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Resumo: Este trabalho mediu a atratividade de municípios do estado de Minas Gerais (MG) para projetos nos segmentos de siderurgia, celulose e papel, móveis, energia e painéis de madeira. Por meio de um questionário, foi construído um índice de atratividade do setor florestal para cada município. Como resultado, verificou-se que 40% dos municípios apresentaram atratividade "média" ou superior. As mesorregiões com maior potencial para o desenvolvimento da silvicultura foram a Região Metropolitana de Belo Horizonte, o Sudoeste de Minas e a Zona da Mata. Os segmentos de siderurgia e celulose e papel encontraram fatores de atratividade em 74,08% e 72,79% dos municípios, respetivamente. Concluiu-se que a metodologia aplicada mostrou o quanto uma localidade estava próxima de atender às características das indústrias de base florestal. Espera-se incentivar futuras pesquisas e influenciar o planejamento estratégico para a expansão do setor florestal no país.

Palavras-chave: Política florestal. Indústria florestal. Planejamento florestal.

Abstract: *This paper measured the attractiveness of municipalities in the state of Minas Gerais (MG) for projects in the steel, cellulose and paper, furniture, energy and wood panel industry segments. A questionnaire was used to construct an index of attractiveness of the forestry sector for each municipality. As a result, it was found that 40% of the municipalities presented "average" or higher attractiveness. The mesoregions with the greatest potential for forestry development were the Belo Horizonte Metropolitan region, Southwestern Minas and Zona da Mata. The steel and cellulose and paper segments found attractive factors in 74.08% and 72.79% of the municipalities, respectively. It was concluded that the methodology applied showed how close a location was to meeting the characteristics of forest-based industries. It is expected to encourage future research and influence strategic planning for the expansion of the forestry sector across the country.*

Keywords: *Forest policy. Forestry industry. Forest planning.*

Resumen: *Este trabajo midió el atractivo de los municipios del estado de Minas Gerais (MG) para proyectos en los segmentos de la industria siderúrgica, celulosa y papel, muebles, energía y paneles de madera. Se utilizó un cuestionario para construir un índice de atractividad del sector forestal para cada municipio. Como resultado, se constató que el 40% de los municipios*

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presentaban un atractivo "medio" o superior. Las mesorregiones con mayor potencial de desarrollo forestal fueron la Región Metropolitana de Belo Horizonte, el Sudoeste de Minas y la Zona da Mata. Los segmentos siderúrgicos y de celulosa y papel encontraron factores de atracción en el 74,08% y 72,79% de los municipios, respectivamente. Se concluyó que la metodología aplicada mostraba lo cerca que estaba una localidad de reunir las características de las industrias de base forestal. Se espera que fomente futuras investigaciones e influya en la planificación estratégica para la expansión del sector forestal en todo el país.

Palabras clave: *Política forestal. Industria forestal. Planificación forestal.*

INTRODUCTION

Forest products are present in many aspects of people's daily lives, whether in the steel used in construction, the different types of paper used throughout the day, or the furniture inside the house. Wood is the raw material of several industries, such as pulp production, steel, wood and sawn wood panel production, and furniture manufacturing, as well as an energy generator through charcoal and firewood consumption, among other industries, which together characterize the forestry sector. In Brazil, planted forests span practically all states in varying concentrations and species (usually Pinus sp. or Eucalyptus sp.). Forest-based enterprises are more concentrated in the south, midwest, southeast and recently in the northeast of the country (COELHO JUNIOR et al., 2010; IBÁ, 2019, MARTINS et al., 2018; SUELA et al, 2023).

The state of Minas Gerais (MG), where the present study is focused, stands out in the charcoal steel sector but falls short in the cellulose and wood panel sector when compared to other states (IBÁ, 2019; IBGE, 2019; SINDIFER, 2020). Although Minas Gerais is at the forefront in terms of the area planted with forests, the number of investments made in its territory has not kept pace with this growth and is sometimes directed to other states or even other countries (SEBRAE-INAES, 2014). The last major investment in the state was in the 1970s, with the establishment of the Celulose Nipo-Brasileira S/A (Cenibra) pulp mill in Belo Oriente (ALMG, 2017). During the same period, states such as Mato Grosso do Sul and Bahia opened new pulp mills and invested in forest plantations (ELDORADO CELULOSE, 2015; FONTES, 2014; PREFEITURA DE TRÊS LAGOAS, 2014; SUZANO, 2020).

Investments in plantations were also made in Maranhão and Piauí to supply Suzano's demand (SEBRAE-INAES, 2014). Only in 2018 did the new cycle of large investments in the MG territory begin, with the announcement of Duratex's Joint Venture with the Austrian company, Lenzing, to build a new soluble cellulose plant (LD Celulose) in the mining triangle between Araguari and Indianópolis (DURATEX, 2018). This “escape” of state enterprises to other regions stimulated this research on: what decision-making criteria are used to select a location? How the state of MG fits into these criteria, and which regions/municipalities present the industries’ desired conditions?

To answer these questions, a methodological proposal was developed based on measurable municipal characteristics to identify regions/cities with greater attractiveness to 5 different segments of the forestry sector: Cellulose and paper, steel, furniture (predominantly wood), energy (charcoal and firewood), and wood panels. For this purpose, locational criteria were used, which were factors that influenced investment location decisions. Some examples of these factors were proximity to markets, favorable working climates, locations of competitors, quality of life, essential services, and government incentives (ALVES AND ALVES, 2015; OLIVEIRA et al., 2020; SANTOS JUNIOR et al., 2022; MOREIRA et al., 2017; NOORT AND REIJMER, 1999; REZENDE AND OLIVEIRA, 2013; RAHMAN AND KABIR, 2019). However, in general, the best location is the one that provides the greatest benefit to the company, whether in obtaining inputs, in the production process, in the consumer market, or even in socioeconomic, political, and environmental aspects (ALVES AND ALVES, 2015; NUNES et al., 2023).

By studying which criteria companies use to select their location, we sought to understand how the attractiveness of cities in the state of Minas Gerais is distributed. The article is structured in three sections, in addition to this

introduction. The second section describes the indicators and questionnaire used. This is followed by the results and discussion by sector and a general analysis. It ends with a conclusion.

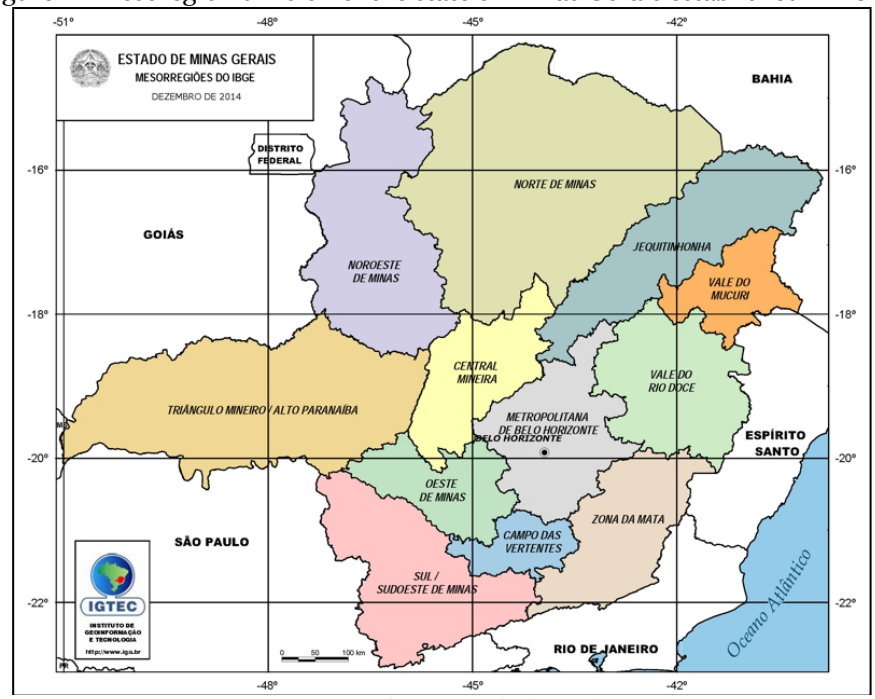
2 –METHODOLOGY

The methodology consisted of two parts: the first part involved sending the questionnaire to wood-consuming companies to score the criteria previously identified in the literature, and the second part applied this score to the indicators to generate a Municipal Attractiveness Index (MAI).

2.1 - Study area and population

The study was carried out for the state of Minas Gerais, the fourth largest Brazilian state in size and the first in the number of municipalities (853 municipalities). With respect to the forestry sector, the state has the largest area of planted forests in the country and the largest silvicultural production (R$ 4.39 billion) (IBGE, 2019). The data were analyzed according to the mesoregion division proposed by the IBGE for the state of Minas Gerais (Fig. 1).

Figure 1 - Mesoregion division of the state of Minas Gerais established in 2014.



Source: Minas Gerais (2020).

The questionnaire was sent by email to companies in the forestry sector within the state of Minas Gerais. The email addresses were obtained from a list of companies associated with the Union of the Pulp, Paper and Cardboard Industries in the State of Minas Gerais (SINPAPEL, in Portuguese), the Forestry Industry Association of Minas Gerais (AMIF, in Portuguese), professional contacts in the area and companies registered on the "Minas Gerais Industrial Registry" website organized by the Minas Gerais Industrial and Business Center (CIEMG, in Portuguese) and the Minas Gerais State Federation of Industries System (FIEMG, in Portuguese). The selected segments were the steel, pulp and paper, energy

(charcoal and firewood), wood panel, and furniture (furniture with a predominance of wood) industries. In total, 868 e-mails were collected, 761 from the wooden furniture sector and the remaining 107, corresponded to the other sectors. Questionnaires were sent to all the obtained e-mails.

To determine how the forest-based companies choose where to install their operations, a questionnaire was emailed to these industries, listing possible criteria that could interfere with the choice of where to locate a plant. The questionnaire was divided into five parts (social, environmental, municipal, economic, and business aspects), in addition to asking for general information on the market in which the respondent operates and its position. Twenty-six criteria were determined based on previous research (REZENDE AND OLIVEIRA, 2008; SEBRAE-INAES, 2014; VIANA, 2016), and the questionnaire was subsequently sent to postgraduate students, professors, and engineers with experience in the private sector for validation. Each criterion was assigned a value of 1 to 5 according to its importance (relevance) in the decision of locational investment, with (1) being that the variable was irrelevant, (2) not very important, (3) important, (4) very important, and (5) essential. Some criteria were also detailed to determine which situation was desirable (TABLE 1). Six criteria were descriptive questions.

In this first part of the work, we sought to create a locational profile based on measurable variables that could be used to represent investor preferences on the characteristics of places where investments are implemented. The responses to the questionnaire were analyzed for each industrial segment of the forestry sector, including wooden furniture, cellulose and paper, steel, wood panels, charcoal, and firewood.

2.2 - Selection of indicators

The indicators used to calculate the attractiveness of the Minas Gerais municipalities were based on the works of Bomfim (2014), on the methodology used by Sebrae-Inaes (2014) to assess the attractiveness for forestry investment in the state of Minas Gerais, and on the questionnaire responses. The indicators were selected according to their availability at the municipal level, periodicity, and reliability (government agencies and recognized foundations). Twelve indicators were created from 25 variables (S1 Appendix). The combined analysis of the indicators resulted in the Municipal Attractiveness Index used in the present work. The data used to develop the indicators were collected between April and May 2020.

Average Annual Gross Domestic Product (GDP) Growth Rate

For the present work, we chose to use the GDP growth rate, as opposed to using the annual GDP, as a way of measuring the evolution of municipal production over time (CALLEN, 2020). For the calculation of this indicator, the Eq. 1 and data from 2015 and 2017 obtained from the website Portal Receitas of the Court of Accounts of the State of Minas Gerais (RECEITAS, 2020) were used. After calculating the annual growth rate, the data were normalized as explained in the next section (topic 2.5).

$$Tc = \left(\left(\frac{Vf}{Vi} \right)^{\frac{1}{t1-t0}} - 1 \right) * 100 \qquad (1)$$

where, Tc is the annual growth rate (%); Vf is the value of the last year in the analyzed range; Vi is the value of the first year in the analyzed range; to is the starting year; and t1 is the final year.

Table 1 - Questionnaire on the degree of importance of preselected variables in making business decisions on selecting investment locations.

Criteria	Level of importance	Desirable situation
Human development index	1 2 3 4 5	-
Availability of local workforce	1 2 3 4 5	-
Specialization of the workforce	-	Primary education Secondary education Higher education Technical Specialized
Existence of schools in the municipality	1 2 3 4 5	-
Municipal environmental council	1 2 3 4 5	-
Municipal environmental laws	1 2 3 4 5	-
Environmental conservation unit	1 2 3 4 5	Present Absent Indifferent
Indigenous communities, quilombolas and/or archaeological sites	1 2 3 4 5	Present Absent Indifferent
Size of the municipality	1 2 3 4 5	Small municipalities Large municipalities Indifferent
Urbanization rate	1 2 3 4 5	Higher concentration of people in the city Higher concentration of people in the countryside
Municipal infrastructure	1 2 3 4 5	-
Presence of other wood-consuming companies	1 2 3 4 5	Sequence in the production chain Same line of business Absence of companies in the same line of business Indifferent
Municipal revenue	1 2 3 4 5	High collection Low collection
Tax incentives and subsidies	1 2 3 4 5	-
Value of municipal tax	1 2 3 4 5	-
Price of land	1 2 3 4 5	-
Proximity to state and federal highways?	1 2 3 4 5	-
Proximity of the plant to railroads?	1 2 3 4 5	-
Proximity of the plant to watercourses?	1 2 3 4 5	-
Own plantation	Descriptive	-
Fostered or leased	Descriptive	-
Relevance of local slope	1 2 3 4 5	-
Willingness to plant on slopes greater than 25 degrees	Descriptive	-
Wood species used	Descriptive	-
Maximum distance to raw material?	Descriptive	-
Maximum acceptable distance from the consumer market	Descriptive	-

Source: Prepared by the authors.

Human Development

This indicator sought to evaluate the socioeconomic development of the municipalities, and for that purpose, the FIRJAN index of municipal development was used, which, unlike the Human Development Index (HDI), has an annual frequency and analyzes the areas of Employment and Income, Health and

Education (FIRJAN, 2018). As it is an index and its scale is standardized between 0 and 1, normalization was not necessary.

Tax Burden on Municipal GDP

The tax burden represents how much money is taxed by the government in relation to the economic value and is calculated as the ratio between tax revenue and GDP (KHAIR et al., 2005). The tax revenue used in this work was provided by Portal Receitas (2020) for the year 2017 (a site designed to monitor and supervise municipal tax collection) and considers taxes on equity (urban predial and territorial tax (IPTU), property transfer tax (ITBI), rural land tax (ITR-Convênio), income tax (withholding income tax), taxes on circulation of services (ISS), fees, contribution improvement and other taxes (RECEITAS, 2020). The GDP was obtained from the same source for 2017. The data were normalized and reflected according to Eq. 2. The reason for this is because the indicator is inversely proportional to the ventures' desires, that is, the higher the tax level is, the lower the attractiveness of the place to new ventures.

$$R = 1 - N \quad (2)$$

where, R is the reflected value and N is the normalized value.

County Size

The size of the municipality is related to the area available for the expansion of planted areas and influences the number and size of industrial groups, favoring the formation of economies of scale, specialized work, and wholesale and purchase markets (KARASKA, 1969; RIBEIRO, 1982). Municipalities with environmental laws determine the percentage of the area that can be purchased by foreigners or even restrictions on the cultivation of some crops. For this indicator, data from the municipal area available in the Minas Gerais Social Responsibility Index (IMRS, acronym in Portuguese) for 2018 were used (IMRS, 2020). After downloading the data, they were normalized.

Rate of Urbanization

The urbanization rate represents the amount of the population living in the urban area in relation to the total population. Urbanization, with its associated investment in institutions and infrastructure, has the potential to accelerate economic growth by creating wealth, improving the quality of life, facilitating access to credit and, at the same time, maximizing production, reducing production costs by reducing transaction costs and internal specialization (NGUYEN AND NGUYEN, 2018; GLAESER, 2013; KRENZ, 2019; KUMAR AND KOBER, 2012; ROBINSON AND SWILLING, 2012). This indicator sought to understand which type of population (rural or urban) was most targeted by each sector. Urbanization is also related to the growth of cities and the rural exodus. IMRS data from 2018 on the urbanization rate were used. After downloading the data, they were normalized.

Municipal Economic Infrastructure

With this indicator, we sought a means of measuring municipal development that encompassed social, economic, and sustainable characteristics. The Sebrae Local Economic Development Index (ISDEL, acronym *in Portuguese*) was used for this purpose. This index was created to "represent the dimensions of development in quantitative terms" (ISDEL, 2020). To that end, it synthesized data from the five dimensions responsible for promoting local economic development, namely, entrepreneurial capital, business fabric, governance for development, productive

organization, and competitive insertion. As this index was ready and used the same standardization methodology as that in the present study, it was not necessary to normalize it. Data from the 2018 publication, referring to 2016, were used.

Legal Environmental Infrastructure

Municipal environmental councils (ECs) have emerged as a way to include local interests in the environmental management process, aiming at sustainable development and better control and use of natural resources (CASTRO et al., 2019; FERREIRA AND FONSECA, 2014). This indicator sought to assess the legal environmental support in the municipality, which consisted of the existence of an EC and its environmental legislation. The data were obtained on the IMRS website for 2018. The scores used for to assess environmental legislation were 0 (no environmental legislation) and 1 (has environmental legislation). The score used for the EC was slightly different, as there were municipalities that had a council, but it was inactive. Thus, the score was 0 for municipalities without a council, 0.5 for municipalities with inactive councils and 1 for municipalities with active councils.

Availability of Qualified Labor

For this indicator, we sought to gather information that would help measure the qualification and availability of the workforce. For this, the following data were used: a) Percentage of the unemployed population, b) Average monthly salary of official workers and c) Number of higher education institutions (universities), technical and/or professional. The first two were obtained from the *Portal Receitas*. For the latter, the official websites of the institutions were used to search for the addresses of the units. Data on universities were obtained from the website of the Ministry of Education and Culture (MEC, 2020). The percentage of unemployed persons was calculated by inverting the values of the employed population by the municipality.

The number of educational institutions per municipality was calculated by adding all the institutions analyzed. The three variables were normalized. After normalization, weights were added using 0.4, 0.4, and 0.2 for the percentage of unemployed persons, average salary, and educational institutions, respectively.

Transport System

The transport systems most used for cargo transportation in Brazil are roads and rail, so we chose to consider only these in the survey. For this indicator, the municipalities received a score of 1 when a transport network passed through the municipality and a score of 0 when it was absent. The score was applied to both modes of transport. The data were processed in a geographic information system (ArcGIS) using the *select-by* attributes tool, the attribute being the layer of the railway/road network. The shape of the transport meshes was obtained on the government platform of the state of Minas Gerais IDE-SISEMA website on August 20, 2020.

Forest Resource

Wood itself has a low specific value (that is, its value in relation to its volume is low), so proximity to the source is important, as the cost of transporting this commodity is high, depending on the distance to be covered (DJWA, 1960; RENNER, 1947; SILVA et al., 2007).

The purpose of this indicator was to measure the availability and/or existence of native vegetation that could be sustainably used. For the calculation of this indicator, data on the following were obtained: a) municipal area, b) percentage of

the area with native vegetation coverage, c) areas destined for indigenous reserves, d) areas destined for full protection conservation units (UCs), and e) area coverage of planted forests. All of these data, except for the planted area that was obtained from the 2018 data of the Production of Vegetable Extraction and Silviculture (PEVS *in Portuguese*) (IBGE, 2019), were obtained from the IMRS 2018 data. First, the percentage of the area covered with native vegetation was converted to hectares using the area of the municipality as a reference. Subsequently, the UCs and indigenous areas were removed from the area of native vegetation. After this calculation, the percentage of native vegetation in the municipality was recalculated considering this new value. Then, normalization was performed. With the normalized data, Eq. 3 was applied to calculate the index.

$$FR = PFA * 0{,}75 + NFA * 0{,}25 \quad (3)$$

where, *FR* is a forest resource; *PFA* is planted forest area; and *NFA* is native forest area. For planted forests with a very high amplitude, a score between 0 and 1 was adopted at intervals, as shown in the table below (TABLE 2). Municipalities that did not have planting data were scored as 0.

Table 2 - Score by the range of area (ha) planted.

Range (ha)	*Score*
0	0
Between 1 and 99	0,166
From 100 to 999	0,333
From 1.000 to 4.999	0,500
From 5,000 to 9,999	0,666
From 10,000 to 49,999	0,833
Above 49.999	1

Source: Prepared by the authors.

Domestic Market

The data used for this indicator were a) the 2017 municipal GDP, obtained from *Portal Receitas*, b) the quantity of firewood, charcoal, and wood produced in the municipality, and c) amount collected from these products. The latter two were obtained from 2017 data from IBGE (2019). To prepare the indicator, the "forest market" variable was first calculated using the ratio between the amount collected from forest products and the municipal GDP. Then, the average production in cubic meters (sum between firewood, charcoal and roundwood) between 2017 and 2018 was calculated, generating the "average production" variable. To convert the data from charcoal to cubic meters, a yield rate of 30% was used for the transformation of charcoal into firewood (CGEE, 2010) and a rate of 1.19 was used for the transformation of tons to cubic meters for eucalyptus (IEF, 2012). Before taking the average between the "forest market" and "average production" variables, both variables were normalized. To normalize "average production", the table below was used (TABLE 3).

Forestry Vocation

The variables selected to measure this indicator were a) climate vulnerability index, b) hot spots, c) agricultural cover, d) concentration of cattle and e) planted forests. The first variable was obtained on the "Territorial Vulnerability - General climates" website (CLIMA GERAIS, 2015), which was a survey conducted between 2014 and 2015. As an index having a scale of 0 to 1, normalization was not necessary, but the index was reflected so that the municipalities with the highest scores would be

those with the lowest vulnerability. The other variables were obtained from IMRS (2020) using data from 2018. The heat focus data were also reflected after normalization.

Table 3 - Scoring by production interval (sum of firewood, charcoal and roundwood).

Range (m³)	*Score*
0	0
Between 1 and 499	0.166
From 500 to 999	0.333
From 1,000 to 99,999	0.5
From 100,000 to 499,999	0.666
From 500,000 to 899,999	0.833
Above 899,999	1

Source: Prepared by the authors.

Except for planted forests, the rest of the variables were normalized. In the case of planted forests, 0 (no planting) and 1 (presence of forest planting) were used to characterize the municipalities. Minas Gerais ranks third among Brazilian states in the number of livestock heads (herd) and it is the first in milk production (SEAPA, 2020), so the variable data were not inverted (that is, the smaller the concentration of livestock is, the more attractive to forest industries) because it was assumed that areas with a higher livestock density were more likely to have areas with some level of degradation that could be used for planting eucalyptus. After structuring the data, weights were assigned to each variable according to the Eq. 4 below.

$$FV = CV * 0{,}3 + HP * 0{,}2 + CA * 0{,}2 + CB * 0{,}1 + FP * 0{,}2 \quad (4)$$

Where, FV represents forestry vocation; CV represents Climate vulnerability; HP represents hot spots; CA represents coverage by agriculture and livestock; CB represents the concentration of bovine herds; and FP stands for planted forests.

2.3 - Normalization of indicators and generation of the attractiveness map

As the indicators were developed using data of different units and scales, it was necessary to convert all the data into the same base unit/scale, thus allowing the comparison between them. Normalization serves this purpose (OECD, 2005). Several methods can be used for this purpose, such as ranking, rescheduling, and standardization. For the present work, the rescheduling normalization method was chosen (OECD, 2005), using the Eq. 5 described below. The same equation was also used by Sebrae-Inaes (2014) and Bomfim et al. (2014).

$$Vn = \frac{(Vi - Vpiso)}{(Vteto - Vpiso)} \quad (5)$$

where, Vn represents the value after standardization; Vi is the original value of variable i; Vpiso is the lowest observed value among the values of variable i; and Vteto is the highest value observed among the values of variable i.

The indicators were weighted based on the responses obtained in the questionnaire as described in Table 4. The forest resource and forest vocation indicators that did not have a directly related question in the questionnaire so they received a weight of 3. It is worth mentioning that for the transport system and environmental infrastructure indicators, the variables were individualized and weighted individually with the weights assigned to the questionnaire questions. To

obtain the final result (municipal attractiveness index), the weighted average of all the indicators was calculated, that is, each indicator was multiplied by its respective weight, all indicators were added up and then was divided by the sum of the weights. This process was done for each of the sectors analyzed.

For the GDP growth rate, municipality size, and urbanization rate indicators, the indicator was reflected according to the descriptive answer, which meant that the normalized values observed for the indicator were subtracted from 1. This was necessary because the highest value represented the best situation for the enterprise. Thus, if the response to the municipality size index was "small", the indicator was reflected so that the highest values in the index corresponded to the smaller municipalities. The final weight of the responses was determined by the majority of responses obtained; when there was a tie, the average was calculated and rounded up and when there was no consensus in the responses, the value of highest importance was adopted.

After calculating the municipal attractiveness index, it was classified in terms of attractiveness and analyzed by attractiveness class and mesoregion. The geographic information system (ArcGIS) software and the shape of the Minas Gerais municipality boundaries obtained on the IDE-SISEMA website were used to prepare the maps. The data were attached to the shape by the Join tool and classified into 5 classes as follows: Very Low (for values below 0.400), Low (from 0.400 to 0.499), Medium (from 0.500 to 0.599), High (0.600 to 0.699) and Very High (above 0.699).

Table 4 - Questions that served as a basis for the creation of the indicators and the questions whose answers were used to give weight to the indicators.

Indicator	**Basic question**	**Weight (answer to question)**
GDP growth rate	14 Municipal revenue	Municipal revenue
Human development	1 Human development index	Human development index
Tax revenue over GDP	15 Value of municipal tax	Value of municipal tax
Municipality size	10 Size of municipality	Municipality size
Urbanization rate	11. Urbanization rate	Urbanization rate
Municipal economic infrastructure	12 Municipal infrastructure	Municipal infrastructure
Environmental legal infrastructure	5 Municipal environmental council 6 Municipal environmental laws	Municipal environmental council Municipal environmental laws
Availability of skilled labor	2 Availability of labor 3 Labor level 4 Presence of schools	Availability of labor
Transportation system	17 Proximity to state and federal highways 18 Proximity to railroads	Proximity to state and federal highways Proximity to railroads
Forest resource	7 Environmental Conservation Unit 8 Indigenous communities	3
Domestic market	13 Presence of other wood-consuming companies	Presence of other wood-consuming companies
Forestry Vocation	Other factors affecting forest planting (climate, occurrence of fires, existence of planted forests, agriculture and livestock)	3

Source: Prepared by the authors.

3 - RESULTS AND DISCUSSION

3.1 Questionnaire

There were 25 responses to the questionnaire, 13 of which were from the furniture sector, 4 from the steel sector, 3 from the energy sector, 2 from the panel sector, and 2 from the cellulose sector (TABLE 5). What may have contributed to the low number of responses was that some emails bounced back as "address not found", the recipient may not have known enough about the subject, or the email may have been forwarded to spam. With the questionnaire, it was possible to verify the preferences and differences between the sectors analyzed. The steel, energy, cellulose and paper sectors showed similar behaviors in the scored criteria. The furniture and wood panel sectors were different from the others. While the first was less selective about the installation location of its factory, the second showed the opposite behavior, showing greater care in selecting their location criteria for all sectors except the furniture sector, the criteria showed some degree of importance, scores from 2 (not very important) to 5 (essential).The furniture sector had the lowest scores of importance for the analyzed criteria. For this sector, the most relevant criteria were availability of "labor", "size of the municipality", "infrastructure", "presence of companies that continue in the production chain" and "proximity to highways" - scores of 4 (very important) and 5 (essential). In the steel industry sector, the criteria "availability of labor", "proximity to watercourses" and "price of land" were considered essential for choosing a location. For the energy sector, the criteria "human development", "municipal infrastructure", "presence of companies that continue in the production chain", "value of municipal taxes" and "proximity to highways and railways" were considered to be very important. The wood panel sector had the highest scores of importance for the criteria, with "availability of labor", "municipal infrastructure", "presence of companies that continue in the production chain", "value of municipal taxes", "land price" and "proximity to highways" considered essential.

The last sector analyzed the cellulose and paper sector, which considered the "proximity to watercourses" criterion as essential and the "environmental laws", "conservation units," "indigenous communities", "absence of companies in the same industry performance", "land price" and "proximity to highways" criteria very important.

Each sector has its own demands and needs in general, the criteria that had the highest scores were "availability of labor", "infrastructure of the municipality", "presence of other companies that consume wood", "price of land" and "proximity to highways", which did not differ from the literature (CASAROTTO FILHO, 2010; KON, 1999; REZENDE AND OLIVEIRA, 2008). Some considerations were made in the questionnaire section for comments, which are set out below.

Wood panels: The issue of environmental restrictions, which can prevent environmental licensing, was raised. Until 2011, environmental licensing was regulated by federal and state laws, as of that date, there was an incentive to decentralize environmental licensing to the municipality, which now has legislation that regulates environmental licensing.

Charcoal and firewood: The charcoal and firewood sector are closely linked to the forest, so the issue of already converted areas was pointed out, which was different from the other sectors because deforestation is not necessary for these resources.

Table 5 - Score of criteria by companies in the forestry sector.

Aspect	Criteria	Sector					Sum by criteria
		Furniture	Steel	Energy	Wood panels	Pulp and paper	
Social	1 Human development index	3	4	4	3	3	17
	2 Availability of labor	4	5	5	5	3	22
	3 Level of labor	Spe.	Fund.	Tec.	Tec. HG	Tec. Spe.	-
	4 Presence of schools	1	3	4	4	3	-
Environmental	5 Municipal environmental council	2	2	3	2	3	12
	6 Municipal environmental laws	2	4	3	4	4	17
	7 Environmental Conservation Unit	2	3	3	4	4	16
	7.1 Best situation	Ind.	Not having	Ind.	Not having	Have	-
	8 Indigenous communities, quilombolas and/or archaeological sites	1	4	3	3	4	15
	8.1 Best situation	Ind.	Absent	Absent	Absent	Absent	-
	9 Proximity of the plant to watercourses	1	5	3	3	5	17
Municipal	10 Size of municipality	4	2	3	4	2	15
	10.1 Best situation (size of municipality)	Larger	Minors	Minors	Larger	Minors	-
	11. Urbanization rate	3	2	2	4	3	14
	11.1 Best situation (population concentration)	City	City	Field	City	City	-
	12 Municipal infrastructure	5	3	4	5	3	20
Economic	13 Presence of other wood-consuming companies	4	3	4	5	4	20
	13.3 Best situation (market)	SC	SA	SC	AC SC	AC	-
	14 Municipal revenue	3	3	2	4	3	15
	14.1 Best situation (level of revenue)	High	Low	Low	High	Low	-
	14 Tax incentives and subsidies	2	4	3	4	3	16
	15 Value of municipal tax	3	4	4	5	3	19
	16 Land price	3	5	3	5	4	20
	17 Proximity to state and federal highways	5	4	4	5	4	22
	18 Proximity to railroads	1	2	4	4	3	14
Total score by sector		49	62	60	73	61	288
Responses		13	4	3	2	2	26

Source: Prepared by the authors.
*Score: 1 - not important; 2 - not very important; 3 - important; 4 - very important; 5 - essential. Acronyms: Spe. - specialized; Fund. - fundamental education; Tec. - Technical; HG - High school; Ind. - Indifferent; SC - sequence in the production chain; SA - Same branch of activity; AC - Absence of companies in the same branch of activity.

In addition, they also raised concerns about water availability, developed forests with adequate clones, agriculture as well as the availability of manpower for silvicultural activities in the region.

Steel industry: Similar to the charcoal and firewood sector, the steel sector also highlighted the issue of agriculture in the region. Interestingly, the area of the municipality is more than 60% rural and it has a tradition of agricultural/forestry activities.

Furniture: It was observed that the level of education, which varies according to the position to be filled and depends on the sector, may need to be improved through SENAI courses. Thus, the presence of technical and specialized teaching units (such as SENAI) in the municipality or its surroundings can be an additional factor for municipalities to attract new investments.

Cellulose and paper: The economic importance of environmental issues (Permanent Preservation Areas, RL, and others) was reinforced in this sector, as was land use, forest productivity (soil analysis), location and transport distance (routes and tolls), operational costs (forestry, harvest, and transport), farm access investments formation of blocks/environment; rainfall index and temperature, and water availability (factory). Other environmental factors were considered in forestry and industrial decisions. It is worth mentioning that the comments and observations made were from individuals, so they may not be true for all companies in the industry. The qualitative criteria (TABLE 6) sought to understand how enterprises dealt with wood supply and product sales. Although it was not listed as a criterion for evaluation, the proximity to forest-producing centers and the availability of wood in the local market were fundamental criteria for the success of an enterprise, since wood itself is costly to transport.

Table 6 - Qualitative criteria raised by the questionnaire.

Criteria	Furniture	Pulp and Paper	Steel	Coal and firewood	Panels
1 Own plantation	No (83,33%) Yes (16,67%)	Yes (100%)	Yes (100%)	Yes (80%) No (20%)	Yes (100%)
2 Promotion or lease for wood acquisition	No (83,37%) Yes (16,66%)	Yes (100%)	No (75%) Yes (25%)	No (60%) Yes (40%)	No (50%) Yes (50%)
3 Maximum distance between plant and raw material	5 to 500 Km	250 to 350 Km	50 to 300 Km	10 to 300 Km	100 to 150 Km
4 Maximum distance from consumer market	30 to 240 Km	700 Km /Export	250 to 300 Km	30 to 500 Km	1.000 km /Export
5 Wood species used	Eucalyptus, Pinus, others	Eucalyptus	Eucalyptus	Eucalyptus and Pinus	Eucalyptus and Pinus

Source: Prepared by the authors.

The main objectives of forest plantations are to maintain businesses, meet the demands of companies, and ensure a constant supply (BRAINER, 2018). The results demonstrated that all sectors own forest plantations, but to different degrees. For example, in the furniture sector, only 16.6% of the enterprises have their own plantations. According to data from Ibá (2020), the forest area planted in Brazil is primarily owned by the cellulose and paper sector (36%), followed by the steel and charcoal (12%), wood panel and laminated floor (6%), and solid wood products (4%) sectors, independent producers (29%) and independent investors (10%). In the case of the furniture sector, a factor that may have contributed to the low plantation ownership was the use of already processed wood, such as panels, agglomerates, and plywood, for the production of furniture (BRAINER, 2018). In Minas Gerais, forestry legislation (MINAS GERAIS, 2013) requires that companies that industrialize, trade,

benefit, use or consume an annual volume of wood, charcoal, or firewood from the native forest over 8,000 m³, 4,000 m³ and 2,000 m³, respectively, to use planted wood, either directly or through partnerships. These partnerships can be carried out through contracts, forest out-grower programs, and/or leases (FISCHER, 2009). The latter two practices occur in all the analyzed sectors, although it is not unanimously practiced in the forestry sector. Forest out-grower programs can be of public or private origin (EISFELD et al., 2017).

Regarding the distance between the plant and the source of raw material, it is worth mentioning that the wood itself has a low specific value (that is, its value in relation to its volume is low), so the cost of transporting this commodity is high, varying significantly with the distance to be covered (SILVA et al., 2007). In Brazil, most of the wood is transported by roads, although it can also be transported by rail and pipelines, thus the quality of the roads and the type of vehicle are additional influences on transport costs, among others (SILVA et al., 2007). Table 6 shows the minimum and maximum values observed among the responses. Each sector showed variations, possibly due to the size of the project and the amount of raw material demanded. The furniture sector had the highest variability in distance (between 5 and 500 km), followed by energy (10 to 300 km) and steel (50 to 300 km).

A study by Darski (2014) also demonstrated that the type of management performed in the forest stand, and consequently the type of product obtained, can influence the viable distance for selling products. By thinning plantations to obtain higher quality products, the added value gain allows for a greater distance between the raw material and the industry, as seen in the results from the furniture sector, which presented the greatest distances compared to the others. The reverse is also valid, since plantations without thinning produce lower value-added wood, for charcoal and firewood for example, and the profitable distance is relatively small. According to the author, in this scenario (compared with a savings rate of 6% and the cost of land added), the maximum profitable distance would be 35.85 km. In general, the feasibility of transporting wood to the processing unit is linked to the cost of transporting wood and relevant legislation, as occurs with charcoal in Pará (LACHINI et al., 2018; PARÁ, 2013).

On the other hand, the distance from the consumer market is more varied, considering that the enterprise can operate in both domestic and foreign markets. In both cases, but mainly for exports, access to good logistics is a crucial factor for the flow of a product, in which case the distance is less relevant. Although it was not pointed out in the responses of the participants, it is known that all sectors analyzed, except for the energy sector, have a significant share in the foreign market (MDIC, 2019). Waibel (1979) points out the costs of transportation and emergency consumption as relevant factors in determining the maximum distance from the consumer market; however, as the sector's products are not perishable, there are other factors that influence this selection, such as logistics, tax incentives and tariff reductions, and labor, among others raised in the questionnaire (SOUZA AND MUNIZ, 2010). Considering the supply of the local market, the radius of influence of the enterprise in the local market, according to the survey results, varied from 30 to 1,000 km. The furniture sector had the smallest supply radius, ranging from 30 to 240 km, followed by steel (250 to 300), and the energy sector (30 to 500 km).

The pulp industry is largely export-oriented (more than 69.6% of production is exported (IBÁ, 2020), and 2.77% of the cellulose consumed is imported). For the domestic market, the company's distribution radius reported in this survey was 700 km. Independent paper industries are usually close to the consumer market due to issues such as the need to provide post-sale technical assistance for some types of

paper (graphics, for example), high numbers of inventory maintenance units, direct sales to consumers and low added value (which makes long-distance freight more expensive), which are some of the reasons raised by Hora et al. (2018). The market supplied by the panel sector is diversified and able to meet the demand of furniture and civil construction (BRAINER, 2018; VIDAL AND HORA, 2014). On the other hand, this sector has little representation, with few industries based in the country, though it is becoming more concentrated in the southern region (IBÁ, 2020). For this reason, to supply the internal demand, it is necessary to have a greater radius of action, which in the case of the present research has reported a maximum distance of 1,000 km.

In conclusion, it is worth noting that the factors that drive industrial location are not immutable over time. They keep updating and complementing themselves with the emergence of new technologies and demands from society and the market, always seeking the best efficiency and economic performance (SANTOS, 2012; SOUZA AND MUNIZ, 2010).

3.2 Municipal Attractiveness Index (MAI)

The MAI was applied to each sector separately, ranking the most attractive municipalities in the state, and after classification, a map was generated for better spatial visualization (Fig. 2). Although some criteria are more relevant than others, they were analyzed together to obtain a better average performance, considering that all the criteria presented some degree of importance (except for in the furniture segment).

Steel industry

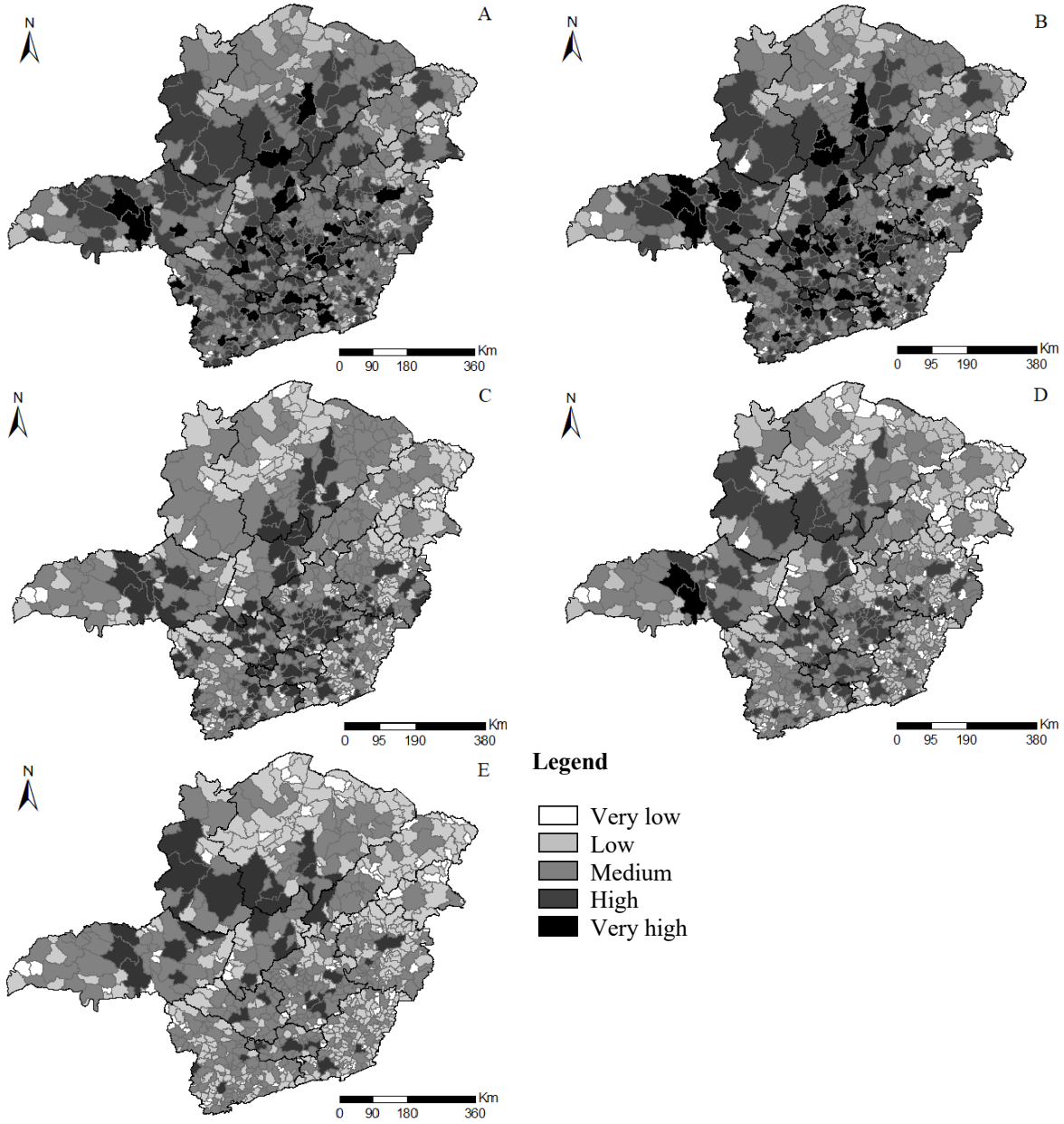
For the steel segment, considering the preferences detailed in the questionnaire, 43 municipalities were classified in the “very high” attractiveness class (Fig. 2a), with the Belo Horizonte Metropolitan, Southwestern Minas and Zona da Mata mesoregions having the three highest concentrations of municipalities, with 11, 8 and 5, respectively, increasing to 57, 60, 35 when considered together with the “high” attractiveness class. In the Belo Horizonte Metropolitan mesoregion, there is a strong steel hub with 43 independent pig iron plants in partial or total operation in the region (SINDIFER, 2020). As pointed out by the questionnaire, steel mills consider the presence of enterprises of the same industry in the municipality to be important, so this mesoregion met this requirement. In general, 25.20% of the municipalities in Minas Gerais were classified as having a “low” or “very low” attractiveness, 39.04% as having medium attractiveness, and 35.76% as having “high” or “very high” attractiveness. However, in the case of the steel industry, in addition to the supply of inputs to ovens (charcoal), it is also necessary to consider the sources of raw minerals such as iron. In this case, it would be necessary to merge the obtained data with a map of mineral deposits to optimize the selection process for the location of manufacturing units, as large volumes of minerals are required.

Cellulose and Paper

The three mesoregions with the greatest potential ("high" or "very high") for the development of the cellulose sector are Southwestern Minas Gerais, Metropolitan Belo Horizonte, and Zona da Mata, with 20.51% (56), 19.78% (54), and 9.89% (27) of the total municipalities in the analyzed categories (Fig. 2b). These mesoregions were responsible for the production of 3.74%, 25.48%, and 0.50% of round wood for cellulose and paper, respectively (IBGE, 2019). The municipalities of Belo Oriente,

where Cenibra's plant is located, and Betim, where Klabin's plant is located, were also classified as having "very high" attractiveness potential, which shows that the index developed is in line with the actual location of the factories and that they are well located. In general, 27.08% of the municipalities in Minas Gerais were classified as having a "low" or "very low" attractiveness, 40.92% as having medium attractiveness, and 32.00% as having "high" or "very high" attractiveness.

Figure 2 - Attractiveness of Minas Gerais municipalities for investments in the forestry in 2021. **Sector**: (A) Steel; (B) cellulose; (C) energy; (D) wood panels and (E) furniture (made predominantly of wood) - 2020.



Source: Prepared by the authors.

Energy

Charcoal is one of the most prominent products in forestry production in Minas Gerais, mainly due to the high concentration of steelmakers in the state (more than 40% of companies), in which charcoal is used as a thermal reducer for the production of pig iron and alloy (IBÁ, 2020; REZENDE AND SANTOS, 2010). In

addition to its use in the steel industry, charcoal and firewood have alternative uses, such as domestic, commercial (pizzeria, steakhouse), industrial (boilers), chemical (products), and agricultural (grain drying) uses (COELHO JUNIOR et al. 2006a, 2006b; RODRIGUES AND BRAGHINI JUNIOR, 2019). Similar to the furniture segment, this segment did not have a "very high" classification (Fig. 2C). A total of 142 municipalities were classified in the "high" attractiveness class, with higher concentrations in the mesoregions of Metropolitan Belo Horizonte, Southwestern Minas, and Western Minas. It is worth mentioning that the Metropolitan Belo Horizonte mesoregion is where the steel industry is located, which the main consumer of charcoal in the state. In general, 43.84% of the municipalities in Minas Gerais were classified as having "low" or "very low" attractiveness, 39.51% as having medium attractiveness, and 16.65% as having "high" or "very high" attractiveness.

Wood panels

The wood panel segment in the state is represented mainly by Duratex, the only large company of this segment in the state, located in the municipality of Uberaba (IBÁ, 2020). This municipality, as well as Uberlândia, was the only municipality classified with "very high" attractiveness, showing that the company, according to the criteria of the present work, was well located (Fig. 2D).

For the municipalities classified as having a "high" attractiveness, 102 municipalities were observed, of which 53.92% were concentrated in only three mesoregions: 25 municipalities in the Belo Horizonte Metropolitan, 18 in the Southeastern Minas, and 12 in the Western Minas. In general, 55.09% of the municipalities in Minas Gerais were classified as having "low" or "very low" attractiveness, 32.70% as having medium attractiveness, and 12.19% as having "high" or "very high" attractiveness.

Furniture

When processing data from the furniture sector, it was found that no municipality was classified as having a very high attractiveness (Fig. 2E). Thirty-seven municipalities with a "high" classification were observed for the sector. Of the municipalities with this classification, 45.94% were concentrated in three mesoregions, namely, the Triângulo Mineiro (16.21%), Belo Horizonte Metropolitan (16.21%) and Northern Minas (13.52%). Considering the municipalities with "average" attractiveness together, the number of attractive municipalities rises to 362, making the Southwestern Minas (with 68 municipalities), Belo Horizonte Metropolitan (61 municipalities) and Triângulo Mineiro and Vale do Rio Doce (38 municipalities) more attractive. In general, 57.56% of Minas Gerais municipalities were classified as having "low" or "very low" attractiveness, 38.10% as having medium attractiveness, and 4.34% as having "high" or "very high" attractiveness.

The main furniture hubs in Minas Gerais are located in the Zona da Mata (municipality of Ubá and surroundings) and Western Minas (Carmo do Cajuru and surroundings) mesoregions, and on average, the municipalities that are part of the hub were classified as having "medium" attractiveness (LIMA, 2020; QUADRILÁTERO, 2017).

Analyzing the segments together, it was found that the most promising mesoregions for the development of the forestry sector as a whole were Belo Horizonte Metropolitan, Southwestern Minas, and Zona da Mata, which presented the highest sum of municipalities classified as having "high", "very high" or "medium" attractiveness. The southern regions of the state are more economically developed and have greater industrial diversity than those in the north of the state; therefore,

the attractiveness to new ventures is greater due to the presence of basic companies and the production chain (MINAS GERAIS, 2010). However, as seen in the maps in Fig. 2, municipalities in the north of the state also had high ratings.

According to the work discussed by Gonçalves et al. (2000), more developed regions tend to attract more investments. However, in the case of industrial locations, enterprises do not necessarily need to stay in these developed centers; they are able to stay in nearby regions and enjoy the positive effects of development. In addition, technological development itself has enabled projects to be located at greater distances (GONÇALVES et al., 2000). Another relevant point is that the introduction of a new enterprise or a group of enterprises can stimulate the arrival of complementary industries to the region (MATTE JÚNIOR AND ALVES, 2017). In this sense, the incentive for the development of the forestry sector in the state of Minas Gerais has been linked to the idea of diversification by boosting the development of several forest-based segments in the same region, such as the wood panel and furniture segment, considering that the first segment generates inputs for the second (ARAÚJO et al., 2019; PATERLINI, 2014). The solid wood segment could also be developed in the same place, according to the same principle.

By knowing the locational demands of industries, the public sector can direct public policies that improve low-scoring criteria, and thus, even regions that lack strong economic development can attract new enterprises that can evolve and increase their economic growth (FERREIRA et al., 2016). In this way, public policies will be oriented according to the territory and will be more effective (MARCUSSO; STREIT, 2022).

In addition to the raised criteria, which were thought to represent the characteristics of the municipality, other factors that were not considered in this research also strongly influence a company's decision in choosing a location. For example, political factors (corruption, legal insecurity, high bureaucracy, and regulatory environment) can influence the investment climate (DOLLAR et al., 2005). In Minas Gerais, a factor that has negatively influenced the state is the poor standardization among the Regional Environmental Regulation Superintendence (SUPRAM), which is responsible for the analysis of environmental licensing processes and, together with the high bureaucracy and complexity of state environmental laws, results in a slower and more costly process, which already has a high cost (JORNAL SIF, 2016; RURAL PECUÁRIA, 2017; SCHMID, 2017).

CONCLUSION

The application of the methodology made it possible to identify the municipalities and regions with characteristics closest to those sought by industrial segments and to identify their geographical distribution. With this, strategic planning at the state level is possible for the development of the forestry sector, as well as for the analyzed industrial segments, optimizing the selection of the locality and highlighting the factors that could be improved.

According to the questionnaire data, some criteria were more relevant and stood out for all sectors analyzed, such as the availability of labor, municipal infrastructure, the presence of other wood-consuming companies, land prices, and proximity to highways, which can confer good logistic benefits. These are basic and essential criteria for selecting a location, but they are not the only ones. Each sector, and each enterprise per se, has its selection criteria that best meet its particular objective, so there is variation between them, and it is not possible to develop a universal methodology.

Although there were few respondents to the questionnaire from the forest sector, the variables incorporated and included for the development of the Municipal Attractiveness Index of Minas Gerais for the forest sector indicated that the main mesoregions with potential for the strategic development of this sector were Belo Horizonte Metropolitan, Southwestern Minas and Zona da Mata. On average, 58.24% of Minas Gerais municipalities were classified as having "medium" or greater attractiveness.

For the steel, cellulose and paper, and charcoal and firewood sectors, the best mesoregions were Southwestern Minas, Belo Horizonte Metropolitan, and Zona da Mata. All three mesoregions already produce charcoal, firewood, and roundwood for the production of cellulose and paper, which can be further developed with the results of this study. The steel sector, on the other hand, has a production center in the Belo Horizonte Metropolitan mesoregion. For the furniture sector, the medium and high attractiveness mesoregions were Southwestern Minas, Belo Horizonte Metropolitan, Triângulo Mineiro, and Vale do Rio Doce. The most attractive ones for the wood panel sector were Southwestern Minas, Belo Horizonte Metropolitan, and Western Minas.

It is worth mentioning that even in municipalities with a "very low" attractiveness, forest-based industries (mainly small enterprises, such as suppliers of firewood, wood for civil construction, and regional furniture) can still be installed, as they are important and necessary for local markets.

With this initial insight into the locational demands of forestry companies, it is hoped that the work can contribute to the development of public policies aimed at the sector. And that future research can deepen the methodology and influence strategic planning for the expansion of the forestry sector in an orderly manner, not only in Minas Gerais, but throughout the country. In this way, the development of a highly profitable, socially inclusive and environmentally responsible market would be favored by national and international sustainability policies.

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