CO-171

GEOGRAPHIC INFORMATION SYSTEM FOR 3D MODELING OF THE SPECIFIC AIRPORT PROTECTION ZONE PLAN AND URBAN PLANNING

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ABSTRACT

This paper presents a Geographical Information System (GIS) developed for zoning of land use and its occupation, in terms of the gauge or height of buildings, defined by the Municipal Master Plan Design for Environmental and Development (PDDUA) in an area surrounding Salgado Filho International Airport, city of Porto Alegre, Rio Grande do Sul State, south of Brazil. The analyses takes information from the terrain elevation, the Airport's Safety Zoning Specific Plan (PEZPA) applied to this region and the urban land parceling in the area of study. This work aims at providing a tool for decision making support in urban planning, at cadastral level, in order to map and analyzes constructive feasibility considering its altimetric aspect taking into account the above elements. The implementation of this GIS together with its methodology highly contributes to contemporary society as far as it permits quick analysis of technical feasibility of constructive projects or infrastructure projects, either public or private, in compliance with recommendations given by PEZPA and by PDDUA. For this purpose we developed products from graphic and non-graphic pre-existing information and also from new information especially generated for this work. Results together with generated products enable the achievement of the proposed analysis and uncover new possibilities for improving Geographical Information System.

BACKGROUND AND OBJECTIVES

The use of Geographic Information Systems (GIS) for urban planning and for aeronautical application is an important tool to provide technician staff with analysis and products to support their activities. The urban land management applications deal with a great amount of data, in different scales, since they consider several factors regarding city's planning. The same applies to aeronautical applications. When we consider the land use and occupation in areas around airports, many others factors are critical and must be taken into account in order to guarantee the safety of takeoff and landing operations.

The aeronautical community has recognized the acute need for accurate three-dimensional geospatial information in and around the airfield critical to flight safety, specifically for accurate runway positions, obstruction locations and heights, and topography around airfields (Wang, Hu and Tao, 2004).

There are some legal aspects based on legal documents which support and indicates conditions for construction and implementation of enterprises at the airport area and its surroundings in order to reduce risks. Surroundings may be several kilometers and it depends on the aerodrome's class, its gauge and some other aspects.

International Civil Aviation Organization (ICAO) decided for the need of operational certification for airports with international air traffic. This institution created international patterns and recommended practices of restriction in order to prevent inadequate enterprises in areas surrounding aerodromes (IAC, 2008).

Airport's Protection Zones are defined by general and specific plans which are determined by the limiting surfaces that define the land use restrictions within such zones. Three-dimensional imaginary surfaces created by the specific airport protection zone plan (PEZPA) are important elements to establish the volume of airspace at and around the airport that must be kept free of obstacles. The delimitation imposed by PEZPA aims at prohibiting the construction of such obstacles in order to minimize danger to aircraft arriving or departing the Airport.

Besides the impacts caused by PEZPA, it is important to consider the city's urban planning especially concerning the construction of vertical buildings. Combining information from PEZPA and from the urban zoning, regarding the gauge and height of buildings, it is possible to have an approach concerning the land use and occupation related to the safety and operation of air transportation.

This paper presents the GIS developed for establishing land use zoning and occupation in an area surrounding the International airport of Porto Alegre. The object of this research is to show how GIS can help decision making in urban planning regarding the geometry of urban space use having in mind flights' safety from PEZPA's specifications.

This research proposes a bi-dimensional (2D) and three-dimensional (3D) modeling of the geometry of the use of urban space considering legal and technical aspects, either anthropic or natural, especially regarding the terrain elevation. Usually 3D applications for PEZPA's analysis takes into account just flight's safety. On the other hand, urban planning applications are usually 2D and general since they consider several other factors regarding city's planning. This work links these two perspectives in a GIS developed for decision making support in urban planning. It also establishes land use and occupation zoning in the area surrounding the International Airport Salgado Filho in the city of Porto Alegre, state of Rio Grande do Sul, south of Brazil. This system generates zoning by urban land parcels and it indicates the parameters that should be followed, concerning height and gauge, when construction is decided. Analyses here were performed based on information from terrain elevation, PEZPA applied to that area and urban land parceling.

The implementation of this GIS with the chosen methodology allows a quick analysis of technical viability of building and infra-structure's construction either by private or public initiative. Both have to respect recommendations made by PEZPA and by the urban and environmental development plan (PDDUA). This work has developed products that permit such analysis from graphic and descriptive information. Such products, plus the results of this research, allow such analysis and moreover disclose new possibilities for the improvement of this system from the developed method.

The spatial analysis done for this purpose aims at:

• Establishing the zoning of urban plots concerning terrain elevation;

• Establishing the zoning of urban plots concerning terrain elevation and PEZPA to indicate parameters to be followed, concerning height and gauge, when construction is decided.

This research was done using the ESRI ArcGIS - ArcInfo 9.2, together with the 3D Analyst and the Spatial Analyst extensions.

The study area for this research is located in the north part of Porto Alegre, capital city of the State of Rio Grande do Sul, in the south of Brazil (fig. 1), between 30˚02' and 29˚58' south latitude, and 51˚05' and 51˚15' west longitude, and it is about 140 Km2 large. The airport site is 3.8 Km² large.

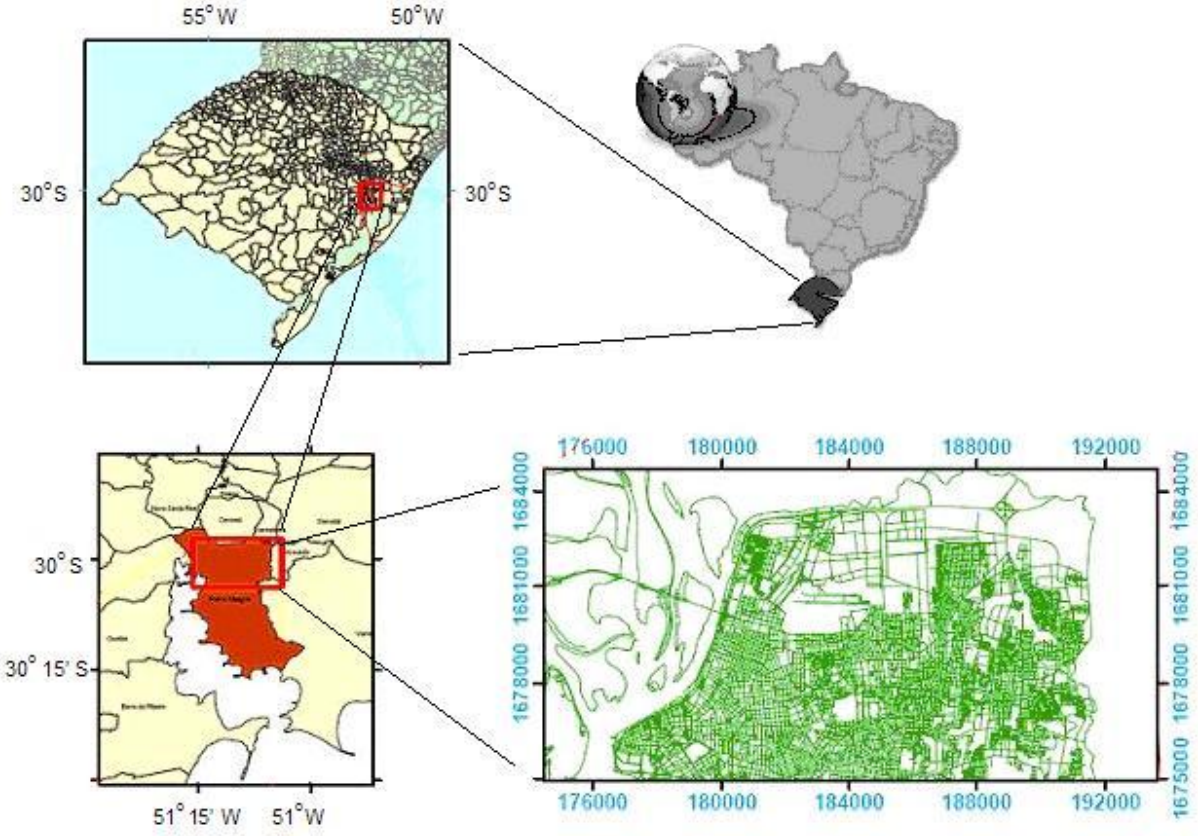

Figure 1- Map of study area

APPROACH AND METHODS

The procedures for data modeling and GIS implementation imply activities that define the operational steps of the chosen methodology. These steps entails: 1. Data source inventory and selection (cartographic,

alphanumeric and bibliographic information); 2. Database design: definition of the required data (features, attributes and topology), the operations and the processes to support the system implementation; 3. Data input: 2D and 3D modeling, geographical operations and spatial analysis; 4. Output process: evaluation and results.

The data used for this research refer to terrain elevation, urban land parcel (plots) and PEZPA. Terrain elevation and plots data were obtained from 32 topographic maps, in scale 1:1.000, with contour lines at 1 m vertical interval. Complementary data, concerned to the urban plots, were gotten from different sources, like the technical cadastre and notary land. The data related to PEZPA came from graphic and non-graphic pre-existing information. These data are the 2D cartographic representation of PEZPA (fig. 2) generated by the Aeronautical Cartography Institute (ICA) – Department of Aerial Space Control, in the scales of 1:250.000, 1:50.000 and 1:20.000, and document no 68 dated May, 2nd, 2005 from Brazilian Airspace Control Department (DGCEA, 2005).

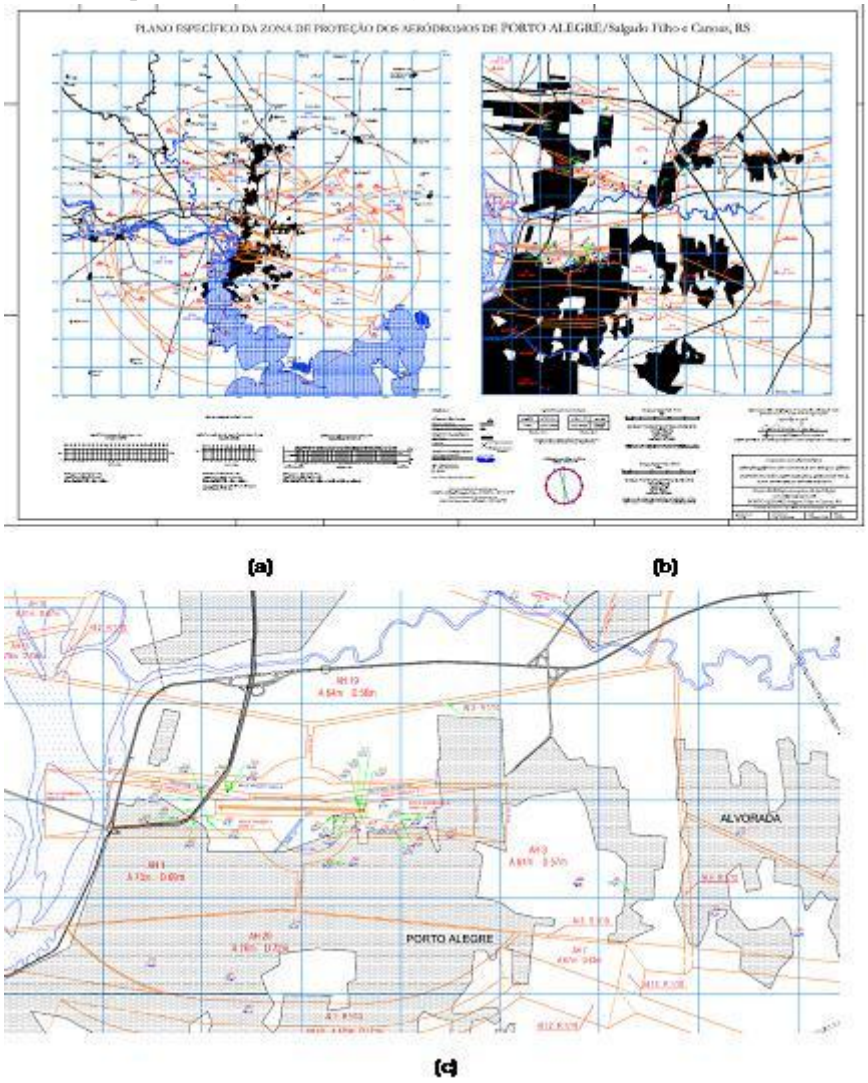

Figure 2 - 2-D cartographic representation of PEZPA: (a) 1: 250.000, (b) 1: 50.000, (c) 1: 20.000 (DGCEA, 2005)

The procedures for GIS implementation - data input, graphic editions, geographical operations, spatial analysis and results - are depicted on figure 3. After data acquisition and selection we perform the data entry in order to generate the information levels (layers) that support the GIS implementation. Three information levels are used for 2D and 3D modeling of the geographic database. These layers with their cartographic features associated to attributes and topology are: terrain elevation, plots and PEZPA.

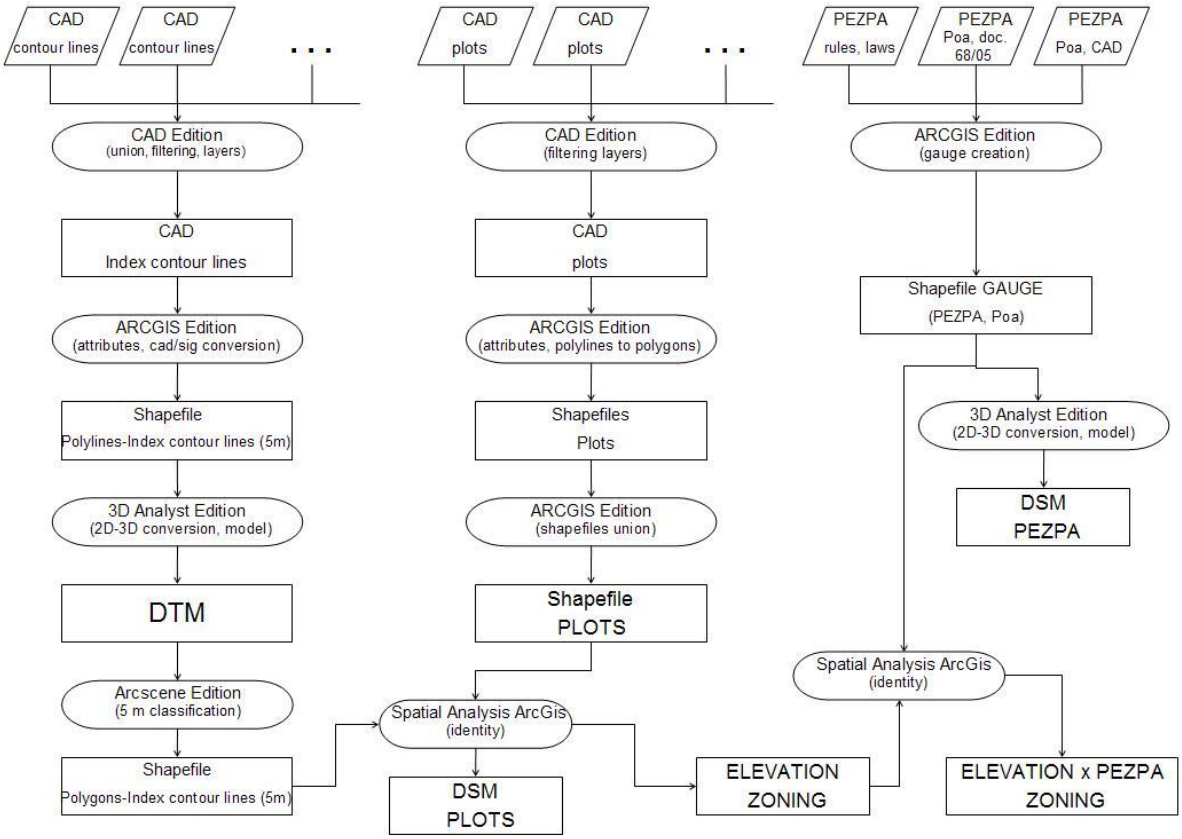

Figure 3 - Procedures for GIS implementation

To create the terrain elevation layer we used just the index contour lines (5 meters vertical interval) of the 32 topographic maps dating from 1982, and digitized in 2001/2002. The CAD files (dwg/dxf) were first edited and converted to shapefile (polylines) (fig. 4). In order to perform geographical operations and spatial analysis from terrain elevation layer it was necessary to generate the digital terrain model (DTM). In this research we used the Triangular Irregular Network (TIN) model to generate the DTM (fig. 5). After this procedure the polylines topology was converted to polygons topology, to facilitate the operations and analysis concerning plots and elevation zoning, with the association of medium values of bounding contour lines to the polygons. Doing this, the analysis related to plots and terrain elevation can be performed with ±2.5 meters precision. With 5 meters vertical interval of contour lines the average elevation of a polygon is ± 2.5 meters and it is possible to characterize the gauge of building height. This is due to the fact that this precision is considered as an approximation of the most usual height of a floor in town, defined by the building code, which is 3 meters. Thus for the purpose of analysis ± 2.5 meters represents one floor above or one floor below.

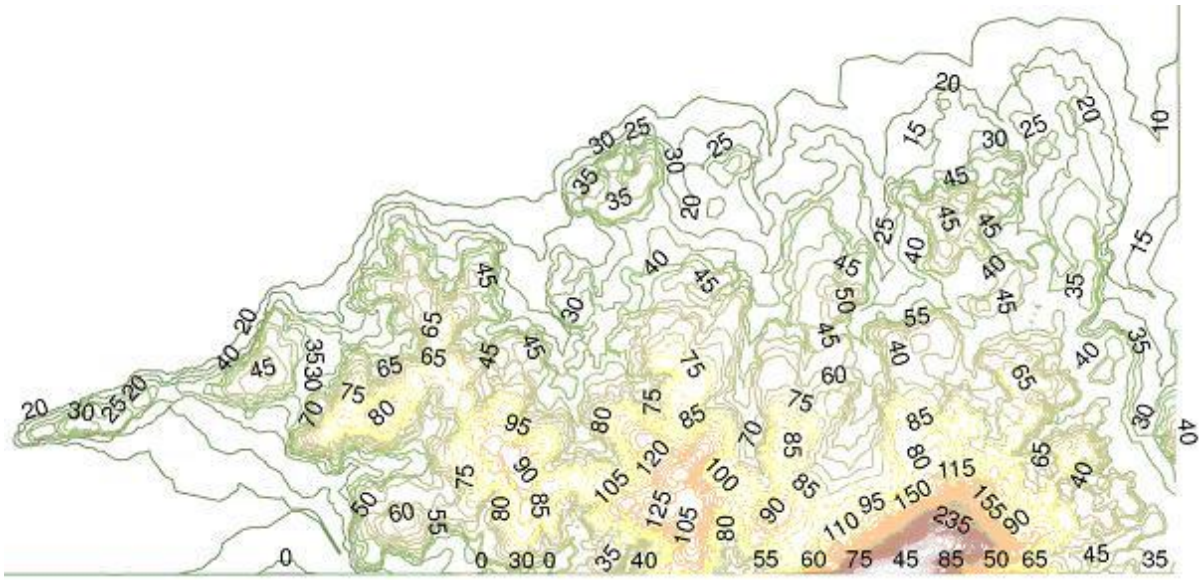

Figure 4 - Index contour lines with 5 meters vertical interval (shapefile)

Figure 5 – Digital Terrain Model (DTM) in perspective view

The plots layer was created from the 32 topographic maps. The corresponding CAD features (dwg/dxf) were edited and converted to shapefile polygon features with associated attributes. Figure 6 shows the resulting shapefile for plots layer.

Figure 6 - Plots layer

The 3D modeling of the limiting surfaces of PEZPA, unlike the elevation and plots layers, had to be created manually based on the graphical information provided by ICA and the descriptive documentation from different rules and laws and also in document no 68/05 from Brazilian Airspace Department (DECEA, 2005). The resulting shapefile with the 3D representation of the ramps and surfaces that compose PEZPA was built considering the specific gauges. Also, a digital surface model (DSM) representing PEZPA was created (fig. 7). The attributes linked to this layer refer to area name, area type and elevation.

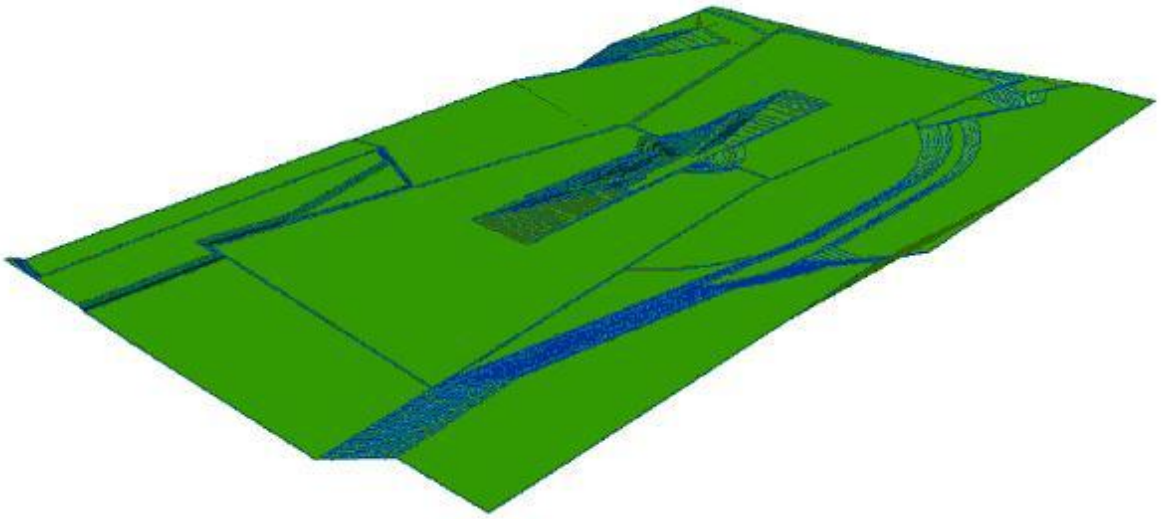

Figure 7 – Digital Surface Model (DSM) representing PEZPA

RESULTS

The results were achieved from spatial analysis performed using the proposed GIS to establish the zoning of land use and its occupation, in terms of the gauge or height of buildings defined by the PDDUA and considering the volume of airspace that must be kept free of obstacles imposed by PEZPA. The analyses

were performed using information about the terrain elevation, the PEZPA applied to this region and the urban land parceling in the area of study.

The result presented in figure 8 shows the spatial analysis performed using the DTM and the DSM representing PEZPA. It is possible to identify three main regions where the terrain elevation already exceeds the limiting restriction surfaces. These areas are critical and constructions there may not be allowed. Figure 9 shows the critical area (A) in detail.

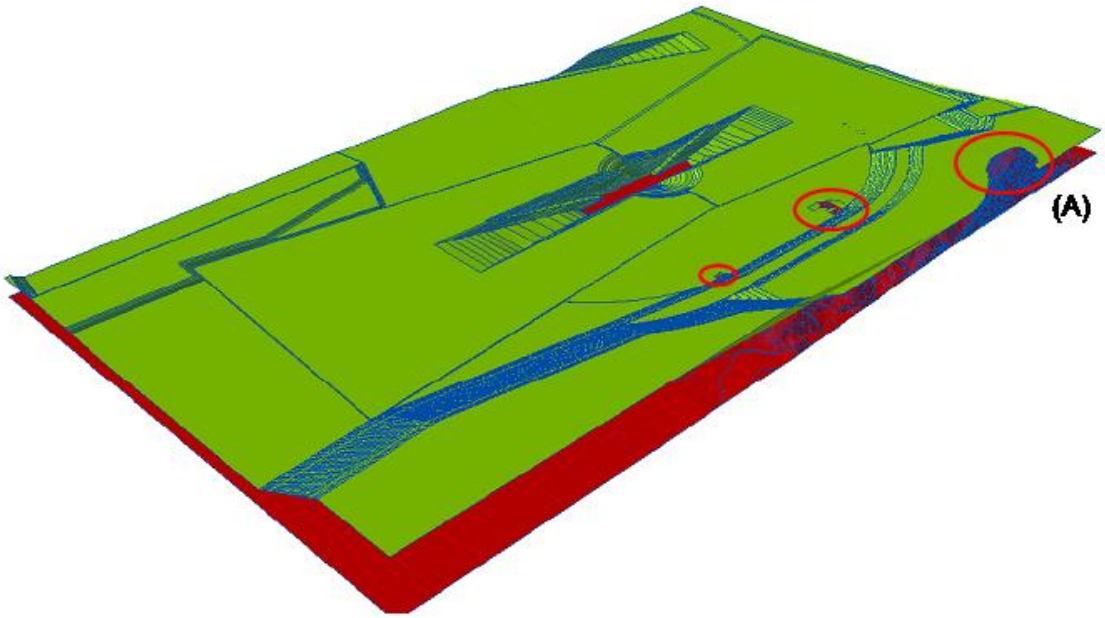

Figure 8 - Critical areas detected by DTM and DSM (PEZPA) overlap

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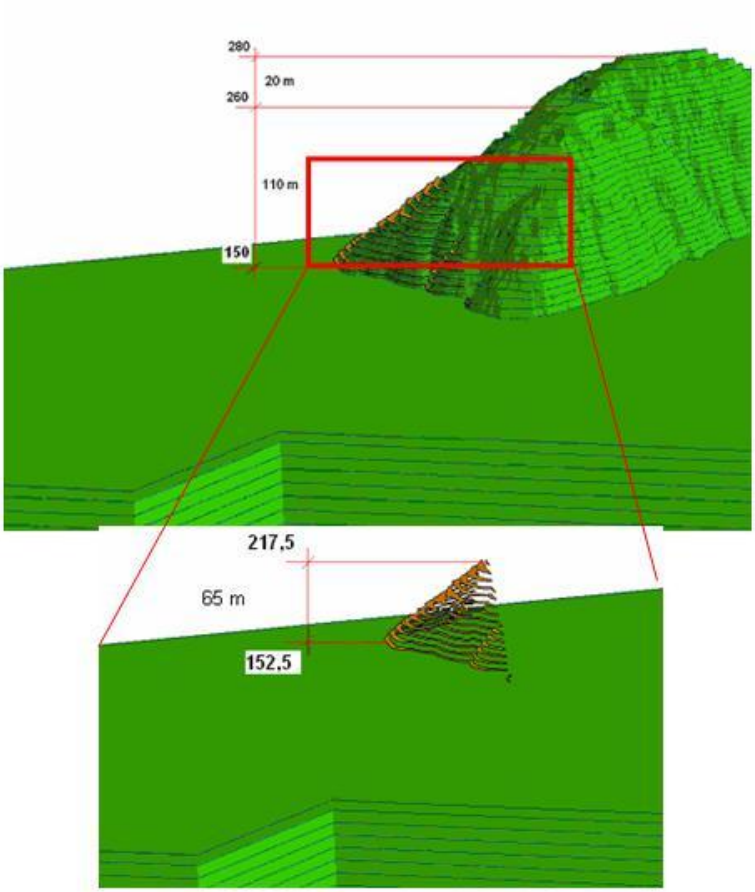

Figure 9 - Detail of the critical area (A)

The thematic map in figure 10 shows the constructive feasibility grouped into five classes. These classes indicate the height of buildings that are allowed to be constructed in those specific plots.

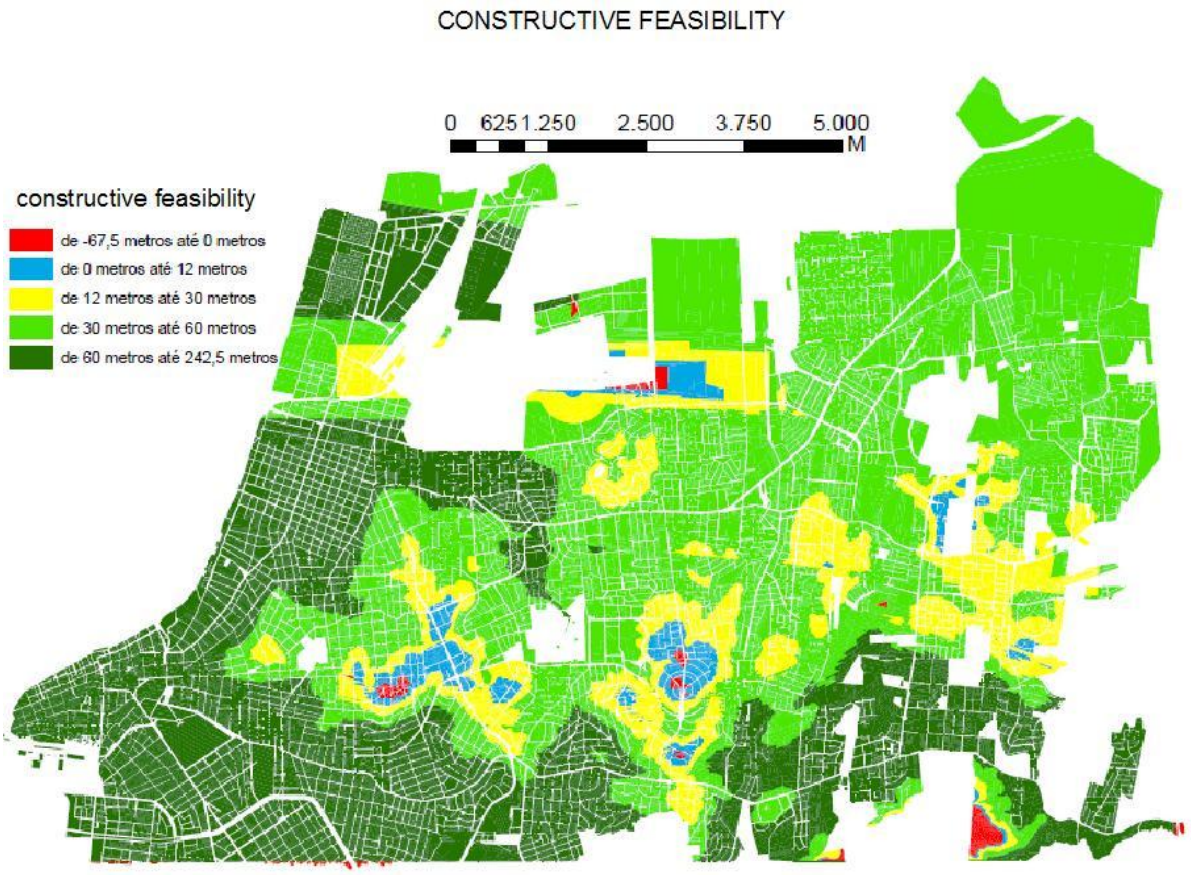

Figure 10 – Thematic map: constructive feasibility

With the implemented GIS it's possible to view, to locate and to query the elevation of a specific plot and its relation with PEZPA and to visualize its spatial distribution and pattern. Figure 11 presents the thematic map of the zoning of plots according to PEZPA. In this map we can visualize the "hot zones" - critical regions (yellow to red) - that demand a more detailed analysis before defining its use and occupation.

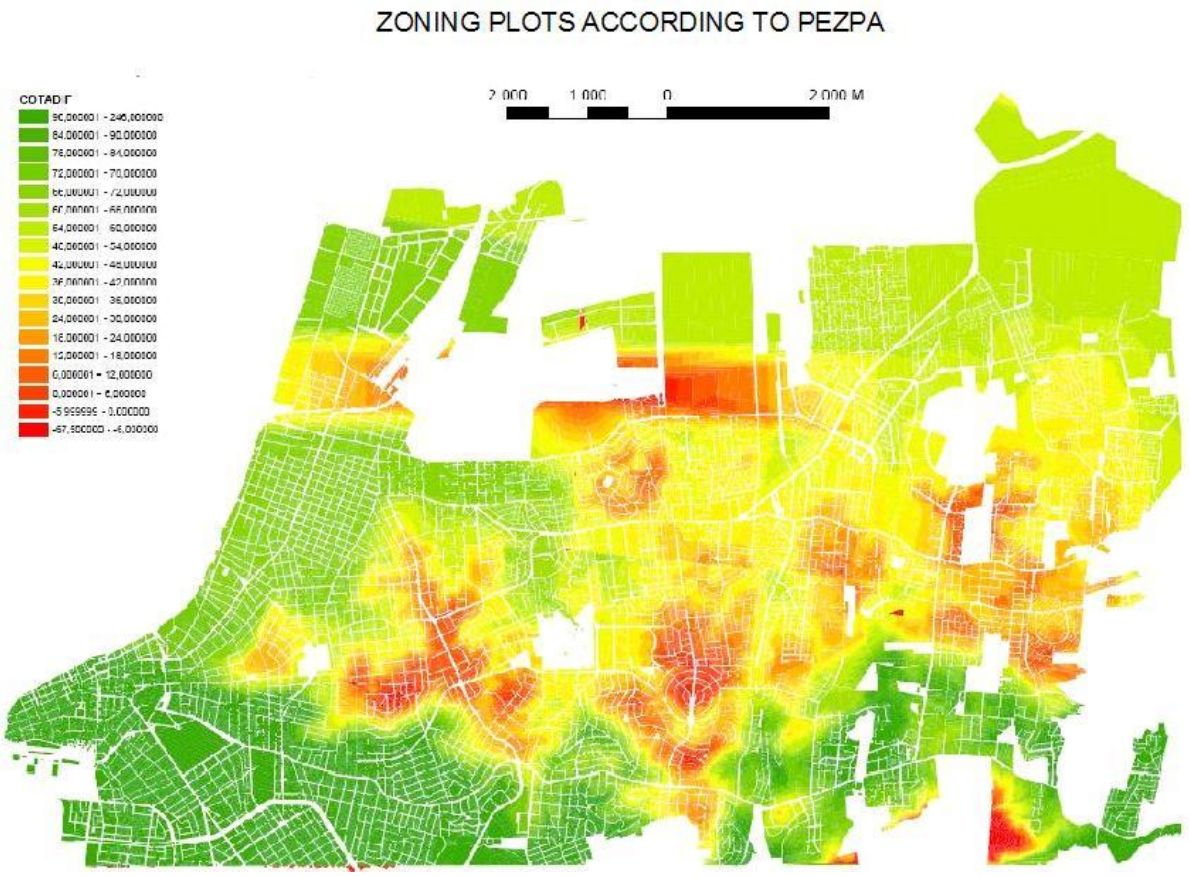

Figure 11 - Thematic map: zoning of land use and occupation considering plots elevation, PDDUA and PEZPA

CONCLUSION AND FUTURE PLANS

The development of a GIS for zoning plots of land concerning PEZPA and PDDUA faces the problem of geometry of urban space use from legal and technical aspects. This work establishes a methodology to create zoning focusing on elevation and having in mind more than one delimiting altimetric element.

This research is also important for economic matters as far as land use and occupation zoning determines the features and the potential of use of each registered plot of land and it also makes possible the analysis of technical and financial feasibility of a future undertaking. Yet, in terms of economy, this research faces the problem of GIS having in mind airport issues, that is, the dimension of its infra-structure determines the autonomy and the size of aircrafts allowing or not transportation and it's logistic for importation and exportation matters.

This work achieved its objective in developing a Geographic Information System which determines the zoning of land use and occupation concerning gauge and heights' constructions in the area surrounding Porto Alegre International Airport.

The implemented GIS allow mapping viability of constructions in cadastral level with a precision of 2.5 meters and then it helps the process of decision making on these matters. Such system answers most of the questions and doubts about elevation viability without the need of going to the place in analysis. At the same time, it allows to determine places where the visit is necessary considering each characteristic of the project: topographic, of urban zoning or related to PEZPA. With GIS all activities related to the approval of projects become faster, more accurate and more economic.

GIS is such a fundamental tool for decision making support especially in Porto Alegre's urban planning and urban zoning. It also gives support for creating other products, tools and applications. For future researches and considering the results achieved here we hardly recommend the observation of the following issues:

- The PDDUA can be qualified with an altimetric zoning of this type. Elevation definition of constructive gauge, of macro zones, units and sub-units can be supported by this kind of project.
- For better results it's necessary to have up-to-date cartographic information.

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