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IGNACIO A. SÁEZ ARANEDA
ignaciosaezaraneda@gmail.com

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KEVIN WRIGHT

CORRECCIÓN DE ESTILO/proofreader
OLGA OSTRIA REINOSO

GESTIÓN WEB/webmaster
KARINA LEIVA

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EDITORIAL

Editorial

ANA ZAZO MORATALLA 1

Territorios circulares

Este 2022 cumple 50 años el informe *Meadows* que ya en 1972 ponía la alerta sobre el límite del crecimiento y sobre el carácter finito de los recursos naturales que se encuentran al servicio del sistema de desarrollo. Se tuvo que esperar hasta el año 1987 para que la ONU publicara el Informe Brundtland, inicialmente conocido como *Our Common Future,* y definiera el concepto de desarrollo sostenible resaltando la necesidad moral de realizar un uso responsable de los recursos para la conservación del planeta. Sin embargo, este concepto, muy desgastado y desvirtuado en la actualidad, no implicaba explícitamente una mirada crítica al modelo lineal imperante basado en la extracción, producción, consumo y el desecho.

En ese sentido, el concepto de "circularidad" amplía al de desarrollo sostenible ya que avanza en reorientar el actual modelo de producción hacia el cierre de sus ciclos, asimilándolos así a los ecosistemas naturales. La circularidad apuesta por la construcción de un círculo virtuoso que reduzca al máximo los recursos empleados en el origen del sistema, así como los residuos de salida, mediante la reparación, la reutilización o el reciclaje.

La idea no es nueva en la historia, algunas civilizaciones antiguas ya contaban con sistemas de gestión de residuos avanzados que incluían el reciclaje de materiales. Durante las últimas décadas del siglo XX, reaparece este planteamiento de la circularidad de la mano de una nueva conciencia de la realidad socioecosistémica de las ciudades y de su funcionamiento metabólico. Algunos enfoques como el diseño regenerativo o la ecología industrial, emergentes en la década de los 80, ya incluían intrínsecamente esta idea.

Ahora bien, el término "economía circular" no fue formulado hasta 1989 por los economistas ambientales David W. Pearce y R. KerryTurner en su libro *Economics of Natural Resources and the Environment*. En él, los autores describieron un sistema económico donde debiera primar el aprovechamiento de las materias primas y los recursos en los procesos para reducir el impacto ambiental. Otro gran referente, en este marco, es la Ellen McArthur Foundation que en 2015 determina que la economía circular crea capital económico, natural y social, que separa los ciclos biológicos de los técnicos, y que se basa en tres principios: (1) eliminar los residuos y la contaminación desde el diseño; (2) mantener los productos y materiales en uso; y (3) regenerar los sistemas naturales.

En el ámbito nacional, el Ministerio de Medio Ambiente (MMA) chileno sacó en 2021 la *Hoja de Ruta para un Chile Circular 2040*, en la que se establecen 7 metas a largo plazo que deben tomarse como indicadores de que se avanza en la transición del sistema:

1. Generación de empleos verdes.
2. Disminución de la generación de residuos sólidos municipales por habitante.
3. Disminución de la generación total de residuos por PIB.
4. Aumento de la productividad material.
5. Aumento de la tasa general de reciclaje.

1 Editora Revista Urbano
Doctora Arquitecta en Sostenibilidad Urbana
Académica del Departamento de Planificación y Diseño Urbano, Facultad de Arquitectura, Construcción y Diseño
Universidad del Bío Bío
http://orcid.org/0000-0003-1912-9448
azazo@ubiobio.cl

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Figura 1, 2 Asentamiento humano Los Algarrobos segunda etapa. Fuente: MGI Piura, 2022

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6. Aumento de la tasa de reciclaje de Residuos Sólidos Domiciliarios (RSD).
7. Recuperación de sitios afectados por la disposición ilegal.

Para alcanzar estas metas, la Hoja de Ruta propone cuatro ejes de trabajo: (1) innovación circular, (2) cultura circular, (3) regulación circular, y (4) territorios circulares. El primero, busca fomentar la creatividad para la transición a sistemas productivos de bajo impacto socioambiental; el segundo, educar integralmente a una sociedad consciente que cuida su medio ambiente; el tercero, ajustar el marco regulatorio para que potencie y facilite la integración de la EC; y, el último, promover un desarrollo local sostenible y compatible con las visiones y vocaciones de cada territorio.

Para avanzar en la transición de los territorios hacia la circularidad en general, y alcanzar las metas en particular, cada región debe abordar este desafío de acuerdo a sus particularidades locales. La diversidad regional de Chile es muy amplia y, por ello, cada territorio debe reconocer sus realidades y apalancar fortalezas y todas sus potencialidades. Sin embargo, la gestión de residuos sólidos urbanos es actualmente un problema transversal a todo el país que, redirigido desde una perspectiva circular y aplicado a toda la cadena alimentaria, podría reducir los impactos ambientales del sistema y actuar como motor de economía local y de cambio de modelo en muchos territorios.

Con el objetivo de trabajar la circularidad en los sistemas alimentarios urbanos, FAO propuso la pirámide de la priorización en la que las políticas públicas deben apuntar a reducir el volumen de residuos mediante estrategias previas a la valorización o el desecho. En ese sentido, en primera instancia, es fundamental proponerse estrategias de prevención y reducción de pérdidas y desperdicios alimentarios en origen y redistribuir alimentos que, por razones estéticas, no puedan ser vendidos en canales convencionales. En segundo lugar, se puede reutilizar y reciclar, redirigiendo a alimentación de animales, usos de fertilizantes, digestión anaeróbica y compostaje. Todo lo que no haya sido posible reducir, redistribuir o reutilizar en las anteriores etapas, puede ser conducido a relleno sanitario o a incineración.

Por otra parte, la realidad chilena implica una gestión de residuos en tres ámbitos, a saber: (1) la redirección o reutilización de los desperdicios en la etapa de producción; (2) la recolección de residuos de la etapa de comercialización de los grandes generadores urbanos: nodos logísticos, supermercados y ferias libres, que al desarrollarse en el espacio público requieren de una intervención municipal; y (3) la recolección de los residuos del final de la cadena alimentaria, derivados del consumo. Estos pueden realizarse de forma organizada por la municipalidad, o bien, mediante el "puerta a puerta" para conducirlos a una planta de compostaje comunal, como asimismo a través de la gestión de composteras comunitarias o individuales. En algunos casos, en ausencia de una gestión comunal, las experiencias surgen de forma autogestionada por los vecinos, de forma comunitaria o individual. En este último ámbito, hay un par brechas primordiales a la hora de promover esta transición: tanto la infraestructura de valorización de residuos como los recursos e inversión I+D+i se encuentran principalmente concentradas en la Región Metropolitana.

Al día de hoy, en el Área Metropolitana de Concepción, sólo Santa Juana cuenta con una planta de compostaje a la que llegan los residuos orgánicos mediante una recogida diferenciada puerta a puerta. El compost que se produce es devuelto a las personas que contribuyen con residuos orgánicos y también a los agricultores del programa PRODESAL, cerrando el círculo virtuoso alimentario. Chiguayante, por otra parte, está trabajando con las vermicomposteras comunitarias en algunas juntas de vecinos. Otros municipios se encuentran planteando cómo poner en práctica una valorización de residuos y cómo transitar a una economía circular para sus territorios, no obstante, se trata de miradas e iniciativas que se están planteando de forma aislada e independiente, sin una mirada de territorio metropolitano integrado en la que la cooperación y las alianzas municipales puedan ser la base de la transición hacia una economía circular que beneficie de forma solidaria a todas las municipalidades.

¿Cuándo vamos a asumir que los recursos y los ecosistemas no son infinitos? ¿Cuándo vamos a transitar de un modelo lineal basado en la cultura del descarte a una economía circular que además sea motor del desarrollo endógeno de los territorios? ¿Cuándo vamos a entender que formamos parte de un territorio integrado que no debe concebirse desde los límites administrativos? ¿Cuándo vamos a comenzar a trabajar de forma colaborativa y generando alianzas que permitan poner en práctica un uso más responsable de los recursos públicos?

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PLACE ATTACHMENT AND VOLCANIC RISK PERCEPTION OF OLDER ADULTS IN ÑUBLE, CHILE[1]

APEGO AL LUGAR Y PERCEPCIÓN DEL RIESGO VOLCÁNICO EN PERSONAS MAYORES DE ÑUBLE, CHILE

JOSÉ SANDOVAL DÍAZ [2]
SARON MONSALVES PEÑA [3]
VIVIANA VEJAR VALLES [4]
CRISTÓBAL BRAVO FERRETTI [5]

1 Article financed by DIUBB 191624 3/R Local management of volcanic risk and resilience within exposed communities of the Ñuble Region

2 Doctor en Psicología
Universidad del Bío Bío, Chillán, Chile. Director del Centro de Estudios Ñuble, Académico, Departamento de Ciencias Sociales.
https://orcid.org/0000-0001-7247-7113
jsandoval@ubiobio.cl

3 Psicóloga
Universidad del Bío Bío, Chillán, Chile. Psicóloga del Hospital de Huépil.
https://orcid.org/0000-0002-0130-1177
smonsalve@ubiobio.cl

4 Psicóloga
Hospital de Huépil, Huépil, Chile. Psicóloga del Hospital de Huépil.
https://orcid.org/0000-0002-4127-4281
vivivejarvalles@gmail.com

5 Doctor en Ciencias Humanas mención Discurso y Cultura
Universidad del Bío Bío, Chillán, Chile. Académico, Departamento de Ciencias Sociales.
https://orcid.org/0000-0002-0395-6046
cbravo@ubiobio.cl

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Chile presenta un alto grado de exposición y susceptibilidad ante escenarios de riesgo de desastre y es, además, uno de los cinco países con más volcanes activos a escala global. A lo anterior, se suma el sostenido aumento del envejecimiento poblacional, lo que convierte a las personas mayores en un grupo vulnerable ante potenciales desastres socio-naturales. Sustentado en lo anterior, el presente trabajo busca comprender la relación entre el apego al lugar y la percepción del riesgo volcánico de personas mayores residentes en la zona de exposición del complejo volcánico Nevados de Chillán, en el sur de Chile. Por medio de un diseño de caso cualitativo, de corte fenomenológico, se aplicaron 15 entrevistas semiestructuradas y un grupo focal, cuyo análisis se realizó bajo la teoría fundamentada. Los resultados señalan que las personas mayores presentan una baja percepción del riesgo volcánico, lo que conlleva i) minimización de los peligros naturales del entorno, ii) conocimiento informal basado en experiencias previas, y iii) desconocimiento de las características del riesgo natural y sus consecuencias negativas. Por otra parte, el apego al lugar y la vulnerabilidad social no solo actúan como obstaculizadores contextuales de la aceptación del riesgo volcánico, sino que también impactan en la falta de implicancia, adquisición y despliegue de capacidades de afrontamiento individuales y colectivas. Como conclusión, sostenemos la importancia de incorporar tanto el “envejecimiento en el lugar”, como el agenciamiento activo de la población adulta mayor en los procesos de planificación y gestión local del riesgo de desastre socio-natural.

Palabras clave: riesgo volcánico, percepción de riesgo, apego al lugar, vulnerabilidad social, personas mayores.

Chile has a high degree of exposure and susceptibility to disaster risk scenarios, and it is among the top five countries in the world regarding active volcanoes. Meanwhile, sustained population aging is making the older population vulnerable to potential socio-natural disasters. This article, using these concepts, seeks to understand the relationship between place attachment and the perception of volcanic risk among the older population, focusing on older adults residing in the hazard zone of the Nevados de Chillán volcanic complex in the Ñuble Region in southern Chile. Using a phenomenological qualitative case design, 15 semi-structured interviews and a focus group were applied, with the analysis carried out based on grounded theory. The results indicate that the older population has a low perception of volcanic risk, entailing i) the minimization of the surrounding natural hazards, ii) informal knowledge based on previous experiences, and iii) ignorance of the natural risk characteristics and their negative consequences. On the other hand, it is seen that place attachment and social vulnerability act not only as contextual barriers to accepting the volcanic risk but also lead to a lack of engagement, acquisition, and deployment of individual and collective coping mechanisms. In conclusion, the authors outline the importance of including “aging in place” and the active agency of the older population in socio-natural disaster risk planning and local management processes.

Keywords: volcanic risk, risk perception, place attachment, social vulnerability, older people.

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I INTRODUCTION

Natural disasters have become one of the main obstacles to development (UN Office for Disaster Risk Reduction [UNDRR], 2015). In 2019 alone, there were 317 global catastrophes, resulting in the death and/or disappearance of 11,497 people and an economic impact of over US$146 billion (Swiss Re Institute, 2020).

Given the importance of climate change and the intensification of extreme events, the study of remote probability risks, such as volcanological ones, has been displaced (Favereau, Robledo & Bull, 2018). Since the turn of the century, more than 2,000 deaths from volcanic disasters have already been recorded, in addition to the exposure of approximately 800 million people living within a radius of 100 km from a volcano (Marín, Vergara-Pinto, Prado & Farías, 2020). However, despite their high intermittency, the effects of volcanic eruptions can be long-lasting and become a sustained problem for human settlements (Davis, Ricci & Mitchell, 2005; Marín *et al*., 2020).

Although exposure is a necessary condition, it is not enough to set up disaster risk scenarios, but rather the different root causes of vulnerability (Wisner, Blaikie, Cannon & Davis, 2004) need to be incorporated, such as i) poverty, ii) racial/class/gender oppression, iii) chronic diseases and/or disabilities, iv) immigration status, and v) critical ages, such as childhood and older adulthood (Cutter, Boruff & Shirley, 2003). The latter lacks research, despite having a high susceptibility to natural hazards (Rodríguez, Donner & Trainor, 2018; Sandoval, Monsalves & Vejar, 2022; Sandoval & Cuadra, 2020)

Regarding places where risks are located, older people tend to manifest greater attachment, developing an "extensive interiority of the self" (Hidalgo & Hernández, 2001) and attaching great importance to the home, both in terms of daily security, and the memories that living there entail (Shenk, Kuwahara & Zablotsky, 2004). According to Aceros (2018), the concept of "aging in place" has highlighted the socio-physical dimension of space, contributing to the construction of autonomy, security, and well-being (Costa-Font, Elvira & Mascarilla-Miro, 2009).

However, complex relationships emerge from this experience, such as the development of attachment with structurally inadequate spaces and/or ones that are exposed to natural risks (Berroeta, Pinto de Carvalho, Di Masso & Ossul Vermehren, 2017), which negatively affect the perception and acceptance of risk (Kelman & Mather, 2008), hindering evacuation processes and/or the abandonment of homes during disasters (de Dominicis, Fornara, Cancellieri, Twigger-Ross & Bonaiuto, 2015).

In the case of communities displaced after volcanic disasters, Berroeta, Ramoneda, and Opazo (2015) reported a lower place attachment for the population resettled elsewhere (compared to their neighborhood of origin); a phenomenon reaffirmed by Maldonado, Kronmüller, and Gutiérrez (2020). Along the same lines, Ruiz and Hernández (2014) analyzed socio-spatial links before and after underwater volcanic eruptions, concluding that feelings of identity loss could be linked to place attachment.

Based on the above, this article seeks to understand the relationship between place attachment and volcanic risk perception among the older residents in Ñuble, Chile (Figure 1). The different facilitating/hindering characteristics of the perception of volcanic risk will be analyzed, considering vulnerability and place attachment. In terms of relevance, although the relationship between perceived risk and place attachment in the general population has been researched, studies on older people are scarce. It should also be mentioned that Chile has an accelerated population aging (National Institute of Statistics [INE], 2020) and is home to about 10% of the world's most active volcanoes (Chilean National Geology and Mining Service [SERNAGEOMIN], 2020a).

II CONCEPTUAL FRAMEWORK

One of the underlying factors of disaster vulnerability is the "perception of risk" (hereinafter PR), understood as the dispositional judgments about the probability, course, and mechanisms that affect decisions regarding a natural hazard (Dzialek, 2013). On the other hand, "risk acceptance" refers to the estimation of benefits, losses, and gains between options (Wachinger, Renn, Begg & Kuhlicke, 2013).

Although PR has been studied for a wide range of threats, few investigations focus on natural hazards, compared to those of the sanitary, safety, and anthropo-technological types (Dzialek, 2013).

According to Favereau *et al*. (2018), the following are found among the main factors that affect the perception and acceptance of volcanic risk: i) confidence, ii) experience, iii) knowledge, iv) religion, v) sense of community, vi) social vulnerability, and vii) citizen participation (Table 1). In summary, the volcanic risk assessment is influenced by different elements, which vary depending on the person, group, position of power, and place (Perry & Lindell, 2008; Rodríguez-VanGort & Novelo-Casanova, 2015).

Regarding "place attachment", there are varied perspectives at conceptual, methodological, and evaluative levels, which understand it as the "symbolic relationship of people towards a particular environment, manifested through culturally shared emotional and affective meanings, of a home that is physical and symbolic, simultaneously material and imaginative, multiscale, individual, public and political" (Pinto de Carvalho & Cornejo, 2018, p. 4).

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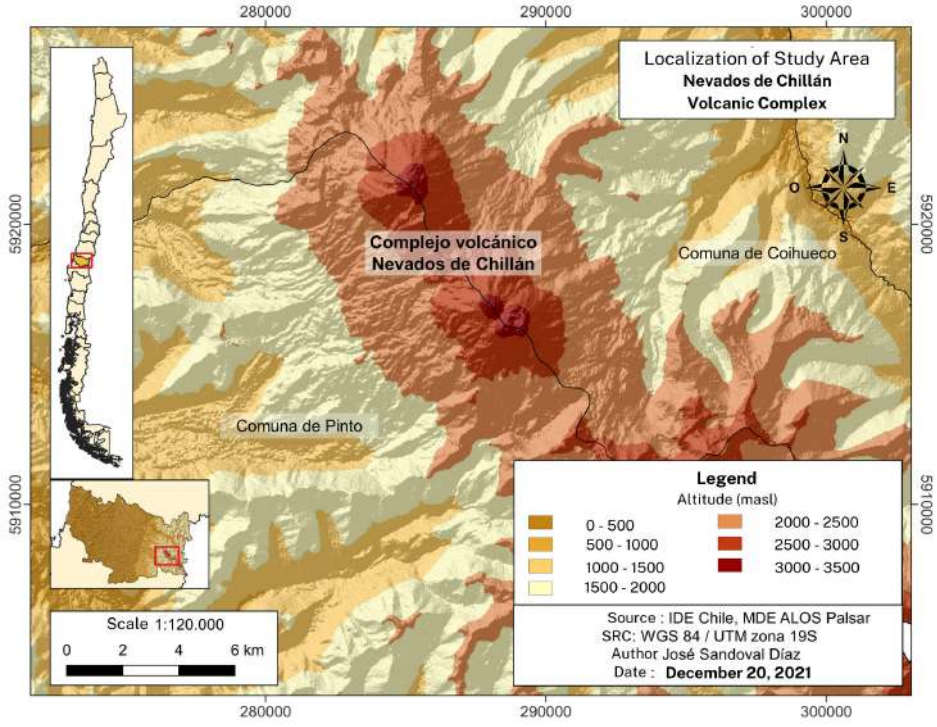

Figure 1. Location map of the case study. Source: Prepared by José Sandoval-Diaz

Factors	Definitions
Confidence	Internal confidence: People perceive themselves as self-effective and capable (or not) of acting appropriately in the face of a threat. External confidence: the trust or confidence people and communities have in scientists and/or local and government authorities.
Experience	Previous experiences of exposure to, suffering, and damage from previous disasters.
Formal knowledge	Formal information that the people and/or communities have regarding volcanic risk and emergency plans.
Religion	Beliefs about volcanic hazards and their impact on decisions and actions.
Sense of community	Feeling of belonging in a community where there are affective and cognitive ties, and shared common interests.
Social vulnerability	Levels of susceptibility and differentiated capacities among social groups to prevent, respond, and recover from a disaster.
Citizen participation	The collaborative process between the community and the authorities which strengthens their sense of self-efficacy and their trust in the authorities.

Table 1. Factors that influence the perception and acceptance of volcanic risk. Source: Preparation by Saron Monsalves-Peña using Favereau et al. (2018).

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For Seamon (2014), "place attachment" emerges and develops from contextual everyday life, promoting the generation of a significant space of affection and interpersonal-community reciprocity, with the ensuing impact on socio-spatial links. Scannell and Gifford (2010) include the concept in the conglomerate of socio-spatial ties related to action, classifying it into three dimensions: i) personal, ii) process, and iii) place.

The "personal dimension" includes the following levels: i) individual (associated with experiences and biographical memory, contributes to the formation of socio-spatial meanings), and ii) group (as shared meanings and ties). The "processes dimension" considers three psychological links: i) affective: positive and/or unsettling-traumatic link; ii) cognitive: co-construction of meanings and spatial senses through memory and ways of thinking; and iii) behavioral: the decision to stay and/or recover settlements.

"Place dimension" highlights physical-spatial aspects of the environment, such as material and environmental goods, through the interactional links that these facilitate and/or have (Berroeta *et al*., 2015).

To sum up, the development of place attachment is a daily experience, which is beneficial in multiple aspects, such as quality of life, physical-mental health, satisfaction with the environment, and interpersonal relationships. It also promotes community participation, involvement, protection, and self-regulation (Anton & Lawrence, 2014). However, evidence has also been found that these attachment ties can negatively impact the lack of preparation for risk situations (Mishra, Mazumdar & Suar, 2010). Likewise, when a threat is imminent, a greater attachment to the place tends to mean that people do not leave and/or accept the risks involved (Anton & Lawrence, 2014).

III. CASE STUDY

The Commune of Pinto

Pinto is a commune located 30 km from the regional capital of Chillán. Regarding population aging, the commune has 10,827 inhabitants, 14.8% of which are elderly, and has an Older Adults Index (IAM, in Spanish)**6** of 81.67, way above the national average of 56.85 (INE, 2017). As for social indicators, it has an income poverty rate of 25.06 and a multidimensional**7** rate of 37.13; values that are above the regional and national average (Ministry of Social Development and Family, 2018). In

Figure 2. Nevados de Chillán volcanic complex. Source: Files of Saron Monsalves-Peña.

6 The Older Adult Index (IAM, in Spanish) is defined as the number of older adults per hundred under 15s. This is the ratio between the population aged 60 and over and the one under 15 years of age.

7 The Multidimensional Poverty Index (IPM, in Spanish) identifies multiple deficiencies at household and individual levels in the areas of health, education, and living standards.

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N°	Gender	Age	Marital Status	Schooling	Place of Residence	Years of Residence	Housing	Members of the Household	Community Participation
No. 1	Man	73	Married	Seconding Schooling	Los Lleuques	22	Own	3	Seniors club Rayuela club[1]
No. 2	Woman	80	Married	3rd Year of University	Recinto	13	Own	2	Seniors club Craft workshop
No. 3	Man	85	Married	Finished university	El Rosal	24	Own	2	Seniors club Neighborhood Group
No. 4	Woman	83	Widow	Year 12	El Rosal	20	Own	2	Seniors club
No. 5	Woman	75	Widow	Year 11	El Rosal	75	Own	2	Seniors club
No. 6	Woman	68	Married	Year 12	Los Lleuques	43	Own	2	Seniors club
No. 7	Man	82	Widower	Year 8	Recinto	50	Own	1	Seniors club
No. 8	Woman	81	Single	Finished university	El Rosal	13	Own	1	Seniors club
No. 9	Woman	65	Married	Finished university	Pinto	40	Own	2	Seniors club Workshop Church
No. 10	Woman	86	Married	Year 12	El Rosal	24	Own	2	Seniors club
No. 11	Woman	74	Widow	Year 4	Recinto	37	Own	2	Seniors club
No. 12	Man	79	Married	Year 12	El Valle	33	Own	2	Seniors club
No. 13	Woman	74	Widow	Finished university	Pinto	50	Own	1	Seniors club
No. 14	Woman	75	Married	Year 8	El Valle	67	Own	2	Seniors club
No. 15	Man	71	Divorced	Technical Studies	El Rosal	8	Own	2	Seniors club

Table 2. Characterization of the study participants. Source: Preparation by Viviana Vejar-Valles.
1 Rayuela is a typical Chilean sport, where the players throw either coins or a disc toward a line made on the ground or a wooden container with mud, where the winner is the one closest to the line.

geographical terms, the western sector of the intermediate depression is a suitable place for crops and livestock, while the east is characterized by its mountainous and wooded geography, perfect as a great tourist attraction (Figure 2) thanks to its Hot Springs and the Nevados de Chillán Volcanic Complex [CVNCh] (Municipality of Pinto, 2015).

The volcanic complex has seventeen emission centers, spread over two sub-complexes (Cerro Blanco and Las Termas). At a height of 3,216 m.a.s.l., its basal area is 14 km^2, and its estimated volume is 148 km^3. Its last major eruption occurred in 1973 (Dixon *et al.*, 2010). Its main hazards are detritus flows, lava flows, and lahars; the latter being the most significant due to its proximity to the channels (Orozco, Jara & Bertin, 2016). Since April 5th, 2018, an "orange technical alert" has been decreed by the National Volcanic Monitoring Network (RNVV, in Spanish), given the important eruptive pulse seen, which registered its greatest magnitude (height of 3,300 meters) at the start of 2020 (SERNAGEOMIN, 2020b).

IV. METHODOLOGY

Design and participants

The research uses a qualitative case study of a phenomenological nature aimed at producing the meanings of situated experiences and practices (Coller, 2005). 15 older people took part (Table 2), selected "according to the relevance of the cases, rather than by their representativeness"

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(Flick, 2007, p. 80). The sample inclusion criteria were: i) age equal to or greater than 65, ii) residing in Pinto, iii) residential time equal to or greater than eight years, and iv) residing in the exposure area (in this case, the SERNAGEOMIN hazard map was used (Figure 3), which points out that the communes of Pinto and El Rosal are sensitive to secondary lahars, and Recinto and Los Lleuques, to volcanic eruptions.

Procedures: production and analysis

The fieldwork was carried out between July and October 2019. Regarding the data, the *semi-structured interviews* took 60 minutes on average. Their thematic script addressed: i) volcanic risk assessment, ii) affective ties with the place and iii) previous experiences with disasters. Subsequently, a *focus group* with ten participants was set up. This began with reading a journalistic piece about the local volcanic pulses.

After the complete transcription of the data, the grounded theory coding process was used, validating the coding through cross-auditing between researchers. Finally, to organize and support the coding process, the ATLAS ti. V7 Software was used.

IV RESULTS

The results are divided into the following two thematic lines: i) perception of risk, and ii) place attachment. Each narrative result is accompanied by anonymous textual quotations. Finally, an integrated outline of both lines is presented.

Perception of volcanic risk

The low perception of volcanic risk noticed throughout the study is manifested in the limited importance assigned to natural risks, where, in addition, a physicalist, contingent, and uncontrollable conception of socio-natural disasters prevails. In addition, the direct and continuous neighborhood experience with the Volcanic Complex, and its constant, but "harmless" eruptive pulses, have not had disastrous consequences so far. This subjective experiential immunity to risk has led not only to ignorance about the extent of the surrounding dangers, but also to limited community involvement in building comprehensive risk management plans, impairing the acquisition and development of coping skills regarding the response, emergency, and subsequent recovery. The following extracts from the opinions collected express this:

> "I'm not afraid, because volcanoes are things of nature"

> "I get up and I don't even think about the volcano, I don't even look over there, it's not my concern"

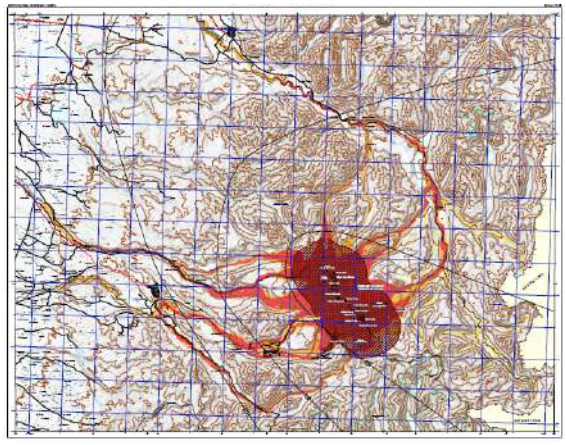

Figure 3. CVNCH hazard map.Source: Geological Chart of Chile, Environmental Geology Series 28: 34 pg.1 map scale 1:75.000 (Orozco et al., 2016).

> "I would just stay in my little house. I've seen that everyone talks about the volcano and everything… but running away, that's too much"

Added to this, on one hand, is the lack of formal knowledge about volcanic risks, which is (over) compensated by the vast direct experience acquired, as informal knowledge; and, on the other, the perception of institutional shortcomings regarding communicational management of communal emergency plans, either due to lack of interest, coverage problems and/or issues related to the gap in digital literacy:

> "No one has told us about them, and I think there are very few who know about them [...] they should get us together and show us all the escape routes, but they don't"

> "I don't use a phone, WhatsApp, or a computer, only the TV and I keep myself informed using the radio. I don't like modernity."

These communication problems are accompanied by a lack of trust in authorities and technical institutions, due to the perception of there being few spaces for participation focused on effective local risk management:

> "The authority needs a constant agreement with the citizens, with their neighbors, ... they are the ones who handle the evacuation measures in case of an eruption, and those measures have to be given in advance [...] here we are in diapers"

However, this group perceives and accepts other daily risks, such as roads in disrepair, which, in an emergency, could complicate an evacuation:

"I'm old and I have to leave on foot ... and the road is in a bad way"

Another influential element behind the low PR is social vulnerability, which increases the susceptibility to damage in the older population. As a first condition, access barriers and inequalities in the treatment they receive at the institutional level are identified, exemplified by the lack of specialists in local health services. This socio-demographic vulnerability is counterproductive in the face of potential risk scenarios, since health access constitutes a determinant for reducing disaster risk, even more so in this population. This is revealed by the following comment:

> "...I would still be waiting for them to attend me, because at the hospital, heck, they take an hour to give you an appointment, how many people are there on TV who have died ... And since then, I haven't done any more tests, why? Because I gave up waiting for an answer."

Finally, although the old-age pension is identified as the main economic resource, it is perceived as insufficient to cover the basic needs of food, transport, and health. To generate extra income, older people must take sporadic jobs (selling products and craft workshops) that are harmed by what they call "local disaster sensationalism", which affects not just local tourism but also the possibility of earning extra money to mitigate their economic vulnerability: "... the TV overplays it..., they are deceiving people, that's the truth; because it doesn't exist, ... they are cornering people".

The place

Another conditioning element, according to the results, is place attachment, where four dimensions are identified: ii) personal, ii) behavioral, iii) physical, and iv) social. The first dimension is linked to personal experiences and memories, associated with the idea of the effort involved in getting their homes and the family-community *memories* there: "I suffered a lot, moving from house to house, so I value this land so much ... it's mine, it had to sacrifice a lot".

Secondly, the behavioral dimension is linked to the insistence on continuing to live in a risk area, despite the acceptance of a potential disaster. This is accentuated if we consider the stage of the life cycle these people find themselves in: living day to day and, therefore, avoiding medium and long-term plans: "Leave! No, I'd die first... the volcano can explode, but I'm not moving from my house."

The physical dimension is described as those topographic space features (structure of the house, yard, transport access, etc.), signified as familiar, safe spaces and, above all, of high personal-communal consequence. Likewise, the landscape features of the inhabited environment stand out, in terms of tranquility and relative autonomy, compared to the regional capital. This landscape valuation of the place is expressed in the appreciation and valuation of the natural environment's resources, which foster a relationship of well-being between older people and the built environment, where the aesthetic beauty of the landscape, the climate, the vegetation, and, especially, the bond with pets and livestock is highlighted: "The tranquility… because I would never go back… even if they gave me an apartment. ...I would be like a caged bird... here I have all the freedom in the world."

The social dimension is manifested not just in community and family ties, but also through the sense of belonging and identity of those who were "born and raised here", highlighting the reciprocity and relational familiarity that the social support of a familiar environment promotes:

> "I feel good. Although I live alone, I have many friends ... friends who are practically family, they are always looking out for me".

> "I was born and raised here... if they came to get me, and took me somewhere else, I wouldn't get used to it."

Although the different socio-spatial dimensions identified produce greater well-being, it is in potential disaster risk situations where place attachment becomes maladaptive, making invisible not only the territorial exposure of volcanic hazards but also the relevance of having local risk management plans. In turn, this sustained permanence in place hinders the ability to adjust to other contexts or living conditions, in the potential scenario of a displacement process and/or post-disaster reconstruction:

> "My brothers tell me: "Hey, how are you doing with the volcano? Go to Chillan." I tell them that I had no idea that the volcano was so angry... that things are going to happen with or without a warning."

> "When you chat with neighbors, you realize that, if there's an eruption, you'll have to get out... what other choice is there."

> "I would have to get to know new people, new places. It's so difficult to adapt at my age."

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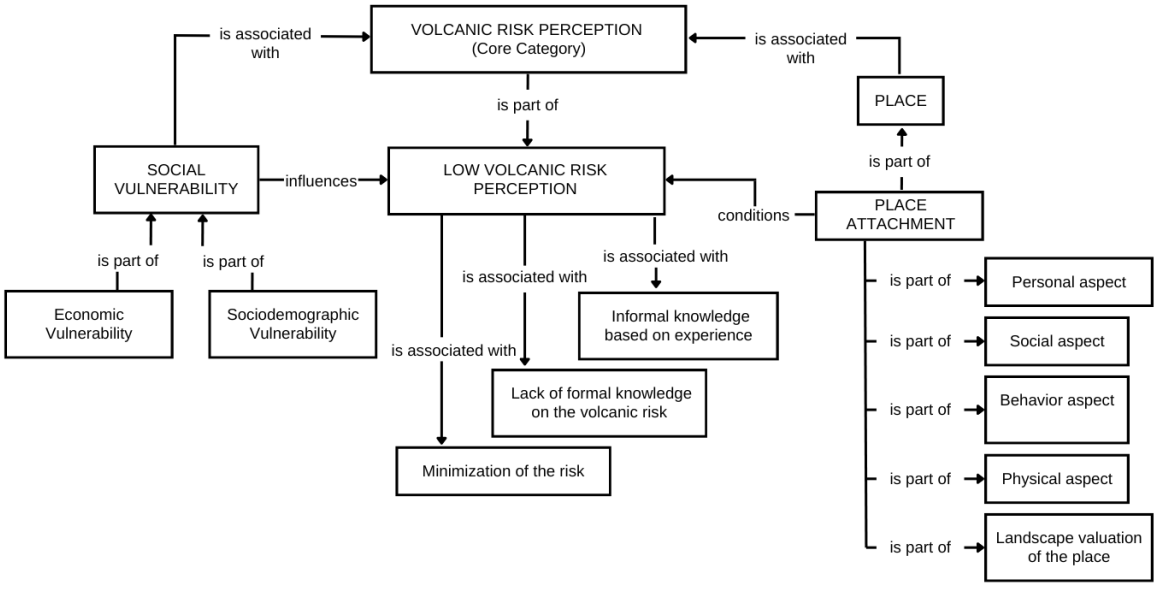

Figure 4. Integrated axial coding of the results. Source: Prepared by Saron Monsalves-Peña.

Synthesis of results

The volcanic PR (Figure 4) of older people is influenced both by i) *social vulnerability*, in terms of demographic susceptibility due to structural barriers to access and unequal treatment at a health and economic level, as well as by ii) positive evaluations of the personal, socio-spatial, and landscape dimensions of the "place" they inhabit. Although the literature reviewed highlights the positive relationship between "healthy aging" and place attachment, the latter, faced with a potential disaster risk scenario, becomes a negative determinant of the low perception and acceptance of volcanic risk. In dispositional terms, this entails a minimization of the surrounding dangers, associated with iii) direct experiential knowledge, where emergency and/or disaster situations have not been experienced, and iv) formal ignorance not just of the characteristics and types of volcanic hazards, but also regarding the acquisition and implication on individual coping strategies, as well as at household and institutional levels.

VI DISCUSSION

In line with Williams and Vaske (2003), the case study has a marked dependence on place, both because of the landscape characteristics (and the built environment) to do activities and achieve collective goals, as well as a strong identity of place, as an emotional space with symbolic ties that define the community "we" (Berroeta *et al*., 2017; 2015; Maldonado *et al*., 2020). This contributes to building autonomy, security, and physical and emotional well-being, a key to "aging in place" (Aceros, 2018). However, this plays a negative role in disaster risk situations, bypassing further still, the diminished perception and acceptance of volcanic risks (Kelman & Mather, 2008; Tobin & Whiteford, 2002).

In this way, it is possible to classify the different hindering factors of PR into three levels: structural, institutional, and personal.

Structural: (i) economic vulnerability, as the main measure of access to resources, (ii) limited trust of authorities and the media, (iii) scarce participatory and recognition spaces for the older population, (iv) generational gaps in access and technological use. *Institutional:* (v) inadequate training and communication in local risk management. *Personal*: (vi) subjective immunity to remote probability risks, and (vii) physicalist conception of disasters (Favereau *et al*., 2018; Sandoval *et al*., 2022).

On the other hand, the way of life instituted between the place and the community permeates not only the senses of belonging and attachment but also the levels of personal and collective well-being. From the urban point of view, according to Sánchez (2015), experts agree on the design of social policies

and territorial planning focused on the aging-in-place process, identifying three core elements: i) the social space of opportunities to deploy skills, ii) the positive perception towards the environment, in terms of attachment, community identity, and housing satisfaction, and iii) the positive influence on physical and mental health, social connection, life satisfaction, and healthy aging (Corbin & Pangrazi, 2001).

Regarding the limitations of the study, although the flexible and comprehensive nature of the qualitative approach used is noteworthy, future studies must incorporate subjective and objective measures of the built environment (Sánchez, 2015), methodologically triangulating not only the properties linked to exposure and vulnerability through geographic information systems (GIS), but also proposing a better integration, operationalization, and evaluation of the concept of "aging in place" under disaster risk scenarios (Aceros, 2018).

To conclude, to improve local risk management, it is essential to strengthen not just information channels and content, but also the degree of involvement, participation, and recognition of abilities that the older population possesses. In terms of living, although this group must adapt to a series of physical, cognitive, and participatory changes and barriers, this does not imply the absence of the capacity of agency in risk situations (Arriagada. Vallejos, Quezada, Montecino & Torres, 2016; Ojeda & López, 2017; Sandoval et al., 2022). Consequently, the situated change of collective capacities such as memory, local experience, local knowledge, community ties, and organizational capacity, will contribute to giving greater intelligibility to the scientific-technical knowledge of experts and, most especially, to the strengthening of trust and social capital of the different organizations linked to local risk management (Paton, Smith, Daly & Johnston, 2008; Sandoval & Martínez, 2021).

VII CONCLUSIONS

This article has questioned the relationship between place attachment and the volcanic PR of the older population, an age group identified as vulnerable to disaster risk processes (Rodríguez *et al*., 2018; Sandoval & Cuadra, 2020). In this way, based on a case from central-southern Chile, from a qualitative phenomenological approach, the perspectives of older people faced with a natural risk were analyzed, revealing their perceptions about exposure, vulnerability, and the place they inhabit. As the main result, the role of place attachment stands out, as a negative determinant of the perception of volcanic risk, and the consequent hindrance on the effect and deployment of coping strategies (de Dominicis *et al*., 2015), added to the multiple negative barriers of social vulnerability's structural and age conditions (Cutter *et al*., 2003; Wisner *et al*., 2004).

From this perspective, even though the literature highlights the benefits of place attachment on the quality of life, physical-mental health, satisfaction with the environment, and interpersonal relationships (Anton and Lawrence, 2014), this work reaffirms its negative influence not only on the perception and acceptance of natural hazards (Kelman and Mather, 2008) but also on the involvement and preparation for potential disaster risk scenarios (Mishra and *et al*., 2010) and/or the potential abandonment of areas under an imminent emergency.

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APEGO AL LUGAR Y PERCEPCIÓN DEL RIESGO VOLCÁNICO EN PERSONAS MAYORES DE ÑUBLE, CHILE
JOSÉ SANDOVAL DÍAZ, SARON MONSALVES PEÑA, VIVIANA VEJAR VALLES, CRISTÓBAL BRAVO FERRETTI
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ERICK SOLO DE ZALDÍVAR, VÍCTOR MONTRE ÁGUILA, FRANCISCO MATURANA MIRANDA
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EMPLOYMENT TRAJECTORIES AND ECONOMIC SPECIALIZATION IN THE COMMUNES OF THE ÑUBLE REGION IN 1982, 1992, 2002, AND 2017 [1]

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ERICK SOLO DE ZALDÍVAR [2]
VÍCTOR MONTRE ÁGUILA [3]
FRANCISCO MATURANA MIRANDA [4]

1 Article based on theoretical reflections and methodological contributions of the FONDECYT Initiation Project N° 11150087 “Transition towards new metropolitan spaces. Comparative analysis between Temuco, Valdivia and Puerto Montt”.

2 Magíster en Ordenamiento Territorial y Geografía
Gobierno Regional de Ñuble, Chile. Analista Sistema de Información Territorial, División de Planificación y Desarrollo.
https://orcid.org/0000-0002-4855-8121
erick.solodezaldivar@goredenuble.cl

3 Magíster en Investigación Social y Desarrollo
Universidad Católica de la Santísima Concepción, Concepción, Chile. Académico, Departamento de Historia y Geografía.
https://orcid.org/0000-0002-7391-1054
victor.montre@ucsc.cl

4 Doctor en Planificación Territorial, Urbanismo y Dinámica del Espacio
Universidad Austral de Chile, Valdivia, Chile. Académico, Instituto de Ciencias de la Tierra.
https://orcid.org/0000-0003-3963-5807
francisco.maturana@uach.cl

DOI: https://doi.org/10.22320/07183607.2022.25.46.02

El objetivo de este estudio es analizar los cambios en los sectores económicos ocurridos durante 1982, 1992, 2002 y 2017 en el sistema de ciudades, junto con comprender la evolución y trayectoria funcional del empleo en la Región de Ñuble. La investigación posee un enfoque cuantitativo y aplica un diseño correlacional. La base de datos fue extraída de los censos del Instituto Nacional de Estadística (INE) de los años mencionados a través del programa REDATAM. A partir de lo anterior, se realizó un análisis de componentes principales (ACP) mediante el software R, visualizado a través de tablas, gráficos y cartografías. Los resultados señalan que existe una tendencia que diversifica las ramas económicas en la región, las cuales evolucionan desde la agricultura hacia el comercio, servicios, enseñanza y construcción. Los índices de especialización demuestran que existe una trayectoria hacia la homogeneización de los sectores terciarios y que, en una cantidad reducida de comunas, el sector primario representa una parte importante de la actividad local. Además de la disminución del empleo agrícola e industrial, se concluye que las diferentes comunas de la región presentan una vocación primaria y terciaria, reconociéndose una coevolución entre las diferentes ramas económicas.

Palabras clave: trayectorias de empleo, especialización económica, evolución cofuncional, sistema de ciudades.

The goal of this study was to analyze the changes that have taken place in the economic sectors in the system of cities between 1982, 1992, 2002, and 2017, alongside understanding the evolution and functional trajectory of employment in the Ñuble Region. The research approach is quantitative and applies a correlational design. The database was extracted from the 1982, 1992, 2002, and 2017 censuses of the National Institute of Statistics (INE, in Spanish) using the REDATAM program. Then, a principal component analysis (PCA) was performed using R software, shown through tables, graphs, and cartographies. The results indicate a trend that diversifies the region's economic branches, evolving from agriculture toward commerce, services, education, and construction. The specialization indexes show a trajectory towards the homogenization of tertiary sectors and that, in a small number of communes, the primary sector represents a relevant part of local activity. In addition, from the decrease in agricultural and industrial employment, it can be concluded that the different communes of the region have a primary and tertiary vocation, recognizing a co-evolution between the different economic branches.

Keywords: employment trajectories, economic specialization, co-functional evolution, system of cities.

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I. INTRODUCTION

Urbanization is progressing steadily over time. It is estimated that currently, 56% of people live in cities and that this proportion will increase by 13% by 2050 (United Nations, 2021). Part of the cause behind this phenomenon lies in the fact that the world's population will move its place of residence from rural to urban areas.

In the Latin American context, this phenomenon has also been clear. The continent's cities concentrate the economic, political, and administrative power, and it is estimated that more than 80% of the region's population is urban (Montero & García, 2017). This implies profound transformations derived from socio-economic restructuring processes, as part of the phenomenon of globalization, which have a significant impact on the growth dynamics of cities (de Mattos, 2002).

In Chile, about 87% of the population is urban, which has fostered the development of the export sector and generated changes in the employment and production structure. This urbanization process is expressed through the transition of the agricultural sector towards that of services (Rehner & Rodríguez, 2017; Pérez, 2019; UN, 2021).

The Ñuble Region is immersed in the national extractivist and exporting economy of minerals, forest, fruit, and wine products. Thus, the region is a space that has a great diversity of landscapes (mountain ranges, valleys, rivers, lakes, and sea) and a wealth of natural systems, which constitutes the basis of its economy given the agricultural activities, with a strong presence of the traditional agricultural sector, agribusiness, tourism and, recently, the forestry industry. Together, these give a cultural and territorial identity to the inhabitants of the area (Acuña *et al*., 2015).

In the context of the Ñuble Region's administrative start-up, it is interesting to use it as a study territory to contribute with analysis that aims at developing territorial policies for the equity and well-being of the region's inhabitants. In addition, this type of study allows contributing to a better design of public policies for the territory's organization, based on the diagnosis and territorial analysis, in view of the preparation of the first Regional Territorial Organization Plan (PROT) for the Ñuble region.

From the geography and economics area, it is important to understand the development processes linked to a new region, recognizing the changes and transformations that exist in the economic structure of a territory.

This research seeks, in short, to deepen the understanding of the dynamics of the regional space, from the analysis of the functional employment trajectory, to reveal the relationships and behaviors of the cities in the Ñuble Region over time, considering that researching this topic makes it possible to propose public policies based on updated empirical information and, thus, project territorial development models. In this way, the intention is to answer questions at a territorial level, such as what has been the behavior of the labor market in the Ñuble Region? Are there any changes in the economic structure of the Ñuble Region? And, which communes have a labor market specialization over time?

City systems

The economic, social, political, or cultural interactions between communes can be understood within the framework of the theory of city systems (Picard & Zenou, 2018; Pumain, 2018). In this sense, Pred (1977) argues that urban centers are interdependent and interconnected with each other, to the extent that a significant change in an urban area will affect the rest of the centers that make up the system to which they belong.

It is proposed, from a theoretical level, that the study of the city system emerges as a tool capable of analyzing the behavior of cities, which contributes to the preparation of diagnoses of regional spaces aimed at the design and implementation of more effective public policies, particularly those aimed at a territorial organization (Lindón, Aguilar & Hiernaux, 2006).

There are two relevant notions for the analysis of city systems. One that refers to the hierarchy of the city, which is expressed in the connection of the amount of population, the inequalities in the weight, and the size of the cities considering their interactions; and one that relates the functional aspects (Pumain & Saint-Julien, 2001). Regarding the latter, the analysis of the notion of "specialization" arises, which associates the spatial division of production and labor with the idea of functional interdependence.

The specialization of a spatial unit defines its specificity within a geographical system and its contribution to the particular form that this system acquires. The functional specialization of places results from the trend manifested by certain activities or functions to concentrate on some sites (Pumain & Saint-Julien, 2001). Geographically, specialization is appreciated through the activities it encompasses, produces, and the modes of work organization. Thus, for example, at a

regional level, wine and cereal regions can be identified in an agricultural system. And, in the communal environment, tourist and service cities.

In Chile, the city system is characterized by an early macrocephaly, accentuated from the 1940s by the process of industrialization and expansion of the central state (Maturana, Peña-Cortés, Gasic & Sepúlveda, 2021). An important factor is the functional coevolution of the city system, characterized by the tendency towards the homogenization of certain tertiary sector activities, specifically, the areas of trade, real estate, and construction (Maturana, Sepúlveda, Prada, Fuenzalida & Stafolleri, 2019).

Such processes unfold in a context of changes, explained, in part, by the transformations from the economic restructuring of the country, based on free market strategies, which have had an impact on the structure of urban labor markets in cities, generating a change in their functional profile (Hidalgo, de Mattos & Arenas, 2019; Pumain, 2018). In this way, the evolution and behavior of city systems are characterized by the hierarchical stability they present and a certain tendency to the homogenization and outsourcing of the economic employment branches of the cities' inhabitants, for which it is necessary to delve into the factors that affect the deepening of relations between urbanization and economic production. This evidences a positioning of the aforementioned cities together with small cities, as a relevant factor for the articulation of the respective urban systems and the dynamization of the contiguous territories, particularly rural ones.

II. METHODOLOGY

This work was structured in 2 stages. The first one was the selection of the study area, focusing on the communes of the Ñuble Region (created in 2018). The analysis covered the 21 communes that this territorial unit comprises. Given the creation of Chillán Viejo in 1996 and, based on the forming of the conurbation with Chillán, this area was established as a unit for information analysis. Four study periods were used. These are related to the information available in each of the national censuses (Figure 1): 1982, 1992, 2002, and 2017. For each census (provided by the National Institute of Statistics of Chile (INE, 2017), and through the REDATAM program, the "line of business" variable was used, through which it was possible to obtain the economic area where a person works under the United Nations' International Standard Industrial Classification (ISIC).

The second stage comprised building databases. A specific base was made for the different periods of analysis, using the census information of the different years. In the 2017 census, the number of jobs linked to certain economic areas had to be merged, since they were presented in an aggregated or disaggregated way in different cases. In the last stage, a specialization index of the communes of the Ñuble Region was built.

The first analysis was related to the evolution and percentage changes experienced by the commune and in specific years, the result of the new categorization expressed in participation percentages in each branch based on the total employees per commune. Subsequently, a principal component analysis (PCA) was made using the R program and the FactoMineR package, which allowed describing the trajectories of the economic structures of the communes, interpreting the first two components of the factorial plane (Paulus, 2004; Pumain & Saint-Julien, 2001) through the coordinates of the first and second factorial plane obtained from the PCA. The linking of the coordinates of each spatial unit, through a line, makes it possible to show the employment trajectories in the 21 communes of the region, through the interpretation of the correlation circle.

Finally, the specialization coefficient was calculated by comparing the economic structure of the commune against the region, using an interval of between 0 and 1, where, close to 0, it is considered a very diversified structure and, close to 1, a very specialized economic structure. The specialization of the communes was represented through maps built in the ESRI software for the census years of 1982, 1992, 2002, and 2017.

The limits of the research are related to the economic-labor aspect of the data used in making the study; information where social dimensions or public policies are not applied to generate new approaches. It is also recognized that the unit of study at a communal level could delve deeper by using a smaller scale of approximation to the object of analysis. Ultimately, the study is quantitative, leaving aside the possibility of mixed research that describes and interprets the historical processes of transition to an economic structure of the Ñuble Region.

III. RESULTS

The results of the research are presented in three sections, which describe the evolution of the economic branches in the Ñuble Region, the presentation of the functional employment trajectories of the different communes, and

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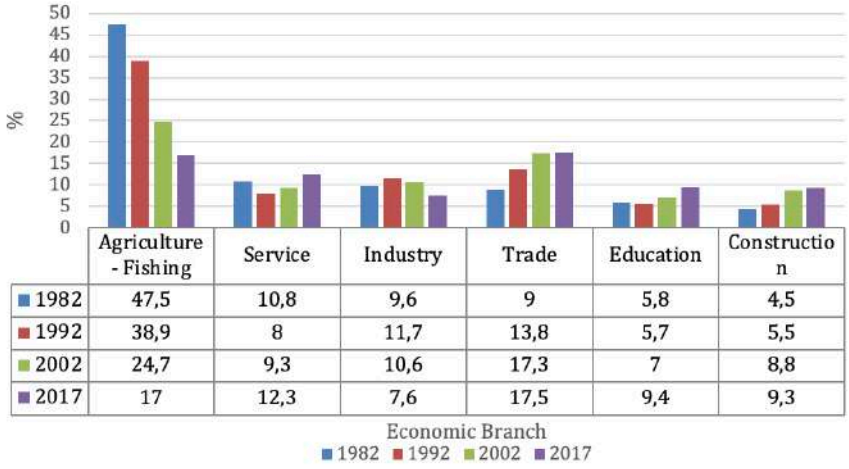

	Agriculture - Fishing	Service	Industry	Trade	Education	Construction
1982	47,5	10,8	9,6	9	5,8	4,5
1992	38,9	8	11,7	13,8	5,7	5,5
2002	24,7	9,3	10,6	17,3	7	8,8
2017	17	12,3	7,6	17,5	9,4	9,3

Figure 1. Evolution of the main economic branches in the Ñuble Region in 1982, 1992, 2002, and 2017. Source: Preparation by the authors using data from the censuses of 1982, 1992, 2002, and 2017.

the later visualization and explanation of the economic specialization charts of 1982, 1992, 2002 and 2017 of the communes.

Evolution of the economic branches in the Ñuble region in 1982, 1992, 2002, and 2017

As a first element and to contextualize the specialization analysis, the data of the 5 main economic branches that generate the most jobs, according to the censuses of 1982, 1992, 2002, and 2017, are presented. The description is developed here in conjunction with the presentation of the specialization statistics for the different censuses.

Figure 1 contains information on the percentage of employment generated by each of the economic branches in the study area. The variables involved are the number of employees in the activity, measured in percentages and represented in the different periods. In global terms, the table shows the employment behavior at four points over 35 years, which reveals significant decreases in agricultural activity and increases in the tertiary sector, such as trade and education.

Figure 1 shows that in 1982, the agricultural sector predominated as an economic branch, with 47.49%, a trend that decreased in 1992 by 8.6%, registering 38.9%. The services activity reached 10.7% in the first stage, and then showed a slight decrease in 1992 when it reached 8%. Among the branches that have upward trends, is the industry that in 1982 represented 9.6%, before rising to 11.7% in the 1990s. On the other hand, trade, which initially had 8.9%, increased to 13.8%, being the branch with the greatest increase in the first period of analysis (4.9%). In global terms, a fall in the agricultural sector can be seen in contrast to the increase in tertiary and secondary activities.

For the analysis period corresponding to 1992 and 2002, the agricultural sector showed a significant decrease, falling from 38.9% to 24.7%. Another activity that decreases here is industry, which starts at 11.7% and decreases to 10.6%. Trade, meanwhile, showed a 3.5% increase, rising from 13.8% to 17.3%, consolidating itself as the second most important economic branch in the study area for this interval. In general, the contraction trend in agriculture as an employment-generating economic branch is confirmed and a slight decline in the industrial sector is observed. In contrast, trade confirms its upward trend.

Between 2002 and 2017, several changes occurred in the labor market structure of the analyzed area. The trade sector does not show a significant increase in its growth but comes out top, as the economic branch that generates the largest number of jobs. In the case of agriculture, its fall is confirmed, from 24.7% to 17%. Industry decreases from 10.6% to 7.6%. On the other hand, some increases demonstrate outsourcing of the regional economy, for example, it is observed that the service sector is the third most important branch. In global terms, it is evident that the labor market structure

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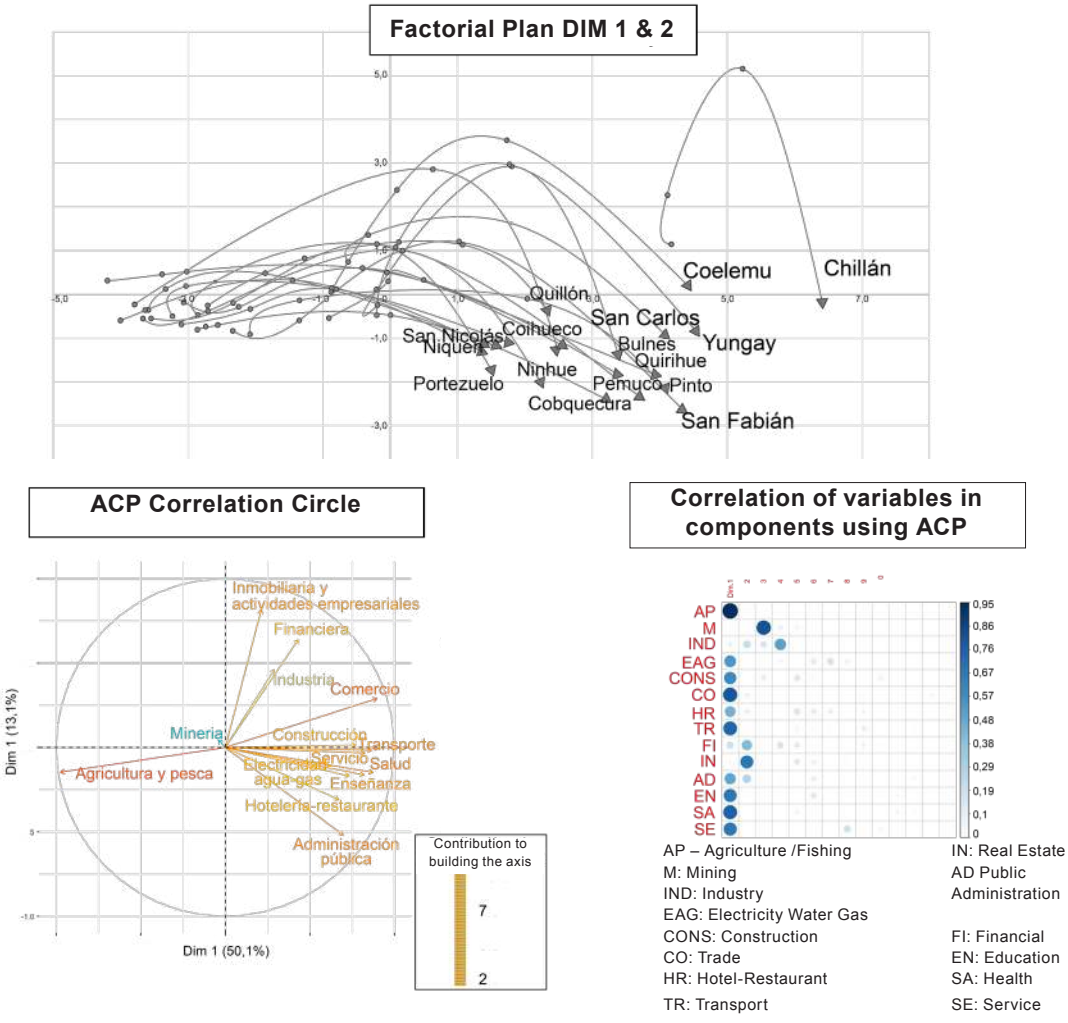

Figure 2. Functional trajectories of cities in the Ñuble region between 1982 and 2017, according to the analysis of the main components between economic sectors.

has notable changes, the downward trend of agriculture is consolidated, and the branches of the tertiary sector rise in most of its activities.

Functional trajectories of the Ñuble Region in 1982, 1992, 2002, and 2017

The results obtained from the functional trajectories of the region's cities can be appreciated, based on two aspects. The first is the functional co-evolution from primary activities to tertiary sectors. The second is that as the general population increases, cities tend to become less specialized.

It is acknowledged that in the first two components there is a significant cumulative variance of around 63% (Figure 2). The highest correlation in component 1 corresponds to agriculture and fishing, which is on the negative axis (this can be seen in the correlation circle in Figure 2). Then, the other activities are linked to the tertiary sector, such as trade, service, health, education, transport, and, to a lesser extent, public administration and hotels and restaurants. These activities are on the positive axis of component 1. On the contrary, in component 2, activities such as real estate, finance, and industries are identified.

In Figure 2, the functional trajectories according to the censuses of 1982, 1992, 2002, and 2017 can be seen, observing that the economic profile in the cities has been linked from the beginning to agriculture-related activities, as has generally happened throughout the country's regional urban system (Maturana *et al*., 2021).

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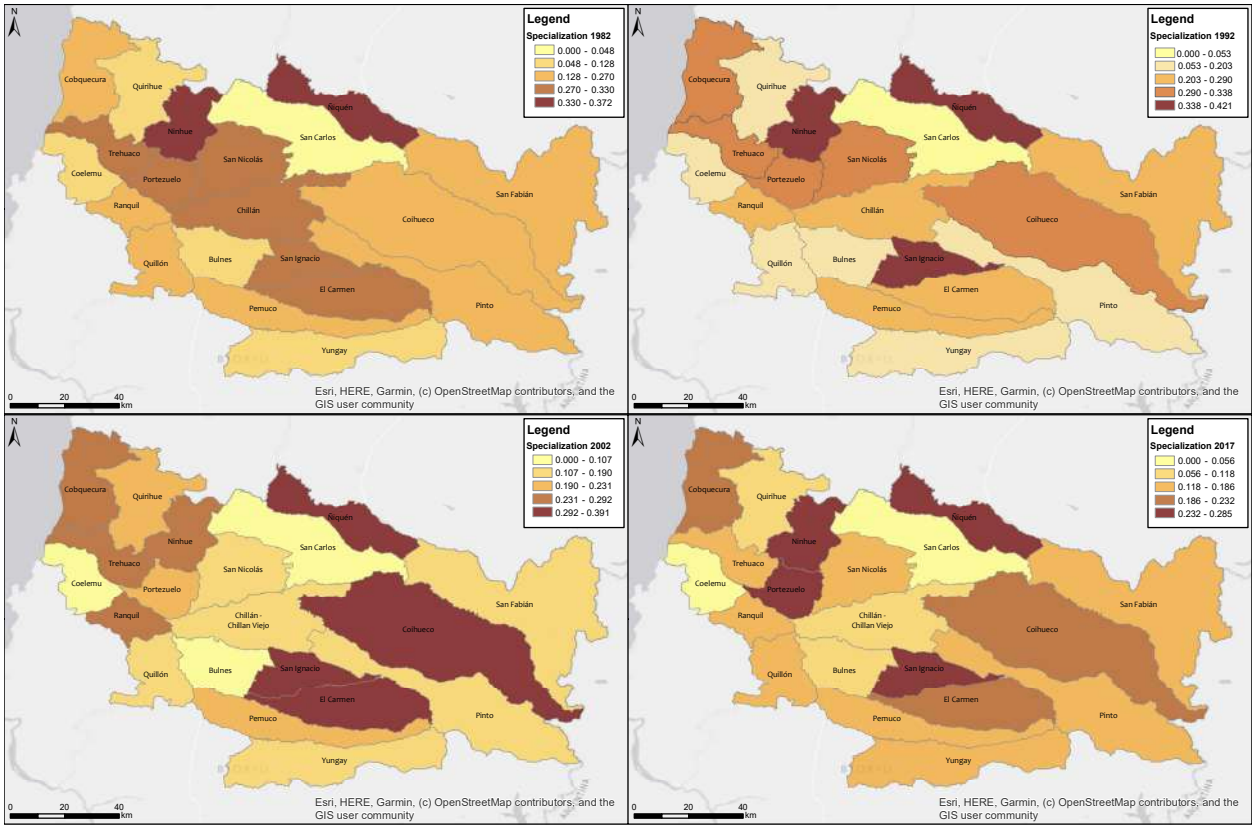

Figure 3. Specialization of the communes of the Ñuble region, according to censuses of 1982, 1992, 2002, and 2017. Source: Preparation by the authors, based on the censuses of 1982, 1992, 2002, and 2017.

That is, there is a coevolution that allows an economic diversification towards tertiary sector activities, where services in advanced areas of knowledge are not present, as is the case in the United States or some European countries (Bretagnolle, 2021; Paulus & Vacchiani-Marcuzzo, 2015), but rather being circumscribed to retail, hospitality and catering, education and, with a high participation, construction.

Agriculture has lost importance within the Ñuble region in terms of specialization and job generation. However, the relevance of the process is that it is in line with what urban and economic theory expects from the dynamics of cities as they grow in terms of population (Duranton & Puga, 2000; Markusen & Schrock, 2006).

These dynamics are contextualized and intensified with the economic liberalization policies in the 1970s and 80s in Chile, which were implemented in the context of insertion into globalization, which sought to use resources with a high level of efficiency (de Mattos, 2016; Pino, 2006). In this sense, there was a liberalization of imports, promoting the development of foreign investment and, in turn, encouraging the export of raw materials (Turmo & Moslares, 2007).

In the Ñuble Region, it is observed that a large part of the communes that specialized in traditional agriculture, over the years evolved into ones with agro-industrial characteristics, which is evidenced in the transition of many of these territories towards services and transport branches, the result of the outsourcing process of urban economies (Figure 2). However, not all communes show a similar evolution. The diversification of Chillán is characterized, in this framework, by developing in its same quadrant, which does not happen with other communes whose transit is much more noticeable (Figure 2). In addition, these particularities of Chillán are expressed in the curve between 2002 and 2017, due to the fall in real estate and business activities, an aspect that is more attenuated in all other communes.

Specialization of the communes in the Ñuble Region

Figure 3 contains information on specialization data in the Ñuble Region for the periods of 1982, 1992, 2002, and 2017. Broadly speaking, Figure 3 shows the behavior of economic activities at four moments over a range of 35 years, making the changes of a time of profound economic transformations in the country visible.

The data for the 1982 census reveal that the agriculture branch is the one that generates the largest number of jobs in the then province of Ñuble, which is followed by the service branch with a lower percentage. Regarding the specialization results, in part 1 of Figure 3, it is observed that Ninhue and Ñiquen are located as cities with very high specialization. In both cases, the importance of agricultural activity positions them as the economic branch that generates the largest number of jobs, with a high participation in the economic system.

For the 1992 period, the branches that produced the largest number of jobs were the agricultural sector and trade. Regarding specialization, it is noted that Ninhue and Ñiquen continue with a very high level of specialization, to which the commune of San Ignacio is added, during this period. In this way, they are consolidated as labor market territories that support small-scale agricultural and trade functions. There are followed in high specialization, by Portezuelo, Coihueco, San Nicolás, Trehuaco, and Cobquecura.

In the 2002 to 2017 period, a trend towards a decrease in agricultural and industrial activity was identified, explainable by an acceleration of modernization, which is seen in the fall in employment in the primary and secondary sectors. On the other hand, a functional co-evolution of this set of cities of the Ñuble Region is recognized, characterized by a homogenization of the process towards the construction, transport, service, health, education, and public administration sectors.

IV. DISCUSSION

The city system of the Ñuble Region shows an employment trajectory between 1982, 1992, 2002, and 2017, that is prone to a functional co-evolution, characterized by the tendency towards the homogenization of certain activities of the tertiary sector, specifically, in the areas of transport, service, health, education, hotel-restaurants, and public administration.

This trajectory is distinguished by a significant drop in the agricultural sector in terms of its employment-generating capacity, since it went from being the main branch, in 1982, and generating 47% of jobs in the study area, to producing only 17% in 2017. From this information, it follows that Ñuble transitions from being a "traditional" rural sector to one where the agro-export model predominates; a transformation that brought with it a decrease in jobs in the territory. According to Montero and García (2017), this sector is undergoing important restructuring derived, directly or indirectly, from the modernization process and the impact of globalization and insertion into global markets. In fact, the rural sector of Ñuble has been undergoing relevant mutations that imply changes in the traditional rurality, in the productive structure (Fawaz & Vallejos, 2012), and in the employability of the agricultural sector.

From this, there is an occupational profile that is transforming from the economy's primary sector to the tertiary, which can be verified through the growth of economic branches such as trade, service, and education. In addition, the trajectory of the communes of the Ñuble Region is similar, in terms of co-evolution, to what has happened in other city-systems of the world, each with its own particularities (Paulus, 2004). However, this transition is towards a simplified branch of the aforementioned activities and not towards one oriented to financial, scientific, or technological services (Pérez, 2019; Rehner & Rodríguez, 2017).

Finally, it is evident that the co-evolution of cities is different both in terms of scale and their displacement towards the service sector, observing, on one hand, the loss of economic areas linked to the production of goods (agriculture and industry) and, on the other, the approximation of other sectors, such as commerce and public-private services, to a post-Fordist city model or urban tertiary (Manero, 1998; Díaz & Lourés, 2003).

V. CONCLUSIONS

This work serves, first of all, as an input for the generation of plans, policies, and programs in the Ñuble Region. In the context of the start-up of the new territorial unit, the analysis and processing of information becomes more relevant because the policies that will be implemented in the territory in the coming years are beginning.

In particular, work behavior has important changes in its structure. For the study period, the predominance of the agricultural sector is identified as the activity that, in the beginning, generates the greatest amount of employment in Ñuble. However, it ends up projecting downward. On the contrary, the branches of the tertiary sector are consolidated as those that generate the greatest amount of employment.

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The specialization processes, within the transition, have concentrated toward the outsourcing of the economy, where the preponderance of activities linked to sales, teaching, and construction services is recognized (Maturana *et al*., 2019). This has generated a movement of workers towards the city, through a modification of the production systems and forms of employment organization (Pumain & Saint-Julien, 2001).

The transformation of the economic structure has implied that labor, social, political, and cultural interactions differ in each of the study's censuses (Picard & Zenou, 2018; Pumain, 2018), whereby the need to build and implement public policies at different territorial scales is manifested (Lindón, Aguilar & Hiernaux, 2006).

Regarding the specialization of the labor market, it is observed that, in principle, it was linked to the agricultural sector, located in inland rainfed communes, and that, in the following periods of analysis, the economic unit was registering a lower specialization of the labor market. Such behavior reveals profound changes in the Ñuble Region, as it transitions from the primary sector of the economy to outsourcing employment in the communes of the territorial unit.

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PLANNING THE RURAL URBAN FRINGE OF SANTA EUFEMIA, CÓRDOBA, ARGENTINA[1]

PLANIFICACIÓN DE LA FRANJA URBANO RURAL DE SANTA EUFEMIA, CÓRDOBA, ARGENTINA.

EMILIANO JAVIER CAHE [2]
JORGE DANTE DE PRADA [3]

1 Research financed by the PERHID CIN Postgraduate Scholarship

2 Magíster en Ciencias Agropecuarias
Universidad Nacional de Río Cuarto (UNRC), Río Cuarto, Argentina.
Docente-Investigador, Departamento Economía Agraria, Becario Doctoral, Instituto de Investigaciones Sociales, Territoriales y Educativas (ISTE) - Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)
https://orcid.org/0000-0002-2967-2287
ecahe@ayv.unrc.edu.ar

3 Doctor en en Economía Agraria y Recursos
Universidad Nacional de Río Cuarto (UNRC), Río Cuarto, Argentina.
Docente-Investigador, Instituto de Investigaciones Sociales, Territoriales y Educativas (ISTE) - Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)
https://orcid.org/0000-0001-9732-0497
jdeprada@ayv.unrc.edu.ar

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El objetivo de este artículo es mostrar cómo diseñar y evaluar la visión estratégica territorial de la Franja Urbano Rural (FUR) en la localidad de Santa Eufemia, Córdoba, Argentina. La metodología se basa en un procedimiento multicriterio por fases dirigido al gobierno municipal y los actores que éste involucró. En la fase 1, se identificaron los problemas (oportunidades) y aspiraciones locales mediante entrevistas en profundidad. En la fase 2, se diseñó y valoró un menú de alternativas para dos decisiones estratégicas que emergen de las entrevistas: la regulación hídrica (desagües) y la provisión de alimentos de proximidad. En la fase 3, se relevaron las preferencias de los actores y se evaluaron las alternativas mediante el algoritmo Promethee. Las alternativas elegidas fueron incluidas a la visión de FUR y complementan tres decisiones estructurales (localización de un parque industrial, poblamiento urbano futuro y gestión de residuos). Comparada con las prognosis, dichas alternativas presentan mejor performance, aunque se reconocen algunas limitaciones. Una de ellas reduce 50% los escurrimientos hídricos que potencialmente afectarían a la localidad y otra incrementa la producción de alimentos de proximidad 27%, genera excedentes económicos (12 puestos de trabajo) y minimiza significativamente los riesgos de enfermedades zoonóticas y de contaminación por agroquímicos. Ahora bien, las alternativas requieren más inversiones y un esfuerzo político institucional mayor que la prognosis. Por último, los actores valoraron las alternativas diseñadas junto a las tres dimensiones de la sostenibilidad (criterios de comparación) y acordaron avanzar en una decisión de compromiso sobre la visión de FUR.

Palabras clave: ordenamiento territorial, periurbano, diseño colaborativo, ayuda multicriterio discreta.

This article seeks to show how to design and evaluate the territorial strategic vision of the Rural-Urban Fringe (RUF) in Santa Eufemia, Córdoba, Argentina. The methodology is based on a multi-phase multi-criteria procedure for the municipal government and the actors involved. In phase 1, local problems (opportunities) and aspirations were identified through in-depth interviews. In phase 2, a menu of alternatives was designed and assessed for two strategic decisions that emerged within the interviews, namely, rainwater drainage and local food provision. In phase 3, the actors' preferences were revealed, and the alternatives were evaluated using the Promethee algorithm. The chosen alternatives were included in the RUF vision and complemented three structural decisions (location of an industrial park, future urban settlements, and waste management). Compared with the prognosis, the alternatives chosen, have a better performance, although some limitations are recognized. One of the alternatives reduces the water runoff that could potentially affect the locality by 50%. Another alternative increases local food production by 27%, generating an economic surplus (12 jobs) and significantly minimizing the risks of zoonotic diseases and agrochemical contamination. However, the alternatives require more investment and an increased institutional political effort than in the prognosis. Finally, the actors appreciated the alternatives designed with the three sustainability dimensions (comparison criteria) and agreed to move forward on a compromise decision about the RUF vision.

Keywords: spatial planning, peri-urban, participative design, discrete multi-criteria analysis

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I. INTRODUCTION

The Rural-Urban Fringe (RUF) is a synergistic territory for urban and rural development, with a high risk of disintegrating. Disintegration has been associated with the phenomenon of dispersed urban sprawl (Scott *et al.*, 2013; Le Bivic & Melot, 2020) and the loss of complementarity between different land uses and services of the RUF (Gallent, 2006; La Rosa, Geneletti, Spyra, Albert, & Fürst, 2018). In some regions, such as Latin America, the impacts of disintegration are alarming (Inostroza, 2017). For example, in the south of Córdoba, Argentina, the growth of 69 urbanized areas was scattered and, among the other effects recorded, it was three times greater than the population increase between 2001-2018 (Cahe & de Prada, 2022)

To minimize disintegration and appraise the services of the RUF, territorial planning received increased attention. The RUF was assessed to develop green belts, agricultural parks, and to reserve areas for future urban development in England (Gallent, 2006), to facilitate the mixed and complementary use of land in Sweden (Hedblom, Andersson & Borgström, 2017), to regulate the water cycle in Mexico (Nanninga *et al*., 2012), and/or to mark off local productive areas in Argentina (Zulaica & Ferraro, 2013; Hermida, 2015)

Different planning approaches have been used in this sphere. Scenario planning was used in South Africa to manage new urban developments on the RUF (Cash, 2014), collaborative planning was used to resolve conflicts on dispersed urbanizations in Peru (Haller, 2017), and territorial planning was considered to support the urban-rural spatial balance in the urban fringes of two regions of Italy (Cattivelli, 2021), and to identify areas of conflict with productive potential near La Plata, Argentina (Baldini, Marasas, Tittonell & Drozd, 2022).

Participatory and collaborative approaches have demonstrated a better performance to start the planning process (e.g., they help to identify problems for actors and possible solutions), although they are limited and methodologically imprecise. In that sense, Nanninga *et al*. (2012) used participatory planning and combined it with scenarios to improve the understanding of the study addressed. Scenario planning seems to overcome this situation for specific RUF issues (future urban settlement, drains, transport), but the methods that consider stakeholder interactions are reduced (Geneletti, La Rosa, Spyra & Cortinovis, 2017). This has triggered the use of methods such as land use planning (LUP) (Gómez Orea, 2008) and the integration of approaches such as LUP and ecosystem services (Gallent, 2006; Scott *et al*., 2013), geographic information systems and multicriteria decision analysis (de Prada *et al*., 2017; Boggia *et al*., 2018) to explore planning opportunities, bring together actors, and support decisions. However, LUP plan preparation times are rarely pragmatic for political timeframes and need innovative approaches to link RUF services with the needs of each case addressed.

This article shows a phase-based multicriteria procedure (PMP) to design and evaluate the vision of the RUF of Santa Eufemia, Córdoba, Argentina. The hypothesis behind this research is that there is at least one vision of RUF that can synergistically integrate local aspirations and needs with the services of this territory, and overcome the trend. Along these lines, an online PMP for planning the RUF is laid out here, showing how stakeholder involvement helps to identify relevant issues for the local agenda.

II. THEORETICAL FRAMEWORK

The Rural-Urban Fringe (RUF) is a transitional territory between the urban and the rural with multiple services. The RUF can be a territory to locate a future urban settlement (Le Bivic & Melot, 2020), for the supply of essential goods and services for the population (e.g. fruit and vegetable food production) (Boccolini & Giobellina, 2018), as well as to promote local economic growth with new industrial and commercial areas (Cattivelli, 2021). In the same way, it can constitute a territory to hierarchize ecosystem services, and amenities (Baró, Gómez-Baggethun & Haase, 2017), and to strengthen the regulation processes of the water, air, and nutrients cycle (e.g. waste, effluent) from human activities.

The academic field has recognized the RUF as a territory, differentiated from the urban and rural, that requires planning (La Rosa *et al*., 2018). Planning of the RUF is recent and regions such as Europe, the USA, Canada, and China are more advanced in the development and application of planning approaches (Geneletti *et al*, 2017). The authors propose a new planning approach, called sustainable planning, which is related to the spatial distribution of the RUF's land and human activities. The approach incorporates sociological and sustainability principles, which help to align the aspirations of the actors who take part in the planning process, and encourage thinking about a long-term territorial vision.

The design of the vision is the starting point of territorial planning and, for this, there are three different approaches. A group of authors designs the visions (Envisioning design system) by generating different images of the landscape from virtual reality or geographic information systems (GIS) (Stock, Bishop & Green, 2007).

Figure 1. Location of Santa Eufemia, Córdoba, Argentina. Note: (33°1130S; 63°1730 O). Source: Preparation by the author.

Others use territorial foresight to structure the objectives and strategy into long-term thinking (Vargas-Lama & Osorio-Vera, 2020). Finally, some use phase-based procedures and discrete multicriteria methods with the participation of the actors to choose the vision (de Prada *et al*., 2017). This work extends the phase-based multicriteria procedure and interacts virtually and face-to-face with the actors to plan the vision of the RUF as a space with its own identity.

III. METHODOLOGY

The study area is a town of 2,700 inhabitants in the south of Córdoba, Argentina (Figure 1). The design of the RUF vision was developed in three phases through face-to-face and online interactions – the result of the Pandemic *SARS-Cov-2* (de Prada *et al*., 2017). These are explained below.

Identification of problems and aspirations

In the first phase, local problems and, gradually, the aspirations of the actors were identified using a snowball method (Otzen & Manterola, 2017). Using Quantum Gis, historical images from Google Earth, and direct observations, a geographic information system (GIS) was built to quantify the evolution of urban sprawl and services (activities and land use) present in the RUF. 14 semi-structured face-to-face interviews were conducted (Díaz-Bravo, Torruco-García, Martínez-Hernández & Varela-Ruiz, 2013), with differentiated protocols for authorities (Intendent, Government secretary, President of the Council, and Councilors) and important local actors (professionals, agricultural and livestock producers, and representatives of social organizations). Eleven interviews were individual, and three in groups, and lasted 35 minutes on average.

Alternative planning visions

The second phase specifically considered planning the vision of the RUF. Work was done to define the surface area and territorial limits. Interactions with the actors took place online, in five meetings using Meet®. In the first meeting, the importance of the RUF was discussed and the actors defined the limits of this territory (Figure 3). The limits considered were administrative falling under the management of the government. In the second meeting, possible solutions to the problems identified in the interviews were discussed, considering the flow of goods and services of the RUF.

In the following three meetings, progress was made in the design of the local runoff and drainage water regulation service and the local food supply service as a solution to two main local problems. For the water regulation service, rural and urban sub-basins were digitized to analyze the runoff and water infrastructure. The curve number (CN) method was used (USDA-SCS, 1968) to dimension the

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maximum runoff of each sub-basin considering a design rainfall of 125 mm and a frequency of 1/25 years. In the GIS, the existing drainage network was designed together with drainage alternatives and soil and water conservation practices in rural areas. Meanwhile, for the local food supply service, three productive modules of one hectare per module were designed, located on vacant (unused) lots owned by the municipality. Module 1 integrates lettuce and tomato horticultural crop systems; Module 2, peach and orange fruit plantations, and; Module 3, sheep, pigs, and dual-purpose (egg and meat) poultry farming.

To make the alternatives comparable, comparison criteria were identified for each sustainability dimension. In the case of the water regulation service, two environmental criteria were developed: maximum flow (m^3 $second^{-1}$) and flood-health risks. The first one considers the aggregate value of the estimated runoff for each sub-basin and is used in relative terms to facilitate the decision. The second qualitatively indicates the physical-health hazards of handling runoff. An economic criterion, investment ($), was also considered, which measures the financial efforts needed for the land volumes to be moved and the meters of canals to be built in each alternative based on data published in the Argentinean Ministry of the Interior, Public Works and Housing.

In the case of the local food supply service, two economic criteria were considered, equivalent annual net present value (EANPV, $ $year^{-1}$) and investment ($), prepared from a private benefit-cost analysis (BCA) of the productive modules, following de Prada *et al*. (2014). An environmental qualitative criterion was also added here, health risk or bad odors. Meanwhile, for both services (Regulation and Supply), a social criterion was considered, Institutional Political Effort (IPE), which indicates the behavioral changes of the government and the community needed to develop either alternative.

Evaluation and selection of the Rural-Urban Fringe vision

In the third phase, the alternatives were evaluated together with local authorities and actors, in two online workshops. The PROMETHEE method was used (Brans & Mareschal, 2005), to rank the alternatives and guide the policy recommendation. The participants' preferences were assessed individually, using a scale of 0 to 10. Preferences with values equal to 0 remove the criterion; 1 indicates that the criterion is unimportant and 10, that the criterion is very important. The common preference function was used for qualitative criteria and the linear function for quantitative criteria. The indifference and absolute preference index values were 10% and 90%, respectively. Finally, a sensitivity analysis was performed considering values of 30% - 70% and 40% - 60%, respectively.

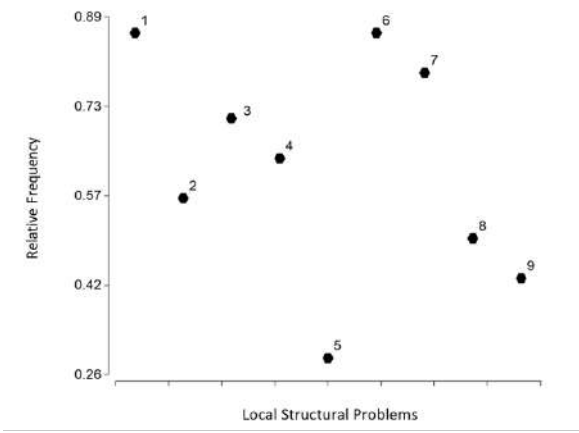

Figure 2. Frequency of structural problems in Santa Eufemia, 2020. Note: 1= Risk of flooding and collapse of storm drains; 2=Lack of local employment; 3=Lack of sewers; 4=High water tables; 5= Clandestine landfills; 6= Spread of zoonotic diseases and loose domestic animals; 7=Contamination from agrochemical applications; 8=Air pollution, bad odors; 9= Lack of green spaces. Source: Preparation by the author.

IV. RESULTS

The results of the interviews showed the perception of nine local structural problems (Figure 2). More than 80% of the interviewees mentioned as the main problems, the risk of flooding and collapse of storm drains; the spread of zoonotic diseases - loose domestic animals, and contamination by agrochemicals. 70% and 60% of respondents cite problems of a lack of sewer services and a high water table, respectively. And less than 50% list problems such as lack of employment; clandestine landfills; bad odors from local industries, and the need for green-recreational areas. In general, the interviewees associate these problems with dysfunctions of the rural-urban space and limited governance. In 8 out of 14 interviews, possible solutions emerged, such as: "create a green belt"; "do afforestation to prevent contamination by agrochemicals"; "if we add forest, we improve the environment too".

Vision of the Rural-Urban Strip

The aspirations of the actors to solve the problems of flood risk and storm drain collapse and the spread of zoonotic diseases and loose domestic animals guided the design of the vision. Through an agreement between the actors, the administrative limits of the RUF were set, and, out of the three proposals analyzed, an area of 625 ha was considered. Figure 3 shows the 2040 territorial vision of

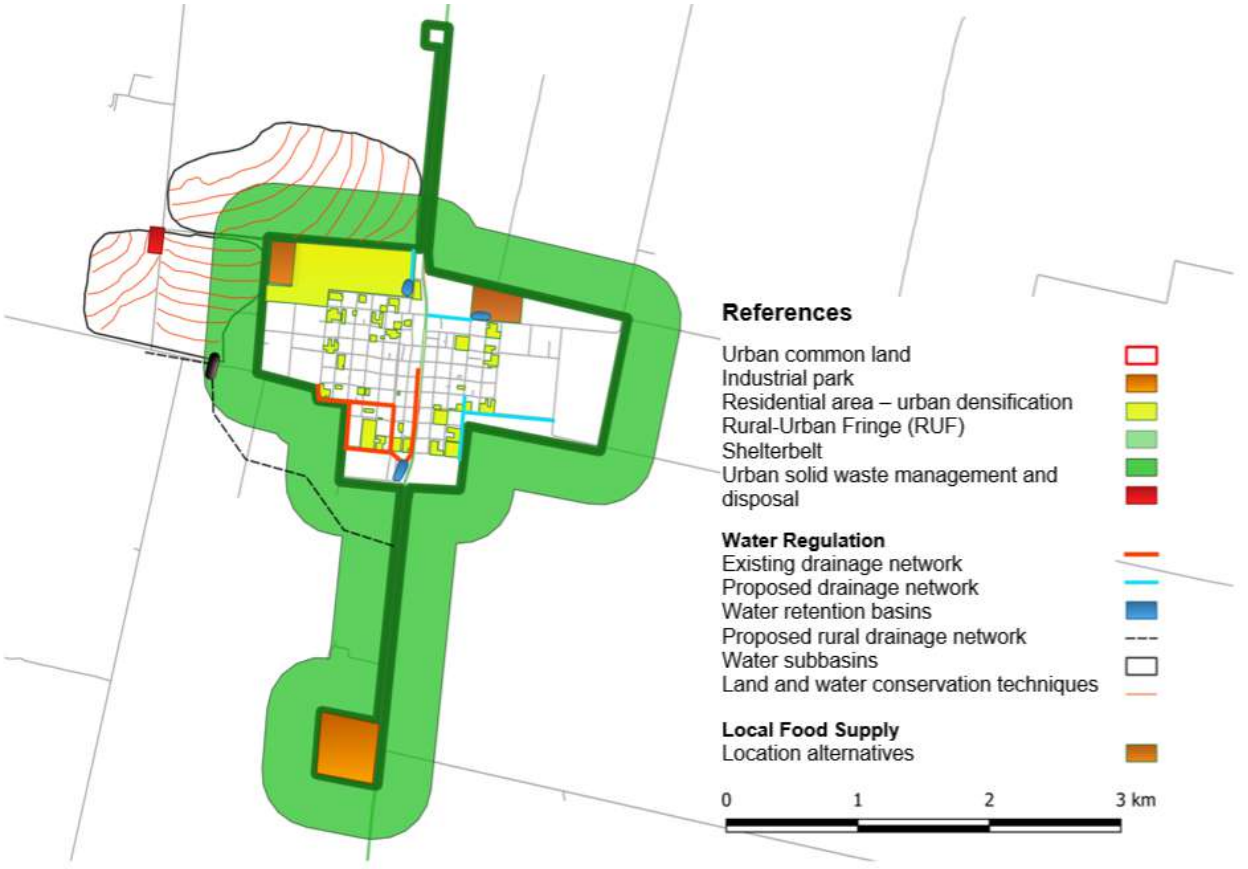

Figure 3. Vision of the Rural-Urban Strip, Santa Eufemia 2040.

the RUF of Santa Eufemia. The vision comprises five strategic structural decisions. Initially, the government addressed the location of an industrial park, the future urban settlement, and solid waste management (de Prada *et al*., 2017). Second, the water infrastructure services (runoff and drain regulations) and the local supply areas, were planned.

Water infrastructure alternatives

For this point, five alternatives were designed for the risk of flooding and collapse of storm drains issue. Alternative 1 considers the trend of the current situation and the drainage network is designed only for new residential areas. Meanwhile, alternatives 2 to 5 propose integrated runoff management (Figure 4). Alternative 2 adds 4.2 km of drainage channels to evacuate surplus water from the most compromised urban and peri-urban areas, as well as a retention basin. Alternative 3 improves the distribution of 3.3 km of drainage channels. Alternative 4, similar to 3, requires 3.8 km of drainage channels and proposes the use of runoff in a forestry area (60 ha). And Alternative 5 incorporates soil and water conservation techniques in rural subbasins west and northwest of Santa Eufemia, which reduces interventions in the drainage network (2.1 km of canals).

Selecting some of the alternatives *a priori*, revealed certain compromises between the actors (Table 1). Alternative 1, although it does not solve the problem, keeps the flood risk high, requires less investment, and less institutional political effort. In contrast, alternatives 4 and 5 reduce the levels of maximum runoff (better environmental performance) but need greater economic and political efforts to build public works, as well as motivate a change in the behavior of agricultural producers towards water conservation at a farm level.

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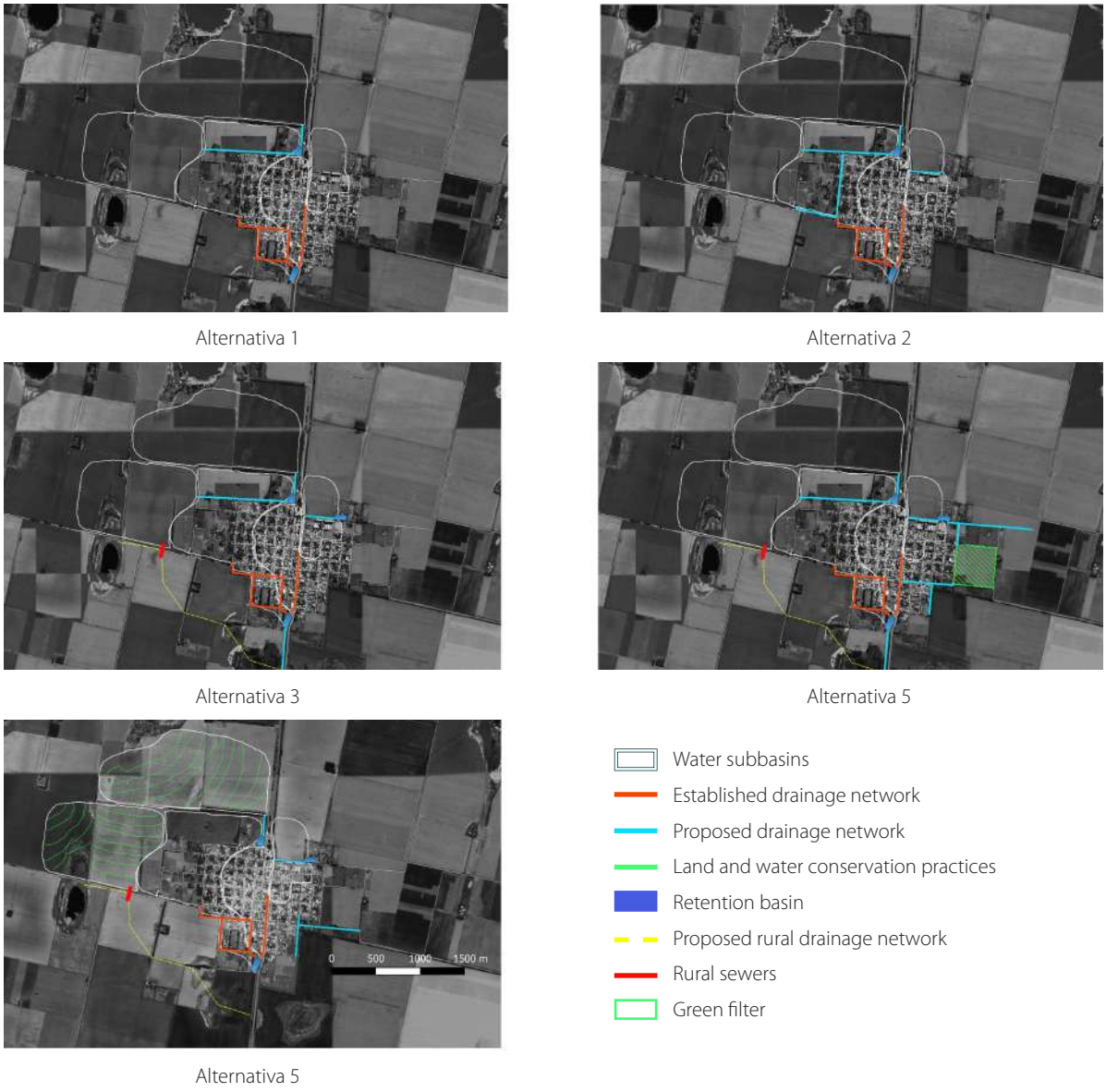

Figure 4. Water infrastructure alternatives. Source: Preparation by the author.

The actors' preferences evaluate the four criteria used as "important", although with some differences in magnitude (Table 2). The flood risks criterion has higher preferences on average and captures the essence of the problem. In order of importance, it is followed by the maximum flow criterion, which captures the problem quantitively. Meanwhile, the IPE criterion had a lower assessment and a marked dispersion, possibly due to differences in the perception of the actors who have Government responsibilities versus civil society representatives. The Investment criterion is evidenced as "important" for the participants and as "intermediate" between IPE and the criteria that capture the essence of the problem.

Based on the preferences of the actors, alternative 5 and alternative 3 turned out to be promising for hierarchizing the water regulation service, and a superior one in terms of strengths and weaknesses did not emerge in the individual analysis. In the analysis by participants, alternative 5 shows fewer weaknesses (Table 2), while in the strengths,

	C1	C2	C3	C4
Alternative_1	4.276.078	58	High	Low
Alternative_2	9.184.890	39	Medium	High
Alternative_3	8.737.282	35	Medium	Medium
Alternative_4	11.551.412	29	Low	High
Alternative_5	7.813.452	25	Very Low	Very High
Objective	minimize	minimize	minimize	minimize

Table 1. Multicriteria matrix: Water infrastructure alternatives by criteria. Source: Preparation by the author.
Note: C1: Investment ($); C2: Maximum Flow (m3 s-1); C3: Flood-Health Risks; C4: Institutional political effort (IPE).

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Participant	C1	C2	C3	C4	Strength	Weakness
I	6	8	5	5	A2	A5
II	6	8	10	5	A3	A5
III	9	8	10	10	A1	A5
IV	9	7	8	6	A2	A5
V	8	9	10	9	A2	A5
VI	8	8	10	9	A2	A5
Average	7,7	8,0	8,8	7,3	A2	A5
Standard deviation	1,4	0,6	2,0	2,3		

Table 2. Individual preferences by criterion, water infrastructure alternatives. Source: Preparation by the author.
Note: C1: Investment ($); C2: Maximum Flow (m3 s-1); C3: Flood-Health Risks; C4: Institutional political effort (IPE).

Alternative 2 has a greater frequency. After the individual reflection, the participants agreed on Alternative 5 followed by Alternative 3 as the best options. Alternative 5 has a better performance to solve the structural problem, while the economic effort is evaluated as "intermediate" and demands more institutional political effort (IPE).

Local food supply alternatives

The supply alternatives guided the search for solutions to the spread of zoonotic diseases and to improve local food production. Currently, there are 11 family producers scattered over 1.5 hectares to the west of the town. The actors together explored five underutilized spaces on the RUF (Figure 5) and combined the productive modules as follows. Alternative 1 considers the 11 producers adjusted to the legal framework[4]. Alternative 2, located to the northwest, is made up of two hectares with 1 horticultural module and 1 animal module. Alternative 3, located to the west, comprises five hectares with 2 horticultural modules, 2 animal modules, and 1 fruit module. Alternative 4, located to the west and north, is made up of six hectares with 3 horticultural modules, 2 animal modules, and 1 fruit module. Finally, alternative 5, located to the north, comprises three hectares with 1 horticultural module, 1 animal module, and 1 fruit module.

The alternatives had differences from one another (Table 3). Alternative 1 maintains the current operation and

4 Argentine Food Code (Law 18.284, Decree 815/99); Animal health according to SENASA: (Law 27.233); Organic, ecological and/or biological production SENASA (Law 25.127/99); Phytosanitary management (Provincial Law 9164).

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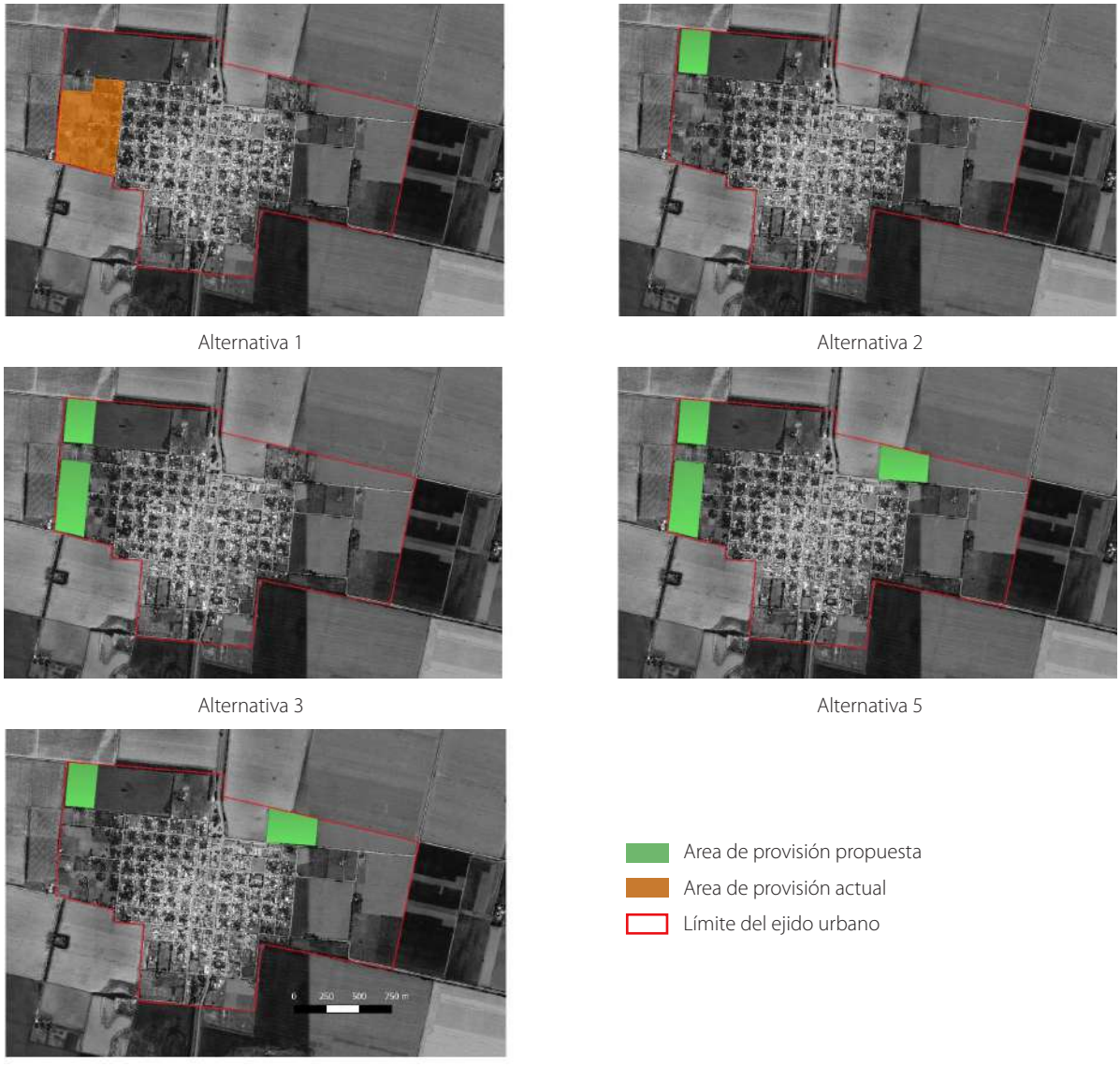

Figure 5. Location of local production. Source: Preparation by the author.

evidences local discontent with the means of production. It shows poor economic and environmental performance, contributes minimally to economic growth (lower EANPV), and retains environmental risks for the urban population. The health risks and bad odors criterion helps to detect these shortcomings. The only advantage it has is that of a lower IPE because it keeps the *status quo*.

On the contrary, alternatives 4 and 5 show adequate behavior in the economic and environmental dimensions. Both triple the economic surplus (EANPV) of alternative 1 and also exceed it environmentally. The same alternatives are located far from the residential area and areas where they can potentially contribute to the regulation and use of surplus rainfall. However, both require more investment and demand more IPE than Alternative _1

The participants' preferences show that all four criteria are important (Table 4). The highest rated criterion, with maximum score and no dispersion, was health risks and bad odors. This finding highlights the potential of a qualitative criterion for

	C1	C2	C3	C4
Alternative_1	1.975.785	441.528	Medium	High
Alternative_2	2.652.288	590.492	Low	Medium
Alternative_3	6.804.522	1.278.597	High	Medium
Alternative_4	7.872.600	1.574.738	High	Low
Alternative_5	4.367.136	688.105	Medium	Low
Objective	minimize	minimize	minimize	minimize

Table 3. Multicriteria matrix: Local food supply alternatives. Source: Author's elaboration.
Note: C1: Investment ($); C2: Equivalent annual net present value, EANPV ($ year-1); C3: Institutional political effort (IPE); C4: Health risks and bad odors.

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Participant	C1	C2	C3	C4	Strength	Weakness
I	7	7	9	10	A4	A5
II	6	8	8	10	A4	A5
III	5	8	10	10	A4	A5
IV	8	8	9	10	A1	A4
V	8	6	8	10	A4	A4
VI	7	7	8	10	A4	A5
Average	6,8	7,3	8,7	10,0	A4	A5
Standard deviation	1,2	0,8	0,8	-		

Table 4. Individual preferences by criterion, Supply Alternatives. Source: Preparation by the author.
Note: C1: Investment ($); C2: Equivalent annual net present value, EANPV ($ year-1); C3: Institutional political effort (IPE); C4: Health risks and bad odors.

political decision-making. The IPE and EANPV criteria reached intermediate preferences. Meanwhile, the investment criterion was the least valued, although with greater dispersion in their preferences.

Based on the preferences of the actors, alternative 5 was chosen to rank the local supply services. This has fewer weaknesses for all participants and, in terms of its strengths, it was surpassed by Alternative 4. The participants agreed that Alternative 5 is the best followed by alternative 4. In environmental terms, alternative 5 minimizes the health risk. Economically, alternative 5 generates 55% more economic surpluses than Alternative 1. And, in the social field, it has a greater IPE.

V. DISCUSSION

The availability of RUF-oriented planning approaches is scarce. Four years ago, Geneletti *et al.* (2017) mentioned this limitation, which still persists (Cattivelli, 2021; Žlender, 2021). The PMP (de Prada *et al.*, 2017) is used in this work as a regulatory planning approach to design the vision of the RUF and include local aspirations in successive online and face-to-face interactions.

There are several multicriteria methods (Barba-Romero, 1996), some of which have been used to support RUF decisions. The AHP (Analytic Hierarchy Process) method was used together with GIS to evaluate land use (Liu *et al.*, 2007), manage groundwater (Jesiya & Gopinath, 2020), and analyze territorial policies for local productive areas (Baldini *et al.*, 2022). Here, the PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation) over-classification method was applied as in the territorial planning works (de Prada *et al.*, 2017) and urban waste management planning (Cahe & de Prada, 2019), as it allows communication with and between actors, and significantly facilitates their participation from the design of alternatives to the selection of relevant criteria and other interventions (determining the objectives, weighing their

importance, and establishing preference and indifference thresholds).

Finally, qualitative criteria have the potential to guide the decision of the actors and are quick to build. Londoño Cadavid and Ando (2013) describe the flooding risk criterion (in basements, or gardens) as the most preferred. In this study, maximum preferences were also obtained for a similar criterion, Flood–health risk. And, in fact, the qualitative criteria of the environmental and social dimension, achieved more preferences and helped to guide the political decision. This same situation was identified by Smith, Meerow, and Turner (2021) and Liu *et al*. (2007)

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VI. CONCLUSIONS.

This work shows a phase-based multicriteria procedure to plan the vision of the rural-urban fringe (RUF) of Santa Eufemia, Córdoba, Argentina. According to interviews with authorities and actors, the risk of floods - collapse of storm drains, and the spread of zoonotic diseases – loose animals, constitute the main structural problems of the locality. Respectively, these problems were considered to prioritize the water regulation and food supply services of the RUF. For the regulation service, five alternatives were designed that recondition the existing drainage network, create a new network, and vary in their scope. For the local supply service, five alternatives were also designed that integrate new productive management and locations. To distinguish between alternatives, four comparison criteria were developed for each service, covering the different sustainability dimensions. Meanwhile, to survey the preferences and evaluate the alternatives, online workshops were held and the PROMETHEE multicriteria method was used.

Concerning both services, alternatives emerged that overcome the current handling and help the authorities to create an agenda for the RUF. In the case of the regulation service, an alternative was identified that greatly reduces potential water runoff and minimizes the risks of temporary flooding. The alternative requires intermediate investment, needs a high government effort, and the actors are aligned to materialize it. In the case of the supply service, an alternative emerged that showed a better overall performance to solve the spread of zoonotic diseases issue that improves the technical capabilities of local production. In addition, the alternative generates economic surpluses and proposes to synergistically locate new local productions within the urban area.

Finally, the research presented has two limitations to be considered in future works. Firstly, the vision of the RUF is prepared as the first content of the territorial plan, without considering the design of the strategy and the action plan for the local political agenda. Secondly, the designs of the regulation and supply services addressed are considered as a first approximation based on primary field data and secondary data that require precision.

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STABILITY CYCLES, AND FAST-SLOW CHANGES AND VARIABLES IN LANDSCAPES OF THE CONCEPCION METROPOLITAN AREA [1]

USING THE STUDY OF SOCIO-ECOLOGICAL SYSTEMS: AN EXPLORATORY ANALYSIS

CICLOS DE ESTABILIDAD, CAMBIOS Y VARIABLES LENTAS-RÁPIDAS EN EL PAISAJE DEL ÁREA METROPOLITANA DE CONCEPCIÓN. A PARTIR DE ESTUDIOS DE SISTEMAS SOCIO ECOLOGICOS: UN ANÁLISIS EXPLORATORIO

CAROLINA GRACE OJEDA LEAL [2]
KAY BERGAMINI LADRÓN DE GUEVARA [3]

1 Investigación financiada con la Beca de Doctorado Nacional ANID no. 21200455

2 Magíster en Desarrollo Regional y Medioambiente
Pontificia Universidad Católica de Chile, Santiago, Chile.
Estudiante Doctorado en Arquitectura y Estudios Urbanos. Profesora Part time Departamento de Historia, Facultad de Comunicación, Historia y Cs. Sociales, Universidad Católica de la Santísima Concepción.
https://orcid.org/0000-0002-9830-9203
ccojeda@uc.cl

3 Doctor en Gestión Ambiental, Paisaje y Geografía
Pontificia Universidad Católica de Chile, Santiago, Chile.
Profesor Asistente Instituto de Estudios Urbanos y Territoriales
https://orcid.org/0000-0001-5490-1435
kay@uc.cl

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CICLOS DE ESTABILIDAD, CAMBIOS Y VARIABLES LENTAS-RÁPIDAS EN EL PAISAJE DEL ÁREA METROPOLITANA DE CONCEPCIÓN
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CAROLINA GRACE OJEDA LEAL, KAY BERGAMINI LADRÓN DE GUEVARA
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Los paisajes son capaces de maximizar sus fortalezas en momentos de estabilidad al desarrollar de manera profunda su carácter y, así, manejar las presiones o disturbios que generan cambios en los Sistemas Socio Ecológicos (SSE) en sus variables lentas y rápidas para evitar su transformación. Las variables rápidas son aquellas que explican los cambios de corto plazo y procesos violentos de ruptura en los ciclos de estabilidad/cambio en las temáticas de desastres naturales. Por su parte, las variables lentas corresponden a aquellas que explican los cambios a largo plazo y procesos más complejos en los ciclos de estabilidad/cambio. El trabajo que sigue se abocó al estudio del Área Metropolitana de Concepción (AMC), Chile, la cual ha sufrido cambios relevantes a lo largo de su historia, pero no ha sido estudiada como un SSE en sus variables lentas y rápidas. De forma exploratoria, se realizó una revisión literaria de 150 artículos en las bases de datos científicas sin uso de software científico de apoyo, considerando como palabras claves “Concepción” y “Área Metropolitana de Concepción”. Como resultados principales, se destacan ciclos de fenómenos de corto plazo -variables rápidas- con gran impacto, ejemplificados en desastres naturales (terremotos, maremotos, inundaciones, incendios y sequía), y cambios en los planes de urbanismo (planes urbanos e higienismo), así como fenómenos de largo plazo -variables lentas-, con impactos más memorables en ciertas áreas clave: política (conquista y guerra entre indígenas/españoles/chilenos), economía (auge/caída de ciclos económicos) y medioambiente (intervención humedales, creación de diversas leyes de protección).

Palabras clave: sistemas socio ecológicos, Área Metropolitana de Concepción, paisajes, estabilidad, cambio

Landscapes can maximize their strengths in moments of stability by deeply developing their character and, thus, managing the pressures or disturbances behind slow and fast changes in the Socio-Ecological Systems (SES) to avoid their transformation. Fast variables explain short-term changes and violent rupture processes in stability/change cycles for natural disaster issues. On the other hand, slow variables explain long-term changes and more complex processes in stability/change cycles. The work below focused on studying the Concepción Metropolitan Area (AMC, in Spanish), Chile, which has undergone relevant changes throughout its history but has not been studied as an SES using its slow and fast variables. An exploratory literary review of 150 articles was made in scientific databases without using scientific support software, considering “Concepción” and “Concepción Metropolitan Area” as keywords. The main results highlight short-term phenomena cycles -fast variables- with a major impact, exemplified in natural disasters (earthquakes, tsunamis, floods, fires, and drought), changes in urban planning (urban plans and hygienism), as well as long-term phenomena -slow variables-, with more notable impacts in certain key areas, namely political (conquest and war between indigenous/Spanish/Chilean peoples), economic (boom/bust of business cycles) and environmental (wetland intervention, creation of different protection laws).

Keywords: socio-ecological systems, Concepción Metropolitan Area, landscapes, stability, change

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I. INTRODUCTION

The Concepción Metropolitan Area (AMC, in Spanish) (72ºW - 36ºS), like other Chilean metropolitan areas (Orellana & Gilbert, 2013), comprises several adjoining communes and has one of the largest populations in the country. Indeed, it has undergone a demographic transition with a sustained increase from 507,870 inhabitants in 1970 to 985,034 in 2017 (National Institute of Statistics [INE], 2017). It has also seen a sustained urban expansion (Rojas, Pino & Jaque, 2013), which has fragmented its natural coastal ecosystems, wetlands, and protected areas (Romero Aravena & Smith, 2009; Rojas *et al*., 2006), generating an effect of confinement by pressuring its public property against urban areas (Jaque, Ojeda & Almendra, 2020). Likewise, it has also been considered in the specialized literature as an area with multiple threats (Araya, Metzger, Stuart, Wilson & Carvajal, 2017; Garreaud *et al*., 2020; Mardones & Vidal, 2001), both because of its Mediterranean climate (Sarricolea, Herrera & Meseguer-Ruíz, 2016), and for being inserted between two large geomorphological units, the coastal plains, and the coastal mountain range.

As for its economy, this has been based on the import-export of natural resources through their exploitation or use. Its services include malls, clinics, hospitals, universities, and government offices, and its tourism sector is based on its wide-open beaches (Rojas Quezada, Muñiz Olivera & García-López, 2009). This has been to the detriment of its traditional agricultural and peasant economy, which has declined to the former's benefit (Torres, Azócar, Rojas, Montecinos & Paredes, 2015; Hernández, 1983).

The AMC is also facing the challenges of climate change (Sarricolea *et al*., 2016; Garreaud *et al*., 2020; Gallardo Klenner, 2016), which adds uncertainty to its analysis, considering the unsustainable nature of the urban growth planned so far (Rojas, Pino & Jaque, 2013), and its abuse of resources in its natural systems (Torres *et al*., 2015; Hernández, 1983). These systems have cumulatively and negatively altered their properties. However, so far, they have avoided forced transformability, that is to say, the creation of "a fundamentally new system as the ecological, economic, or social conditions - including political ones - make the existing system unsustainable" (Walker *et al*., 2006, p. 3).

Based on this context, the objective of this article is to identify and make an exploratory analysis of the cycles of stability–change, as well as the slow-fast variables in the AMC landscape, using Socio-Ecological Systems or SESs as a theoretical basis (Hertz, García & Schlüter, 2020). It also proposes identifying key elements that configure the AMC as an SES because it has only been recognized as a metropolitan area from urbanism, and from geography, as part of the Biobío basin and one of the last Mediterranean climate zones in the country. To do this, 150 articles from indexed journals, in Spanish and English, were analyzed through a literary review with two key terms: "Concepción" and "Concepción Metropolitan Area". The working hypothesis is that the SESs in the AMC are subject to fast changes, followed by long cycles of stability, whose slow drivers are mostly of anthropic origin and fast are mostly of a natural origin, that is to say, the landscapes of the AMC will evolve rapidly without an SES perspective that sustainably incorporates the key concepts, creating unstable landscapes in their natural and human systems.

The importance of this work is that it allows, based on the available bibliographic evidence, identifying and relating landscape variables with the growth of the AMC, which would constitute the evidence needed to move toward sustainable and resilient urban development. The theoretical framework is presented below, whose focus lies in the SES, before then outlining the methodology used in the literature review and the results, which are finally discussed and concluded.

II. THEORETICAL FRAMEWORK

SES studies are found in the interaction between natural and social sciences (Berkes Colding & Folke, 2011) and try to respond to the requirements of a planet that is immersed in uncertainty, dealing with phenomena that the human species does not understand (Intergovernmental Panel on Climate Change [IPCC], 2007; Foley *et al*., 2005; Kirksey, 2021). SSES are defined as:

> complex adaptive systems in which humans and nature are deeply intertwined, and which consist of a complex network of ecological-social relations in constant evolution, and need to be conceived as an integrated system, rather than two systems that exist independently (Hertz *et al*., 2020, p. 2)

They are based on key concepts from the General Systems Theory such as processes, events, stability, resilience, transformation, continuous changes, dynamism (Mancilla García, Hertz, Schlüter, Preiser & Woermann, 2020; Holling, 2001), multi-actors, multi-agencies/agents and multi-scales (Elsawah, Guillaume, Filatova, Rook & Jakeman, 2015) (Figure 1). This conception differs from other interdisciplinary models such as the FES-system (FES, 2021), where systems are understood as intertwined organisms. Likewise, it differs from the coupled systems (*coupled human-landscape systems*) that are based on

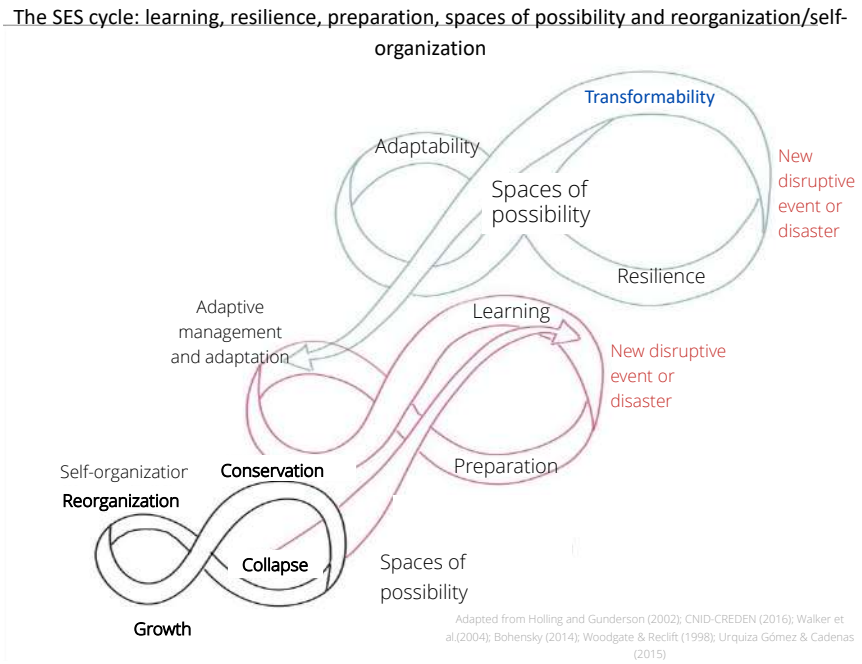

Figure 1. Outline that comprises the operation of feedback loops and the stages that SESs undergo. Source: Preparation based on Holling and Gunderson (2002, p. 34); CNID-CREDEN (2016); Bohensky and Leitch (2014); Woodgate and Reclift (1998); Urquiza Gómez and Cadenas (2015).

mathematical modeling to understand how the physical dynamics of landscapes influence human systems (Werner & McNamara, 2007). It is also distinguished from the concept of landscape, which corresponds to a set of physical-human elements in permanent transit (Ingold, 1993; Nogué, 2014).

In this sense, all the aforementioned models argue that natural and human systems closely interact with one another by establishing positive or negative feedback loops (Schoon & van der Leeuw, 2015), that is, they have cycles that allow their positive permanence through learning, resilience, and adaptability, or, on the contrary, have negative cycles that generate collapses in complex societies (Tainter, 1988; Diamond, 2010) that can lead to transformability (Figure 1). As a result, the SESs move between cycles of stability and change (Hertz *et al*., 2020), which are described below:

- **Stability cycles:** long-lasting stages populated by slow variables, namely, those phenomena that are grouped, according to their nature, into political, economic, and environmental, that explain long-term changes and complex processes and where the components of natural and human systems have characteristics that make them recognizable for long enough to be studied. For example, in the case of human systems, these stability cycles correspond to historical periods, and in the case of natural systems, ecosystems. In them, it is also possible to find the idea of *biostasis* and *homeostasis*, which has to do with the capacity - applicable to the SESs - to self-regulate once a change has occurred within the same limits that the system allows (Arnold and Osorio, 2008), that is to say, stability is what the identity of a system itself defines (Rubio, 1996).

- **Cycles of change:** these are those periods characterized by fast variables comprising disruptive events that present challenges to the SESs that break with the previous stability, as they offer them possible spaces to adapt, learn lessons, be resilient, prepare, collapse, or transform definitively. A concrete example of a cycle of change occurs with earthquakes that, unexpectedly, reveal whether the SESs have positive or negative feedback loops. If they are positive, they will be able to be resilient or adapt by moving to a new stability cycle, maintaining their main components in their natural and human systems. In the event of an earthquake, reconstruction work will begin quickly. If the cycles of change are negative, they will harbor collapses in both systems proving that they were not able to learn lessons and will transform into new SESs, whose non-human and human components

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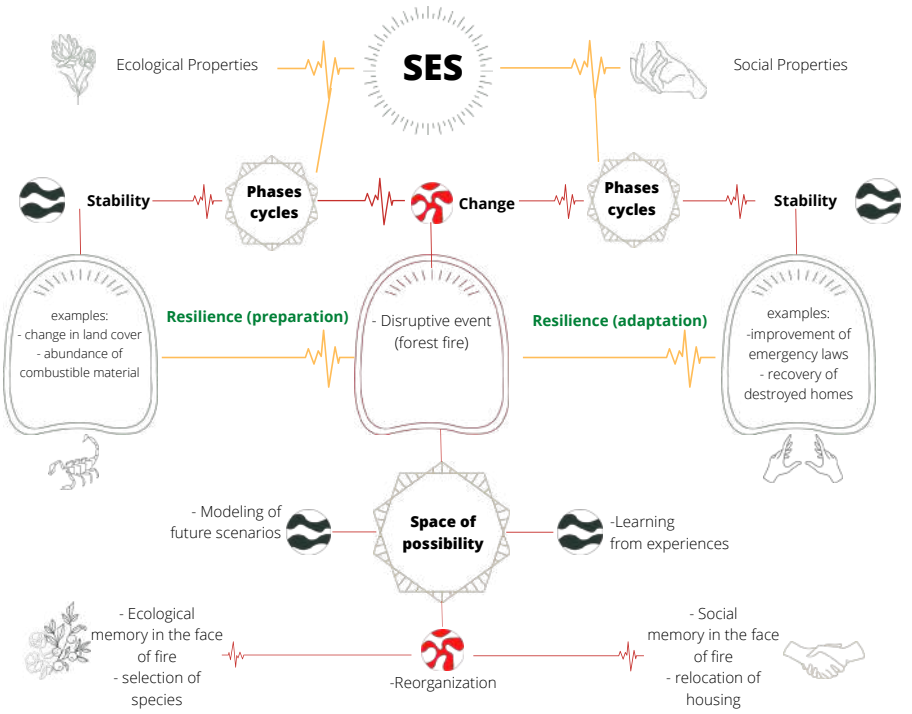

Figure 2. Abstract outline that identifies the cycles of stability and change in the SESs, taking as an example, a disruptive event in the cycle of change, in this case, a forest fire. Source: Own preparation.

> will not be adequately prepared. In the case of the earthquake, the political and social instability exacerbated after the disaster will lead to problems of urban violence, contamination, and migration problems.

All-in-all, the concept of stability is a topic of discussion that has not been settled. One of the positions that stand out is that natural and human systems would not be stable, but "meta-stable" (Winder, 2007), and would create a dynamic biosphere where living beings would interconnect in a complex network of relationships (food, social, etc.) (Capra, 1998). In contrast to this, Grimm, Schmidt, and Wissel (1992), Ludwig, Walker, and Holling (1997), Cumming (2011), and Iannucci and Munafò (2012) follow a more traditional position by considering stability as a concept that has its simile in a static well where systems strive to remain despite constant changes. In this exploratory article, the position of Cote and Nightingale (2012) is chosen, who consider stability as a moving baseline comprising multiple states, which would theoretically allow all SESs to go through stages or cycles of stability that can be studied at different times (Figure 2).

IV. METHODOLOGY

In this qualitative study, a literature review was carried out (Arksey & O'Malley, 2005; Arts *et al*., 2017; Pullin & Stewart, 2006) that contemplated three stages developed during 2020 - 2021:

- *Stage 1: Review question selection - search term:* The Web of Science (WOS), SCOPUS, and Google Scholar databases were used to search for the keyword "Concepción", which was supplemented with similar terms such as: "Área Metropolitana de Concepción", "Metropolitan Area of Concepcion" and "Concepción Metropolitan Area". Related terms such as "changes", "cycles" or "SES" were also considered if the former did not bear fruit. More than 300 selected articles were fully reviewed taking into account the keywords of each article, abstract, title, and development. These were accessed virtually from the Library of the Pontifical Catholic University of Chile.

- *Stage 2: Selection criteria or filters:* Once the articles with the keywords had been identified, they were subjected to new exclusion filters and organized in an Excel©

Cayucupil-Chile

•19th Century, 1857 – Chilfón del Diablo Mine, 1869 – Foundation of Cayucupil, 1880 Sleepers plantation.
•1910 – Arrival of Cattle farming; 1920 – Cereal crop agriculture, 1939 – Creation of Nahuelbuta National Park; 1940 Creation of BIMA Forestry Company
•1950 – New cereal crop farming, Mininco Forestry Company, and Forests Law (afforestation with pine trees)
•1960 Coñihual Forestry Company; 1962 Agrarian Reform; 1967 Forest surface data (INFOR)
•1971 FASA; 1974 Forestry Development Law; 1979 Intensification of Forestry Plantations.
•1980 Native forest surface data; 1983 Reduction of Nahuelbuta Park's area; 1984 Forestal Sur (Forestry Company); 1985 Mininco Forestry Company, and increase of single-crop farming.

Murcia - España

- Phase 1: Pre-Muslim period > 713 AD
  - Territorial development of large coastal towns
  - Natural drivers of dynamic change (droughts and floods)
- Phase 2: Muslim period (713-1243)
  - Muslim colonization
  - Demographic increase and foundation of Murcia
  - Development of hydraulic engineering
  - Natural (floods) and sociopolitical (war conflicts) drivers of dynamic change
- Phase 3: Christian conquest (1243-1492)
  - Depopulation, black plaque, plagues – hunger and war with the Kingdom of Aragon
  - Extension of watering surface (15th century)
  - Silk industry

Figure 3. Extracts from the results of the analysis model used to analyze SESs in Chile, according to Quiñones et al. (2017), and, in Spain, according to Gutiérrez et al. (2015). Source:Images of Scott Zona - Araucaria araucana 1, CC BY 2.0 (https://commons.wikimedia.org/w/index.php?curid=17346247) and José García, CC BY-SA 3.0 (https://commons.wikimedia.org/w/index.php?curid=31821325).

sheet, a process from which 150 selected articles were obtained. The criteria used were the following:

- must be a peer-reviewed article (not a thesis, book, university journal or magazine article, press release, conference abstract, or editorial);
- must be available on the Internet (not physical paper or files);
- must contain the full search terms defined in stage 2;
- must be based on the Chilean AMC and not on other cities with the same name (e.g., Concepción del Uruguay).

- *Stage 3: Analysis and communication of results:* In this exercise, the agents, stability–change cycles and fast–slow variables studied were identified following the model of Quiñones et al. (2017) and that of Gutiérrez, Suárez, and Vidal-Abarca (2015) (Figure 3). The results were communicated through a timeline (Figure 4) and a summary table (Table 1), with the main findings such as laws, socio-economic activities, agents, and/or relevant natural disasters:
  - For human systems, the cycles of stability and change were considered, dating them according to the available literature. For example, within the articles that address the AMC in the political sphere, it is highlighted that between 1603-1687 there was a cycle of stability associated with the fortification of the Biobío coastal area, then a cycle of changes led by indigenous uprisings, before giving way to a cycle of stability with the creation of border cities.
  - As for natural systems, their cycles of stability and change have very different time scales from the human ones studied separately in the different natural sciences, and, therefore, socio-natural disasters were chosen as representative for the cycles of change of these systems. For example, for natural disasters, there is a period of stability associated with the Regulatory Plan of Conception of Emilio Duhart, which is wiped away by the earthquakes and tsunami of 1960-1962, before a period of stability based on the reconstruction with the Intercommunal Regulatory Plan of 1963.
  - For both systems, slow-fast variables were considered, which were identified by considering keywords in the texts (*screening*) that were categorized and organized chronologically in Excel© (Figure 4). For example, for the text by Leonel Pérez Bustamante and Edison Salinas

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Varela (2007), "Urban growth and globalization: transformations of the Concepción Metropolitan Area, Chile, 1992-2002", keywords were identified (in red) associated with a slow variable that covers the economic area, from 1950 to the present day:

* "...In Concepción... the metropolitan dimension clearly begins with the installation of the Compañía de Aceros del Pacifíco – *Pacific Steel Company* (CAP) in Huachipato, around 1950..."

¤ Agents are those anthropic elements associated with people, organizations, or institutions that can lead to stability cycles or new changes in natural and human systems.

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V. RESULTS.

Cycles of stability and change

The articles analyzed express an anthropic perspective and identify cycles of change-stability that have very different feedback loops from agents, laws, and economic activities. This happens because they are short-lived cycles originating in natural systems, namely, catalyzing events for natural systems grouped into earthquakes, tidal waves/ tsunamis, droughts, forest fires, floods, and tornadoes. As a sample, in 1751 there was a change event caused by a tidal wave that broke with the previous stability of the city in Penco, so when the earth stopped shaking it allowed human systems to move the population to the Mocha Valley in 1754 (Salinas & Baeriswyl, 2017) (Table 1).

Some exceptions were identified in the AMC, such as the intervention-occupation processes of wetlands since 1955, and those for soil erosion since 1960, which occur to this day. Both are an exception because they are elements that do not show signs of going through stability cycles, so they could be catalysts for the transformability of the SESs unless they are stabilized with anthropic management based on ecological criteria. The results report that their space of possibility strongly depends on their surrounding historical and social conditions, and also coincide with traditional historiographical and economic references (Salazar & Pinto, 1999-2002):

- a period marked by bellicosity between indigenous people and Spanish conquistadors, from 1554 to 1800, which led cities to periods of construction and reconstruction;
- a period of formation of republican agents associated with the agricultural exports of vineyards-wheat initiated by the Bishopric of Concepción in 1780 and those by the bourgeoisie with the coal mines in 1850. This ended with the great migrations of peasant laborers to the flourishing industrial cities of the AMC, between 1960 -1970;
- a period of scientific and cultural formation that began with the founding of the El Sur Newspaper, in 1900, and the University of Concepción in 1919. It continues to this day with the arrival to the AMC of creative classes with a high educational and economic level, both from other regions of Chile and from nearby provinces (Los Angeles, Chillán, Laja, San Carlos, and Yungay).

The legislation (Table 1) that has affected the human and natural systems mentioned in the articles reviewed, coincides with the different traditional political periods studied by Salazar and Pinto (1999-2002), among other authors. These are linked with:

- a period of war where the Mapuche–Spanish border is established (1554-1850);
- a Chilean republican period that begins with the first Civil Code (1856) and the first police of the Province of Concepción (1830-1860), and ends with the 1973 coup d'état;
- a period where the appearance of environmental-extractive policies that began with the agrarian reform of Eduardo Frei M. - Salvador Allende (1964-1973) and DL 701 promulgated in 1974, and continue to this day with the successive improvements to Law 19.300, the General Environmental Law (1994).

The socio-economic activities of human systems are directly related to the laws and policies identified by Salazar and Pinto (1999-2002). There the following stand out:

- a first period where an economy of essential goods production for survival in times of war predominates (fishing and farming) that lasts until 1830, expanding throughout the territory;
- a second period to establish a proto-industrial economy of exploitation of natural resources (fishing, wheat, and coal) which lasts until 1930;
- a third period of recovery after the 1929 crisis, focusing on the import substitution economy where the extractive industrialization of coal, steel, and fisheries is consolidated, which remains until the global recession of 1982;
- the current period where this area is inserted in a neoliberal global economy that restricts its industries through import substitution to become a center of services – consumption. A new type of extraction and processing of forest-fishery natural resources begins, which takes shape with the privatization of Forestal Arauco between 1977-1979, is consolidated with the closure of coal mines between 1994-1997, and continues to this day, spreading throughout the territory.

Topic.	Year	Initial stability	Change	Final stability	Agents
Natural disasters	1751	City in Penco	Tidal Wave	Transfer to the Mocha Valley in 1754	Governors and intendants
Natural disasters	1835	Charles Darwin's Trip to Chile	Earthquake and tsunami	Development of theories of evolution and plate tectonics	Charles Darwin
Urban development	1856	Conservative Republic (1830-1860). Civil code.	Urban Plan for Concepción by Pascual Binimelis	Urban sanitation and improvement. Organization of agricultural and semi-spatialized peonage in artisanal work	Governors and intendants, urban planners
Natural disasters	1960-1962	Regulatory Conception Plan by Emilio Duhart	Earthquake and tsunami	Intercommunal Regulatory Plan of 1963	Governors and intendants
Natural disasters	2006	Ribera Norte Urban Recovery Program (PRURN) since 1990	Floods	Management of Biobío River's Northern Bank has decreased the risk of seasonal flooding, controlling the risks of mass embankment removal and hill escarpments	Governors and intendants, urban planners
Natural disasters	2010	PRC (Communal Regulatory Plan) with risk studies	Earthquake and tsunami	Tsunami-resistant housing structures in Tomé and Tumbes	Governors and intendants, urban planners, Neighborhood Councils
Political	1605-1803	Mapuche Spanish border	Destruction of the city by indigenous people in 1554-1555	Reconstruction in 1557	Conquistadors, indigenous people
Political	1603-1687	Fortification of the coastal zone	Indigenous uprisings	Creation of border cities	Conquistadors, indigenous people
Economy	1830-1930	Frontier economy opening up to export (wheat - cattle - wine)	The advance of the railroad and bridges over the Biobío River	Urbanization expanded to other communes, formation of the AMC	Government of Chile, Chilean and foreign mining bourgeoisie (Cousiño-Schwager), Municipality
Economy	1850-1997	Mining boom Lota Coronel	Closure of Puchoco and Lota mines	Conversion of cities to "dormitories"	Government of Chile, Chilean and foreign mining bourgeoisie (Cousiño-Schwager), Municipality

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Topic.	Year	Initial stability	Change	Final stability	Agents
Political	1900-today	Formation of the commercial entrepreneurship of Concepción in the final decades of the nineteenth century	Foundation of the University of Concepción in 1919, creation of the El Sur Newspaper	Population with a high educational level migrates to Gran Concepción, especially from Los Angeles, Chillán, Laja, San Carlos, etc. Formation of a creative class	The University of Concepción, local elite, Freemasonry
Economy	1930-today	ISI-type industrial development in the intercommunal area. Railway progress	Decline in industrial development with the 1982 crisis and the neo-liberalization of the economy after the coup of 1973	The AMC assumes a role as a distribution, services, and consumption center until today	Huachipato CAP Steel works, San Vicente Port, Huachipato homes, Agüita de la Perdiz, Paños Bellavista Factory, Tomé, CORFO, Aurora de Chile
Environmental	1955-1980	Occupation and intervention processes in the wetlands of the AMC	Erosion, mass removal processes, drought	Accelerated urbanization and forest plantations, homogenization of the landscape. 1st survey and diagnosis of the state of maritime-coastal wetlands.	Neighborhood councils, Chilean Government, MOP (Public Works Ministry), MINVU (Housing and Urbanism Ministry), forestry companies (CMPC, ARAUCO)
Environmental	1994-today	The repertoire of the 1992 Legislation of environmental relevance in force in Chile	Law 19.300 on General Environmental Guidelines	Increase of planning instruments oriented to caring for the environment and the development of the EULA Center	Eula Center, urban planners, mayors, governors, universities
Natural disasters	2017	mega drought	Mega Fire 2017	Erosion in fire zones, the progress of urbanization/forestation, and the loss of peasant economies	Forestry companies, governors, intendants, small farmers and landowners, Neighborhood Councils, Chilean Government MOP, MINVU, forestry companies (CMPC, ARAUCO)

Table 1. Summary of the stability-change cycles and events obtained from the literature review. Source: Own preparation based on literature review. Note 1: Fast variables have changes in years or months and slow variables have changes in decades or centuries. Note 2: Human actors can be individuals or institutions.

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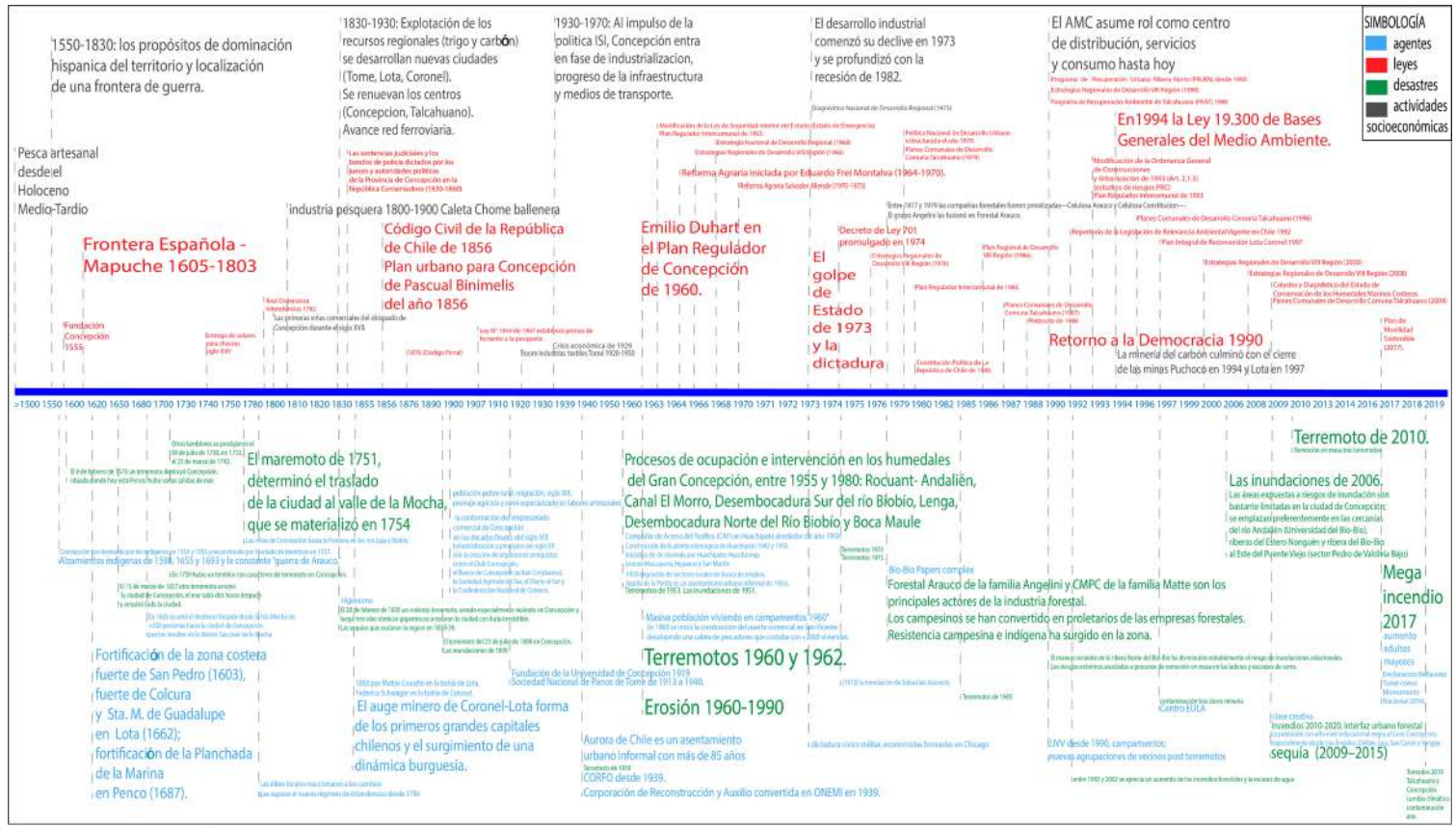
Slow and fast variables from the SSEE perspective

Two types of variables were observed in the SESs called slow and fast (Walker *et al*., 2006). Fast variables (Figure 4) are those that explain the short-term changes and the violent rupture processes in the stability cycles and, in this case, were observed in the themes of natural disasters (earthquakes, tidal waves, floods, fires, and drought) and those of urbanism (e.g., urban plans and sanitation). The slow variables, on the other hand, correspond to long-term changes and complex processes in the cycles of stability/change, which were grouped in the political (war between indigenous/Spanish/Chileans), economic (boom/bust of economic cycles), and environmental (wetland intervention, creation of different protection laws) spheres.

The variables of non-human systems are considered as slow variables, since their stability is longer lasting than their changes, which have been caused, as was found, entirely by external pressures such as earthquakes, tsunamis, extreme climatic events, and human actions (e.g., management of the Biobío North Bank and port construction). Likewise,



Elementos del Área Metropolitana de Concepción que constituyen un Sistema Socio Ecológico obtenidos desde la revisión bibliográfica de 150 artículos en las bases de datos WOS, GOOGLE SCHOLAR y SCOPUS (2020-2021).

Figure 4. A timeline that indicates the slow and fast variables in the AMC's SESs based on the literature review. Source: Own preparation based on literature review.

long-standing phenomena associated with the land were noticed (mass removal processes, drought, erosion in fire zones, and coal extraction); an increase/decrease in sedimentary concentrations in the water bodies of the Biobío, Andalién rivers, and their wetlands, as well as the anthropic exploitation of trees (forest plantations) and animals (livestock, fishing, and algae collection).

VI. DISCUSSION

The slow-fast variables have been studied from the SES perspective, mostly through mathematical modeling, which makes it difficult to access qualitative models or those focused on understanding the entire phenomena (Hertz *et al*., 2020; Walker, Holling, Carpenter & Kinzig, 2004). The Quiñones *et al.* (2017) model does something different with the Cayucupil basin in Chile by complementing satellite image studies with an in-depth literature review to explain the proposed SES. Similarly, in the United States, it is shown how forest fires (disruptive events that generate changes) can be understood from the SES perspective (Steelman, 2016). Another example is given in Spain, where the cycles of stability and change in the SESs have been addressed using ecosystem services and a bibliographic review of periods spanning 2,000 years (Gutiérrez *et al*., 2015) allowing for a more complete analysis of the cycles since more information is available from chronicles and archives that narrate the history from the anthropocentric perspective of both systems.

On the other hand, the variables associated with natural or non-human systems are more difficult to establish without the help of areas associated with landscape ecology and General Systems Theory, which focuses on understanding the dynamics of different ecosystem processes (Holling, 2001) incorporating economics, resilience, and governance (Berkes et al., 2003). Solutions have been proposed with the new multidisciplinary, multi-scalar, and multi-spatial intersections (Goldman, Nadasdy & Turner, 2011), where researchers work with other ontologies:
"You will follow all matter, through every material, and understand the earth systems of our collective now without dividing them into the irrelevant and outdated categories of 'society' and 'nature'. You will know that fences don't stop earthly flows..." (Green, 2021, p.1).

Some examples of this desire to cross frameworks have been given in the Agrarian Change Project which integrates SES methodologies into the multifunctional landscapes of Africa (Sunderland *et al.,* 2017). Likewise, interdisciplinary methods have been applied in Pakistan to evaluate Social-Ecological Landscape Systems (SELS) in aspects of mobility and degree of urbanization (Abbas, Shirazi & Qureshi, 2018). The Wadden Sea, which is a protected area shared between the Netherlands, Germany, and Denmark, is added to these (Sijtsma, Mehnen & Angelstam, 2019).

In this exploratory study, the cycles of stability, changes, and slow and fast variables in the AMC's SESs are discussed, based on a review of national and international academic production that focused on this area in its numerous sources. In this sense, it is observed that environmental history and case study historiographic works have contributed to understanding the area, through a qualitative approach that allows combining scientific sources of a diverse nature, to originate an analysis of interdisciplinary characteristics. This opens up possibilities of applying conceptual models that establish scenarios and forecasts of what could happen there in the future, in addition, to promoting improvements in territorial planning, development policies, and economic incentives and pointing to ways of life in human systems with fewer negative feedback loops. This means opening up to the idea that systems have cycles of stability and change that can be taken advantage of to move towards adaptable, resilient SESs, which include a non-speciesist posthumanist perspective and that are capable of handling significant learning. In this sense, for example, the legislation that has required higher levels of earthquake resistance in buildings (NCh 433 and NCh2369) and the determination of non-construction zones that are included in the regulatory plans stand out. Both have made it possible to save countless human and non-human lives, reduce post-disaster reconstruction costs, and promote cycles of change with fast variables that allow fluent transitioning to stability cycles.

VII. CONCLUSIONS.

From the work carried out, it can be pointed out that the working hypothesis is fulfilled, namely, that the SESs in the AMC are subjected to fast changes followed by long stability cycles whose slow drivers are, for the most part, of anthropic origin, and their fast ones are also mainly of a natural origin. Among the findings of the study, it is highlighted that, in human systems, the catalysts of changes can be grouped into laws, agents, and socioeconomic activities, and, in natural systems, are only natural disasters. The fast variables were appreciated in natural disasters for natural systems and changes in urbanism. The slow variables for human systems were grouped into political, economic, and environmental variables. In this line, cycles of stability and changes and slow and fast variables that influence these cycles for the AMC in Chile were identified. These results constitute a contribution to the extent that they point to the availability of the concepts analyzed from the perspective of the SESs and their integration into the available literature on the AMC, which has

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different temporalities. The limitations of this study are given by the areas that have been studied in this territory.

As a reflection, it should be mentioned that interdisciplinary integration becomes arduous to survey the knowledge of the SESs from a point of view that is not purely anthropic, mathematical, or ecological, since the reviewed articles refer to their own areas, concepts, ontologies, and epistemologies. This makes a multi-scalar and/or multidisciplinary process difficult and, even more so, to incorporate the SES perspective for the general public and decision-makers in the AMC. In this sense, this work seeks to open the door for research such as those of Winder (2007), Iannucci and Munafò (2012), and Cote and Nightingale (2007) to be replicated in the AMC. They work across areas on systems theories, SESs, and historiography to understand how systems behave, a fact that is demonstrated in this article.

When looking at public policies, this article reveals the importance of natural disasters as a key element in the phases of change that were evidenced in the AMC. In this context, in recent years, in Chile, coordinated efforts have been made to integrate the concepts and processes that SESs provide through the formation, in 2016, of the National Commission for Resilience against Disasters of Natural Origin (CREDEN), under the auspices of the National Council for Innovation for Development (CNID); the creation, in 2019, of the Institute for Disaster Resilience (ITREND); and through the formation of the Interministerial Committee for Just Socio-Ecological Transition (TSEJ), in 2022. Thus, it is worth finishing with the words of the Minister of the Environment, Maisa Rojas:

> Just Socio-Ecological Transition is a concept that we have coined for a series of transitions that Chile has to go through and thus move from a situation of environmental degradation, climate crisis, and destruction of biodiversity - affecting the population-, to a model where we give greater well-being to Chileans. (Ministry of the Environment [MMA], 2022)

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WALKING ACCESS TO URBAN WETLANDS[1]

AN OPPORTUNITY FOR RECREATION AND WELLBEING

ACCEDER CAMINANDO A LOS HUMEDALES URBANOS
UNA OPORTUNIDAD DE RECREACIÓN Y BIENESTAR

ACCEDER CAMINANDO A LOS HUMEDALES URBANOS
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CAROLINA ROJAS QUEZADA, FELIPE JORQUERA GUAJARDO, STEFAN STEINIGER
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CAROLINA ROJAS QUEZADA 2
FELIPE JORQUERA GUAJARDO 3
STEFAN STEINIGER 4

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2 Doctora en Geografía en Sistemas de Información Geográfica, Cartografía y Teledetección
Pontificia Universidad Católica de Chile, Santiago, Chile.
Profesora Instituto de Estudios Urbanos y Territoriales
https://orcid.org/0000-0001-9505-4252
carolina.rojas@uc.cl

3 Magíster en Asentamientos Humanos y Medio Ambiente
Universidad de Concepción, Concepción, Chile
Estudiante Doctorado en Ciencias Ambientales, Facultad de Ciencias Ambientales - Centro EULA.
https://orcid.org/0000-0003-1854-2994
fejorquera@udec.cl

4 Postdoctorado en Ingeniería Geomática
Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile.
Profesor Escuela de Ingeniería de la Construcción y Transportes - Investigador Asociado Centro de Desarrollo Urbano Sustentable CEDEUS, Santiago, Chile
https://orcid.org/0000-0002-0025-9878
stefan.steiniger@pucv.cl

DOI: https://doi.org/10.22320/07183607.2022.25.46.05

Los humedales de las ciudades chilenas constituyen uno de los ecosistemas urbanos más afectados por los desarrollos inmobiliarios. A pesar de sus valores en recreación y en biodiversidad, sufren una constante pérdida de superficie, debido a deficientes procesos de planificación urbana. Sin embargo, ante el auge de las ciudades verdes y sustentables, se están revalorizando por medio de proyectos de restauración y de parques urbanos abiertos, de valor natural para el bienestar de los hábitats y la población. En este sentido, propiciar una accesibilidad con una infraestructura adecuada aportará a mejorar la calidad de vida de los habitantes y por supuesto del entorno urbano, concretamente a través de la integración de infraestructura verde-azul (*blue-green infrastructure*). Con la finalidad de contribuir al acceso a la naturaleza en ciudades, se realiza aquí un análisis de accesibilidad a pie, a una red de humedales llamada “La Ruta del Agua”, mediante una encuesta de percepción. Los humedales urbanos evaluados son 5 ecosistemas con distintos entornos barriales en Concepción Metropolitano (Chile). Si bien se trata de un caso de estudio local, representa una contribución metodológica relevante, dada la existencia de una gran cantidad de humedales urbanos degradados en Latinoamérica y en peligro de desaparecer. Los resultados de acceso muestran que los humedales son accesibles por vía de la caminata, pero el hecho de que sean poco visitados, pese a su cercanía a las zonas residenciales, revela su falta de integración como espacios abiertos, verdes, ricos en biodiversidad y aptos para la recreación en la ciudad de Concepción. Los resultados de este estudio son valiosos para el diseño de futuros de proyectos de parques en humedales, parques que deben considerar los valores ecosistémicos, la biodiversidad y la recreación para el bienestar de las personas.

Palabras clave: hábitat, política pública, asentamientos precaristas

Urban wetlands in Chilean cities are one of the urban ecosystems most affected by real estate developments. Despite their importance for recreation and biodiversity, they are constantly shrinking due to deficient urban planning processes. However, with the recent boom of green and sustainable cities, wetlands are being revalued through restoration projects and open urban parks, with natural value for the well-being of habitats and the urban population. In this sense, promoting accessibility through suitable infrastructure will contribute to improving the quality of life of inhabitants and the urban environment, specifically through the integration of blue-green infrastructure. Walkable access to a network of wetlands called “La Ruta del Agua” (“the water trail”) has been analyzed here, through a perception-based survey, looking to improve access to nature in cities. The urban wetlands assessed comprise five ecosystems located in different types of neighborhoods in the metropolitan area of Concepción, Chile. Although this is a local case study, it is relevant from a methodological perspective, given the existence of a large number of degraded urban wetlands in Latin America that are in danger of disappearing. The results show that wetlands are accessible by walking, but the fact that they are rarely visited, despite being close to residential areas, reveals a lack of integration as open green spaces, rich in biodiversity, and as places of recreation in the city of Concepción. The results of this study are valuable for the design of future “wetland parks”, one which must consider the ecosystem values, biodiversity, and recreation for people’s well-being.

Keywords: accessibility, urban wetlands, walkability, perception, well-being

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I. INTRODUCTION

Today wetlands are in serious jeopardy of global disappearance (Darrah *et al*., 2019) which is of great concern given that there is widespread evidence of their innumerable benefits for people and habitats. They mitigate floods, protect the coast from erosion, are biodiversity habitats, clean the air, and sequester carbon, among other contributions (Basu *et al*., 2021; Dabrowska-Zielinska *et al*., 2014; Penatti, Ribeiro, Ferreira, Arantes & Coe, 2015). In fact, more recently, they are being valued as nature-based solutions, to solve the problem of urban flooding, as well as for the design of urban parks focused on the common good (Zhai & Lange, 2021).

Urban growth has been one of the main contributors to the damage to these water ecosystems. It is for this reason that several protection, conservation, and restoration initiatives, among other actions, have emerged in cities. For example, in New York (USA), the restoration of wetlands and their transformation into public spaces, namely, into "flood parks", has been a strategy to face the consequences of hurricane flooding (Campo, 2016). In Vitoria-Gasteiz (Spain), the restoration of the Salburua wetlands and their "green belt" have transformed the city into an internationally recognized green capital. In the U.K., the government is aiming to create 100,000 hectares of wetlands (Wildfowl & Wetlands Trust [WWT], 2021), and, in China, the so-called "Sponge Cities" are being created, which include parks with urban wetlands, whose goal is that 80% of Chinese cities absorb and reuse at least 70% of their rainwater by 2030 (Caprotti, Springer & Harmer, 2015).

However, in Latin America, the integration of urban water ecosystems with the city is more complex. The region leads the global loss of wetlands due to land use changes (Darrah *et al*., 2019). Even so, some successful experiences stand out, such as the case of the "Pantanos de Villa" wetland in Lima (Peru) which, despite its intervention, has been recognized as a Ramsar wetland, and as a point for ecotourism, leisure, research, and environmental education. "Pantanos de Villa" is an example of biodiversity protection in one of the most desert-like cities in the world (Chung-Velásquez & Lopez-Manrique, 2021; León Sulca, 2020). The Várzeas de Bacia do Alto Tietê Park in Sao Paulo (Brazil) is equally successful, where flood plains have been restored, improving risk mitigation and access to green infrastructure (Mayorga-Moral, 2013).

In Chile, thanks to the "Urban Wetlands Protection Law 21.202" (de Urresti, 2019), which recognizes wetlands as areas of natural value, there is a growing interest in protecting and visiting them. Consequently, a greater demand is predicted for the planning of parks with wetlands and, with it, an increase in the possibilities of accessing and enjoying their benefits in Chilean cities. Thus, in a scenario of a potential increase in demand for access to these valuable ecosystems, this work proposes research that analyzes, through a perception instrument, people's access to a potential urban wetlands network, trying to answer the question: how is access to these natural ecosystems perceived? The objective of the study is to support future blue-green infrastructure projects in the Concepción Metropolitan Area (Chile), one of the areas with the greatest presence of wetlands, and one most affected by urban pressure, thus contributing to reducing knowledge gaps on access to urban wetlands.

The value of accessing urban wetlands

Access to nature contributes to well-being, as has been demonstrated by different research projects that associate the benefits of proximity to nature with people's physical and mental health (Van den Berg et al., 2015; Gascon *et al*., 2016; Crouse *et al*., 2018). Nevertheless, access to nature can also be approached from a distance, as a critical aspect, since it refers not only to distance from home or proximity but also to the ability to access and interact with natural spaces. In fact, from a distance, the 15-minute paradigm has been consolidated, as a suitable travel time to receive the benefits of the city such as parks. Currently, and especially after the pandemic, several studies are evaluating 15-minute accessibility to different opportunities (Abdelfattah, Deponte & Fossa, 2022; Pinto & Akhavan, 2022), a threshold that has been consolidated as a suitable time to access multiple services (health facilities, education, food, green areas, among others). This aspect constitutes an attribute of the sustainable city and a strategy for climate change, which prioritizes mobility by walking and zero-emission trips.

The evaluation of people's accessibility to natural spaces is considered very timely and contributes to the future design of parks with urban wetlands. With the latter, the pandemic has revealed more empirical evidence on the benefits of this type of park for people's health. In China, the closure of wetland parks and the limitation of access to these spaces increased users' perception of the psychological benefits of visiting them in a normal year (Zhai & Lange, 2021). Consequently, urban wetlands represent a concrete alternative for the development of blue-green infrastructure projects for leisure, biodiversity, and people's well-being, especially in cities that lack green areas. Considering urban wetlands in this green infrastructure network could increase accessibility, as has been seen for the city of Valdivia in Chile, where the grouping of green spaces, together with wetlands and longer walks, has led to higher levels of accessibility (Rojas, Paéz, Barbosa & Carrasco, 2016).

ROCUANT-ANDALIÉN WETLAND

Type of Wetland	Coastal with saline intrusion
Surface Area	2,860 hectares
Vegetation	Halophiles, Glasswort (Sarcocornia fructicosa) and Denseflower Cordgrass (Spartina densiflora)
Birds	Grey Plover, South American Tern, Whimbrel, Black Swan, White-faced Ibis, Oystercatcher, and the Lesser Yellow Legs
Ecosystem Services	Cultural, leisure, tourism, education, and research ES Regulation ES, flooding, controllers of rainfall flooding, water reservoir, as support for agricultural activity, and water regulation.
Urban Fabric	Medium density residential fabric.
Land uses	Forestry plantations, open areas with bare soils and little vegetation, and industrial areas
Neighborhoods	Medium-density neighborhood units, and low-density social housing
Green Infrastructure	Pedestrian access from the Talcahuano sector
Barriers and Threats	Micro-landfills Invasive species, and real estate development pressure

VASCO DE GAMA & PAICAVI WETLAND

Type of Wetland	Palustrine
Surface Area	91 hectares
Vegetation	Hydrophyte, reeds or bulrushes (Schoenoplectus californicus), sedge (Cyperus eragrostis), and pond sedge
Birds	Southern lapwing, Black-crowned night heron, Cinnamon teal, White-tailed kit, and Austral kestrel
Ecosystem Services	Cultural, leisure, tourism, education, and research ES Regulation ES, flooding, controllers of rainfall flooding, water reservoir, as support for agricultural activity, and water regulation.
Urban Fabric	Medium density residential fabric.
Land uses	Open areas with little vegetation, educational areas
Neighborhoods	Low-density neighborhood units, and housing blocks
Green Infrastructure	There is access, and green areas alongside the wetland
Barriers and Threats	Micro-landfills and real estate and industrial development pressure

LOS BATROS WETLAND

Type of Wetland	Palustrine
Surface Area	149 hectares
Vegetation	Hydrophyte, reeds or bulrushes (Schoenoplectus californicus), sedge (Cyperus eragrostis), and native vegetation like the olive.
Birds	Spectacled tyrant, Whimbrel, and Black Swan
Ecosystem Services	Cultural, leisure, tourism, education, and research ES Regulation ES, flooding, controllers of rainfall flooding, water reservoir, as support for agricultural activity, and water regulation.
Urban Fabric	Low-density residential fabric.
Land uses	Forestry plantations, wetland, and agricultural plantations
Neighborhoods	Garden city, and residential condominiums
Green Infrastructure	Access to the wetland and wetland urban park
Barriers and Threats	Micro-landfills

BOCA MAULE WETLAND

Type of Wetland	Palustrine, river, and coastal
Surface Area	65 hectares
Vegetation	Lesser bulrush (typha angustifolia), reeds (Schoenoplectus californicus), common red (phragmites Australia), Macrophytes – floating pennywort (hydrocotyle ranunculoides), South American spongeplant (limnobium laevigatum) and fat duckweed (lemna gibba).
Birds	Kelp gull, Brown-hooded gull, and Neotropic cormorant
Ecosystem Services	Cultural, leisure, tourism, education, and research ES Regulation ES, flooding, controllers of rainfall flooding, water reservoir, as support for agricultural activity, and water regulation.
Urban Fabric	Low-density residential fabric.
Land uses	Wetland, open areas with bare soils, and forestry plantations
Neighborhoods	Low-density social housing, and low-density neighborhood units
Green Infrastructure	Current access, along with green infrastructure improvement projects
Barriers and Threats	Natural barriers for invasive species, micro-landfills, and land taken for self-builds.

Figure 1. Characterization of the "Water Route" wetlands network. Source: Preparation by the authors based on fieldwork (2021) and Water Route (Regional Government - Consultant, Edáfica 2019), Rojas & Jorquera (2021).

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	Wetland				
	Los Batros	Rocuant - Andalién	Paicaví - Vasco Da Gama	Boca Maule	Total
Total base	210	125	187	118	640
Gender	%	%	%	%	%
Male	30.5	39.2	43.3	47.5	40.1
Female	69.5	60.8	55.6	52.5	59.6
Other	0	0	1.1	0	0.3
Age (average)	45	49	42	45	45
Main occupation	%	%	%	%	%
Primary (fishing, agriculture)	0	1.6	3.2	0	1.2
Secondary (industry)	11.9	13.6	8.6	21.2	13.8
Tertiary (services)	22.4	28.8	24.1	22	24.3
Full-time Head of household	34.3	26.4	17.1	30.5	27.1
Studying	12.4	8.8	25.1	11.9	14.6
Retired	10	16	16.6	13.6	14.1
Unemployed	9	4.8	4.3	0.8	4.7
Does not answer	0	0	1.1	0	0.3
Educational level	%	%	%	%	%
Without studies	1	0.8	0	1.7	0.9
Elementary School	15.2	11.2	4.8	17.8	12.3
High School	49.5	36	47.6	55.1	47.1
Higher	34.3	52	47.6	25.4	39.8
Participates in environmental organizations	%	%	%	%	%
Yes	1.9	0.8	3.2	0	1.5
No	98.1	99.2	96.8	100	98.5

Table 1. Sample characterization (N=640). Source: Preparation by the authors.

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II. CASE STUDY

Of the Chilean cities, Metropolitan Concepción is recognized for its diversity of coastal and lake wetlands. Even though urban wetlands are presented as an open space to access nature, the city of Concepción has not yet consolidated a restoration and valorization process by improving access, infrastructure, signage, and information on the species found in the wetlands. However, their valorization is incipient. In 2018, the Regional Government implemented the "Water Route" project, to increase urban green infrastructure projects**5** comprising: (A) the Rocuant-Andalién wetland, located between the commune of Talcahuano and Penco; (B) the Vasco de Gama wetland, in the commune of Hualpén, and the Paicaví wetland, in the commune of Concepción; (C) the Los Batros wetland, in the commune of San Pedro de la Paz; (D) and the Boca Maule wetland, in the commune of Coronel. The main ecological and urban environment characteristics of this route are shown in Figure 1. In the same year, the first Park in the area was inaugurated, recognizing a portion of the Los Batros Wetland. Today, the Boca Maule Wetland Park is being developed, and the Santa Clara Park on the edges of Rocuant-Andalién is in the files.

5 The objective of the project is to characterize and enhance the water system of the Concepción Metropolitan Area, protecting and promoting wetlands as urban spaces of ecological and social value. In this way, it is connecting public spaces with ecosystems of high value and biodiversity.

6 Financed by ANID FONDECYT, Nº 1190251.

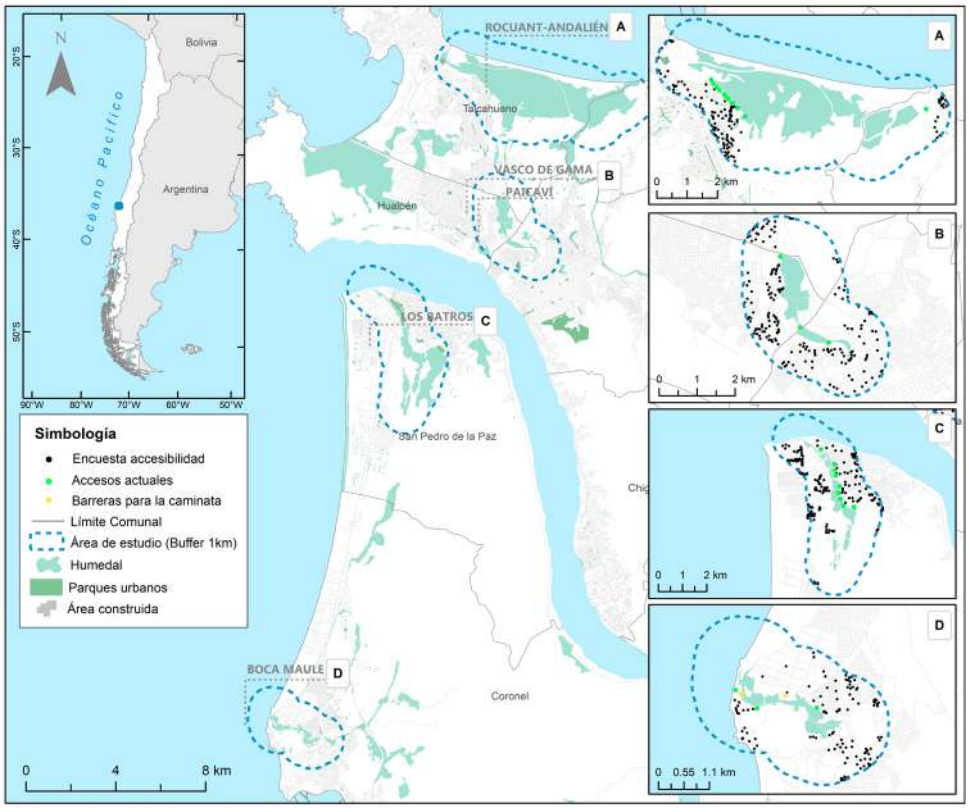

Figure 2. Spatial distribution of the surveys in the urban wetlands of Metropolitan Concepción: (A) Rocuant-Andalién; (B) Paicaví and Vasco de Gama; (C) Los Batros; (D) Boca Maule. Source: Preparation by the authors based on a wetlands perception survey (Urbancost, 2021).

III. METHODOLOGY

Accessibility survey

The perception of accessibility was made through a residential field survey, between January and March 2021. This was applied to residents living near the urban wetlands[6]. A representative population sample of 640 surveys was determined using the results of the 2017 population census. The distribution by wetland is shown in Table 1.

The survey was residential, i.e., it was carried out at the respondent's home. It used georeferencing of the home and location in the neighborhood adjacent to the wetland (Figure 2). The sample (N=640) had a gender distribution of 59.6% women and 40.1% men with an average age of 45. The main occupation registered was that of the head of household (27.1%), followed by that of tertiary sector worker (services) (24.3%). For participation in environmental organizations, 98.5% stated that did not participate (Table 1).

The questionnaire lasted 15 minutes and included questions on accessibility, wetland definition, attachment, and ecosystem services. On this occasion, only the answers to the accessibility dimension are analyzed, whose questions were the following:

How long have you lived in your current neighborhood? (Less than 1 year, More than 1 year)
Can you see the wetland from your home? (Yes/No)
What can you see of the wetland? (water, vegetation, fauna, people, garbage, others)
Walking to the wetland from home is: (Easy, Normal, or Difficult)
How often do you visit the wetland? (At least once a week, at least once a month, at least once a year, Every day, Never)
During a typical visit, how long do you visit the wetland? (Less than an hour, 1-2 hours, Half a day, All day, Never)
What is the most frequent purpose of your visit? (Sport, Transit, Photography, Work, Walking, Contemplating, Meeting Friends)
How do you normally visit the Wetland (wetland name)

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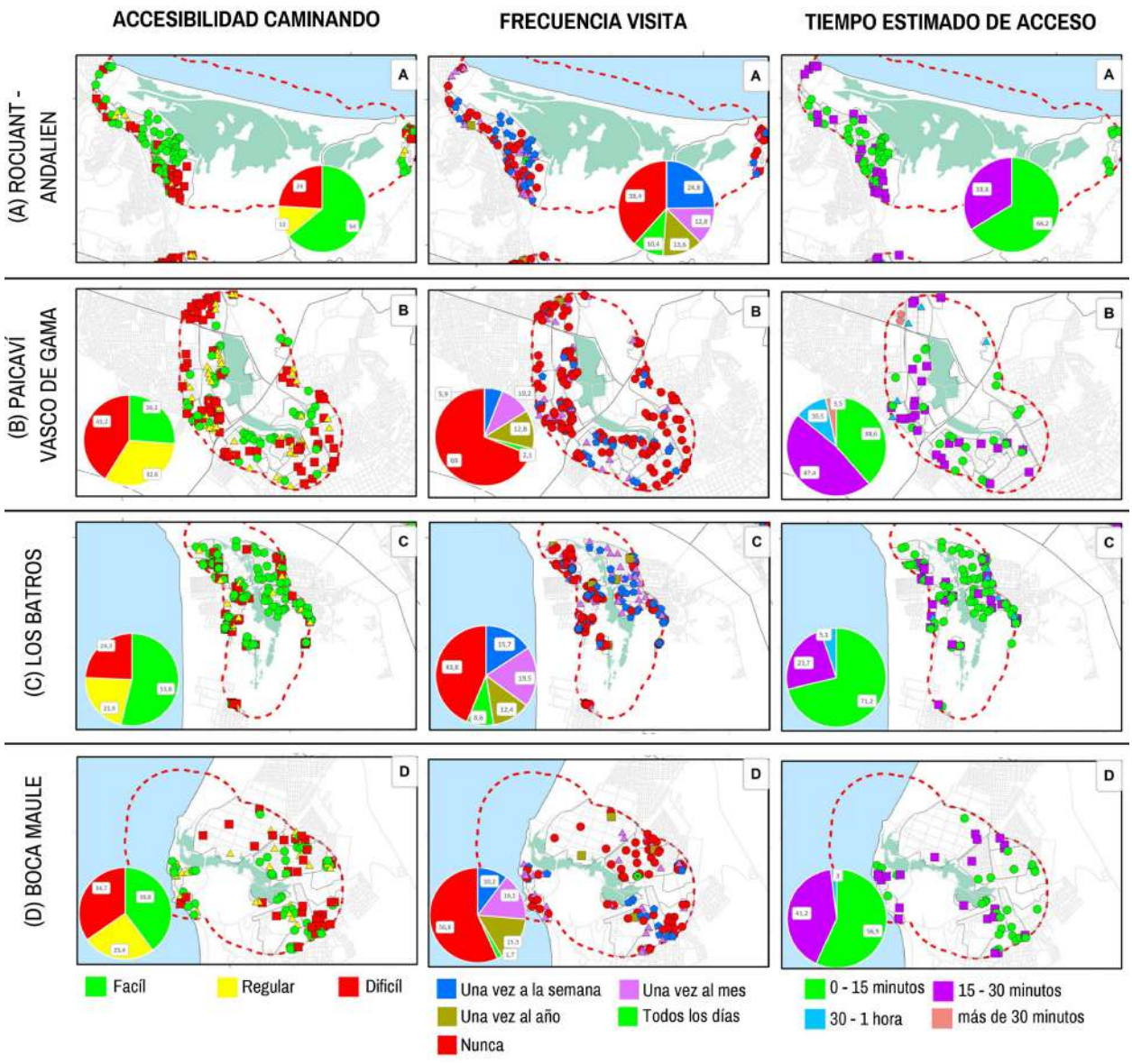

Figura 3a. Perception of accessibility to wetlands based on the results of the "Concepción Urban Wetlands Perception Survey" (Urbancost, 2021).Source: Preparation by the authors.

from your home? (Bicycle, Walking, Car, Public Transport, Other)
On the most frequent route to visit the wetland from your home: How long does it take? (0-15 min, 15-30 min, 30-1 h, more than 1 h)
Why do you not visit the wetland? (It is dangerous, I have no access, There is no light, There are no signs, It is not interesting, It Is dirty, It is very far away, Others)

IV. RESULTS

The general results (Figure 3) indicate that 96.7% have been living in the neighborhood for "more than a year" and that only 3.3% have lived there for less than a year, so this is a settled population in the area.

Regarding the ability to see the wetland from their neighborhood, 95% cannot see it, and only in Los Batros and Rocuant-Andalién, is

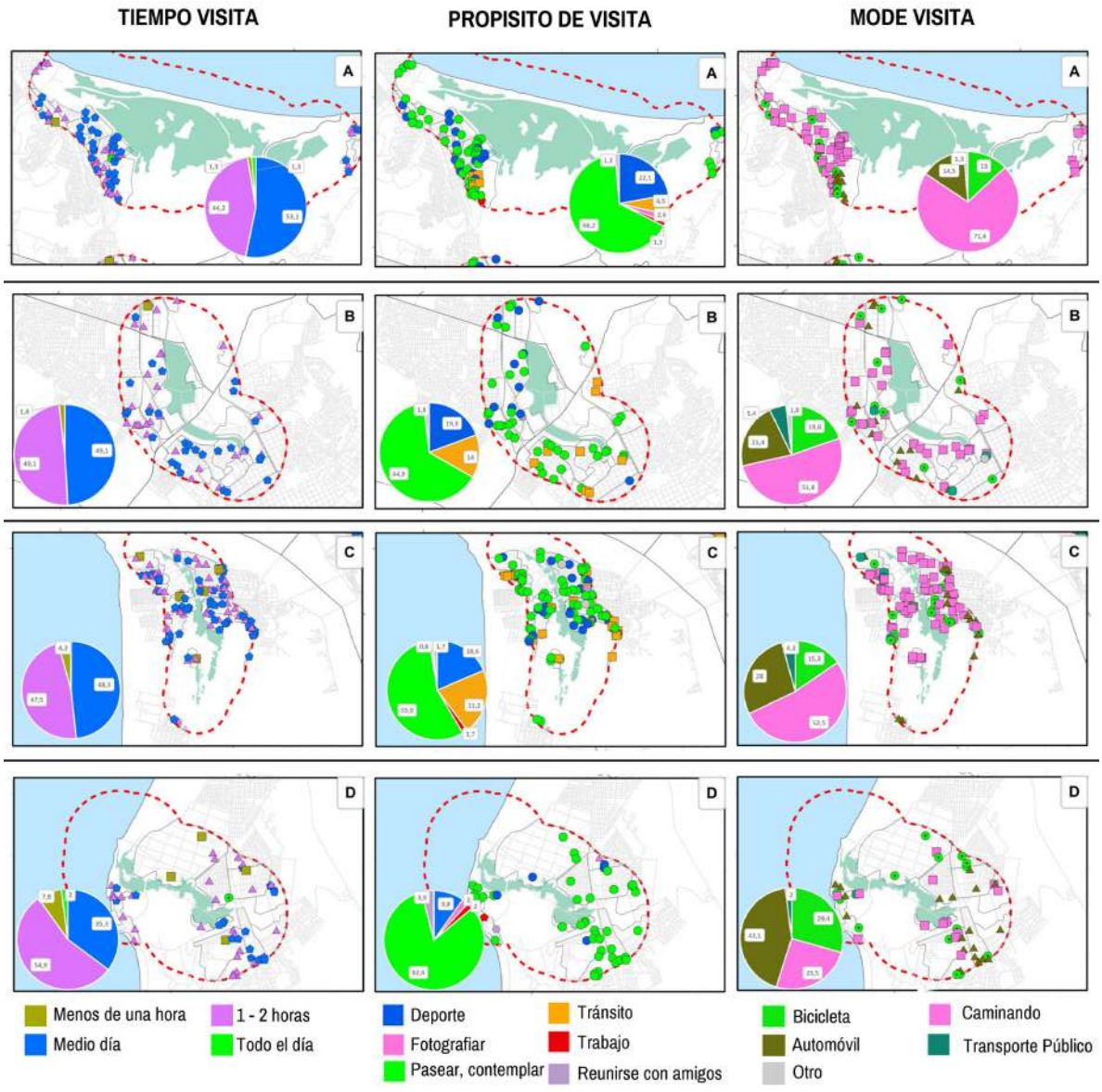

Figura 3b. Perception of accessibility to wetlands based on the results of the "Concepción Urban Wetlands Perception Survey" (Urbancost, 2021).Source: Preparation by the authors.

this above 5%. Of the 5% of inhabitants who can see the wetland (35 people), they appreciate the vegetation (62.8%), the fauna (52.1%), and the water (49.5%); three positive aspects of wetlands. In Los Batros, what is most appreciated is the vegetation (78.9%) and the fauna (52.6%); in Rocuant-Andalién, it is the vegetation (88.9%) and the water (77.8%); and in Vasco de Gama, the fauna (100%). As for visible negative attributes, garbage is mentioned, in 60.5%, especially in the Los Batros wetland.

Specifically, for walking, it was asked whether, walking to the wetland from home, was "easy, normal, or difficult". 46% indicated that the wetland is easily accessible, 23%, that it is normal, and 31%, that it is difficult. The Los Batros wetland stands out as the easiest to access and Paicaví – Vasco De Gama and the Boca Maule as the most difficult (the latter is being transformed into an urban park). Regarding how often people visit the wetland, 52% of the population indicated they "never"

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visit it; 14.7%, "once a month"; 14.2%, at least "once a week"; 13.5%, "once a year"; and 5.6%, "every day". The most visited wetlands are the Rocuant-Andalién and Los Batros, even registering visits "every day" (10.4% and 8.6%, respectively). The survey ended here for the respondents who do not visit any wetlands, so the following questions were only applied to the remaining 48%.

303 people regularly visit the wetlands. A typical visit lasts "less than an hour" in 46.5%; "between 1 to 2 hours", in 48.9%; "half a day", in 3.8%; and "all day" in just 0.9%. In the visits of the largest group (less than an hour), Rocuant-Andalién, Paicaví-Vasco de Gama, and Los Batros stand out. The most frequent purpose of the visit is to "walk and contemplate" (53.9%), which is directly related to leisure; the Boca Maule, Rocuant Andalién (66.2%), and Paicaví-Vasco de Gama (64.9%) wetlands lead the visits to "walk and contemplate", (82.4%). "Sport" is still relevant, led by Rocuant-Andalién (22.1%), and "transit", mainly, in Los Batros (21.2%) through the Boca Sur and Candelaria neighborhoods.

As for the mode of transport to visit the wetlands, walking is the main way, with 40.2%, followed by the car (21.4%), the bicycle (15.5%), and, in a distant last, public transport (3.6.%). According to the survey, the most walkable wetlands are the Rocuant-Andalién and Los Batros, and the most "cyclable" are Boca Maule (43.1%) and Paicaví-Vasco de Gama (21.4%). Regarding the estimated time it takes to get to a nearby wetland (travel time), 46.6% of those consulted perceive that they arrive in less than 15 minutes, or the best accessibility threshold. For the Los Batros wetland, this threshold is 71.2%, and in Rocuant, 66.2%. In any case, more than 90% can reach a wetland within 30 minutes of walking.

Finally, to understand the reasons why the wetland is not visited, 41.3% comment that they do not find it interesting; 33.9% do not point out any specific aspect; 18.8%, that it is remote - which contradicts the mentioned travel times; and 9.2%, that it is dangerous.

V. DISCUSSION

This research is valuable for the design of blue-green infrastructure in cities, even more so when the coronavirus pandemic has increased the demand for green safe spaces (Grima *et al*., 2020).

The study strengthens the discussion on the urban fabrics built in the area (Rojas & Jorquera, 2021). The inability to see wetlands from home only reaffirms the fact that low-density urbanism has turned its back on natural ecosystems, despite their proximity to residential areas. Of the components that are visualized, water – although it is not the main visual resource - presents a huge opportunity for restoration, because it has been shown that living near water spaces, or blue spaces, also has benefits for the sake of a healthier life (Crouse *et al*., 2018)

A key point for accessing urban wetlands is biodiversity. Recent research has found that people who visit wetlands do so for biodiversity (Song, Albert & Prominski, 2020). In this case, biodiversity as such was not measured, which is a limitation of the study, but the visualization of vegetation was captured, which ends up being the most important attribute. The value of fauna is also demonstrated in the survey, coinciding with the fact that one of the most valuable features of wetlands is its birds. It is important to emphasize here the attractiveness these spaces represent for ornithological tourism, although there is not always suitable or accessible infrastructure for birdwatching (Vivanco Calderón, 2020). These attributes contribute to the leisure value, which is consolidated as the main purpose of the trip. Of course, this is related to a healthier life, consistent with the evidence about improvements in mental health, specifically, with the reduction of stress (Reeves *et al.*, 2019) and improvement of well-being (Hartig, Mitchell, de Vries & Frumkin, 2014), an aspect that should be addressed and connected to access in future research.

On the other hand, there are some divergences between the value of biodiversity and the increase in accessibility to enhance leisure and the number of visits, since the increase in visitors could have consequences in the degradation and homogenization of the landscape, for example, with the proliferation of exotic plants (Pauchard, Aguayo, Peña & Urrutia, 2006; Price, Spyreas & Matthews, 2020). In fact, it has been shown that areas denser in population, located on the edges of wetlands, have better access possibilities, but they are areas of lower biodiversity and more intervened (Rojas, Sepúlveda, Jorquera, Munizaga & Pino, 2022). Taking this situation into account, "edge access" could be promoted with landscape criteria, such as the one made in Llanquihue, considering several aspects: geographical scope, a vision of territory, conservation objectives, urban well-being, threats, their monitoring, among others (Gárate & Fernández, 2020; Moreno & Gárate, 2020). It is important to note that there are already design proposals that aim to adapt the existing vegetation for rainwater collection (Bellalta, 2021). Likewise, it is key to consider biodiversity in its breadth when developing a green-blue infrastructure network,

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and not just vegetation, of which homogenization and intervention in dense areas have been documented (Pauchard *et al.*, 2006; Rojas *et al*., 2022). The same goes for the distribution and nesting periods of birds. In this sense, it will be necessary to distinguish coastal wetlands from marshes, because the former are more sensitive in terms of bird nesting: this is the case of the Oystercatcher, where 1% of the population reproduces in the Rocuant-Andalién wetland, from August to February (Barros, 2018).

Given that more than 50% of the population never visits wetlands, it will be important to explore how much the lack of infrastructure affects walking around them, visiting them, recognizing their biodiversity, and understanding the ecological functions they perform. Thus, it will be necessary to incorporate into new research, an assessment of the wetlands' capacity for tourism as a preventive planning mechanism, due to the potential increase in visitors to spaces of high natural value (Martín Varisto, Rosell & Rosake, 2009) along with evidence of stress reduction.

Finally, for accessibility to nature studies, from the population mobility approach, in addition to the health benefits, it has been proven that there is also a purpose of "transit" travel, mainly in the Los Batros Wetland, which is linked to horticultural and neighborhood activity. In fact, some of these spaces are used as a "shortcut" to the final destination (Villagra, C. Rojas, Alves & O. Rojas, 2022). For the same reason, and given the lack of accessible open and green spaces, using edges as walkways that promote walking and cycling, is a very good fit (Vivanco Calderón, 2020).

VI. CONCLUSIONS

This work contributes to reducing the gap in research of these areas, providing support for the integration of wetlands into cities, for example, in the design of parks and/or the definition of routes or guided tours for their valorization. It was shown that, even though the population resides in the study area, they do not know the wetlands and, for the most part, do not visit them. Alongside this, it was found that the built neighborhoods have not integrated the natural value of the environment in urbanization, since many of its attributes are invisible. Regarding access, the network's wetlands are reachable on foot, although most of them do not have a suitable infrastructure.

There is an imminent potential to develop a green-blue infrastructure network with walkable access, mainly for "walking and contemplating" because today, even without infrastructure and information, they are considered easily accessible and "once a month" and "once a week" visits are mentioned, lasting between less than 1 hour to 2 hours. Therefore, by promoting environmental education and self-guided tours to get to know and contemplate nature, this value would undoubtedly be enhanced. Transit in wetlands constitutes, at the same time, an opportunity that can be developed by implementing trails, insofar as these are a valid alternative for people who prefer to walk through natural spaces than through normal and noisy streets, especially when going to work, which ratifies the potential for connectivity and linearity offered by urban wetlands. However, these urban wetlands are ecosystems with a delicate ecological balance, since they house habitats of flora and fauna species, hence, when enabling access, care must be taken with biodiversity and planning well in urban terms.

The Rocuant-Andalién, Los Batros, and Boca Maule wetlands are the ones with the greatest opportunity for walking access. They are apt for working with their edges and integrating them with the neighborhood. As for the Paicaví and Vasco de Gama wetlands, despite their proximity to residential areas, they have difficult access, so they require a prior restoration process to recover biodiversity and enhance their qualities to generate better accessibility to the landscape for residents.

In short, having good accessibility from residential neighborhoods to natural open spaces or public green spaces, which in the future will tend to be a single system, makes the city a more attractive place, where the likelihood of walking is increased and active mobility and healthy habits are promoted, which encourage better mental health, more social interaction, and a better quality of life and well-being.

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AN APPROACH TO PUBLIC POLICY FOR URBAN HERITAGE PROTECTION IN COLOMBIA

USING PATH DEPENDENCE (1954-2019)

APROXIMACIÓN A LA POLÍTICA PÚBLICA DE PROTECCIÓN DEL PATRIMONIO URBANO EN COLOMBIA EN CLAVE DEL PATH DEPENDENCE (1954-2019)

OSCAR YESID FONSECA ROA 2

1 Research within the framework of a Doctoral thesis in Architecture of ETSAVa of the University of Valladolid (Spain)

2 Magíster en Planeación Urbana y Regional
Universidad de Valladolid,Valladolid, España.
Estudiante Doctorado en Arquitectura - Director Programa de Arquitectura, Facultad de Arquitectura, Diseño y Urbanismo, Universidad de La Salle, Bogotá, Colombia
https://orcid.org/0000-0003-3056-6841
oscaryesid.fonseca@alumnos.uva.es

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El patrimonio urbano es una categoría del patrimonio cultural. Los centros históricos están protegidos por un marco jurídico que salvaguarda los valores que son objeto de la declaratoria correspondiente. El estudio de la política de protección del patrimonio urbano en Colombia ha estado limitado por la perspectiva clásica. En contraste, esta investigación realiza un estudio de caso sobre la legislación de conservación y los centros históricos declarados en Colombia como BIC del ámbito nacional, entre 1954 y 2019, desde el institucionalismo histórico. La metodología empleada es el Esquema de Aplicación del *Path Dependence* (EAPD), que se orienta a reconocer las relaciones entre variables, periodos y trayectoria del objeto de estudio, para demostrar la hipótesis de este trabajo: el surgimiento del patrimonio urbano y los mecanismos de protección se debe al agotamiento de la ley e ideas del patrimonio histórico. Las conclusiones preliminares evidencian cinco periodos de evolución de esta temática y enfatizan la dependencia mutua del patrimonio urbano y la política de protección, como también la reciente emergencia de la participación ciudadana, la pérdida de flexibilidad y versatilidad del marco legal con manifestaciones de irreversibilidad en la conservación del patrimonio urbano.

Palabras clave: patrimonio urbano, *path dependence*, política urbana, protección.

Urban heritage is a category of cultural heritage. Historic centers are protected by a legal framework that safeguards the values that are the object of the declaration. The study of urban heritage protection policy in Colombia has been limited by the classical perspective. In contrast, this research performs a case study on conservation legislation and the historical centers declared in Colombia as Assets of Cultural Interest (BIC, in Spanish) between 1954 and 2019 from historical institutionalism. The methodology used is the Path Dependence Application Scheme (EAPD, in Spanish), which seeks to recognize the relationships between the variables, periods, and trajectory of the object of study; to demonstrate the hypothesis of this work, namely the emergence of urban heritage and protection mechanisms is due to the debilitation of the law and ideas of historical heritage. The preliminary conclusions outline five periods and emphasize the mutual dependence of urban heritage and protection policies, as well as the recent emergence of citizen participation, and the loss of flexibility and versatility of the legal framework with manifestations of irreversibility in the conservation of urban heritage.

Keywords: urban heritage, path dependence, urban policy, protection

I. INTRODUCTION

Urban heritage in Colombia comprises neighborhoods, sectors, architectural ensembles, historical centers, and small towns with homogeneity and authenticity values, declared and defined under the category of Heritage Asset (BIC, in Spanish) within the national, departmental, district, or municipal sphere. These are protected by urban, architectural, and environmental conservation regulations; formulated, approved, and adopted by the local authority with citizen participation in the last 25 years. The urban heritage protection policy in Colombia has been addressed in a disjointed fashion, using studies that focus on the generation of new legislation (Salazar, Cortés & Niño, 1989), the administrative-technical balance (Salazar, Niño & Téllez, 1996), understanding the role of historical centralities in the contemporary city (Beuf & Martínez, 2015), chronological accounts of heritage (Escovar & Cárdenas, 2018), the approach to urban renewal and globalization (Yory, 2019), and explorations from urban historiography (Mejía & Martínez, 2021). Some works present a balance with broken-down contributions to identify the institutional decisions that have shaped the urban patrimonial corpus and its corresponding public protection policy (Barbosa, 2001).

Urban heritage and public protection policy are legal creations (Melé, 2006). Through juridization, a specific legal status is granted to singular buildings and historical sectors as an exclusive way of protecting historical heritage. In this way, the State, on behalf of society, recognizes the architectural and urban values declared as BIC (Melé, 2015). The protection policy promotes and regulates the revitalization of urban areas, the strengthening of territorial management (Yory, 2019), and citizen participation as conservation strategies.

The protection legislation determines actions aimed at declaring new historical centers and creating institutions, structures, and mechanisms that reinforce the sense and presence of heritage in the social collective (Sydow, Schreyögg & Koch, 2020). "Political institutions" are understood as interconnected rules and routines that define the right actions — in terms of relationships between roles and situations — (Sorensen, 2020), where two main events emerge: eras characterized by their relevance and solutions to challenges within the functional framework of politics (March & Olsen, 1989). The linking of protection legislation has promoted the conservation of urban complexes but has also triggered urban development, an irreversible effort for the conservation of urban heritage.

The protection of urban heritage is subject to the temporality of the protection policy, the administrative structure, and the established management mechanisms. Faced with this, this work identifies the temporal trajectory between urban heritage and protection jurisprudence to determine how the connection of legislation and planning and management instruments induce the protection and irreversibility of conservation. To this end, laws, decrees, and resolutions issued between 1954 and 2019 for the declaration and protection of urban heritage are analyzed, with the aim of specifying internal and external variables that are subsequently broken down into three dimensions and submitted to the Path Dependence Application Model (EAPD, in Spanish).

II. THEORETICAL FRAMEWORK

Latin American states began to acknowledge and include urban heritage in public policies in the mid-twentieth century. The materialization of the *historic center* as a center of political and ideological power, the city builder, and the object of urban policies in Latin America (Carrión, 2000), was achieved by overcoming theoretical and practical limitations, achieving international cooperation, and building projects in central heritage areas for the consolidation of an interdisciplinary and multi-institutional debate scenario (Coulomb, 2015).

The emergence of legislation to safeguard national monuments in Latin America emerged in the 1950s. Then, in the 1970s, the interest of authorities migrated towards the conservation of heritage to (1) consolidate it in a dispersed and growing manner until placing it as an object of urban policies at the beginning of the twenty-first century (Delgadillo, 2008, p. 818) and, (2) align it to protection, nuanced by the variety of cultural heritage intervention alternatives (Gutiérrez, 2009).

Currently, urban heritage has problems related to the trajectory, trend, and application of protection policies (administrative structure and management mechanisms). The understanding and explanation of the approach proposed by historical institutionalism are considered a research method that focuses on the creation, persistence, and change of institutions over time, known as "*path dependence*"**3** and are used to reaffirm central ideas where: (1) specific time and sequence patterns matter; (2) a variety of social outcomes may be possible from similar starting conditions; and (3) major consequences may result from relatively "small or contingent" events (Pierson, 2017, p. 712).

3 Translated as dependent path or dependency pattern.

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Figure 1. Effects of irreversibility on the protection of urban heritage (a) San Gil, (b) Socorro, and (c) Bogotá, D. C. Source: Preparation by the author.

DEPARTAMENTO	CIUDAD	FUNDACIÓN	DECLARATORIA	
BOYACÁ	Villa de leyva	1572	Dec. 3641/54 Ley 163/59	DÉCADA 1950
ANTIOQUIA	Santafé de Ant.		Ley 163 de 1959	
BOLIVAR	Cartagena de Indias	1533		
	Santa Cruz de Mompox	1537		
BOYACÁ	Tunja	1539		
CAUCA	Popayán	1536		
CUNDINAMARCA	San Miguel de Guaduas	1644		
MAGDALENA	Santa Marta	1524		
NARIÑO	San Juan de Pasto	1539		
TOLIMA	San Sebastián de Mariquita	1549		
VALLE	Guadalajara de Buga	1558-1569		
	Cartago	1540-1691		
	Santiago de Cali, La Merced	1536		
	El Cerrito	1560		
ANTIOQUIA	Marinilla	1709	Dec. 264 de 1963	DÉCADA 1960
	Rionegro	1581		
BOGOTA D.C.	Bogotá D.C:	1538		
NORTE DE SANTANDER	Pamplona	1549		
SANTANDER	San Gil	1689		
	San Juan de Girón	1631		
	Socorro	1683		
NORTE DE SANTANDER	Villa del Rosario	1734	Dec. 102 de 1971	DÉCADA 1970
TOLIMA	Honda	1560	Dec. 1192 de 1977	
SANTANDER	Barichara	1752	Dec. 1654 de 1978	
TOLIMA	Ambalema	S. XVII Y XVIII	Dec. 776 de 1980	DÉCADA 1980
ANTIOQUIA	Jardín	1860	Dec. 1132 de 1985	
BOYACÁ	Turmequé	Siglo XVI	Dec. 1940 de 1989	
CUNDINAMARCA	Tenjo	1603	Dec. 2530 de 1993	DÉCADA 1990
MAGDALENA	Ciénaga	1538 - 1751	Dec. 2012 de 1996	
ATLÁNTICO	Barranquilla	1629	Res. 1614 de 1999	
ANTIOQUIA	Concepción	1760	Res. 1617 de 1999	
CALDAS	Manizales	1849	Dec. 2178 de 1996	
CESAR	Valledupar	1550	Res. 795 de 2000	DÉCADA 2000
CORDOBA	Santa Cruz de Lorica	1722	Res. 796 de 2000	
CALDAS	Aguadas	1808-1814	Res. 1883 de 2001	
ANTIOQUIA	Abejorrral	1808	Res. 619 de 2002	
BOYACÁ	Iza	Siglo XVII	Res. 617 de 2002	
CASANARE	Pore		Ley 936 de 2004	
ATLÁNTICO	Barrio El Prado, Bellavista y Altos del Prado.	1919-1930	Res. 0087 de 2005	
BOYACÁ	Mongui	1601		
CALDAS	Salamina	1827		
CUNDINAMARCA	Zipaquirá	1692-1758		
NORTE DE SANTANDER	Playa de Belén	1862	Res. 0928 de 2005	
	El Cármen	1686	Res. 0929 de 2005	
ANTIOQUIA	Jérico		Res.0663 de 2018	DÉCADA 2010

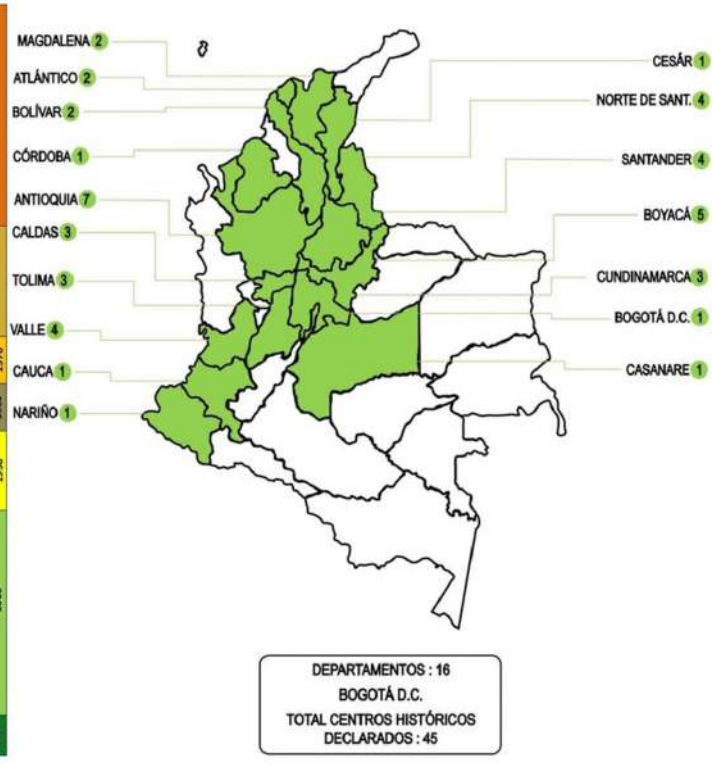

Figure 2. Declarations by decades and localization of urban heritage in Colombia. Source: Preparation by the author.

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Figure 3. Dimensions and determining variables of urban heritage and protection policies (1954-2019). Source: Preparation by the author.

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Path dependence establishes courses of action in institutions, that are virtually impossible to reverse and difficult to change over time, hence, small choices at the beginning can have significant long-term impacts (Sorensen, 2015; Pierson, 2017) and generate irreversibility (Figure 1) in the trend of a decision (Vergara, 2020). Current and future institutional results are closely linked to particular events of the past (Arthur, 1989; Trigo, 2015), a recurring feature where the concept arises.

The starting point assumes the creation of urban heritage as a legal fact (Melé, 2015) where the State recognizes unilaterally selected historical areas (Figure 2), to highlight values of collective social representation and induce mechanisms with the capacity to motivate collective representation (Melo, 2020). Historical institutionalism, through the EAPD, aims at identifying the effects of positive feedback on the urban heritage protection policy, which offer sound conceptual support and tools to analyze continuity and change in public policies (Sorensen, 2020).

III. CASE STUDY

The study carried out focuses its analysis on the identification of the progressive issuance in Colombia of legislation, institutions, programs, and instruments dedicated to the urban heritage, comprising 45 historical centers declared as BIC nationally, between 1954 and 2019. All of them constitute, in this framework, determining variables that have been arranged in three dimensions (Figure 3).

Based on Law 163 of 1959, the streets, squares, squares, piazzas, historical buildings, common land, and houses within the perimeters of towns from the 16th, 17th, 18th, and 19th centuries were declared historical and national heritage. Starting from Law 397 of 1997, on the principles of decentralization, autonomy, and citizen participation, the declaration and management of cultural heritage for registered urban heritage was transferred to regional entities. The declaration of the BIC is a protection mechanism established by the Culture Law that includes the assessment of historical, aesthetic, and symbolic aspects, covered by a special protection system and the formulation of a protection plan.

The declaration of urban heritage and the protection policy are made from three dimensions: *dimension 1*, dedicated to the heritage creation process, comprising the declaring entity, number of historical centers, and declaration category; *dimension 2*, groups the administrative structure (public, private, or international); *dimension 3*, contains the legislation, planning and management instruments along with development programs for historical centers.

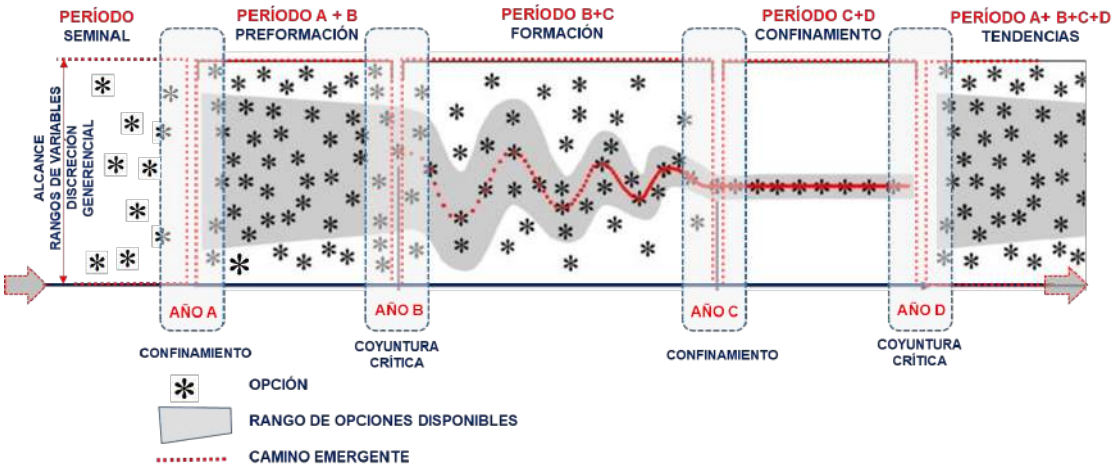

Figure 4. Path dependency application outline. Source: Preparation by the author based on Sydow et al. (2009).

IV. METHODOLOGY

Path dependence (EAPD) is used to establish the temporality of urban heritage and the protection policy through variables. This subdivides a process into periods governed by several causal regimes. It establishes varied scenarios for the interpretation of institutional action and decision-making (Sydow, Schreyögg & Koch, 2009). It focuses its concerns on the fact that history has a dependent and continuous trajectory in political processes, where an event that occurred in previous stages limits the range of possible events in later stages (Tilly, 2006; Trigo, 2015).

According to Sydow *et al*. (2009), the EAPD (Figure 4) illustrates the connection of variables in periods, by segregating determining structural conditions such as linearity and trajectory dependence into a successive temporal chronology (moments identified by differential phenomena in the transition between them). The time sequence denotes a beginning and an end in a constant, successive, and evolutionary way. It provides meaning to the dynamic nature of political, legislative, and social decisions in a cumulative process on a specific roadmap called path dependence. It emerges as a phenomenon of self-reinforcement that leads it to an irreversible state of total inflexibility or confinement (Sydow, 2020).

The *seminal* period is characterized by options with no available range. It generates decisions focused on forming a structure to stabilize situations and events in recognizable and repetitive patterns, through the interdependent actions carried out by multiple actors (Sydow *et al.*, 2020). The ideas that arise are linked to new forms of association. They seek mutual recognition and integration of larger scales to legitimize State actions through the emergence of common dialogs and agreements on diverse issues conducive to the creation of efficient, responsible, and legitimate routines (Sorensen, 2019). The transition of the *seminal* period to one of *preformation* is evident from an action called *confinement*. This occurs at a specific moment motivated by an unpredictable, efficient decision, a precursor of new trends (Monnet, 2020). The options from eras linked by their thematic, ideological, and functional connection contribute to the breadth of the range of action.

The *preformation* period is framed within a defined time span, characterized by a sound range of available options, with a broad field of action. This gives rise to a condition of unpredictability (Sorensen, 2020). The decisions made during this period trigger a self-reinforcing effect that narrows the range of options and stimulates a critical juncture at the end of the period (Trigo, 2015), namely, path dependence emerges. The critical juncture comes from creation factors. The basic reasoning conceives a situation of change based on discontinuities or interruptions of social processes that tend to become founding moments of new institutions and political structures (Sydow *et al*., 2020). In the words of Pierson and Skocpol, it means that "strictly defined path-dependence processes involve a clear logic", regarding the critical juncture results and "unleash feedback mechanisms that reinforce the recurrence of a particular pattern in the future" (2008, p. 13).

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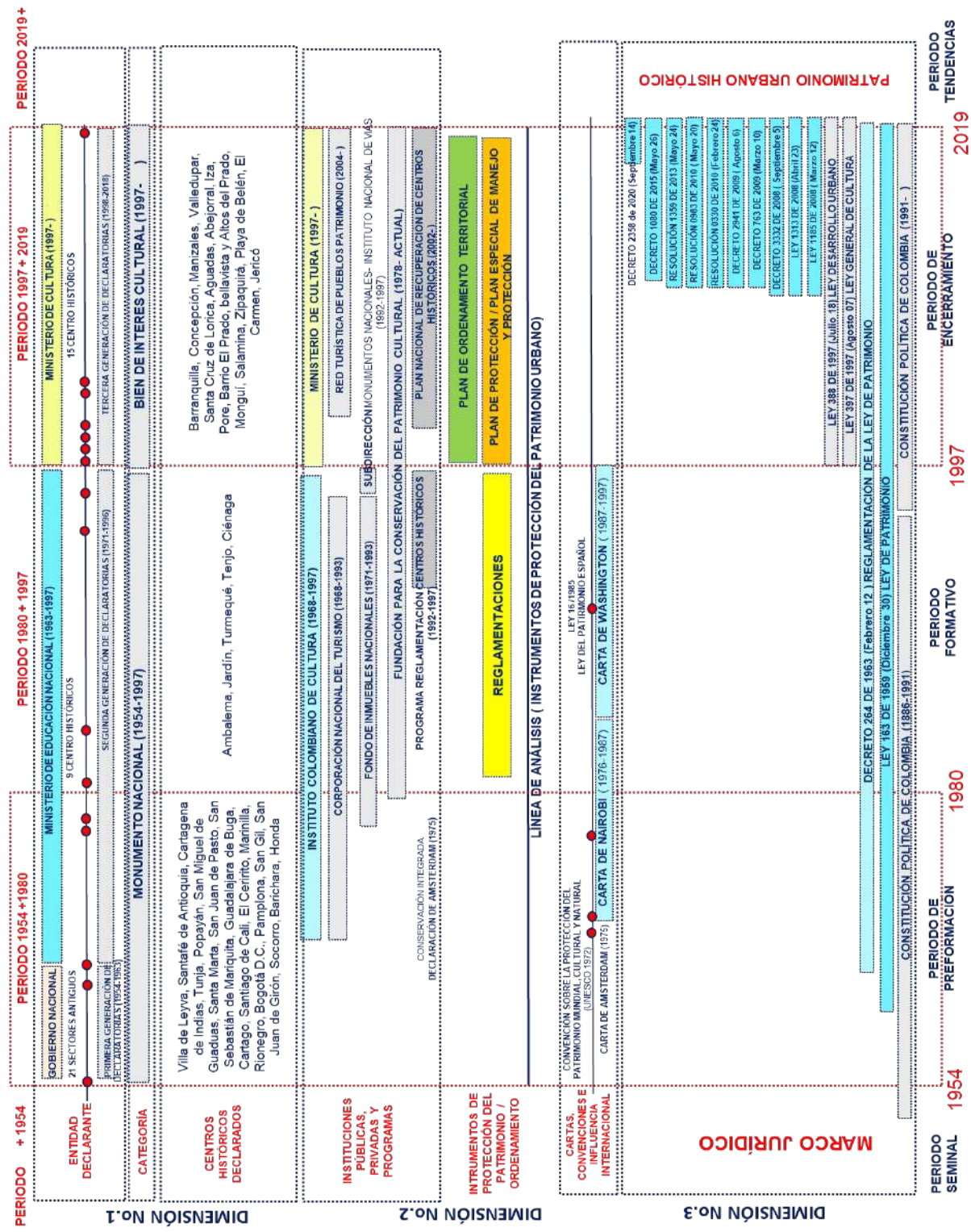

Figure 5. Determining variables in the EAPD and protection policy. Source: Preparation by the author.

Time is the main star of the *formation* phase in two senses: (1) the phenomena that occurred at the beginning of the period apply pressure where the desired result stimulates the transition to another stage through a confinement action; (2) the probability of the emergence of the dominant action pattern becomes increasingly irreversible, the range of options is reduced, and progressively it becomes difficult to reverse the initial action where it appears that the path dependence evolves (Sydow *et al*., 2009). The sum of the actions in the process of transition to the *confinement* period eventually leads to a blockage. The dominant decision pattern takes on a deterministic character, the choice of a particular action is transformed into a predominant mode and loses flexibility, and remains tied to a path, even new participants in this field of action cannot refrain from adopting it in their behavior (Sydow, 2020).

A new critical juncture has an impact as a creative factor for the emergence of discontinuities that originate tendencies to new options, starting from decisions of different levels. They trigger institutional persistence with renewed forms of management, transfer, or decentralization of attributions, conceptual shifts, and changes in regulatory mechanisms, hence, a renewed range of available options enhances the present and future fields of action.

V. RESULTS

The arrangement of determining variables and historical centers in the EAPD facilitates the finding of five periods (Figure 5) in urban heritage legislation. The seminal stage (1918-1954) laid the grounds for the State structure to promote the valuation of the real estate heritage through Law 48 of 1918, by which the forts, sculptures, paintings, and ornaments of the colonial period, pre-Columbian monuments, and public buildings are declared as national historical heritage. The National Directorate of Fine Arts attached to the Ministry of Public Instruction is created and, in addition, the destruction, repair, and ornamentation of property are prohibited without prior authorization (Salazar *et al*.,1989).

The declaration of public property for places of singular beauty, antiquity, and tradition in the mid-twentieth century triggered a sensitivity oriented to safeguarding and encouraged property restoration and interest in the declaration of monuments in different expressions of nationality (Gutiérrez, 2009). During the dictatorship of Rojas Pinilla, the municipality of Villa de Leyva was recognized as a national monument (1954). The agreements derived from the Seventh Pan American Conference (1933) motivated the issuance of Law 163 of 1959 (on the defense and conservation of the historical and artistic heritage and monuments of the nation) behind the creation of the National Monuments Council.

The creation of the Colombian Institute of Culture (Colcultura) in 1968, attached to the Ministry of Education, sought to decentralize the administration of culture, stimulate interest in heritage from academia to promote research, train professionals, and create repositories of cultural interest real estate inventories in the different regions of the country (Salazar and *et al*., 1989; Escovar & Cárdenas, 2018). The promotion of events and scenarios for dialog and ideological exchange around the recent dimension of culture and the adaptation of the concept of cultural heritage are contributions of Colcultura. At the end of the *preformation* period (1954-1980), an old urban sector was regulated (Cali), and the first declaration of a historic center was made in 1980 (Ambalema). 21 old sectors were also declared as such.

The *formative* period (1980-1997) accentuated the urgency of updating heritage-dedicated legislation. Colcultura, with the support of UNESCO, fostered a national dialog between public and private actors on the "Cultural policy for historical centers and immovable heritage" in 1989, the origin of the General Culture Law (1997). With this document as a reference and after restructuring Colcultura in 1990, the Historical Centers Regulation Program emerged (1992-1997). The "Handbook for the regulation of old urban sectors" (1991)**4** provides instructions for structuring conservation from the cultural standard applied to 17 historical centers that pass the formulation, approval, and adoption process. The institutional exhaustion, not only of culture but of the State and society, led to the passing of the Political Constitution in 1991 (Melo, 2020), with a conceptual twist regarding cultural heritage and territorial planning formalized through the issuance of laws 397 and 388 in 1997 — General Culture and Urban Development, respectively.

These laws are the transition between the formative period and the start of the confinement period (1997-2019). The Special Management and Protection Plan (PEMP, in Spanish) and the Territorial Planning Plan (POT, in Spanish) are guarantors for safeguarding cultural heritage and urban development. While the former promotes the conservation and revitalization of the historical center, the latter deals with the remaining urban area and rural areas considering development aspects (municipal-regional) and the search for socio-economic well-being. The formulation, approval, and adoption of the PEMP fall within the National Plan for the Recovery of Historic Centers (PNRCH) created in 2002, with 31 approved plans out of a total of 45. The POT, which is mandatory for municipal entities and cities, reaches 100% and is in its second version.

4 The manual is a product of the City and Historical Centers project promoted by Colcultura and Unesco UNDP (1988-1990).

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The transition of a National Monument to the BIC outlines the linking of isolated legislation to a public policy for the protection of urban heritage after two decades, where Decree 2358 of 2019 represents the critical juncture that opens the door to new trends (Sydow *et al*., 2020) of cultural heritage. The recognition and treatment of cultural landscapes, the updating of the PEMP structure, and the conceptual adoption of Historical Urban Heritage (PUH, in Spanish) confirm the path dependence of heritage under construction. The latter legislation introduces the *trend* period (2019-present), where the PNRCH faces the challenge of finalizing the formulation of the PEMP, assuming the application of the PUH, and integrating it into the institutional routine that is maintained, reproduced, renewed, or transformed on the fundamental features that persist in its existential sequence (Vergara, 2020).

VI. DISCUSSIONS

The emergence of historical centers and protection legislation falls into two periods: (1) pre-formative and (2) formative (1954-1997). In the former, the import of foreign concepts, policies, and referent institutions (designed for other socio-geographical, cultural configurations, and state structures) are the cause of chaos and mismanagement (Granes, 2022) of historical heritage, predominant for 43 years. In the formative period, arise the issues generated by cultural heritage, the reflection from academia, and the contribution of international entities through charters and conventions that intervene in the transition from the National Government (1954-1963) to the Ministry of Education (1963-1997) as a declaring entity and administrator of historical heritage. The problem of these periods lies in the limitations of the Heritage Law, its lack of versatility due to the rigidity of its postulates, the promotion of individual safeguarding of historical heritage, and the absence of safeguarding mechanisms.

The origin behind the need to protect historical centers in the mid-80s emerges from the absence of management techniques and homogeneous mechanisms in the Heritage Law (positioned by international influence and dissemination, especially UNESCO). The procedure for declaring historical centers is freed from colonial heritage (Fonseca, 2019) to justify republican ideas in conceptual and scientific methods closer to a modern country in search of its symbols of identity. This shift in the State vision permeated social structures: the passer-by went from being a passive observer of the national monument to a participatory builder of the BIC within the scope of their territory.

The link between the production of urban heritage and the protection policy emerges from two trends: the first, isolated legislation for historical centers representative of an elitist society of the mid-twentieth century —national monuments - that is transformed by the extenuation and loss of conceptual and operational strength; and the second, a concept of cultural heritage that includes the social collective, recognizes popular manifestations and expressions in different categories for the heterogeneous construction of the nationality (Melo, 2020; Granes, 2022), and introduces citizen participation under a protection policy located in the confinement period (1997-2019); this is consistent with the needs of contemporary management. From positive feedback comes the creation of urban heritage and protection legislation (Melé, 2015).

VII. CONCLUSIONS

The EAPD is an appropriate mechanism for the transdisciplinary analysis of complex scenarios that require the integration of temporal variables of diverse origins. The analysis is not intended to generalize about a single approach to the problem identified, but rather presents a resource that is little used and apt for the case study. The path of urban heritage and the public protection policy in Colombia is governed by five periods.

The protection of urban heritage emerged in the 1990s, due to the debility of Law 163 of 1959. The individual expressions of historical heritage declared as national monuments are transformed into thematic groupings associated with the concept of cultural heritage, comprising material and intangible manifestations recognized as BIC in the territorial scale that recognizes them (national, departmental, and municipal). The public protection policy emerges and begins its construction after 1997, regulating the declaration and protection procedures of the BIC through the PEMP (an instrument that combines the cultural standard -the regulation-, and management from the international charters and methodologies of UNESCO and Icomos).

The path of the protection and urban heritage policy is no more than three decades and is based on two ideas of a nation: (1) the agreements of the Seventh Pan American Conference of 1933, still persistent due to the dependence on the nationalist phenomenon; and (2) the positive feedback between them that validates the concept of *path dependence* due to the importance of the time and sequence patterns within the constitutive relationship of its current structure. This has generated effects of irreversibility in the conservation of the historical centers declared as BIC, its effectiveness being questionable in the face of the state of recently declared historical areas where protection actions registered within early citizen participation and territorial planning are evident.

In conclusion, the conservation of historical centers between 1954 and 2019 has shaped urban heritage and protection mechanisms simultaneously through initially isolated legislation and, in recent decades, through a large volume of

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legal acts dedicated to cultural heritage. The consolidation of a public policy for the protection of urban heritage has not yet been identified, although it is possible to show its existence linked to the idea of defending the historical heritage present in the sense and the notion of the protection of historical centers in the complex contemporary urban dynamics.

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THE URBAN REDENSIFICATION OF MEXICO CITY AND COVID 19[1]

LA REDENSIFICACIÓN URBANA DE LA CIUDAD DE MÉXICO Y EL COVID 19

VICTOR JAVIER NOVOA GUTIÉRREZ 2

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VICTOR JAVIER NOVOA GUTIÉRREZ
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1 Research financed by a Doctoral Scholarship of the National Council on Science and Technology of Mexico (CONACyT).

2 Magíster en Estudios Políticos y Sociales.
Universitat de Barcelona, Barcelona, España.
Estudiante de Doctorado en Sociología en Universitat de Barcelona.
https://orcid.org/0000-0002-3467-7576
ymsocio@hotmail.com

DOI: https://doi.org/10.22320/07183607.2022.25.46.07

Políticas públicas como la redensificación urbana, antes que meras intervenciones técnicas ante problemas concretos, funcionan como mecanismos de poder. Analizar la visibilización de las políticas de vida –biopolítica– y de muerte –necropolítica– en la Ciudad de México derivada de la pandemia del COVID-19, permitirá comprender esta función. Además, dará cuenta de la paradoja de que una misma política, la redensificación, sea un fracaso como política pública y simultáneamente un éxito como política de vida y de muerte. A partir de la sociología y con base en una metodología genealógica, se estudian datos relativos a los efectos de la redensificación urbana y de la pandemia en la Ciudad de México, para entrecruzarlos y reconocer una relación entre ambos. Se presta especial atención al periodo de confinamiento no obligatorio y a dos demarcaciones colindantes de la Ciudad de México: Iztapalapa y Benito Juárez. Se reconoce así una configuración de clase del espacio ligada a la planificación urbana que incidió en las consecuencias localizadas de la pandemia.

Palabras clave: biopolítica, necropolítica, Ciudad de México, Covid-19, redensificación

Public policies such as urban redensification, rather than mere technical interventions addressing concrete problems, work as a power mechanism. Analyzing the visibility of the politics of life - biopolitics - and of death - necropolitics - in Mexico City derived from the COVID-19 pandemic will allow an understanding of this. In addition, it will allow revealing the paradox that the same policy, redensification, is a failure as a public policy and, simultaneously, a success as a policy of life and death. Starting from sociology and based on a genealogical methodology, data on the effects of urban redensification and the pandemic in Mexico City were analyzed, to subsequently intertwine them and recognize a relationship between them. Special attention was paid to the period of non-compulsory confinement and two neighboring districts of Mexico City: Iztapalapa and Benito Juárez. Thus recognizing a class configuration of space linked to urban design that influenced the localized consequences of the pandemic.

Keywords: biopolitics, necropolitics, Mexico City, covid-19, redensification

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I. INTRODUCTION

The relationship between population control and space was evident during the COVID-19 pandemic and was essential for its containment. Consider, for example, the lockdowns and mobility restrictions. However, the pandemic interacted with forms of space-related social control. To recognize them, it is proposed here to pay attention to the effects of urban redensification in Mexico City (CDMX) and those of the pandemic, to make the relationship between them visible.

Population control, alongside practices and behaviors, encompasses life and death. These are the areas of its competence because they generate or maintain certain social functioning. Here, for example, is the management of birth and mortality.

To talk about control is to talk about power. This especially has an impact on life and death through the ways to manage them: *biopolitics* (Foucault, 2000) and *necropolitics* (Mbembe, 2011). Therefore, it is worth asking: in what way are the policies of life – biopolitics– and death –necropolitics– made visible in Mexico City with the COVID-19 pandemic, specifically those related to the urban redensification policy that has been implemented since the start of this century?

To answer this, a comparison of the effects of COVID-19 will be made between two neighboring areas with a similar population density and a dissimilar socioeconomic configuration (Table 3, Table 4, Table 5, Table 6, Table 7, and Table 8) during the "lockdown". It will be noted how the same process, replanning CDMX through redensification, influenced the constitution of biopolitical and necropolitical processes. These sectors are the municipalities of Benito Juárez (BJ) and Iztapalapa (Figure 1). The first is homogeneously populated by middle and upper sectors - a situation related to gentrification linked to urban redensification**3**-; while Iztapalapa has historically been home to the working classes.

Gentrification functions as a power mechanism that acts on the reconstruction of urban areas and influences the location of certain groups in specific spaces. This brought these groups closer to or further away from illness and death.

The objective of this work is to recognize that redensification, by consolidating class spaces, influenced the way the consequences of COVID-19 were spatialized.

II. THEORETICAL FRAMEWORK

Power and urban space

Foucault (2006) identifies three types of power: the sovereign, the discipline, and the security. The sovereign acts on the territory, discipline on the individual, and security on the population. They all have an expression in space. The sovereign, through the law and the ability to implement it in a specific space, the territory. The discipline is of a strict nature and builds under specific guidelines, from which there should be no distance. Any negativity has to be avoided or rectified. Spatially, this translates into building from scratch, in empty or emptied spaces, in a spatial design that involves outlines, aesthetics, relationships, activities, and meanings. There reigns a principle of functional localization, separation, and homogenization that seeks a certain perfection.

The security power does not have that totalizing and homogeneous longing. It accepts negativities as long as they are reduced to a minimum and the positive is potentialized (Foucault, 2006, p. 39). It does not correct specific acts, and negativities are treated by handling the *probability* of occurrence. In the face of the restrictive, localizing, and homogeneous nature of the discipline, it highlights mobility and polyfunctionality, including negativities.

In the words of Foucault:

> What is a good street? A street is one in which there is [...] circulation [...] diseases, [...]. Merchandise will be taken down the street, in which there will also be shops. Thieves and possibly rioters will also be able to move down the street. Therefore, all these different functions of the town, some positive and others negative, will have to be built into the plan. (2006, p. 39)

The power mechanisms are not replaced, they converge at the same time. What varies is what prevails.

Biopolitics and Necropolitics

Linked to security, is *biopolitics*. It acts through population control, in the form of a non-individualized human species crossed by the biological (Foucault, 2000). It is attentive to birth, morbidity, old age, and the effects of the environment (including the city). It is a set of techniques, abilities, and practices - a technology - related to medicine and statistics.

The associated diseases and deaths are endemic, not epidemic in nature: "illness as phenomena affecting a

3 On the gentrification-redensification relationship in Mexico City, see Aguayo (2015), Novoa (2016), Delgadillo (2016), Masato (2017), and Gómez (2018).

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population. Death was no longer something that suddenly swooped down on life- as in an epidemic. Death was now something permanent, something that slips in life, […] diminishes and weakens it (Foucault, 2000, p. 221).

In the sovereign, life is also present, note its maxim, "to make live and let die". To let die is not restricted to murder, it includes "every indirect form of murder: the fact of exposing someone to death, increasing the risk of death for some people, or, quite simply, political death, expulsion, rejection, and so on." (Foucault, 2000, p. 232). Biopolitics reverses that "to make live and let die" maxim.

Mbembe (2011), on the other hand, notes that biopolitics is insufficient to explain "the contemporary forms of subjugation of life to the power of death" (p. 75) and proposes *necropolitics*. It is not the biological management of life, but a power of death over specific groups that revitalizes the sovereign. Space, in this context, is useful for physical and geographical control, just as can be taken from his concept of "territorialization":

> it is a matter of writing on the ground a new set of social and spatial relations. [...] ("territorialization") produced boundaries and hierarchies, zones and enclaves; the classification of people according to different categories; resource extraction; and, finally, the manufacturing of a large reservoir of cultural imaginaries. (Mbembe, 2011, p. 43)

Mbembe categorizes space as "the raw material of sovereignty and the violence it carried with it" (2011, p. 43), conceptualizing the former as "the ability to define who is important and who is not, who is devoid of value and can be easily substituted and who is not" (p. 46).

Although this author connects territorialization with sovereignty, these processes are also visible in scenarios where security prevails with discipline. An example of this is gentrification which redraws borders from inscriptions of new relationships from the reconfiguration of urban space.

Gržinić (cit. in Estévez, 2018) emphasizes that biopolitics is reserved for the first world, and in the second and third, necropolitics echoes. In the first, "lifestyles" are built, in the others, "death is administered". These geographical specificities do not just distinguish countries. Now big cities, within the framework of globalization, can contain the great distances, conflicts, and contradictions that used to differentiate countries (Augé, 2007). The same space, the same city, can contain biopolitical and necropolitical processes. For example, when Mbembe, referring to Gilroy, reflects on the slave plantations where their "inhabitants live non-synchronously" (2011, p. 32). Without equating slavery on a plantation with urban inequality, it is possible to say that in today's large cities, their inhabitants can live non-synchronously.

Gentrification

"Gentrification" encompasses a diverse number of situations where there is urban segregation. It is clarified that it will regain and problematize, its "classic" meaning, "a bourgeoisification by substitution of the residents of a given urban sector" (Díaz Parra, 2015, p. 14). Generally linked to the compactness and supposed land grabbing and housing of European cities, Latin American gentrification occurs in low and middle-income sectors, and owners of the homes they occupy (Valadez & Sabatini, 2017). Thus, displacements are no longer inevitable (Sabatini, Sarella & Vásquez, 2009) (Valadez & Sabatini, 2017). Gentrification not only displaces; it also acts as a homogenizing filter by establishing who inhabits a space.

Gentrification is a construction of space made possible from its material and symbolic transformation, which entails a change of practices, relationships, meanings, and, even, architecture. It distinguishes an exercise of power and the imposition of a life project. It is more notorious if it occurs from interventions in the space with planning policies. In this way, this life project is civilizing. It has even been defined as "neighborhood-scale colonialism" (Clark, 2005, p. 266).

Urban redensification

Redensification is an urban planning policy that seeks to concentrate the population in certain areas. It is linked to smart development and is commonly accompanied by verticalization, mixing land uses, renovation, and urban recycling. Its "technical" *raison d'être* is efficient management of space to take advantage of areas with underutilized potential.

The redensification discussed here is related to sustainability, liberal democracy, and the Global City. Hence, it is located in a concrete historical framework where the nation-state has reformulated its link with capitalism, and a service economy is consolidated - where the financial and the information dominate.

In this historical framework, city design will not only be an expression of the values of democracy, tertiary capitalism, and globalization but a way of achieving and consolidating them - as can be seen in HABITAT II (United Nations [UN], 1996)-: a better, fairer, and ecological world from the city building. Within this model, redensification, under

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the concept of sustainability, will be paramount (UN, 1996), and it will be an adjuvant in the building of the relationships and practices desired for the large cities of the 21st century.

Nevertheless, it is linked to gentrification. Densification is linked to an increase in land rents (Jaramillo, 2008, p. 191), which, in turn, occurs with real estate speculation and socio-spatial segregation (Trivelli, 1982; Rodríguez, 2014; Encinas, Truffello, Aguirre & Hidalgo, 2019).

III. CASE STUDY.

Urban redensification in Mexico City

Although there have been previous redensifying experiences in Mexico City, the one since 2000, when the institutionalization of the Global City model took place in CDMX, will be addressed (Novoa, 2018). It went from a model focused on small and medium-sized cities to seeking to establish internationally competitive tertiary cities (Presidency of the Republic [PR], 2001). In the goal of forming a global city, urban planning was an essential third party. If building a space is to generate guidelines for relationships, meanings, and acts, it is possible to see the reason behind this. Jobs, companies, production, and forms of consumption linked to a globalized and tertiary city were made possible. Under the banner of sustainability and through redensification, this planning took on particular architectural expressions, while gentrification came hand in hand. In the map of Figure 2, the concentration of light, medium, and advanced gentrification and unchanged areas can be noted in BJ, while in Iztapalapa, areas of decline dominate **4**, and some with light gentrification.

CDMX is divided into 16 areas, but look at 13 of them, 9 with conservation land**5**, and 4 considered central. The latter had population decline trends, adequate infrastructure, and underutilized spaces. Redensification was located there for population concentration and protection of conservation land.

The focus on BJ and Iztapalapa is justified by their proximity, socioeconomic disparity, and high population density; a point of special interest for the pandemic. If the population concentration was conducive to infection, then high population densities were problematic. Contrasting both will reveal that population density was

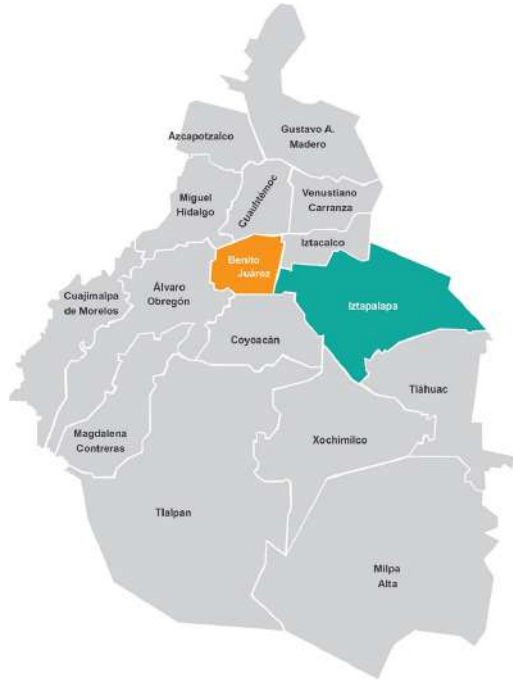

Figure 1. Map of CDMX. Source: Preparation by the author.

only an inconvenience when compared with other factors. When doing so, this is not an attempt to draw a linearity on the relocation of people displaced from BJ in Iztapalapa, but to recognize how the construction of the space was part of the class consolidation in both localities.

IV. METHODOLOGY

This paper is a genealogical analysis of interwoven data related to the urban redensification of CDMX and the effects the COVID-19 pandemic had on that city. It is an interpretative exercise based on the analysis of figures and documentary review. Genealogy seeks to rebuild the possibility conditions of an event by exalting its historical singularity, breaking historical linearities, denying original causes, and simple cause-effect causal linearities (Foucault, 2004). It tries to recognize redensification as a possible condition of the concrete spatialization of the pandemic consequences in CDMX as a

4 Decline refers to the opposite of gentrification, the population change towards groups of lower socioeconomic status (Bournazou, 2015)

5 Conservation land is for recharging aquifers; as a barrier against particles, caused by pollution, hoppers, and fires; CO2 capture and soil stability (Environmental and Territorial Planning Office [PAOT], no date).

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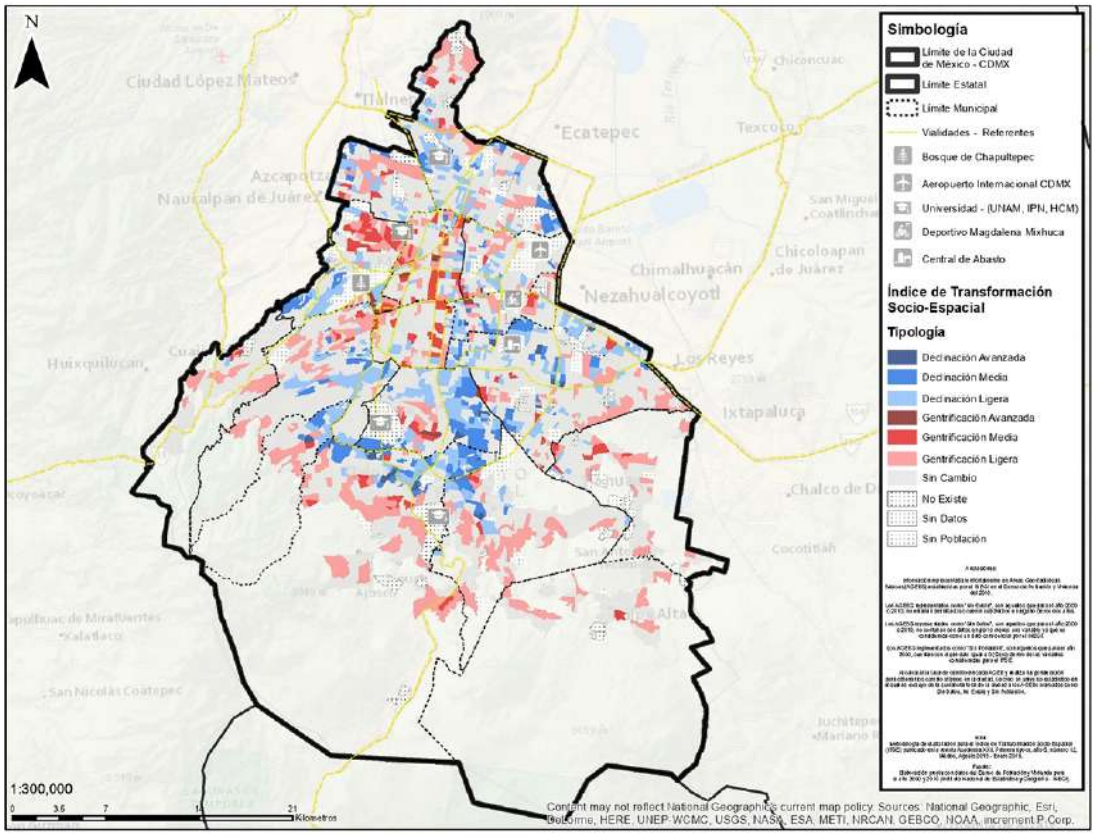

Figure 2. Map of gentrification and decline in CDMX, ITSEa (2000-2010). Source: Bournazou (2015), cited in Valadez and Sabatini (2017). a Socio-spatial Transformation Index.

central element of Mexico City's replanning with gentrifying effects.

Regarding redensification, data from development programs and the National Institute of Geography and Statistics [INEGI] are contrasted. As for the pandemic, the source was the Ministry of Health of the Mexican Government and data from the National Council of Science and Technology [CONACyT].

The data were used for a comparative exercise. In the case of redensification, a comparison was made between the alternative redensification plan of the Federal District within its General Urban Development Program (PGDUDF) (Gobierno del Distrito Federal [GDF], 2003) and the population censuses of 2000, 2005, 2010, 2015, and 2020 (INEGI). To analyze the effects of the pandemic on the city, Mexican government data were used, contrasting municipal data on cases and deaths in Benito Juárez and Iztapalapa. The work covers the period from the end of the "National Healthy Distance Day" (JNSD, in Spanish), at the end of May, to September 2020. This limit is due to the need to include the lockdown and mobility as variables.

V. RESULTS

The redensifying failure

In 10 years, 1,151 hectares of conservation land were lost[6]. Of the 9 areas with conservation land, 7 exceeded the desired growth (INEGI, 2020). The differences varied by area. In some cases, the difference is apparently insignificant, although observing the year when the registered population would have appeared in the planned scenario, such an assessment is false (Table 1).

6 This is the result of contrasting the number of hectares reported in the General Development Program of the Federal District 2013-2018 (GDF, 2013) and the PGDUDF of 2003.

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	INEGI	E.P.	Difference %	Year.*
Á. Obregón	759,137	723,749	4.89	2068
Cuajimalpa	217,686	172,819	25.96	2164
Magdalena Contreras	247,622	240,213	3.08	2050
Milpa Alta	152,685	116,786	30.74	2147
Tláhuac	392,313	357,878	9.62	2937
Tlalpan	699,928	631,059	10.91	2123
Xochimilco	442,178	417,883	5.81	2114

Table 1. Percentage difference between the planned scenario and population census of municipalities with conservation land in 2020 and their year in the planned scenario.TSource: Preparation by the author using data from the PGDUDF (2003) and the 2020 Census (INEGI).
* Year of the census population considering the planned scenario. Namely, the year when the population registered by the INEGI in 2020 would have been presented considering the GDF's planned scenario (2003). These data were obtained by making a projection that takes the population indicated for 2025 and the growth rate for each area in the PGDUDF planned scenario as a starting point (GDF, 2003).
The years when the population registered in 2020 are far off the target is because, in wanting to avoid population growth there, almost zero growth rates were expected. For example, the case of Tláhuac with a growth rate of 0.01% (GDF, 2003).

Entity	INEGI	E.P.	Difference %	Year.*
Federal District	9,209,944	9,199,857	0.11	2020
Benito Juárez	434,153	383,620	13.17	2066
Cuauhtémoc	545,883	560,190	-2.55	2012
Miguel Hidalgo	414,470	388,828	6.59	2041
Venustiano Carranza	443,704	480,780	-7.71	Not applicable

Table 2. Percentage difference between the planned scenario and the population census of central municipalities of 2020 and their location in this scenario. Source: Preparation by the author with data from PGDUDF (2003) and INEGI (2020).

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Of the four areas to be redensified, Venustiano Carranza kept a constant population decrease until 2015, changing the trend to 2020. Even so, there are fewer inhabitants than reported in 2000. Cuauhtémoc has maintained constant growth, although far from the planned one. Its population in 2020 was 545,883 inhab., the amount forecast for 2012 (GDF, 2003)[7] (Table 2).

Miguel Hidalgo and BJ considerably exceeded the forecasts. MH registered, in 2010, 372,889 inhabitants, but it was just short of reaching the forecast of 377,431. By 2015, with 364,439 (INEGI, 2015), it reduced its population below what would have been expected in 2006. From 2015 to 2020 it grew enormously, reaching 414,470 inhabitants, which was expected for 2041[8](Table 2).

BJ currently has 434,153 inhabitants, the expected population for 2066[9]. This data should not be surprising, as it maintains the trend already evident in 2010. At that time, the population counted -385,439 – was the one expected for 2022. It should be noted that 388,898 inhabitants were expected by 2025 (GDF, 2003) (Table 2).

All of this should be observed taking into account that the general growth of CDMX to 2020 was 0.1% above the planned scenario (Table 2).

7 Considering a growth of 0.32% (GDF, 2003), a population of 545,823 was expected for 2012.

8 Considering a growth of 0.3% (GDF, 2003), for 2020-2025 and the municipality of Miguel Hidalgo (this data was used because it was the last period indicated in the planned scenario), a population of 414,031 was expected in 2041.

9 Considering a growth of 0.27% (GDF, 2003), for 2020-2025 and the municipality of Benito Juárez (this data was used because it was the last period indicated in the planned scenario), the population closest to that reported in 2020 would have been expected in 2066, with 434,357.

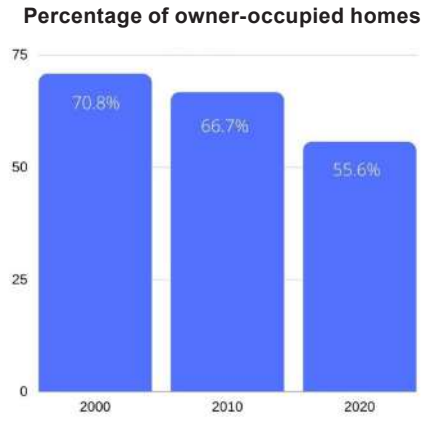

Figure 3. Percentage of homes inhabited by owners between 2000-2020, in CDMX. Source: Preparation by the author using data from INEGI (2000, 2010, 2020).

In addition, this period saw the number of homes inhabited by their owners decrease by 15% (INEGI, 2000, 2010, 2020) (Figure 3).

Recognizing the relationship between densification and the rise in land rent, it is understood that the places affected by these dynamics become attractive for "investment". Thus, BJ is the first place to offer residential apartments for rent -at between 15 and 30 thousand Mexican pesos - and residential housing -at between 30 and 80 thousand pesos-, in CDMX. BJ also comes top in the percentage of residential real estate supply, contributing 18% of the total in CDMX. Iztapalapa is in first place in the offer of economic/social housing for rent – up to 5 thousand pesos - and, with 5% of the general offer of CDMX, it is tied with Cuajimalpa, behind 7 other municipalities (Lamudi, 2019).

Spatialization of life and death in Mexico City during lockdown

In the Municipal Human Development Report 2010-2015 of the United Nations (UN) (United Nations Development Program [PNUD], 2019), a high Human Development Index (HDI)**10** was reported in the municipality of BJ. It also pointed out that, although CDMX improved its living standards, inequality remained (UNDP, 2019, p. 194); inequality that would be a factor in the exposure to death during the pandemic.

The ravages of the pandemic were focalized on specific bodies and marked by that inequality. At the end of May 2020, in Mexico, 71% of those killed by COVID-19 had primary schooling or less; while the population that did not have a job – was unpaid, unemployed, housewives, retirees, and pensioners - comprised 46% of the deaths (Hernández, 2020). Precariousness is thus confirmed as a facilitator of death.

Lockdown in Mexico was neither mandatory nor punishable. The reason was not wanting to punish people for their socioeconomic status, given that a large part of the population lives "day-to-day" and going out is necessary for their livelihood. Staying at home was a privilege.

At the national level, BJ was the best-rated municipality in restricting mobility by staying at home, reducing its mobility by 75% (PR, 2020). Iztapalapa, during the same week, reduced it by 35% (Quintero, 2020).

The lockdown policy in Mexico can be thought of in two stages: the JNSD and the restriction of mobility and activities under the Risk Traffic Light system. The JNSD was in place from March 23rd to May 30th. It highlights the suspension of productive, work, and school activities. From May 30th, a population management policy and activities using a traffic light system were established. Red indicated a maximum risk – practically the continuity of JNSD–; orange, a high risk; yellow, medium; and green, low. Each color implied the opening of a greater number of activities.

The differences between BJ and Iztapalapa are shown in Tables 3 to 8.

Concept	Benito Juárez		Iztapalapa	
Population 2020[1]	434,153		1,835,486	
Area km2	26.63		116,7	
Population density2	16,303 inhab x km^2		15,728 inhab x km^2	
HDI 3	2010	2015	2010	2015
	0.929	0.944	0.792	0.813

Table 3. General comparison between Benito Juárez and Iztapalapa
[1] INEGI (2020).
[2] Prepared by the author using local government data (GDF, 2008), Delegación BJ (DBJ, 2016), and INEGI (2020).
[3] Municipal Human Development Report 2010-2015. Transforming Mexico from the local (UNDP, 2019).

10 "The Human Development Index (HDI) is a composite measure that summarizes the achievements of countries, states, municipalities, or individuals in three basic dimensions of human development: a long and healthy life, access to knowledge, and a decent standard of living. [...] The Municipal Human Development Index is the same as the geometric mean of its three components: HDI = (Education Index* Income Index * Health Index)" (UNDP, 2019, pp. 314-320).

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Percentage of the population aged 15 and over	Benito Juárez	Iztapalapa
Elementary School	11.8%	43.5%
High School	18.2%	30%
Higher Education	69.3%	23.4%
No schooling	0.5%	2.5%
Not specified	0.2%	0.1%

Table 4. Comparison of schooling in Benito Juárez and Iztapalapa 2020. Source: INEGI (2020).

Municipality	Economically active population	Economically inactive population
Benito Juárez	70.4%	29.4%
Iztapalapa	63.5%	36.3%

Table 5. Comparison of economically active and inactive population. Source: INEGI (2020).

	Benito Juárez	Iztapalapa
Population affiliated with health services	79.8%	67.5%
Population eligible for the Popular Insurance	3.4%	24.4%
Population eligible for PEMEX, SDN, or SM1	0.9%	1.3%
Population eligible for ISSSTE2	17.6%	16.2%
Population eligible for IMSS3	65.5%	55.1%
Population affiliated with private insurance	20.5%	2.0%
Population affiliated with another institution	1.1%	1.9%
Beneficiary in Welfare Health Institute	0.3%	0.3%

Table 6. Social security comparison between the municipalities of Benito Juárez and Iztapalapa. Source: INEGI (2020).
[1]Mexican Petroleum Company, Secretary of the Defense or Secretary of the Navy.
[2]Institute of Security and Social Services of State Workers.
[3]Mexican Institute of Social Security.

	Cases per 100,000 population				
	End of JNSD1	End of red traffic light2	1st month with orange3	2nd month with orange4	3rd month with orange5
Benito Juárez	281	485.5	645.4	880.1	1,109.9
Iztapalapa	309.6	495.1	675.2	833.1	1,006.8
Difference %	10.2%	8%	4.60%	-5.3	-9.3

Table 7. Comparison of COVID cases in the municipalities of Benito Juárez and Iztapalapa. Source: Preparation by the author with data from the General Directorate of Epidemiology [DGE] (2020).
[1] To 05-30-2020.
[2] To 06-30-2020.
[3] To 07-30-2020.
[4] To 08-30-2020.
[5] To 09-30-2020.

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	Deaths per 100,000 population				
	End of JNSD1	End of red traffic light2	1st month with orange3	2nd month with orange4	3rd month with orange5
Benito Juárez	30.4	47.9	57.9	68.2	78.5
Iztapalapa	48.4	70.1	84.1	94.7	104,65
Difference %	59%	48.5%	45.1%	38.8%	33.2%

Table 8. Comparison of COVID deaths in the municipalities of Benito Juárez and Iztapalapa. Source: Preparation by the author with data from the DGE (2020).
[1] To 05-30-2020.
[2] To 06-30-2020.
[3] To 07-30-2020.
[4] To 08-30-2020.
[5] To 09-30-2020.

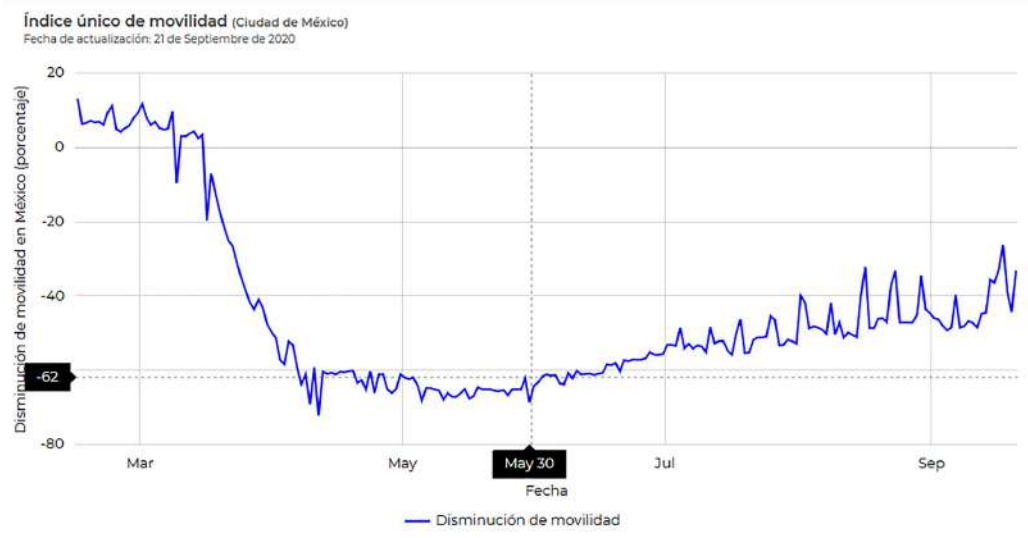

Figure 4. Mobility in Mexico City between March and September 2020. Source: CONACyT (2020).

The evident inequality in the identified items stands out here because of their relationship with COVID-19-related death: precariousness and educational level.

Iztapalapa, at the end of the JNSD (May 31st), had 10% more cases and 58% more deaths per 100,000 inhabitants than BJ. The figures show a disparity regarding death and illness. These differences decrease over time due to increased mobility. Although the red traffic light was the continuation of the JNSD restrictions, one day after the end of the latter the increase was noticeable (Secretaria de Salud, 2020) (Figure 4).

When the strictness of the lockdowns was relaxed, the class situation ceased to be a differentiating variable. Mobility led inequality-linked factors, such as education, poverty, and work precariousness, to become less relevant. In cases per 100 thousand inhabitants, the trend was reversed. BJ overtook Iztapalapa. In deaths per 100 thousand inhabitants, a considerable reduction was recorded. However, the difference continued to be evident. One of the elements that can explain this is the difference in access to health and its implications (Table 6), especially if it is considered that the proportion of comorbidities was similar in both areas (DGE, 2020).

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VI. DISCUSSION

The redensifying failure is not a disparity between figures, but rather a discrepancy between means and ends. The expectation that city building under the principles of sustainability and with the technical force of redensification would bring populationally diverse spaces and avoid the expansion of the urban sprawl, was denied.

The over-densification and the decrease in housing owner-occupiers may be indicators of the format of a scenario similar to that of the compact and supposedly more controlled European city, which may mean in the future that displacement processes around gentrification will be more notorious and commonplace. It could be argued that before suggesting gentrification without displacement, the existence of different times for this to occur should be considered. Gentrification may be building a scenario that will later link it to indirect population expulsions.

Just as redensification is a failure, redrawing social boundaries is also a biopolitical success. Returning to Gržinić (cit. in Estévez, 2018), thanks to the way of urbanizing, lifestyles are consolidated. This is clear in BJ. Its high HDI caused a stir: its similarity to Switzerland was broadcast on different media outlets (Aquino, 2019). The report's coordinator commented: "Human development implies broadening people's opportunities so that they have greater freedom to do and live according to their desires" (Blanco, 2019). Well-being is no longer seen as a pillar for building lifestyles. The quality of life in this municipality is something that the authorities of the area had already boasted: "If [...] Benito Juárez were a country, it would have the twelfth best standard living in the world, on a par with the United States" (Delegación Benito Juárez [D.B.J.], 2009, pp. 13-14). Despite the gloating, it should be noted that living conditions do not come from an improvement intervention; they are linked to processes of locating social groups that already have these conditions and shielding the space against those who do not. The discipline nature of gentrification is notorious. It spatially locates specific relationships in the urban plan.

This ghetto form of privilege exists because of its counterpart, as the other side of a coin. If there was not an opposite of privilege, it would not exist. Not in conceptual terms, much less material. Residential segregation related to land rent is formed, which affects the reproduction of living conditions. Land rent is key: "The rich do not segregate themselves from the poor; the rich segregate the poor. They do it [...] through land rent, for example, [...] to make their status visible by promoting and maintaining the social homogeneity of their neighborhoods" (Rodríguez, 2014) or, indirectly, through redensification. This reflects how the appreciation and depreciation of areas occur in a joint process. The segregated and the segregator, which is not necessarily intentionally so, are paradoxically united by distance.

The reproduction of living conditions restricts or exponentializes the means of interacting with reality. During the pandemic, this was evident.

VII. CONCLUSIONS

The disease not only affected bodies with certain conditions, but was also located in spaces marked by inequality, one particularly related to city re-planning.

Policies such as redensification are exposed as security territorialization processes. Not by inscribing new spatial relationships, but by homogenizing them. Not producing "demarcation lines", but, more along the lines of Augé (2007), redrawing and reinforcing boundaries. The inequality between BJ and Iztapalapa was not established with the implementation of Mexico City's urban redevelopment, but rather was a pillar for its consolidation. A biopolitical or necropolitical pillar, depending on the space.

Just as the mechanisms of power are not replaced, biopolitics and necropolitics are not opposites in a hyperconnected and related world. They are configured under the same events but located in different spaces. Their relationship allows the protective lifestyles to affect others that they push toward death. The location of groups with well-being-related conditions in certain spaces, at the same time, locates elsewhere those who do not have them. In the city, during the pandemic, this made visible that the spatialization of death is linked to the spatialization of well-being.

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URBAN ECONOMY CIRCUITS AND LATIN AMERICAN TERRITORIAL-HERITAGE[1]

XOCHIMILCO MARKET, MEXICO CITY

CIRCUITOS DE LA ECONOMÍA URBANA Y PATRIMONIO-TERRITORIAL LATINOAMERIANO
MERCADO DE XOCHIMILCO, CIUDAD DE MÉXICO

EVERALDO BASTISTA DA COSTA 2
DANIEL RODRÍGUEZ-VENTURA 3
ILIA ALVARADO-SIZZO 4

1 Research developed within the framework of the project “Markets and Street Markets, uses of Latin American territorial-heritage and territory in Mexico” (DGAPA-PREI-UNAM), and the project, “Lower circuit of the urban economy and territorial-heritage in Latin American markets (CNPq-Brazil-2023-PQ2)

2 Doctor en Geografía Humana
Universidade de Brasília, Brasilia, Brasil.
Profesor Asociado, Departamento de Geografía - Investigador del Consejo Nacional de Dessarrollo Científico y Tecnológico de Brasil (CNPq-PQ2-2023)
https://orcid.org/0000-0003-0734-6680
everaldocosta@unb.br

3 Magíster en Geografía Humana
Universidad Nacional Autónoma de México, Ciudad de México, México.
Profesor de Asignatura Ordinario Nivel “A”, Colegio de Desarrollo y Gestión Interculturales, Facultad de Filosofía y Letras - Candidato a doctor por el Posgrado en Geografía de la UNAM
https://orcid.org/0000-0002-1488-2740
danielrv.geo@hotmail.com

4 Doctora en Geografía Humana
Universidad Nacional Autónoma de México, Ciudad de México, México.
Investigadora Titular, Instituto de Geografía
https://orcid.org/0000-0001-9479-9973
ialvarado@geografia.unam.mx

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Los mercados tradicionales en las metrópolis latinoamericanas pueden mitigar riesgos derivados de la urbanización y la comercialización en sitios históricos y pactar las interacciones campo-ciudad y ancestralidad-contemporaneidad. Considerando que el Mercado Xochimilco (Ciudad de México) genera fuerzas centrípetas y centrífugas activadoras de la economía local (formal e informal), el objetivo del artículo es analizar la indisolubilidad de sus espacios de comercio interior y exterior aledaño (zonas de productores, de chinampas y ambulantaje), constitutivos de un territorio de abasto, labor y supervivencia de la población empobrecida. Se adopta un diseño metodológico mixto, con observación participante, entrevistas semiestructuradas, codificación y análisis espacial cualitativo. El concepto decolonial "patrimonio-territorial" y la teoría de los "circuitos de la economía urbana" aplicada al Sur Global permiten comprobar las experiencias socioespaciales y permanencias que, desde el mercado, han mantenido sujetos y familias, en un escenario de modernización selectiva de los territorios metropolitanos y aumento de la informalidad en el continente.

Palabras clave: circuito inferior de la economía urbana, mercado tradicional, informalidad, abasto, patrimonio-territorial.

Traditional markets in Latin American metropolises may mitigate the risks of urbanization-commercialization in historical sites and mediate rural-city and ancestral-contemporary interactions. Considering that the Xochimilco Market (Mexico City) generates centripetal-centrifugal forces which activate the local economy (formal and informal), the goal of the article is to analyze the indissolubility of its neighboring internal and external trade spaces (producer zones, informal trade, chinampas), creating a territory of supply, labor, and subsistence of the impoverished population. A mixed methodological design is adopted, with participant observation, semi-structured interviews, and qualitative spatial analysis. The decolonial concept of " territorial-heritage" and the theory of "circuits of urban economy" applied to the Global South helps verify the socio-spatial experiences and permanence that, from the market, subjects and families have maintained, in a scenario of selective modernization of metropolitan territories and growth of informality onto the continent.

Keywords: lower circuit of the urban economy, traditional market, informality, supply, territorial-heritage

I. INTRODUCTION

Recent studies have explained the problems of obsolescence and the decline of traditional Latin American markets (Zazo & López, 2018), with their commercial gentrification (Salinas & Gómez, 2021; Lacarrieu, 2016), and the change of urban land use in their immediate surroundings (Briones, J. Heras & V. Heras, 2021; Costa, 2018). Likewise, there have been critical approaches to the political-technical content of unequal and selective territorial modernization (Santos, 2000) that impacts the continent's markets (Ávila, 2019; Delgadillo, 2016).

For Costa (2018), traditional markets mitigate risks[5] of urbanization and commercialization in historical sites and agree upon countryside-city and ancestry-contemporaneity interactions in Latin American metropolises. Markets, although they are artifacts of colonialism and face an economic-cultural resignification, they have the social and cultural capital to favor the reconstruction of histories, concepts, and epistemes (silenced by an exclusivist Eurocentric vision and representation of universality, culture, and heritage [Hira, 2016; Shlossberg, 2018; Alvarado-Sizzo, 2021; Costa, 2021]), since they conserve products, knowledge, and deeds of subjects whose links are reproduced in their daily work and community. Everyday life under pressure, where the market is still home to products from native communities, for example, the Amazonian *Shuar* from Ecuador (Paños, 2020), Zapotecs in Oaxaca (Molina & Campos, 2017), and Mapuche in Temuco (Iturriaga, Rojo & Escalona, 2020).

The Xochimilco market, in the south of Mexico City (CDMX) –a heritage pre-Hispanic site of production and supply, and currently one of the most touristic areas of the capital (through new uses of the jetties, canals, and indigenous chinampas)-, is a continental example of a commercial establishment for survival and working-class cultural expressions. As integrating city equipment, it generates centripetal and centrifugal forces that activate the (formal and informal) local economy, and establish spatial links with the chinampas, the two producer zones (consolidated for/by Chinampa farmers), and street vending, paradoxically, in a detrimental urbanizing process for the lacustrine ecosystem and chinampa agriculture (Costa & Alvarado-Sizzo, 2019) that intensifies inequality and population impoverishment. These conflicts justify the choice of this market for the study presented here.

This research, with a mixed methodological design, participant observation, semi-structured interviews, coding, and qualitative spatial analysis, reviews the indissolubility of the internal and external trading spaces alongside the Xochimilco market, considering (i) its role as a place of supply, work, and survival of the impoverished population; (ii) the subjects and families that, formally or informally use the territory, through it; and (iii) the identifying (and ancestral) products still sold, which prove the pressured relationship of merchants and producers with the local life and work, even the chinampa area. Thus, the concept of "territorial-heritage" with a Latin American decolonial approach (Costa, 2016; 2017; 2018; 2021)[6], and the theory of the "circuits of the urban economy" applied to the countries of the south (Santos, 2018, 2000; Silveira, 2020), is adopted. Together, they explain the different socio-spatial experiences and permanences that, partially, sustain the market's role of working-class supply and survival, in a scenario of unequal and selective modernization of metropolitan territories and an increase of urban informality in Latin America.

II. THEORETICAL FRAMEWORK

The 'circuits of the urban economy' theory applied to the countries of the south

Milton Santos (2018) proposed the "circuits of the urban economy theory" on understanding that modernization forces are extremely selective, their technical variables are not received equally in time or intensity in each place, the territory is multi-polarized by the different levels of decision, the Global South maintains deep regional and local income inequalities (and individual consumption), and that the behavior of the territory is related to these geographical, individual situation, and spatial selectivity disparities.

"The city cannot be studied as a solid machine (...) We understand two subsystems, the upper or modern circuit, and the lower circuit" (Santos, 2018, p. 22), which work dialectically, constituting the urban system. The first

5 According to Costa, risk is a probable threat to the human dimension and the world, where the term projects and warns about the future of people and geographical objects, located, as is the case of heritage (and traditional markets); "it defines the coming social-natural tensions that can worsen a destructive event. The consummation of a threat announced as a risk, links a series of spatial policies and economies with the narratives of life, death, production, and technological consumption" (2018, p. 3).

6 In Ortega (1998) and Orozco (2020), the territorial-heritage debate (unscripted) is a systemic-monumental-European episteme that induces tourism intensification. In Costa (2016, 2017, 2018, 2021), the script refers to the existential connection between the subalternized-situated subject and the territory, as a vital and current link of ancestral socio-spatial experiences from the South.

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		Accumulation	Work	Techniques/ Technologies	Territorial logic	Employment/Salary
Upper Circuit	pure	of capital	formal links/production cost	intensive use/ state-of-the-art technology	territorial fluidity/ verticality	reduced- qualified/ dominant
	marginal	of capital	formal links/super-exploitation of labor/ production cost	intensive use/obsolete technology; used equipment	knowledge of the place/use of local advantages	reduced- professionalized/ dominant
Lower circuit		population survival and social inequality	intensive use/ unstable and informal relationships	residual use of techniques and technologies	strong local ties, horizontal territorial relations	bulk-low qualification/ not mandatory

Table 1. Circuits of the urban economy. Source: Santos (2018), Silveira (2020), and Boscariol (2020).

derives from technological modernization and vertical extraterritorial relations, and the second, from horizontal small-scale activities, focusing on the locally rooted impoverished population, as established by the markets. Each circuit has internal differences and interconnections.

According to Silveira (2020), current territorial modernizations (based on technoscience, information, and finance, capitalized on business centers, globalized markets, and modern sectors of metropolis and territories) coexist with subordinate dependent activities, involved with a diversity of means of survival and low technological capital labor divisions, susceptible to the hegemonic economy. For this reason, the two circuits constitute the unity of the urban phenomenon (Table 1), have autonomy of meaning, are interdependent, and result from the successive territorial modernizations associated with deep income inequality in Latin America. Thus, "When the degrees of technology, capital, and organization are high, we recognize an upper circuit, including its marginal portion, and, when they are low, we identify a lower circuit" (Silveira, 2020, p. 481).

This theory, in the perennial misery and impoverishment of Latin American countries, shows the importance of traditional markets for the working classes. In 2020, 51% of the continent's population worked in the informal sector. In Bogotá, Uruguay, Montevideo, and Mexico City [CDMX], between 40 and 45% of people of working age were unemployed (a situation aggravated by the Covid-19 pandemic), and 28% of the Mexican population was below the poverty line (ECLAC, 2022). CDMX has profound income differences, and most of the population works in intensive services as low-skilled labor. It also expands and diversifies territorial uses (some with pre-Hispanic roots) through the lower circuit. For all this, it is relevant to identify the territorial-heritage that survives in the city.

Latin American territorial-heritage in the lower circuit of the urban economy

When Descartes defined the "universal" as eternal knowledge, substituting the "Christian God" for the "I" and disassociating the subject of a body, territory, or spatial determination - thereby inaugurating the ego-politics of knowledge where the subject of enunciation (and universal rationality) was erased and hidden - (Grosfoguel, 2008; Dussel, 2016), he influenced all Western thought, even on the current idea of heritage.

In contrast to this position, the territorial-heritage of the geographical existential and Latin American decolonial nuance reconnects the subject«territory, proposing a twist on the Western heritage conception (Costa, 2016; 2017; 2018; 2021)**7**. Its location lies in the "territories of exception" (spaces of revenge, impetus, and popular belonging, defying the historical modernizing conditioning). The concept/ act of "territorial-heritage" replaces the marginalizing sense attributed to the situated impoverished individual, denounces the peripheralization, and localizes popular culture (Costa, 2016, 2021; Santos, 2000). It is the identity, cultural and urban-rural permanence of subjects subjugated by the territorial modernization and unequal urbanization of Latin America, resisting supposedly universal powers and knowledge from their location (Costa, 2016; Dussel, 2016; Souza, 2019). The concept incorporates popular epistemes and oralities, which are powerful systems to preserve spatial memory, objects, places, rituals,

7 The concept has also been used by Rúbio-Schrage (2019), Rodríguez (2020), Alves (2020), Mesquita (2020), Hostensky (2020), Sousa (2020), Silva and Queiroz (2020), Maluly (2020), Andrade (2021), Araújo (2022), Fernandes and Fazito (2022), Silva Junior and Boscariol (2022), and others.

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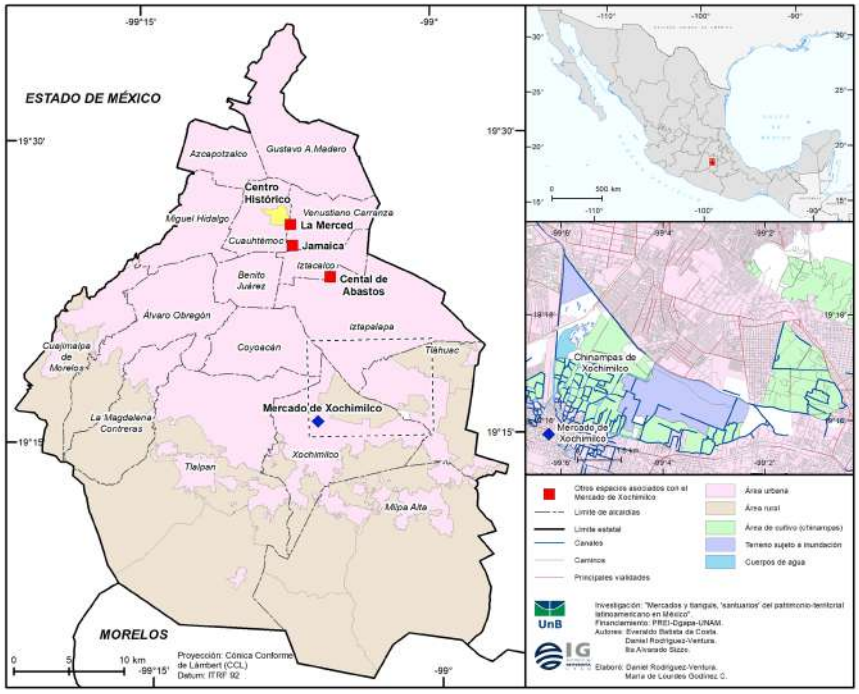

Figure 1. Xochimilco Market and chinampera zone in CDMX Source: Preparation by the authors.

productions, products, and their generational transmission, as occurs in Xochimilco.

Territorial-heritage is the material-immaterial expression of indigenous, Afro, or popular knowledge, located, independently from the state marketing institutionalization. It is a singularity (the making *of* and *in the* place) in the face of multiple particularities (regional and national political economies), confronting and, at the same time, assimilating work relationships, beliefs, and incoming customs (Costa, 2017; Hira, 2016). It is an element of popular mobilization and overcoming in Latin American urban-rural peripheries, where expressions involving the political, economic, or cultural autonomy of the impoverished tend to be socio-spatially stigmatized. The site and its popular ancestral reconstitution define the territorial-heritage. The Latin American unit contains the localized lasting mechanisms that the subalternate groups generated or appropriated to exist under pressure/oppression, such as the traditional market, *locus,* and materialization of the territorial-heritage.

For Santos (2000), globalization generated the necessary conditions for the emergence of the subjects denied by it, and the influence of a culture of masses that sought to homogenize and impose itself on popular culture, forcing it to react. In the "popular period of history", as the author defines, popular culture exercises its quality of discourse of those "from below", emphasizing the everyday life of the impoverished, of the majority, through the exaltation of daily life. Territorial-heritage gains strength in this situated policy (Costa, 2021). If in the lower circuit, the impoverished are those who do not have regular access to current consumer goods, to the indispensable social minimum, they rarely have access to bank credit, being the essential customers of small businesses - they are non-employees, underemployed, and low-wage employees (Santos, 2018; Silveira, 2020)-, none of that completely eliminates the attribute of daily sustenance, endorsed by spatial links of their territorial-heritage.

The theory of circuits and territorial-heritage applied to the Xochimilco market indicates that the lower circuit of the urban economy is governed by attachment to the territory and the reduced use of capital, stimulating production, small-scale trade, survival, hope, and solidarity in the Latin American metropolis.

III. CASE STUDY

Xochimilco is one of Mexico City's southern municipalities (Figure 1). Its lacustrine system based on chinampas (artificial

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Figure 2. Canal and productive chinampas of Xochimilco (horticultural and transport, 1930; flowers and tourism, 2019. Source: INAH-Mexico Photo library and collection of the authors.

Figure 3. Sections of the Xochimilco market. Source: Authors' collection (February 2022).

productive islets with native habitat, constituting an agri-food landscape) (Figure 2), the last relict of the pre-Hispanic use of the territory in the Valley of Mexico, justifies the titles of World Heritage (1987) and Historic Center (two sites connected by canals, today limited to Xochimilco and Tláhuac due to urban growth) (González-Pozo, 2016; Costa & Alvarado-Sizzo, 2019).

Xochimilco, and other places, would send their indigenous horticultural crops in canoes (pulque, corn smut, chili pepper, spinach, beans, fruits, vegetables, flowers, corn, and other seeds) (Figure 2) to supply markets, squares, and corners within central CDMX. This lacustrine circulation lasted until 1938 when the Canal de la Viga was buried, but the supply has continued by other means, diversifying and oscillating in intensity (Moncada, 2010).

The explosion of informality in the squares and streets of Mexico City and the historic state attempt to control the ancestral indigenous street markets (as an indigenous site of exchanges in the public space) brought on the market program of Ernesto Uruchurtu (regent of the Federal District/1952-1964), which had reached a total of 219 establishments in the capital in 1970 (Costa & Alvarado-Sizzo, 2022). As a result of this policy, the Xochimilco market was

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inaugurated in 1957 (Figure 3) in two sections: market 44 (447 stalls) and 377 (968 stalls). The objective of controlling the historical street vending of the piers and squares (Delgado, 2015) did not have the expected success, as the results of this study confirm.

The market resists in a context of conflicts of territorial uses derived from metropolization, which threaten its territorial-heritage: construction debris deposited in canals, the urbanization and tourism of chinampas and canals (Figure 2), water pollution and loss of fauna and flora, the introduction of new aquatic species (predators of young specimens of ancestral fish, frogs, freshwater shrimp, and axolotls) and agricultural pesticides.

IV. METHODOLOGY

This research has a mixed methodological design and applies participant observation techniques, semi-structured interviews, coding, and qualitative and spatial analysis (Hay and Cope, 2021; Sepúlveda, 2018).

In February 2022, the first visit to Xochimilco market was made, to observe specific and general, everyday commercial manifestations and the potential of its territorial-heritage. The connection between internal market trade, street vendors, and the producer area was identified, even with the presence of chinampas agriculture and the Central de Abastos (Supply Center) (Figure 1), components of the circuits of the metropolitan urban economy. The evidence led to the empirical-theoretical thesis here on the *conflictive indissolubility* between the market as an appropriate building and the peripheral street vendors.

In March of that year, the participant observation work was carried out on-site, to map/interpret the socio-spatial and economic interactions between the market's inside and outside. Using the "snowball" technique (Hay & Cope, 2021), eight semi-structured interviews were applied (four for saleswomen from inside the market and four for saleswomen from the producer area) to understand their perceptions and experiences about the market's trade and supply, agriculture in chinampas and its crops, as well as their objective and subjective attachments, and their values encoded in the territorial-heritage.

The third piece of fieldwork (March-April, 2022) allowed georeferencing, typifying, and qualifying the (formal and informal) elements of the lower circuit dynamics of the urban economy of the Xochimilco market and its surroundings. Two tours were made. The first was to set up the GPS point and to make the description and analysis of each street stall identified around the market's two sections and in its surrounding streets. With the second route, the ordinary route of a family of merchants and producers was georeferenced, observed, and characterized, with its work nodes, movements (streets and canals), and their home, as a qualitative example of the daily practices that connect economic activities between the market, the producer area, and the chinampas.

The transcripts of the interviews were encoded and analyzed in Atlas.ti (Saldaña, 2013), to identify the patterns and build semantic networks of codes, as a synthesis of the empirical data that have qualified or endowed the reflections and cartography with experience and daily life. Using a Geographic Information System, the Kernel density calculation was applied **8** to the GPS points collected to map the concentrations and spread of the street stalls and reveal their interaction with inside the market.

V. RESULTS

The *conflictive indissolubility* between commercial sales spaces-survival and formality-informality

The Xochimilco market exerts a centripetal-centrifugal commercial force defined inside and outside its building (areas with producers, merchants with isolated stalls, and street vendors), as well as three goods supply areas: CDMX Central de Abastos (Supply Center), rural areas of the south (Municipalities of Xochimilco, Tláhuac. and Milpa Alta), and the chinampa zone of Xochimilco (Figure 1). Figure 4 clarifies the content or the popular uses of the territory and represents the centripetal-centrifugal force, of greater locational-commercial density in the two producer zones (spaces for the trade of chinampa crops), alongside the second section of the market. It also evidences the centripetal-centrifugal force of the market towards the structuring of peripheral street vendors (207 informal stalls were analyzed and located along the route). Through the distribution, distance relationships, types of business, and sales (Figure 4), it is clear that these businesses constitute a moving street market that penetrates the two buildings of the Xochimilco market (Figure 9).

The trade inside the market and the peripheralized vendors define territorial uses on the scale of the subject (and family areas), where the sale of food and other products sustains the surrounding low-income

8 Ehe spatial Kernel density calculation considers the distribution and clustering of georeferenced data for their clustering trends.

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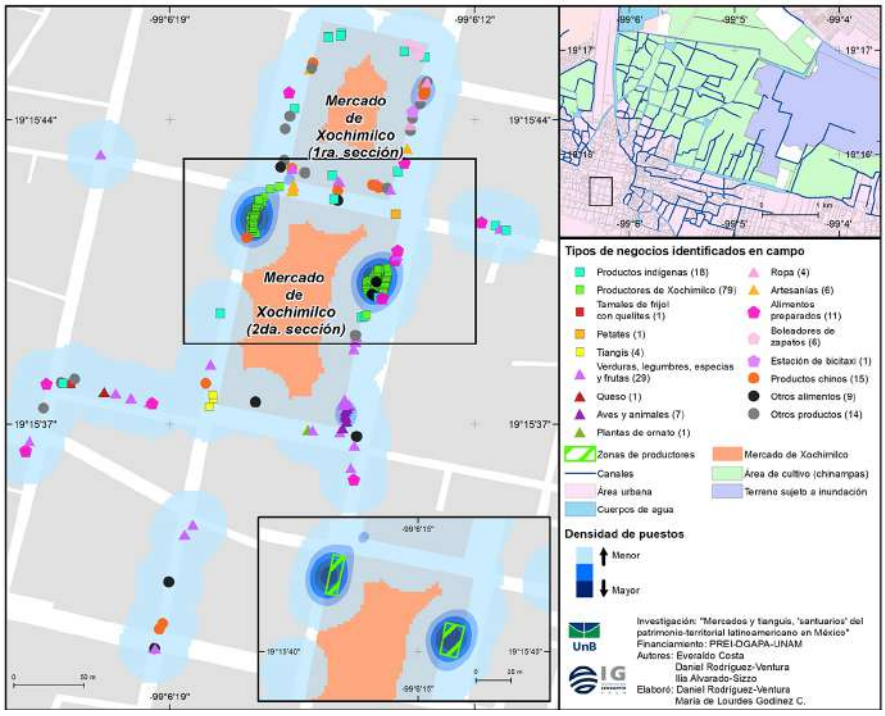

Figure 4. Territorial use by street vendors around two sections of the Xochimilco market. Source: Preparation by the authors.

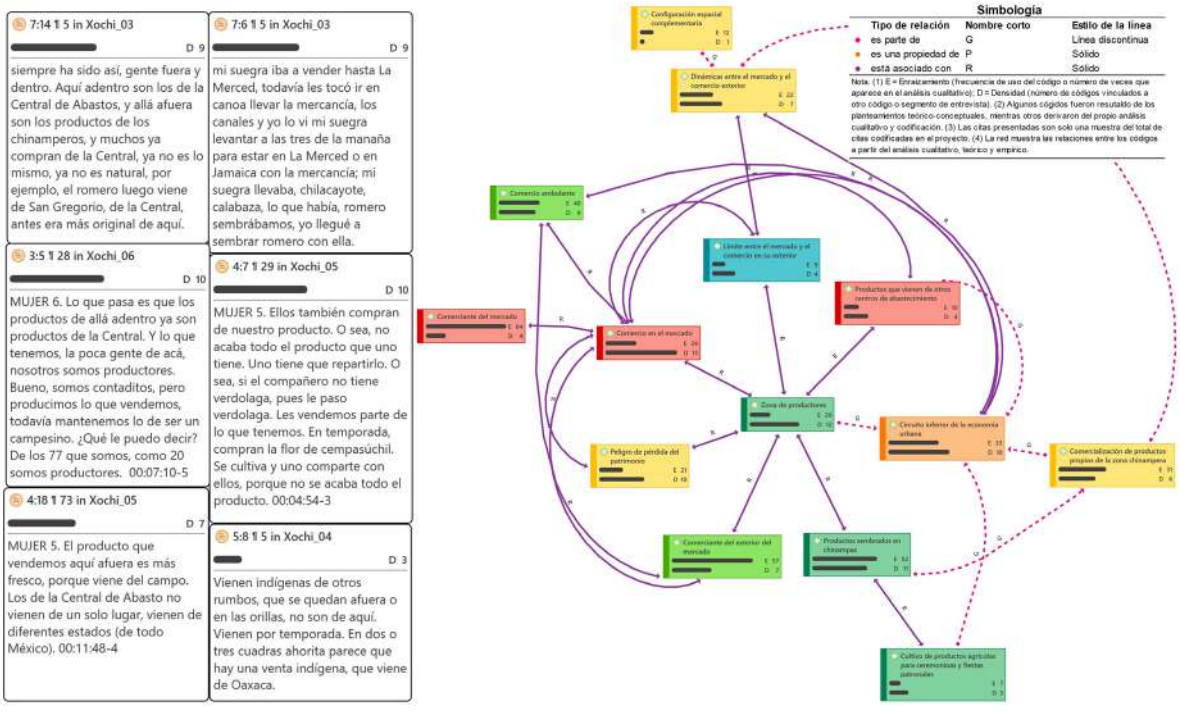

Figure 5. Xochimilco Market in the lower circuit of the urban economy. Source: Preparation by the authors.

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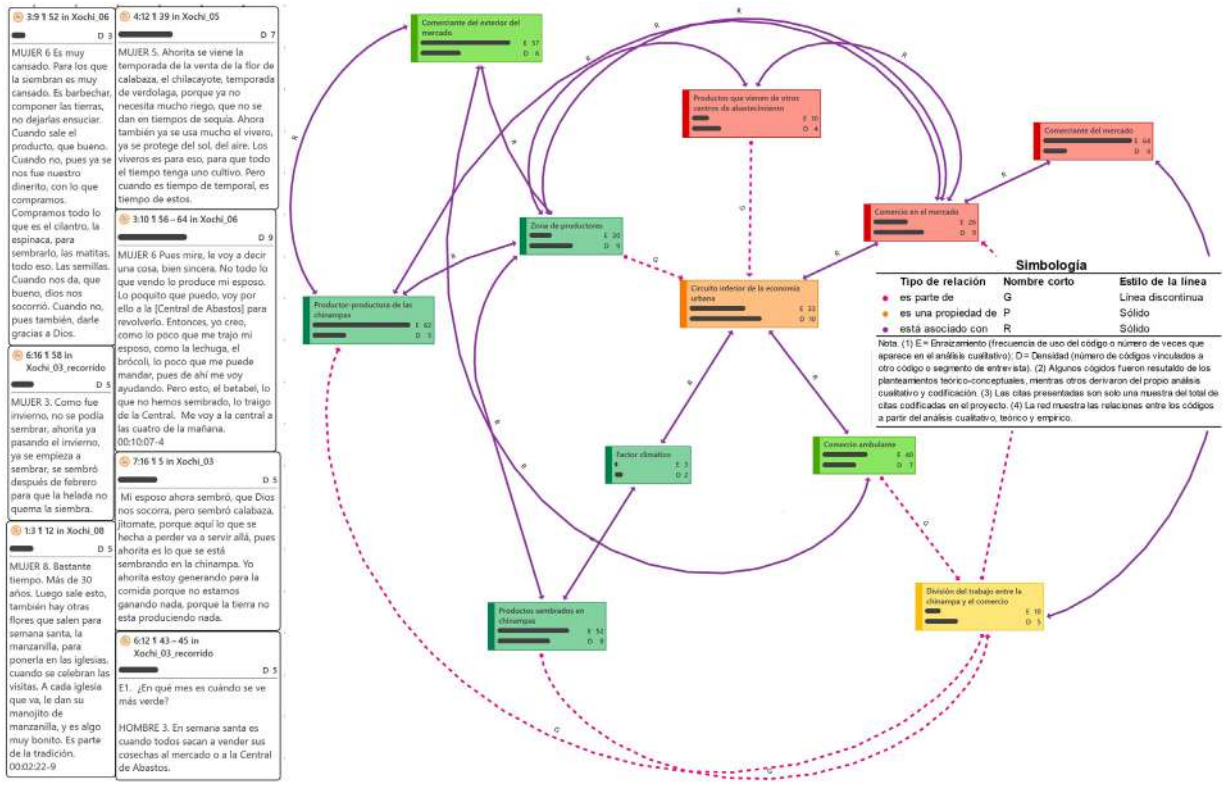

Figure 6. Chinampas and trade in the lower circuit of the urban economy. Source: Preparation by the authors.

inhabitants. Local consumers and tourists flock to the market and the chinampas. The offer of products is diverse, ranging from Chinese products, clothes, toys, handicrafts, flowers, and plants, to fresh or prepared foods (mixiotes, bean tamales with quelite, quesadillas, blue corn dough tortillas, etc.). Part of these products – offered by vendors in isolated stalls and passing street vendors – are indigenous, from other regions of Mexico (such as Puebla and Oaxaca), and even from the metropolis, materializing the territorial-heritage as a utopianism of spatial basis and for survival.

The interviews prove that most of the fruits, vegetables, and legumes sold in this integrated territory come from the Central de Abastos CDMX, articulating formality/informality dialectically in the upper and lower circuits of the urban economy. Despite the problems related to the "urban colonization of the chinampas" and the consequent contamination of the canals, products grown in them are marketed inside and outside the market: radishes, spinach, cilantro, parsley, broccoli, purslane, cauliflowers, chilacayotes, chayote, quelites, amaranth, pumpkins, epazote, tomato, tomatillo, chilies, and buckbrush. Some of these are used in festivals and ceremonies: chamomile, lemongrass flowers, and Christmas Eve (Figure 5, Figure 7, and Figure 10).

Both groups of traders recognize competencies, differences, and inequalities among themselves. Most of the products inside the building come from the Central de Abastos, while a large part of the goods in the producer area come from the chinampas and are valued by consumers as being fresher (Figure 5 and Figure 7). The merchants inside the market express solidarity (typical of the lower circuit) by recognizing the needs of street vendors and the producer area in general but consider that the sale is disloyal, when they offer the same products in nearby stalls, at a lower price, and without taxes. It was found that consumers make discretionary purchases inside and outside the market building to supplement their own needs.

Connection of the lower circuit of the urban economy and territorial-heritage

The sexual and territorial division of labor (and between producer/merchant families), the formal-informal territorial uses (which resignify the mutual assimilation between the

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Figure 7. Female traders in the producer areas, inside the market, and street vendors of Xochimilco. Source: Authors' collection (March 2022).

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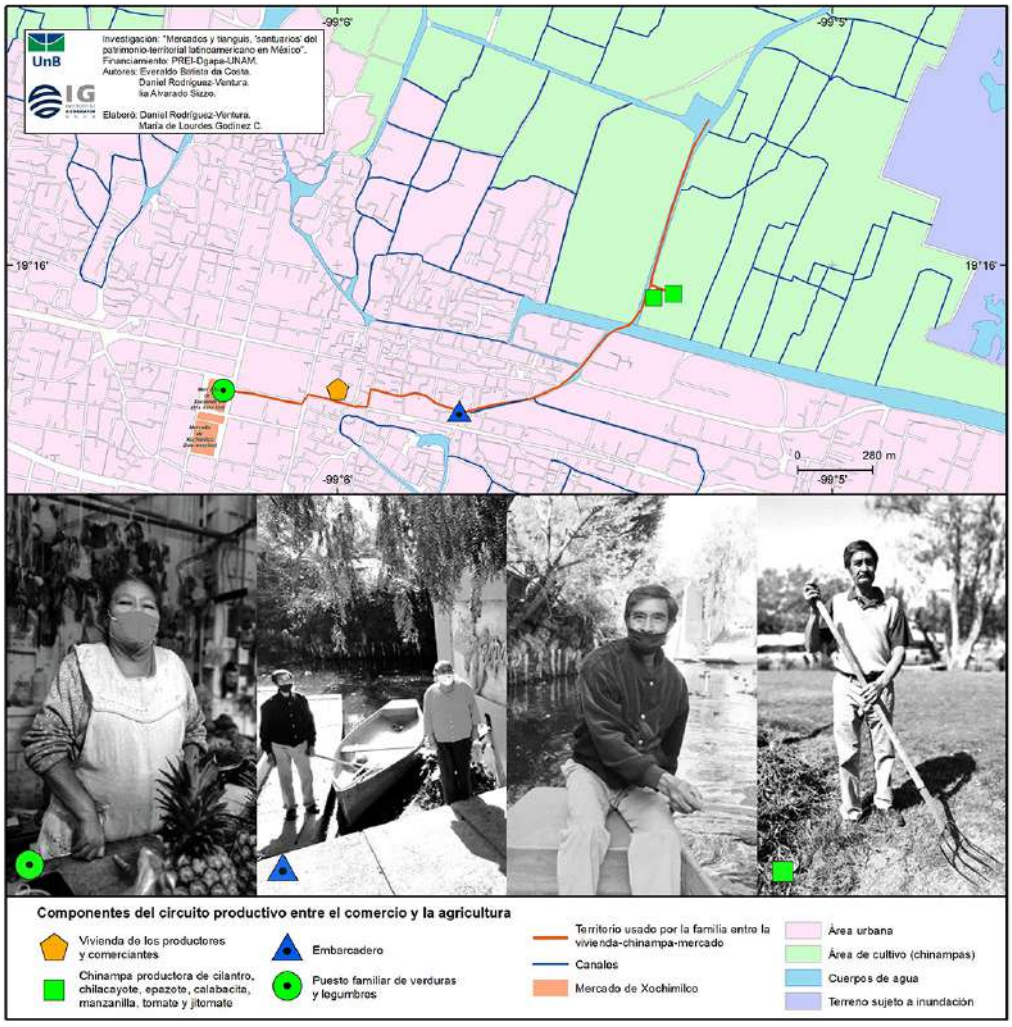

Figure 8. Everyday-familiar use of the territory in the lower circuit of the urban economy between la chinampa and the Xochimilco market. Source: Preparation by the authors.

Castilian form-content market and the street markets as an original site of pre-Hispanic indigenous exchanges, culminate in a historical struggle for space) and the products themselves (some ancestral) form existential particularities that express the lower circuit of the urban economy and the territorial-heritage. Men - mainly older adults - are responsible for the upkeep and preparation of the land in the chinampas, the cultivation, harvesting, and transportation of their products with canoes, along the canals, to the market or the producer area, where they are delivered to the women of the family for their sale (Figure 6, Figure 7, and Figure 8). The merchants, mainly from the producer area, sell their surpluses to the stalls inside the market, but in greater volume during the peak production seasons of each crop (associated with the biological characteristics and climatic conditions of this area of CDMX). Both merchants from inside and outside the building buy and take products from the Supply Center to their stalls by private or public transport, connecting the two circuits of the urban economy.

The merchants' work experience and search for subsistence from inside and outside the Xochimilco market, maintain the socio-spatial processes where their forefathers were producers and merchants in neighboring street markets who, over time, managed to get a fixed stall (Figure 8 and Figure 9) through mutual and conflicting assimilation. Simultaneously,

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Figura 9. Xochimilco: street markets in February 1920; old market in September 1957; inauguration of the new market in October 1957. Source: INAH-Mexico and MAF-Mexico.
Figura 10. Pre-Hispanic products mentioned in the interviews. Source: Preparation by the authors.

the loss of connection of new generations of merchants and their descendants with their cultivation practices, canals, chinampas, and the market was identified, which constitutes a risk of loss of the only chinampa activity in the world. The permanence and resistance to maintain this territorial-heritage fall on the "situated subjects"[9]: chinampa farmers and producers, merchants of pre-Hispanic indigenous Chinampa products (Figure 10), merchants with permanent stalls inside the market with roots in Xochimilco and, notably, metropolitan street vendors who continue offering their products around the market and condensing the lower circuit (with the activated territorial-heritage) (Figure 4 and Figure 7).

These subjects are characterized, above all, as older adult men (in the chinampa agriculture), older adult women (in the market trade and production areas), and inhabitants of the chinampas, neighborhoods, and towns around the Xochimilco market. Male and female street vendors (of different ages in the centripetal-centrifugal attraction zone of the market) are also recorded. This agriculture and trade (formal-informal in the market or informal in the street) span ancestral knowledge, products, and feelings that reciprocally link the situated subject with the territory (Figure 8, Figure 9, and Figure 11).

The results of this qualitative spatial analysis show how the Xochimilco market favors the survival of the population most affected by the politically produced socio-spatial inequalities, with intensive, unstable, and informal work, the residual use of techniques and technologies, but also with a strong local link or horizontal territorial relations, typical of the lower circuit of the urban economy, which tends to be benefitted by the territorial fluidity of the upper circuit inherent to the metropolis.

9 See Costa (2016, 2017, 2021), on the debate of the situated subject and in an enduring space situation, characterized by the historical struggle for survival and the right to use the territory, conditioned vertically in Latin America.

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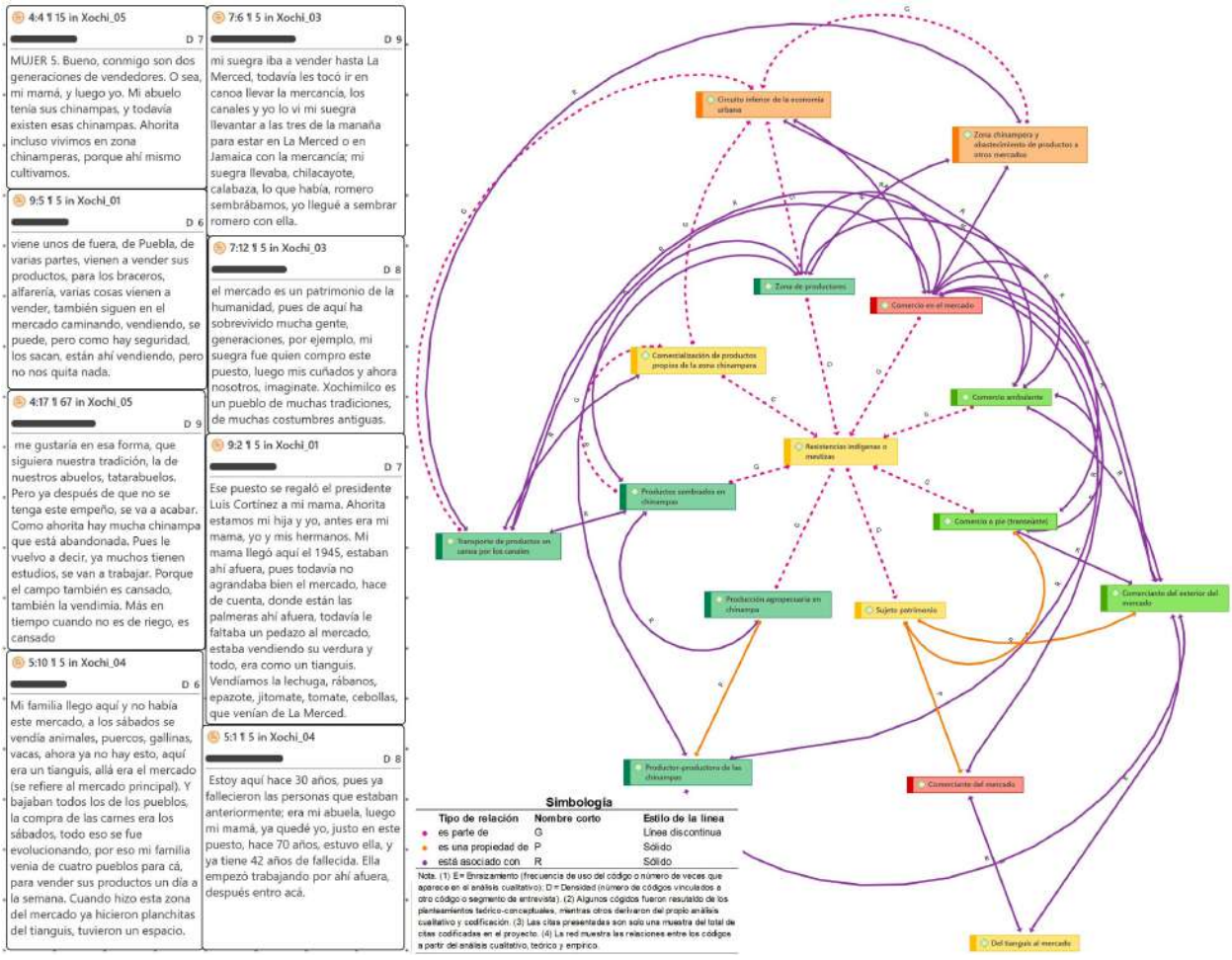

Figure 11. Situated subject, lower circuit of the urban economy and territorial-heritage. Source: Preparation by the authors.

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VI. DISCUSSION

Most of the stand holders of the Xochimilco market, as well as the surrounding street vendors, buy products at the Central de Abastos (the commercial link between the products of the whole country and the markets and street markets of the metropolis) which, although it does not represent the upper circuit, is structuring the economy of the CDMX and determines, on a daily basis, the prices of retail products in the neighborhoods. In contrast, supermarkets of national and international chains have their productive and technical supply networks, components of the subsystem of the upper circuit of the urban economy (Santos, 2018; Silveira, 2020).

Despite the increase and expansion of supermarket chains in the metropolis, the markets, street markets, and neighborhood street vendors remain as support of the lower circuit, since this is where the working classes sell and buy their food and products to survive (Santos, 2018). The particularities of the Xochimilco market show how trading activates both the productive chinampas and the daily and historical practices of its merchants and agricultural producers, forming existential meanings typical of a Latin American territorial-heritage (Costa, 2016; 2017; 2021).

Territorial uses and daily working life, activated, paradoxically, by the need for survival, but also by memory, pride, love, gratitude, and identity as chinamperos-producers of Xochimilco, are transtemporal and transscalar drivers of territorial-heritage (Costa, 2021). Nevertheless, the relocation processes of stalls in the producer area, the lack of promotion of territorial policies to recover and promote food agriculture in chinampas, the impoverishment of its producers, (which has led them to sell

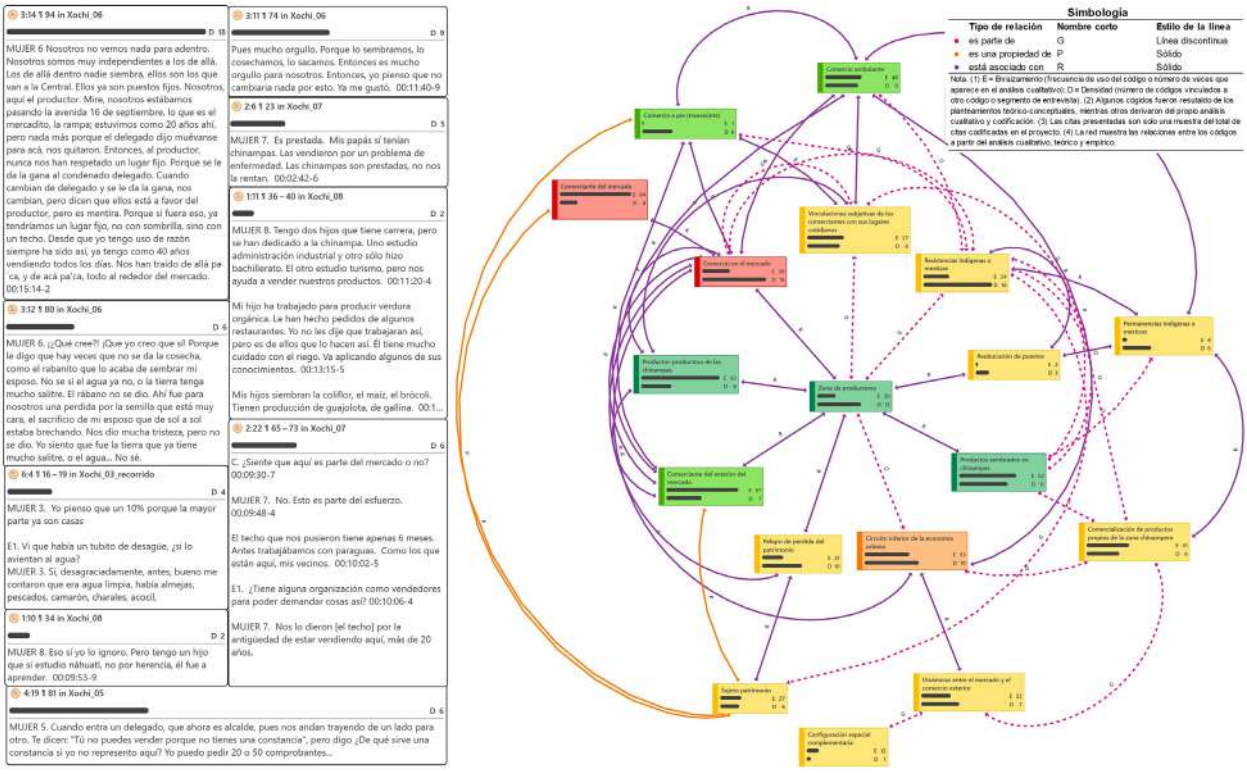

Figure 12. Existence and permanence of territorial-heritage. Source: Preparation by the authors.

up), water pollution due to the urbanization of the chinampas, and the stigma towards their vegetables (due to the pollution of the canals), indicate a lack of recognition and appreciation of these elements by the authorities as aspects with unique cultural/commercial value, while they promote tourism and the production of ornamental plants as souvenirs (Figure 2 and Figure 12). These events jeopardize the traditional relationship with the land and the survival of the people *in* and *of* the market. This is the justification behind this research, which reveals the territorial-heritage that still keeps it alive, in the "course of a traditional agricultural productive dimension of the chinampas (from meanings-permanences), to the lacustrine emphasis in a world governed by technique and finance (signifier-fluid)" (Costa & Alvarado-Sizzo, 2019, p. 14).

Despite this, the "situated subjects" (Costa, 2016, 2021) have (formally or informally) developed ways to preserve their agricultural-commercial tradition materialized in the market and the streets. The consolidation of two producer areas, after several relocations, gives them hope and an alternative to support their families and economy through chinampero and street trade. On the other hand, the merchants and producers point out the effort to generate affective bonds in their children to preserve the territorial link or the commercial and agricultural tradition - from initiatives such as learning Nahuatl in formal schools - or by applying professional and university knowledge in their agriculture and tourism with greater local economic impact, regardless of whether their trade is inside or outside the market. The need to understand the role and complex content of the lower circuit of the economy and the urban scale itself in the commercial complementarity established between the architectural space of a market and the fabric in which it is inserted is clear (Zazo & López, 2018), to identify the strength of the territorial-heritage under the historical labor dynamics of impoverished and stigmatized subjects in Latin American metropolises (Costa, 2021; Shlossberg, 2018).

VII. CONCLUSIONS

This work tests the hypothesis about the indissolubility between different trading spaces and, at the same time, of survival: inside two buildings of the Xochimilco market and the surrounding stalls of street vendors (established or semi-established cartographed stalls), where the permanence and mitigating conflicts occur by force of a territorial-heritage that brings life to

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the trade and agriculture of this hub of the lower circuit of the urban economy in CDMX.

The symbiosis between the ancestral indigenous street markets and the market (Castilian form-content of commercial exchange) resulted in a conflictive complementarity, where the peripheralized street vendors alongside the buildings (present like a wound of colonialism throughout Latin America) also contain the territorial-heritage. In the dialectic of the circuits of the urban economy, the impoverished "situated subject" is driven by the centripetal and centrifugal forces, stimulated and represented by trade, from the traditional market of the metropolis; survives in the lower circuit, crosses the market, locates themselves on the street, activates the ancestral chinampas and producers zone. This subject creates mechanisms to continue using the territory, seized from indigenous heritage - despite its systemic invisibilization -, between formality and informality, ancestral and globalized products, competition and solidarity, the stigmas of street vendors and the historical significance of the street markets and its products.

The territorial-heritage denounces, in its essence, the Latin American historical logic of the society-nature interaction based on expropriation, genocide, and ecocide, which have generated existential problems, mainly for indigenous and Afro-descendants (violence related to gender, ethnicity, culture, identity, religion, location, at work, linguistics, etc.); a scene that the existing traditional markets in Latin American cities enliven by constituting a form of violence against the reproductive *locus* and alternative of working-class life. If the territorial patrimony brings the utopia of benefiting - symbolically, affectively, and materially - the subalternate population on the continent, the Xochimilco market concretizes it, activated (the market), and activating it (the territorial patrimony) in the lower circuit of the urban economy, surprisingly, as a means of survival of impoverished and peripheral subjects in the global metropolis.

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PRINCIPAL COMPONENT ANALYSIS OF THE URBAN BUILDING MORPHOLOGY OF THE METROPOLITAN AREA OF MENDOZA, ARGENTINA[1]

ANÁLISIS DE COMPONENTES PRINCIPALES DE LA MORFOLOGÍA URBANO EDILICIA DEL ÁREA METROPOLITANA DE MENDOZA, ARGENTINA

MARIELA EDITH ARBOIT [2]
DORA SILVIA MAGLIONE [3]

1 This research falls within the project, “Cultural heritage of Mendoza. Registry, analysis, and planning of cultural-environmental common assets as a local development resource and socio-cultural innovation” 2017-2022 PUE CONICET 22920170100036 and Research Project 2020-2023 - DIUM. “Interrelation between Urban Planning and Mobility. The case of the Mendoza Metropolitan Area”.

2 Doctor en Arquitectura
Instituto de Ciencias Humanas, Sociales y Ambientales (INCIHUSA) -
Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Mendoza, Argentina.
Investigador Independiente
https://orcid.org/0000-0003-1929-5382
marboit@mendoza-conicet.gob.ar

3 Magíster en Estadística Aplicada
Universidad Nacional de la Patagonia Austral, Río Gallegos, Santa Cruz, Argentina.
Docente investigadora Instituto de Trabajo, Economía y Territorio
https://orcid.org/0000-0003-4708-7089
dmaglione@uarg.unpa.edu.ar

ANÁLISIS DE COMPONENTES PRINCIPALES DE LA MORFOLOGÍA URBANO EDILICIA DEL ÁREA METROPOLITANA DE MENDOZA, ARGENTINA
MARIELA EDITH ARBOIT, DORA SILVIA MAGLIONE
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Las ciudades insertas en zonas áridas afrontan una serie riesgos que amenazan su sostenibilidad, al ser impactadas por los efectos del cambio climático y la urbanización, y consecuente inequidad de consumos y agotamiento de los recursos naturales. Existen muchas variables que determinan la forma urbano-edilicia, las que a su vez influyen en el consumo de energía en las ciudades. Por ello, el objetivo de este trabajo es condensar la información aportada por las variables morfológicas urbano-edilicias en solo algunas variables o combinaciones de ellas para las manzanas urbanas ubicadas en los seis departamentos del Área Metropolitana de Mendoza (AMM). Metodológicamente, se computaron datos cuantitativos de la distribución espacial de las variables urbano-edilicias, se calcularon sus correlaciones y se aplicó un análisis de Componentes Principales para sintetizar la cantidad de variables. Los resultados identifican como principales variables de la primera componente principal -en cinco de los seis departamentos del AMM- a la densidad edilicia, la separación edilicia y el Índice de Vegetación de Diferencia Normalizada (NDVI); las dos primeras relacionadas al ambiente construido y la tercera, a la vegetación. Al incorporar datos del arbolado urbano disponibles solo para el departamento de Capital, los resultados incluyen las variables magnitud, completamiento y trasmisividad del arbolado, junto a las ya identificadas en las primeras tres componentes. Los hallazgos del trabajo brindan información sobre las variables urbano-edilicias representativas de la ciudad oasis que permitirán a futuro establecer prioridades de intervención considerando un número reducido de variables sintéticas, a fin de proponer estrategias de eficiencia y generación energética.

Palabras clave: morfología urbano-edilicia, análisis de Componentes Principales, desarrollo urbano sostenible.

Cities located in arid areas are facing several risks that threaten their sustainability due to the effects of climate change and urbanization, and the resulting consumption inequality and depletion of natural resources. There are many variables that determine the urban-building form, which, in turn, affects energy consumption in cities. Therefore, the goal of this work is to condense the information provided by the urban-building morphological variables into just a few variables or combinations for the urban blocks located in the six departments of Mendoza's Metropolitan Area (MMA). Methodologically, quantitative data of the spatial distribution of urban-building variables were considered, their correlations were calculated, and a Principal Component Analysis was applied to synthesize the number of variables. The results identify the Building Density, Building Separation, and Normalized Difference Vegetation Index (NDVI) as the main variables of the first principal component, in five of the six departments of the MMA. The first two are related to the built environment, and the third is to vegetation. By including data on urban tree cover, available only for the Capital department, the results include the tree-cover magnitude, completeness, and transmissivity variables, together with those already identified in the first three components. The findings of the work provide information on the representative urban-building variables of the oasis city that will allow, in the future, establishing intervention priorities considering a reduced number of synthetic variables, to propose efficiency and energy generation strategies.

Keywords: urban-building morphology, principal component analysis, sustainable urban development

I. INTRODUCTION

Currently, most of the world's population lives in urban centers. Cities inserted in drylands, which have adapted historically to the environment and the lack of resources, face more profound challenges with land and soil degradation, the water crisis, extreme climatic events, disparate expansion models, and consumption that threaten the habitat's sustainability and deepen inequities.

Based on these problems, this research is justified by the relevance the urban-building form issue has gained in recent decades for sustainability (Bibri, 2021; Burton, Jenks & Williams, 2013; Jabareen, 2006; Jenks, Kozak & Takkanon, 2013; United Nations, n/d; Sharifi, 2021), and for its influence on energy consumption (Owens, 1986), with a special focus on the quantitative analysis (Artmann, Kohler, Meinel, Gan & Ioja, 2019).

Contemporary research on urban morphology intersects with the themes of smart cities, computational geometry, and information management, to explore the urban form through large use collected and/or generated datasets (Boeing, 2021). This allows applying statistical methods, among which Principal Component Analysis (PCA) stands out (Johnson & Wichern, 1998). Methodologically, there is a history of spatial studies that have applied Principal Component Analysis (PCA) to evaluate the characteristics of neighborhoods and identify territorial differences in certain variables (Maiullari, Esch & Timmeren, 2021; Wu, Peng, Ma, Li & Rao, 2020) or to identify the urban form and understand the transformations induced by expansion processes (Lemoine-Rodríguez, Inostroza & Zepp, 2020). Meanwhile, other background information from PCA analysis connects the urban form to vegetated spaces and ecosystem services (Grafius, Corstanje & Harris, 2018).

The study on an urban scale, compared to the building scale, is more complex and demanding in terms of time and resources, especially in highly forested cities. The local challenges include overcoming information segmentation and identifying and analyzing the urban-building form from the available data.

In this work, the Mendoza Metropolitan Area (MMA) was chosen as a case study. It is located on an urban plot with orthogonal block grids, of approximately 100m x 100m, and a cardinal deviation of 12º to the east. Over time, its development has been heterogeneous, generating denser central areas and others characterized by dispersed growth, expanding into the periphery with marked morphological variations.

In previous works on the MMA, partial analyses of some urban-building variables have been made and presented. The objective proposed here is to determine the relationships between urban-building morphological variables and identify from the group of variables, those that most differentiate the blocks within each department and for the Mendoza Metropolitan Area by implementing a PCA. The goal is to obtain representative combinations of this oasis city's urban-building variables.

II. THEORETICAL FRAMEWORK

Urban-building morphology has been studied for its effects on the urban microclimate, outdoor thermal comfort, building energy behavior, solar availability on north facades and roofs, solar gains, and wind direction and speed (Chen, 2021; Nowak & Greenfield, 2018). The theme presents distinctive features in arid urban environments since energy balance is dependent on the solar irradiance received by the morphologies (Oke, 1988). Articles on the relationship between urban-building form and energy have pointed out key indicators in energy demand (Al-Saaidy, 2020; Biljecki & Chow, 2022; Chen, Han & de Vries, 2020). The gaps in knowledge point to the need to recognize essential urban-building variables, reveal their correlations and develop rigorous tools to implement statistical models that avoid endogeneity (Quan & Li, 2021). In this sense, the Principal Component Analysis tool is optimal for capturing the variables that express most of the total variability in the data, examining the correlations, and reducing analysis by defining new synthetic variables, called Principal Components (PC) (Johnson & Wichern, 1998).

From a historical and local perspective, the form of the AMM has inspired several investigations that have determined diverse spatial processes (Bórmida & Dabul, 2014; Ponte, 2008). The study of Mendoza as an "oasis city" proposes achieving the environmental conditioning of a desert sector through a configuration of a vegetation architectural structure and outlines nine basic components within the city's matrix at the beginning of the last century: layout, green squares, parks, avenues-streets-sidewalks, canals, groves, continuous facades, articulated volumes, yards, and orchards (Bórmida, 2014). Numerous authors have also focused on urban expansion trends and the impact of growth in the last 50 years on the MMA (Bernabeu,

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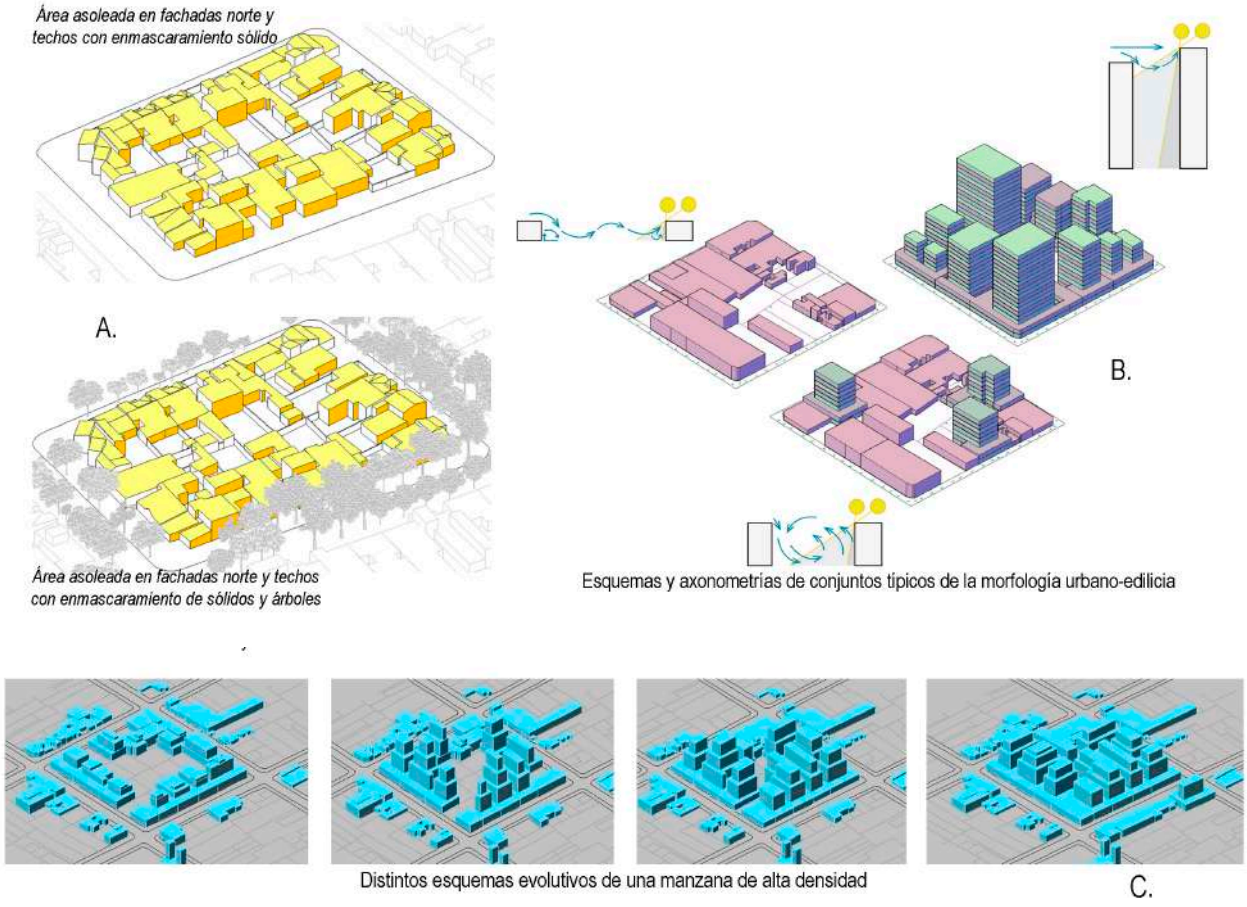

Figure 1. Layouts and axonometries of the urban-building morphology of MMA's blocks. Source: A. Prepared by Mariela Arboit; B. Graphic collaboration by Cecilia Camino; C. Mesa, Arboit, Herrera & de Rosa, 2010.

Navarrete & Ávila, 2019; Gray de Cerdán, 2005; Gudiño, 2018; Molina, Arboit, Maglione, Sedevich & Mutani, 2020; Pastor, Marchionni & Torres, 2020). In addition, work has been done on variables that consider urban and building morphology related to energy behavior (Ganem, Balter & Alchapar, 2021; Mesa & de Rosa, 2001) (Figure 1), as well as some characteristics of the urban-building form, but detailed analysis of the relationships between these variables is still pending.

III. CASE STUDY

The Mendoza Metropolitan Area (MMA) is located in the central-western region of Argentina. It is home to approximately 1,193,327 inhabitants and contains several territorial characteristics: oases and non-irrigated lands, and urban and rural-urban portions. The area has a marked aridity as a result of low rainfall, high levels of sunshine, and significant seasonal and daily temperature variations. The average annual relative heliophany is high - above 8 hours a day-, and the cloud cover has annual values of less than 40% of the sky covered, with an average annual global solar radiation of 18.06 MJ/m^2 day. The annual heating degree-days on a 18ºC base are between 1300ºC and 1500ºC, and those of cooling on a 23°C base, are at 163°C.

The MMA is the result of a conurbation of 6 municipalities (Capital, Godoy Cruz, Guaymallén, Las Heras, Luján de Cuyo, and Maipú) that were physically laid out around Mendoza (Figure 2). In recent decades, the urbanized area has undergone changes, growing at a higher rate than the urban population. If this trend continues, an even greater energy-environmental deterioration of the habitat is foreseeable (Molina *et al*., 2020).

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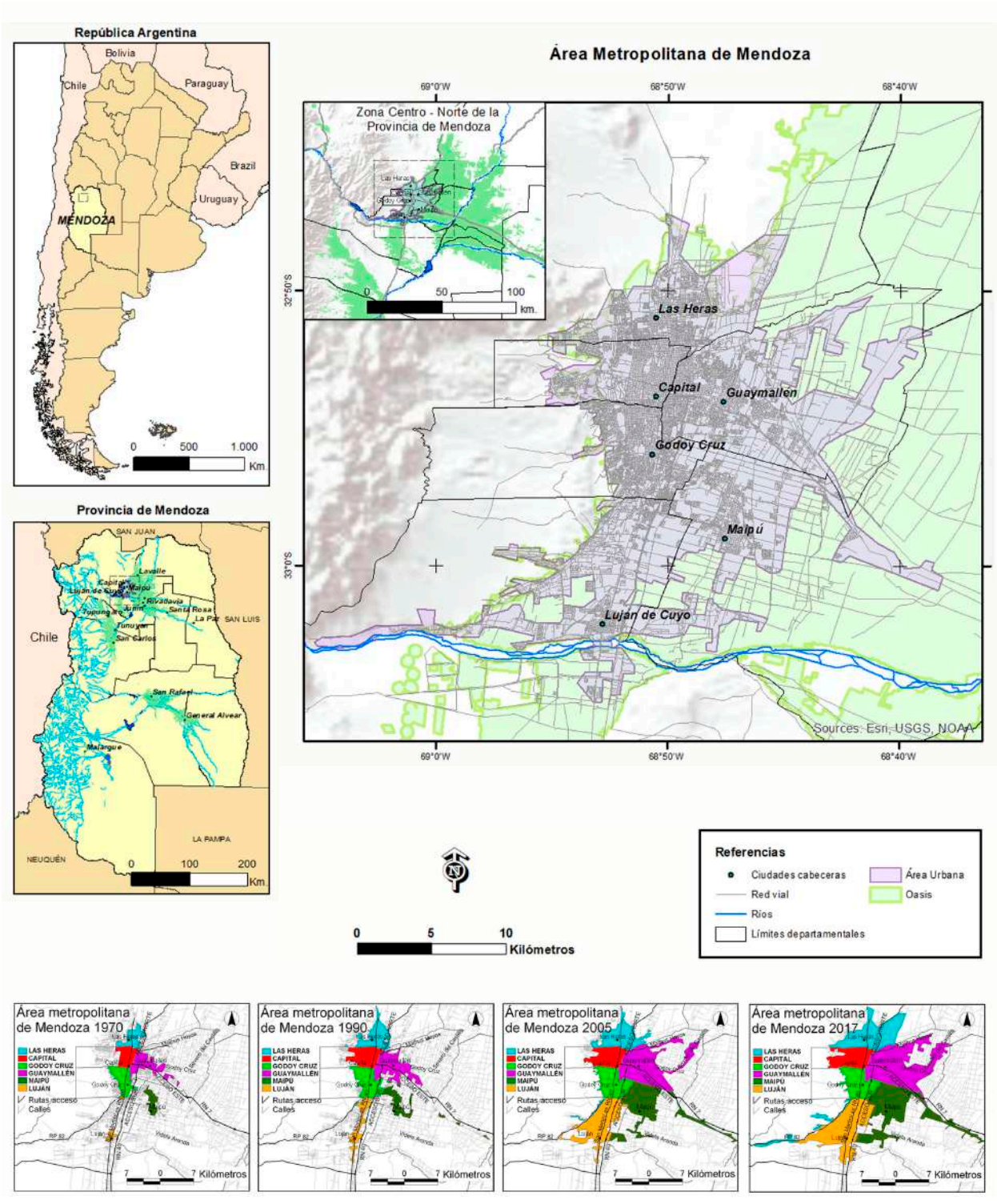

Figure 2. Location of the Mendoza Metropolitan Area and change of urban form from 1970 to 2017. Source: Prepared by Ricardo Cohn, based on Molina et al. (2020).

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IV. METHODOLOGY

Although the methodology used in this research has already been partially reported in previous publications, it is necessary to present a synthesis to help understand the results of recent tasks that are presented for the first time here. The already completed stages have been:

1. Collection of available cadastral information and its mapping for the entire MMA in geographic information systems (GIS), using urban-building data (General Directorate of Cadastre (n/d); Mendoza Infrastructure Spatial Data [IDE], 2022), satellite images (United States Geological Survey [USGS], 2018) and georeferenced census of public tree cover 2012 (Capital Municipality, n/d).

2. Description of the group of urban and building morphology variables related to a greater or lesser extent with energy behavior.

Urban-building variables

1. Block (BlockF): proportion of the sides of approximately rectangular apples.

2. Block orientation (BlockO): the angle formed by the longest side of the block and the N-S line.

3. Street Width (SW): distance between blocks (with null data correction and excluding unbuilt blocks larger than 30,000 m^2).

4. Normalized Difference Vegetation Index (NDVI): normalized quotient between spectral bands (red and near-infrared) from the monthly satellite images, for the 2013-2017 period (considering annual averages, winter, and summer).

5. Urban tree cover: spatial distribution of the four most common species per block that includes three subgroups of variables explained below: Magnitude, Completeness, and Transmissivity. Magnitude: its value depends on the size and physical characteristic of the specimen; Completeness: number of tree specimens in the block's perimeter compared to the admissible number in the same block taking into consideration the appropriate separation between trees, in percentage; and Transmissivity: describes the portion of average global radiation that passes through branches and foliage, compared to the unobstructed amount in the same period. The three subgroups of variables are available only for the Capital department that has a survey of urban tree cover.

6. Building footprint (BF): the ratio between the built building area on the ground floor and the total surface area.

7. Total building factor (TBF): the ratio of the total built area and the total surface area, expressed as a fraction.

8. Building height (BH): average height of constructions calculated as the number of floors by their average height (3 m). Here the average value of the block was calculated.

9. Building separation (BS): distance between buildings calculated as the average distance of a building within a radius of 100m in relation to the 30 nearest buildings.

10. Building height/building separation ratio (BH/BS): quotient between the building height and the average separation of the buildings in the setting.

11. Building orientation (BO): predominant orientation of the building; direction of the longest facade.

12. Building density (BD): the ratio between the built
volume on the block and the area of the block (m^3/m^2).

13. Surface/volume ratio (SExp1/V and SExp/V): ratio between the exposed area (vertical + horizontal) of a building envelope and its volume (m^2/m^3) which considers, for SExp1/V, one horizontal surface (roofs) and, for SExp/V, two horizontal surfaces (floors and roofs).

3. Calculation of urban-building variables. The urban block (delimited by streets on all sides) was considered as a unit of study. 9,320 of the 10,390 urban blocks of the MMA are contemplated for the study (once the blocks with missing or erroneous data have been eliminated). Subsequently, the results are calculated and mapped throughout the MMA. For 880 blocks of the Capital department, a detailed study is expanded by incorporating the variables of 48,419 urban trees. Figures 3 and 4 show the cartography of two variables chosen as representative: building separation and building density.

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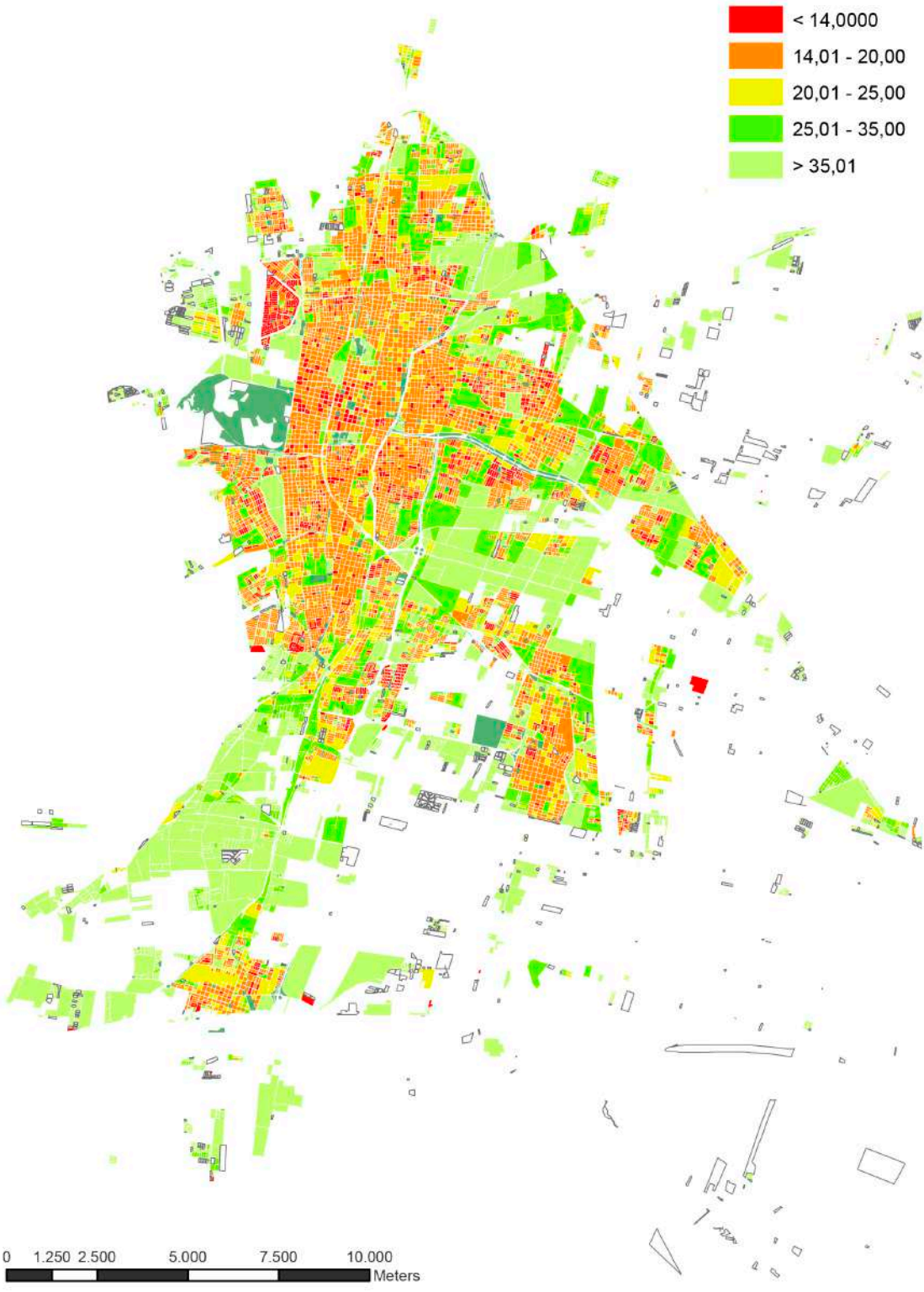

Figure 3. Building Separation in the urban blocks of the MMA. Source: Preparation by Manuela Fontanive.

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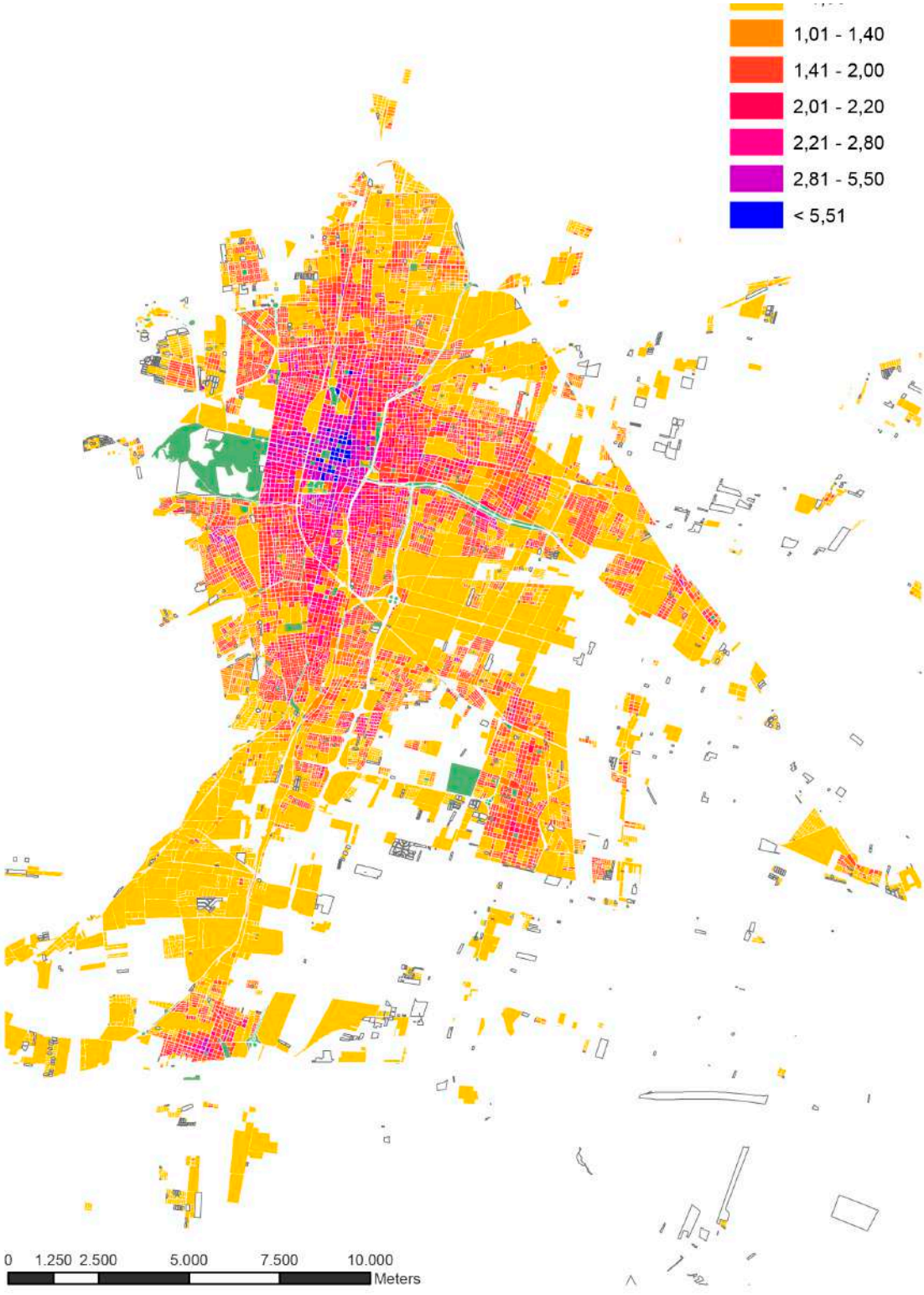

Figure 4. Building Density in the urban blocks of the MMA. Source: Preparation by Manuela Fontanive.

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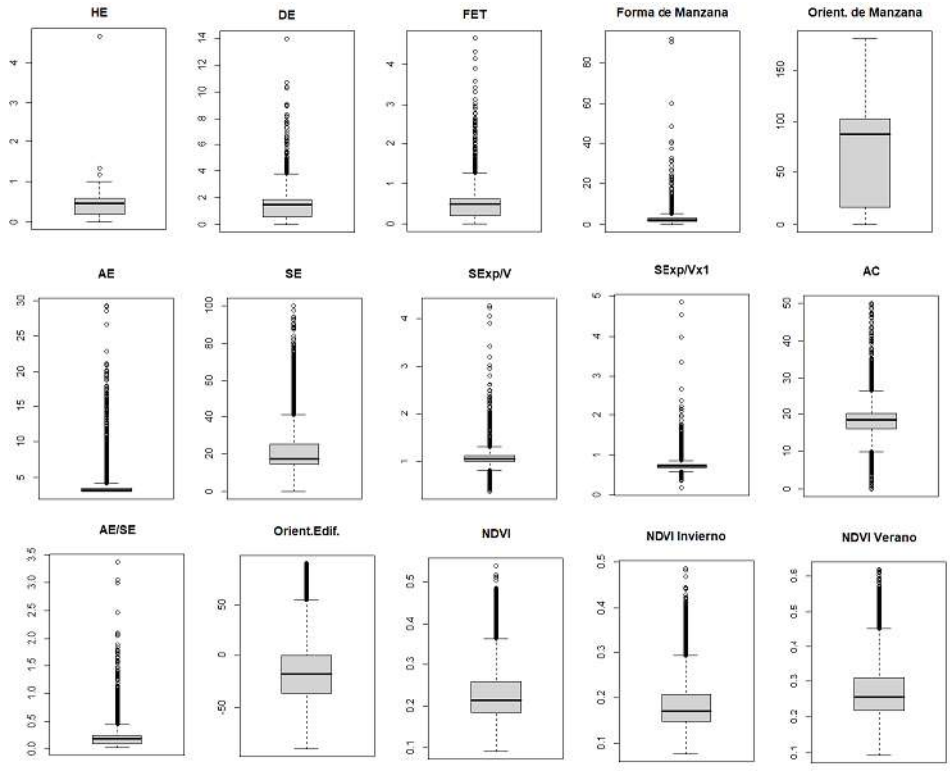

	Media
HE	0,44
DE	1,46
FET	0,49
FManz	2,52
OManz	71,65
AE	3,57
SE	23,83
SExp/V	1,06
SExp1/V	0,72
AC	18,85
AE/SE	0,21
OE.	-15,88
$NDVI_{Anual}$	0,22
$NDVI_{Inv}$	0,18
$NDVI_{Ver}$	0,27

Figure 5. Summary measurements of the urban-building variables in the MMA. Source: Prepared by Dora Maglione.

Below, the tasks carried out recently are described:

4. Database integration. The set of urban-building variables was integrated into a single database.

5. Correlation analysis. To inspect the strength of associations and avoid collinearity, the (Pearson and Spearman) correlations were calculated for each urban block. For the subsequent analysis, strongly correlated variables were eliminated (Spearman correlation coefficient >0.80).

6. Principal Components Analysis. All metrics with Z transformation were centered and scaled to make them comparable, ensuring that they had the same contribution to subsequent models. To reduce the number of variables, a Principal Component Analysis was applied, arguing that a high degree of variance can be captured in a smaller number of dimensions than with the original data. These new Principal Components (PC) are uncorrelated. The Kaiser (1960) criterion was also used for the selection of the PC (Jolliffe, 2002), retaining only the components with values greater than 1 and for each of them, variables that had moderate to high correlation with the PC were prioritized ((|r|> 0.45).

7. Using the estimated PC for each block, the averages by department, were compared using a variance analysis with heteroscedasticity by department, and the Fisher test was applied for peer comparison.

V. RESULTS

Figure 5 shows different summary measurements of the urban-building variables.

Correlations between variables.

When interpreting the p-values of the Pearson and Spearman tests, there is a correlation between variables (Figure 6). To ensure a set of non-highly correlated urban building variables, BF, TBF, BH/BS, $NDVI_{summer}$, and $NDVI_{annual}$ were eliminated, although it is noted that they are just as representative as those that are correlated.

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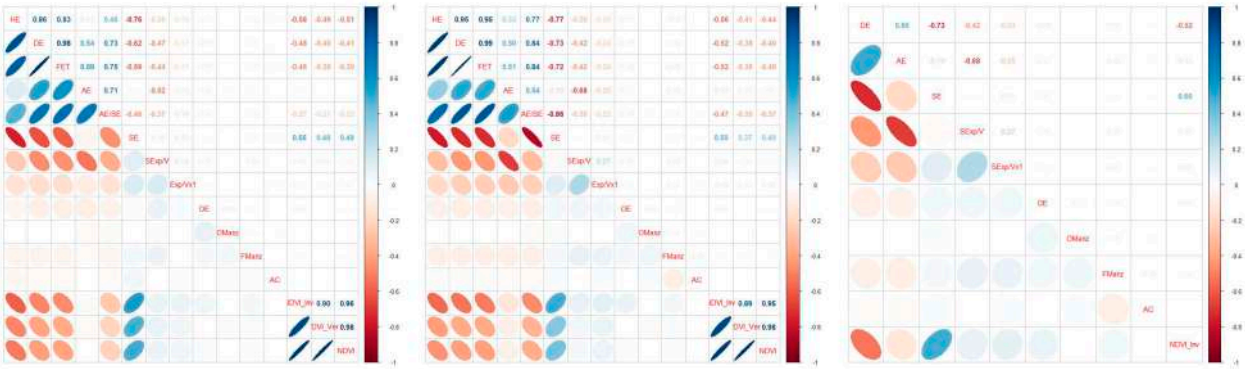

Figure 6. Pearson correlation coefficients (left) and Spearman (center and right). Source: Prepared by Dora Maglione.

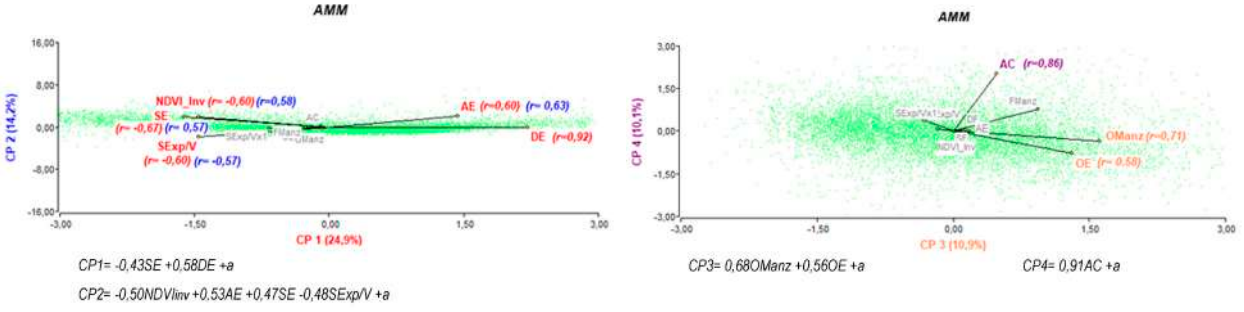

Figure 7. PC for MMA, significant correlations, and resulting equations. Source: Prepared by Dora Maglione.

Principal Component Analysis.

In the analysis of the results for the MMA, the first two components mainly evaluate the building density, building separation, building height, NDVI, building separation, and surface/volume ratio (SExp/Vol) variables. PC1, which groups blocks with high building density and low building separation, on one side, and blocks with low building density and high separation on the other, reveals a 25% variability between blocks, while PC2, has a 14% variability. The third component (11% of the variability) mainly evaluates the orientation of the building and the block, and the fourth component does so for the width of the street (Figure 7).

The analysis by department indicates that there is a coincidence in the first two components, although the importance is different depending on the department. For all departments, the building density is represented in PC1, and the building separation, in five of the six departments in MMA where the NDVI also appears as important (this groups at one end, blocks with high building density and low building separation and NDVI values, and at the other, blocks with high building separation and NDVI values and low building density values). For these departments, PC2 is characterized by the variables "building height" and "surface/volume ratio" (SExp/Vol), grouping high building height values with low SExp/Vol (Figure 8). The analysis of the other components of the different departments reveals that there is a coincidence in the building orientation, block orientation, and block form variables.

In the case of Capital, the characterization of form is different. The results show that the first four variables are building (building density, building height, surface/volume ratio -SExp/Vol-, and building separation) and the fifth is NDVI (considering PC1 and PC2). PC3 is associated with the orientation and form of the blocks, and PC4, with the width of the streets (with approximately 10% variability).

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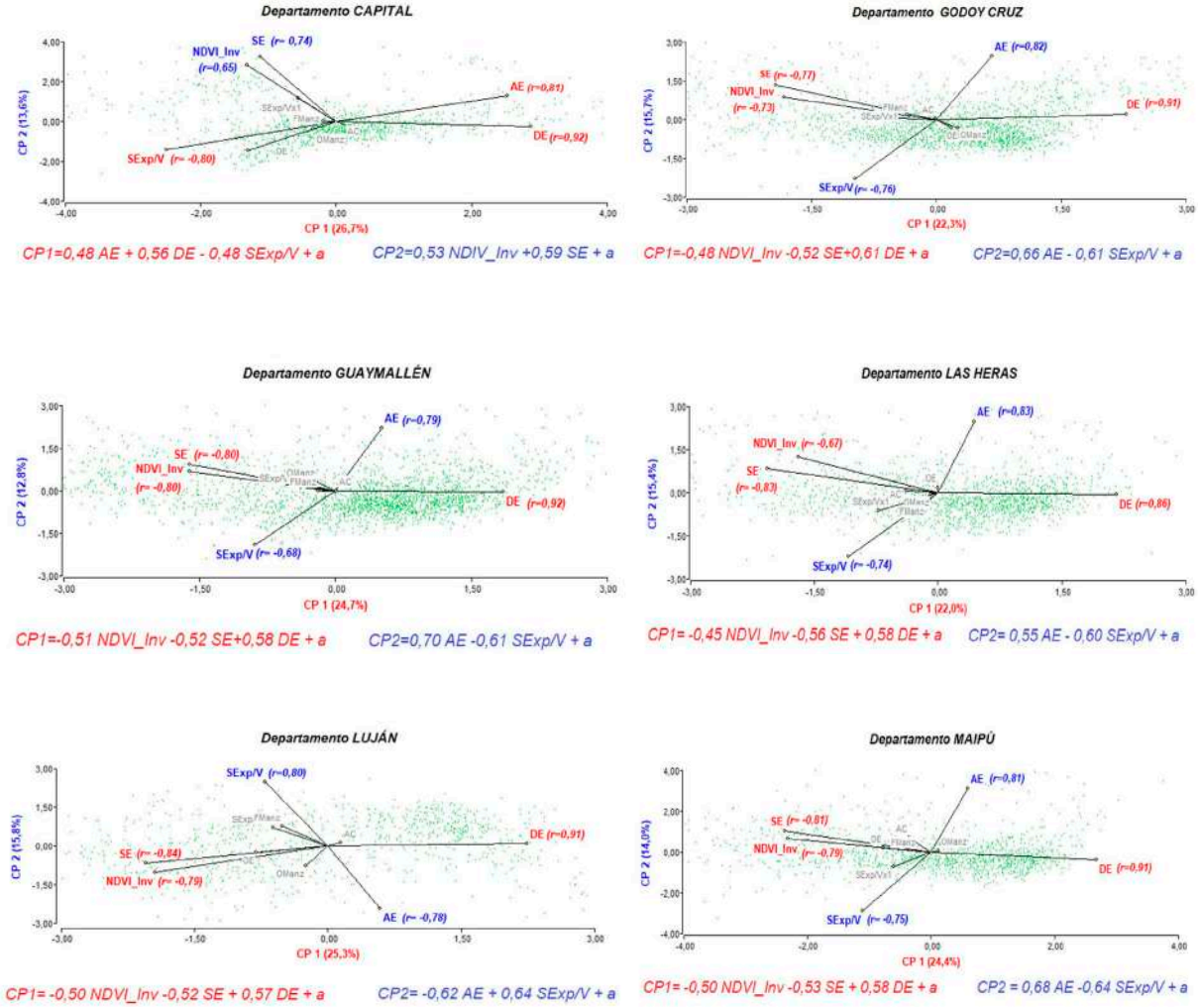

Figure 8. PC by department, significant correlations, and resulting equations. Source: Prepared by Dora Maglione.

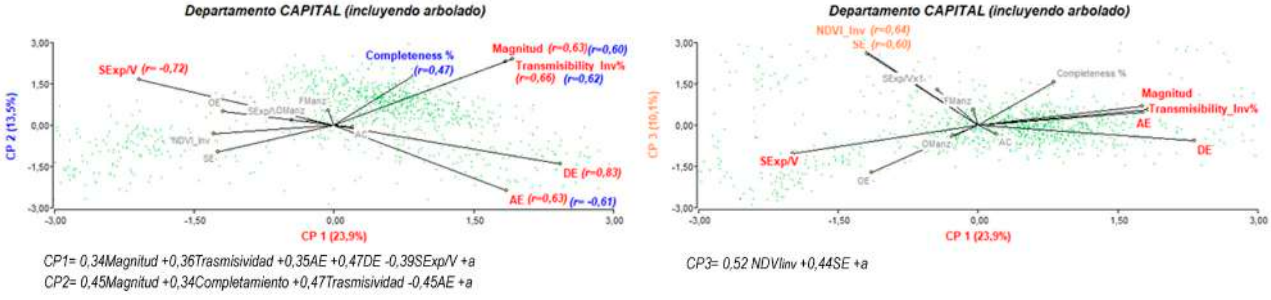

Figure 9. PC for Capital including urban tree cover variables, significant correlations, and resulting equations. Source: Preparation by Dora Maglione.

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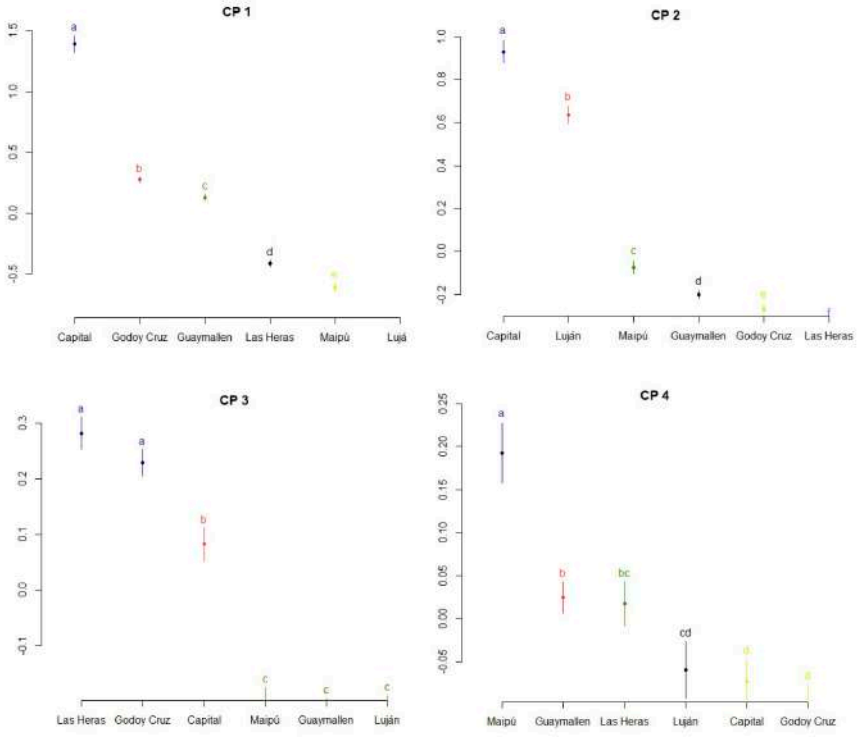

Figure 10. Mean difference test for each PC in the MMA (Departments that share the same letters indicate statistical equality). Source: Prepared by Dora Maglione.

Figure 9 presents the results for the Capital department, incorporating the Magnitude, Completeness, and Transmissivity of the trees. The highly correlated variables were excluded from the study: total building factor, $NDVI_{summer,}$ and $NDVI_{annual}$.

The results show 5 PCs that explain the differences between blocks. These reach an accumulated proportion of 64%. PC1 records 24% variability. The variables that best represent the PC1 are building density, area/volume ratio (ACP/Vol), transmissivity, building height, and tree magnitude. In PC2, the three urban tree cover variables and building height can be observed.

Finally, in Figure 10 the values of the 4 PC are compared for general analysis (MMA). It is noted that there are differences between the average values of the blocks between departments. For PC1, the average values are different in all departments: the highest corresponds to Capital and the lowest, to Luján. Capital is the one with the highest building density and lower building separation (both combined), while Luján has a lower building density and greater building separation. In the case of PC2, the same thing happens, all the average values are different: the largest corresponds to Capital and the smallest, to Las Heras. In PC3, there are 3 groups.

VI. DISCUSSION

The results of this research show coincidences with the historical perspective, with the relevant theoretical-conceptual background on the urban form and with the presence of elements for the environmental conditioning of a desert sector (Bórmida, 2014) (Figure 11).

For the MMA, the first Principal Component (PC) identifies building density and building separation, while for five of the six departments of the MMA, the NDVI variable is added to these. Of these three variables, it is worth detailing the following:

-The blocks with high building density represent a low proportion in the MMA. These blocks are more energy efficient than blocks with independent single-family homes

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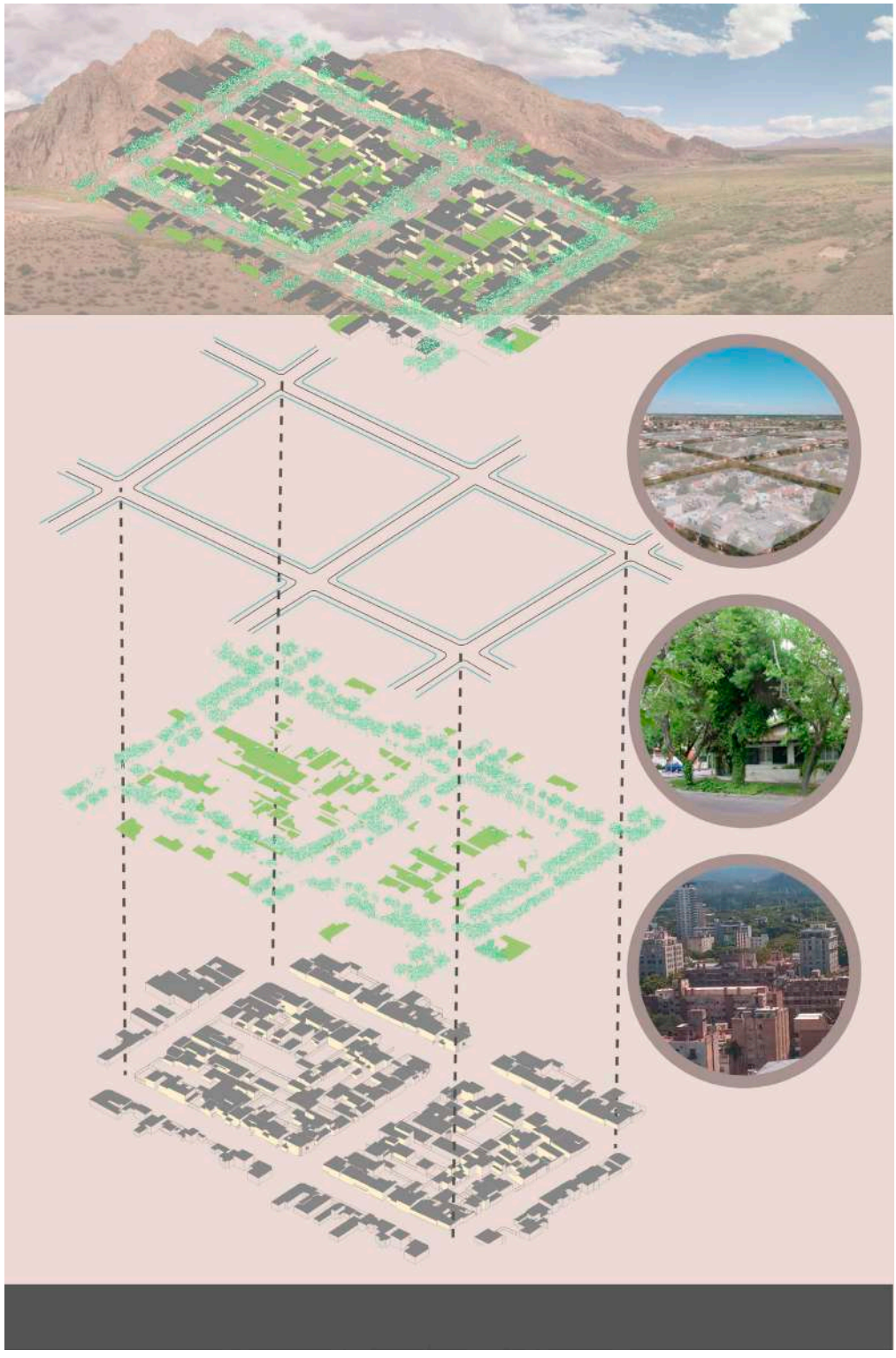

Figure 11. Analysis overlay outline. Source: Preparation by Cecilia Camino. The functional system of the oasis city based on Bormida (2014).

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(Mesa & de Rosa, 2001), which leads to lower specific consumption (kWh/m^2) in the central area of the city (Capital) (Mutani, Fontanive & Arboit, 2018). However, an increase in available sunny areas has been observed with the decrease in building density mainly on roofs (Mesa & de Rosa, 2001) (Figure 1). In this sense, solar energy offers great potential for active and passive space heating, domestic water heating, and photovoltaic generation.

-The "building separation" variable affects shading and airflows (Oke, 1988). After evaluating building separation, the values of the urban blocks of the MMA were significantly different in all departments, among which Luján stands out for having the highest average values. The building separation has an important impact on the effective sunshine on the northern facades. The presence of open spaces, combined with front and side setbacks, has a positive difference in the season with the highest energy requirement. In this way, Godoy Cruz and Capital stand out as the departments most compromised by their building separation, which could affect direct solar gain, ventilation, and daylighting (Figure 1).

-The NDVI describes the presence of vegetation in various strata. From the analysis of the results for all the blocks, which included the urban blocks by department, Luján de Cuyo registers the highest average value. The vegetation in summer reduces the surface temperature and allows keeping the radiation reflected towards the neighboring surfaces low, improving the habitability of public open spaces. Likewise, it increases air quality, mitigates runoff, provides habitat for biodiversity conservation, and favors community integration (Chen *et al*., 2020; Nowak & Greenfield, 2018).

In the case of Capital, the urban-building morphology is different due to the building height and the surface/volume ratio (SExp/Vol), in addition to the three urban-building variables mentioned above as PC1 and PC2. In this department, the construction technology, envelope use, and strategies differentiated by height are relevant (Ganem *et al*., 2021). When including tree cover, the "transmissivity", "magnitude" and "completeness" variables are significant. Urban public tree cover is capable of mitigating the negative impact of buildings, especially in the spring-summer seasons; while, in winter, deciduous species allow access to solar radiation (Figure 11).

This research will allow, in the future, to connect the findings of the Principal Component Analysis with the specific consumption (kWh/m^2) and total consumption (MWh) results (Mutani *et al*., 2018), to determine desirable intervention priorities and, in this way, implement energy efficiency and generation strategies, on different application scales. Another challenge that the work poses is to expand the study aimed at Capital incorporating tree cover data for all the blocks in the MMA. In this sense, the provincial government is working on an inventory of tree species that, from now on, will make it possible to update the analysis made and expand it to the remaining departments.

VII. CONCLUSIONS

Considering the number of variables that determine the urban-building form and its influence on energy consumption, this work has contributed by recognizing the urban-building variables representative of the oasis city, revealing their correlations, defining the Principal Components, and offering calculation equations for each of them.

It has been possible to contribute updated and quantitatively related data. Obtaining quantitative data on some variables is usually an inconvenience, so finding a representative combination of three or more variables (instead of thirteen) is another significant contribution when temporarily monitoring the urban-building morphology of the MMA for the future.

In summary, the results identify, in five of the six departments of the MMA, "building density", "building separation", and "NDVI". as essential variables of the first principal component. By including urban tree cover data in Capital, the results identify the "transmissivity", "magnitude" and "completion" variables together with those already recognized in the first three components. In conclusion, it can be stated that, in the face of climate change and urbanization, the MMA has the tools for adaptation and mitigation in its urban-building morphology, based on a territorial culture of controlled resource management, with which it has managed to accumulate valuable cultural capital that is reflected in the built landscape. All of this reflects a particular quality and, at the same time, a high fragility and vulnerability. Therefore, the high levels of complexity are not limited to morphological issues. In addition, the contribution of social science studies that address the issue of patrimonialization of the "oasis city" as a cultural-environmental common property of adaptation to the semi-desert climate and as a resource of local development and socio-cultural innovation, is required.

Finally, in a context of water scarcity, the main challenge lies in *how to revalue, preserve, and regenerate* the current "oasis city" model that allows access to the sun in the winter, access to night breezes in the summer, and a cool island during the middle of the day generated by the benefits of vegetation in the warm season. Some key

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aspects could be associated with the Principal Components of the urban-building morphology that will allow, in the future, proposing energy efficiency and generation strategies. Likewise, it is worth highlighting the need to link these environments with the native landscape through urban space *renaturalization* strategies.

The transdisciplinary work will allow focusing on urban-building morphologies to face the different cultural contexts, urban-building and landscape heritage, different opportunities, and limitations for progress towards energy-environmental sustainability.

VIII. BIBLIOGRAPHIC REFERENCES

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