Geological Heritage and Conservation: A Case Study of the Visual Axis Through Digital Terrain Modeling

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Abstract. The use of GIS tools for monitoring environmental and cultural heritage through digital terrain models and visual axis in order to ensure a local preservation and demonstrate the relevance to conservation. This conservation is to maintain the local as a tourist, cultural and historical place. Since the survey can be done in a digital platform, there is a new possibility to work for the preservation of the cultural and environmental heritage.

Keywords: Geological heritage · Conservation · Visual axis · Digital modeling · Urban planning · Conservation policies

1 Introduction

Until the twentieth century, the discourse of preservation has always been linked to the concepts of cultural or environmental heritage, especially when it came to preserve the memory and the landscape of a place. The policies for the goods of Cultural and Environmental Heritage dates back to the late of the eighteenth century, which sought to ensure the existence and maintenance of monuments intended to invoke the memory and prevent forgetfulness of the past deeds and as the material resources which were used, record the occurrence of endemic species, and reserve genetic information in the areas protected for future use (Zanirato and Ribeiro [1]; UNESCO [2]; Choay [3]).

Following these criteria, a good could be considered a heritage since endowed with historical and artistic value that shows the importance for the development of art or history. The understanding of this about the history and their testimony restricted the ability to assign to other agents and their creations one story sense. Thus the cultural heritage concepts and environmental, underwent some changes over the time, moving towards a conception of heritage that understood as a set of cultural assets, referring to collective identities. Being considered as well, property and intangible, tangible and intangible (Zanirato and Ribeiro [1]; UNESCO [22]; Choay [3]; Filgueiras et al. [4]).

When the matter was directing the assessment of abiotic or its preservation, despite being predict that addressed the subject resented further studies on geology, to preserve

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the memory of a place, the concept of geological heritage occurred from the twentieth century (Brilha [5]; Azevedo [6]; Nascimento [7]).

The concept of goods, which were on natural question concerned the environmental and landscape issues with the focus on "areas that are natural landscapes or transformed by man and delineated areas which constitute urban settlements or non-municipal structures, which have particular value of civilization" (Zanirato and Ribeiro [1]). It is given priority to the goods that have a unique geographical or ecological character and a relevant interest to natural history, or to document the civic transformation of the natural environment by human activities. This definition resulted from the realization that the cultural identity of a people is forged in the environment that they live, and that the most significant human constructions get part of their beauty of the place where they are located (Zanirato and Ribeiro [1]).

Just since the twenty-first century, when it starts working new themes and concepts on the issue of heritage, were included other elements for the preservation, which before was very connected to the biotic, recently expanded to the abiotic (Brilha [5]; Azevedo [6]; Nascimento [8]).

In Brazil, the concept of Geological Heritage began to spread in the 90 s, after the First International Symposium of the Geological Heritage Protection which was held in Digne- les- Bains, France, which marked the beginning of actions to conserve the European geological heritage and also dissemination through the geotourism. Among the consequences of this first symposium, was the mark of appreciation of the geological heritage and UNESCO Geoparks program created in 2004, which had among its objectives to create a territory with boundaries and with the significant presence of geological heritage, ecological, archaeological, historical and cultural (MINEROPAR [9]; CPRM [10]; Ruchkys [11]; Nascimento *et al*. [8]; Schobbenhaus and Silva [12]).

An important contribution of Geoparks program was the possibility of aggregate the geological heritage to visitors, that is, the geotourism, which planned and directed, is able to contribute to the conservation and protection, seeking to "connect people to the place ", fulfilling the value function and becoming a tourist resort and preservation of great value (Ruchkys [11]; Murta and Goodey, 1995).

In addition, the geotourism enabled tourism coupled with the heritage, work up the concept of geoconservation that in designing a Geopark, consists of strategies related to conservation and tourism and educational use of geodiversity (Ruchkys [11]; Nascimento *et al*. [8]; Schobbenhaus and Silva [12]).

Seeking help Geological Heritage management associated with tourism, it is possible to use some GIS tools (Geographic Information System), specifically the tools for the terrain analysis, the ability to manipulate systematically a large volume of data. This feature enables documentation, visualization and analysis of the place, facilitating the investigation of spatial relations through representation by maps and charts. Mainly for simulation of possible spatial scenarios to evaluate interventions and make predictions and have a higher realm of the possible outcomes of a project or proposed laws and parameters in order to assist in making more systematic and accurate decisions by the managers.

According to Fisher [13], determining the visible areas of a location in the landscape is the process through which the landscape architects have long handled. With the spread

of GIS observed the increase in the application of spatial analysis of visibility in many spheres of human activity, especially for tourism planning, strategies for conservation and preservation of natural landscapes, archaeological studies and management of the urban landscape (Germino *et al*. [14]; Moura [20]; Sevenant e Antrop [15]; Popelka e Vozenilek [16]; Chamberlain e Meitner [17]; Phillips *et al.* [18]).

Thus, this article aims to apply GIS tools to demonstrate the study of the potential target axes to preserve the natural landscape, presenting the case study of the Serra da Calçada, in the Region of the Iron Quadrangle, state of Minas Gerais, Brazil.

2 Case Study

The Serra da Calçada (Fig. 1) is located in the Iron Quadrangle, located in the center-southeastern of the state of Minas Gerais/Brazil, occupying an area, of approximately, 7.000 km^2 with considerable geotouristic potential, for geological and geomorphological peculiarities, and for the tourism. The Iron Quadrangle is an important historical and mineral pole for Brazil.

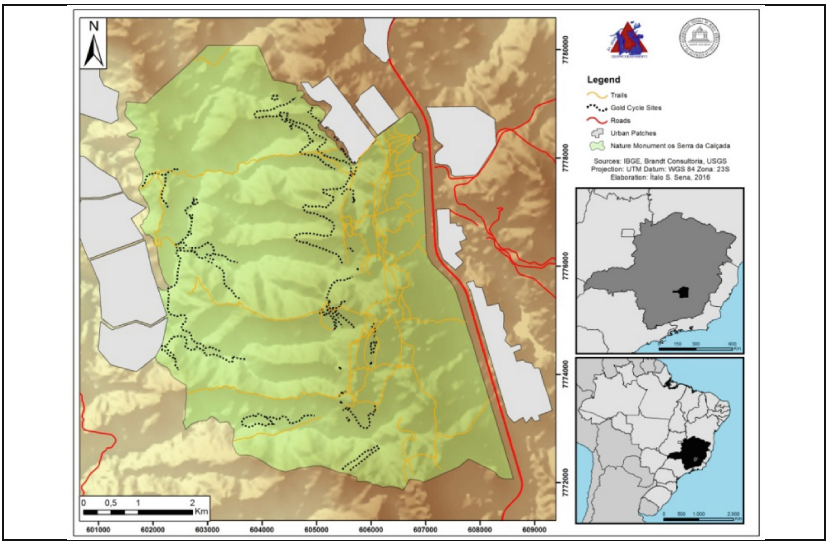

Fig. 1. Location of the Serra da Calçada. Soure: Authors

Throughout the development of the history of Brazil, passing through the colonial and imperial times, the gold mining had a preponderant role in the emergence of what we now have as geological heritage, with its peak during the second half of the eighteenth century. During this period, known as the Gold Cycle, the exploration of gold spread across multiple locations in Brazil, meeting its end in the early nineteenth century. The Serra da Calçada, as well as other formations of the Iron Quadrangle, boasts wide variety of historical trace dating back to the Gold Cycle, significantly integrating the landscape of the place. These cultural elements associated to the privileged geographical location

and the great scenic beauty of the place grants to Serra da Calçada a significant potential for geotouristic and geoconservation (Sena *et al*. [19]).

Because of these characteristics is an important area for geosciences and natural sciences, which is often visited for academic purposes, tourist and sports practice (Ruchkys [11]). Justified the choice of this region to be a much visited place, with a great diversity of attractions for all the visitors.

3 Methodology

"(…) Establish a process that will bring progress, one forward walking, in spelling or representation of the earth." Geoprocessing means not only represent, but associate to this act a new look at the space-generating knowledge through of information. Includes digital image processing, digital mapping and geographic information system (GIS). The GIS is a set of methods and techniques for the collection, processing, representation and spatially localized data analysis (Moura [20]).

The GIS's are, according to CÂMARA *et al.* [21], "systems that perform computational treatment of geographic data and store the geometry and attributes of the data that are georeferenced, located on the earth's surface and represented in a cartographic projection" (Câmara *et al*. 2004, p. 27) [21].

Currently it uses the GIS (Geographic Information System) to make representations of space. So GIS is a digital representation in which the map information is not necessarily geographica, but rather the data (Moura [20]).

Among the potential of using GIS to support the conservation management of the Cultural and Environmental Heritage include: The possibility of drawing up prognoses from the cartographic survey; creating simulations - fictional characteristics to a set of data for analysis and construction of hypothetical situations; create environmental scenarios - based on assumptions, which "…represent situations resulting from the adoption of these premises"; analyze the interaction potential - analysis interactions between events or entities in the geographic space, considering the set; analyze the visual axes; assist in the preparation of zoning; and assist in decision making.

From these results one can address different possible applications of GIS as an important tool to be used in the study area of Cultural and Environmental Heritage. Seeking spatialise the tourism potential of the heritage of Serra da Calçada was released the use of the Viewshed, an visibility analysis tool, in the Spatial Analisty toolkit from the software ArcGIS 10.4. To this end, it performed the acquisition of the raster data relating to the altitude, which were obtained in EarthExplorer platform, from the United States Geological Service (USGS). The data are from the mission Shuttle Radar Topographic Mission (SRTM), and were originally acquired with a resolution of 90 m, yet are available with pixels of 30 m, held by digital image processing (Fig. 2).

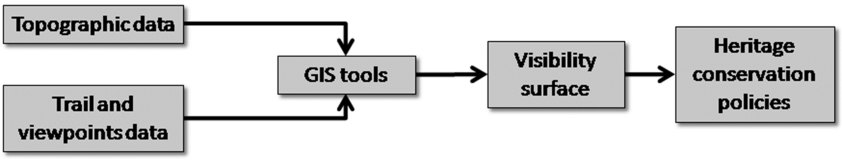

Fig. 2. Methodological framework.

The visibility analysis algorithm works on a matrix structure representing a digital elevation model, each input pixel lifting receives a numerical output value according to the position (x, y, z) of a given observer. That is, a pixel can be viewed from various points, in which each point is given a numerical value larger than a pixel to be viewed from another point with the lowest number of observers. The points without visibility will receive zero (0). The analysis was based on the vector files lines representing tourist tracks, where the vertices are considered the same observers points (Fig. 3).

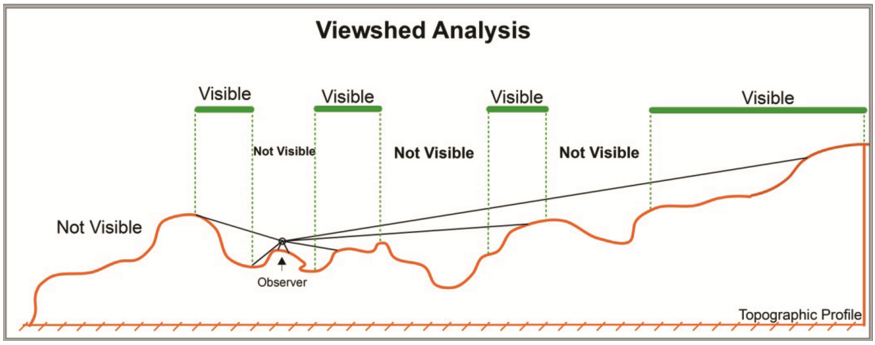

Fig. 3. Representative scheme of visibility analysis according to Moura (2005 [20]).

The representation also hold an visualization in 3D, linking the information lithology of the region, with the help of software ArcScene 10.4.

4 Results and Final Considerations

From the result it is possible to address different applications of GIS as a tool with relevant application in the field of cultural and landscape heritage studies. We can discuss the use of GIS to observe and monitor the change of the elements protected in different time phases, especially with the advent of new measurement technologies and presentation of relief data, such as the LiDAR technology.

In addition, you can discuss how the easy access to information and its virtual availability encourages the establishment of a broad dialogue among the various kind of people involved; government agencies, civil, institutional or individuals and developing heritage registry maps.

The target axes allow us to observe the areas more than 60 km away (Fig. 4). Based on the results obtained in the processing of visibility of data you can see that from the tracks located in the Serra da Calçada the spectator has the ability to view the eastern flanks of Serra do Gandarela and Serra do Caraça, the southern flank of the Serra do Curral, and the north flank of the Serra de Ouro Preto.

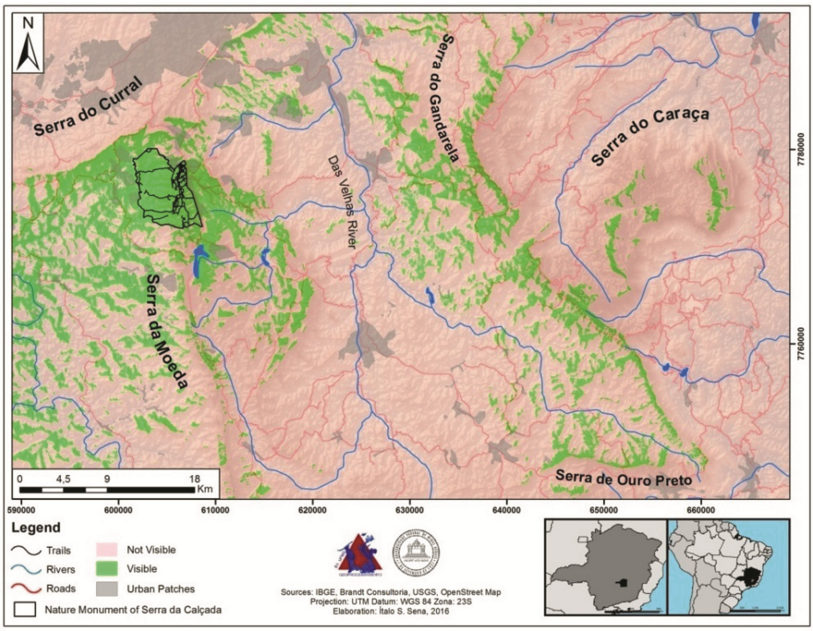

Fig. 4. Analysis of the results of the visual axis from the trails at Serra da Calçada.

In addition, there is an very high importance of the region in the Brazilian tourism scene, and its relevance as the preservation of geological and mining heritage. This mining heritage can happen even in a mining area that still being used until today. This happen because of the functions of the landscape in build a mental map for the people who lives in the region, once the occupation, by people, of this area is linked with mining activities and the landscape view (Moura [23]). Because it is a location close to a major urban center, the Serra da Calçada, attract considerable number of tourists. It stands out among the activities that can be practiced on site for adventure sports (trekking, mountain bike), contemplation of nature (photography, birdwatching).

Thus, it can be seen by Fig. 5(A) and (B), which the data is generated by the tool Viewshed data are consistent with the reality. Once the Fig. 4 you can see that the Serra do Gandarela is visible over the study area, and confirmed by Fig. 5(A), and the track, with the target to the south (Fig. 5B) shows the same principle as evidenced by the visibility map.

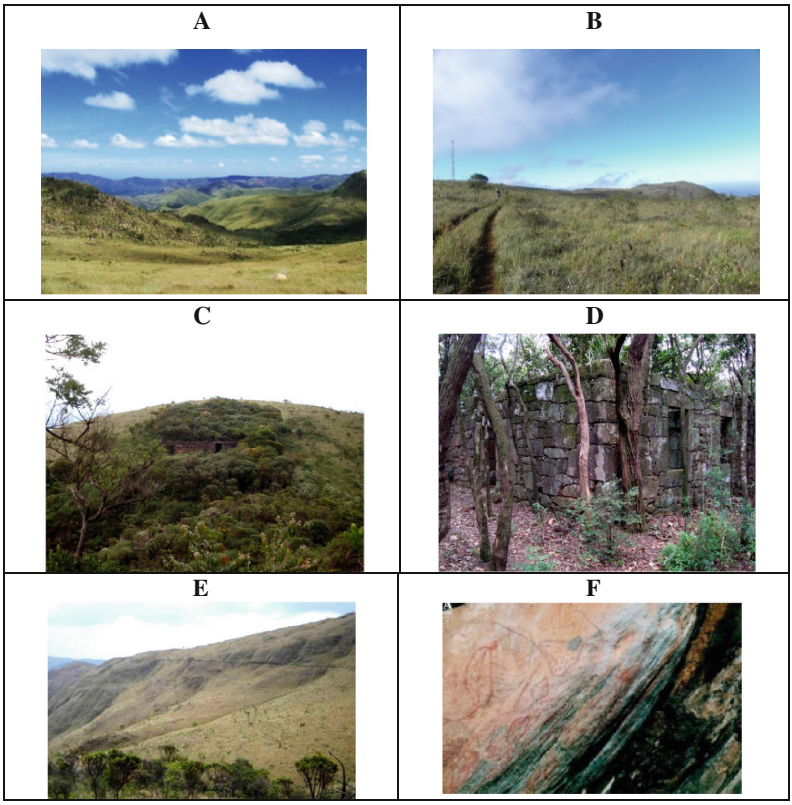

Fig. 5. (A) View to the east Axis of Serra da Calçada - With the Serra do Gandarela in the landscape; (B) Trail at Serra da Calçada; (C) View of the historic site of the Brumadinho's Fort; (D) Interior of the historic site of the Brumadinho's Fort; (E) Historical site of Grande Canal. (BORGES *et al*. [25]); (F) Cave with paintings located at Serra da Calçada (BORGES *et al*. [24]).

Figures 5(C) and (D) correspond to the cultural heritage, since they are images of Brumadinho's Fort, place there during the colonial mining period, where worked a British farm, where gold castings were made, and agricultural activities to grown food for the gold exploration employees. In addition to this function on mining, today is a point of tourist visits, well preserved and of great importance in regional history.

Since Fig. 5(E) corresponds to a drainage channel, which was used in the period of gold mining for lead the water to the site where the gold is found and thus make the mining process (Antonil [24], 1711, ed. 1997).

And, by the end, Fig. 5(F) corresponds to cave paintings, also linked to the cultural and heritage due to its location in a cave at the area and its great archaeological importance, being one more place for tourist that visits the area.

Therefore, the application of GIS tools for analyzing the target field shows to be advantageous, mainly because of the availability of free data, and the versatility to be used in regional analysis and it can prove through digital data relevant landscape view,

since it is not always possible to have an easy access to a particular location to show the local visual axis. In addition, it assists in the preservation and maintenance of the heritage by the ones who are responsible for that, being easy on handling and processing all the data.

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