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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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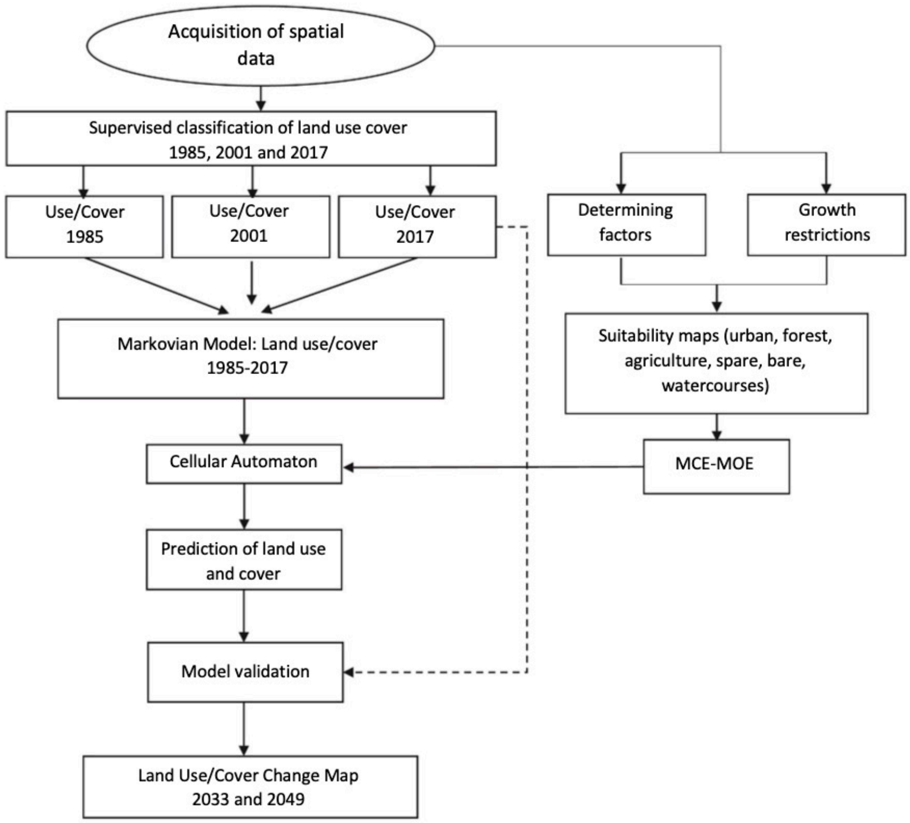

Figure 1. Methodological Model. Source: Preparation by the Authors, adapted from Morales & Maturana (2019).

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.

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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).

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:

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

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).

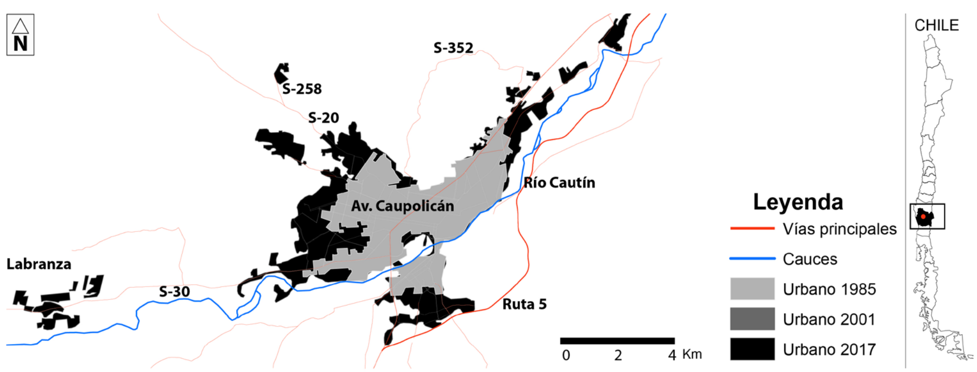

Figure 2. Area of study and urban growth between 1985 and 2017. Source: Preparation by the Authors.

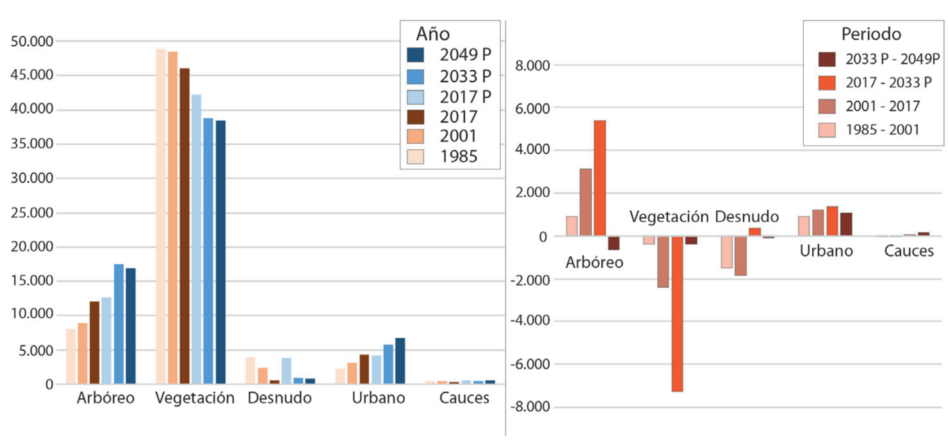

Figure 3. Real and simulated Land Use/Cover change values in Temuco (P: refers to the simulated or projected values). Source: Preparation by the Authors.

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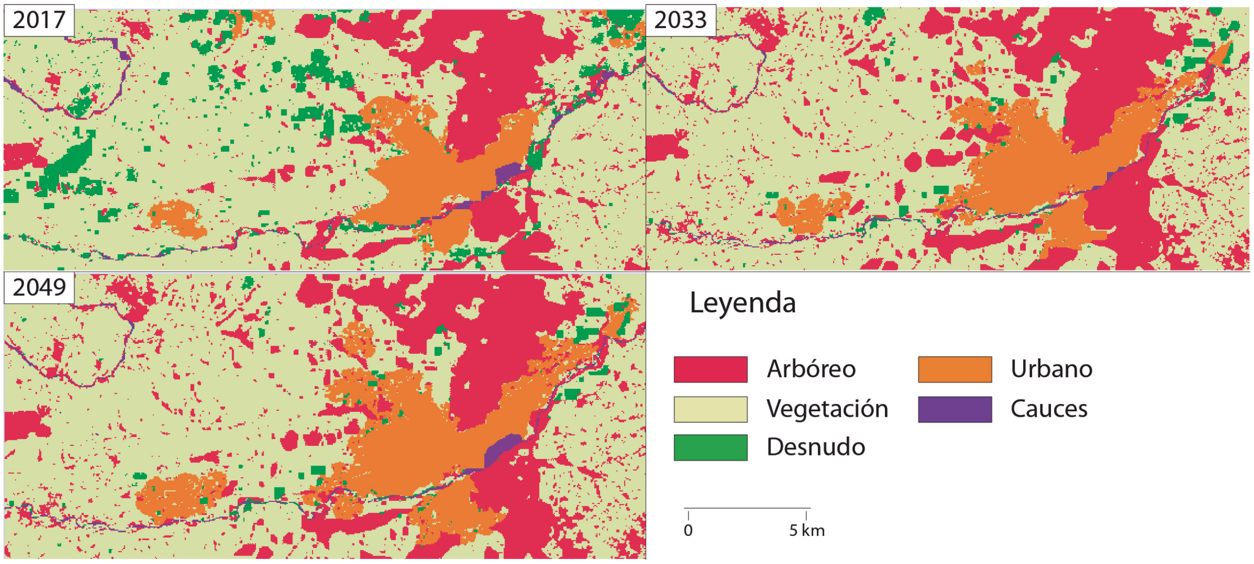

Figure 4. Scenarios simulated in 2017, 2033, and 2049. Source: Preparation by the Authors.

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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

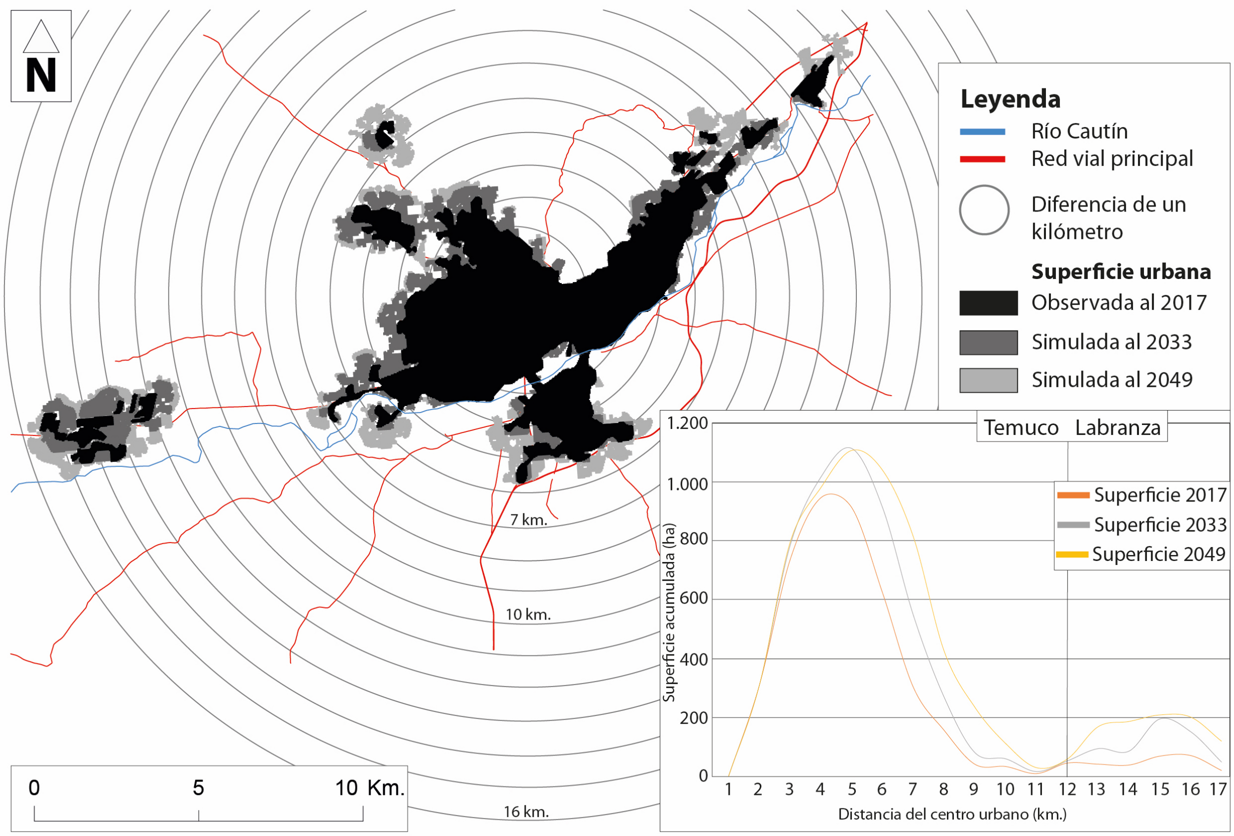

Figure 5. Simulation of the urban growth of Temuco in terms of distance. Source: Preparation by the Authors.

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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