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## **THE USE OF GIS IN VISUAL LANDSCAPE MANAGEMENT AND VISUAL IMPACT ASSESSMENT OF A QUARRY IN PORTUGAL**

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### **Abstract**

A visual impact assessment is prepared when an expansion of existing quarries is proposed. The use of geographic information systems based, visualization techniques historically has been used to help communities understand and manage their resources. Understanding impacts of planning policy in mountainous areas is often lost in the two-dimensional presentation. To facilitate this understanding new technologies, similar to that found in a flight simulator, were developed to help people visualize change. Three-dimensional imaging for characterization of quarry sites is beneficial in perceiving the whole picture and in making better and quicker decisions because of the higher capacity in visualization. The development of 3D images helped to minimize visual and other negative impacts of a quarry expansion project in Portugal.

*Key words: landscape management, visual impact, sustainable landscape, quarry.*

### **Introduction**

Scenic landscapes are integral component of the natural resource base. Those landscapes are identified and described in any regional development plan. With the development of more stringer practices codes and environmentally based guidelines, quarry managers must provide more detailed and comprehensive visual impact assessments with their development plans. A visual impact assessment (VIA) is prepared when the quarry plans to expand. The visual impact assessment should be made available for public review and demonstrate that the proposed operations will achieve the visual quality objectives (Lucas, 1991).

The use of geographic information systems based, visualization techniques historically has been used to help communities understand and manage their resources. GIS systems provide a remarkably efficient means of storing and retrieving information on ownership, vegetation, wildlife habitat, geology, slopes, zoning and a host of other attributes that can provide at least a gross understanding of the characteristics of large areas (Campbell and Ogden, 1999). The 1980s saw a great proliferation and adoption of GIS technology in the urban and regional planning community, assisting in different phases of the visual landscape planning and decision making processes (Leitão, 1996).

Geographical information system technology was used by land-use planners to assess the criteria requested to define the suitability of preserved landscape (Florent and Musy, 2001), to estimate changes in the visibility of land cover (Miller, 2001), to assess land-use impacts on biodiversity and conservation planning (Theobald et al., 2000), in visual impact assessment (Fisher, 1996; Leitão, 1997; O'Sullivan and Turner, 2001) and in urban landscape planning and design processes (Kodmany, 2000).

Understanding impacts of quarrying in mountainous areas is often lost in the two-dimensional presentation. When it comes to visualizing how something will look before it is actually made, three-quarters of the general population just cannot see it. Two-dimensional representations, model boards and artist renderings have proven inadequate. When people believe they understand what a project will look like, most of the time their perceptions are wrong. To facilitate this understanding new technologies, similar to that found in a flight simulator with an impact analysis extension, were developed to help people visualize change. The development of computer tools for creating and representing virtual worlds has dramatically increased our abilities to capture some of the basic elements of the landscape and communicate them to audiences remote from the landscape under study (Orland et al., 2001). The speed

and quality of generation of visual imagery, as well as the editing power computers offer, has already dramatically extended the capabilities in representing scenic views.

Three-dimensional imaging for characterization of environmental sites is beneficial in perceiving the whole picture and in making better and quicker decisions because of the higher capacity in visualization. The citizens of many communities are often the visionaries and are ahead of the most government officials in their interest in developing sustainable landscapes.

This project will give the opportunity to the government officials and interested citizens to have a look on the results of the planned projects before their implementation starts. In this study it will be presented the visual impact assessment of a limestone quarry in "Moitas Negras", Portugal.

### **Materials and methods**

Visual impact assessment is often regarded as a subjective process. However, in the present study were developed techniques which ensure that investigations can be undertaken in a systematic, consistent fashion, making the assessment as objective as possible. The primary functions of a visual impact assessment are to identify key viewpoints from which the development will be visible; to evaluate the sensitivity of these critical viewpoints; to assess the impact of visibility; and to modify the quarry design in such a way as to reduce potential impact to a minimum.

To create the database of the project was handled digital land use and topographic maps and digital air photos. After the above, it was prepared a visual landscape inventory where it was identified, classified and recorded the locations and quality of visual recourses and values of the study area. Also it was made digital maps of the visual sensitivity (visual absorption capability) and existing visual condition. A numerical rating was assigned indicating low, moderate, or high sensitivity. A landscape with low sensitivity rating can absorb a lot of development without losing its quality. It was identified the location of key viewpoints on the topographic maps. Viewpoints were those to which users will have frequent access and from which they will see significant existing or potential views.

The visual impact assessment was conducted exploiting the means of travel used by the average visitor or traveller (car, bicycle or on foot). The location of key viewpoints were selected in the office and identified on the field. At each viewpoint was taken pairs of photographs offset by few meters so a stereographic pair could provide a three-dimensional image that could be used for landform analysis. A Global Positioning System (GPS) was used to more accurately determine the x, y and z UTM coordinates of each viewpoint. It was estimated the visible portion of the proposed operations on the topographic base map.

The development of more than one design option for each proposed operation may make the design and visual impact assessment process more efficient and cost effective. Consequently, it was prepared three design options: sketching, photographic manipulation and computer simulation depending on the complexity of the proposed operation, number of viewpoint and visual sensitivity criteria. Free hand sketching was used in low risk situations to estimate and draw the shape and position of the proposed operation. Photomontages created from juxtaposed and mounted photos were used to create a panoramic view when placed on backup maps to provide an overall visual impact. Computer simulations were used when quarry was visible from more than two key viewpoints.

A Digital Terrain Model (DTM) was generated from digitised contour maps. In order to evaluate conditions in year 2034, at the completion of the quarry, the DTM was modified with the contours of the finished quarry. From the final DTM was studied the potential intervisibility of the area and the viewshed of the proposed quarry expansion. A viewshed is the two-dimensional map of all areas visible from a given point at a given height.

### **Results**

Figure 1 shows the existed quarry and proposed expansion on the study area and the visible portion of the area from one observation point that was considered key viewpoint. For this observation point was used 80° visibility angle and 2000 meters maximum distance that was considered sufficient to not decrease the truthfulness of the results. Maximum distance is a very important factor that has to be taken in consideration in a view shed analysis, because the longer the distance the lower the visual impact that an object can bring to the landscape depending always on the size, form, texture, line and colour of it (Matos, 2001).

Visibility analysis based on viewsheds is one of the most frequently used geographic information system analysis tools. First was determined how visible the landfill and its support facilities would be. There were two primary populations of viewers: viewers from households and travellers of the highway E80. Viewshed analysis of the quarry expansion project showed what areas of the disturbed surface can be seen by observers for any visible position and how many observers can see the position. The result was a grid theme with visibility attributes assigned to every cell (figure 2). It was produced simulations from every key viewpoint.

Views to the quarry from the households were computed and revealed that the "Vale Alto" community will view the greatest number of points on the quarry. However, only 8% of the quarry will be visible from the community and from a relatively high distance of 2000 meters.

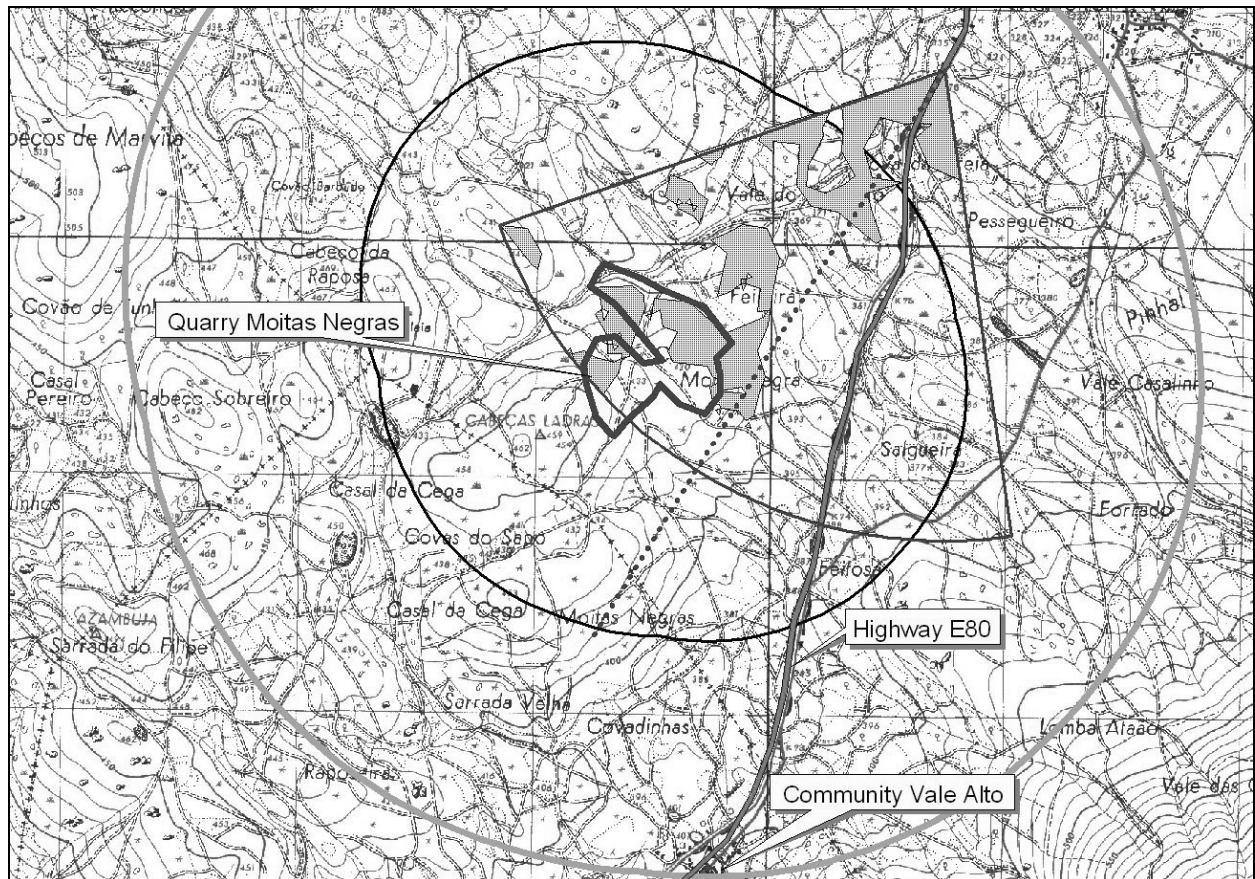


Figure 1. Map of the study area and the quarry "Moitas Negras". The shadowed area is showing the visible portion of it from one observation point (a traveller on the highway going from North to South, with 80° visibility angle and 2000 meters maximum distance).

Travellers from highway E80 will also view the quarry as they drive through the valley. From field surveys was recorded that 3598 meters of highway are visible from the quarry and with a travelling speed of 120km/h the quarry will be visible for relatively short period of time. Forty one seconds was the longest viewing time at close range (1375 meters were visible in the 1000 meter buffer). However, it was found that less than 50% of the quarry will be visible from any point of the highway. It was also found that the travellers going from South to North will view only an insignificant area of the quarry, while the others travelling the opposite direction will experience the highest visual impact.

One of the purposes of the VIA is to recommend mitigation measures. Various visual mitigation measures were proposed and evaluated, including vegetative screening, screening with landforms, native shrub and tree planting, adjustment of the location of structures and footprint of the finished quarry.

Finally aerial photographs were superimposed on the terrain to simulate a realistic view of the area. Various digital fly-over videos were generated to simulate in a realistic way the appearance of the proposed expansion. The Arcview GIS 3D Analyst extension was used to generate three-dimensional

views of the actual and completed ground surfaces. The fly-over video was constructed after a digitalisation of a path in a 2D map display that was then traversed in the 3D scene. However, the 3D extension of Arcview was permitting to freely navigate in 3D space and to relate representations in 2D maps with 3D scenes synchronizing user interaction with the database model.

A report of visual impact assessment was prepared for governmental officials that approve quarry development projects. The report content included: maps, photographs and a copy of the visual landscape simulation (sketch, photographical manipulation and computer simulation). Digital fly-over video was made because high public concern and expectations required public presentation and consultation. A snapshot of one fly-over video made from the DTM of the study area can be seen in figure 3.

The report and the evaluation method could help governmental officials to take the appropriate decision: accept, reject or suggest aesthetical modifications in any proposed project in the study area. Public consultation of proposed quarrying projects in areas with high aesthetic value could be facilitated if three-dimensional information of the virtual landscape would be transferred through the Internet by VRML technology (Honjo and Lim, 2001). Similar visual landscape management plans could be made for the rest of the territory using the visual impact plan for the area of "Moitas Negras" as a model.

Three-dimensional imaging for characterization of environmental sites is beneficial in perceiving the whole picture and in making better and quicker decisions because of the higher capacity in visualization. The development of a 3D geographic information system will help to minimize visual and other negative impacts of quarrying.

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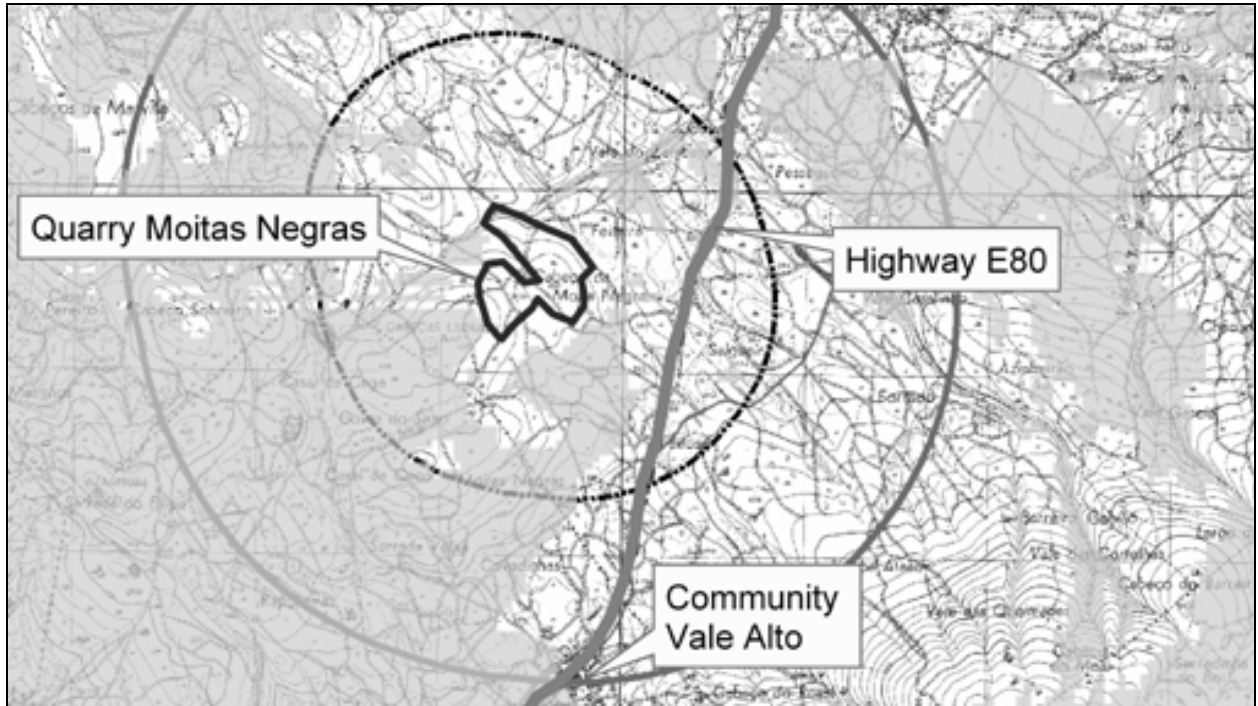


Figure 2. Viewshed analysis of the quarry. The shadowed surface is showing which will be the areas that observers cannot see any part of the disturbed surface.

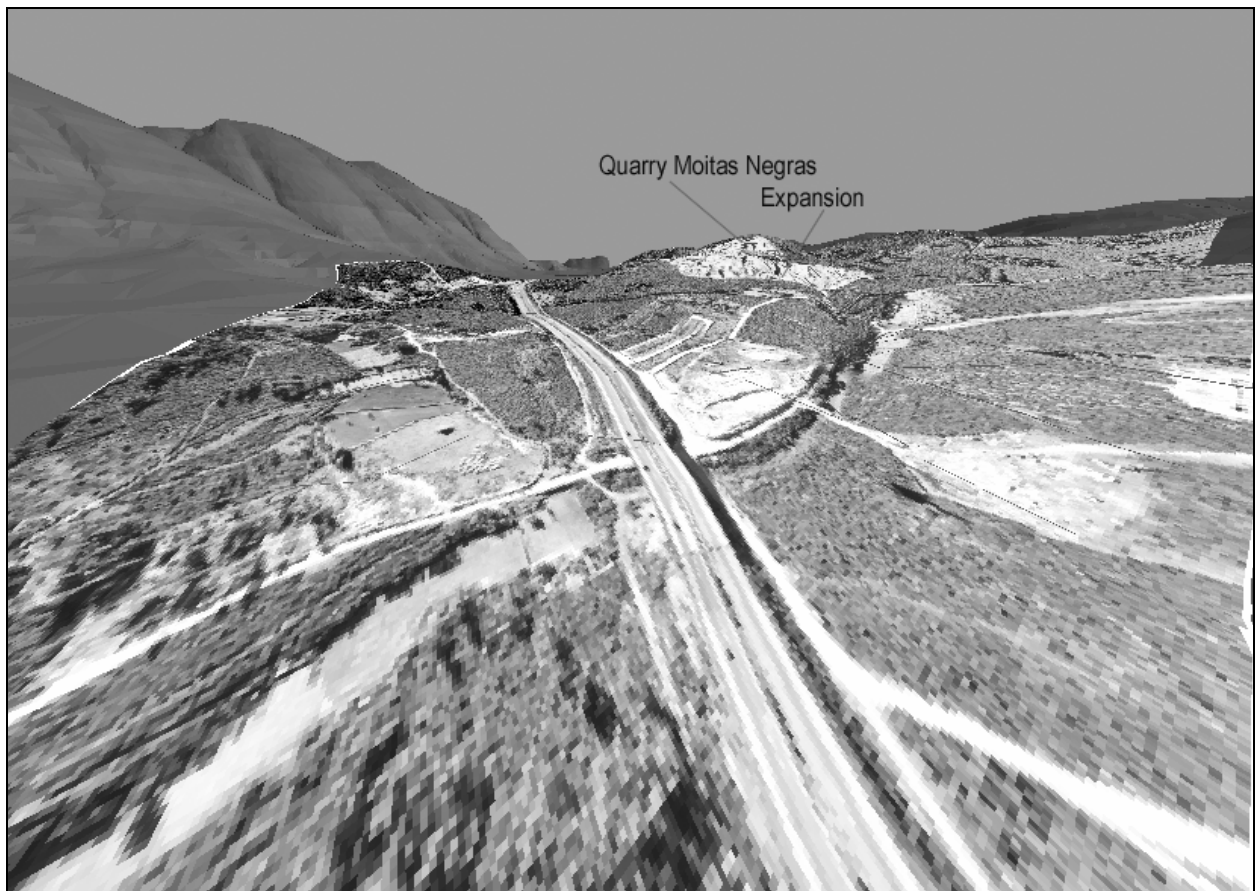


Figure 3. A photo captured from the fly-over digital video created from a digitalisation of a path in a 2D map display which was then traversed in the 3D scene aimed to visualize the location of existed quarry and proposed expansion.