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Sección General

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Dynamics of rural land conversion to urban land.

Territorial analysis and prospective[1]

Dinámicas de transformación del suelo rural a suelo urbano.

Análisis y prospectiva territorial

Dinâmica de transformação de terrenos rurais em terrenos urbanos.

Análise territorial e prospectiva

Dynamiques de transformation du territoire rural vers le territoire urbain.

Analyse territoriale et prospective

Fuente: Autoría propia

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Abstract

Cities are the result of complex relationships within various actors in a territory. Understanding and predicting their growth can be challenging, but prospective techniques, and long-term planning, may help mitigate uncertainty. This article analyzes the factors that determine urban growth in Montería, Colombia, and proposes prospective scenarios by the year 2033. Geographic information and secondary data were used to identify transformations, along with expert analysis and structural equation techniques, which helped consolidate growth factors. The results show that there are factors that trigger and drive urban growth, often unexpected or less intuitive. They also offer a new perspective on the articulation of territorial foresight techniques, since structural equations made it possible to identify the significance and direction of the variables' influences within and between macrocategories. This facilitates expert consultation and the construction of prospective scenarios. Understanding the factors of urban growth and prospective scenarios, which do not always coincide with the desired and planned scenarios, provides decision-makers with tools to correct and reorient urban development.

Keywords: urban planning, prospective, participatory research, structural equations

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Resumen

Las ciudades son el resultado de relaciones complejas entre diferentes actores en un territorio. Comprender su crecimiento y proyectarlo es un desafío, pero las técnicas de prospectiva y planificación a largo plazo pueden ayudar a reducir la incertidumbre. Este artículo analiza los factores que determinan el crecimiento urbano en Montería, Colombia, y propone escenarios prospectivos para el año 2033. Se utilizó información geográfica y datos secundarios para identificar las transformaciones, junto con análisis de expertos y técnicas de ecuaciones estructurales, que permitieron consolidar los factores de crecimiento. Los resultados muestran que hay factores que detonan e impulsan el crecimiento urbano, muchas veces inesperados o menos intuitivos. También ofrecen una nueva perspectiva de articulación de técnicas de prospectiva territorial, ya que las ecuaciones estructurales permitieron identificar la significancia y la dirección de las influencias de las variables dentro y entre las macrocategorías, lo cual facilita el ejercicio de consulta a expertos y la construcción de escenarios prospectivos. Conocer los factores del crecimiento urbano y los escenarios prospectivos, que no siempre coinciden con los escenarios deseados y planeados, brinda a los tomadores de decisiones herramientas para corregir y reorientar el desarrollo urbano.

Palabras clave: desarrollo urbano, prospectiva, investigación participativa, ecuaciones estructurales

Résumé

Les villes sont le résultat de relations complexes entre différents acteurs d'un territoire. Comprendre et projeter votre croissance est un défi, mais les techniques de planification et de prospective à long terme peuvent contribuer à réduire l'incertitude. Cet article analyse les facteurs qui déterminent la croissance urbaine à Montería, en Colombie, et propose des scénarios prospectifs pour l'année 2033. Pour identifier les transformations, des informations géographiques et des données secondaires ont été utilisées, ainsi que des techniques d'analyse experte et d'équations structurelles, qui ont permis de consolider les facteurs de croissance. Les résultats montrent qu'il existe des facteurs qui déclenchent et stimulent la croissance urbaine, souvent inattendus ou moins intuitifs. Elles offrent également une nouvelle perspective sur l'articulation des techniques de prospective territoriale, puisque les équations structurelles ont permis d'identifier la signification et la direction des influences des variables au sein et entre les macrocatégories, ce qui facilite la consultation d'experts et la construction de scénarios prospectifs. Comprendre les moteurs de la croissance urbaine et les scénarios prospectifs, qui ne coïncident pas toujours avec les scénarios souhaités et planifiés, fournit aux décideurs des outils pour corriger et réorienter le développement urbain.

Resumo

As cidades são o resultado de relações complexas entre diferentes atores de um território. Compreender e projetar o seu crescimento é um desafio, mas técnicas de planejamento e previsão de longo prazo podem ajudar a reduzir a incerteza. Este artigo analisa os fatores que determinam o crescimento urbano em Montería, Colômbia, e propõe cenários prospectivos para o ano 2033. Foram utilizadas informações geográficas e dados secundários para identificar as transformações, juntamente com análises especializadas e técnicas de equações estruturais, que permitiram consolidar os fatores de crescimento. Os resultados mostram que há fatores que desencadeiam e impulsionam o crescimento urbano, muitas vezes inesperados ou menos intuitivos. Oferecem também uma nova perspectiva sobre a articulação de técnicas de prospecção territorial, uma vez que as equações estruturais permitiram identificar a significância e a direção das influências das variáveis dentro e entre as macrocategorias, o que facilita a consulta a especialistas e a construção de cenários prospectivos. Compreender os impulsionadores do crescimento urbano e os cenários prospectivos, que nem sempre coincidem com os cenários desejados e planejados, fornece aos tomadores de decisão ferramentas para corrigir e redirecionar o desenvolvimento urbano.

Palavras-chave: desenvolvimento urbano, prospectivo, pesquisa participativa, equações estruturais

Mots-clés : planification urbaine, prospective, recherche participative, équations structurelles

Introduction

Cities are central to social development and the formation of socio-territorial exchanges and relationships. The physical layout of a city reflects the evolution of its society, the transformations and factors that have influenced it, as well as the preferences and political regimes linked to its socioeconomic assets and growth dynamics (Anzano, 2012); therefore, cities remain attractive to populations. Urban growth leads to socio-spatial phenomena that define population, economic, and physical development (Andrés-López, 2023). Despite the growth of cities, economic interests often dominate urban development. This can lead to increased segregation and territorial inequality, preventing all inhabitants from benefiting fully from the social, economic, and environmental advantages of urbanization. In other words, not all citizens have equal access to the goods and opportunities that contribute to a high quality of life in cities.

Urbanization involves not only the expansion of infrastructure and urban construction but also a set of complex dynamics that shape the city's framework. Urban growth is boosted cyclically, as physical growth and the expansion of urban areas lead to local and global changes that dynamize and make the city more attractive (James et al., 2013). In other words, the more a city grows, the more it diversifies its goods and services. Thus, it has more potential to attract population and incorporate formerly rural areas into its perimeter. Intermediate cities, such as Montería in Colombia, have experienced rapid growth in their urbanized area and population in recent years. Understanding the factors driving this growth and the transformations occurring in the territory requires a comprehensive analysis of the city, including the identification of the areas that facilitate or constrain this growth and acknowledging that changes are constant and can have various directions.

The primary objective of this study was to propose prospective urban growth scenarios for Montería city until 2033, based on the identification and analysis of the city´s transformations between 2002-2020, and of the factors determining the dynamics of growth and conversion of rural land into urban land. Four categories were identified: economic, physical, population and environmental. The study involved creating scenarios with expert opinions to assess the likelihood of these scenarios and infering potential outcomes for Montería by 2033.

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We aimed to identify new possibilities for integrating variables in the physical, population, economic and environmental dimensions of Montería by 2033, in the belief that the future can be shaped through present actions (Romero & Babativa, 2016).

Literature Review

As Pírez (2016) states, contemporary capitalist urbanization is the result of combining market and non-market production and consumption processes. Urban growth can occur both formally and informally. In Colombia and in Latin America, a significant portion of cities grow informally (Metzger et al., 2016), meaning without following the urban planning regulations. Territorial urban planning, understood as a comprehensive process that guides and regulates the long-term location and use of land, faces enormous challenges in fragmented, disorganized, unequal cities with governance problems, such as those in Latin America (Silva et al., 2016).

Urbanization in Latin America is characterized by rapid acceleration and particularities in its physical structure and socioeconomic conditions, which BDDAL (2017) describes as urbanization without development. This often results in unplanned and unsafe construction. Informal settlements, construction, land use distribution, and territorial transformations are determined by the inhabitants themselves, often in contexts of poverty and need (BDDAL, 2017). Informal settlements can exacerbate poverty and low quality of life due to the limited access to public services, health care, education, facilities, and government involvement (López, 2016). Formal urban growth depends on five areas of comprehensive public policy: urban land use planning, infrastructure provision and mobility regulation, housing market flexibility, and the existence of coordination and governance mechanisms at the metropolitan level (Perrotti, 2014).

Urban growth has two primary expressions: compact or diffuse. Compact urban forms are characterized by high density, mixed land use, housing and workplaces, and the presence of one or more urban centers where public and political space converge. Diffuse urban forms exhibit horizontal real estate development, low density, specialized land use, and distance from central facilities. Hybrid urban forms are also emerging, combining high housing density with land specialization (Sanabria and Ramírez, 2017). The growth of Colombian cities involves a mix of both forms, depending on various factors. Some areas experience diffuse expansion, often formal and of high socioeconomic level, while others are more compact but lack significant mixed use. This has been called the confused city Abramo (2012) or the mestizo city (Silva et al., 2016); which highlights, in any case, the heterogeneity in its forms of production and consumption (Pírez, 2016). In other words, although cities are engines of opportunity, social inequality in Latin America forces a significant portion of the population to resolve their housing needs through the social production of habitat (Vitale, 2017).

According to Medina & Becerra (2022), the accelerated changes in urban processes require new and more sophisticated methods to anticipate and make informed decisions. In this context, territorial foresight is a tool to provide a systematic and organized reflection that helps anticipate possible, probable and desirable futures (Do Carmo & Santos, 2021). Foresight does not aim to make exact predictions but rather probabilistic statements; so, scenarios are narratives that describe potential future paths.

The difference between forecasting and foresight includes the distinction between possible and probable. Possible refers to anything that could happen (Mojica, 2006), while probabilities involve statistical analysis, which is fundamental to foresight and is based on expert opinion or extrapolation of trends (Medina & Becerra, 2022). Foresight does not predict the exact future but provide clarity about potential possibilities. They are probable futures that project different outcomes based on hypotheses, allowing people to envision what might happen.

According to Astarriaga (2016), when envisioning the future, the present can be transformed and gives rise to foresight. Anticipation, combined with action, clarifies the future (Godet et al., 2000). However, there is no single future; different scenario probabilities can be combined with varying degrees of likelihood depending on the environment and current decisions. The guiding principle of foresight is to focus on desirable futures and provide tools that facilitate their realization (Mojica, 2006). Foresight can serve various purposes, such as understanding environmental needs to create visions and exchange knowledge, addressing uncertainty for decision-making, stimulating imagination to expand the range of societal alternatives (projective function), and fostering science and global perspective to enhance government capacity (educational function).

There are several methods for conducting foresight exercises, including expert opinions, trend analysis, statistical methods, descriptive and matrix methods, economic decision evaluation methods, modeling and simulation, and scenario building (Puebla, 2017). Common outputs of foresight research include trend and driver analyses, scenarios, forecasts, critical technology lists, technology road maps, research priorities, and policy recommendations. In the context of territorial foresight, tendency, planned, optimistic, and pessimistic scenarios are created to envision potential actions based on desired outcomes for the city.

The optimistic scenario represents the ideal future for the city, where its strengths are maximized. The tendency scenario illustrates the potential outcomes if current trends and agreements continue. The planned scenario is guided by established guidelines, such as the Land Man-

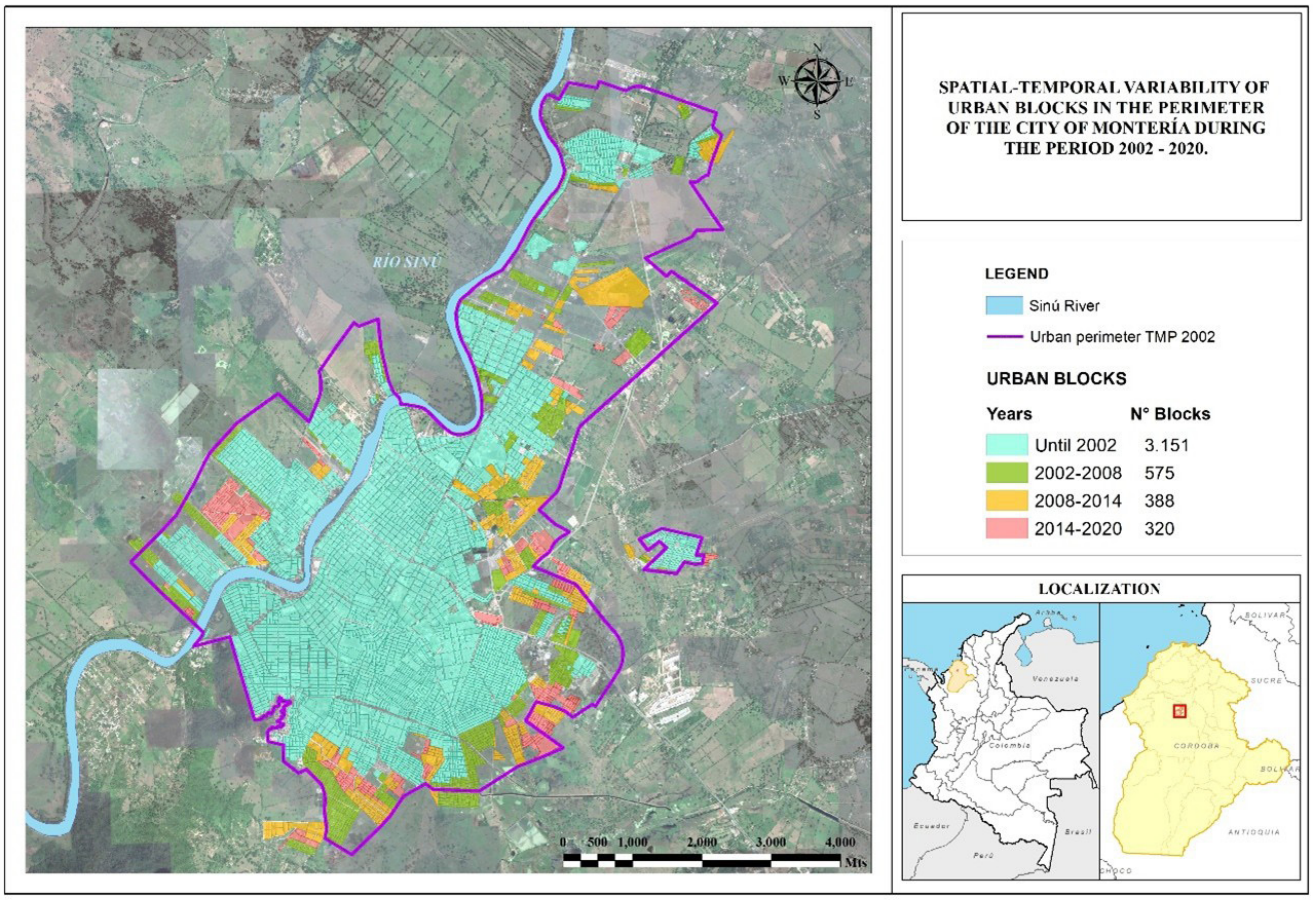


Figure 1. Map of the study area and the temporal variability of urban blocks (2002-2020) in the urban area of Montería (purple), inside departament of Córdoba (yellow) located at the north-west of Colombia

Source: The authors.

agement Plan (LMP), Municipal Development Plans and other plans, public policies and instruments that shape the physical and socioeconomic development of the territory. The pessimistic scenario is created under unfavorable conditions that limit the potential for improving the quality of life of the population.

Statistical and modeling methods include Structural Equation Modeling (SEM), which is based on multivariate techniques and is used in various fields of the social sciences. SEM allows for the representation of the relationships between a series of measured variables that are caused by various unobservable or latent phenomena, which are often important but difficult to measure precisely (Romero & Babativa, 2016). This method decomposes observed correlations into a system of equations that mathematically describe hypothesized causal relationships, based on linear and nonlinear relationships (García, 2011).

When using SEM models, it is assumed that an underlying mechanism creates a theoretical covariance structure between a vector of random variables. The goal is to develop a model that can capture this underlying mechanism to understand the relationships being measured. SEMs allow identifying the type and direction of the expected relationships between the variables in the model and then estimating the parameters specified by the proposed theoretical relationships (García, 2011). By estimating these parameters, the model confirms the measured relationships (Covas et al., 2020). Many of the same variables influence each of the dependent variables, but with varying degrees of impact. However, during the model-building process, researchers must make decisions about the relationships between the measured variables (Arrogante et al., 2016).

A significant contribution of SEM is its ability to combine qualitative research with quantitative data and to test theoretical models, making it a versatile tool for studying causal relationships in non-experimental data, especially

when they are linear (Kerlinger & Howard, 2002). However, these models cannot definitely prove causality; they only help identifying hypotheses of significant causal variables. Therefore, the true value of this technique lies in specifying complex relationships between variables identified beforehand and evaluating how many of these relationships are represented in the empirically collected data (Weston & Gore, 2006). Several statistical tests must be conducted to determine if the proposed theoretical structure adequately fits the empirical data.

In the context of urban planning, understanding the factors of growth in a constantly changing city can be challenging, but can also lead to the identification of trends, problems and potential solutions. These insights can support territorial planning and guide decisions toward scenarios that enhance the qualities of each zone, promote citizen participation, and optimize resources.

Methodology

The research supporting this article employed a mixed-method approach, combining both qualitative and quantitative techniques. This methodology enabled the identification and evaluation of transformations, growth factors and future scenarios. Additionally, it allowed quantifying the magnitude of changes, the significance of city-growth factors and the development of potential hypotheses to inform scenarios in Montería for the year 2033.

This exercise triangulated observable and measurable data from the territory, the objectives declared in planning and land use planning instruments, and the expert opinions of individuals familiar with the case study city.

Research was conducted in the municipality of Montería, capital of Córdoba Department, located in the Caribbean region of Colombia (see Figure 1). As of 2021, Montería had a population of 505, 334, consisting of 48.5% men and 51.5% women. Projections for 2033 indicate a population growth up to 542,384, with 416,718 residents expected to be located in the municipal capital and 125,666 in populated centers and dispersed rural areas (DANE, 2021).

Population, Physical, Environmental, and Socioeconomic Transformations in Montería, 2002-2020

To understand the transformations in Montería city, satellite images from various years were processed during the study period to quantify changes in urban blocks, green areas, roads and infrastructure. Socioeconomic transformations were analyzed using official statistical data (DANE, 2021).

2002 was established as the baseline, referencing the information and cartography (in CAD format) from the municipal LMP adopted the previous year. Landsat satellite images for 2008, 2014, and 2020, which are free and were downloaded from https://eos.com/es/find-satellite/landsat-8/, were processed and analyzed using ArcGIS 10.4.1. Processing consisted of a manual delimitation of the urban perimeter of Montería in three stages, based on the urban perimeter defined by the LMP, units of analysis were delineated at the urban-rural boundary.

Determining Montería's Growth Factors

An exhaustive review of secondary information from Scopus and Web of Science databases identified potential factors contributing to urban growth at the global level. A preliminary survey, designed and evaluated by academics from Montería using a Likert scale, selected factors that, according to their criteria, had the greatest impact on the city's development. Additionally, urban development plans, the 2002 and 2021 LMPs, and reports issued by governmental entities were thoroughly analyzed to understand the policies and proposals for change intended for Montería.

To interpret the identified growth factors more clearly, they were reorganized and classified into three macro-categories: economic, physical and population. Likewise, the river was included as an environmental factor to determine its role in the urban development of the city.

The results evaluated involved the scores of each factor (see Table 1). Its relevance was pondered by using the ADANCO 10.2.1 free software, which allows generating and modeling structural equations. Based on the most significant factors identified in each macro-category, a second survey was developed and administered to a select group of academic experts and representatives of public institutions in Montería. The goal was to gain a deeper understanding of the key elements that have propelled the city's growth and how they have influenced its development.

Scenarios Construction

Once the significance of each factor is determined, hypotheses are created. Optimistic, trend, planned, and pessimistic hypotheses are proposed for each significant factor in the model, based on the SEMs. Each hypothesis corresponds to optimistic hypothesis: what is desired for Monteria in an ideal way; trend hypothesis: based on an analysis of current dynamics to propose potential future

outcomes; planned hypothesis: according to the planning instruments that indicate future actions in the city, and pessimistic hypothesis: catastrophic scenarios that could occur in Monteria within the considered horizon.

Hypotheses are transferred to a *Google Forms* survey for easy qualification (Aguilar, 2022). Experts with relevant knowledge in each of the analyzed macro-categories (physical, population, economic, and environmental) are contacted to assess the probability of occurrence of each hypothesis on a Likert scale. These experts are associated with educational and environmental institutions, the municipal administration, or participated in the creation of the LMP 2021-2033.

An initial analysis of the experts' answers prepares the data for entry into the free platform *La Prospective, pour penser et agir autrement*. This program includes a tool that enables scenario creation through morphological analysis. The first module, called the prospective radar, allows for the creation, sharing, discussion, and capitalization of dimensions and factors within the prospective system. This is a mandatory step in establishing a prospective and scenario reference (Godet & Durance, 2018). The program provides various visual representations of linked levels (global context, ecosystems or nearby context, specific system or internal variables) and associated dimensions or three dimensions (levels, dimensions, variables, hypotheses).

The second module, *Morphol*, proposes a construction of prospective scenarios through morphological analyses articulated in an intuitive and interactive manner, represented as a three-dimensional parallelepiped (Godet & Durance, 2018). This allows for the construction of linked scenarios, a user-friendly method for selecting hypotheses first by dimension, then by levels, and finally by global scenarios. The results can be visualized on the prospective radar.

With the probabilities of occurrence for each qualified and evaluated hypothesis, we proceed with the narration of scenarios for each macro-category. Scenarios are composed of the narrative articulation of hypotheses, forming a common thread that concretizes the projection of the city evaluated by the experts. These narratives represent probabilities of occurrence that allow us to approach the future more realistically but do not guarantee their occurrence, as they depend on multiple behaviors and decisions that are impossible to predict. The creation of the most probable scenario for Montería 2033 involves the compilation and articulation of each macro-category, forming a comprehensive narrative.

Results

Transformations of Montería, 2002-2020

Urban growth was measured in city blocks, although this is not a homogeneous unit of area. During the analyzed period, there was an increase in the number of blocks: in 2002, Montería had 3,151 blocks; between 2002 and 2008, 575 additional blocks were created, and 388 in the period 2008-2014. In 2020, there were 320 additional blocks, representing a cumulative growth of 29.5%.

The changes in the number and location of blocks, as revealed by the processing of cartographic images, indicate that during 2002-2008, there was isolated growth on the left bank of the river, disrupting the existing urban network. In the period 2008-2014, more blocks were integrated into the existing urban network. Between 2014 and 2020, new areas were urbanized, creating a continuous polygon without vacant land. Additionally, some blocks outside the urban perimeter were joined to the urban area during 2002-2008.

In the south, there has been a continuous increase in the size of the urban polygon, exceeding the urban perimeter established by the 2002 LMP. Since 2002, there has been a concentration of housing and growth to the south, which has continued in subsequent years and consolidated this area of the city. In the northern part of the city, growth is dispersed and corresponds to the expansion zones presented in the LMP 2021-2033 (see Figure 1).

Montería's Growth Factors

Selection of main urban growth factors.

After the exercise of selecting the growth factors proposed by the experts for each macro-category, a broad but refined list was obtained for the city (see Table 1). This process was supported by the responses of 75 experts, who contributed to validating and prioritizing the most relevant factors.

In the first round of surveys, an open-ended question evaluated the Sinú River. It was identified that the river has been perceived by Montería's inhabitants as a special urban space due to its diversity and landscape, enabling activities different from those found in other cities. The river is linked to tourist attraction, economic development, and river development, as river routes have been included in mobility plans. It is also the main source of water supply for the city.

Macro-category	Var	Factor
Economic	E1	Specialized medical centers
	E2	Shopping centers
	E3	Student's residential occupancy
	E4	Cost of living
	E5	Mobility
Population	P1	Displacement caused by violence
	P2	Venezuelan Migration
	P3	Subsidized housing (VIS and VIP, in Spanish)
Physics	F1	Hotel Offer
	F2	Offer of sports, recreational and cultural scenarios
	F3	Neighborhood Densification (constructions in height)
Environmental	En1	Esplanade along the river
	En2	Green areas
	En3	Waste generation and its management (solid and liquid)

Table 1. Growth Factors for Each Category of Analysis in Montería
Source: The authors.

Analysis of Growth Factors with STEM.

The analysis of the identified factors, grouped into macro-categories, was conducted through Structural Equation Modeling (SEM) using the Partial Least Squares (PLS) method implemented in ADANCO 2.3.1. This statistical technique was selected for its robustness in handling small sample sizes and latent variables, allowing the estimation of direct and indirect effects among constructs.

The iterative modeling process generated six alternative models to explain the relationships between the economic, population, and physical growth factors in Montería. Each model was evaluated through the standardized path coefficients (β) and the coefficient of determination (R^2) for each dependent construct (see Table 2). Models with path coefficients greater than 0.35 were considered to have significant explanatory power within their respective macro-categories (University of Twente, 2025).

Of the six estimated models, Models 4 and 5 showed the best adjustment indices, with statistically significant relationships ($p<0.05$) based on bootstrapping with 5,000 subsamples. However, Model 4 presented superior explanatory capacity ($R^2=0.716$) and consistent directionality among variables, making it the selected structure for the forecasting exercise (see Table in Figure 2).

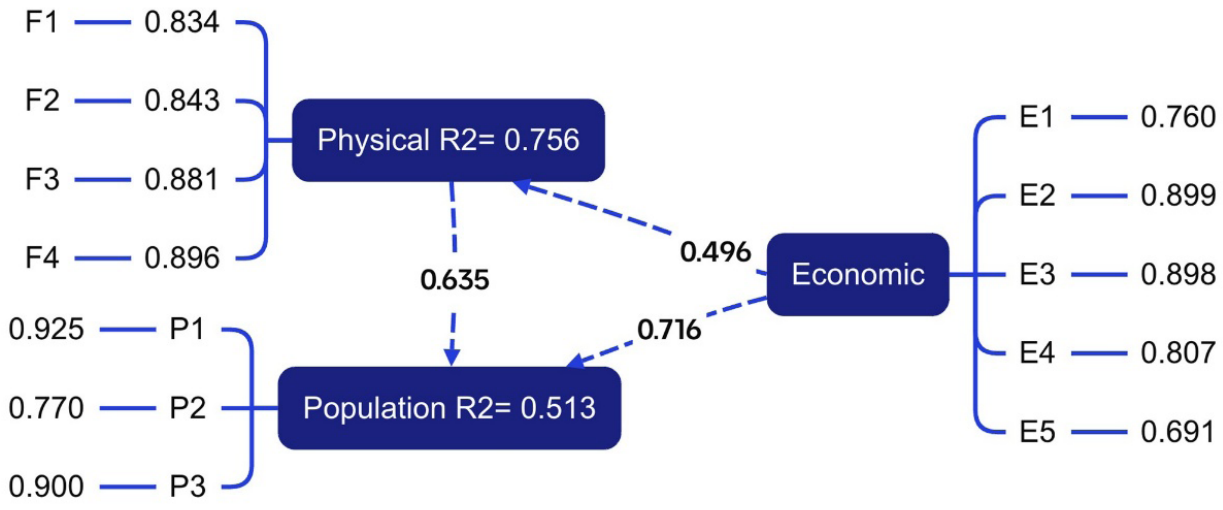
In Model 4, a direct and significant relationship was established between the economic ⊚ population ($\beta = 0.716$, $p = 0.001$), economic ⊚ physical ($\beta = 0.496$, $p = 0.004$), and population ⊚ physical ($\beta = 0.442$, $p = 0.011$) macro-categories. The physical macro-category exhibited the highest R-square value ($R^2 = 0.716$), confirming its role as the main outcome variable influenced by both economic and population factors (see Figure 2).

In contrast, Model 5 inverted the direction of influence, showing relationships from physical ⊚ economic ($\beta = 0.813$), physical ⊚ population ($\beta = 0.635$), and economic ⊚ population ($\beta = 0.200$), with significant but lower explanatory power ($R^2 = 0.661$ for the economic and $R^2 = 0.651$ for the population macro-categories).

Both models presented statistically significant coefficients ($p < 0.05$) across all factors. Nonetheless, Model 4, with higher overall explained variance and theoretically coherent causal direction, was retained as the validated model for the subsequent prospective scenario construction.

Scenarios Construction

The most likely scenarios, according to expert opinions, were identified for each of the four macro-categories (see Table 2). The construction of scenarios was based on expert assessments of the significant factors identified through the SEM model. The results reveal optimistic tendencies in the economic and physical dimensions, while population and environmental factors follow trend sce-



Model	Model 1	Model 2	Model 3	**Model 4**	Model 5	Model 6
R-squared	0.65	0.67	0.75	0.75	0.66	0.67
Maximum path coefficient	0.63	0.66	0.49	0.71	0.81	0.79
Minimum path coefficient	0.20	0.19	0.44	0.55	0.63	0.18
Model conclusion	Discarded	Discarded	Discarded	Accepted	Accepted	Discarded

Figure 2. Model 4 generated by ADANCO for the statistical analysis of growth factors in Montería, and the table with the evaluated models and selection criteria

Source: Authors' elaboration based on ADANCO.

narios, outlining Montería's most plausible urban development trajectory toward 2033.

Economic Scenario.

Montería is expected to become an intermediate city with an attractive cost of living and accessible essential services for all socioeconomic strata. Agricultural investments will be promoted to establish Montería as an agropecuary city, enhancing agricultural areas and livestock for the production and processing of mass consumption products. Additionally, shopping centers will be located at various locations to diversify supply and boost the economy. Sustainable and efficient mobility will improve access to local food in markets, promoting equal accessibility for all people.

Physical Scenario.

Montería is planning to increase tourism and consolidate itself as a regional economic and service center. The creation of sports, recreational, and cultural venues such as urban parks and park-endowment nodes will attract more visitors. Urban development will be environmentally responsible, with a balanced densification of housing, commerce, and services.

Population Scenario.

The city will remain attractive to the migrant population due to its average standard of living. The Venezuelan population, facing scarce resources, will continue to settle in high- risk areas in Montería. Due to economic constraints, these areas will have limited access to public utilities and substandard housing. To address this problem, the government will implement housing programs such as Priority Interest Housing (VIP, in Spanish) and Social Interest Housing (VIS, in Spanish) aiming to improve living conditions for low-income households and create a more equitable and inclusive city.

Environmental Scenario.

In Montería, urban afforestation will continue to be promoted by planting fruit and endemic trees in public spac-

Scenario	Factor	Hypothesis	Probability
Ecnomic	Specialized medical centers	Trend Hypothesis: Montería will be consolidated as a service delivery city with medium complexity levels.	31%
	Shopping centers	Optimistic Hypothesis: Montería will be a city with shopping centers located in different neighborhood centralities to increase the city's commercial network.	41%
	Student residential occupancy	Optimistic Hypothesis: The educational offer will be positioned in various parts of the city, expanding student residential occupancy.	35%
	Agricultural investment	Planned or Desired Hypothesis: Montería will be proclaimed as one of the largest agricultural production centers in the country, playing a fundamental role in the strategy of sovereignty and food security, primarily for the Caribbean region.	31%
	Cost of living	Optimistic Hypothesis: The moderate cost of living in the city attracts people from the surrounding area to Montería, promoting economic dynamization.	31%
	Mobility	Planned or Desired Hypothesis: Montería will encourage sustainable, efficient, integrated, and accessible mobility for all inhabitants and visitors to the city.	28 %
Physical	Hotel offer	Trend Hypothesis: Montería will continue to offer medium-growth hotels, responding to the city's passing tourism.	42%
	Provision of sports, recreational and cultural venues	Optimistic Hypothesis: Montería will foster the creation of sports, recreational, and cultural venues in each neighborhood center.	33%
	Densification of the neighborhood (high-rise buildings)	Optimistic Scenario: Montería will promote the densification of neighborhoods in areas with neighborhood facilities, sustainable mobility, and access to goods and/or services.	28%
Population	Displacement caused by violence	Trend Scenario: The displaced population in Montería will eventually be located in high-risk areas, making them vulnerable.	34%
	Venezuelan migration	Trend Hypothesis: The Venezuelan population continues to settle in high-risk areas in Montería, and migration processes will continue to increase.	35%
	Subsidized housing	Trend Scenario: Montería will continue to promote the construction of Social and Priority Interest Housing (VIS and VIP, in spanish) for the poor population, aiming to improve the quality of life of the city inhabitants.	31%
Environmental	Green areas	Trend hypothesis: Montería will continue with the city's plan for tree planting on public roads and facilities.	31%
	Esplanade	Trend hypothesis: Montería will continue to gradually construct kilometers of esplanade to allow its inhabitants to enjoy public space.	28%
	Waste generation and its management (solid and liquid)	Trend hypothesis: Montería will not use solid waste and will continue to send water to the installed treatment systems.	31%

Table 2. Economic, Physical, Population and Environmental Scenarios: Most Probable Factors and Hypotheses Shaping the Scenario for Montería 2033

Source: The authors.

es to improve rainwater infiltration and reduce flooding. Additionally, this will increase shade in the city, boost cycling mobility, and pedestrian routes.

An Integral Solid Waste Management Plan (ISWMP) will be implemented to promote the reduction, reuse, recovery, recycling, and final disposal of waste. However, a lack of recycling culture may result in higher waste rates in landfills and a decrease in their service life. The three liquid waste treatment plants in the city will help decontaminate wastewater and improve water quality in the Sinú River.

The Sinú River will be a focal point of the city's public space, featuring a linear park that provides access to biodiversity and tourism dynamics. By 2033, the esplanade will be extended with landscaping and will be articulated with the rest of the city, especially the historic center and the two banks of the river.

Discussion

In the field of spatial planning and foresight, scenario building has become a fundamental tool for understanding and addressing the complexity and uncertainty associated with the future of a territory. According to a Scopus search for "foresight + urbanization or urban planning", studies dating back to the 1990s demonstrate a growing interest in these types of tools. However, very little information about Latin America appears in this and other databases. Nevertheless, authors such as (Capra-Ribeiro, 2024; Mattioli et al., 2023) agree that foresight offers a framework for building the desired future in territorial planning exercises, allowing us to overcome the limitations of traditional reactive approaches and manage uncertainty.

In Latin America, successful cases of territorial foresight exercises are reported in countries such as Colombia, specifically in Valle del Cauca and Bogotá, the objective was to build a vision and a future agenda; in La Guajira and Huila foresight was used to build regional productive plans and initiatives (Mera, 2015). The Greater San Juan (GSJ) conurbation in Argentina was the case study for the application of an alternative prospective methodology that integrates the vision of territorial foresight with the theory of complex systems (Mattioli et al., 2023). According to Mera (2015), Brazil stands out for having successfully translated the results of prospective studies into political decision-making levels, although in many Latin American countries territorial prospective studies have been promoted by ECLAC since the 1980s. However, as Capra-Ribeiro (2024) points out, there are very few territorial foresight exercises at the subnational scale.

This approach highlights the urban growth patterns and factors that influence them. Moreover, since the last decade, authors like Fernández Güell & Redondo (2012) have emphasized the importance of future studies in the process of territorial planning. Foresight, as a methodological approach, deploys a set of techniques and tools that allow for exploring various possibilities and building plausible scenarios reflecting different potential futures. The presented exercise starts from a triangulation between actual transformation trends observed in the territory, expert judgment, and statistical analysis of information, beginning with the SEM. The consulted experts are familiar with and live in the municipality and work on issues related to territorial management planning in some of its dimensions. The SEM allows for establishing the significance of factors and the relationships -magnitude and direction- between categories. This triangulation is valuable as it enables the validation and complementarity of information from one source to another, as proposed by Moscoloni (2005).

The exercise presented could have multiple directions and assessments according to the votes by experts and the factors they wish to manage. The quality of results is subject to available information and to the experts' knowledge and opinions on the subject being evaluated, which may contain biases, as Mattioli et al (2023) and Mojica (2006), also point out. The number and validity of each expert shape and determine the results of that part of the exercise, reducing the uncertainty associated with possible futures. In this case, since few experts participated, each expert's assessment played a significant role in weighting each hypothesis. This situation increases a possible error associated with results (Herrera et al., 2022), but it can be managed by triangulating with other information that allows verifying its consistency (Salgado 2007). In many cases, the knowledge of each expert and the territorial dimension of their specialization will shape the exercise.

The SEM method allows synthesizing information collected among the academic community, with the help of structural equations as a tool to connect undefinable variables and understand phenomena (Kerlinger & Howard, 2002). This generates an input for the development of reading exercises and spatial planning, as the latent variables or dimensions, called macro-categories in this exercise, are difficult to quantify. The SEM allows interpreting macro-categories and significant factors for each one in the field of quantifiable and flow measurement, simplifying exercises such as foresight and supporting decision-making. This type of analysis is consistent with new theories for the construction of prospective exercises, which involve integrating ways of understanding the relationships between factors and variables. For example, the exercises developed by Fusco (2012) and Provot et al.

(2020) are based on a Bayesian model or GIS techniques, integrating causal analysis to understand the relationships and directions of these in population growth processes.

Regarding urban growth, Cifuentes (2009) highlight the usefulness of a statistical methodology to model urban growth, as presented in this article, where interdependencies between population macro-categories are established, as well as economic, physical, environmental, and political aspects. It is striking that the scenario built for Montería only partially coincides with the planned hypotheses taken from the proposals of the LMP, whose horizon coincides with that of this exercise. Despite the subjectivity that may be present while selecting scenarios for scenario construction, it is remarkable that optimistic hypotheses predominated in the economic and physical dimensions, with some leaning toward the optimistic side. Planned hypotheses appear only in the economic dimension. The environmental and population dimensions were dominated by trend hypotheses, suggesting that no significant changes are expected in how these components have been handled in the city, despite having a recent plan. In other words, although the LMP's task is to "...direct and manage physical development of land and land use" (Art. 9 Act 388 of 1997), there seems to be a gap between the vision proposed in this plan and that forecast in this work.

Conclusions

The identification, prioritization, and validation of urban growth factors in Montería were valuable starting points because they complemented traditionally named and applied factors in spatial planning exercises, providing a broader perspective.

In this article, methodologies were combined that break from the orthodoxy of the French school of prospective, leading to a broader vision and the identification and validation of new tools that allow foresight to revitalize in this context of its application to the territory. The adopted methodology, combining expert analysis with modeling tools such as structural equations, has proven effective in working on uncertainty scenarios related to spatial planning. By classifying and evaluating growth factors in macro-categories (economic, physical, population, and environmental), the study has not only identified key dynamics that model Montería's growth but has also provided a solid foundation for the articulation of planning strategies.

The constructed scenarios reveal a city in constant evolution, influenced by a variety of internal and external forces. From physical growth and urban sprawl to demographic changes and environmental pressures, Montería faces challenges and opportunities that require careful management and strategic planning. The inclusion of the environmental dimension, particularly the role of the Sinú River as a connecting axis for public space, underscores the importance of integrating ecological considerations at the heart of urban planning.

Beyond identifying growth factors, this study clarifies how the theoretical foundations, the SEM-based methodological approach, and the empirical results converge to explain Montería's present and future trajectory. The city's current spatial dynamics, visible in its expansion patterns, socio-demographic pressures, and environmental constraints, serve as the temporal anchor from which foresight modeling projects plausible futures to 2033. By linking present territorial conditions to scenario outcomes, research demonstrates how foresight can translate empirical evidence into actionable guidance for decision-making, reinforcing planning processes aimed at shaping a more coherent, equitable, and sustainable urban environment.

This study contributes to the field of urban and territorial planning, demonstrating the power of foresight and interdisciplinary analysis to present pathways towards a sustainable and resilient future for Montería. In doing so, it provides inputs for other cities to address their own challenges of growth and transformation in an increasingly complex and changing world.

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