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NATURAL ASSETS IN GLACIALIZED AREAS AND THE USE OF GIS FOR THE VALORIZATION OF HIGH-MOUNTAIN REGIONS

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ABSTRACT: G. Diolaiuti *et al.*, *Natural assets in glacialized areas and the use of gis for the valorization of high-mountain regions.* (IT ISSN 0394-3356, 2005).
The paper presents the preliminary results obtained through an experimental project focused on the use of GIS software to manage environmental data surveyed in a sample area in the high Italian Alps (Val Viola Bormina, SO). The processing of the data (collected from field surveys with the GPS RTK technique and from aerial photogrammetry analysis) made it possible to obtain geomorphological and vegetational maps (1:10.000 scale). The environmental assets were identified in the sample area through the application of some floristic indices to the vegetational data and a national sheet for the identification and the evaluation of GEOSITES (according to the international UNESCO protocol) applied to the surveyed geomorphological evidences. These assets were called "*high-quality floristic and vegetational zones*" in the case of the botanical assets and "*geomorphological sites or geomorphosites*" for the geomorphological assets. The identification of the environmental assets represents the first phase of a valorisation and tourism-promotion project regarding high mountain areas.
Some naturalistic educational trails were prepared for this purpose. They suggest some locations for tourists to stop and observe the main environmental features of the natural landscape (both *germorphosites* and *high-quality floristic and vegetational zones*). The trails are reported in the GIS on a specific layer and the linked browser also contains logistic information (time needed to reach the trail, difficulty level, hut presence, etc.) useful for organizing the trip. An advantage of the system is that users can make queries (by using the browser and/or the links on the thematic maps) to obtain information or to make changes and variations in the trail route (for instance adding new stops in the vicinity of some of the geomorphological or botanical evidences reported on the maps, but perhaps not included along the suggested trail route). This feature makes the system flexible, serving also for school use (for preparing a school trip or taking a virtual tour of the mountain region before the real trip in the field). The distribution of this product will take place through some computer points located close to the mountain regions studied and by means of an open-source CD-ROM.

RIASSUNTO: G. Diolaiuti et al.*,* Beni naturalistici in aree glaciali e l'uso del GIS per la valorizzazione di aree di alta montagna. *(IT ISSN 0394-3356, 2005).*
Si presentano i risultati conseguiti nell'ambito di un progetto pilota che ha visto la gestione in ambiente GIS di un database georeferenziato contenente tutte le informazioni naturalistiche di un'area campione dell'alta montagna alpina italiana (Val Viola Bormina - SO). L'elaborazione dei dati (sia telederivati che rilevati sul terreno attraverso campagne dedicate con l'ausilio di strumentazione GPS) ha portato alla compilazione di cartografia geomorfologica e vegetazionale alla scala 1:10.000. L'applicazione di appositi indici ai dati vegetazionali e del protocollo nazionale per l'identificazione dei GEOSITI ai dati geomorfologici ha permesso l'identificazione dei beni naturalistici presenti nell'area studiata e definiti "zone di qualità floristico-vegetazionale" per la botanica e "beni geomorfologici o geomorfositi" per la geomorfologia. L'identificazione dei beni naturalistici rappresenta la prima fase di un progetto di valorizzazione e di promozione turistica delle aree di alta montagna alpina. Sono stati allestiti percorsi didattici che suggeriscono al turista frequentatore alcuni stop dai quali è possibile osservare le principali emergenze naturalistiche, i geomorfositi e le aree di qualità floristico-vegetazionali presenti. I percorsi sono inseriti nel GIS in layer dedicati ed i relativi database contengono anche informazioni tecnico-pratiche (difficoltà, tempo di percorrenza) per affrontare l'itinerario. L'interattività del sistema permette, inoltre, al potenziale turista di personalizzare ed arricchire l'itinerario prescelto attingendo le informazioni dall'intero data-base naturalistico a disposizione, suggerendo un approccio didattico ed un turismo virtuale dell'area in preparazione alla vera uscita sul terreno. La divulgazione del prodotto avverrà presso opportune postazioni informatiche localizzate in prossimità delle aree studiate e attraverso CD-ROM distribuiti a cura dei competenti uffici regionali.

Keywords: Geomorphosites, High mountain environment, GIS.

Parole chiave: Beni geomorfologici, Ambiente di alta montagna, GIS.

1. HIGH-MOUNTAIN NATURAL ASSETS: PREVIOUS STUDIES AND FEATURES

The idea that among "cultural assets" we have to consider man-made evidences, as well as those created by Nature, is not limited to scientific spheres, for it is also a common belief (Panizza, 1988). The same may be said about the knowledge, valorisation and conservation required for these kinds of assets, which can be defined as true land resources (Burlando, 1997a).

Among natural assets, geomorphological assets are the most widespread and visible (Panizza, 2001). Surely they are also the simplest, most understandable and recognisable because of their actions in characterizing and determining the landscape. The interest in natural assets *sensu latu* (biological and non-biological ones) and particularly in the geomorphological type (*geomorphosites*), with efforts being made for their inventory, conservation and promotion, is a relatively recent phenomenon. After some pioneer studies (for

example Nangeroni, 1968), it was only in the 1990s that a "*scientific culture in geo-conservation*" (translated from Panizza & Piacente, 2002) saw development. More recently, following the 2nd International Symposium on the Conservation of Geological Heritage in Rome (1996), many efforts and projects have contributed to the growing circulation of some initiatives such as the classification, conservation and promotion of GEOSITES. There is now a large number of papers and other published works dealing with inventories, evaluations and methodology of conservation and promotion of Italian geomorphosites (see for example Panizza *et al.*, 1983; Bertacchini *et al*., 1999 for the Apennine area; Burlando, 1997b; Brancucci & Burlando, 1999 for Liguria; Barca & Di Gregorio, 1991 for Sardinia).

Instead, there has been less interest in high-mountain areas (indicating in this non-specific way, the zones above the *tree-line*, Smiraglia, 2001a). This could be due to numerous factors: the more limited surface extension of these areas with respect to others located downvalley, the more difficult conditions involved in visiting high-mountain lands and consequently, the problems involved in checking data collected through indirect survey techniques, the lower influx of tourists and thus the less pressing need (from a theoretical point of view) to understand the morphogenetic systems and to conserve the geomorphosites. Some inventories of geomorphosites have been conducted in the Province of Turin (Mortara, 2001), while others have focused on glacial geomorphological sites located in Upper Valtellina, on their promotion (Diolaiuti & Smiraglia, 2001; Diolaiuti *et al*., 2001ab; 2002) and on glaciers in Lombardy (Pelfini *et al*., 1989).

There are at least two strictly connected reasons suggesting a need to dedicate more interest in high-mountain geomorphosites. The first one is the need for conservation and ethic promotion resulting from the increase of the tourism in high-mountain areas. This influx has made climbing and trekking popular activities not only in the Alps, but also in mountain chains outside of Europe such as the Himalayas and the Karakoram, with the inevitable growth of the magnitude of human impact and pollution. The second reason is the rapid evolution of high-mountain geomorphosites, which could shortly (a few decades) bring about not only detectable changes in their geometric and morphological features, but also their complete extinction.

These last considerations may apply for particular types of morphologies, among which Alpine glaciers, which with their appeal and scenic value, determine high-mountain landscapes and which, more than other natural elements of the same morpho-climatic system, are characterised by swift dynamics in responding to climatic variations through modifications in shape and volume, and through changes in the features of the landscape.

In this paper, our intention is to underscore the possibility of considering glaciers and some glacier morphologies as *cultural assets*, more precisely as *geomorphosites*, and also, to suggest a method of study that is based on scientific knowledge of this natural asset, on an understanding of the natural laws governing its evolution and on an awareness of its value for mankind. We also suggest consideration of the other natural assets present in high-mountain areas and that are strictly dependent on glacier dynamics such as the floristic and vegetational assets. These biological assets respond quickly to climatic and environmental changes and have a profound impact on the mountain landscape. Moreover, this kind of asset also needs to be inventoried, conserved and promoted, for an understanding of them and knowledge about them could contribute to a complete and exhaustive picture of the history of high-mountain environments (Fig. 1).

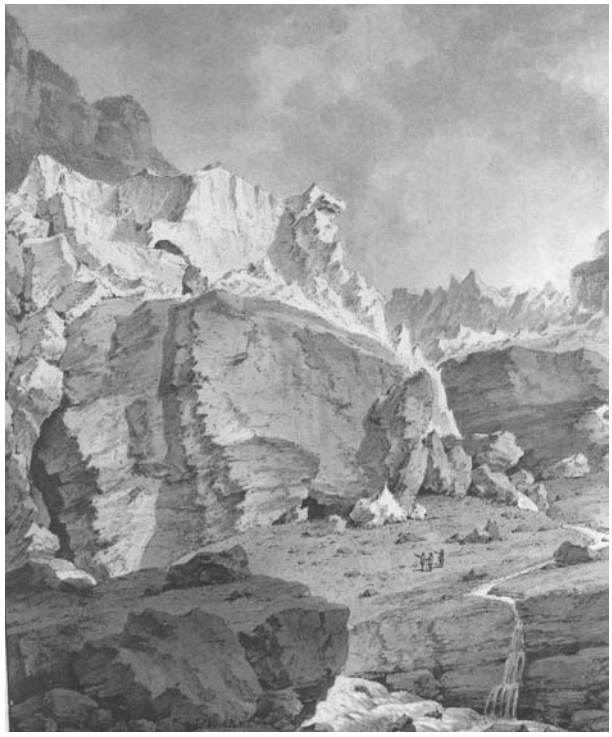


Fig. 1 - Glacier as cultural asset: a black and white version of a painting of the Grindelwald Glacier by Joann Ludwig Aberli (1762).

Il ghiacciaio come bene culturale: una versione in bianco e nero di un dipinto del Ghiacciaio di Grindelwald di Joann Ludwig Aberli (1762).

It is also important to note that natural processes are particularly rapid in the Alpine environment and their evolution is detectable on a human time scale. Therefore, the importance of glaciers as hydrological and hydro-electrical resources, as tourist attractions, as well as the geomorphological and vegetational features observable on them and on their proglacial areas, makes high-mountain zones precious lands to be conserved and promoted.

2. HIGH-MOUNTAIN TOURISM: DISTRIBUTION AND DIFFERENCES

High-mountain Alpine regions are used for both traditional economical activities (agro-pastoral type) and more recently, for leisure time activities. These latter, and particularly trekking, climbing and skiing, are not distributed in a homogeneous way in the Alps. They

are instead concentrated in limited areas, where some elements and features of the physical landscape constitute attraction factors for tourists or where the presence of anthropic infrastructures (hotels, huts, trails, roads and cableways) make tourism possible. The result is thus that some high-mountain areas are subjected to a heavy tourist frequentation, while other areas are less well known or not known at all, and therefore completely ignored by tourists.

The issue at hand is how we can contribute to an increased awareness about these lesser known areas, which are also frequently rich in unknown or undervalued natural assets, and also increase the tourist influx there, while protecting the assets.

In order to obtain a greater influx to these areas, the construction of tourist infrastructures and facilities (cableways, roads, huts and hotels) is a possibility - a possibility, however, that will increase not only frequentation of these zones, but also human impact on the natural landscape.

If our purpose is not merely the quantitative increment of human frequentation and we aim also to increase the quality of the tourist flow, the solution may lie in our knowledge and valorisation of these areas through surveys and inventories of the existing natural assets. The environmental assets identified and inventoried have to be proposed to potential tourists in order to encourage and prepare them for a conscious use and responsible frequentation of high-mountain areas, with the aim being sustainable tourism.

A first attempt to resolve this issue was proposed by the operative unit of the University of Milan through the research program "*Valorizzazione turistica e fruizione compatibile dello spazio naturale delle Alpi Lombarde*", in the national Cofin-Murst 40% framework "*La valorizzazione turistica dello spazio fisico come via alla salvaguardia ambientale*" (National Leader: Prof. R. Terranova, Local coordinator: Prof. M. Pelfini) and in the research program "*Pericolosità geomorfologica in ambiente montano in relazione alle modificazioni climatiche ed alla frequentazione turistica*" in the national Cofin-Murst 40% framework "*Il clima e i rischi geomorfologici in relazione allo sviluppo turistico*" (National Leader: Prof. M. Piccazzo, Local coordinator: Prof. M. Pelfini). The study reported here proposes some methodologies for increased knowledge and valorisation of high-mountain glacial areas that are undervalued and less or not frequented at all by summer tourists.

3. APPLIED METHODS

This study was carried out according to the following stages and with the adoption of the following methods:

1) Identification of a sample area
2) Identification of the geomorphological, vegetational and floristic features by aerial photogrammetry analysis and through field surveys, combined with the GPS RTK technique for the georeferencing of data.
3) Data entered into a geographical browser processed by GIS software.
4) Selection of the surveyed features and definition of the "*geomorphosites*" (according to the international protocol for the identification and evaluation of geomorphological assets) and of the "*high-quality floristic and vegetational zones*" (by applying botanical indices to the data collected).
5) Valorization plan for the sample area by means of tourist trails to visit the environmental assets identified.

4. SAMPLE AREA

On the basis of the authors' previous experience and knowledge of the areas, a region in Upper Valtellina (Lombardy Alps) was selected as the sample area because of its natural and anthropic characteristics. The study area is Val Viola Bormina (SO) (Fig.2). This valley is divided into two sectors. In the first one, with a NE aspect, tourists are virtually an unknown presence because of the absence of lodging facilities (hotels, huts, etc.) or roads that would allow travel at least by jeep, while paths are either inexistent or poorly marked. The NW sector is instead well known and witnesses a strong influx of summer tourists due to the presence of huts and restaurants, a trail that is easily traveled by jeep and well-marked paths. The NE sector (particularly Val Cantone di Dosdè and Val Dosdè) offers a wealth of geomorphological features mainly linked to present-day glaciation and glacial and periglacial morphology, in addition to a wealth of botanical features. All of the region's glaciers are located here (with the sole exception of the Cima Piazzi glaciers) and though the region may not reach very high altitudes (barely approaching 3,300 m), the peaks offer a picture of a high-mountain landscape, which, owing to the glaciers, stands up to any comparison with higher regions. The aim of the project was to promote frequentation of the NE valley sector through some trails that would allow tourists to understand and to learn to appreciate the natural resources present there. Therefore, our attention was focused on this valley sector untouched by tourism until now, in order to identify the natural features there, particularly those of a geomorphological-glaciological and vegetational type, and of such importance and significance as to be classifiable as *natural assets* (Fig. 3).

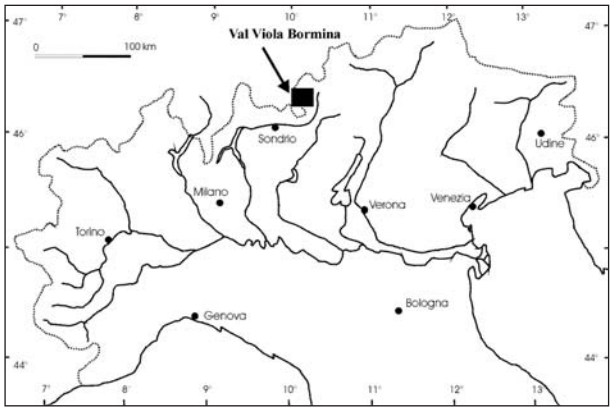


Fig. 2 - Location map.
Ubicazione dell'area di studio.

5. WORK STAGES

Survey methods and laboratory analyses were both used for this research. In the preliminary stage, the interpretation of aerial photographs of the study area was carried out to identify the geomorphological features and the various typologies of vegetation.

This first stage was followed by field surveys performed using GPS instrumentation (Fig. 4) as confirmation of the results of the aerial photograph analysis and to inventory all the other evidences that were not identifiable on the aerial photographs because of their small size. All the data collected were then entered in georeferenced browsers (differing for botanical and geomorphological features and for the abiotic features also divided in different layers on the base of the different processes active: glacial, periglacial, wasting of slopes, runoff water, man made) and processed by GIS software to produce thematic maps (1:10,000 scale) (Figs. 5a and 5b).

Fig. 3 - Natural assets in Val Viola: glaciers, peaks and moraines in the NE sector.
Beni naturali in Val Viola: ghiacciai, cime di montagne e morene nel settore NE.

Fig. 4 - GPS survey on Dosdè Est Glacier.
Rilievo GPS sul Ghiacciaio di Dosdè Est.

Some floristic indices applied to the vegetational data and an international protocol for the identification and the evaluation of the GEOSITES applied to the surveyed geomorphological evidences, made it possible to identify the environmental assets in the sample area. These latter were called "*high-quality floristic and vegetational zones*" in the case of the botanical assets and "*geomorphological sites or geomorphosites*" in the case of the geomorphological assets.

Floristic indices (degree of rarity, naturalness and species richness) were applied to the vegetational data and non-biotic indices (educational value, scenic appeal, scientific value, rarity and uniqueness) were used for the geomorphological data to identify which of the various evidences (both vegetational and geomorphological ones) fully qualify as *natural assets* because of their special characteristics (Fig. 6).

An increasing numerical score (scale 1-5) has been applied to quantify the value of each surveyed evidence for each considered index (both abiotic and biotic ones). The browsers allowed to analyze all the inserted values and to verify the possibility for each evidence to be considered as a *natural asset*. We considered *natural asset* only the vegetational evidences that have a value ≥ 3 for all the three considered indices or the geomorphological evidences that reach (considering the sum of all the indices) a value of 15.

The survey of the *natural assets* was conducted with the aid of GPS instrumentation in order to set up a georeferenced browser, which is indispensable for entering data in a GIS. The data on natural assets that were gathered during special survey campaigns were organized in dedicated layers for the purpose of producing thematic maps (glaciological, geomorphological and vegetational maps), sectorial maps or maps derived from the overlapping of different thematic layers.

Emergences defined as *natural assets* as a result of the previous stage of analyses, were considered to be the quintessential points of the areas studied, and were thus utilized as points of attraction for tourists also interested in the scientific and cultural aspects of the areas.

Using the data collected, hypotheses were then formulated concerning the possible valorization of the study area. More specifically, the data on natural elements entered into the browsers for the preparation of the thematic maps, were used to propose multi-theme itineraries through the valley sector (the NE one), which is not as well known, but rich in interesting elements. The objective is to promote tourism through the identification and interconnection of preferential observation points.

Each itinerary lies within a dedicated layer and is characterized by a linked browser, in which it is possible to find data on the characteristics that make the natural element an environmental asset, as well as

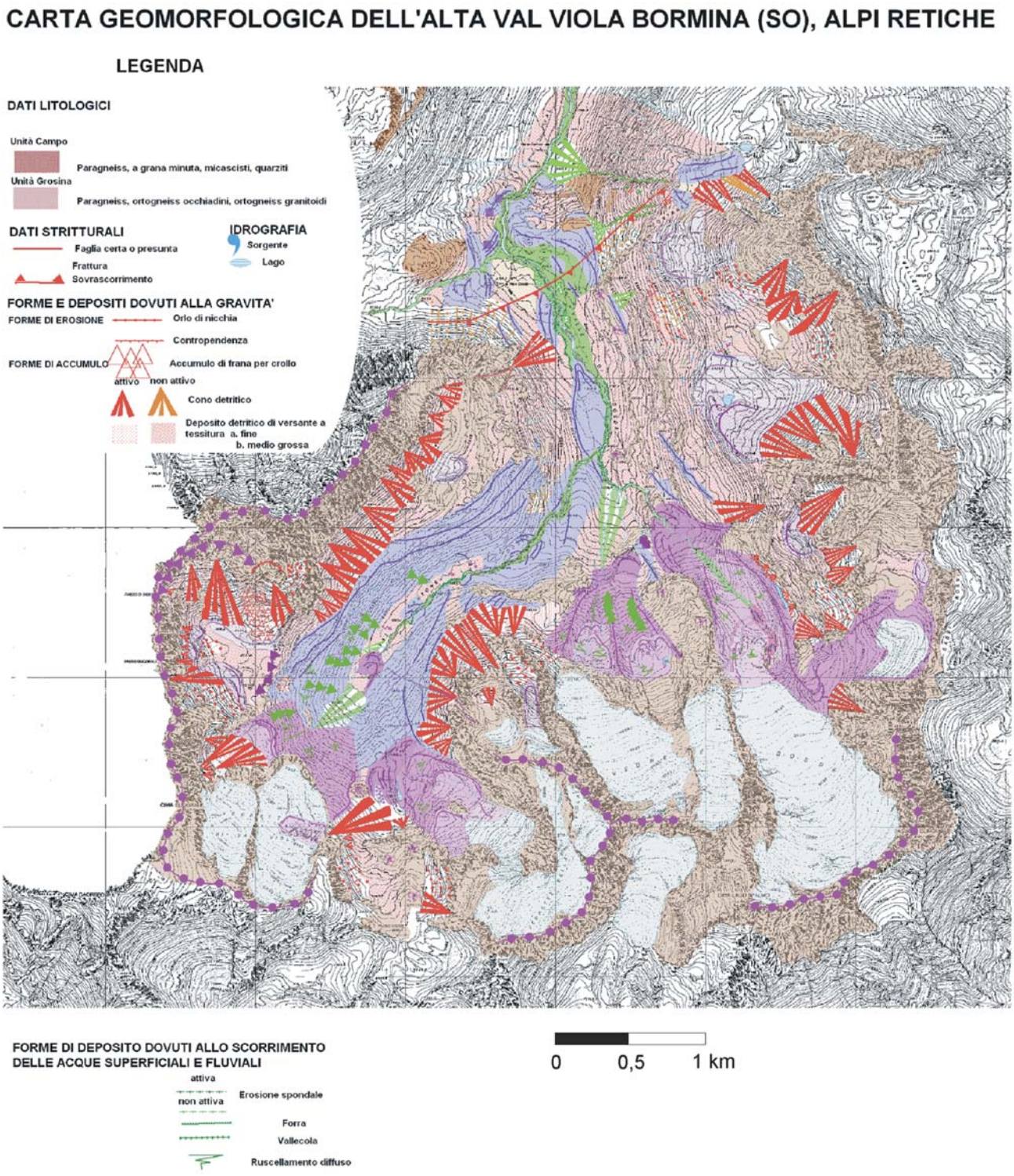


Fig. 5a - Geomorphological map of the studied area processed by GIS software (all the thematic layers are showed).
Carta geomorfologica dell'area studiata elaborata con programmi GIS (tutti i layers tematici sono visualizzati).

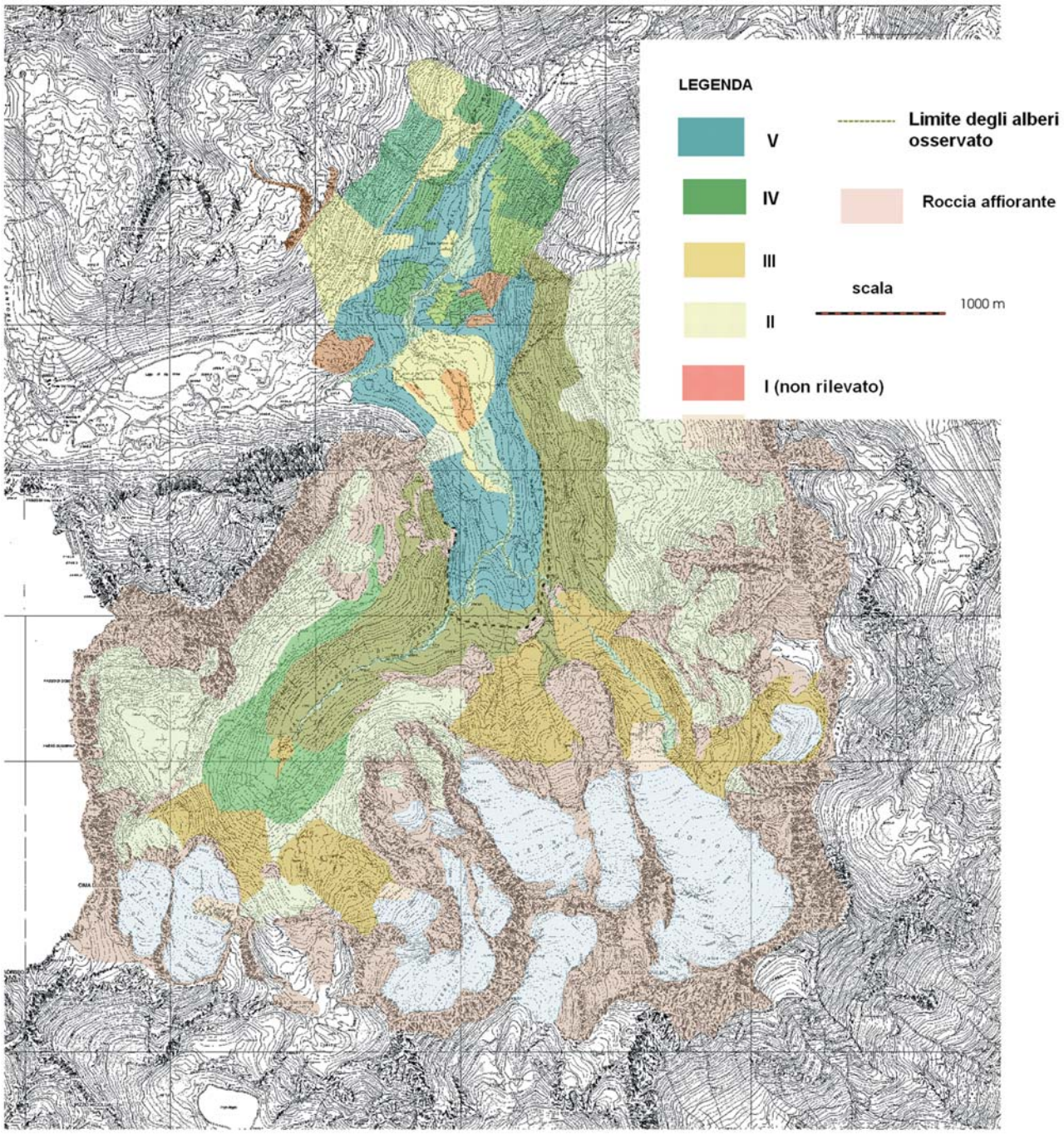
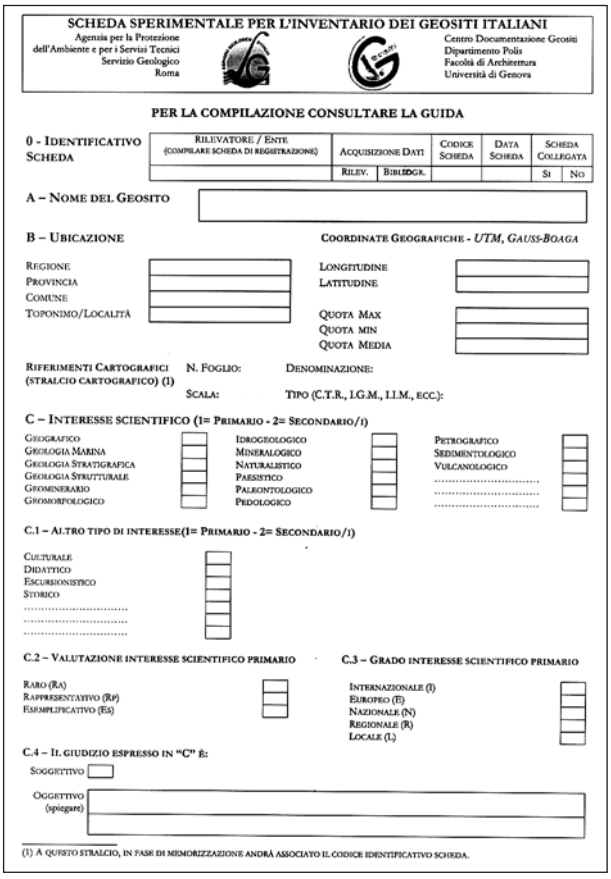


Fig 5b - Map about the vegetation quality of the studied area processed by GIS software (all the thematic layers are showed).
Carta della qualità vegetazionale dell'area considerata elaborata con programmi GIS (tutti i layers tematici sono visualizzati).

information on logistics for the route proposed (traveling time, degree of difficulty, distances from the main lodging or assistance facilities such as camps and huts) (Fig. 7).

Therefore, single-theme or multi-theme itineraries are proposed to the tourist to use and gain knowledge about this high-altitude valley. Special attention is given to the proglacial areas, which have undergone intensive changes in the recent period. In these regions, the recent rapid glacier recession, followed by the brief advancing phase of the 1970s and 1980s, has left relatively ample areas exposed. Geomorphological evidences left by glacial activity are easily observable there, particularly the newly formed moraines (Diolaiuti, 2001; Rossi *et al.*, 2003), roches moutonnées, and subglacial morphological features, where stream, periglacial and slope morphodynamics are presently predominant. Geomorphological interests can be combined with botanical interests. In fact, the pioneer vegetation is colonizing larger sectors of the area, transforming them



SCHEDA SPERIMENTALE PER L'INVENTARIO DEI GEOSITI ITALIANI

Agenzia per la Protezione dell'Ambiente e per i Servizi Tecnici – Servizio Geologico – Roma

Centro Documentazione Geositi – Dipartimento Polis – Facoltà di Architettura – Università di Genova

PER LA COMPILAZIONE CONSULTARE LA GUIDA

0 - IDENTIFICATIVO SCHEDA | RILEVATORE / ENTE (COMPILARE SCHEDA DI REGISTRAZIONE) | ACQUISIZIONE DATI: RILEV. BIBLIOGR. | CODICE SCHEDA | DATA SCHEDA | SCHEDA COLLEGATA: SI NO

A – NOME DEL GEOSITO

B – UBICAZIONE

REGIONE
PROVINCIA
COMUNE
TOPONIMO/LOCALITÀ

COORDINATE GEOGRAFICHE - *UTM, GAUSS-BOAGA*

LONGITUDINE
LATITUDINE

QUOTA MAX
QUOTA MIN
QUOTA MEDIA

RIFERIMENTI CARTOGRAFICI (STRALCIO CARTOGRAFICO) (1) N. FOGLIO: DENOMINAZIONE:
SCALA: TIPO (C.T.R., I.G.M., I.I.M., ECC.):

C – INTERESSE SCIENTIFICO (1= PRIMARIO - 2= SECONDARIO/1)

GEOGRAFICO
GEOLOGIA MARINA
GEOLOGIA STRATIGRAFICA
GEOLOGIA STRUTTURALE
GEOMINERARIO
GEOMORFOLOGICO
IDROGEOLOGICO
MINERALOGICO
NATURALISTICO
PARASITICO
PALEONTOLOGICO
PEDOLOGICO
PETROGRAFICO
SEDIMENTOLOGICO
VULCANOLOGICO

C.1 – ALTRO TIPO DI INTERESSE(1= PRIMARIO - 2= SECONDARIO/1)

CULTURALE
DIDATTICO
ESCURSIONISTICO
STORICO

C.2 – VALUTAZIONE INTERESSE SCIENTIFICO PRIMARIO

RARO (RA)
RAPPRESENTATIVO (RP)
ESEMPLIFICATIVO (ES)

C.3 – GRADO INTERESSE SCIENTIFICO PRIMARIO

INTERNAZIONALE (I)
EUROPEO (E)
NAZIONALE (N)
REGIONALE (R)
LOCALE (L)

C.4 – IL GIUDIZIO ESPRESSO IN "C" È:

SOGGETTIVO
OGGETTIVO (spiegare)

(1) A QUESTO STRALCIO, IN FASE DI MEMORIZZAZIONE ANDRÀ ASSOCIATO IL CODICE IDENTIFICATIVO SCHEDA.

Fig. 6 - The international sheet used for the inventory of the geomorphosites surveyed in the studied area. Each point of the sheet became a field in the geomorphological browsers linked to thematic layers (divided on the base of the different geomorphological processes active: glacial, periglacial, wasting of slope, runoff water , man-made) in the GIS project carried out for this study.

Il protocollo internazionale utilizzato per il catasto dei geomorfositi rilevati nell'area di studio. Ogni punto del protocollo inizia con un campo nelle tabelle geomorfologiche collegate ai layers tematici (divisi sulla base dei differenti processi geomorfologici attivi: glaciali, periglaciali, gravitativi, di scorrimento delle acque superficiali , antropiche) nel progetto GIS portato avanti per lo studio.

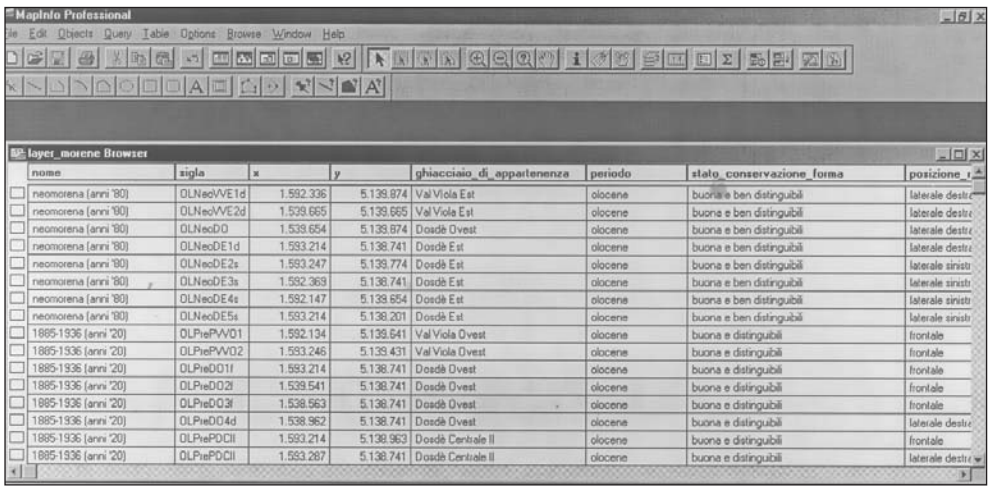
into actual open-air laboratories.

In addition to the preparation of thematic maps and specific tour routes, the environmental assets inventoried and entered in the GIS offer users an interactive selection regarding the route to follow or the natural asset to identify and visit. So the users have the option of making queries (using the browser and/or the links on the thematic maps) to obtain information or to make changes and variations in the routes (for instance adding new stops in the vicinity of some of the geomorphological or botanical assets reported on the maps, but perhaps not included on the suggested path). This feature makes the system flexible, serving also for school use (for preparing a school trip or taking a virtual tour of the mountain region before the real trip in the field).

In this manner, tourists will have the option of locating the assets in the database, taking into account scientific criteria (quantitative and descriptive data concerning the assets) and other criteria concerning logistics and recreational aspects.

For the concluding stage of this research, the proposal consists of making available information on the tour routes and the related natural aspects through the creation of a WebGIS dedicated to the promotion of natural resource tourism in Val Viola. Circulation of all the material in the school system is another possibility. This would allow schools that are planning trips to the area to prepare students in advance as to what they will find there, as well to offer a sort of virtual tour with the GIS prior to the actual trip.

On-site signs and markings of the proposed itineraries must be carried out with the intention of keeping environmental impact to an absolute minimum, taking full advantage of any pre-existing paths or tracks. In this regard, the suggestion has been made to follow the respective indications on the subject contained in a path manual published by the Italian Alpine Club (Club Alpino Italiano, 1999). In practical terms, a general information panel board is a possibility for the valley entrance zone. The board would serve for viewing the routes in their entirety, along with a description of the respective observation points. In cases where paths are unmarked, the routes will be marked by trail sign stakes



nome	sigla	x	y	ghiacciaio_di_appartenenza	periodo	stato_conservazione_forma	posizione_r
neomorena (anni '80)	OLNeoVVE1d	1.592.336	5.139.874	Val Viola Est	olocene	buona e ben distinguibili	laterale destra
neomorena (anni '80)	OLNeoVVE2d	1.539.665	5.139.665	Val Viola Est	olocene	buona e ben distinguibili	laterale destra
neomorena (anni '80)	OLNeoDO	1.539.654	5.139.874	Dosdè Ovest	olocene	buona e ben distinguibili	laterale destra
neomorena (anni '80)	OLNeoDE1d	1.593.214	5.138.741	Dosdè Est	olocene	buona e ben distinguibili	laterale destra
neomorena (anni '80)	OLNeoDE2s	1.593.247	5.139.774	Dosdè Est	olocene	buona e ben distinguibili	laterale sinistra
neomorena (anni '80)	OLNeoDE3s	1.592.369	5.138.741	Dosdè Est	olocene	buona e ben distinguibili	laterale sinistra
neomorena (anni '80)	OLNeoDE4s	1.592.147	5.139.654	Dosdè Est	olocene	buona e ben distinguibili	laterale sinistra
neomorena (anni '80)	OLNeoDE5s	1.593.214	5.138.201	Dosdè Est	olocene	buona e ben distinguibili	laterale sinistra
1885-1936 (anni '20)	OLPrePVV01	1.592.134	5.139.641	Val Viola Ovest	olocene	buona e distinguibili	frontale
1885-1936 (anni '20)	OLPrePVV02	1.593.246	5.139.431	Val Viola Ovest	olocene	buona e distinguibili	frontale
1885-1936 (anni '20)	OLPreDO1I	1.593.214	5.138.741	Dosdè Ovest	olocene	buona e distinguibili	frontale
1885-1936 (anni '20)	OLPreDO2I	1.539.541	5.138.741	Dosdè Ovest	olocene	buona e distinguibili	frontale
1885-1936 (anni '20)	OLPreDO3I	1.538.563	5.138.741	Dosdè Ovest	olocene	buona e distinguibili	frontale
1885-1936 (anni '20)	OLPreDO4d	1.538.962	5.138.741	Dosdè Ovest	olocene	buona e distinguibili	laterale destra
1885-1936 (anni '20)	OLPrePDCII	1.593.214	5.139.963	Dosdè Centrale II	olocene	buona e distinguibili	frontale
1885-1936 (anni '20)	OLPrePDCII	1.593.287	5.138.741	Dosdè Centrale II	olocene	buona e distinguibili	laterale destra

Fig. 7 - An example of a thematic browser linked to each layer.

Un esempio di tabella tematica collegata ad ogni layer.

and cairns, made of natural materials characterized by low environmental impact.

6. CONCLUSIONS

The work presented here represents an example of the combination of research and its application. In fact, it is based on traditional methodologies adopting geomorphological and botanical analyses in high-altitude regions (identification of geomorphological and botanical evidence, along with the preparation of the relative maps). The analyses, however, are also utilized for the identification and selection of the high-mountain natural assets. The most important assets characterising the high-mountain landscape have been identified as glaciers and proglacial morphologies, with the resulting necessity to survey, inventory, evaluate and protect them. The different values (scientific, cultural, socio-economic and scenic) of these assets make them natural resources that cannot be neglected and identifiable not only as objects of the natural landscape, but also as sensitive systems (Smiraglia, 2001b) and true examples of geo-diversity. Moreover, glacier action on the extension, velocity and degree of development of the vegetational distribution is underscored, for it adds further value to the high-mountain environment and can itself be defined as a natural asset.

The use of the international protocol for the identification of the geomorphosites is suggested and applicable to glacier lands and morphologies. However, some changes in this protocol are also required in order to take into account the characteristics and features specific to these landforms.

It is particularly important to underscore two features that augment the scientific quality of glacier environments, but also the difficulties involved in studying them. The first feature is the rapid evolution time of Alpine glaciers and glacier morphologies in responding to the climatic and environmental driving factors of landscape change. The second factor is that they represent excellent keys for the study and understanding of the World's global equilibrium. Regarding the fast evolution of high-mountain landscape changes, the rapidity, dimensions and dynamics of the changes in glaciers, allow the glaciers themselves to take on a representative and emblematic role in the global environmental system and in its delicate and changeable balance.

Glacier changes over time do not affect solely their scientific value, but also the other values of these landforms, particularly their scenic value.

A good example of this last feature comes from the comparison of historical iconographies. It provides further clarification of the weight of glaciers in modelling the high-mountain landscape and their influence on human perception of the Alpine environment.

As for the function of glaciers in the World's environmental balance, we must stress the key role they play in all scientific research aimed at understanding the relationships between the lithosphere, hydrosphere and atmosphere, in reconstructing past climate history and in terms of their importance as sensitive climate indicators.

All things considered, glaciers really can represent true environmental assets and natural resources and to repeat the words of Sharp (1988), they are "*unusual, intriguing elements of our natural environment..., a never-ending source of fascinating information and discovery..., in themselves beautiful and mysterious. By their actions they have helped create some of the most spectacular scenery of this earth.*"

In conclusion, the main aim of the project was to increase popular knowledge about high-mountain regions through the promotion of a tourism that is non-destructive and of low impact, especially with respect to areas where tourist traffic is inexistent or very limited. The application of a GIS revealed to be a useful and flexible tool for this purpose and it allowed for simple management of all the natural assets surveyed.

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