Reflections on effects of the urban development policy.
A study in Montes Claros, Minas Gerais, Brazil

Reflexiones sobre los efectos de la política de desarrollo urbano.	Reflexões sobre os efeitos da política de desenvolvimento urbano.	Réflexions sur les effets de la politique de développement urbain.
Un estudio en Montes Claros, Minas Gerais, Brasil	Um estudo em Montes Claros, Minas Gerais, Brasil	Une étude à Montes Claros, Minas Gerais, Brésil

Fuente: Autoría propia

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Cómo citar este artículo:

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Abstract

The implementation of the City Master Plan of 2001 and its successive updates aimed to promote significant changes in the urban morphology of Montes Claros, MG, Brazil, in terms of decentralization. This study aims to understand the effects of the master plan guidelines related to urban mobility and the alignment of dialogues at the local development level through a set of indicators commonly found in specialized literature. This is an exploratory case study developed based on data and information available from the Brazilian Institute of Geography and Statistics, João Pinheiro Foundation, and others. Additionally, some statistical exercises were conducted to highlight the assumptions regarding the effects of implementation this plan, using the PAST 4.3 software. As a result, Montes Claros does not have a significant urban concentration among the 19 planning regions, with a compactness index of 0.658 (moderate). The spatial concentration of economic activities in this city decreased by half between 2001 and 2021, reflecting the effectiveness of the plan.

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Resumen

La implementación del Plan Maestro de la Ciudad de 2001 y sus sucesivas actualizaciones tuvieron como objetivo promover cambios significativos en la morfología urbana de Montes Claros, MG, Brasil, en términos de descentralización. Este estudio pretendía comprender los efectos de las directrices del plan director relativas a la movilidad urbana y la alineación de los diálogos a nivel de desarrollo local a través de un conjunto de indicadores que se encuentran comúnmente en la literatura especializada. Se trata de un estudio de caso exploratorio basado datos e información públicos disponible del Instituto Brasileño de Geografía y Estadística, Fundación João Pinheiro y otros. Además, se realizaron algunos ejercicios estadísticos para resaltar los supuestos sobre los efectos de la implementación de este planutilizando el software PAST 4.3. Como resultado, Montes Claros no tiene una concentración urbana significativa entre las 19 regiones de planificación, con un índice de compacidad de 0.658 (moderado). La concentración espacial de las actividades económicas en esta ciudad se redujo a la mitad entre 2001 y 2021, lo que refleja la eficacia del plan.

Palabras clave: migracíon pendular, morfología, desarrollo local, plan maestro

Résumé

La mise en œuvre du Plan Directeur de la Ville de 2001 et ses mises à jour successives visaient à promouvoir des changements significatifs dans la morphologie urbaine de Montes Claros, MG, Brésil, en termes de décentralisation. Cette étude visait à comprendre les effets des lignes directrices du plan directeur sur la mobilité urbaine et l'alignement des dialogues au niveau du développement local en utilisant un ensemble d'indicateurs couramment trouvés dans la littérature spécialisée. Il s'agit d'une étude de cas exploratoire développée sur la base de données et d'informations disponibles auprès de l'Institut brésilien de géographie et de statistique, Fondation João Pinheiro et d'autres organismes. De plus, certains exercices statistiques ont été réalisés pour mettre en évidence les hypothèses concernant les effets de la mise en œuvre de ce plan, à l'aide du logiciel PAST 4.3. En conséquence, Montes Claros n'a pas de concentration urbaine significative parmi les 19 régions de planification, avec un indice de compacité de 0.658 (modéré). La concentration spatiale des activités économiques dans cette ville a diminué de moitié entre 2001 et 2021, ce qui témoigne de l'efficacité du plan.

Mots-clés : migration alternante, morphologie, développement participatif, plan directeur

Resumo

A implementação do Plano Diretor Municipal (PDMC) de 2001 e suas sucessivas atualizações visaram promover mudanças na morfologia urbana de Montes Claros, MG, Brasil, em termos de descentralização. Este estudo buscou compreender os efeitos das diretrizes do plano diretor relacionadas à mobilidade urbana e ao alinhamento dos diálogos no nível do desenvolvimento local por meio de um conjunto de indicadores comumente encontrados na literatura especializada. Trata-se de um estudo de caso e exploratório desenvolvido com base em dados e informações públicos disponibilizados pelo Instituto Brasileiro de Geografia e Estatística, Fundação João Pinheiro e outros. Adicionalmente, foram realizados alguns exercícios estatísticos para evidenciar os pressupostos relativos aos efeitos da implementação desseplano, utilizando o software PAST 4.3. Como resultados, Montes Claros não possui concentração urbana significativa entre as 19 regiões de planejamento, com índice de compacidade de 0.658 (moderado). A concentração espacial das atividades econômicas nesta cidade diminuiu pela metade entre 2001 e 2021, refletindo a eficácia do plano.

Palavras-chave: deslocamento urbano, morfologia, desenvolvimento local, plano diretor

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Introduction

Mitigating urban sprawl through urban densification, promoting local economic activities that generate employment and income while reducing commuting times, especially pendulum trips, are some of the main directives of the City Master Plan (CMP) of Montes Claros, Minas Gerais (MG), Brazil (Law No. 2,921 of December 1, 2001). In 2016, the city government enacted Complementary Law No. 53, which updated and improved the CMP, in accordance with Article 40, paragraph 1 of the City Statute - Federal Law No. 10,257 of July 10, 2001.

CMP is an instrument that guides the city's Integrated and Sustainable Urban Development Policy (PDUIS) and consolidates principles and guidelines of public policies. According to Article 2, paragraph 2 of Complementary Law No. 53 of 2016, the PDUIS consists of a package of plans and actions to organize the development of the social functions of the city, capable of ensuring "a socially fair, ecologically balanced, and diversified use of its territory to promote the well-being and quality of life of its residents.

Urban structure plays an essential hole in the dynamics of labor and commercial activities in the daily life of any society, in which elements such as density, land use, diversity, and urban design have a direct effect on urban mobility or are correlate with it. Urban spatial patterns affect travel patterns, which are associated with several urban problems, including motorization, traffic congestion, energy consumption, air pollution, and psychological and health issues (García-Palomares, 2010; Jun, 2020). The multiple aspects of urban mobility provide greater balance between the dimensions of the socio-spatial and environmental economy when well planned (Wallington, 2013).

In fact, it doesn't seem to be an utopia for researchers aiming for greater equity in urban development, considering the dystopian challenges imposed at several stages of the capitalist model of land use production and consumption, creating reservation, valuation, and real estate speculation (Lukas & López-Morales, 2018); guiding political decisions on local and regional development or peripheralization, enhancing gentrification, whose initial studies date back to the 1950s and 1960s (Zuk et al., 2018); and raising several arguments about compact cities versus sprawling cities, considering the contradictions regarding the well-being subjectivity (Ewing et al., 2016; Mouratidis, 2019).

Certainly, analyzing the behavior of transport users, given the public transport options available, provides information about the levels of trip generation and attraction, which are essential for municipal urban planning (Schéele & Andersson, 2018). Regarding Montes Claros - MG, 95% of the total population is concentrated in the city. This situation is a remnant of the 1960s and 1970s and denotes the inequality at the interurban scale and in its processes of production and structuring.

With the assumptions related to the transformation of the urban morphology of this municipality, we seek to analyze the effects of the Montes Claros' CMP guidelines related to urban mobility and their interaction with local development. The analysis of the dynamics of internal com-

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muting in Montes Claros, their effects on urban structure and local economy, and vice versa, is based on the basic premise that there is a direct correlation between these two guidelines; thus, subsidies for public interventions in transportation planning and land use can be promoted. Therefore, this study focused on exploring three major CMP guidelines: urban development, urban mobility, and economic development.

Methods and Theory

Urban Development Dilemma and Local Development Strategies

Urban transport systems are so deeply embedded in the socio-economic life of individuals, institutions, and corporations that they become invisible to consumers. This is a paradoxical ubiquity (Rodrigue et al., 2013), as the perceived invisibility of transportation arises from its efficiency, mobility is essential for economic and social activities.

The economic analysis is limited to understanding the urban form from the perspective of population density and city size, in contrast to urban planning, for which the urban form represents the spatial pattern of elements that compose the city, including its networks, buildings, spaces, which are defined based on its geometry. Considering this dilemma, urban economists assume a uniform distribution of people in space, which is a misconception, as it ignores the fact that urban forms result from the interactions of individuals, businesses, and governmental decisions about where to live, install businesses, and place infrastructure. Therefore, urban form and land use patterns cannot be adequately identified based only on density (Duque et al., 2019).

In addition to the strong correlation of commuting patterns observed in the urban structure based on the spatial relationship between jobs and housing, soft factors, such as socio-economic factors, in the people's travel patterns impact transportation. At the city level, these factors can include urban history, culture, economy, and institutional variables, whereas at the individual and family level, they can include several individual and family socio-economic characteristics and individual attitudes (Lin et al., 2015b). Therefore, the pursuit for a balance between jobs and housing favors land use planning and contributes to the reduction of daily commuting, traffic congestion, and other negative transport externalities, as described in studies on the Chinese government intervention for a balanced local development.

The fact is that there is no consolidated consensus on the ideal and most effective model for providing equitable urban mobility and local and regional developments, as mapped in the vast literature available on urban forms, as monocentric versus polycentric cities and compact versus sprawling cities (Li & Liu, 2018; Cortinovis et al., 2019; Elias & Pequeno, 2018; Clark, 2008; Ewing et al., 2016; Ewin et al. 2018; García-Palomares et al., 2018; Huang, 2020; Jun, 2020; Lee et al., 2017; Lukas & López-Morales, 2018; Mouratidis, 2019; Serrano-López et al., 2019; Travisi et al., 2010; Zachary & Dobson, 2021). Considering Montes Claros-MG, the presumption is that the morphological transformations resulting from the implementation of the CMP corroborate the concept of polycentricity.

The approach of polycentric urban spatial structure carries both morphological and functional connotations (Acheampong, 2020). Morphologically, polycentricity can refer to a form of spatial organization in which several adjacent centers are within the same urban system. The multi-scale approach emphasizes the functional dimension of polycentricity, focusing on the connections between different centers, such as daily commuting flows or the strength of business networks. From this multi-scale perspective, the polycentric spatial structure can be characterized as intra-urban, interurban, and inter-regional, serving as an antidote to the increasing challenges of the monocentric model (Burges, 1925) and contributing to solving the issue of the growth of suburban areas and peripheral cities. An intra-urban polycentric spatial structure can be considered a population or employment cluster within a metropolitan area or a functional urban region, making it possible to assess the functional connections between adjacent centers within the same urban system.

Li & Liu (2018) used statistical regression to assess the impacts of urban spatial structure on economic productivity. They found that a more polycentric structure favors the urban productivity in cities with high population density, whereas monocentric structures can favor the achievement of high levels of productivity only in less densely populated cities. Nevertheless, the problem of unequal distribution of population and facilities among subcenters in relation to agglomeration diseconomies persists. Consequently, empirical studies on the economic effects of urban spatial structure remain inconclusive.

Urban mobility efficiency occurs within networks, but the effects of externalities on urban growth are often connected to analysis of agglomeration economies. Huang et al. (2020) concluded that the urban network externality has a significant effect on promoting urban economic development; and cities with greater centrality in proximity tend to benefit from higher economic growth due to their central position in the network, as, in a broad sense, ur-

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ban development depends more on the interaction and spatial spillover effects between cities than on their functions and characteristics.

In recent decades, patterns of urban growth and expansion have been marked by suburbanization and decentralization and accelerated transformation of monocentric cities into polycentric cities (Jun, 2020). These transformations have been particularly observed in peripheral cities, focused on rationalizing the working day emerging from the information society, thus mitigating negative externalities concerning the city center (Clark, 2008). These changes have been accompanied by increased population density and improvements in accessibility to public facilities, residential areas, and workplaces. The emergence of subcenters in the peripheries attracted businesses and human capital, resulting in a significant increase in inter- and intra-subcenter commuting, facilitating shorter commutes. These were some of the findings of Jun (2020) when studying the Seoul Metropolitan Area. However, one immediate consequence of this dynamic was that in the newly formed subcenters, the gains from reduced travel times due to improved accessibility were lost. Congestion and other negative traffic externalities emerged (Jun, 2020), corroborating the conclusions of studies by Zhang et al. (2017), Mouratidis (2019), and Li & Liu, (2018), regarding the need for greater balance in agglomerations and density among subcenters, considering the "vocations" or influences exerted by each one. Both monocentric and polycentric urban configurations have several advantages and disadvantages, with no consensus regarding the predominance of one over the other, as "disputes" persist among the interests of the involved agents about urban planning goals, as well as institutional, individual, and sociodemographic factors, built and relational environments.

Studies on the relationship between a city's productivity and different metrics of urban forms in Latin American cities with more than 50,000 inhabitants revealed that city residents value compactness as a consumption amenity, while companies do not appear to be directly affected by urban form as a requirement for the decision to choose their location, with no evidence of significant impacts on business productivity. Based on the concept of urban neoliberalism and considering new institutional arrangements and strategies for local and regional development, the State provides financial incentives for investments in real estate and infrastructure markets in certain urban areas (Lukas & López-Morales, 2018). Furthermore, Zhang et al. (2017) had already observed that the polycentric planning as a strategy to address agglomeration diseconomies has not produced the expected effects, leading researchers to doubt the effectiveness of this urban form.

According to Lee et al. (2015), a compact city is highly dense, enables mixed land use, and provides public transport systems by offering sustainable transportation and high accessibility to local services and jobs, promoting walking, and cycling. These characteristics align with the nature of the CMP of Montes Claros, as they are focused on promoting the benefits of the agglomeration and density economies, reduce travel time and the number of trips, and encourage the use of urban public transport, with the potential to generate positive effects on the efficient use of resources, citizen health, social cohesion, and cultural dynamics, while mitigating pollution, limiting the loss of green and natural areas, and controlling urban growth (Bibri et al., 2020).

Furthermore, in the realm of urban and local economic development, the reduction in transportation and communication costs resulting from advancements in information and communication technology is a continuous process that will gradually interconnect urban centers and transform urban areas from monocentric agglomerations into more polycentric systems, with urban centers integrated into sub-centers. This is based on observations of Functional Urban Areas (FUA) of regional polycentricity in 29 OECD countries, considering the population size of centers, their distribution, and connectivity, i.e., the correlation between more polycentric urban forms and socioeconomic conditions can be reflected in regional per capita GDP levels (Brezzi & Veneri, 2015).

Urban Forms, Mobility, and Local Social and Economic Implications

According to the information provided in the previous subsection, interventions by several stakeholders in different urban structures aim to promote a greater balance in territorial development with a strong emphasis on sustainability.

Regarding Montes Claros, the guidelines of the CMP of 2016 attempt to promote urban development based on polycentrism, combat sprawl, and encourage short travels, active mobility, and the promotion of formal job opportunities close to residences for mitigating the burdens on the population and enhance its quality of life. These aspects outlined in the CMP of 2016 resonate with the literature (Banister, 2008; Brezzi & Veneri, 2015; Cortinovis et al., 2019; Dong et al., 2018; Ewing et al., 2016; Kjærås, 2021; S. Lee et al., Travisi et al., 2010; Wang et al., 2020).

In the 2010s 37% of daily commutes in the metropolitan region of Rio de Janeiro, covered an average distance of 3 kilometers. A recent O-D survey conducted in 30 traffic zones in Montes Claros in 2018 found that motorized trips lasted an average of 28 minutes, while non-motorized trips lasted 18 minutes. Acheampong (2020) studied

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the logical relationship between land use and travel in the metropolis of Kumasi, Ghana, and found that home-work distances greater than 0.3 km and relatively higher incomes have influence on the choice between motorized transportation and use of car for work trips, whereas walking to work is strongly associated with lower income levels and living in suburban areas. Nevertheless, it is expected that the mentioned changes in people's relationships with cities will align with the incorporation of new information and communication technologies and provide highly flexible travel times due to mobile and remote work, offering significant opportunities for leisure, shopping, and other activities in terms of time not spent in commuting (Banister, 2008).

Focused on understanding the interaction between the urban development, mobility, and local economy guidelines outlined in the CMP of Montes Claros, MG, the present study presents two non-mutually exclusive approaches, but in accordance with changes in urban morphology, i.e., in accordance with the decentralization directive: one approach focuses on urban compactness, whereas the other addresses urban sprawl. Studies on the morphology of medium-sized cities or intermediary cities, such as Montes Claros, are of interest to the international community. According to Serrano-López et al. (2019) citing the McKinsey Global Institute report, small and medium-sized cities in emerging markets will account for 65% of global growth by 2025, although they may not imply homogeneous behavioral patterns in the travel of citizens and urban development. This proposal involves the use of a combination of methods due to its complexity.

Methodological Approach

Data and Research Methods

The data and information were obtained from in-depth and careful bibliographic research on urban morphology and local development, such as theses and peer-reviewed scientific articles in the Scopus, Web of Science, and Scielo databases, discussed in section 2; socio-economic and demographic data, capital investments, and other information regarding the last two decades were obtained from the IBGE, the JPF, official websites of the state and city government's portal. Information on capital expenditure related to infrastructure investments made by the city government between 2002 and 2022 was obtained from the city government's portal, which were published in the form of the annual budget law for each year.

Data on transport fleet and internal travel were obtained from the City Planning, Management, and Traffic Education Company (MCTrans), and Veloso (2021). Considering that there was no continuous data on the number of passengers transported by bus in public transport from 1996-2021, a coefficient of variation (CV) with a five-year periodicity was used to fill the gaps for 2003, 2004, 2006 to 2010. Regarding the generation of internal travel, the data are from Logitran (2016).

Data on employment were obtained from the Ministry of Labor and Employment (MTE), and GEPAD/Unimontes. Considering the need for understanding the dynamics of internal functional travel and that since 2016 the city has been divided into 19 Planning Regions (PRs) (França, 2019; Leite, 2020; Oliveira, 2021), it was important to know other aspects associated with each PR, including the number of households, resident population, average household income, and number of commercial enterprises, for establishing some relationships of these variables with trip generation, degree of agglomeration (Yan & Wang, 2022), compactness index (Song et al., 2018), degree of concentration, and other indicators, such as urban diversity using the Channon entropy indicator (Purvis et al., 2019; Zambon et al., 2017).

According to Ewing et al. (2018) and Serrano-López et al. (2019), the use of multivariate analysis methods favors the obtaining of better results regarding correlations between different variables. Considering this perspective, the software PAST (Paleontological Statistics) version 4.13 was used as technological resource; it is a free online statistical software developed by Oyvind Hammer from the University of Oslo (Norway) and enables the analysis of scientific data, providing functions for data manipulation, graphing, univariate and multivariate statistics; it is used not only by paleontologists but also by researches from many areas of life sciences, earth sciences, engineering, and economics.

Results and Discussion

Peculiarities of the Urban Morphology of Montes Claros, MG, Brazil

Montes Claros (see Figure 1) is one of the 853 cities in the state of Minas Gerais, located in the north and 420 km away from the capital, Belo Horizonte. It has a population of 417,478, with 95.2% living in urban areas. Montes Claros comprises 160 neighborhoods, and the city's growth dynamics have favored the emergence of subcenters. The current urban transport network was put into operation in early 2020 and consists of 41 bus lines distributed throughout the city, aiming to better serve the population, divided into diametral, radial, circular, and peripheral routes (Montes Claros-MG, 2022).
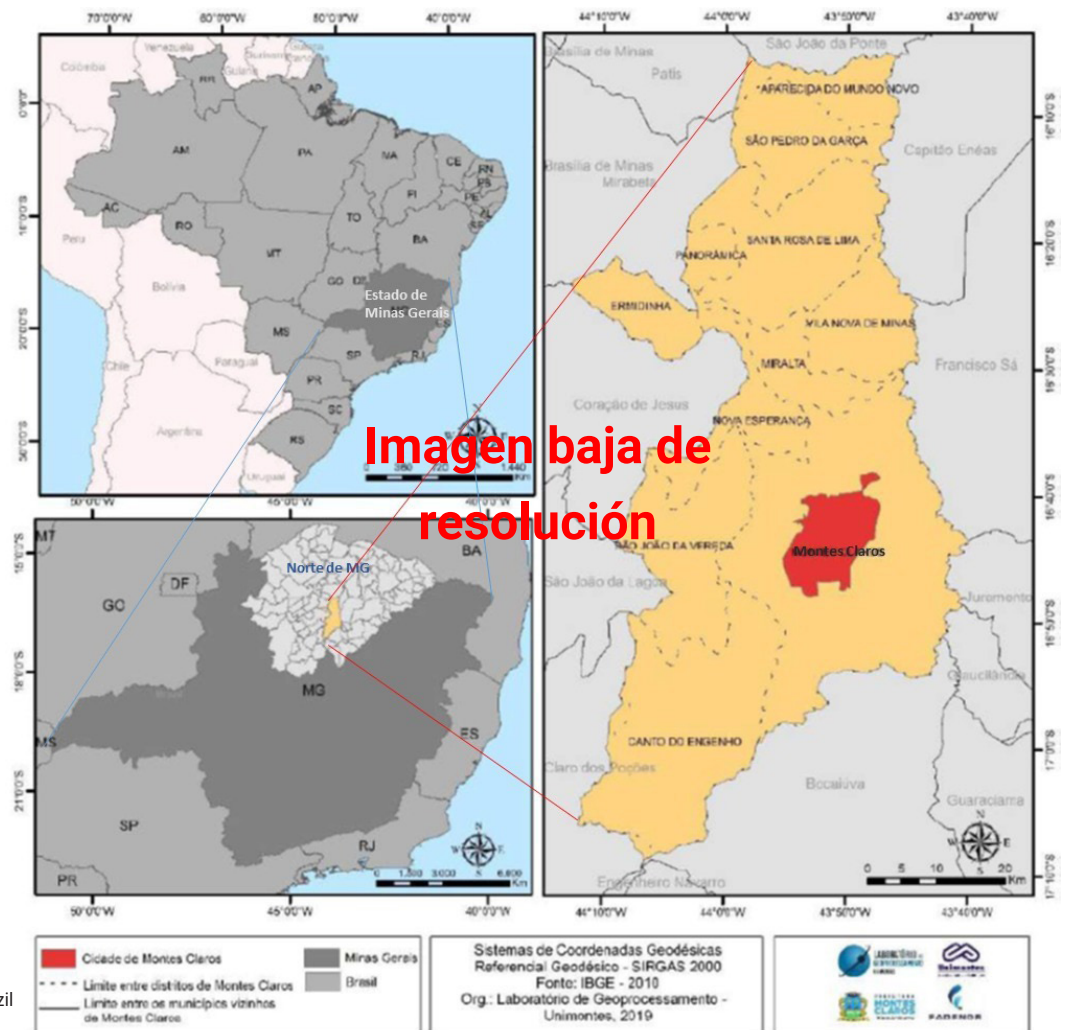
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Figure 1. Location of Montes Claros, MG, Brazil
Source: Montes Claros-MG, 2021.

According to França (2020), the urban expansion in Montes Claros occurred horizontally until the 1990s (sprawling of the urban fabric due to rapid and intense city growth). An intense process of urban verticalization through the occupation of vacant areas occurred from the year 2000 onwards, as illustrated in Figures 2 and 3.

The urban structure of Montes Claros undergone significant transformations throughout the 1990s, shifting from a mononuclear structure (with a single center concentrating commerce and services) to a polynuclear urban structure, thus configuring the decentralized model (Gomes, 2007). Nevertheless, the dynamics of this process of urban expansion with decentralization occurred conservatively, preserving the "ritual" and principles of the capitalism exploitation, aimed at reservation price and real estate speculation (Lukas & López-Morales, 2018). França (2020) observed that the expansion of Montes Claros has been directed towards the south, east, and west sectors since 1980, characterized by particular features: to the south of the city, low-income families and immigrants from neighboring cities predominate, forming densely populated neighborhoods, such as Major Prates and Maracanã; to the west of the city, there is a higher concentration of high-income population, as in the Ibituruna neighborhood (intense land development between 1990 and 2000); and to the east of the city, the Independência neighborhood stands out as one of the most populous neighborhoods, where a low-income population is concentrated due to the low urban land value.

According to Figure 2 and 3, the axes primarily connect the central area and its consolidated surroundings to new centers, with "vocations" for several businesses and services, especially shopping centers, supermarkets, and hotels.

Currently, the process of verticalization in Montes Claros is spreading to avenues that serve as axes for the development of several economic activities, such as the foothills of Serra do Mel. The launch of the Minha Casa Minha Vida Program between 2009 and 2015 and the creation of residential areas to meet the demands of so-
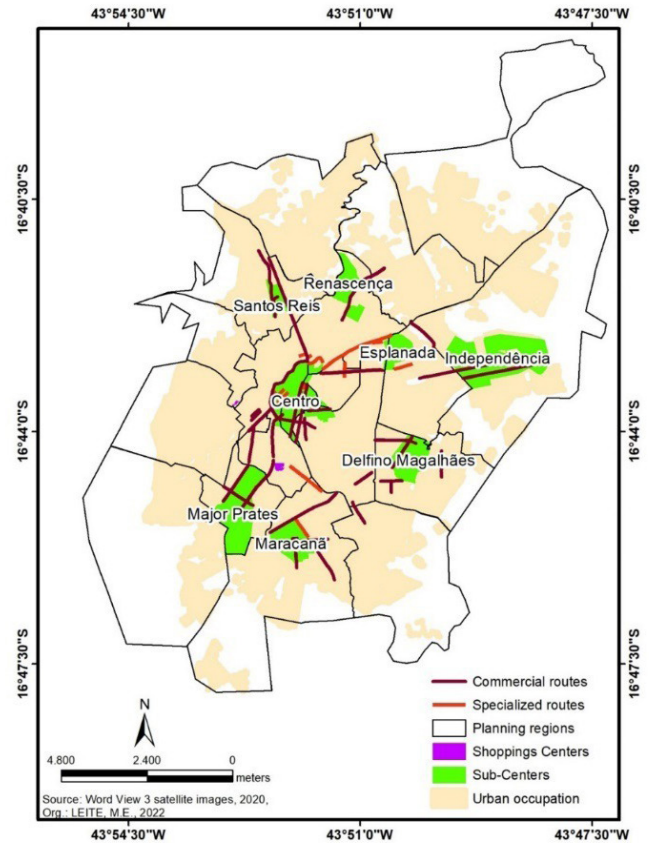
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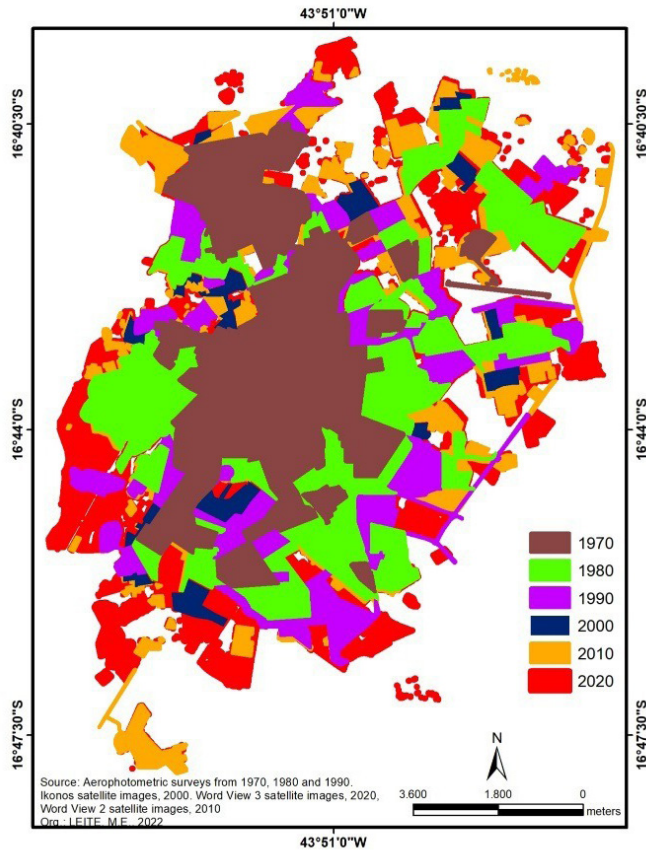
Figure 2. Urban Expansion Evolution of Montes Claros, MG, from 1970/2020
Source: Leite & França (2022)

Figure 3. Recent Urban Expansion Axes in Montes Claro, MG
Source: Leite & França (2022)

cial housing intensified the horizontal urban expansion. Montes Claros has more than 90,000 households in the urban area, with 60% of trips originating or ending in the city center, resulting in an average total travel time of 35 minutes. This has resulted in the emergence of subcenters in regions of high demographic density.

Thus, the guidelines of the Montes Claros' CMP seek to balance land use and occupation through urban densification and agglomeration policies, prioritizing intermodal public transport, with shorter commutes compared to economic guidelines.

City Master Plan Results on Urban Morphology and Development in Montes Claros

The data obtained were subjected to a normality test, using the software PAST 4.3, which showed that they did not follow a normal distribution. Thus, they were normalized through logarithmization. Subsequently, some statistical correlations between variables were evaluated. Spearman's correlation was chosen, which varies from -1 to +1, representing highly unfavorable and highly favorable correlations, respectively, as Pearson's correlation;

values closer to zero indicate moderate correlation (either negative or positive). The variable Land Use has a high positive correlation with Employment (79.24%) but is virtually insignificant in relation to Population (-3.85%) and Investments (-10.53%). This may indicate a need for adjustments in urban planning policies related to public infrastructure investments.

The explanatory importance of each variable is represented in Figure 4 by the length of the arrow and the quadrants; the shorter the arrow, the less the significance. In this case, the variables Employment and Land Use are much more significant than Trip Generation and all other variables. Investments has an adverse (opposite) effect on population size, income level, and transportation supply. However, when considering the dispersion of planning regions (PRs), only Center and São José (STJ).

The data analysis also denoted that Montes Claros does not have significant urban concentration among the 19 PRs. The spatial concentrations of businesses and households, obtained by the Herfindahl-Hirschman Index (IHH), were 1885 and 793, respectively. According to Hirschman's parameters, indices above 1800 indicate a very moderate concentration of commercial facilities.
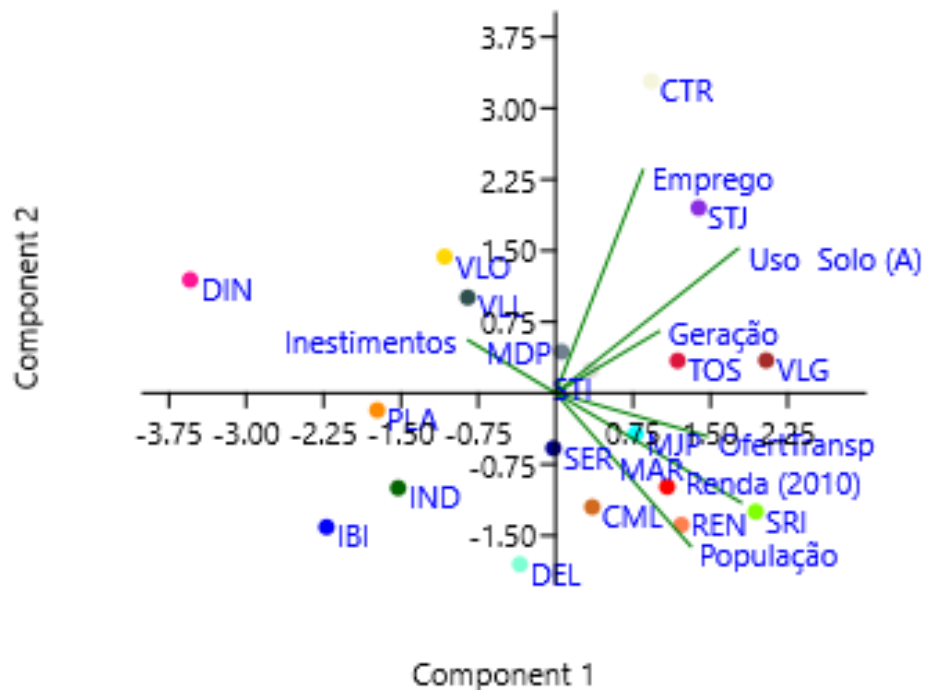
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Figure 4. Scatter Plot
Source: The authors.

This is useful in terms of land use and occupation. Considering the perspective of wealth concentration, the Gini index (G) found was 0.93 (highly concentrated), highlighting the PRs Santa Rita and Vila Guilhermina; the Center showed less significance.

According to Yan & Wang (2022), while the degree of polycentricity representes the spatial distribution of economic activity between the main cities within an urban area, the degree of agglomeration refers concerns the spatial distribution of economic activity across all cities within an urban area. From this perspective, a degree of agglomeration of 0.56 was obtained among 19 PRs.

The spatial concentration of economic activities in Montes Claros has been reduced by half in the last two decades (2001 to 2021); it was 0.36 (2001-2010) and decreasing to 0.17 (2011-2021). Based on performance expectations of the economy of the state of Minas Gerais (JPF, 2021), projections could be made for Montes Claros-MG, despite the dynamics of the spatial distribution of economic activities. According to this indicator, the data obtained corroborate the assumption that the guidelines established in the City Master Plan of 2005 and reformulated in 2016 regarding decentralized urban development have been fulfilled, producing some effective transformations.

The compactness index and diversity are ubiquitous criteria in the literature on urban structure (morphology). Based on formulations by Song et al. (2018), Montes Claros has a compactness index of 0.658, considered moderate. Center, followed by Todos os Santos, and Maracanã, have the highest indices (above 0.75) among the 19 PRs.

Diversity is a key dimension in the analysis of polycentricity, as stated by Huang et al. (2020), Meijers (2008). An adaptation of the formulation by Huang et al. (2020) was made for this study; therefore, the calculations were performed using the variable Employment observed in each PR, resulting in a value of 0.081. An urban diversity value of 0.177 was found, when considering the diversity approach described by Cervero et al. (2009), which considers the proportion of non-residential to residential areas. Other formulations for detecting polycentricity regarding urban diversity consider the Channon entropy index as relevant and imperative (Meijers, 2008); this index is also mentioned in the works of Purvis et al. (2019) and Zambon et al. (2017).

The variable Residents Living in each PR was used in this study; the urban diversity value found was 1.384, which is a very close result to that obtained when, by ab-

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straction, the variable Population was replaced by Number of Companies in Each PR. This approach was used to analyze the dynamics of these polycentricity indicators regarding physical infrastructure and urban densities, as they are responsible for the set of generated trips, which consequently affects the local economy dynamics.

Shannon's formulation was also used to assess the dynamics regarding urban mobility, through the variable Trip Generation in each PR. The Shannon index found was 0.636. Considering a locality point of view, the Center (index of 3.0) and Santos Reis (1.33) had the higher indices, whereas Renascença and Via Oliveira (0.167 and 0.111, respectively) presented less connections, i.e., less access to urban public transport lines.

According to a mesoscopic analysis of accessibility and the impact of this indicator on land use, the access to employment and services is much better in São José and Vila Guilhermina, and worse in Delfino and Ibituruna. The best offers of urban public transport are in the Center, where all lines cross, followed by Major Prates (7.529), Carmelo (7.407), and Renascença (7.334). Industrial District-1 and Ibituruna account for the most significant UPT deficiencies, with 1.545 and 1.638, respectively.

The emergence of motorcycle taxis as an option for short and quick commutes in response to the rigid itineraries of UPT was not elastic; i.e., the concept of cross-price elasticity of demand was used to explain the possibility of shifting trips from UPT to motorcycle taxis, considering the assumption that the availability of public transport networks is in dissonance with the lines desired by users, and these are in accordance with the service economy growth. This indicator was 0.43 (inelastic) during the period from 2005 to 2021, despite significant elastic responses observed in 2012 and 2014.

Conclusions

This research focused on understanding phenomena that explain the transformations in the urban morphology of Montes Claros, MG, Brazil, from 2001 to 2021, based on legal measures embodied in the City Master Plan (CMP) of 2005, updated in 2016. The complexity of the research lay in the fact that it involved elements related to urban planning and local economy vis-à-vis the availability of robust data and information to support the formulated arguments. Therefore, a combination of applicable methods was used to identify and describe the phenomenon and produce conclusive insights, well founded in the scientific literature on urban morphology, polycentricity, mobility, transportation systems, and the performance of

the local economy. As a premise, the urban development of Montes Claros maintains a direct and positive relationship with the CMP guidelines, reflecting on local economic dynamism and vice versa.

Exploratory research made it possible to find studies on the topic that contributed to developing a critical thinking capable of supporting the understanding of the "size" of this relationship, i.e., whether the efforts resulting from the CMP guidelines have produced results in terms of polycentricity. However, the fragility of data regarding quantity and continuity required the use of statistical arrangements and other indicators well-established in the literature, including urban diversity, degree of agglomeration, elasticity. The PAST 4.3 software package has proven to be a powerful and user-friendly statistical tool in several fields of study.

Montes Claros has undergone significant socioeconomic transformations in its social and spatial tissue in the last twenty years, with a relative weight in the process of decentralizing its urban development while preserving the features deified by the capitalist mode of exploitation of urban space and territory. Considering this perspective and the compliance with the City Statute (Federal Law No. 10,257 of July 10, 2001), the government of Montes Claros formulated and implemented a City Master Plan in 2005, which was updated in 2016. The urban area of Montes Claros was divided into 11 planning regions (PR) until 2010, increasing to 19 PRs from 2015 to 2016. These territorial rearrangements facilitate the adoption of more effective public policies for urban development and for the local economy, based on identifying the specific needs of each subdivision and the (re)design of a whole package of stressors for sustainable development associated with high concentration (congestion, noise and air pollution, social and economic determinants of mental health, accidents, among others).

The findings of this study significantly contribute to technical and scientific knowledge, complementing several research studies that have been developed in the territory of Montes Claros, including those by França (2020), Gomes (2007), and Leite (2020). From a practical point of view, the present study provides information to support local authorities in urban planning and development and has the potential for replication in other regions or intermediate cities.

The use of different methods to assess a particular phenomenon has proven to be significantly useful. In fact, finding results that converge and align with internationally established literature reinforces understanding and exploratory insights. This was the case for the morphological transformations in Montes Claros-MG, which

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showed a moderate rigidity in relation to the most recent CMP, considering the volume of available data. However, when the use of different methods results in substantial divergences, further reviews are necessary, which is the opposite of the present study.

As recommendations, we suggest further research on this topic with the application of multi-criteria methods using more robust data. Experts and local academic and political communities could be consulted through interviews or structured questionnaire forms. Tools such as Smart-PLS, Fuzzy-AHP, and system dynamics modeling could reveal many insights into causal or hierarchical relationships within urban morphology and local development resulting from the implementation of City Master Plan guidelines.

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