THE USES OF GEOPROCESSING TECHNIQUES IN THE IDENTIFICATION OF LOCATIONS SUITABLE FOR THE IMPLEMENTATION OF AIRPORT INFRASTRUCTURE IN THE NORTH VECTOR OF THE RMBH

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Abstract

Introduction: The inspiration for this article came from a dissertation paper written for a specialization course in Geoprocessing undertaken by one of the authors. That work studied the identification, by way of geoprocessing techniques, of areas most suitable for implementing airport infrastructure within a specific region north of the city of Belo Horizonte, capital of Minas Gerais, Brazil. This paper follows the same issues and concerns. The demands for transport and airport services in many locations around the world has led field specialist to rely on the planning of procedures to resolve future impasses, as well as impasses already reached. The advantages of implementing rigorous assessments, regarding soil use and occupation towards specific goals are numerous. For instance, the choice for the ideal location in a municipality for installing structures, potentially leading to a better use of space and a better physical and territorial ordering for implementing urban infrastructures. Consequently, the acceptance and use of geoprocessing techniques in urban planning has gradually increased, leading to the implementation of a number of geoprocessing techniques and tools. Therefore, in the search for suitable locations for implementing a larger airport capacity in the North Vector of the RMBH, geoprocessing was used, as it is believed that it serve as an important aid for that sort of decisions. Objectives: The goal of this paper is to demonstrate the legitimacy and validity of applying geoprocessing in the identification of adequate locations for implementing airport infrastructure. Methodology: The search for adequate locations for the installation of airport infrastructure was undertaken from a regional centre, with a *modal* project. To this end the analysis adopted a radial profile. The variables mapped where identified through consultation with specialists in airport design, construction and

management. The process used was Multi-criteria Analysis, with which it was possible to evaluate different variables, as well as indicate locations which are most suitable for the installation of the airport infrastructure. Maps were produced by the cross-referencing of technical, economical and operational maps, since they are, in principal, the most relevant to evaluate those locations which are the most appropriate for the installation of the airport infrastructure in the area considered. This choice of analysis was based on the belief that Multi-criteria analysis allows more rigorous analyses, as it incorporates and associates a larger range of information, promoting a more holistic and integrated comprehension of the region under consideration. <u>Results:</u> According to the results, the least viable locations for implementing airport infrastructure are found more than 20000m from Belo Horizonte, as they provided inadequate road access. However, by comparing predictions with reality, we may perceive that the beneficial potential of the operational variables for North Vector was not totally evaluated, when the present airport was constructed. <u>Conclusions:</u> The conjoint of geoprocessing techniques detailed represent a tool that can dialogue with specialized knowledge, as well as adapt itself to environmental variations. This was verified in the present study, especially when the Decision Tree was calibrated and the analysis for the Final Calibrated Synthesis map was carried out. Therefore, bearing in mind its characteristics, geoprocessing may be utilized in prognostic studies, highlighting advantages such as lower costs for the implementing of enterprises and requiring less time for identifying viable locations.

1. Introduction

Geoprocessing, understood as a continuous development of the Earth's representation, allows the association of this exercise to new perceptions of geographical space, by a gaining of knowledge, which means, by acquiring information (Moura, 2003: 8). Digital processing of images, digital cartography and Systems of Geographic Information (SIG) are undertakings of geoprocessing.

In a manner analogue to the article 'O uso de geoprocessamento na busca de áreas para aterros' (Maillard, Santos and Santos, 2002), when using the available tools of geoprocessing – such as computer aided cartography and the System of Geographic Information – the office tasks will be referenced. Therefore, field work and the time for selection will be kept to a minimum, resulting in cheaper options.

As detailed in the paper quoted above, by using the geoprocessing techniques, a proposal for methodological improvement will be formed, founded in the progressive elimination of options, according to previously chosen characteristics. The goal is 'to optimize time and costs of work for developing a landfill site, differing from traditional methodology' (Maillard, Santos and Santos, 2002: 30). In the present research, instead of a landfill site, the object of study is the installation of airport infrastructure.

The advantages of allowing more rigorous selections, regarding soil use and occupation with specific goals, like, for instance, the choice for the ideal location in a municipality for installing a landfill site, lead to a gradual increase to the acceptance and use of geoprocessing.

Therefore, urban planning has utilised a number of techniques and tools offered by geoprocessing, since it needs space based solutions for conflicts of use, as well as a better

physical and territorial ordering for implementing urban infrastructures. It is easily comprehendible that it aims for, as stressed by Moura (2003), a structuring of heuristic space, related to using SIG, since it allows the selective evaluation of variables and the accompaniment of environmental variations (monitoring).

2. Objectives

The goal of this paper is the application of a methodology for the identification of adequate locations for implementing airport infrastructure, which supports decision making and considers a number of variables, through geoprocessing techniques.

The goal is to check the suitability of the Tancredo Neves International Airport in order to explore the techniques of GIS in a situation which was already studied. The results will be seen as the simulation of an area chosen to built the airport as the geoprocessing techniques were used to support the decisions in the choice of site for the airport.

3. Methodology

Specialist consultations had as their goal the defining the variables to be mapped, and analyzed by geoprocessing apparatus. Further more, the experience of the interviewees is potentially a great assistance in conducting this research. The search for adequate locations for the installation of airport infrastructure will occur from a regional centre, with a *modal* project. In this way, this analysis will adopt a radial profile, according to the following variables to be mapped:

- Gradients
- Geomorphologic units
- Annual average precipitation (mm) – rain period at RMBH – Climatologic Normal (1961 – 1990)
- Atmospheric discharge densities at RMBH – rain periods (2004 – 2007)
- Limit of the *APA Carste* of Lagoa Santa
- Soil use and occupation
- Integration grid – Road accesses
- Distance from the limits of the municipality of Belo Horizonte

The variable *Distance from the limits of the municipality of Belo Horizonte* initially recommended by specialists is the distance from the country's urban centers. However, for a more viable operation of the application of geoprocessing techniques, it was decided to adapt it, to account for the distance from Belo Horizonte, as the distance to São Paulo, Rio de Janeiro and Brasília can be inferred. The distances to these cities' are important because they are the locations of the more important airports in Brazil.

The files: Annual average precipitation (mm) – rain period in the RMBH – Climatologic Normal (1961 – 1990) and Atmospheric discharge densities at RMBH – rain periods (2004 – 2007) are from the energy company of the Minas Gerais state (CEMIG) and were already formatted as matrixes.

Furthermore, the data in the files applied to the following coordinates: y1: 7844000, y2: 7796000, x1: 576000, x2: 629000. The cell size attributed was 20m, according to Moura

(2007), as mentioned above, since the number of lines and columns are 2400 and 2650 respectively.

Additionally, the files form the dimensions of the following encompassing quadrant: y1: 7844000, y2: 7796000, x1: 576000, x2: 629000. The size attributed to each cell was 20m, according to the recommendation of Moura (2007) as was previously mentioned, although the number of lines and columns are 2400 and 2650, respectively.

On the other hand, economical variables are those that restrict or motivate certain uses of geographic space, allowing greater or lesser generation of capital, many times with the goal of promoting environmental preservation. They are covered by environmental and urban legislation, and therefore are used as tools for urban management and planning. In the present study, the economical variables are: Limit of the *APA Carste* of Lagoa Santa and Soil use and occupation.

The operational layers are those that are effectively the most important, with regard of implementing an airport, since it is regional centres that may construct infrastructure in outlying areas. The objective of the interventions is to grant necessary support so that the airport operations proceed without delays or complications, since air transport is characterized by speed, comfort and safety. The Integration grid variables are defined as – Road accesses and Distance from the municipal limit of Belo Horizonte.

All executed procedures aimed to facilitate a Multi-criteria Analyses, according to 'a methodological procedure of intersecting variables, widely accepted in spatial analyses' (Moura, 2007: 2901). Some call it a Hierarchical Analyses of Weights or of Decision Trees (see Figure 1). The tool is based 'on variable mapping by a plan of information and on the definition of the degree of pertinence for each information plan and each of the components of the legend for the construction of the final result' (Moura, 2007: 2901).
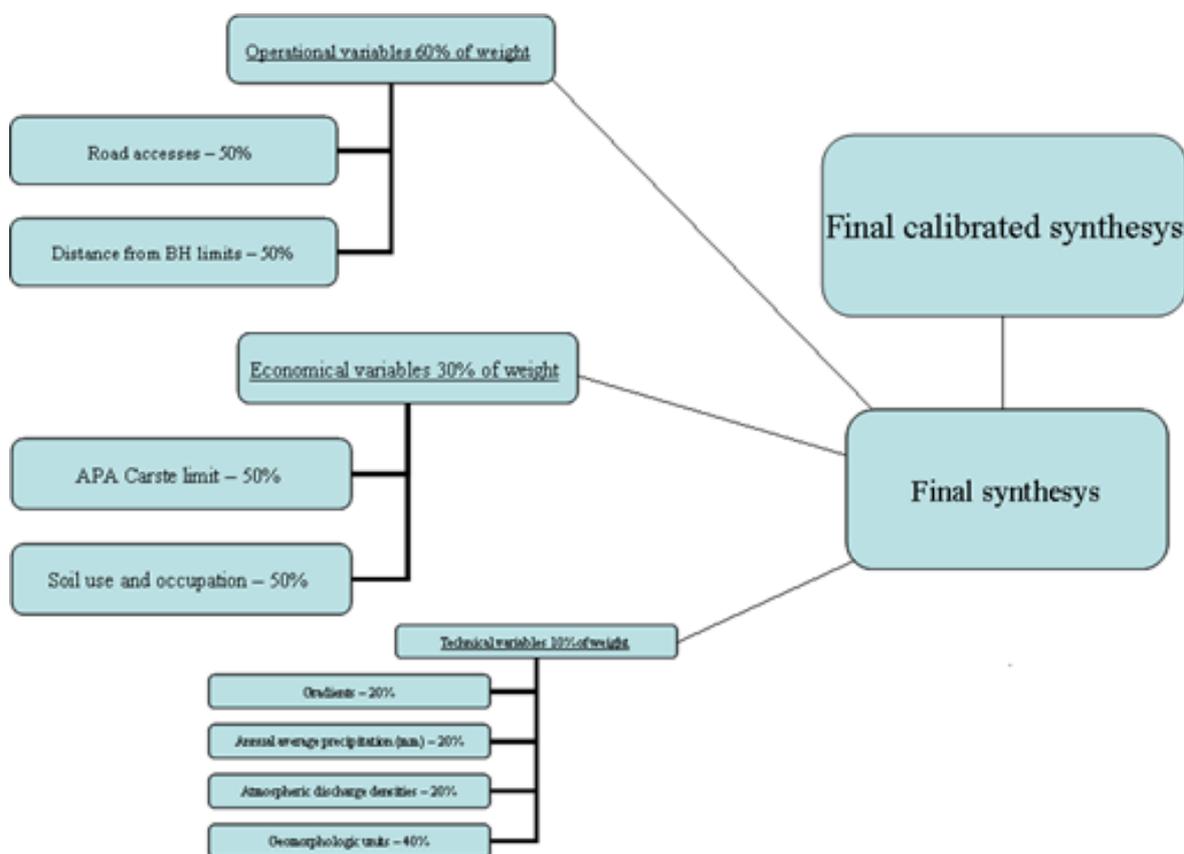
Figure 1: Decision Tree. Source: Compiled by the authors.

Grades	Interest in implementation	Viability attributed to location
0 < e > or = 1	Low	Not recommendable
1 < e > or = 3	Medium to low	Not recommendable
3 < e > or = 5	Medium	Intermediately recommended
5 < e > or = 7	Medium to high	Well recommendable
7 < e > or = 10	High	Best location solution

Table 1: Classification of grading for mapped variables. Source: Compiled by the authors.

Therefore, according to the Multi-criteria Analyses performed, based on specialists' recommendation, the following weight for technical, economical and operational variables were respectively 10%, 30% and 60%. The values allocated to these aspects are detailed in table 1 above, and were also used in the production of the following maps: Final Synthesis and Final Calibrated Synthesis.

4. Multi-criteria and spatial analyses: final map

The map was produced by the cross-referencing of technical, economical and operational maps, since they are, in principal, the most relevant to evaluate which are the most appropriate locations for the installation of the airport infrastructure in the area considered. This hypothesis is based on the argument that it allows more rigorous analyses, as it

incorporates and associates a larger range of information, promoting a more holistic and integrated comprehension of the North Vector.
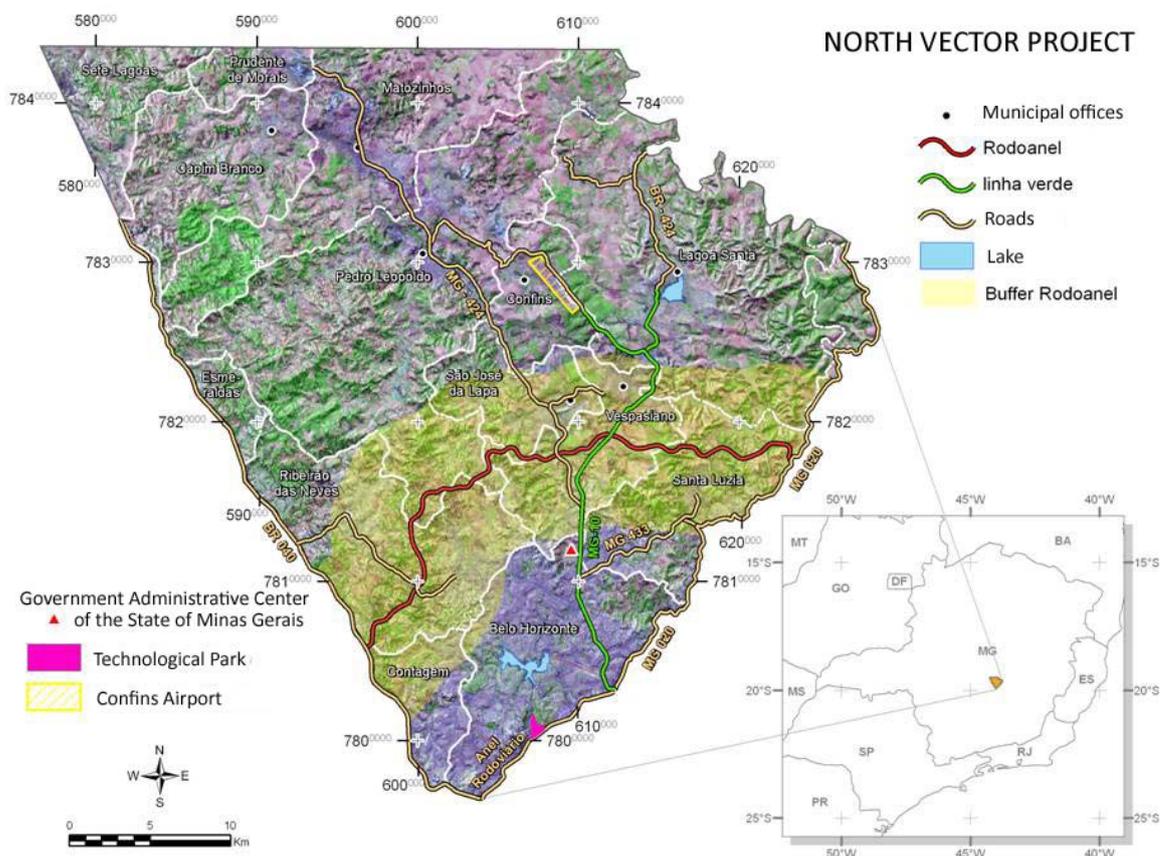

Figure 2: Case Study. Source: North Vector project by the Mayors Office of Belo Horizonte

According to the results, the least viable locations are found more than 20000m from Belo Horizonte, as they present low densities of road access. It is emphasized that the closer to regional centres the placing is, the better the integration with the road grid, this detail was closely considered in the Decision Tree presented above. Therefore, the locations in these regions were highly valued and evaluated as the best locations for the implementation of airport infrastructure.

Regarding the results obtained, the predominance of the operational aspects over the other aspects is evident, which was already expected because of its 60% weight.

However, we may consider undertaking further Multi-criteria Analysis, of the specified target area of the North Vector. This observation is founded on the possibility for the transformation of the region's roads, especially in the regions further than 10000m from the municipal limit of Belo Horizonte, and in the case of interstates, by the expansion of carriageways and state interventions. The hypotheses are plausible, due to the low density of constructed spaces in these areas, which tends to alter the public investments that are being undertaken.
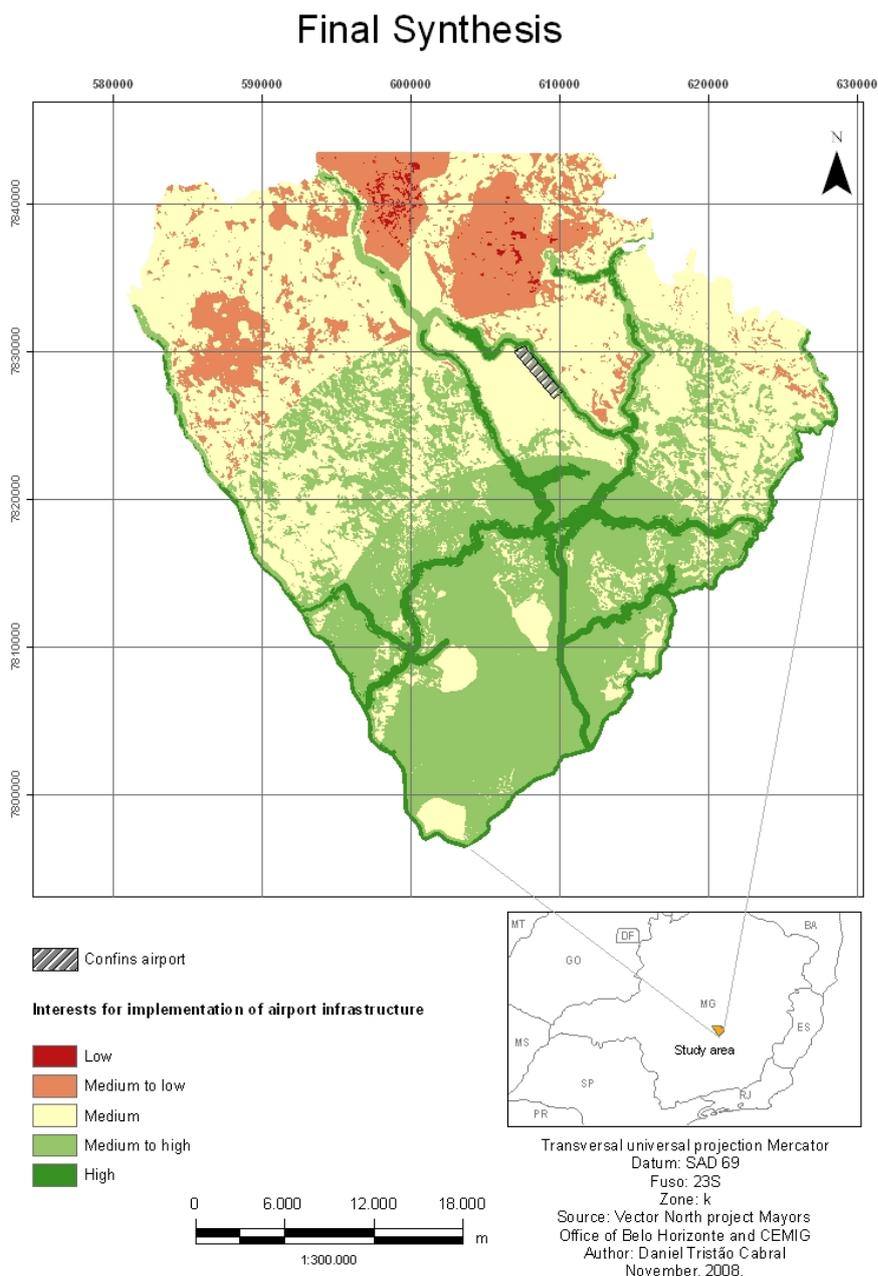
Final Synthesis

Figure 3: Map of Final Synthesis. Source: North Vector project by the Mayors Office of Belo Horizonte and CEMIG

Therefore, by comparing predictions with reality, what Bonham-Carter (1994) and Moura called heuristics (Moura, 2003: 18), we may perceive that the beneficial potential of the operational variables for North Vector were not totally evaluated. Therefore, the Decision Tree will be prepared again, considering the following weighs for the technical, economical and operational variables, respectively 10%, 45% and 45%. The increase of importance given to economical aspects is due to the comparative importance the APA North Vector is located in.
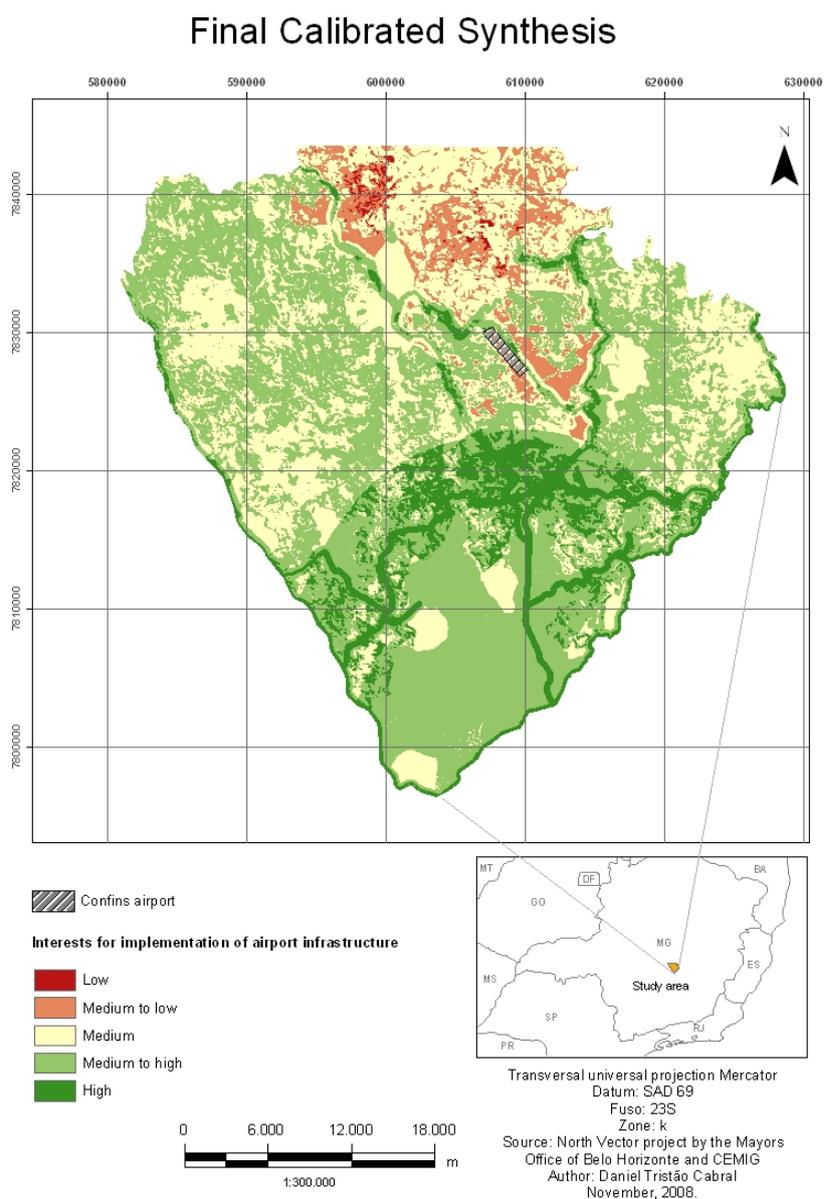
Figure 4: Map of Final Calibrated Synthesis. Source: North Vector project by the Mayors Office of Belo Horizonte and CEMIG

After a new algorithm was produced, the resulting map demonstrates that the consideration of medium interest increased to one of high interest for the region under consideration, particularly to the West, Northwest and East of the Tancredo Neves International Airport, near to BR – 040 and MG 020. At the meeting of the ring-road with MG 010 and MG 424, to the South of Confins, a location was evaluated as optimum for the implementation of the airport infrastructure. However, it is demonstrated that that location is not the most advisable, due to its proximity to a high density of constructions, which impedes or makes difficult several kinds of interventions.

5. Conclusion

This study's objective was to demonstrate the relevance of geoprocessing techniques, in undertaking complex analyses that require evaluation of several variables simultaneously, like the identification of adequate locations for implementing airport infrastructure. The expectation for a better performance regarding the results come from the perceived assistance offered by this tool in making decisions, through the undertaking of a more precise diagnostics, since it allows a larger and better spatial visualization of the analysed aspects.

Multi-criteria Analysis has been proven to be an indispensable tool in selecting the most appropriate locations. If geoprocessing had been used at the time of the state's choice for positioning the Tancredo Neves International Airport, maybe more interesting options would have been raised, like the areas indicated in the Final Calibrated Synthesis map.

The conjoint of geoprocessing techniques represent a tool that can dialogue with specialized knowledge, as well as adapt itself to environmental variations. This was verified in the present study, especially when the Decision Tree was calibrated and the analysis for the Final Calibrated Synthesis map was carried out. Therefore, bearing in mind its characteristics, geoprocessing may be utilized in prognostic studies, highlighting advantages such as lower costs for the implementing of enterprises and requiring less time for identifying viable locations.

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