of the station in its territory is well captured by the node-place model, which analyzes the potential of a station and its surroundings for different forms of urban development (Bertolini, 1999). The station as a node, offers a certain potential for physical human interaction, captured by the accessibility of the node, since "the more people can access it, the greater the possible interaction is" (Bertolini, 1999, p. 201). The station as a place depends on the intensity and diversity of activities performed there and around it, and represents the realization of the aforementioned potential, based on the idea that the "more activities there are, the greater the interaction that effectively takes place is" (Bertolini, 1999, p. 201).

A value is assigned to node and place components that allows giving a score to each station and, through a diagram (Figure 1), observing the situation of each station compared to others from a same line or network. Among the factors that are considered for the node function, the available railway services and the intermodality level of a station are included. Among the elements analyzed for the place function, the population that lives around the station is included, as are the services and land uses found there. Considering the performance of each station as node and place, it is possible to evaluate their urban role alongside a single line. If the node and place role are equally strong, there is a balance, but when both values are very high, a station finds itself in a "stress" situation. But if both are low, the station is "dependent" on other areas. If one component is much stronger than the other, a station can become an "unbalanced node" or an "unbalanced place". Then, the determination of the role of a station does not exclusively depend on its intrinsic features, but rather on the contrary, it is based on the comparison between the stations that serve the same area or region.

Despite having been prepared and initially applied in the Netherlands, the node-place model has shown potential for application in different settings. Literature on the subject (see the revision of Lyu, Bertolini & Pfeffer, 2016) has used the model to analyze short lines and dense domestic networks, contemplating a different radius of influence around stations based on their role and position in urban contexts or in low density surfaces -usually 400 or 800 meters for walkable urban areas, and 1500 meters for stations accessible by car- (Pucci, 2019). Successive applications of the model have elaborated more sophisticated analyses that, in sectors with substantial train use, have also managed to study station design and user experience (Caset, Derudder, Witlox, Teixeira & Boussauw, 2019). The versatility of the node-place model suggests the possibility of applying it in regions where the model has not yet had practical applications, like Chile, and where the results could strengthen the fledgling role that the train plays in mobility on a metropolitan scale.

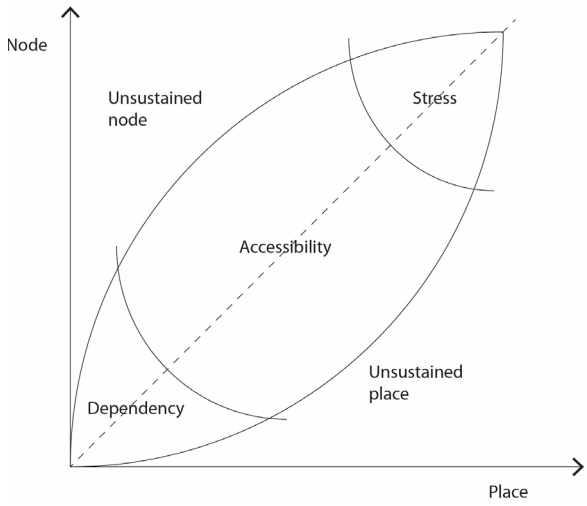


Figure 1. The node-place model. Source: Bertolini (1999, p. 202).

## III. CASE STUDY

The analysis presented, focuses on the railway stations of the Greater Santiago Southern Railway, that includes 10 stations spread over a 20-kilometer long section (Figure 2). The section in question is used by three services: a suburban service, the Metrotren Nos, which covers the section between Alameda (Estación Central) and Nos (San Bernardo) -the segment being analyzed-; a regional service, the Metrotren Rancagua, that serves the city of Rancagua and the peri-urban areas between it and Santiago; and a medium distance service, TerraSur, between Santiago and Chillán. The study addresses the urban stations of Santiago because of the availability of data, the different services, and the high number of passengers on Metrotren Nos, that transports 88% of the line's users (EFE, 2019). The stations are located in four communes -Estación Central, Pedro Aguirre Cerda, Lo Espejo and San Bernardo-, which, with the exception of San Bernardo, have a low Urban Quality of Life Index (Observatorio de Ciudades, 2019).

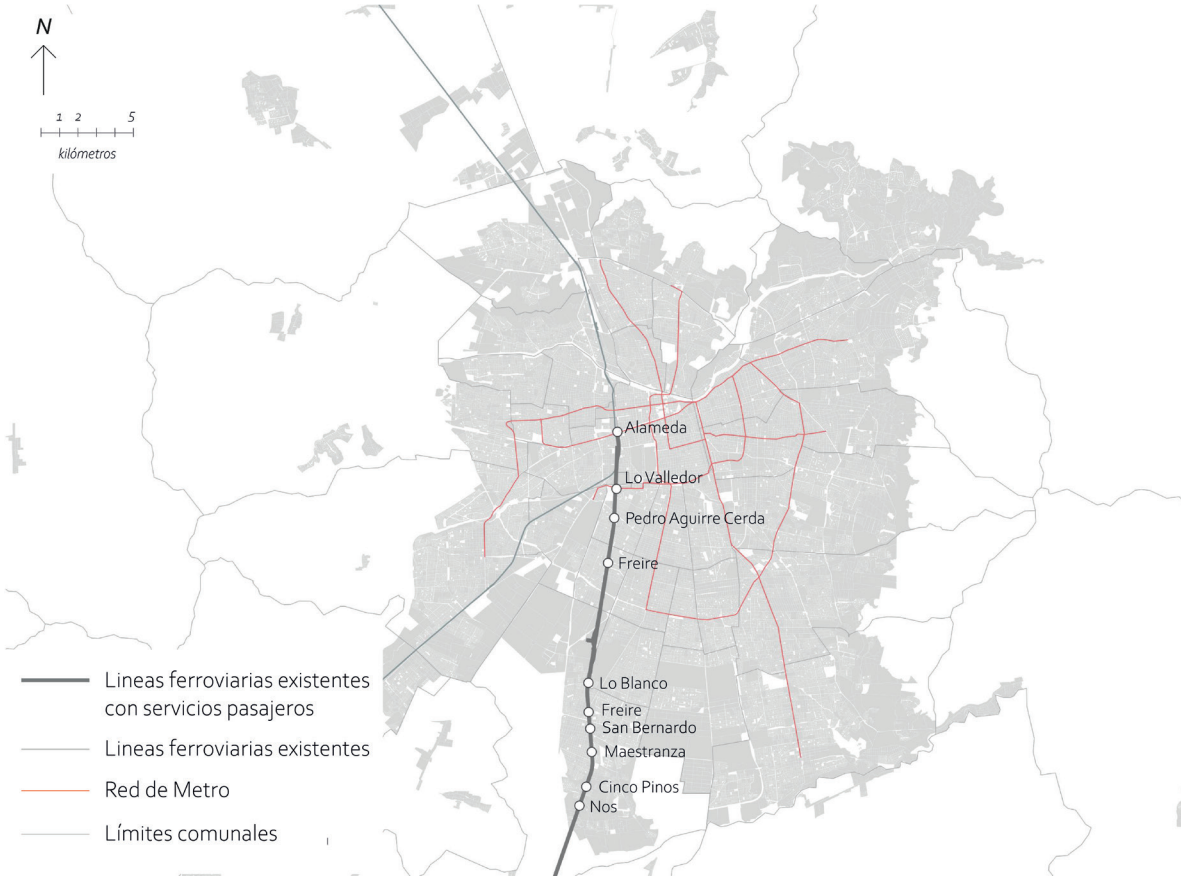


Figure 2. Stations analyzed in Santiago. Source: Preparation by the Author.



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## IV. METHODOLOGY

Bearing in mind that the stations revised are in an urban context, the indicators analyzed for the node and place functions consider an 800-meter buffer, that corresponds to a 10-minute walkable distance for urban stations (Currie, 2010). Based on indicators used in other applications of the node-place model and on the available data, the study considers five indicators for the node function and seven for the place (Table 1). These refer to available mobility offer around the stations, using public data available from EFE and the Metropolitan Public Transportation Directorate, as well as inhabitants and land uses found in their surroundings, using information from the 2017 Census and the Internal Revenue Service. The available data does not allow considering other significant elements, like intermodality with cars, or characterizing in detail the potential train users, or observing the number of employees in relevant work sectors.

Using GIS software, the number of elements there are in each station and their area of influence -length of cycle-paths, number of inhabitants per block, square meters of shops, etc.- are counted for each indicator, taking into consideration the elements within the buffer. For example, to analyze public transport, the bus stops included in the buffer are considered, and the number and frequency of lines in operation are quantified. The value of the indicator corresponds to the sum total of elements found within the area of influence. A standardization of results is made for each indicator, adjusting them in a range of 0-1. Finally, the standardized indicators are averaged, which allows calculating the role of each station as node and as place. The standardization of the scores makes it

| Dimension | Indicators for each station | Data source | References |
|---|---|---|---|
| Node | Destinations served by the train | EFE, 2020 (web page of the railroad company) | Bertolini (1999), Lyu et al. (2016), Reusser et al. (2008), Pucci (2019), Vale (2015) |
| | Railroad transportation offer (number of daily trips) | | Bertolini (1999), Caset et al. (2019), Lyu et al. (2016), Reusser et al. (2008), Pucci (2019), Vale (2015) |
| | Public transportation lines passing by the station. | DTPM, 2020 (general specification of public transportation feeds – GTFS) | Bertolini (1999), Caset et al. (2019), Reusser et al. (2008), Pucci (2019), Vale (2015) |
| | Public transportation offer (number of daily trips) | | Bertolini (1999), Caset et al. (2019), Lyu et al. (2016), Reusser et al. (2008), Vale (2015) |
| | Cycle paths (meters) | OCUC, 2019 (.shp cycle path network) | Reusser et al. (2008) |
| Place | Inhabitants | INE, 2017 (Census, microdata at a block level) | Lyu et al. (2016) |
| | Active population (15-64) | | Bertolini (1999), Reusser et al. (2008), Pucci (2019), Vale (2015) |
| | Residential surface area (meters squared) | SII, 2017 (use surface area) | Pucci (2019) |
| | Commercial surface area (meters squared) | | Pucci (2019) |
| | Industrial surface area (meters squared) | | Pucci (2019) |
| | Educational establishments | Ministry of National Assets (-shp Educational Establishments) | |
| | Healthcare services | Ministry of National Assets, 2020 (.shp Healthcare Facilities) | |

Table 1. Indicators used for the analysis. Source: Preparation by the Author.

possible to evaluate the performance of each station in comparison with others of the same line.

## V. RESULTS

### Stations as nodes

The stations analyzed play their node role differently along the railway line. Alameda and San Bernardo stations stand out due to the additional presence of mid and long distance railway services. However, the element that determines the greatest differentiation between stations is the presence of public transportation. Alameda, with a metro line and more than 40 bus routes, clearly stands out as the main node of the line. Because of the multiple combinations that it offers with public transportation and with Metro line 1, the terminal also has the highest number of passengers. Given the great differences with the other stations of the line, the decision is made to not consider Alameda Station in the node-place model, to thus more clearly appreciate the characteristics of the other stations.



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Figure 3. Population density around the stations examined. Source: Preparation by the Author based on INE data (2018).

A second group of stations, served by ten lines, is located in an intermediate position. However, it is possible to imagine that the switching of lines they have is quite limited. For example, Lo Valledor Station allows switching to Metro Line 6 at the station with the same name, but it is used just by the Metrotren Nos service. A third group of stations is served by fewer routes, probably because of their location on the outskirts. Regarding cycle paths, it has to be mentioned that these are found in some sectors, limited to the surroundings of some stations -from Alameda to Lo Blanco- and are not seen in the commune of San Bernardo. In conclusion, excluding Alameda, San Bernardo appears as the main node of the line, thanks to the railway services that stop at the station and the multiple public transportation routes that pass nearby. On the other hand, the stations located in less consolidated urban settings are weaker in this sense.

## Stations as places

In Santiago, the urban sectors the train passes through, are characterized by a certain level of similarity among them (Figure 3). These are mainly areas with a medium-low density in comparison to other areas of the city, that are at the same time characterized by a residential and, to a lesser extent, commercial purpose. The Estación Central area is also an exception in this case, thanks to the presence of universities and cultural spaces in its surrounding area. Considering the other stations of the line, most of the places analyzed are in prevailingly residential settings, with a certain presence of commercial activities, educational establishments, and even healthcare services, when dealing with older urban hubs -like the stations of San Bernardo, and to a lesser degree, Freire-. Lo Valledor stands out here as the station with a greater presence of industries around it. At the same time, the residential areas are differentiated by population density, which is higher in Pedro Aguirre Cerda and Lo Espejo. Now, the balance between the number of inhabitants and the surface areas destined to different activities means that no station stands out because of its strong vocation in the place dimension. On the contrary, the periphery stations of Nos and Cinco Pinos also turn out to be the weakest in this dimension.

## Classification of the stations

Based on the results obtained (Table 2), it is possible to classify the stations considering their role as node and as place (Figure 4). This is an evaluation that compares the stations, considering the relative role of each one. As has been mentioned, the analysis did not include Alameda Station, as this appeared as



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| Dimension | Indicators for each station | Stations | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Alameda | Lo Valledor | P. Aguirre Cerda | Lo Espejo | Lo Blanco | Freire | San Bernardo | Maes-tranza | Cinco Pinos | Nos |
| | | | | | | | | | | | |
| Node | Destinations served by the train | 3 | 2 | 2 | 2 | 2 | 2 | 4 | 2 | 2 | 2 |
| | Railroad transport – daily trips | 96 | 76 | 76 | 76 | 76 | 76 | 92 | 76 | 76 | 76 |
| | Public transportation lines that pass by the station | 39 | 14 | 12 | 12 | 9 | 13 | 12 | 8 | 4 | 4 |
| | Public transportation – daily trips | 7.944 | 1.313 | 1.067 | 1.042 | 1.185 | 1.734 | 1.671 | 1.130 | 620 | 620 |
| | Cycle paths (meters) | 2.307 | 745 | 1.220 | 1.687 | 648 | 0 | 0 | 0 | 0 | 0 |
| | Standardized score (with Alameda) | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Puntaje normalizado (sin Alameda) | - | 0,41 | 0,38 | 0,44 | 0,28 | 0,38 | 0,75 | 0,17 | 0 | 0 |
| Place | Inhabitants | 21.307 | 11.218 | 38.041 | 37.124 | 22.896 | 24.719 | 23.584 | 20.739 | 26.560 | 15.593 |
| | Active population (15-64) | 16.272 | 7.260 | 25.542 | 25.367 | 15.526 | 15.702 | 15.021 | 13.767 | 18.621 | 10.575 |
| | Residential surface area (meters squared) | 829.204 | 560.075 | 1.693.293 | 1.855.317 | 979.287 | 2.018.434 | 2.232.738 | 1.649.866 | 784.458 | 443.757 |
| | Commercial surface area (meters squared) | 807.215 | 294.087 | 91.143 | 52.393 | 96.306 | 306.981 | 466.071 | 100.119 | 12.624 | 44.786 |
| | Industrial surface area (meters squared) | 261.147 | 266.820 | 37.133 | 9.090 | 24.127 | 42.762 | 59.057 | 117.324 | 40.332 | 23.474 |
| | Educational establishments | 7 | 2 | 8 | 11 | 8 | 21 | 27 | 20 | 5 | 3 |
| | Healthcare services | 1 | 0 | 3 | 0 | 2 | 4 | 3 | 0 | 0 | 0 |
| | Standardized score (with Alameda) | 0,66 | 0,33 | 0,63 | 0,61 | 0,32 | 0,52 | 0,58 | 0,43 | 0,35 | 0,14 |
| | Standardized score (without Alameda) | - | 0,24 | 0,57 | 0,44 | 0,3 | 0,62 | 0,68 | 0,38 | 0,18 | 0,06 |

Table 2. Results for each indicator and scores of each station. Source: Preparation by the Author.



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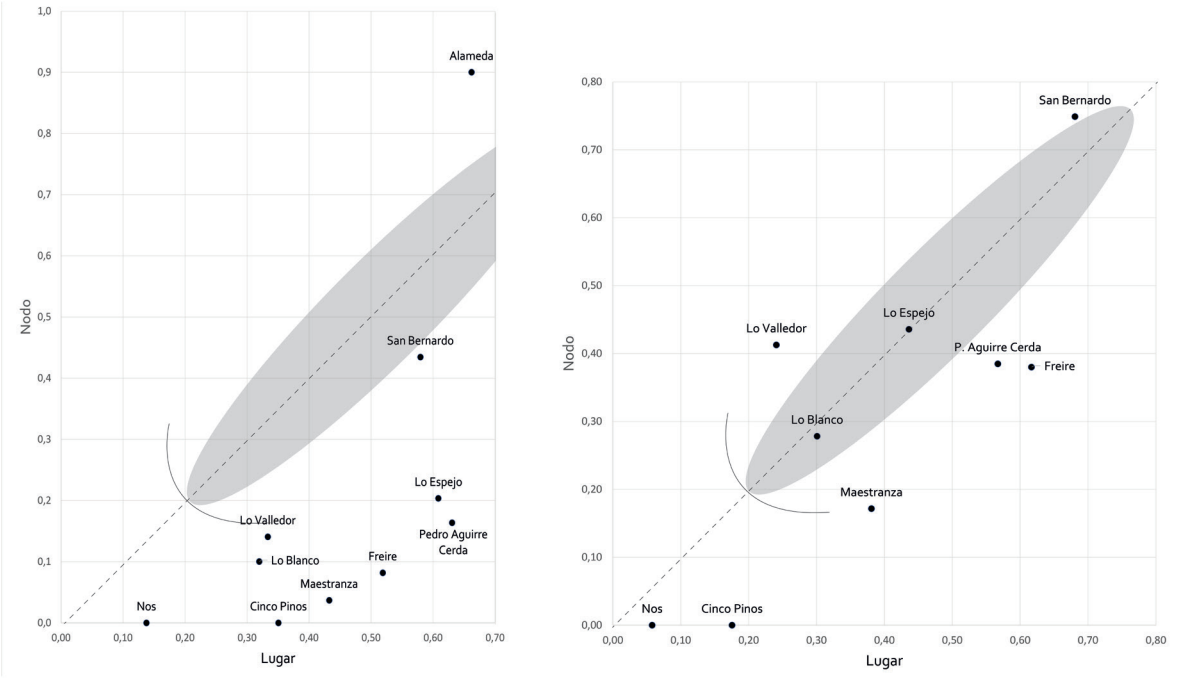


Figur3 4. Results of the node-place model (left: with Alameda; right: without Alameda). The stations in a balanced condition are shown. Source: Preparation by the Author.

an extremely strong node compared to the other contexts examined.

In the framework of the methodology used, it was possible to recognize the following station typologies along the line:

***Balanced stations.*** These are contexts where the role of node and place is balanced. This is the case of Lo Espejo and Lo Blanco, where both functions are balanced, although with a relatively low intensity.

***Dependent stations.*** These are weak contexts as nodes and as places, which are characterized by the relative lack of available mobility alternatives, and by a lower intensity of land use. On the line examined, this corresponds to Nos and Cinco Pinos, which share a periphery location on the outskirts of the urban area of Santiago.

***Unbalanced places.*** These are stations, whose role as place is stronger than their role as node. They are in contexts with relatively high housing densities and with large surfaces destined to trade or industry. In comparison with other stations, they perform a weaker role as node, due to the frequency of the train services and the public transport lines that pass by them. On the line examined, the imbalance is stronger in Maestranza, while Pedro Aguirre Cerda and Freire have a stronger role as nodes and are closer to a balanced condition.

***Unbalanced nodes.*** These are stations, whose role as node is stronger than their role as place. This is the case of two stations: Lo Valledor, the only station with a connection to the Metro; and San Bernardo, which, due to its importance on the line, ends up having high levels of accessibility and is located in a dense context, although a prevailing residential and commercial one.

The analysis does not show stations belonging to another typology individualized by Bertolini (1999), that is to say, ***stations under stress*** -with a high performance as node and as place, that determines a number of potential users that exceeds the current capacity of the station-; compared with the stations analyzed, this could be the condition of Alameda.

# VI. DISCUSSIONS.

### The station as an object of urban policies

The application of the node-place model allows observing the limited urban role that railway stations have in the Santiago context. On being a line with a restricted length that crosses



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Figure 5. Barren lands around the studied stations. Source: Preparation by the Author.

similar contexts in terms of densities and urban roles, the analysis does not show major disparities regarding accessibility levels or the appeal of the urban settings. Despite offering a similar service -in terms of frequency- to the Metro network, around the railway stations there does not seem to have been land valuation or densification processes like those generated by said network (López-Morales, Sanhueza, Espinoza & Órdenes, 2019). In this way, a potential urban development around the stations is seen and to take advantage of it -promoting forms of TOD- the application of the node-place model can contribute to defining intervention guidelines referring to each station typology and to planning, in broad terms.

Regarding the stations, in general it is possible to propose a strengthening of their role as node and as place along the entire line, considering the relatively low scores that also characterize the balanced stations, except for San Bernardo. The dependent stations can be prioritized, from this perspective, promoting new balanced developments -whether residential or not- that are benefitted from the accessibility offered by the train, concentrating in their surroundings land uses that can generate or attract an elevated demand of mobility and that can functionally be integrated with the railway (Vale, 2015). Regarding the stations identified as unbalanced places, for example Maestranza, it is necessary to strengthen their value as node through a multimodal approach (Nigro et al., 2019), namely increasing the possibility of switching through greater and more frequent public transportation routes, and facilitating intermodality at a local scale, through the creation of cycle paths to the stations. Following this logic, promoting densification may generate greater benefits in the unbalanced nodes -Lo Valledor, San Bernardo-, thanks to the good amount of public transportation already in place (Lyu et al., 2016).
In addition, it is possible to develop proposals or specific stations that have positive effects for others too. For example, establishing stops for all the services at Lo Valledor station could strengthen its role as a switching lines node and also reduce the pressure on Alameda, today the only place to switch to the Metro for those living outside Santiago.



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The node-place model also motivates broader considerations about urban and metropolitan scale planning. Considering the levels of accessibility that the railway service and its integration with the public transportation network guarantees, including two metro lines that head to the east of the city, it is possible to promote balanced forms of densification (Vicuña del Rio, 2020) around the stations. There are areas around the railway line that could increase their density, as well as barren sites that be used for new developments (Figure 5). In this vein, it can likewise be proposed to build new stations in locations where an elevated presence of inhabitants and/or future appealing activities are projected. Although the metropolitan planning limits and the lack of coordination between land and transport uses complicate the implementation of an integrated strategy in the current Santiago planning context (Vicuña del Rio, 2017), it would be good to prepare intercommunal plans that coordinate the new developments around stations (Katz et al., 2019). Likewise, it would be relevant to introduce mechanisms to capture the gains generated, to finance public transportation (Mathur, 2019) or other urban regeneration projects (Ruiz-Tagle, Labbé, Rocco, Schuster & Muñoz, 2019).

Finally, the results of the analysis suggest considering the design and management of the stations, thinking about them not just as places of transit, but also as relevant destinations in themselves. For this reason, the quality of station spaces is equally important to foster train use (Pucci, 2019). As the French program to make "open stations" shows (SNCF, 2018), station spaces can be (re)used for coworking, to house associations, for commercial activities, and for basic services. This allows strengthening stations as small neighborhood and communal scale polarities, to improve the limited access to basic services that some peripheral areas of Santiago have today, and to contribute towards increasing the opportunities available on a local scale.

## VII. CONCLUSIONS

The application of the node-place model to Santiago's railway stations shows that the train has an untapped potential for the urban development of the contexts it crosses. The distribution of inhabitants, land uses and the organization of the urban mobility system show that the setting of stations could house forms of transit-oriented urban development, considering that few stations have a balanced situation and their role, be it as node or as place, reveals room for improvement. Likewise, the results show the consequences of the lack of integration between land use and transportation planning, at a metropolitan and municipal level (Vicuña del Rio, 2017). The stations have not been subject of a coordinated planning strategy that, along the line, would recognize the potential of the areas around the train and give a clear role to each station, making their surroundings appealing and improving their connectivity (Cervero et al., 2017). This is shown by the Lo Valledor station that, despite its strong role as a node, it is not served by all the trains passing through, or that of Nos and Cinco Pinos, whose marginal position weighs more than their high accessibility and ends up assigning them as dependent stations, and even those of Maestranza, Freire and Pedro Aguirre Cerda, weak nodes despite the appeal of their surroundings. Facing this scenario, a greater coordination at a metropolitan level between public transportation authorities and regional planning entities could facilitate the strengthening of the line and of its urban stations, through better connections with their possible area of influence (Katz et al., 2019). However, the communal planning also shows significant limitations, since greater densities are not found around stations, unlike what is seen along Santiago's Metro line, and also, within the commune itself, the stations end up performing a different role despite finding themselves in settings with similar characteristics. To sum up, the limitations observed in other Latin American settings are confirmed, related to the regulatory frameworks for the integrated planning of transportation and land uses (Suzuki et al., 2013).

The distribution of inhabitants, land uses, and the organization of the urban mobility system show that the station's surroundings could be subject to initiatives that encourage transit-oriented development. The results of the analysis show that there is still room to maximize the benefits of the high accessibility guaranteed by the train, whether through forms of balanced densification (Vicuña del Rio, 2020) or through the promotion of new local centralities. These initiatives require profound changes in urban planning and mobility in Santiago, as the case of the intense real estate development around Santiago's Metro stations (López-Morales et al., 2019) shows, contrary according to the results, but similar in terms of lack of planning. In this sense, the application of the node-place model allows a first reading of the role that the stations perform and could perform in the region. The model applied here to the urban stations of Santiago could be a relevant analytical tool for other railway lines in the country and in other Latin American contexts that are reactivating their railroads, especially in the case of new services which, from their entry, could contribute to guiding the development of the areas they pass through.

## VIII. ACKNOWLEDGMENTS

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# RESILIENT URBAN DESIGN IN THE FOOTHILLS OF SANTIAGO?

## CONTRAST OF COMMUNAL SCENARIOS WITH SEISMIC RISK DUE TO THE SAN RAMÓN FAULT[1]

¿DISEÑO URBANO RESILIENTE EN EL PIEDEMONTE DE SANTIAGO? CONTRASTE DE ESCENARIOS COMUNALES CON RIESGO SÍSMICO FRENTE A LA FALLA SAN RAMÓN

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Santiago ha experimentado en sus últimas décadas un aumento considerable de áreas urbanizadas en el piedemonte de su borde oriente, donde además se localiza la Falla San Ramón (FSR), de modo que se ha vuelto un nuevo escenario de riesgo geológico. Usando incuestionables atractivos sobre el medio natural, la vista panorámica a la ciudad y un ambiente saludable, se han promocionado proyectos de vivienda de alto costo que conviven con este riesgo sísmico, pero que parecen desestimarlo desde los instrumentos de planificación de nivel comunal y metropolitano. El presente artículo tiene por objetivo explorar las condiciones de diseño urbano que presenta el piedemonte de Santiago para enfrentar la presencia de la Falla San Ramón (FSR), mediante un análisis de contraste de dos sectores específicos localizados dentro de la franja de potencial ruptura superficial (buffer) de la FSR -distrito urbano Hospital de Carabineros en Las Condes y distrito urbano El Peral en Puente Alto- y su forma de articularse con el medio natural y con el medio construido, incluyendo la presencia de infraestructura crítica. Metodológicamente, se aplica un enfoque mixto a través de una matriz de análisis de elementos de diseño urbano que incluye tres ámbitos de acción -construido, natural y normativo- para identificar situaciones críticas de los sectores estudiados, donde se ve elevada o disminuida la respuesta resiliente. Se concluye que contrastar experiencias de diseño urbano en condiciones extremas respecto al riesgo sísmico es ilustrativo, tanto para permear las capas operativas de gestión de riesgo, como normativas comunales y metropolitanas, como para asumir el piedemonte de manera resiliente, reconociendo la Falla San Ramón como un nuevo criterio basal de diseño urbano.

**Palabras clave:** diseño urbano, resiliencia, riesgo sísmico, Falla San Ramón.

In recent decades, Santiago has seen a substantial increase in urbanized areas along its eastern foothills, where the San Ramón Fault (FSR) is also located. This has become a new geological risk scenario. Using the unquestionable appeal of the natural setting, the panoramic view of the city, and a healthy environment, luxury housing projects have been promoted that coexist with this seismic risk, something that seems to have been disregarded by communal and metropolitan planning instruments. The purpose of this article is to explore the urban design conditions on Santiago's foothills to face the San Ramon Fault, through a contrast analysis of two specific sectors located within the potential buffer of the San Ramón Fault - the urban districts of Hospital de Carabineros in Las Condes and El Peral in Puente Alto - and the way these articulate with the natural and built environments, including critical infrastructure. Methodologically speaking, a mixed approach is applied through an analysis matrix of urban design elements that includes three areas of action - built, natural and regulatory - to identify critical situations in the areas studied, where the resilient response is either high or low. It is concluded that contrasting urban design experiences under extreme conditions regarding seismic risk is illustrative, both for permeating the operational layers of risk management such as communal and metropolitan regulations, and to consider the foothills in a resilient way, recognizing the San Ramón Fault as a new base criterion of urban design.

**Keywords:** urban design, resilience, seismic risk, San Ramon Fault



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# I. INTRODUCTION

According to a 2014 ranking prepared by the United Nations University (UNU, 2014), Chile is among the top 10 countries for natural threats, and because of this, "its consequences appear in dimensions and on scales that impact the entire society and affect the country's development" (National Development Innovation Council [CNID], 2016, p.1). The great impact Chile endured as a result of the tsunami caused by 8.8 Mw earthquake in 2010, is an example of this (Vargas et al., 2011), and demands revising how to plan and live in our cities, with their relationship with the coastline, central valley, and mountain ranges, being among the most important areas in this sense.

In particular, Santiago in recent decades has seen a considerable increase of urbanized areas in the foothills along its eastern border, where the San Ramón Fault is located. Nowadays, quality scientific knowledge has been gathered about the San Ramón Fault that allows warning about its geological danger and risk (Easton, Inzulza, Pérez, Ejsmentewicz & Jiménez, 2018). However, luxury housing projects have been promoted, which appeal to the unquestionable attraction of the natural environment, the panoramic view of the city, and a healthy landscape, and coexist alongside this seismic risk. This though seems to have been overlooked in the planning instruments at a communal and metropolitan level.

The purpose of this article is exploring the urban design conditions that Santiago's foothills have, to counter the risk of the San Ramón Fault (SRF), by comparing two specific sectors located within the potential buffer zone of the SRF, - the Hospital de Carabineros urban district in Las Condes and the El Peral urban district in Puente Alto -, and their way of articulating with the natural and built environment, including the presence of critical infrastructure.

The article is divided into 5 parts. First, a theoretical framework is presented with the key concepts of resilient urban design and its connection to the built and natural environment. Then the proposed methodology, comprising an analysis matrix of urban design elements that includes three areas of action -built, natural and regulatory- is explained, which are then applied in the third section, along with the identification of critical situations. The results identify two at risk sectors of the communes of Las Condes and Puente Alto, which are compared to understand how the resilience response increases or decreases on facing this type of seismic risk. Finally, conclusions are provided about the importance of acknowledging the San Ramón Fault in urban regulations, and its incorporation as a new base criterion for urban design.

# II. THEORETICAL FRAMEWORK

## Resilient urban design in inhabited areas of the 21st century

A resilient city is one that is "capable of resisting and quickly recovering from human, social, and environmental risks, minimizing the impact and vulnerability of its citizens" (UN-HABITAT, 2018). Urbanism and resilience have become ever closer to each other as the years have gone by. Urbanism, on one hand, seeks its pragmatic side through urban design and, prior to this, in civic design, while resilience has been transformed in the performance of urban reconstruction and transformation strategies of recent decades, not just to face post-disaster events anymore, but also as a means of permanent action that is transferred to their communities.

This form of resilient action can be found in most international and domestic agreements on strategic urban development and sustainability. The 2016 New Urban Agenda points to the premise of strengthening resilience in cities to reduce the risk and impact of disasters as a priority action (United Nations, 2017), also defining six key concepts to promote in urban development: namely a compact, inclusive, participative, resilient, safe and sustainable city. These concepts are also linked with what was expressed in the new 2030 Agenda for Sustainable Development from 2017 in a broad sense and, in particular, with what was outlined in its ninth goal that seeks "to build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation" (United Nations, 2018, p. 43).

Chile's National Urban Development Policy of 2014 establishes twelve basic notions to achieve sustainable cities and quality of life, where resilience plays a central role. Among those outlined to reach environmental balance, it states "considering natural systems as an essential backbone in the planning and design of interventions in the region" (Ministry of Housing and Urbanism [MINVU], 2014, p. 47). Likewise, the recently launched National Policy for Disaster Risk Reduction, outlined in five priority lines, contributes with a differentiated view about the country, with the third, "Planning and investing in disaster risk reduction for the sake of resilience", standing out (National Emergency Office [ONEMI], 2020, p. 37).

In this way, it is possible to predict that urban development and resilience to foster a sustainable quality of life, are clearly merged in the official agendas, with a systemic view of the regions at risk that, at the same time, show a high vulnerability today.



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| Units of analysis | Concepts / conditioning factors | Elements / components |
|---|---|---|
| Built Aspect | Civility / Urbanity | Community. Collective and public spaces. |
| | Character / Beauty | Landscape. Building.. |
| Natural Aspect | Sustainability / Harmony | Geology. Geomorphology. Risks. Fluvial networks. Forest systems. |
| Interface Aspect | Fluency / Legibility | Urban signs. Public spaces. Mobility networks. |
| Regulatory Aspect | Diversity | Density. Regulatory. Manuals. |
| | Profitability | Investment plan. Execution. Feasibility. |
| | Adaptability / Flexibility | Impact assessment. Projection. |

Table 1. Units of analysis, concepts, and components of the inhabited region. Source: Preparation by authors based on EP&HC (2007).

### The natural, built and regulatory scenario, as a sphere of action

Urban design can build a suitable response strategy for city and town reconstruction, if its core concepts and development stages are considered when building neighborhoods, including the civic attitude of their residents and their cultural practices or assets (Moser, Sou & Stein, 2011). In this line, the "Urban Design Compendium" of the United Kingdom allows obtaining a summary of key actions that should be incorporated in all urban recovery proposals, like promoting spaces for people; integrating the natural and built landscape; providing the urban shape and its mixed uses; managing the investment and production; and designing to provoke changes (English Partnerships & Housing Corporation [EP&HC]. 2007). In a broader overview of these actions, Table 1 connects the analysis units with the classic civic and urban design concepts and elements, to take on a resilient attitude in the inhabited landscape and, from there, to address the foothill region, focus of this research.

Concepts like civility and beauty are key to understanding the built environment of inhabited areas, with respect to communities and the relationship with their collective spaces and ways of living expressed in residential morphology and typology. The effects and the projection that new housing typologies or intercommunal scale facilities generate within a residential unit must be measured (Allan & Bryant, 2011). Meanwhile, the natural environment brings together as a key conditioning factor, the sustainability and harmony of the landscape, including the types of risks, as well as the fluvial and forest systems that ultimately, constitute design elements of the landscape. The "intermediate" or interface space is located within these environments, linking the natural environment with the built one, like Santiago's foothills. These have been transformed into a challenging area given the presence of a potential buffer of the San Ramón Fault, associated to large inhabited sectors and critical urban infrastructure.

As can be seen, an adequate articulation between natural and built environment, by means of fluency between these aspects, will guarantee the best performance of systems that are sought to be reconfigured, regenerated or rebuilt and, as a result, a suitable understanding of the area.

Finally, the regulatory aspect defines the diversity and profitability of a master plan or another type of regulatory planning tool, which can to be adapted in time. It is in this way, that it is crucial to incorporate the components of the inhabited area that arise from urban design in every urban development plan proposed that seeks to recover or renew cities and inhabited areas in a sustainable way. So, a "resilient urban design" is required as an articulator or interface aspect between built and natural environments that includes the relationships of people and their places; their mobility and the urban form; nature; and of course, the development of suitable public spaces from the point of view of their use, maintenance and the balance with their immediate surroundings (Moughtin, 1999).

## III. CASE STUDY

### The San Ramón fault as a seismic risk in the Santiago foothills

The San Ramón Fault is located along the foothills of the Los Andes Mountain Range in Santiago, the capital of Chile and its Metropolitan Region (Metropolitan Ministerial Secretariat of Housing and Urbanism [SEREMI-MINVU], 2012b). The fault has been surveyed on the surface, specifically between 33°19' and 33°37' latitude south (Figure 1). Geologically speaking, the San



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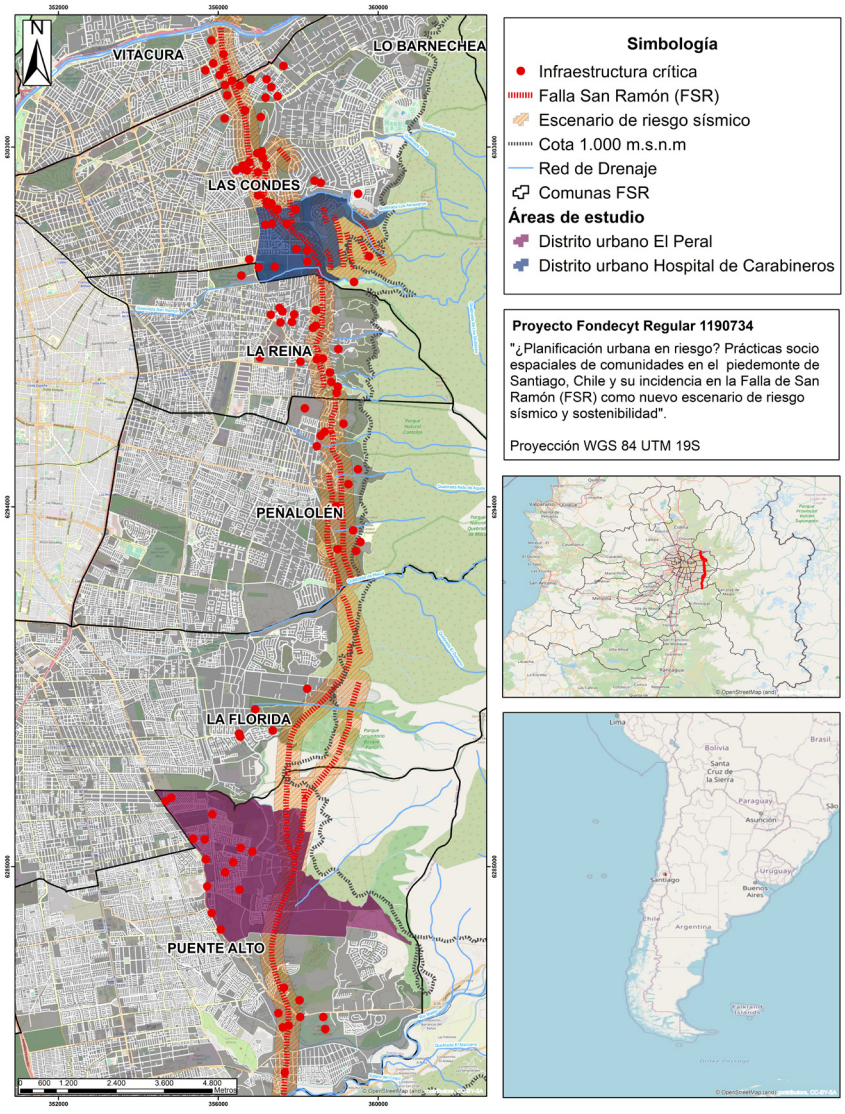


Figure 1. San Ramón Fault and the urban districts under study. Source: Preparation by the Authors based on SEREMI-MINVU (2012a, p. 121), INE (2017) and Curihuinca (2020).



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Ramón Fault is a structure with reverse behavior, that mounts the rocks of the mountain face on the sediment of the central depression and that presents the possibility of generating an earthquake with a surface rupture.

The probability that the San Ramón Fault has of generating a major physical disaster in the Santiago foothills is conditioned by its surface rupture as a risk area, where its so-called 300-meter wide buffer is identified. This buffer, outlined as the seismic risk scenario in Figure 1, was determined based on the structural and morphological observations established in the "San Ramón Fault PRMS Modification and Risk Study. ID N° 640-27-LP10", and specifically graphed in the "Report Stage 2, Analysis of prospection and test results" (SEREMI MINVU, 2012). There it is indicated that, "considering the transversal length of the fault scarps shown in Armijo et al. (2010) and Rauld (2011), and given that the scarps show different degrees of erosion, that have made its morphology fall back, in this study a potential range of influence was considered associated to surface ruptures of the SRF of 300 m; 100 m towards the face of the fault (west); and 200 m facing behind it (east), for the purpose of evaluating the associated hazard" (p. 28).

Regarding its periodicity, Easton et al. (2018) clarify that "geological evidence has shown that the SRF is capable of

| Communes | 0 to14 años | 15 to 64 años | 65 and over | Total | % |
|---|---|---|---|---|---|
| Vitacura | 2.191 | 6.971 | 1.488 | 10.650 | 7,0 |
| Las Condes | 10.967 | 41.859 | 8.132 | 60.958 | 40,0 |
| La Reina | 2.506 | 7.928 | 1.042 | 11.476 | 7,5 |
| Peñalolén | 4.559 | 13.373 | 965 | 18.897 | 12,4 |
| La Florida | 2.794 | 6.833 | 416 | 10.043 | 6,6 |
| Puente Alto | 11.640 | 27.136 | 1.508 | 40.284 | 26,4 |
| Total | 34.657 | 104.100 | 13.551 | 152.308 | 100,0 |
| % | 22,8 | 68,3 | 8,9 | 100,0 | |

Table 2. Population affected by the San Ramón Fault by age group in the census areas. Source: Preparation by the Authors based on INE – National Statistics Institute (2017) and Curihuinca (2020).

| Analysis units | Concepts / Conditioning factors | Elements / Components | Resilience Indicators |
|---|---|---|---|
| Built Aspect | Civility<br>Urbanity | Community | Total district population.<br>Population density.<br>Predominant socio-economic level. |
| Natural Aspect | Sustainability | Landscape risks | Maximum distance to the SRF potential buffer.<br>Minimum distance of critical infrastructure to the SRF.<br>Fluvial and forest systems. |
| Regulatory Aspect | Diversity | Density<br>Investment Plan<br>Execution<br>Feasibility | Housing type<br>Zoning or land use. |
| | Profitability | | Overcrowding.<br>Average assessed and commercial value. |
| | Adaptability | Impact assessment | Critical infrastructure. |

Table 3. Resilient urban design analysis matrix for the San Ramón Fault (SRF) buffer. Source: Preparation by the Authors based on INE (2017); CNDU (2020); Curihuinca (2020).

accumulating tectonic stresses and producing, by itself, major earthquakes, with two large magnitude events (circa 7.2-7.5 Mw) having taken place in the last 17,000 years, the last around 8,000 years ago" (p. 4). Considering the recurrence of the SRF, the possibility of a new activation with surface rupture potential is estimated at around 3% within the next 100 years, an estimation made without statistical basis, but based on paleo-seismological and geological observations that evidence the active nature of this fault (Vargas et al., 2014; Easton et al., 2018).

Now, at a level of the direct area of affectation, and considering the figures of the 2017 Census based on the outlined census areas, there are six communes along the San Ramón Fault, namely Vitacura, Las Condes, La Reina, Peñalolén, La Florida, and Puente Alto, with an affected population of 152,308 people (Table 2), which represents 2.1% of the total population of the Metropolitan Region of Santiago (7,112,808 people), and 9.2% of the total population of the six aforementioned communes (1,649,630 people).

At a communal level, a dissimilar panorama is seen, where two communes have the highest number of people (101,242), representing 66.4% of the total population affected by the San Ramón Fault buffer. Las Condes, with 60,958 inhabitants, and Puente Alto, with 40,284, figures that represent 40.0% and 26.4%, respectively. In age terms, both communes, Las Condes and Puente Alto, show a similar population percentage of under 14s. However, they differ regarding the older age groups of between 15 and 64, and 65 and over, where Las Condes almost doubles the 15-64 group, with 41,858 inhabitants, compared to Puente Alto with 27,136.



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| Analysis unit | Concepts/ conditioning factors | Elements/ Components | Resilient urban design | | |
|---|---|---|---|---|---|
| | | | Resilience indicators | Hospital de Carabineros Urban District | El Peral Urban District |
| Built Aspect | Civility Urbanity | Community | Total district population | 19,085 inhabitants | 31,212 inhabitants |
| | | | Population density | 4,438 Inhab/km$^2$ | 2,856 Inhab/km$^2$ |
| | | | Predominant socioeconomic level**6** | D | C2 |
| Natural Aspect | Sustainability | Risks | Maximum distance to SRF buffer | 1.1 km | 2.8 km |
| | | | Minimum distance of the critical infrastructure to the SRF buffer | 30 meters | 1.05 km |

Table 4. Analysis matrix of Hospital de Carabineros (Las Condes) and El Peral (Puente Alto) urban districts. Source: Preparation by Authors based on INE (2017), Internal Revenue Service [SII, in Spanish] (2020), GOPLACEIT (2020) and Growth Form Knowledge [GfK] (2019).

## IV. METHODOLOGY

This research considers a mixed approach with quantitative and qualitative methods gathered using an analysis matrix of the urban design elements that includes three areas of action -built, natural and regulatory- that allow identifying critical situations with inhabited sectors, where the resilience response increases or decreases on facing the seismic risk that the San Ramón Fault represents. This analysis matrix, presented as Table 3, also combines the concepts/ conditioning factors and the elements/components of the inhabited area of Table 1, as units of analysis, and adds urban quality of life and resilience indicators which have been chosen and reinterpreted from three main sources: 2017 Census (INE, 2017), Chile's National Urban Development Council (CNDU, 2020), and the collection of data taken from the Fondecyt Regular N° 1190734 project.

For the application of these resilience indicators, two specific sectors where there is a larger population affected by the buffer were chosen. These are represented by the communes of Las Condes and Puente Alto, and within them, by the urban districts, Hospital de Carabineros and El Peral, respectively, as shown above in Figure 1. In this sense, the research supposes as a base condition, the vulnerability of said urban districts on being located on an area of high risk of the San Ramón Fault being activated. In this way, these districts are analyzed from their socio-spatial compositions, using georeferenced planimetry with data from the 2017 Census (INE, 2017).

## V. RESULTS & DISCUSSIONS

### Comparison of two communal scenarios with seismic risk

Table 4 presents an analysis matrix that allows comparing two of the most demanded communal settings, selected as case studies.

Regarding the total population affected, the Hospital de Carabineros urban district has fewer inhabitants, 19,085, than the El Peral urban district with 31,212. However the former, located in Las Condes, is a sector with a high population density, 4,438 inhabitants per km$^2$, classified as socioeconomic group D. Meanwhile, the El Peral urban district in Puente Alto, is formed as a less dense area, but one which in recent years has seen an important real estate growth, dominated by the morphology of gated communities for the medium-high socioeconomic level (C2). On comparing this information with Table 2, regarding age groups**7**, both sectors have a similar population percentage of the under 14s -18.4% for Hospital de Carabineros district, and 21.2% for

6 C2 and D are 2 of the 7 socioeconomic groups classified by the Chilean National Automotive Association (ANAC, in Spanish) and the Market Researchers Association (AIM, in Spanish), based on national public statistics. Available at https://www.anda.cl/wp-content/uploads/2019/05/GfK_GSE_190502_FINAL.pdf.

7 It is important to state that the available data of the age groups from the 2017 Census has a partial coverage for both districts, with 0.9% and 3.1% of the age groups undetermined, for the Hospital de Carabineros and El Peral urban districts, respectively.



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| Analysis Unit | Concepts / Conditioning Factors | Elements / Components | Resilient urban design | | |
|---|---|---|---|---|---|
| | | | Resilience indicators | Hospital de Carabineros urban district | El Peral urban district |
| Regulatory Aspect | Diversity | Density<br>Investment Plan<br>Execution<br>Feasibility | Type of housing | 2,735 Houses<br>2,753 Apts.<br>134 Other | 9,155 Houses<br>536 Apts.<br>44 Other |
| | | | Zoning or land use | Housing<br>Commercial | Residential<br>Facilities |
| | Profitability | | Overcrowding | 1.9 | 2.2 |
| | | | Average assessed value | 17,573 UF | 1,700 UF |
| | | | Average commercial value | 13,906 UF | 4,796 UF |
| | Adaptability / Flexibility | Impact Assessment | Critical infrastructure | 16 points<br>Health<br>Sports<br>Worship<br>Infrastructure<br>Education | 15 points<br>Commercial<br>Education<br>Health |

Table 5. Analysis matrix of the Hospital de Carabineros (Las Condes) and El Peral (Puente Alto) urban districts. Source: Preparation by Authors based on INE (2017), SII (2020) and GOPLACEIT (2020).

El Peral-, the data differs for the over 65s, where the Hospital de Carabineros district doubles that of El Peral, with 12.4% or 2,338 inhabitants, compared to 6.5% or 1,963 inhabitants. The situation shown, without a doubt affects the mobility conditions of the sectors involved, on facing an eventual evacuation generated by the activation of the San Ramón Fault.

At a risk level, it is north urban district of Hospital de Carabineros that lives, to a certain extent, with a higher seismic risk, on actually lying on top of the San Ramón Fault's buffer (1.1 km). Within this sector, there is an important road network with streets like Paul Harris and Vital Apoquindo that connect a large part of the "sloped" commune (see Figure 2, images of the urban surroundings). For the case of the southern urban district of El Peral, the highest risk from the buffer is located at a greater distance of 2.8 km from the most urbanized area, with the presence of Camilo Henríquez Ave. which intersects with Gabriela Oriente, El Peñón and El Peral, as crossroads for a possible evacuation (see Figure 3, images of the urban surroundings).

As for communal facilities, both urban districts have important intercommunal infrastructure, like the Carabineros Hospital (DIPRECA) in Las Condes, and the emblematic El Peral Psychiatric Hospital in Puente Alto. For the former, the Hospital is located 30 meters from the SRF buffer, while the El Peral Hospital is a little over a kilometer from it. This situation of great contrast and disparity is one of the essential elements that determine the resilience capacity of each urban district, with a lower articulation for the northern sector of Las Condes.

## Resilient urban design from a regulatory point of view

Typologically speaking, the Hospital de Carabineros northern urban district comprises a similar number of homes and apartments, 2,735 and 2,753, respectively (Figure 2), while in the El Peral southern urban district houses outnumber apartments, 9,155 to 536 (Figure 3). The latter has an influence on the way this type of structure responds when facing a possible earthquake generated by the San Ramón Fault, being able to worsen the situation for the El Peral urban district, on considering both the higher number of dwellings -three times more than the Hospital de Carabineros urban district-, and the overcrowding factor that the southern urban district has compared to the northern sector one, 2.2 to 1.9. Both cases allow a mixed use, mainly represented by that of the houses or residential use, the commercial use -for the northern district- and that of facilities -southern district-.

In both districts under study, risk areas are identified from the Communal Zoning Plans (PRC, in Spanish) of Las Condes -modified by Decree 173/2010-, and Puente Alto -modified by Exempt Decree 423/2003-. However, most of these risks are associated to the type of landslide in the foothills' gorges. In particular, the local PRC ordinance of Las Condes does not outline in its zoning, areas restricted by natural risk, while


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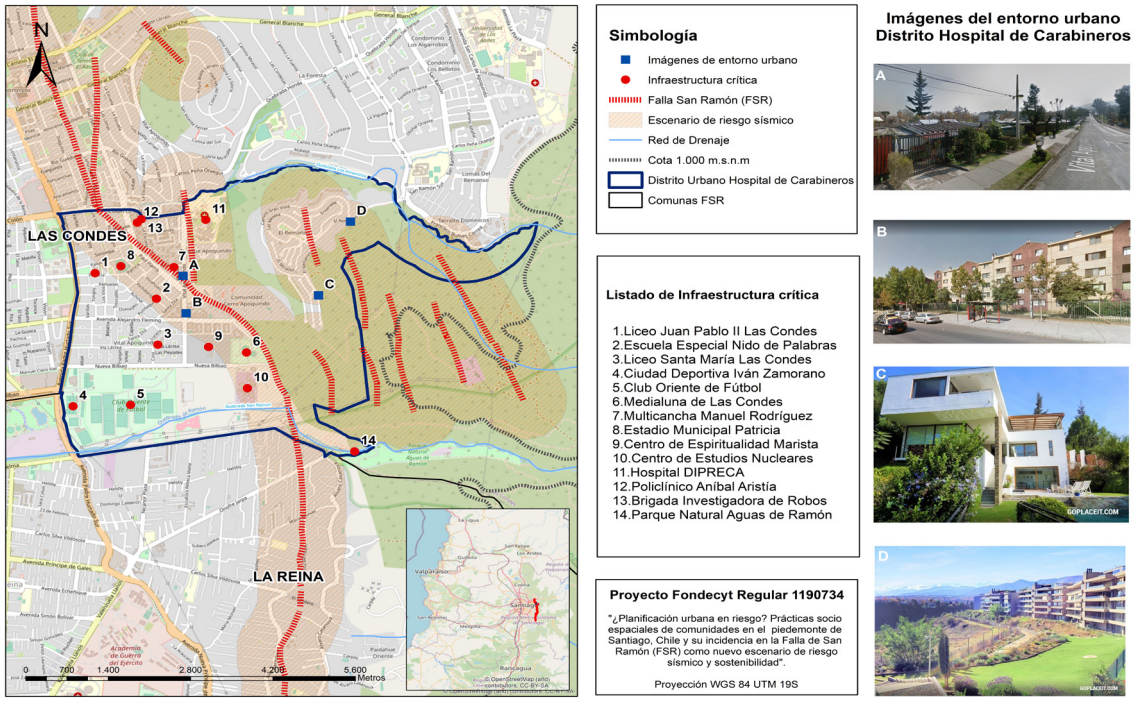


Figure 2. Hospital de Carabineros urban district, Las Condes.Source: Preparation by the Authors based on INE (2017), SII (2020), GOPLACEIT (2020), Google Maps, 2020 and Portalinmobiliario.com

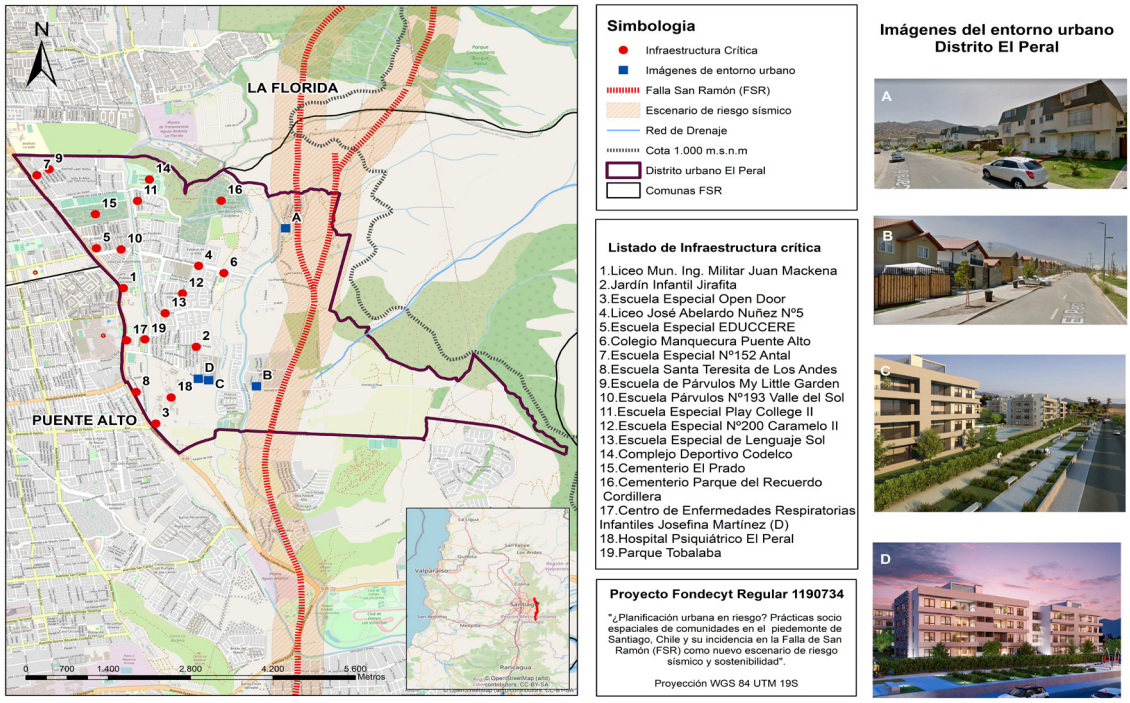


Figure 3. El Peral urban district, Puente Alto. Source: Preparation by the Authors based on INE (2017), SII (2020), GOPLACEIT (2020), Google Maps, 2020 and Portalinmobiliario.com



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| Critical Infrastructure | Hospital de Carabineros urban district, Las Condes | | El Peral urban district, Puente Alto | |
|---|---|---|---|---|
| | Nº | Name | Nº | Name |
| Security | 1 | Theft Investigation Brigade | -- | None |
| Healthcare | 2 | Anibal Aristia Polyclinic<br>DIPRECA Hospital | 2 | Josefina Martínez Chile Respiratory Diseases Center (D)<br>El Peral Psychiatric Hospital |
| Sports | 5 | Manual Rodríguez Sports Facility<br>Iván Zamorano Sports Complex<br>Club Oriente Football Club<br>Las Condes Rodeo Grounds<br>Patricia Municipal Stadium | 1 | Codelco Sports Complex |
| Worship | 1 | Marist Spirituality Center | -- | None |
| Infrastructure | 1 | Nuclear Studies Center | 2 | El Prado Cemetery<br>Parque del Recuerdo Cordillera Cemetery |
| Education | 3 | Juan Pablo II Las Condes Secondary School<br>Nido de Palabras Special School<br>Santa Maria Las Condes Secondary School | 13 | Manquecura Puente Alto School<br>Antal Special School, N°152<br>My Little Garden Nursery<br>Play College II Special School<br>EDUCCERE Special School<br>Valle del Sol Nursery, N°193<br>José Abelardo Nuñez N°5 Secondary School<br>Ing. Militar Juan Mackenna Secondary School<br>Caramelo II Special School N°200<br>Sol Special Language School<br>Jirafita Nursery<br>Santa Teresita de Los Andes Primary School<br>Open Door Special School |
| Public Space | 1 | Aguas de Ramón Natural Park | 1 | Tobalaba Park |

Table 6. Critical infrastructure in the Hospital de Carabineros and El Peral urban districts. Source: Preparation by authors based on photo-interpretation and onsite revision: Infrastructure of Geospatial Data of Chile [IDE] (2020), Ministry of Education [MINEDUC] (2020), DEIS (2020), CERET (2020) and GEORESEARCH (2020).

the local PRC ordinance of Puente Alto includes Article 40 with the Natural Origin Risk Zone from Flooding of Gorges and Artificial Watercourses, in accordance with Articles 8.2.1 and 8.2.1.1, and Zone "R2" of the Santiago Metropolitan Zoning Plan (PRMS, in Spanish). Despite this, a type of specific prohibition associated to seismic risk, and less still, associated to the San Ramón Fault, is not included in any of the analyzed sectors.

Now, in terms of land value, the Hospital de Carabineros urban district is comfortably higher in its average assessed (17,573 UF) and commercial value (13,906 UF) than the land of the El Peral urban district, whose average values are 1,700 UF (assessed) and 4,796 UF (commercial). This unequal land value situation is offset somewhat when the types of dwellings that are currently seen offered in the El Peral urban district (Figure 3C and 3D) are revised. According to the data found on the website www.goplaceit.com and on https://www.inmobiliariafg.cl/, it is possible to see "gated community" type complexes, like for example, Condominio Las Camelias, with different single-family housing models, whose sale prices fluctuate between 5,000 and 8,000 Units of Foment (UF). This situation is interesting to analyze, considering that within the Hospital de Carabineros northern urban district, an apartment type dwelling can be found that costs from 2,307 UF, and a detached house of 27,800 UF (Figure 2C)**8**

With regard to critical infrastructure, Table 6 presents the detail of the facilities for security, healthcare, sport, worship, infrastructure, education, and public space, for both sectors. It is seen there that the Hospital de Carabineros urban district has more of these in the San Ramón Fault buffer. Among this critical infrastructure, the presence of the Nuclear Studies Center is particularly concerning, given its energy



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nature, whose equipment increases the risk further still on facing a possible activation of the SRF with surface rupture. Meanwhile, the southern urban district has the El Prado Cemetery and the Parque del Recuerdo Cordillera Cemetery as part of its infrastructure which, although they constitute a contribution of spaces for rest, at the same time, they imply a considerable floating population of relatives or worshippers who are visiting their loved ones. All in all, the highest risk of the southern district lies in the 13 educational establishments of different levels: preschools (3), primary schools (7), secondary schools (3), whose student population with ages between 4 and 18, would require greater contention or supervision, if there were an evacuation due to the activation of the San Ramón Fault.

It can be confirmed that the sporting and public space facilities that both sectors under analysis have, are favorable options on facing a possible seismic event. In that line, the Hospital de Carabineros urban district has 5 sports centers -Manuel Rodríguez Sports Facilities, Iván Zamorano Sports Complex, Club Oriente Football Club, the Las Condes Rodeo Grounds, and the Patricia Municipal Stadium-, unlike the southern urban district, that only houses the Codelco Sports Complex. However, there is also the Aguas de Ramón Natural Park in Las Condes, which has over 3,500 hectares, including a nature reserve that it shares with the commune of La Reina and that, without a doubt, would contribute to the natural containment of the foothills on facing a seismic-geological activation.

## VI. CONCLUSIONS

The San Ramón Fault is a new geological element that is sounding the social and urban sustainability alarms on facing a possible activation in the foothills. Starting from an analysis that articulates the built, natural, and regulatory aspects, an uneven region can be seen regarding urbanity, sustainability and adaptability, illustrated in the two urban districts that are exposed to the seismic risk of the San Ramón Fault, as contrasting scenarios.

On one hand, the Hospital de Carabineros urban district in Las Condes, is seen as a northern sector with high cost housing, natural facilities (parks) and sports facilities that must however, coexist with critical infrastructure represented by a nuclear center and an electricity substation. On the other hand, the southern sector, with the El Peral urban district in Puente Alto, offers a greater distance from the buffer for its housing areas, but has fewer urban facilities that act as a buffer on facing an activation of the San Ramón Fault, and what is even more complex, is the higher number of schools at risk, meaning a younger population that needs greater contention during an evacuation.

It is concluded that these urban design experiences under extreme conditions vis-a-vis seismic risk, are illustrative both to progress in the socio-spatial survey of the foothills and to permeate through risk management operational levels, like articulated and resilient metropolitan and communal regulations, acknowledging the San Ramón Fault as a new base criterion of urban design. Hence, new analysis of this nature and of other urban scenarios at risk is required, that nourishes and completes an intercommunal panorama of the Santiago foothills.

Specifically, three future areas of action are defined to move forward towards the articulation of the built, natural and regulatory aspects that incorporate "resilient urban design", as the analysis matrix built in this work. The first dimension is at a civic-urban level and refers to the drive for knowledge of local threats and local scale risks, and is in line with what has been suggested by the Ministry of Housing and Urbanism on the reduction of disaster risk and reconstruction. A community that cohabits with their natural risks, like the San Ramón Fault, can increase their resilience capacity, as long as they know both the geological nature -the associated hazard level-, and the socio-spatial nature of where they live. This condition implies a concrete action of investing in community relations, so that these are empowered and can systemically act in an area, with information and tried and tested evacuation protocols.

The second aspect looks at increasing the sustainability and awareness of the natural environment. The Santiago foothills represent, in one way or another, a cultural heritage of all the citizens and, as such, a relationship should be reconsidered, promoting activities and actions that foster the recreational use of this area through parks and trails that at the same time encourage walking around it and valuing its ecological-landscape value. In this vein, a type of facility could be included that reinforces these priorities and nurtures the relationship with the inhabited area through sports centers, cultural and educational activities on risk management.

Finally, a third dimension and probably the longest lasting one, is the generation of urban regulations that are in tune with the risk conditions, that do not only rely on the intercommunal level, like the already proposed modification of the Santiago Metropolitan Zoning Plan (SEREMI-MINVU, 2012a) does, and one that has a greater accent on what is

8 In particular, the following sites were checked to obtain information on property prices in the commune of Las Condes: https://www.goplaceit.com/cl/propiedad/venta/departamento/las-condes/7339105-venta-de-departamento-excelente-oportunidad-en-las-condes-2-dormitorios-48-m2; https://www.goplaceit.com/cl/propiedad/venta/casa/las-condes/5294419-venta-de-casa-los-dominicos



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outlined in the Law and the General Urbanism and Construction Ordinance, but one that also allows implementing specific investment and execution plans for risk management of Santiago's foothills. In the latter, the role that urban design plays is key, as on increasing its application in manuals, section plans or master plans where the buffer of 300 meters from the San Ramón Fault is made visible, it would be possible to guide the uses and types of buildings that are feasible to include within this restriction area.

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## ENFOQUE Y ALCANCE

Urbano (ISSN digital: 0718-3607 / ISSN impreso: 0717-3997) es la publicación del Departamento de Planificación y Diseño Urbano de la Facultad de Arquitectura, Construcción y Diseño de la Universidad del Bío Bío y se edita desde el año 1997.

Urbano está especializada en temas urbanos - territoriales y su principal objetivo es explorar, a través de los artículos que publica, la dimensión territorial que adquiere el estudio de la ciudad y el territorio.

Urbano está destinada a investigadores y académicos cuyos manuscritos aporten una visión crítica sobre el fenómeno urbano y sus consecuencias en la transformación de las ciudades medias y en el territorio a escala local y regional, principalmente, en el ámbito iberoamericano, pero con una mirada abierta a los problemas existentes en el sur global.

Urbano está abierta a la diversidad de enfoques y metodologías, sobre todo a investigaciones de carácter multidisciplinario e interdisciplinario que permitan visualizar la ciudad y la región desde un contexto amplio y aplicable a la gestión urbana y territorial.

Urbano admite artículos científicos resultados inéditos de investigación, tesis de Magíster y Doctorado, y comunicaciones de congresos. También admite revisiones temáticas actuales que aporten conocimiento nuevo sobre temas actuales o conceptos en construcción, que se encuentren dentro del enfoque general de la revista. Esporádicamente publica números monográficos como resultado de convocatorias temáticas o como mecanismo de publicación de ejes temáticos afines de congresos nacionales e internacionales.

Urbano se publica en versión electrónica con periodicidad semestral, en la segunda quincena de mayo y de noviembre, teniendo también versión impresa. Acepta artículos en español e inglés. Los artículos enviados deben ser originales e inéditos, y no deben estar postulados simultáneamente para su publicación en otras revistas u órganos editoriales. El envío de manuscritos presupone el conocimiento y la aceptación por parte de las/os autoras/es de las normas editoriales y de las directrices para autores.

Urbano se encuentra indexada en Emerging Source Citation Index de Clarivate Analytics, Redalyc, Latindex Catálogo 2.0, Avery Index, DOAJ, Dialnet, Redib, EBSCO, Actualidad Iberoamericana, ARLA, HAPI Y ERIHPLUS

Urbano se adhiere a la Declaración De San Francisco Sobre La Evaluación De La Investigación (DORA)

## POLÍTICA EDITORIAL DE PUBLICACIÓN

Urbano está financiada por el Departamento de Planificación y Diseño Urbano y por la Universidad del Bío-Bío, El Equipo Editorial está comprometido con la comunidad científica para garantizar la ética y la calidad de los artículos publicados.

1. Publicación en Urbano

El envío, el proceso de revisión y el proceso de producción del número en el que se inserta el artículo no tiene costo alguno en Urbano.

La revista lanza convocatorias que definen las líneas temáticas de los siguientes números y que son anunciadas en su página electrónica. Además, la revista mantiene una ventanilla abierta para la recepción de manuscritos que pueden optar a ser publicados en los números que se encuentren en proceso.

Los artículos se reciben en español y en inglés a través de la plataforma digital debiendo ajustarse al formato indicado en las Normas Editoriales y Directrices para autores. El no cumplimiento de estas normas editoriales supone el rechazo del artículo en el proceso editorial o el retracto del artículo en caso de haber sido publicado.

Para poder optar a publicar en Urbano es necesario lo siguiente:

1. Los artículos deben estar redactados en formato científico y ser resultados de investigaciones propias. Urbano no publica artículos de investigación aplicada.
2. Los artículos deben ser inéditos y no estar publicados ni postulados para su publicación de forma simultánea en otra revista u órgano o editorial.
3. Los artículos deben ser originales y rigurosos. Urbano se opone al plagio académico por lo que rechaza todo artículo con datos fraudulentos, originalidad comprometida o envíos duplicados.
4. Los artículos deben omitir toda referencia a la identidad del autor/a o autores/as en el texto, siendo la plataforma digital el lugar en el que obligatoriamente se incluyen los nombres, las filiaciones de las/os autoras/es y sus orcid.
5. Los artículos deberán omitir las fuentes de financiamiento de la investigación en el texto, siendo la plataforma digital el lugar en el que obligatoriamente se incluyen las instituciones financiadores, tanto para el caso de proyectos de investigación como tesis de magíster y/ o doctorado.
6. Los artículos deben incluir en el manuscrito las citas

bibliográficas a los autores en los que se basa, siendo obligatoria su recopilación en la sección final "Referencias Bibliográficas".
7. Los artículos deben incluir un mínimo de 20 referencias bibliográficas de las que, al menos un tercio deben tener una antigüedad menor o igual a 5 años.
8. Los artículos limitarán a 3 las autocitas de los/as autores/as.

2. El proceso de revisión editorial y por pares

Una vez recibido el artículo, el proceso de revisión se divide en dos partes: revisión editorial y revisión por pares.

En primer lugar, los trabajos recibidos son objeto de una evaluación preliminar por parte del Comité Editorial que revisa el ajuste a las Normas Editoriales y Directrices para Autores, al enfoque de la revista, a la temática de la convocatoria —en caso de enmarcarse en alguna— y el cumplimiento de unos criterios mínimos de calidad y rigor. A partir del 2019 esta labor se realizara complementada con el software de Plagio Turnitin. Esta evaluación puede culminar en el rechazo del artículo o en su avance en el proceso editorial.

Una vez establecida la pertinencia de los artículos, se someten a un arbitraje anónimo por medio del sistema doble ciego. El panel de expertos está conformado por investigadores nacionales e internacionales especialistas en diversas áreas vinculadas al urbanismo externos a la entidad editora, al menos, en un 80%. Para asegurar la objetividad de las evaluaciones, estos expertos no deben presentar ningún conflicto de intereses con respecto a la investigación, las/os autoras/es y/o los financiadores de la investigación. Los artículos revisados serán tratados de forma confidencial. Los expertos realizan la revisión según la pauta de evaluación de Urbano y recomiendan una decisión al editor que plantea tres categorías:

**PUBLICABLE (cambios sugeridos por evaluador opcionales y por editor obligatorios).**
**PUBLICABLE CON MODIFICACIONES (cambios sugeridos por evaluador y editor obligatorios).**
**NO PUBLICABLE (rechazado).**

En caso de discrepancia entre evaluadores, el artículo se envía a un tercer árbitro. Si este proceso de revisión por pares califica el artículo como PUBLICABLE CON MODIFICACIONES el Equipo Editorial establece la necesidad de una segunda ronda de evaluación, en función de los requerimientos de los evaluadores. En caso de solicitar revisiones menores, no es necesaria segunda ronda de evaluación y el Equipo Editorial comprueba que las sugerencias han sido incorporadas. En caso de solicitar revisiones mayores, el artículo es enviado a una segunda ronda de evaluación. En ambos casos el equipo editorial establece un plazo para recibir las subsanaciones del artículo. Si tras la segunda ronda los evaluadores vuelven a solicitar revisiones mayores, el artículo será rechazado.

La decisión final e inapelable sobre la publicación de un artículo es competencia exclusiva del Equipo Editorial de la revista y es comunicada a través de la plataforma digital.

Algunos datos de interés en relación a este proceso de evaluación durante el 2018 son los siguientes:
1. Se recibieron 34 manuscritos de 9 países.
2. La tasa de rechazo de los artículos en el año 2018 fue de un 30% de los artículos recibidos en el primer proceso de revisión editorial, y de un 15% de los artículos recibidos en el proceso de revisión por pares.
3. El panel de evaluadores estuvo compuesto por 74 expertos de 10 Países.
4. El periodo medio de evaluación por artículo es de 3,8 meses.
5. Se publicaron 16 artículos en los dos últimos números.
6. La pauta de evaluación es accesible por los potenciales autores.

3. Política de acceso abierto

Urbano publica la versión Post-Print del artículo en acceso abierto en su repositorio institucional.
Urbano autoriza a las/os autoras/es a difundir a través de sus páginas electrónicas personales o a través de cualquier repositorio de acceso abierto una copia del trabajo publicado, junto a la cual ha de incluirse el artículo citado de forma completa —incluyendo año, título completo, nombre de Urbano, número y páginas donde fue publicado añadiendo, además, DOI y/o el enlace al artículo en la página electrónica de Urbano.

4. Archivo de datos

Urbano utiliza el sistema LOCKSS para crear un sistema de archivo distribuido entre bibliotecas colaboradoras, a las que permite crear archivos permanentes de la revista con fines de conservación y restauración.

Urbano incluye la bibliografía citada en cada artículo como un campo exportable en formato Dublin Core según el protocolo OAI-PMH.

5. Derechos de autor y licencias

El contenido de los artículos que se publican en cada número de Urbano, es responsabilidad exclusiva de los/as autores/as y no

representan necesariamente el pensamiento ni comprometen la opinión de la Universidad del Bío-Bío.

Las/os autoras/es conservan sus derechos de autor, sin embargo, garantizan a la revista el derecho de primera publicación y difusión de su obra. La publicación del artículo en Urbano estará sujeta a la Licencia de Reconocimiento de Creative Commons CC-BY-SA que permite a otros compartir-copiar, transformar o crear nuevo material a partir de esta obra con fines no comerciales, siempre y cuando se reconozcan la autoría y la primera publicación en esta revista, y sus nuevas creaciones estén bajo una licencia con los mismos términos.


## POLÍTICA DE PUBLICACIÓN

1. Responsabilidades y derechos de las/os autoras/es:

Al enviar el manuscrito, los autores deben enviar un documento en el que declaran de forma responsable:

1. Que todos los/as autores/as han contribuido significativamente a la investigación y/o redacción del artículo.
2. Que los datos de la investigación son originales, propios y auténticos.
3. Que ceden a Urbano los derechos de comunicación pública de su manuscrito para su difusión y explotación a través del Open Journal System —o cualquier otro portal que escoja el editor— para la consulta en línea de su contenido y de su extracto, para su impresión en papel y/o para su descarga y archivo —todo ello en los términos y condiciones especificados en las plataformas donde se encuentre alojada la obra.

Tras las rondas de revisión de pares evaluadores, los/as autores/as deben incorporar las sugerencias o argumentar su rechazo, adjuntando una carta de respuesta a los revisores explicando las modificaciones del manuscrito, dentro del plazo solicitado por el editor.

A lo largo del proceso editorial, los/as autores/as deben incorporar las correcciones formales y de fondo solicitadas por el Equipo Editorial.

A lo largo del proceso editorial, las/os autoras/es tienen derecho a retirar su artículo del proceso editorial, justificando esta decisión al Equipo Editorial.

Tras el proceso de revisión de estilo, las/os autoras/es tienen derecho a revisar la última versión del texto antes de ser publicada. La aprobación de esta versión supone el cierre del texto para su diagramación y publicación, sin posibilidad de cambios a posteriori.

2. Responsabilidades editoriales:

El Equipo Editorial debe tomar en consideración para su publicación todos los manuscritos enviados, basando su decisión en los aportes científicos del mismo y el cumplimiento de las normas editoriales.

El Equipo Editorial debe buscar evaluadores expertos en el área específica del manuscrito preservando en todo momento el anonimato de los/as autores/as y de los/as evaluadores/as y el carácter académico y científico de la publicación.

El Equipo Editorial debe mantener una comunicación constante con autores y evaluadores externos, debiendo aclarar todas las dudas que surjan durante el proceso editorial.

El Equipo Editorial tiene la autoridad completa para aceptar o rechazar un manuscrito. Las razones por las que emita este veredicto pueden ser las siguientes:

1. El artículo no se ajusta a la temática de la convocatoria y/o al enfoque general de Urbano.
2. El artículo no se ajusta a estas Normas Editoriales y/o las Directrices para Autores
3. El artículo no se ajusta a un estándar mínimo de calidad científica y/o de rigurosidad.
4. El artículo recibe evaluaciones negativas en las rondas de revisión por pares.
5. El artículo no incorpora las sugerencias de los evaluadores y peticiones del Equipo Editorial en los plazos establecidos.
6. El artículo recibe solicitudes de cambios mayores en segunda ronda de revisión por pares.

El Equipo Editorial debe publicar correcciones, aclaraciones, retractaciones y disculpas cuando sea necesario.

El Equipo Editorial no debe tener ningún conflicto de interés en relación a los artículos enviados y debe velar porque los evaluadores tampoco los tengan con respecto a las investigaciones que evalúan.

El Equipo Editorial debe asegurar que los artículos publicados en Urbano cumplen con los criterios éticos de publicaciones científicas fijados por el Committee on Publication Ethics (COPE) no permitiendo el fraude académico, inclusión de datos fraudulentos ni el plagio o autoplagio de artículos que supongan partes relevantes de las aportaciones. La detección de estas prácticas supone el rechazo o retracto inmediato del artículo.

El Equipo Editorial debe aspirar a mejorar y actualizar constantemente su revista.

3. Responsabilidades de los evaluadores externos.

Los evaluadores deberán rechazar las evaluaciones solicitadas por el Equipo Editorial cuando no posean suficiente competencia, experiencia y conocimiento del tema específico del manuscrito.

Los evaluadores deberán informar al equipo editorial cuando existan potenciales conflictos de intereses.

Los evaluadores deben realizar un análisis objetivo de los manuscritos que revisen, fundamentando sus observaciones y en el plazo solicitado por el Equipo Editorial.

Los evaluadores deberán mantener la confidencialidad del manuscrito durante el proceso editorial, no siendo posible difundir o utilizar su contenido.

Los evaluadores deberán mantener la confidencialidad sobre su vinculación con el manuscrito.

## FOCUS AND SCOPE

*Urbano* (*Digital ISSN:* ***0718-3607*** */ ISSN printed:* ***0717-3997****)* has been published by the Department of Planning and Urban Design at the University of the Bío-Bío since 1997.

*Urbano* specializes in urban-territorial issues and its main objective is to explore, through the articles it publishes, the territorial dimension of the study of the city and the territory. *Urbano* is open to a variety of approaches and methodologies, especially to multidisciplinary and interdisciplinary research that makes it possible to visualize the city and region from a broad context that is applicable to urban and territorial management.

*Urbano* is intended for researchers and academics whose manuscripts provide a critical vision of the urban phenomenon and its consequences for the transformation of medium-sized cities and territories at the local and regional level, mainly in the Ibero-American arena, but also regarding the existing problems in the global south.

*Urbano* accepts scientific articles on unpublished research results, master's and doctoral theses, and conference proceedings. It also publishes review articles that are within the journal´s general focus and contribute new knowledge on current issues or concepts currently in development. *Urbano* is published biannually in the second half of May and November in digital and paperback editions. It accepts articles written in Spanish and English. The submitted articles must be original and unpublished and must not simultaneously be before another journal or editorial body for consideration. It prints general issues with assorted manuscripts within its focus and scope, and occasionally publishes monographic issues resulting from thematic calls for papers, or as a means of publishing core topics related to national and international conferences. The submission of manuscripts presupposes that authors have knowledge of and accept the Editorial Norms and Guidelines for Authors.

*Urbano* is indexed in Emerging Source Citation Index de Clarivate Analytics, Redalyc, Latindex, Avery Index, DOAJ, Dialnet, Redib, REBIUN, EBSCO, Open Archives, JournalTOCs, Actualidad Iberoamericana, ARLA, ERIHPLUS y HAPI.

Urbano adheres to the San Francisco Declaration on Research Assessment (DORA).



## INDEXATION

AVERY Index, DOAJ, EBSCO, Latindex, Actualidad Iberoamericana (IC), ARLA, RedAlyc, REDIB, DORA, Emerging Source Citation Index de Clarivate Analytics, ERIHPLUS y HAPI

## EDITORIAL POLICIES AND PUBLICATION ETHICS

Urbano's Editorial Team is committed to the scientific community and to ensuring the ethics and quality of the articles published.

**1. Publication in *Urbano***

Urbano does not charge authors any fees for submission, the article-review process or issue production

The journal launches calls for papers that define the thematic lines of the following issues and are announced on its website. In addition, the journal maintains an open window for the submission of manuscripts that can then be published in issues that are in the process of publication.

Articles may be submitted in Spanish or English via the online platform and must conform to the format indicated in the Editorial Norms and Guidelines for Authors. Failure to comply with these editorial norms means the article will be rejected during the editorial process or retracted if it has already been published.

To be eligible to publish in *Urbano,* the following are required:

1. Articles must be written in scientific format and be the results of the author´s own research. *Urbano* does not publish applied research articles.
2. Articles must be unpublished and must not simultaneously be before another journal or editorial body for consideration.
3. *Urbano* opposes academic plagiarism and therefore rejects any article with fraudulent data, compromised originality or duplicate submissions.
4. Articles must omit all references to the identity of the author(s) within the text. The names and affiliations of the author(s) should be given on the online platform.
5. Articles must not cite the sources of research funding in the text, but rather in a footnote on the first page of the article. The names and affiliations of the author(s) should be given on the online platform.
6. Articles must include the bibliographic citations to the research on which the paper is based and these must be compiled in a final "References" section.
7. Articles must include a minimum of 20 bibliographic references, of which at least one third must be less than or equal to 5 years old.
8. Articles are limited to 3 author self-citations.

**2. Peer and editorial review process**

Once the article is received, the review process is divided into two parts: editorial review and peer review.

Firstly, papers are subject to preliminary evaluation by the Editorial Committee, which reviews the article´s conformity to: the Editorial Norms and Guidelines for Authors, the journal´s focus, the theme of the call for papers in the case there is one, and compliance with minimum criteria for quality and rigor. As of 2019, the plagiarism software Turnitin will also be used to complement this evaluation, which may culminate in the rejection of the article or its progression through the editorial process.

Once the pertinence of an article has been established, it is subject to double blind peer evaluation. The panel of experts is comprised of national and international researchers unaffiliated with the publisher in 80%, who are specialists in different areas related to urban planning. These must not have any conflict of interest with respect to the research, the author(s) and/or the financers of the investigation. All evaluations are objective, and the reviewed articles will be treated confidentially. Experts carry out reviews according to the *Urbano* evaluation guidelines and make one of three recommendations to the editor:

**PUBLISHABLE (changes suggested by the reviewer are optional and those of the editor are mandatory).**
**PUBLISHABLE WITH MODIFICATIONS (changes suggested by evaluator and editor are obligatory).**
**NOT PUBLISHABLE (rejected by peer assessment)**

If there is any discrepancy between evaluators, the article is sent to a third to arbitrate. If this peer assessment process considers the article to be PUBLISHABLE WITH MODIFICATIONS, the Editorial Team establishes the need of a second assessment round, depending on the evaluators' requirements. If minor revisions are requested, a second round is not necessary and the Editorial Team confirms that the suggestions have been included. If major revisions are requested, the article is sent to a second round of assessment. The editorial team, in both cases, sets a period to receive the corrections of the article. If, after the second round, major revisions are requested again, the article will then be rejected.

The result of the peer assessment, is made clear to the authors, through the sending of the respective assessment guidelines (in anonymous format).

Some data of interest in relation to this evaluation process during 2017 are the following:

1. 34 manuscripts were received from 9 countries.
2. The rejection rate of the articles in 2018 was 30% of the articles received in the first editorial review process, and 15% of the articles received in the peer review process.
3. The panel of evaluators was composed of 74 experts from 10 countries.
4. The average evaluation period per article is 3.8 months.
5. 16 articles were published in the last two numbers.
6. The evaluation guideline is accessible by potential authors.

**3. Open access policies**

*Urbano* publishes the Post-Print version of the article in open access format in their institutional archive.
*Urban* authorizes the authors to disseminate through their personal electronic pages or through any open access repository a copy of the published work, together with which the cited article must be included in its entirety — including year, title full, name of Urbano, number and pages where it was published by adding, in addition, DOI and / or the link to the article on the Urbano website.

**4. Data archive**

*Urbano* uses the LOCKSS system to create an archive system distributed between collaborating libraries. This system allows creating permanent files of the journal for conservation and restoration purposes.

*Urbano* includes the bibliography cited in each article as an exportable field in **Dublin Core format as per the OAI-PMH protocol**.

**5. Copyright and licenses**

The content of the articles which are published in each edition of Urbano, is the exclusive responsibility of the author(s) and does not necessarily represent the thinking or compromise the opinion of the University of the Bio-Bio.

The author(s) conserve their copyright and guarantee to the journal, the right of first publication of their work, which will simultaneously be subject to the Creative Commons Recognition License CC BY-SA, which allows others to share-copy, transform or create new materials from this work for non-commercial purposes, as long as they recognize authorship and the first publication in this journal, and its new creations are under a license with the same terms.




**PUBLICATION ETHICS POLICY**

**1. Responsibilities and rights of the author(s)**

The authors, on sending the manuscript, must send a document where they responsibly declare:

1. That all the author(s) have significantly contributed to the research and/or writing of the article.
2. That the information of the research is original, their own and authentic.
3. That they transfer to Urbano, the rights of public communication of their manuscript for its dissemination and use in the Open Journal System, or any other social network or online portal which the Editorial Team chooses. This is for the online consultation of its content and its abstract, for its printing in paper and/or for its download and archiving, all this under the terms and conditions specified on the platforms where the work is housed.

The author(s), after the rounds of peer evaluator review, must include the suggestions or argue against their rejection, attaching a letter of response to the revisors, explaining the modifications of the manuscript, within the period requested by the editor

The author(s), throughout the editorial process, must include the formal corrections and grounds requested by the Editorial Team.

The author(s), throughout the editorial process, are entitled to withdraw their article from the editorial process, justifying this decision to the Editorial Team.

The author(s), after the style revision process, are entitled to review the last version of the text before it is published. The approval of this version, entails the closing of the text for its diagramming and publication, with no possibility of making changes later.

**2. Editorial responsibilities.**

The Editorial Team must take into consideration for the publication all the manuscripts sent, basing their decision on their scientific contribution and the compliance of the editorial standards.

The Editorial Team must seek expert evaluators in the specific area of the manuscript, preserving at all times, the anonymity of the author(s) and the evaluator(s) and the academic and scientific nature of the publication.

The Editorial Team must remain in constant contact with the external evaluators and authors, duly clearing up all doubts that arise during the editorial process.

The Editorial Team has the complete authority to accept or reject a manuscript. The reasons why they give this verdict may be the following:

1. If the article does not fit the topic of the call and/or the general approach of Urbano.
2. If the article does not fit the editorial standards and/or the guidelines for authors.
3. If the article does not fit the minimum standards of scientific quality and/or rigor.
4. If the article receives negative evaluations in the peer evaluation rounds.
5. If the article does not incorporate the suggestions of the evaluators or requests of the Editorial Team within the set periods.
6. If the article receives requests for major modifications in the second peer review stage.

The Editorial Team must publish corrections, clarifications, retractions and apologies when so required.

The Editorial Team must not have any conflict of interest regarding the articles sent and must watch that the evaluators do not have any regarding the research they are evaluating. The Editorial Team must guarantee that the articles published in Urbano comply with the ethical criteria for scientific publications established by the Committee on Publication Ethics (COPE) not permitting academic fraud, including fraudulent data or the plagiarism or autoplagiarism of articles which are considered to be relevant parts of the contributions. The detection of these practices will lead to the rejection or immediate withdrawal of the article.

The Editorial Team must aspire to constantly improve and update the journal.

**3. Responsibilities of external evaluators.**

The evaluators must reject assessments requested by the Editorial Team when they do not have enough competence, experience and knowledge of the specific matter of the manuscript.

The evaluators must report potential conflicts of interest to the editorial team.

The evaluators must make an objective analysis of the manuscripts they are reviewing, giving grounds for their comments and doing this within the period established by the Editorial Team.

The evaluators must maintain the confidentiality of the manuscript during the editorial process with it not being possible to disseminate it or use its content.

The evaluators must keep their relationship with the manuscript confidential.

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Urbano es la revista editada por el Departamento de Planificación y Diseño Urbano de la Universidad del Bío - Bío. Urbano se plantea como una publicación semestral especializada en temas urbanos-territoriales, destinada a explorar la dimensión científica y de investigación que adquiere el estudio de la ciudad y el territorio. Se publica en versión impresa y electrónica, con periodicidad regular y salida en los meses de Mayo y Noviembre. La revisión de artículos es realizada por pares evaluadores externos, de forma anónima
Urbano está destinada a investigadores, profesionales y académicos, y su propósito establecer una visión crítica sobre el fenómeno urbanizador con especial énfasis en la transformación de las ciudades medias y el territorio a escala regional y local. Urbano publica trabajos inéditos y está abierta a la diversidad de enfoques y metodologías, resaltando investigaciones de carácter multidisciplinario e interdisciplinario que permitan visualizar la ciudad y la región desde un contexto amplio y aplicable a la gestión urbana y territorial.

Urbano está financiada por la Facultad de Arquitecturas Construcción y Diseño, a través de la vicerrectoría Académica de la Universidad del Bío-Bío y a través de Programa de Información Científica CONICYT /Concurso Fondos de Publicación de Revistas Científicas 2018/ Proyecto Mejoramiento de Visibilidad de Revistas UBB (Código:FP180007)



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