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ENVIRONMENTAL IMPACT ASSESSMENT STUDIES IN THE REGIONAL PARK OF SASSI DI ROCCAMALATINA (NORTHERN APENNINES, ITALY)

MARCO BERGONZONI*, ANNA VEZZANI#, JOSEBA I. LUGARESARESTI+, MAURO SOLDATI# & DOMENICO BARANI#

* *Parco Regionale dei Sassi di Roccamalatina, Guiglia (Modena), Italy.*

Dipartimento di Scienze della Terra, Università degli Studi di Modena, Italy.

+ *DCITYM, Facultad de Ciencias, Universidad de Cantabria, Santander, Spain.*

Abstract

The present paper describes the state of the art of the Environmental Impact Assessment studies carried out in the Regional Park of Sassi di Roccamalatina (Northern Apennines, Italy) within the framework of a European Union funded project concerning the role of geomorphology in the EIA studies (Human Capital and Mobility Project). After some indications on protected areas in Italy, the environmental aspects of the Park are described; then the geomorphological assets and hazards outlined through a 1:10.000 geomorphological survey are analysed. Furthermore a possible application of an EIA procedure based on the above mentioned survey is presented. Finally a few notes on the digitalisation of topographic data and the realisation of a Digital Terrain Model (DTM) are given.

Key words: Environmental Impact Assessment, Geomorphology, Regional Park, Northern Apennines.

Riassunto

Studi di Valutazione d'Impatto Ambientale nel Parco Regionale dei Sassi di Roccamalatina (Appennino Settentrionale, Italia). La presente nota descrive il grado di avanzamento degli studi di Valutazione d'Impatto Ambientale compiuti nel territorio del Parco Regionale dei Sassi di Roccamalatina (Appennino Settentrionale, Italia) nell'ambito di un progetto finanziato dall'Unione Europea che riguarda la definizione del ruolo della geomorfologia negli studi di VIA (Programma: Capitale Umano e Mobilità). Dopo alcune precisazioni sulle aree protette in Italia, vengono descritte le caratteristiche ambientali del Parco in oggetto per passare poi all'esame dei beni e delle pericolosità geomorfologiche che sono stati individuati attraverso un rilevamento geomorfologico a scala 1:10.000. Viene inoltre presentata una possibile applicazione di VIA in un'area campione del Parco basata sul rilevamento suddetto. Infine vengono riportate alcune note sull'informatizzazione dei dati topografici e sulla realizzazione di un Modello Digitale del Terreno (DTM).

Termini chiave: Valutazione d'Impatto Ambientale, Geomorfologia, Parco Regionale, Appennino Settentrionale.

1. INTRODUCTION

This paper deals with the environmental impact assessment studies which are in course in the protected area of the Regional Park of Sassi di Roccamalatina ("Rocks of Roccamalatina") within the framework of

the E.U. Human Capital and Mobility Project "Geomorphology and Environmental Impact Assessment: a network of researchers in the European Community". This Regional Park consists of a protected area of more than 1.000 hectares in the Emilia-Romagna Apennine, province of

Modena (fig. 1).

A scientific research has started in the area which will give in the near future the possibility of applications related to land management. The Earth Sciences Department of the University of Modena and the Regional Park of Sassi di Roccamalatina are the institutions involved in these investigations, with the collaboration of a researcher of the Earth Sciences Division of the University of Cantabria, Santander.

Beside other natural components, the area is particularly interesting and valuable from a geological and geomorphological point of view, but no detailed studies were available on the morphological aspects. For this reason the research has started with a detailed geomorphological survey and mapping (scale 1:10.000 for the whole area of the Park and scale 1:2.000 for the portion which has been established by law as of total protection; see fig. 2). This document will be used as the base for the preparation of a "geomorphological assets map" and of a "hazard map"; assets and hazards have been only generally outlined so far and are described in the following chapters. Digitalisation and computer mapping has been used and further investigations relying on GIS techniques will be applied. The last phase of the research will regard the assessment of the impacts related to both tourism activities and with projects of intervention planned by the regional administration (footpaths, campings, etc.). The EIA studies will enable to propose alternative solutions and/or environmental mitigations.

The present paper, after a short paragraph about protected areas in Italy, describes both the general natural aspects and the geological and geomorphological characteristics of the Park of Sassi di Roccamalatina. Finally a possible application of an EIA procedure using detailed geomorphological survey is presented.

2. PROTECTED AREAS IN ITALY

The fundamental principles for the institution and management of the over 400 protected areas in Italy are defined by law n. 394, promulgated in 1991, which establishes the following subdivision:

- National Parks;
- Regional Nature Parks;
- Nature Reserves (national and regional);
- Protected Marine Areas.

The classification and institution of National Parks and Nature Reserves come under the jurisdiction of the Minister for the Environment, while Regional Parks and Nature Reserves are established and managed by Regional Authorities. At present in Italy there are: 17 National Parks, 140 State Nature Reserves, 172 Regional Nature Reserves, 75 Regional Parks and 35 Wetlands of international relevance. The great number and variety of Protected Areas bear witness to the remarkable richness of the natural heritage of the whole Italian peninsula, although these natural assets are not evenly distributed throughout the country. Among the regions with a high percentage of areas included within Parks and Reserves we find: Liguria (19.9%), followed by Sardinia (17.5%), Abruzzo (13.8%), Lombardy (13%) and Val d'Aoste (12.6%).

3. GENERAL ASPECTS OF THE PARK OF SASSI DI ROCCAMALATINA

3.1 The aims of the Protected Area

The Regional Park of Sassi di Roccamalatina, in the Apennine district of the province of Modena (fig. 1), was established by Regional Law n. 11/1988 (modified and integrated by Regional Law n. 40/1992) after a long phase of

institutional initiatives starting in 1974. At present it covers a surface of over 1.000 hectares, mostly included within the municipal territory of Guiglia and, to a lesser extent, of Marano sul Panaro. The institutive criteria and the aims of the Park are defined by the Park Territorial Plan

(PTP), which provides the guide-lines aiming to define the planning organisation of the structure and the consequent ruling criteria for the activities and interventions within the park (Bulgarelli and Ori, 1990; Nora, 1995).

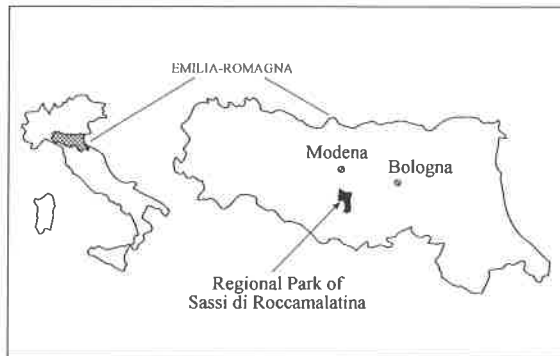


Fig. 1 - Geographical setting of the Regional Park of Sassi di Roccamalatina (province of Modena, Italy).

Fig. 1 - Inquadramento geografico del Parco Regionale dei Sassi di Roccamalatina (provincia di Modena, Italia).

To this purpose, the application of a model of balanced measurement for the natural and artificial elements in the various environments of the park, provides us with fundamental parameters of evaluation. In this way the management aims of the different areas of the park are better identified. On this basis it has been possible to define and qualify the general goals and, in particular:

- the management, the upgrading, the restoration, the improvement of biotopes, geological and geomorphological formations and architectural elements of noticeable historical, scientific, cultural, educational and scenic interest;
- the conservation, reclamation, restoration and improvement of interesting wildlife habitats;
- the promotion and development of local economic activities in order to recuperate also marginal areas and reconstruct and protect ecological balances;

- the improvement of Man-Nature relationships, by means of promoting cultural, educational and recreational activities related to enjoyment of the environment.

These goals may be achieved mainly by considering the following elements:

- the most important geomorphological and geological features: outcrops, erosion furrows, caves, dolines, etc., with attention given both to their conservation and the necessary remedial measures for improving their stability;
- the watercourses and the groundwaters, taking into account their hydric regime and their upgrading and protection from pollutants;
- the woods, their management, conservation and improvement;
- the soil, considering in particular the maintenance of its fertility and the adequate conservation of the elements that make up the landscape, including the architectural heritage of rural civilization;

- all the buildings having historical, architectonic and typological interest, with the aim of preserving and restoring them for general enjoyment.

3.2. Homogeneous territorial zones

In order to achieve the aims expressed by the PTP, an areal subdivision of the park territory into “homogeneous zones” has been carried out. This partitioning does not correspond to a simple differentiated distribution of the protection levels, but implies distinct and complementary management models, adequate to the different areas in relation with their intrinsic properties. In particular the following zoning has been arranged:

- “A” Zone: *total protection*
- “B” Zone: *general protection*
- “C1” Zone: *special environmental protection*
- “C2” Zone: *environmental protection*
- “Outer Zone”: *Pre-park*

In each defined zone (fig. 2) appropriate activity limitations are applied as well as specific development guide-lines, in agreement with legal indications and the guidance derived from the thematic analyses above illustrated. The protection criteria follow a balanced gradient ranging from absolute protection for “A” zones, to natural resource management for “B” zones and up to the various degrees of farming and forestry uses admitted respectively in the two different typologies of “C” zones and in the pre-park “Outer zone”.

3.3 The Park natural environment

The originality of this park is given not only by the presence of the “Sassi” cliffs and by the numerous associated micro-environments but also by the harmonious balance of woods and farmland, as well as architectural elements and past and present human activities linked to popular tradition.

Certainly the Sassi di Roccamalatina are one of the best geomorphological features found in the hilly areas of the Emilia Apennines (they will be described in detail in the following chapters). Attention should now be drawn to other relevant aspects of the park, such as: flora, fauna and historical and architectural sites, which all contribute to the extreme interest of this environment. As for the wildlife, the element of paramount interest is given by the birds (about 200 species), in particular those linked to the rocky cliffs of the “Sassi”. Among birds of prey, worthy of note is the presence of the peregrine falcon (*Falco peregrinus*), practically extinct in other areas of the Apennines, and of other predators such as the kestrel (*Falco tinnunculus*), the buzzard (*Buteo buteo*) and the sparrowhawk (*Accipiter nisus*). Among nocturnal predators, the tawny owl (*Strix aluco*), the barn owl (*Tyto alba*) and the little owl (*Athene noctua*) are found. Mammals are represented by the fox (*Vulpes vulpes*), the weasel (*Mustela nivalis*), the stone-marten (*Martes foina*), the polecat (*Mustela putorius*), the red squirrel (*Sciurus vulgaris*), the dormouse (*Glis glis*) and other small rodents. Among reptiles only few species are found: the collared water-snake (*Natrix natrix*), the coluber (*Coluber viridiflavus*), the common lizard (*Lacerta muralis*) and the green lizard (*Lacerta viridis*). Also some amphibians are found: they live mainly in the damp habitats of the rocky gorges. Among them, worthy of note are the newt (*Triturus vulgaris*) and *Hydromantes italicus*.

The vegetation is typical of the middle mountain area, with oak woods associated with particular micro-climatic conditions. Many parts of these woods show the ecological characteristics of mesophyll vegetation, even if in some dry soils and slopes the xerophyll oak woods thrive.

The most widespread trees found in the mesophyll woods are: the common oak

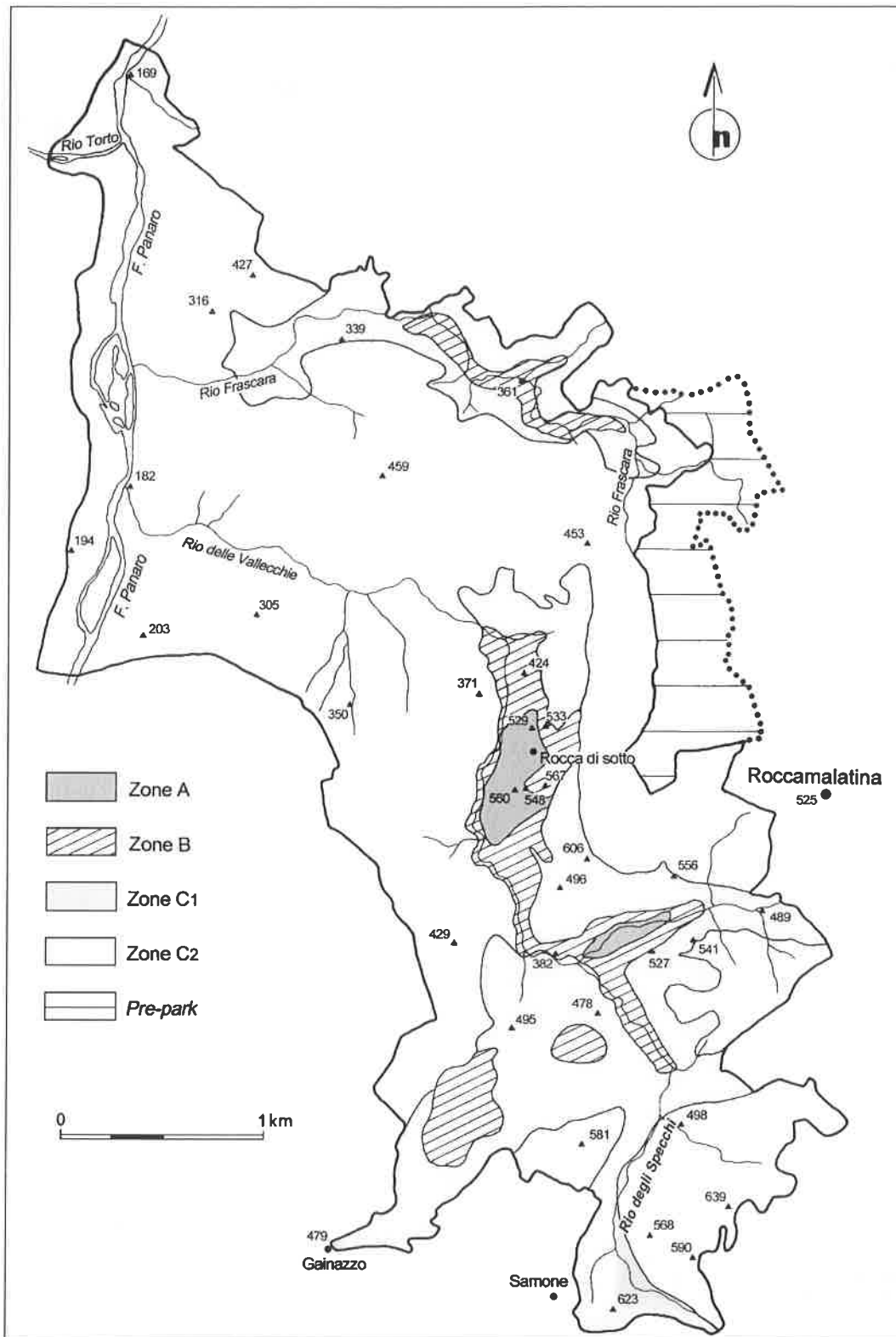


Fig. 2 - Extension of the Regional Park of Sassi di Roccamalatina and schematization of the different protection zones.

Fig. 2 - Estensione del Parco Regionale dei Sassi di Roccamalatina e schematizzazione delle diverse zone di tutela.

(*Quercus robur*), the hophornbeam (*Ostrya carpinifolia*), the flowering ash (*Fraxinus ornus*), the opalus maple (*Acer opalus*), the hazelnut (*Corylus avellana*) and the laburnum (*Laburnum anagyroides*). Among the xerophyll shrubs associated with the pubescent oak (*Quercus pubescens*) numerous specimens of juniper (*Juniperus communis*), broom (*Spartium junceum*) and *Medicago arborea* are present. Another important tree in the park is the European chestnut (*Castanea sativa*), with several specimens over one-hundred-years old: since remote times it has been cultivated as a food source. Finally some of the most important historical buildings should be mentioned. Among them, some famous tower-houses which are a kind of fortified farmhouse. In particular we find: the Castellaro stronghold (XVI century), The Bastiglia bastion (XIV c.), the ancient fortified village of Castellino delle Formiche (XIV-XVII c.), the Romanesque church of Pieve di Trebbio (XI c.), the Grilla (XV c.) and Pugnano (XIV-XVI c.) hamlets.

4. GEOLOGICAL AND GEOMORPHOLOGICAL SETTING

4.1 Geological aspects

The rocks outcropping in the Regional Park of Sassi di Roccamalatina, located in the low Apennines of the Modena province, belong mostly to two important groups: Ligurian and Epi-Ligurian Units.

The Ligurian Units, ranging in age from Lower Cretaceous to Upper Oligocene, are allochthonous formations overthrust north-eastward from the Upper Oligocene to the Lower Pliocene (Dallan Nardi and Nardi, 1972). The Ligurian formations are part of the Cretaceous Basal Complexes which are mainly argillaceous units showing different rates of deformation (tectonites). They are represented in the

study area by the Argille a Palombini (Lower Cretaceous-Cenomanian), outcropping mostly along a stretch of the Panaro River, and the Argille Varicolori and Arenarie di Scabiazza (both dating from Cenomanian-Lower Campanian), found at a higher altitude.

The Epi-Ligurian Units (Middle Eocene-Lower Messinian) are considered as the product of the syntectonic terrigenous sedimentation on the Ligurian accretion prism during its progressive shift towards the Tuscan and Umbro-Marchean sub-Ligurian domains (Bettelli et al., 1987). The Epi-Ligurian Units are here represented by the sandstones and marlstones of the Antognola Formation (Upper Oligocene-Lower Burdigalian) which unconformably overlie the Ligurian Units and mark the return of a sedimentation occurring in turbiditic-emipelagic environmental conditions (Bettelli and Bonazzi, 1979). Other Epi-Ligurian Units, much more widespread in the higher portion of the study area, are given by the alternations of pelites and sands, calcareous sandstones and marlstones of the Bismantova Formation (Upper Burdigalian-Serravallian), which are part of a depositional shelf system (Bettelli and Bonazzi, 1979).

From the tectonic viewpoint the Ligurian Units underwent their emplacement at an already tectonized stage: their structural characteristics are the result of several tectonic phases, in particular of the plicative Ligurian phase (Upper Paleocene-Lower and Middle Eocene) and the translative Tuscan one (Tortonian). Moreover, these formations were subject to well recorded movements of the Apennine margin in more recent times.

The Epi-Ligurian Bismantova Formation outcrops frequently as rigid tabular slabs of various shapes and dimensions overlying the Ligurian clayey formations. Each slab could result from an original calcareous-

arenaceous shelf deposited in a shallow marine environment, subsequently subject to erosional and gravitational dismembering. Usually the structural attitude of the epi-Ligurian deposits is influenced by the mechanical characteristics of the substratum: fracturing and separation of the competent slabs, transport and displacement along the margins, where the geometrical limits and lateral boundaries of the formations are hidden and could have conditioned the disuniformity of the formation thickness (Bettelli and Bonazzi, 1979; Cancelli et al., 1987).

4.2 Geomorphological features

The geomorphological features of the study area are strongly influenced by the geological characteristics, both lithological and tectonic.

Three lithological types are found: sandstones, calcareous sandstones and marls of the Epi-Ligurian Formations and clays of the basal Ligurian Complexes.

In correspondence with the sandstone outcrops the morphological features are characterised by a marked steepness: the slope acclivity is in sharp contrast with the mild morphology of the clayey outcrops: scarps, bluffs and large boulders are often found. In proximity of the poorly cemented coarser layers, weaker surfaces can give way to joints and rock falls. Owing to their perviousness, these rocks have a high amount of percolation water, thus giving origin to springs and favouring a well developed vegetation cover.

Owing to their higher content of calcium carbonate, calcareous sandstones and marlstones are more resistant than sandstones. In correspondence with these rocks karst processes may be found accompanied by soil formation. The landscape is frequently modelled by man's activities, since farming is very widespread.

Clay soils can be highly porous but practically impermeable; they are well known for their plasticity and give rise to gullies and slope movements such as creep and earth flows. Their substratum cannot support the growth of trees and makes farming very difficult. The identification of outcrops of clayey formations belonging to the basal Ligurian complexes was made easier thanks to their morphological features, further emphasised by the contrast with the overlying competent formations. The characteristics of the clayey outcrops are made evident by gully erosion and landslide zones of depletion which show the typical chaotic attitude of these materials resulting from intense tectonic stresses. Apart from these landforms, the slopes show all the characteristics of unstable materials, deriving also from the lithological complexities of these argillaceous formations. Moreover, the presence of blocks and boulders within the clayey matrix increases the discontinuities along which precipitation water percolates. This phenomenon is further emphasised by the exsiccation cracks formed during the dry seasons, thus increasing the depth of percolating water and the general instability tendencies of these slopes along deeper shear surfaces.

The morphology of the area derives mostly from the contrast of competence between the argillaceous rocks and the arenaceous and calcareous formations. Also the attitude of the structural elements in the epi-Ligurian formations has a major influence in the development of particular landforms: the steep cliffs of the Sassi di Roccamalatina are connected not only to the competence of the sandstones but also to the sub-vertical dip of their layers which caused the formation of the most impressive pinnacles.

Finally, the area is characterised by several complex mass movements which in some cases have been interpreted as deep-

seated gravitational slope deformations (Cancelli et al., 1987), with lateral spreading and displacement affecting large competent slabs overlying clayey soils, showing also other elements linked to environmental hazard.

5. GEOMORPHOLOGICAL ASSETS AND HAZARDS

5.1 Assets

In order to analyse the assets of the study area, the methodology of investigation proposed by Carton et al. (1994) was applied.

According to this method, the attributes that can give a value to geomorphological assets are essentially: scientific, socio-economic, cultural, educational and scenic.

From the scientific point of view, a geomorphological asset is defined as such if it shows one or more of the following five evaluation parameters: example of geomorphological evolution, object of educational exemplarity, paleogeographical evidence, a rarity of Nature, ecological importance (the latter comes within the sphere of biological studies).

The socio-economic value is assumed when the asset can be used for touristic, recreational and sport activities. In fact the economic value expressed by the conservation of environmental components often seems to be superior to any other, considering also its future use, and takes priority over ethical considerations.

Culturally speaking, also artistic works or local traditions can be inspired by particular landscape features which can be geomorphological assets.

Following the above mentioned evaluation analysis, a qualitative value can be assigned to each geomorphological asset according to its degree of interest on a space-based scale which can be: worldwide,

national, regional, local, or of no interest at all. The methodological steps to be followed in order to identify and assess scientific assets are: geomorphological survey and mapping (by means of field investigations, remote sensing and collection of reference data) and selection from geomorphological maps of the landforms to which the attribute of asset should be assigned according to its intrinsic value and degree of interest.

The cliffs of Sassi di Roccamalatina may be considered as the main geomorphological asset of the Regional Park, with their pinnacles about a hundred metres high over the surrounding hills. Their morphology is derived from differential erosion mainly controlled by the lithological characteristics, since the "Sassi" consist of sandstones resting on clays and clay shales. Their shape is also due to the subvertical attitude of the strata which makes them more resistant to erosion and inhospitable for the vegetation. In fact where the strata arrangement changes, the sandstones no longer show such an exceptional and unique shape. Like other sandstone outcrops in the park, the "Sassi" are characterized by high permeability so that springs are often found at the sandstone-clay boundary. Where the sandstone cement is weaker, the rocks do not show a compact texture and therefore they are more exposed to weathering and degradation processes. In this way detachment cavities are shaped by the meteoric agents whilst the limestone-rich strata are more subject to carbonate dissolution, resulting in karst landforms. The morphological evolution of these formations is also controlled by the widespread presence of tectonic fractures giving origin to rock and debris falls.

According to the methodological scheme adopted, the "Sassi" can be considered as geomorphological assets on a regional level since they are a rarity in the low Apennines as well as paleogeographical evidence of the presence of the sea and its fluctuations.

Moreover, they have ecological significance since they give shelter to a rich and varied fauna, with the rare presence of the peregrine falcon. Besides its important physiographic characteristics, the Park of Sassi di Roccamalatina offers other points of cultural interest, both historical and artistic as witnessed by the presence of the fortified village of Castellino delle Formiche, the Romanesque church of Pieve di Trebbio and other ancient buildings and hamlets.

Also the socio-economic attributes of this park should be properly recognised and enhanced: they are linked to the great appeal to tourists and the presence of several Nature trails.

As for the elements and structures which constitute a negative impact on the "Sassi", the most striking example is given by a restaurant located at the same height as the cliffs on the opposite slope, in a particularly exposed position; it bears the significant name of "Il Faro" (the lighthouse). The side of the building facing the "Sassi" is entirely covered with glass windows, to offer a better view of the cliffs. Another serious problem is represented by the crowds of tourists that walk along the footpaths and the steps dug into the poorly cemented sandstones, thus noticeably increasing the rate of the erosion processes.

One of the aims of the research is to trace alternative panoramic routes for the tourists that could still offer good views of the "Sassi" without compromising their conservation. In order to analyse the degradability of the cliffs, geotechnical and geomechanical investigations will be carried out on the sandstones, establishing, if possible, quantitative parameters of evaluation. Moreover, analyses on the acidity of the precipitation water will also be carried out.

Other geomorphological assets may be given by pyramid-like erosion forms in the Cretaceous clays north of the Sassi, near the

Pioppa stream. Also these landforms can be considered as assets owing to their rarity as well as an example of geomorphological evolution in argillaceous slopes. The abundance of lithic blocks in these clayey complexes facilitates the formation of this peculiar morphology. Apart from these morphological features, a well developed earth flow is also found, which could be a good educational example for the field identification of a landslide: crown and detachment area, main body and zone of accumulation. There is also an earth slump with evident surface of slide and grooves.

Other possible assets are a waterfall along a sandstone scarp and dolines on calcareous sandstones of the Bismantova Formation.

Other kinds of impact on different parts of the park were given by some dumping sites but, thanks to the initiative of the Guiglia municipal council at the beginning of 1994, these have now been recuperated.

Another form of impact is caused by the presence of active soil pits just outside the boundaries of the park: their negative effect on the environment is not only localised at the quarrying site but also in the surrounding areas and is mainly given by: destruction of natural vegetation, hydraulic disruption and geological instability, air pollution and noise derived from the extraction works and transport, heavy traffic on adjacent roads and carriageways. One abandoned soil pit was terraced and covered with grass but the overhanging slope is still affected by the intense erosion of runoff waters that hinder the growth of spontaneous vegetation.

5.2 Hazards

The hazards along the Panaro river and at lower elevations are given by the presence of clays and clay shales of the Ligurian Units which are characterised by low permeability and high plasticity. Where no artificial drainage is provided, the clays in

contact with rainfall water tend to swell and slide down, disrupting the slope with rill or gully erosion, only locally limited by the shrubby and sparse vegetation. Mass movements, in particular earth flows and slumps, are indeed a real calamity along the Po Valley side of the Northern Apennines. Moreover, slope instability is often increased by river erosion. Remedial measures should consist of drainage systems, re-forestation, retaining structures such as wicker trallis and other effective works for the safeguard of human settlements and the conservation of farming soil, although many previous intervention works have been destroyed by successive reactivated landslides. The "Belvedere trail", the most important footpath of the area, is often affected by slope movements in the stretch running on clayey soils, especially after particularly intense precipitations, such as those that occurred in June 1994.

Moreover, the general instability is increased by the presence of complex mass movements, in some cases ascribed to deep-seated gravitational slope movements, where competent rocks directly overlie weaker argillaceous formations, with differential settlements induced by plastic-viscous flows in the clay shales, towards the less confined external boundaries of the calcareous sandstone slabs. This phenomenon is accompanied by bulging in the clays and formation of large rotational slides, thus undermining the stability of the overlying rocks which are subject to lateral spreading, block-tilting and collapse, being afterwards involved in the superficial earth flows. The resulting features are pseudo-karst landforms such as trenches, gullies and doline-shaped depressions (Cancelli et al., 1987).

The slope stability of the area is therefore controlled mainly by the mechanical characteristics of the argillaceous formations that show a different mineralogical

composition according to the place of rock sampling.

Probably in the near future a camping site will be set out near the Panaro river but, considering that the area is subject to slope movements, it would be preferable to find a different location, far from hazard situations. Adequate hydrogeological investigations should also be carried out in order to find the most appropriate solution for the problems deriving from collection of hydric resources and disposal of sewage waters.

6. A POSSIBLE APPLICATION OF AN EIA PROCEDURE USING DETAILED GEOMORPHOLOGICAL SURVEY

This chapter aims at presenting an overview about different procedures of EIA which may be applied in the impact assessment connected with the recreational projects planned for the Regional Park of Sassi di Roccamalatina. First of all, searching for potential location sites, an artificial division of a sample area in Morphodynamic Units (MDMUs) has been made, taking into account a detailed geomorphological map. The decision regarding alternative solutions requires a definition of MDMUs which can be based on different procedures of appraisal: direct, indirect and holistic.

It is common in the scientific world, particularly in the Environmental Sciences sector, to consider a particular environment as a complex interactive ecological system. The definition of *Natural Environment* is often difficult to be used because of the effect on the present day landscape of human activities during history: e.g. Prehistoric ruins of Peru, Roman Age centuriations of Italy, Arabian drainage works and irrigation systems in 12th century Spain, river channels for navigation in Great Britain constructed

during the First Industrialisation, etc.. With respect to this Gonzalez Bernaldez (1985) explained the difference between *Environment* and *Landscape* as follows. The interpretation of the Environment requires the description of ecological relationships while the Landscape conception is intellectual, philosophical or cultural and involves a subjective interpretation.

Environmental studies are normally used for the definition of terrain characteristics or *attributes* (Cendrero and Díaz de Terán, 1985; Godfrey and Cleaves, 1991) which may be obtained through a geomorphological survey and used for the description of Morphodynamic Units MDMUs. This procedure can be used in EIA studies, for example in the case of a construction of camping installations in the Park of Sassi di Roccamalatina (tabs. 1, 2, 3; fig. 3). For the assessment of the impact and risks connected with the project a detailed geomorphological mapping, remarking active processes, is needed. It may be assumed that landslides, floods and rill erosion activity would affect the camping infrastructure.

The present work cannot give a full solution with respect to the eventual location of the project, but the main contribution consists in showing some assessment procedures.

The geomorphological map on a 1:10.000 scale is the basic document for the description of Morphodynamic Units (MDMUs). The plot levels, at first, allow the inventory and feature integration to be made and a second phase allows the diagnose employing scenarios or real cases to be carried out.

The main difficulty in EIA involving geomorphological surveys is to find methodological criteria. There is not much literature about this problem, because the way of incorporating geomorphology in EIA studies has been defined only recently.

With respect to the identification of the potential value of a territory, nowadays, a simplification of procedures is accepted. The MDMUs allow into photogrammetric information to be transformed into synthetic land units for the assessment of particular problems (Verstappen, 1977). They are useful for taking decisions in environmental management through technical procedures of analysis.

6.1 Examples of methodologies, procedures and applications

There a lot of EIA methodologies involving either quantitative or qualitative procedures. Some of the problems associated with quantitative assessment of impacts involve considerations of the possible financial damages or economic losses from potential hazardous natural threats (diagnose).

6.1.1 A "materialistic" way of assessment

The market conditions assets evaluation using deterministic approaches.

Under this particular condition, it would be possible to work adding definitions founded on index-numbers approaches through mathematical direct procedures for the evaluation of vulnerability in financial terms (see tab. 5).

6.1.2 Subjective assessment of assets

Subjective assessment of *assets* or indirect evaluation. No deterministic models are involved. This approach cannot guarantee a general economic appraisal because its development needs the supervision of a team of experts or an individual assessment with further discussion within the team. First of all, there are no direct market influences, because the main judgements involve an agreement within the team.

ALTITUDE (m)		SLOPE (%)	
Class	Range	Class	Range
1	$190 \leq H < 250$	1	$0 \leq S < 5$
2	$250 \leq H < 300$	2	$5 \leq S < 15$
3	$300 \leq H < 350$	3	$15 \leq S < 40$
4	$350 \leq H < 450$	4	$40 \leq S < 60$
5	≥ 400	5	≥ 60
ACTIVE PROCESSES		LANDFORMS	
Class	Type	Class	Range
1	Rill and gully erosion	1	Rill and gullies
2	Mass movements	2	River bar accretion
3	Small mass movements	3	“Sassi” forms
	Occasional reactivations	4	Earth flows
4	Rock falls	5	Sub-surface deformations
5	Floods	6	Other connected with
6	Other: human activities		human activity

Tab. 1 - List of terrain characteristics for the definition of Morphodynamic Units (MDMUs).

Tab. 1 - Elenco delle caratteristiche del terreno per la definizione delle Unità Morfodinamiche.

	R - 1	S - 2	S - 3	S - 4	S - 5	S - 6	S - 7	H - 1
Altitude	1	1	2	1	3	4	2	5
		2	3	2	4	5		
		3	4	3	5			
Slope	1	3	3	3	3	4	1	1
			4			5	2	2
Active processes	5	1	1	1	3	3	3	6
		3	3	2		4		
Landforms	2	1	1	1	5	3	5	6
			5	4				

Tab. 2 - Morphodynamic Units integration matrix.

Tab. 2 - Matrice di integrazione delle Unità Morfodinamiche.

R - 1	River alluvial flood plains with predominance of accretion processes. River bar forms.	MS - 1
S - 2	Slopes with secondary landslides. Rill and gully erosion. Small landslides.	MS - 2
S - 3	Slopes with sub-surface deformations. Earth flow processes. Complex landslides.	
S - 4	Collapsed slopes with predominance of convex deformations. Well developed landslides.	
S - 5	Stable slopes. Slope surface deformations.	
S - 6	“Sassi” sandstone rock unit. Complex landslides.	
S - 7	Large landslide scarps or steps with possible seismic activation.	
H - 1	Human unit	MS - 3

Tab. 3 - *Morphodynamic Units (in the left and central column) and Morphodynamic Systems (in the right column; MS-1: fluvial; MS-2: slope; MS-3: human).*

Tab. 3 - *Unità Morfodinamiche (nelle colonne di sinistra e centrale) e Sistemi Morfodinamici (nella colonna di destra; MS-1: fluviale; MS-2: di versante; MS-3: antropico).*

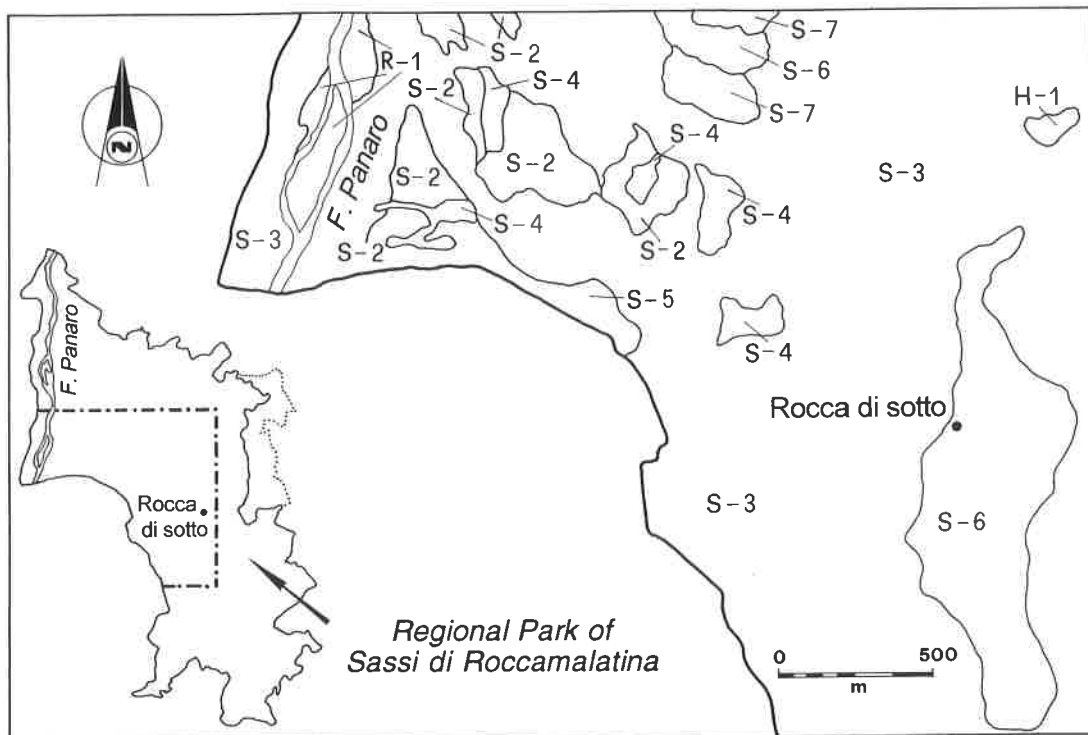


Fig. 3 - *Morphodynamic Units of a sample area in the Regional Park of Sassi di Roccamalatina.*

Fig. 3 - *Unità Morfodinamiche in un'area campione del Parco Regionale dei Sassi di Roccamalatina.*

First of all, there are no direct market influences, because the main judgements involve an agreement within the team.

Some of the most important EIA procedures have also benefited through matrix applications. This is the case of the research of Spagna et al. (1987), which employed single diagnose matrixes and afterwards proposed a mathematical approach for the location of a little hydraulic power station in the Italian Alps. All matrix analysis procedures are derived from Leopold or Bateille tables with some adaptations to the characteristics of a particular project (tabs. 4 and 5).

6.1.3 Mixed models

Finally, it is very important to mention the mixed models or “unanimous models” based on combined approaches.

7. COMPUTER MAPPING

Since a detailed digital elevation map was not available at the beginning of the research, the first step consisted in the digitalisation of the contour lines on a 1:25.000 scale in order to get a first Digital Terrain Model (DTM) of the area studied.

In particular, contour lines with an equidistance of 25 metres were digitised with respect to the whole area of the Regional Park of Sassi di Roccamalatina using a graphic digitiser connected to an ARC/INFO© system.

The result of this operation is the vectorisation of all the contour lines of the above mentioned area.

Attempts were then made to obtain a three-dimensional restitution of the area. From the vector data, in fact, also surface elements were obtained using ARC/INFO techniques and a rendering operation with RAYSHADE (a public domain software) was carried out. The result of these operations is shown in fig. 4. Valleys, slopes and river basins and the unique features of the “Sassi” are here visible, even if the accuracy of the representation is not very high.

The next step of the research will be the digitalisation of contour lines with an equidistance of 10 metres for the whole Park area and 5 metres for the total protection sectors.

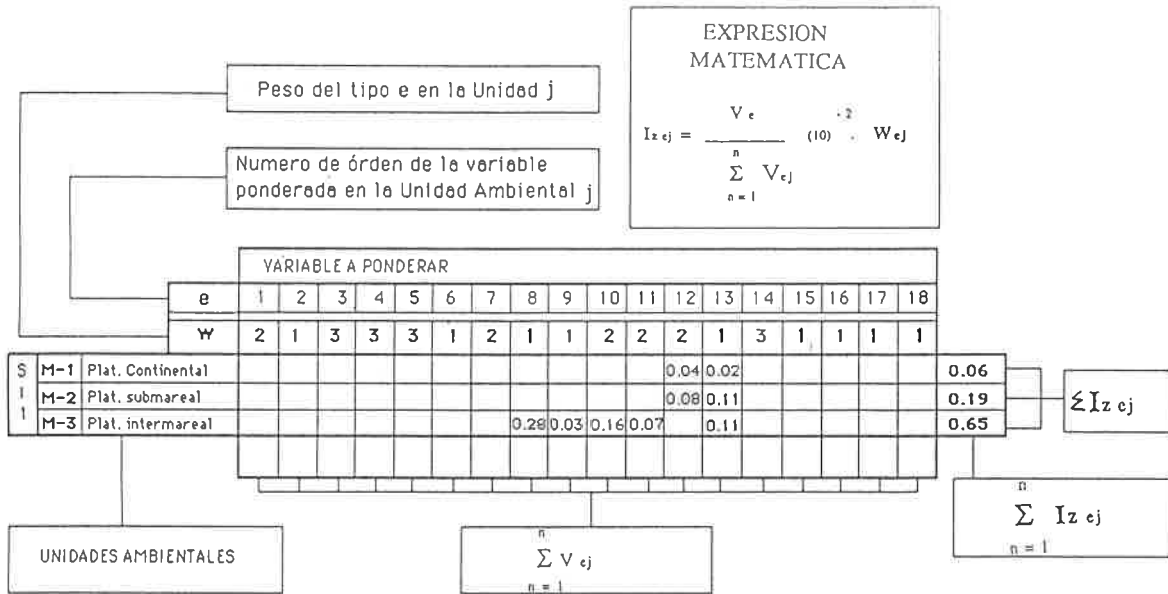
In the future it will be possible to develop more detailed GIS techniques involving also the punctual analysis that is fundamental for EIA.

8. CONCLUSIONS

The research in the Regional Park of Sassi di Roccamalatina will be carried out in the future aiming at a systematic definition of the geomorphological assets and hazard; this will lead to a more comprehensive Environmental Impact Assessment with respect to the projects planned by the regional administration in the Park.

The collaboration between the Universities of Modena and Cantabria and the Regional Park of Sassi di Roccamalatina has been very profitable and will continue in the framework of the Human Capital and Mobility Project.

DIAGNOSE MATRIX



There are two possible ways to make a scoop on a territory. The matrix approaches are considered as indirect procedures and, for this reason, they involve an important charge of subjectivity. The friction between the subjectivity of judgements and the objectivity of mathematical approaches is a consequence of different perceptions on similar environmental problems. This may be considered as a little test of EIA using modified Leopold matrixes.

LISTADO DE PROCESOS	
ORDEN	TIPOS
1	Creeping o reptación
2	Piping
3	Solifluxión
4	Deslizamientos
5	Desprendimientos y vuelcos
6	Avalanchas de rocas
7	Socavación basal marina
8	Abrasión
9	Cementaciones marines artificiales
10	Acumulación de arenas y cantos marinos
11	Aboraje de oleajes de temporal (submersión)
12	Shoaling o agitación marine en aguas portuarias obrigades
13	Efectos de caviteción
14	Arroyade urbana
15	Incisiones lineales
16	Movimiento antrópico de tierras
17	Transporte eólico de arenas

Tab. 5 - A real case of EIA through weight/value approach (Lugaresaresti, 1993).

Tab. 5 - Un caso di VIA effettuato tramite un approccio peso/valore (Lugaresaresti, 1993).

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Chapters 1 and 8 are by M. Soldati; chapters 2 and 3 by M. Bergonzoni; chapters 4 and 5 by Anna Vezzani; chapter 6 by J. Lugaresaresti; chapter 7 by

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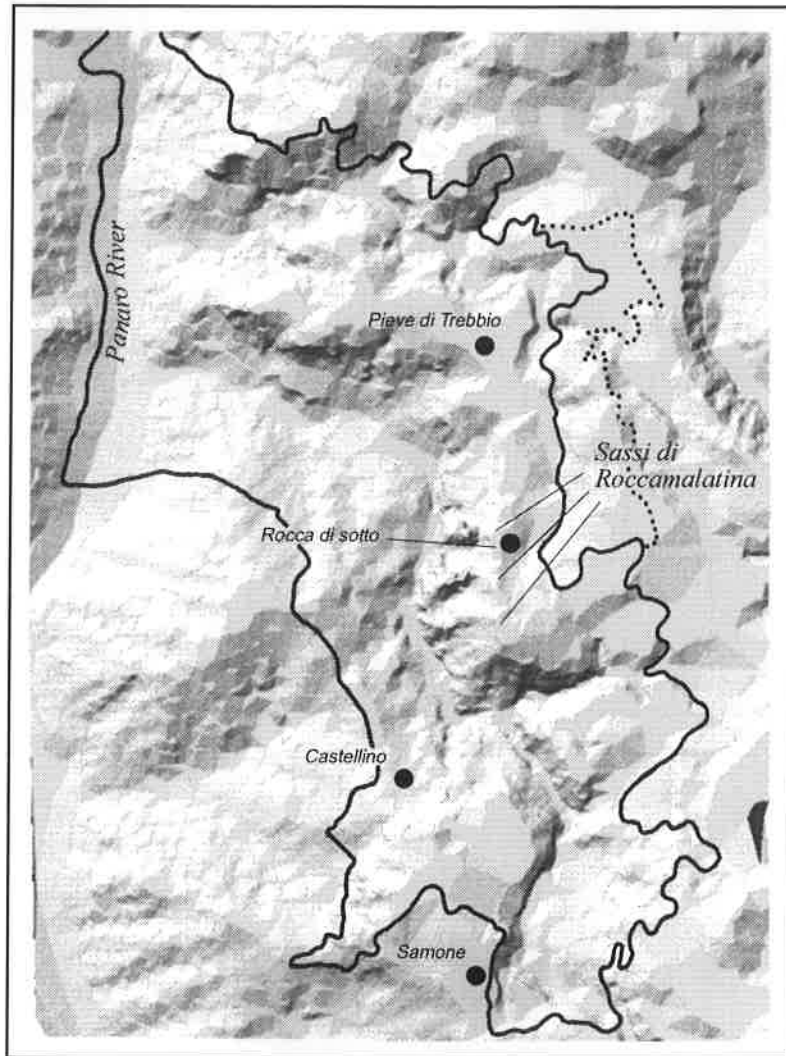


Fig. 4 - Digital Terrain Model (DTM) of the Sassi di Roccamalatina area.

Fig. 4 - Modello Digitale del Terreno (DTM) dell'area circostante i Sassi di Roccamalatina.

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