
A METHODOLOGICAL APPROACH FOR THE EVALUATION OF IMPACTS ON SITES OF GEOMORPHOLOGICAL INTEREST (SGI), USING GIS TECHNIQUES

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ABSTRACT

This paper proposes a methodological approach for the study of one component of the geomorphological asset: the intrinsic quality. This approach is derived from the integration of two methodologies developed by the teams of the University of Cantabria and Modena-Reggio Emilia. The two methodologies have been compared over the basis of the variables that express the same concept.

The new methodology is based on the classification of the geomorphological asset on the basis of digital geomorphological maps. The assets classified are identified on the basis of three independent categories (example of processes, paleogeomorphological example and example of geomorphological evolution). These categories are dimensioned using objective parameters as extent and degree of knowledge. The concept of degree of knowledge developed into this work, is obtained from the bibliography; while the concept of extent is given by the measure of the asset in the digital map. Obviously these concepts have been normalised.

The final value of a single asset is the product of the type of category by the product of its extent by the degree of knowledge. The impact produced by a human activity on the geomorphological assets is measured through the change in the value of the intrinsic quality of the asset, before the human activity and after.

This approach is tested by using the integrated data set of Guipúzcoa, Basque country (Spain).

1 INTRODUCTION

The development of a variety of human activities is conditioned by the geomorphology. However, the geomorphology is not sufficiently analysed in Environmental Impact Assessment (EIA) projects. This is probably due to deficient attention in the EIA Process. Geomorphological components of the environment can be grouped, for EIA purposes, into three categories: geomorphological resources, geomorphological processes, and geomorphological assets, whereby the sites of geomorphological interest (SGI) are included into the latter (Rivas et al., 1997). SGI are part of the natural and cultural heritage; they contain essential information for the interpretation of geomorphological processes and history and have a potential for scientific, educational or tourism use (Rivas et al., 1997).

Geomorphological assets are defined as no-consumable resources, and for this reason it is difficult to evaluate its value through EIA. The value of SGI can be expressed using different methods and criteria. Two different approaches are proposed to solve the problem of evaluating SGI: Panizza et al. (1995), Bertacchini et al. (1999), and Rivas et al. (1997), Barba et al. (1997).

The first two are based on the classification of the assets according to scientific disciplines and then establishing, for each of them, the type ("valenza") and degree of interest ("grado de interesse") (Fig. 1). Degree of interest is ranked in four levels, from local (1) to international (4). The value of the site for each discipline ("gruppo di studio") is obtained by the sum of the values for individual characteristics or qualities ("valence"). Thus, this

value should vary between 0 and 20. The overall value ("qualità") of the site can be obtained by adding up the value for each discipline, or else these can be considered separately. Either total SGI or individual discipline values are modified by a factor, C, depending on the state of preservation.

The second approach is based on the definition of a series of parameters, which can be measured or objectively described and ranked. These parameters refer to intrinsic quality (relative

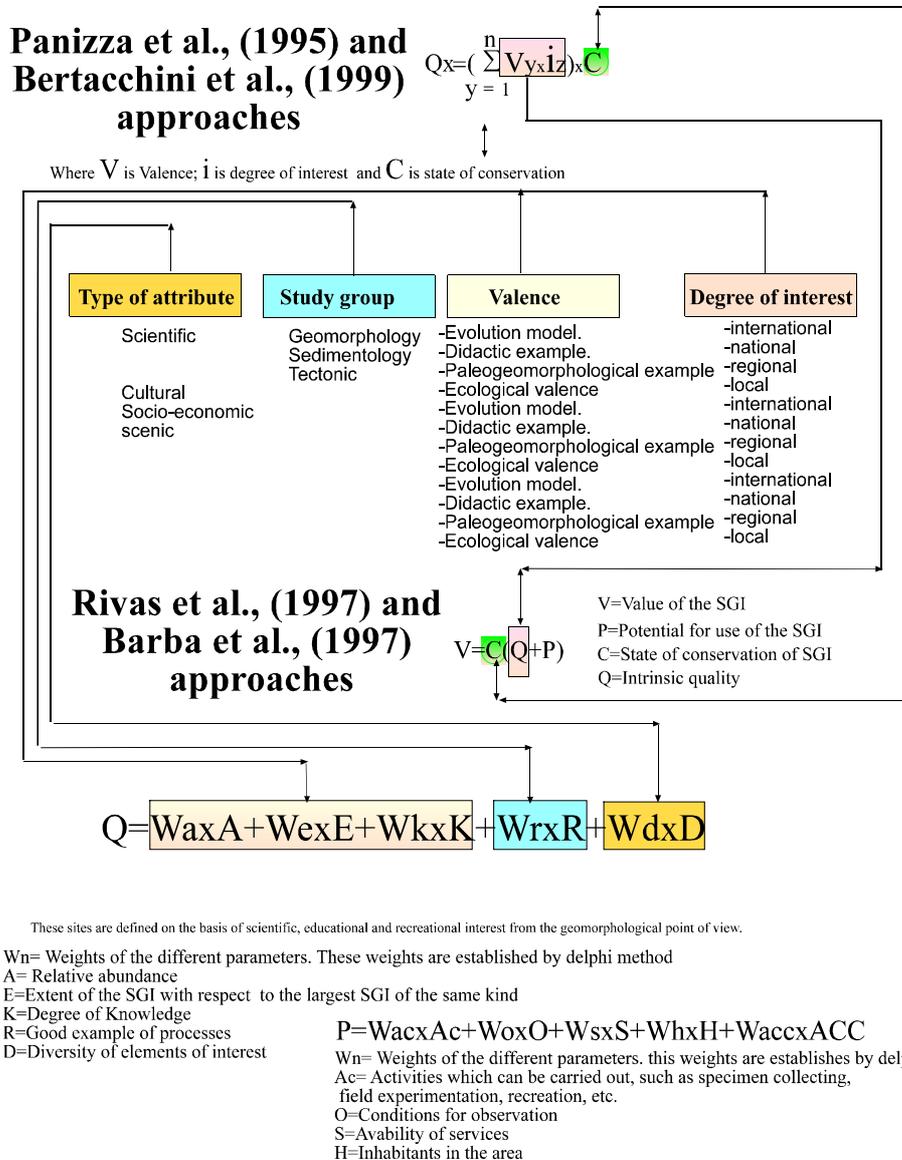


Fig. 1. Comparison between the methodological approaches.

abundance, scientific diversity, extent, example of process, degree of knowledge) and potential for use (activities, population in the area, availability of services, accessibility and conditions for observation). Values (0-4) are assigned to each one of those parameters and quality and potential for use obtained by means of a weighted sum. The value of the SGI is the sum of both, corrected by a "state of conservation factor" (Fig. 1).

It is obvious that motorway construction can produce impacts on SGI. It can alter part of the characteristics or parameters used by either methodology for deriving SGI "value", particularly the state of conservation. Impact assessment should thus include the consideration of the value of sites with and without the motorway.

The most relevant attribute of an SGI is the "scientific merit" ("intrinsic quality" of Rivas et al., 1997; "valenza" and "grado di interesse" of Panizza et al. (1995). These two concepts, although basically equivalent, are expressed quite differently according to each approach. Fig. 1 shows the relationships between the qualities/parameters used by both authors.

The approach proposed here combines the ones described above and can be applied by GIS.

2 METHODOLOGY

The methodology begin with the analysis of the geomorphological information (Fig. 2). The asset identified are classified on the basis of three independent variables: example of processes, V_1 ; paleogeomorphological example, V_2 ; example of geomorphological evolution V_3 . These categories are dimensioned using objective parameters as extent and degree of knowledge. Obviously these concepts haven been normalised.

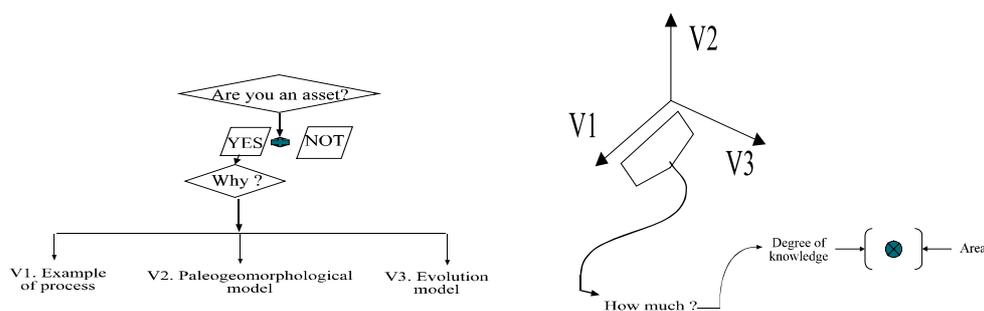


Fig. 2. Conceptual scheme of the methodology

The concept of degree of knowledge developed is obtained from the bibliography. The publications of each SGI are studied and divided into two groups: international and national. The SGI without existing publications are also divided into: newspaper and new data. Those SGI that for some reason, have a journalistic perseverance of their existence or of the some of the features that constitute them, and the SGI that do not have information. Obviously these are the SGI recently defined. Each paper is weighted using an aprioristic method. Figure 3, illustrates the weights used.

weights		International journals	National journals	No scientific information
$P > 50\%$		3/3	2/3	1/3c
$P = 50\%$		2/3	4/9	
$P < 50\%$		1/3	2/9	

C	Example quality	Newspaper	New data
	high	1	1/2
	medium	2/3	1/3
	low	1/3	1/6

Fig. 3. Weights for normalising degree of knowledge

The final value of a single asset is the value of its three variables. The value of each variable is the product of its extent by the degree of knowledge. The value of a large asset is the sum of the values of the single ones, taking into account the diversity and the relative importance of these singular assets.

Using this methodology it is possible to measure the impacts produced by some kind of human intervention on the geomorphological features. The impact could be measure by the difference between the value of the intrinsic quality of a SGI after the construction and the before then, in the previous situation.

This approach has been tested by means of the integrated data set of Guipúzcoa (González-Díez et al., this volume).

3 THE CASE STUDY

The study area (Fig. 4) is located in the lower and middle part of the Deva valley, between Eibar-Elgoibar and Mondragón, Guipúzcoa, Basque provinces, (Spain). It covers approximately 190 km². Altitude ranges between 110 m and 700 m, and mean annual rainfall is about 1,400 m. The population is around 80,000 inhabitants. The economy of the area is based on manufacturing industries and services.

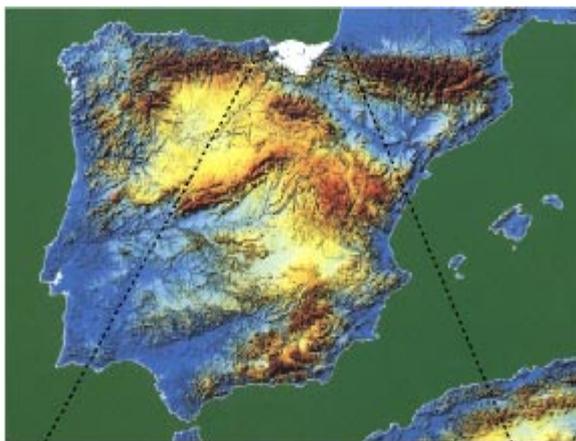


Fig. 4. Location Map

It is an area of rugged relief in which flat areas (gradient <5%) represent less than a tenth of the territory. The climate is mild and humid (average annual temperature around 14°C near the coast and rainfall around 1200-1500 mm).

The area is moderately folded and faulted, with WNW-ESE as the main structural trend. Bedrock materials range from Lower Cretaceous sandstones, siltstones, marls and claystones (Purbeck-Wealden facies) to massive Aptian limestones and Upper Cretaceous marls and marly limestones. Some basaltic pillow lavas appear interbedded within the sedimentary sequence.

The geomorphological character of the area is determined by V-shaped valleys with limited development of the alluvial plains. Valley slopes have gradients around 20-25% and are covered by regolith with thickness between 0.5 and 3 m. The erodibility of soils and regolith (when vegetation cover disappears) is high. The contact between regolith and bedrock often acts as rupture surface for shallow landslides.

The study area has an integrated database where includes maps representing a variety of physical and human elements (DTM, bedrock, surface deposits, aquifers, soils, drainage networks and water quality, land cover, natural hazards, protected areas, sites of scientific interest, etc.)

4 RESULTS

The analysis starts from the analysis of the geomorphological information presented in the Eibar database. This information was implemented with other obtained through field surveys and air-photo interpretation. The sites of geomorphological interest (assets) selected have been classified, digitized and incorporated into a new database (Fig. 5a). In this database was considered the scale of an asset. This concept means that the value of an asset of large dimension is the sum of the values of the single asset that composed the big one.

The Figure 5b shows a table with nine assets located in the area of Eibar. The more relevant assets are accompanied by pictures.

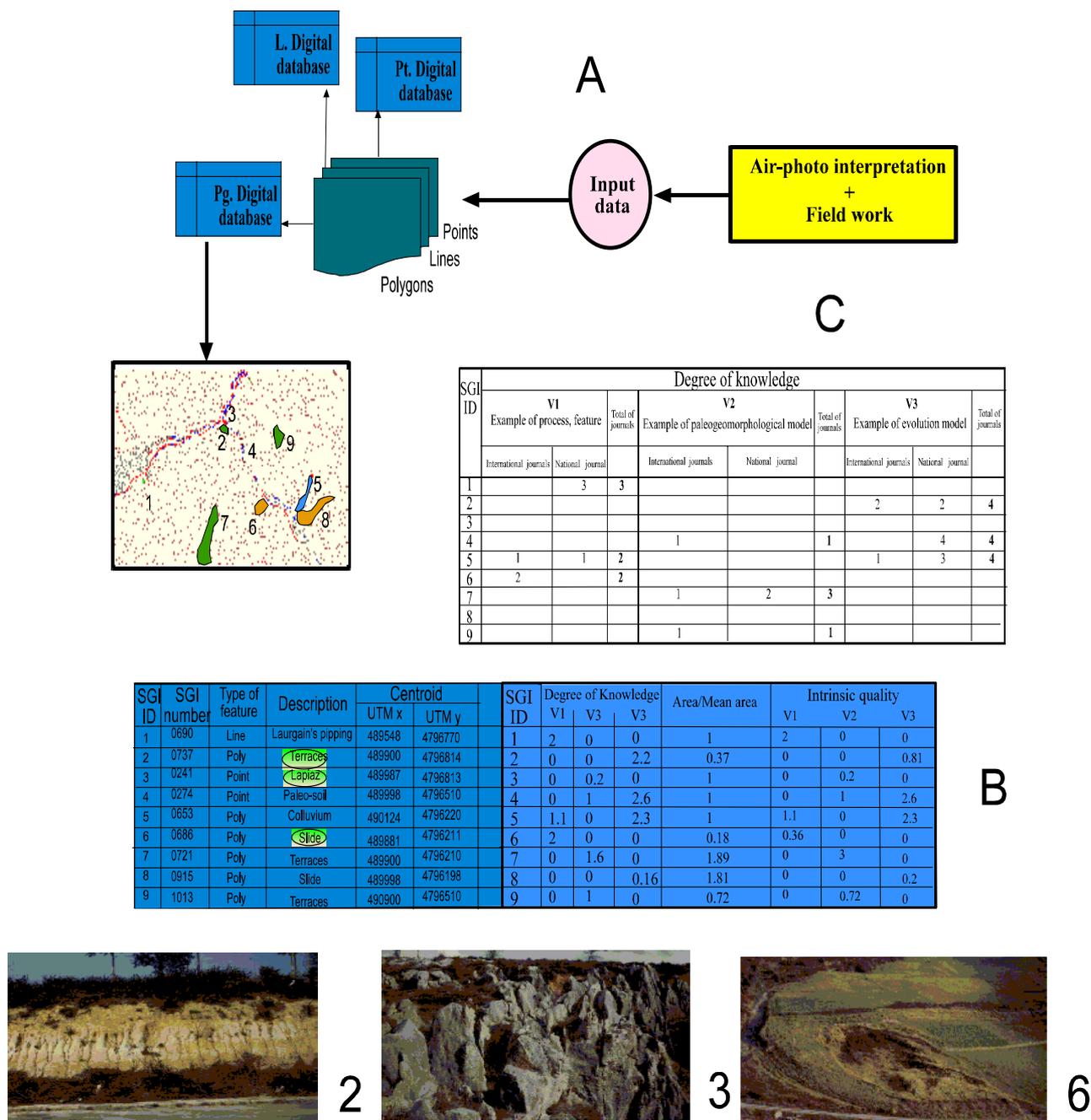


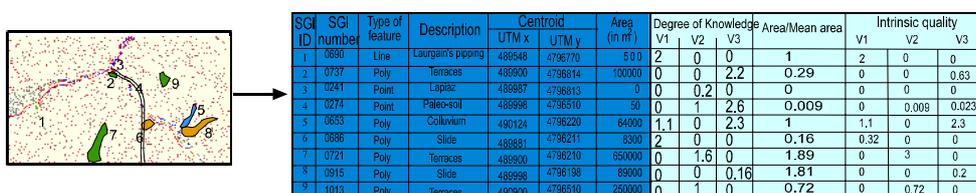
Fig. 5. A. Data input; B. Database and assessment of intrinsic quality; C. Bibliographic research.

The second step begins with a bibliographical research. As it show in the Figure 5c, the number and type of the publications are tanking into account. It is regarded as important that the operator read and classified the articles in respect of the variables described before (example of processes, V₁; paleogeomorphological example, V₂; example of geomorphological evolution V₃). Frequently, are hardly available bibliographical information about an asset. In that case the operator must be classify the asset in the base on his criteria. Figure 5b shows the value of the intrinsic quality for each asset. The concept of extent is given by the measure of the area of each asset in the digital map. The extent is normalised dividing the area of each SGI by the mean area of the process in which this SGI was classified (Fig. 6).

SGI ID	Area (m ²)	Types of process	Mean area (m ²)	Area/Mean area
1	5 0 0	Piping	5 0 0	1
2	130000	Terrace	343333	0.37
3	1000	Laplaz	1000	1
4	5500	Palco-soil	5500	1
5	64000	Colluvium	64000	1
6	9000	Slide	49000	0.18
7	650000	Terrace	343333	1.89
8	89000	Slide	343333	1.81
9	250000	Terrace	343333	0.72

Fig. 6. Example of area normalisation

A



B

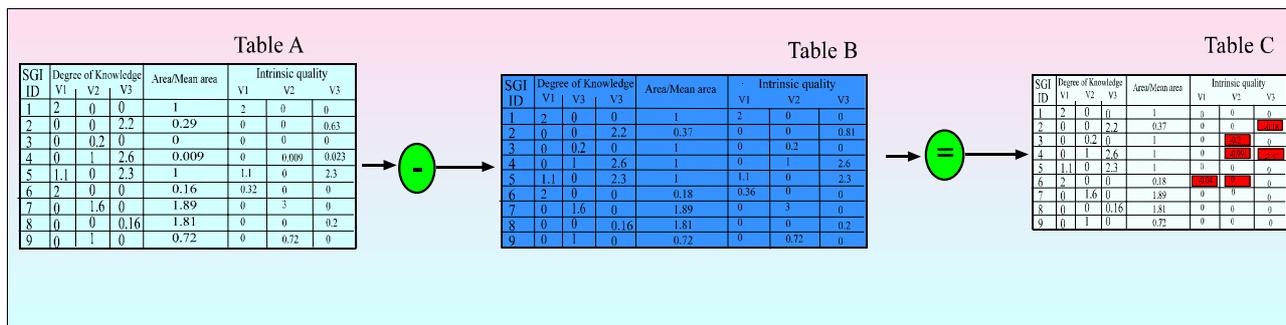


Fig. 7. A. Data input in a situation post human activitie; B. Assessment of impacts on SGI. Table A: post-project value; Table B: baseline value; Table C: impact values.

Figure 7 shows a new situation with a human intervention (a highway). The new value, of the intrinsic quality, for each asset is presented in the table b (Fig. 7a). The impact of the human intervention is measured subtrain from the post project value the pre-project. As it is show, the assets affected have a negative impact value. It is possible that a intervention produces a positive value. This is the case of assets discovered by human intervention.

5 CONCLUSION

The method proposed provides a means to combine expert's evaluation and measurable parameters to determine impacts on intrinsic quality of SGI. It can easily be implemented using widely available GIS tools.

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