

*Review***Territorial knowledge and cartographic evolution**

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Abstract: The role of geological and geotematic mapping has recently come to the forefront in spatial/environmental management. This paper aims to present some cases of boundary extension in the use of contemporary cartographic tools (GIS and WEBGIS). The potential of digital maps and associated databases offers a wide range of applications, responding to the urgent need to make available to users (practitioners in the technical sectors, planners and society as a whole) the most important concepts to concretely achieve better land management, active risk prevention and sustainable resource enhancement. The application of geomorphological maps to issues closer to society can effectively create its approach to more properly technical-scientific issues, fostering a shared awareness, useful in protecting and enhancing the fragile Italian territory. The described experiences focus on GIS, which confirms its effectiveness both for social involvement in environmental issues, and in territorial/environmental management.

Keywords: maps; GIS; knowledge; geomorphology; communication

1. Knowledge about the territory and its cartography: GIS and WebGIS

The need for protection of the territory is a priority for the society, which, by the way, is an integral part of it (unfortunately, this coincidence is often forgotten): the new environmental issues require the development of innovative management strategies and appropriate knowledge and models. The balanced use of resources, essential for the survival and well-being of society, can be optimized through the promotion of the territory. The identification and development of local resources can only be achieved by directing development policies toward a path of integration between ecological needs, protection of the Landscape, and socio-economic and cultural needs. The Landscape, read as the result of the interaction between human and natural processes, is a rich heritage to safeguard, enhance and promote. The critical requirement underlying each cultural and environmental enhancement project is the knowledge of the territory in its various aspects. This knowledge can be appropriately synthesized through cartographic representation: maps are tools for easy access to meaningful data.

Through modern Geographic Information Systems (GIS), the representation displays the values related to each object collected in a database.

A database allows for reorganizing and cataloguing cartographic and bibliographic material and translating it into a well-aggregated set of information, easily accessible with current technologies. Integration of information is often costly in terms of time and cost but has many advantages [1–3]. The data are kept orderly, so it becomes easier to recover and update; in addition, the information can be controlled according to the thematic address that one wants to promote and, if necessary, differentiated according to the user's needs. In a spatial database, the various terms of Landscape's peculiarities are in space (georeferenced) and well-integrated. Spatial databases are managed using computer technologies (GIS, WebGIS) that allow a multi-scale and multi-thematic analysis and representation of all the georeferenced information [4].

The term GIS refers to a set of thematic maps that allow to query a database, perform analyses, and view or edit information placed in space; GIS is a tool to identify, and in some cases discover, the spatial relationship existing between elements of cultural, historical, and naturalistic value present in the territory. WebGIS technology allows for visualization and query online, georeferenced information and associated maps without additional software, proving to be a valuable tool for land planning for the fruition and promotion of cultural and natural heritage [5,6].

PPGIS (public participation geographic information systems) is a relevant GIS evolution. Such tools confirm the role of GIS technology in involving the broader participation of individuals/community/society in joint action for environmental protection and sustainable development. The high potential of PPGIS is not yet developed at the best level, despite the technological progress, primarily referring to shared knowledge, induction of social awareness, and involvement of marginalized populations [7,8].

Nevertheless, it is mandatory to keep on extending the right of participation to everyone, entering the broader and more interesting concept of participatory democracy. There are many fields of application: considering the network of links between the environment and society, the strategic and revolutionary importance of the PPGIS is evident. From monitoring landslides and other forms of hydro-geological hazards to the census of sites of geological interest (Geosites), the function of observatories on the territory is fundamental. Public participation in GIS data collection implies knowledge of the tool and analytical skills. Therefore, it presumes a social involvement in educational

paths that are integrated into the action itself of participation in the GIS through inductive and deductive processes [9].

In this paper, we propose a review of some cartographic projects carried out in digital mapping, analyzing their potential both for the diachronic study of the territory and its evolutions and for the construction of tools and paths of participatory democracy on shared knowledge.

This theme is particularly sensitive in a country like Italy is, both beautiful and fragile, where the atavistic problems linked to the lack of awareness and the consequent lack of prevention policies are added to the syndrome of abandonment, resulting in the depopulation of those areas whose charm is due to the presence of extreme environments.

This review intends to offer the reader (hopefully with a varied background) information to get some information about the efforts performed in the field of study and research, aiming at finding new solutions useful for planning, environmental protection, sustainable development, prevention, education, training, and information.

It is important to emphasize that all cartographic products and GIS are implemented within public research institutes and that they are available free of charge online, which can be consulted through simple procedures.

2. New methodological approach to digital mapping: Landscape Ecology

Getting to know the territory and spreading this knowledge is a priority of great importance, which still influences contemporary society's political and economic development. Thematic maps are complete tools to provide general knowledge, a clear and comprehensive basis indispensable for spatial planning actions. The representation process allows transmission of information, knowledge sharing, information availability over time, updates, and comparison: in virtue of these characteristics, it becomes fundamental in monitoring, management, planning, and prevention [10].

Conceptually, the representation does not follow the action but is a component [11]. Themes and phenomena are oriented and emerge according to the scale of analysis and the point of view. In this context, Earth Sciences offer a vast and complex heritage of knowledge and integrate positively with a relatively new science: Landscape Ecology.

Perception of the Landscape is a fundamental step that humanity faces toward the knowledge of nature. The form, according to Aristotle, is the synthesis of the endogenous and exogenous processes that shape the Earth's surface [12].

Integrating different disciplines for a scientifically significant result, which can be used in land management policies, requires a methodological approach that overcomes differentiation based on a holistic approach. The different knowledge needs suggest new dialogic strategies and interaction procedures between the operator and technological means [13].

A perspective able to interpret the Landscape as the result of all processes, human and natural, occurring in a complex mosaic of ecosystems will guide the territory's planning and management to create places of collective identification.

The basis of proper planning is the intent to protect the territory's aesthetic and cultural resources and create opportunities for social and economic promotion in a harmonious relationship with the concept of protection of natural resources [14]. From a perspective of cognitive recognition of the area under study, the most appropriate methodology is based on Landscape Ecology, whose approach considers the characteristics of natural and artificial ecosystems as parts of a diversified system [15–19].

3. Landscape analysis: “Carta della natura” project

In this sense, one of the most interesting projects in Italy on a national scale is the “Carta della Natura” (map of nature). This tool aims to assess the state of the environment in the entire Italian territory, analyzing the Landscape. Such representation of the Italian territory offers many possible applications, encouraging the opening of a fruitful dialogue between scientific and technical experts and users. The realization of the “Carta della Natura” (coordinated by ISPRA—Institute for Environmental Protection and Research according to the law 394/91) provides for the identification and representation throughout the national territory of “unità di paesaggio” (landscape units) and “habitat”, on which are calculated, through the processing of various indicators, the values of environmental quality and vulnerability.

The methodology follows a holistic approach, taking into consideration all the components of a landscape and then integrating the information, according to the Landscape Ecology theories, which consider Landscape to be the result of interaction among physical, biological, and anthropic phenomena acting on different spatial-temporal scales [18,19].

The tools used are remote sensing and semiautomatic image classification processes, supervised through field controls.

In the “Carta della Natura” project, the entire Italian territory is studied at different scales of analysis, allowing the recognition and evaluation of the territorial reference units. All units at the different scales are identified through an integrated study and synthesis of the composition and pattern of the elements that constitute their physiognomy. The tools used are remote sensing and semiautomatic image classification processes, supervised through field controls [20,21].

The Landscape Physiographic Units (scale 1:250,000) (Figure 2) are homogeneous areas identified by deductive reasoning, accordingly mapped and described. They are classified following a specifically designed legend of landscape types which synthesizes, by inductive reasoning, the associations of typical land features recognizable at a regional scale [20].

The habitats at a scale of 1:50,000 [22] are identified and coded using the CORINE biotopes classification established by the European Union [23] (Commission of the European Communities 1991).

A further step has recently been taken, with the initiation of an investigation of several study areas on a more detailed scale (1:25,000) [24]. At this scale, the units identified can be considered Ecotopes, applied by Carl Troll [25] to landscape ecology as “the smallest spatial object or component of a geographical landscape”.

Environmental quality and vulnerability values are assigned to each territorial unit by applying specially designed models constructed on parameters considered as indicators. These study models are first developed and then applied using GIS, which is particularly suitable for controlling environmental balances [26].

Cartographic products and the associated Nature Map databases, organized in a spatial information system, marked the beginning of a new way of interpreting the territory, rendering a synthetic image of it, accompanied by analytical data, expressed through indices, and represented by classes of values. In this way, they constitute comprehensive tools for the knowledge and management of the territory, which are very useful for identifying and recognizing sites subject to special protection as geological and environmental heritage.

At different scales, each unit is evaluated in terms of Environmental Value and Territorial Vulnerability. The total value of the environmental units at the different analysis scales results from

the superposition of environmental, economic, social, and cultural values [26]. Environmental Sensitivity is intended to be the potential hazard of a habitat being degraded or losing its own identity from external pressures [27]. The considered parameters refer to compositional, structural, and institutional aspects.

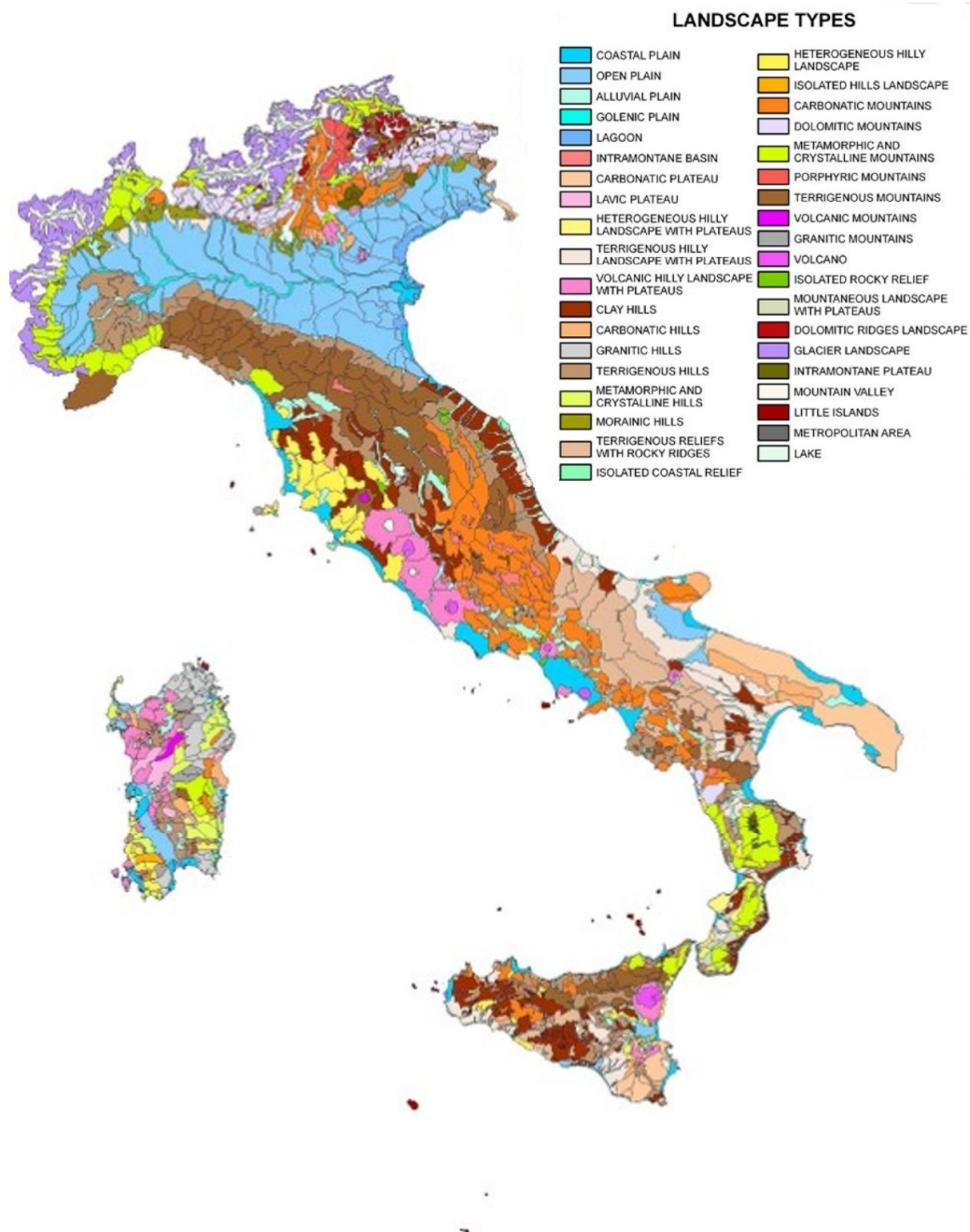


Figure 1. Carta della Natura Map 1:250,000 scale. Landscape Pisiographic Units.

3.1. Application and first results

An interesting application of the “Carta della Natura” GIS in popularization is the one carried out within the framework of the Giro d’Italia cycling race.

The “GeoloGiro”, progressively evolved in EcoGiro, is a project aimed to make comprehensible to the public (as well as to the athletes) the environmental settings of the landscapes crossed by the cycling race “Giro d’Italia”, the most famous stage race in Italy: circa 3500 km, 21 stages, in May. The project was welcomed by the organizers of the Giro RCS Eds., the Italian Cycling Federation, and Rai Sport (the Italian state TV company), which have included in the live programming of each stage—“Anteprima Giro”—a short insert dedicated to offering the public a new and interesting point of view of the landscapes and the sites, linking scientific information to the competitive value of the stage [10].

To test the effectiveness of the project, we tried to obtain an audience analysis from both a micro and a macro point of view. An informal, dialogic survey has been realized on a micro level, conducting a semi-structured interview. An evaluation of the achieved results can be reached by analyzing the audience data, following a quantitative approach. Auditel performs the official method of TV audience measurement in Italy. The method is based on statistical tools, setting up a panel of families representing the Italian population. The selection guarantees a wide range of geographic, demographic, and sociocultural characteristics using an overall panel size (~20,000 people in 1700 municipalities). An electronic tool, the so-called “meter”, measures the audience of each tv by the selected families every day. Nothing is lost with the meter that automatically records every change of channel. The method also guarantees a correct representation of the population’s structure by adopting a weighting by cell system according to which the total of the expansion factors of each individual coincides with the universe of various groups of the individual population (more than 200 groups) and, obviously, with the total of the considered population.

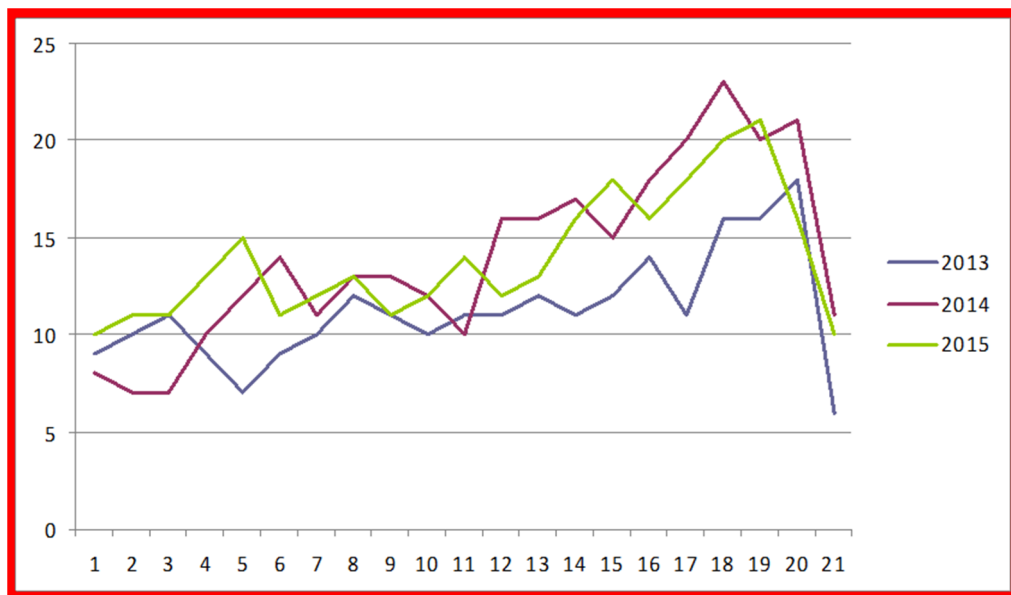


Figure 2. Share/stages of the Giro d’Italia (2013, 2014, 2015).

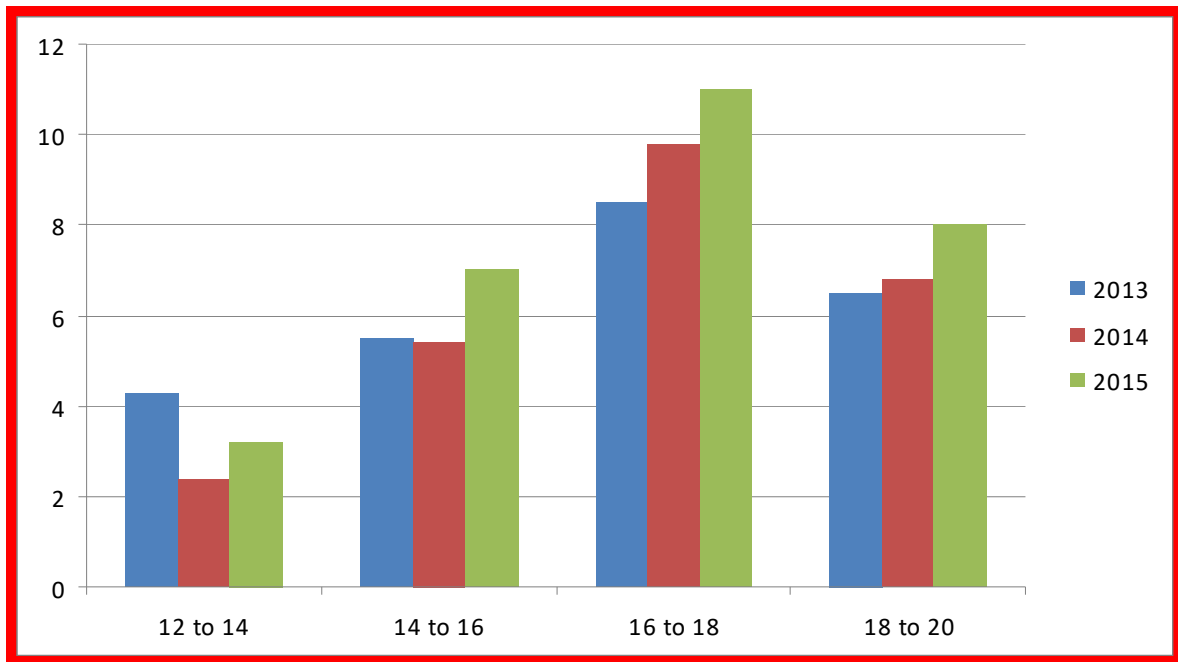


Figure 3. time band/Share—Anteprima Giro TV transmission (2013, 2014, 2015).

Figure 2 links the share to each stage: the maximum peaks correspond to the most critical stages of the Giro, the high mountain ones, mainly at the end of the competition.

The audience represented in figure 3, linking the share of the various ranges of live tv transmission during the same stage, better shows the approval reached by the project. The time band dedicated to “Anteprima Giro” has obtained an increasing audience.

During the last years, media have profoundly changed, so the Auditel system is no longer exhaustive in analyzing the audience. Moreover, it is necessary to consider the vast public following the races on the road when referring to cycling.

Recent experiences testify to increasing social media participation and a related triggering of the audience, on the road too, during the stage.

4. Further proposals. WineGIS: landscapes and terroir of the Italian wine

As already told, cartography, WebGIS, and web applications that allow exploring geographical databases and building tools for administrators and those working in spatial planning are potent means of communication to represent the Landscape in its many aspects. Make one appreciate the value and the distinctive peculiarities, intrigue the user, even if “non-specialized”, and push it to conscious fruition of the territory, a starting point for sustainable tourism development [28,29]. One of the ways to transform these applications from a “working structure” to a “communication tool” consists in finding a theme with a certain “charm” that plays the role of attractor and “fil rouge” to guide the user to discover the territory, first through the application and online navigation, and then accompanying him during the tour on the territory. An exciting example of this is the project WineGIS [30], born in the framework of a program agreement between Globo SRL and CNR-IDPA on the international year of planet Earth. In WineGIS, wine and the French term terroir are the key themes of WebGIS, which form the “core” of the project and allow to explore the complex and rich reality of the typical areas of

Italian wine production, representing it in a unitary way throughout the Italian territory, within a modern geographic information system, available online. Wine GIS is proposed as a tool to support the analysis of environmental and spatial data for the enhancement and protection of the territory through the knowledge of its main characteristics and local wine production and the promotion of projects for the environmental sustainability of viticulture. It also stands as a tool to set up a territorial marketing strategy, starting from the possibility of superimposing the technical cartographic information on the position of the wineries, the associations, the wine roads, the wine-related awards, and anything that moves around the world of wine (Figure 4). An expression of the “success” of WineGIS, born with the will to be a contribution to the growth of the Italian wine culture, is the request by ONAV (National Organization of Wine Tasters) to become an integral part of their “Guida Prosit-Perennial guide to Italian wines” [31]. They are providing the user with the possibility to navigate through maps that describe the landscape features associated with each wine. Significant updates are currently being made to the wine database to align it with the definitions, especially those recently introduced and regulated by the European Union [32].

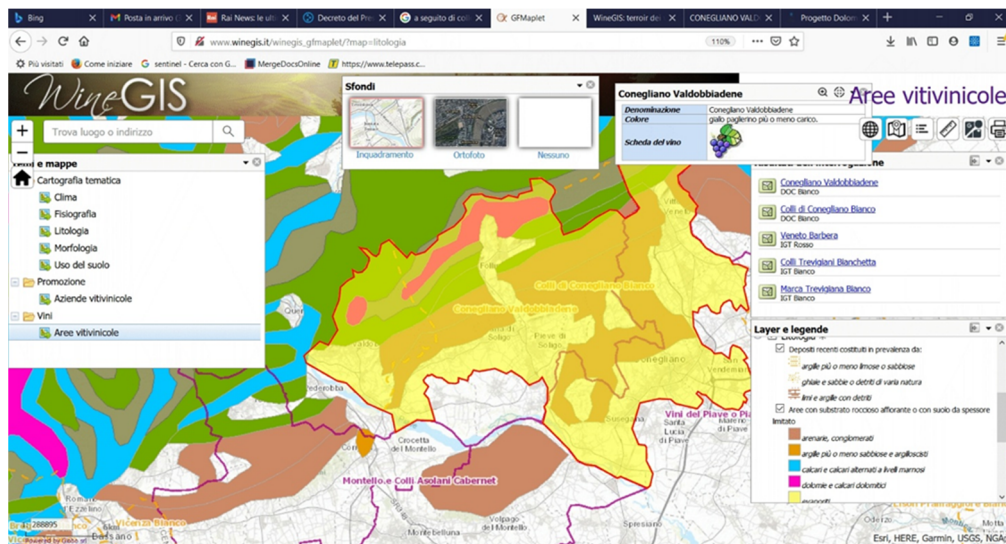


Figure 4. WineGIS (www.winegis.it).

5. Application on the Dolomiti WHS site: OpenALP, Openalp3D, Openalpmaps and La Via Dolomia

From this point of view, it might be interesting to rapidly review the evolution of the projects developed in the province of Belluno through a collaboration of a research institute, a technical high school, and local authorities, as described below. To understand how WebGIS has transformed its role for the representation of the Landscape, connected to the needs of the territory and society, along with the Unesco World Heritage Dolomites Declaration (26 June 2009) and to the promotion of sustainable tourism. The first platform of WebGIS was born as OpenALP® [33] under the Interreg IIIA project “Italia-Austria” (2006–2008: Osservatorio Permanente Naturalistico Alpino, OpenALP®), organized in the mountain community of Agordo, in collaboration with CNR-IDPA (Istituto per la Dinamica dei Processi Ambientali Institute for the Dynamics of Environmental Processes), the section of Milan, the Mining Technical Institute “U.Follador” and, as an Austrian partner TIRIS®.

It is a WebGIS primarily intended for technicians of administrations, rigidly organized to allow users to view different disciplinary levels, accompanied by searchable metadata, and organized in a relational, non-hierarchical way, organized in six other access ways: air, water, ground, animals, plants, man.

While the website has been designed and configured to provide different user scenarios to ensure access to all, the lack of essential expertise needed to consult WebGIS has not encouraged the spread of OpenAlp among the “interested laymen” in environmental, geo-cultural, and geo-tourist information.

Therefore, the WebGIS OpenAlp, though an essential tool for technicians with its cartographic database, has been revealed as a failure to create a reference structure to enhance the Landscape of the Dolomites of Belluno.

In this respect, a new tool, “OpenAlp-3Dolomites”, came into play: a WebGIS with a geo-tourism direction, devoted to the enhancement of the natural and cultural heritage of the “Alto Bellunese”, under the direction of GAL-Piano Regionale di Sviluppo Rurale del Veneto 2007–2013 (GAL—rural development for the Veneto region 2007–2013), Piano di Sviluppo Locale del GAL Alto Bellunese “V.E.T.T.E.” Misura 313 (local development plan of the Alto Bellunese “incentive to tourist activities” Action 4 “Information”) on the territory of the “5 Mountain Communities” of GAL Alto Bellunese, intended as cultural units in the Alpine territory.

In an area whose large part belongs to Unesco World Heritage Dolomites, the new structure of the platform OPENALP-3D [34] must necessarily be aimed at making the individual aware of the characteristics of “their land”, of the conservation needs of the natural and historical-cultural heritage of the territory, of the importance to promoting the development of sustainable tourism.

In OPENALP-3D, a geographical, multi-thematic, and multi-scale database is implemented in connection to the natural, historical and cultural heritage. The primary objective is to make the sources of naturalistic, cultural, tourist and scientific information accessible, thus promoting the landscape resources of the territory.

OPENALP-3D, la “Rete delle Dolomiti” (Dolomites’s network), is a truly “dynamic” WebGIS because users can also become operators, inserting information (once certified) on the platform: this has contributed to the creation of a real community on the territory.

To find a more attractive access mode for local communities and make individuals an active part of the community, additional solutions to share the information in the georeferenced database have been studied. The successful solution consists of a web app which simulates a WebGIS. However, it is easier to use, with straightforward access, that can be consulted both from fixed and mobile workstations, running on any operating system, becoming a means of communication and involvement by each individual on the territory.

The website www.openalpmaps.it, of widespread use throughout the territory, right now contains more than 3000 sheets related to the natural, historical and cultural heritage, allowing the readout of the Landscape throughout the joint observation of a thousand aspects that represent the composite territorial reality, which is the result of the combination of many factors that have shaped it throughout the centuries, making it unique. In www.openalpmaps.it there is now an additional section developed within the program “DOLOMIA”. La “Via della Dolomia”: the journey of the rock in the Dolomites Alps, ITAT 2036”, financed under the second notice of Interreg V A Italy-Austria 2014–2020 led by l’IIS “Follador-De Rossi” of Agordo (BL), where Dolomia is chosen as a “key element” to discover the Landscape, the history and the culture of some areas of the Dolomites (Figure 5). With the web app, QR codes are distributed throughout the territory, for the fast deployment of the contents of maps and illustrative material on the users’ smartphones, right at the sites of interest. The user can “surf” the

territory, comfortably sitting on the sofa, or use the app in situ: one can choose to navigate through geological, historical, and cultural themes or follow the “fil rouge” of “Via della Dolomia”, to discover the “role” of Dolomia in work, history, and Landscape, through the sites and routes where the Dolomia rock emerges, extraction sites, currently use of Dolomia, processing methods, historical buildings, museums, etc.

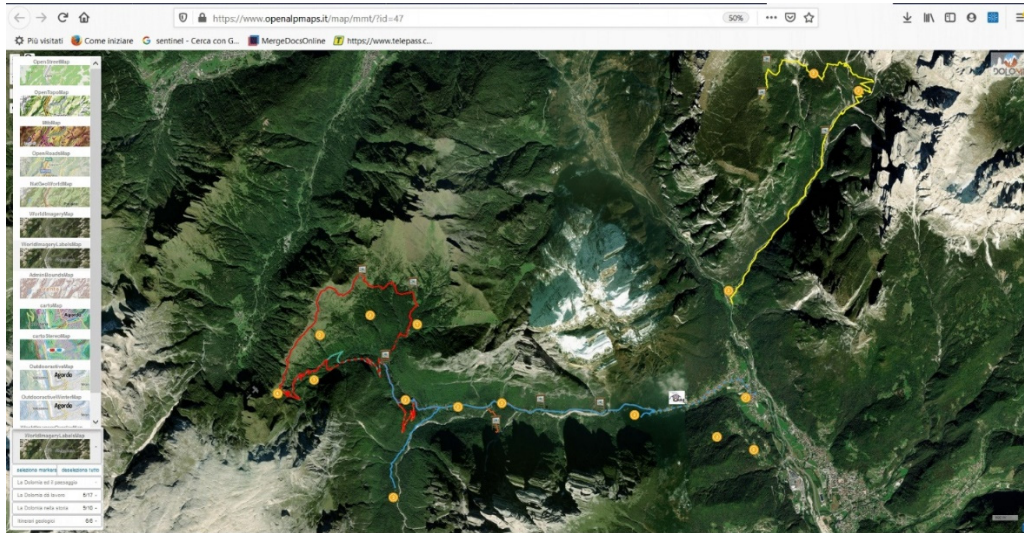


Figure 5. The “Via della Dolomia” project.

6. The effectiveness of GIS in preventing risks. Geomorpho-hazard of tourist trail “Anello della Sibilla”

The “Anello della Sibilla” is a trail of about 12 km around mount Sibyl (2.173 meters a.s.l.), the relief that gives its name to the famous and mythological Sibillini mountains in the homonymous national park in the Apennine (Marche region, central Italy). Each year, many thousands of tourists and hikers frequent this path because of the breathtaking views and the attraction aroused by the legend of the Sibyl. She was a prophetess, and she lived in a cave next to the top of the mountain. With her bewitching charm, she attracted adventurers looking for its myth. Over time Sibyl’s cave became a top-rated destination for pilgrims, wayfarers, knights, and intellectuals who ventured into these inaccessible places looking for the cavern and the testimonies of the prophetess. Their deeds were described mainly in medieval poems and essays, which fed her legend and curiosity. Different historical and literary authors described the sublime landscape of Sibillini mountains, also providing ancient environmental representations which nowadays can be considered useful for geomorphological and cartographic comparisons.

Today, the cave is occluded, and it is possible to admire only its entrance remains. Both earthquakes, intense meteorological phenomena, and human decisions (deterrence for profane rites) acted by collapsing the cavern. A combined geophysical survey (geoelectric and Ground Penetration Radar, GPR) conducted by the University of Camerino [35] has confirmed the presence of a well articulate karst system. These indirect advanced geophysical techniques have been applied to the underground, with the aim to deepening the knowledge in geomorphological data mapping. Geoelectric and GPR method, in fact, are able to recognize empty spaces below the ground surface.

The presence of geological, landscape and historical-mythological aspects gave this trail the image of a cultural itinerary par excellence. Nevertheless, the high frequentation of this path which finds at high altitudes, in often snow-covered areas, and along steep and very exposed slopes, suggested to geologists the necessity to assign an exact classification of the level of geo-excursion risk based on geomorphological hazard.

Because of this, all the cartographic data about this portion of territory have been collected and organized in a GIS database, such as topographic maps, digital elevation models, aerial images, and geological-geomorphological maps (Figure 6). Landscape aspects were also defined during field surveys, useful to assign the precise conditions of the bottom for each portion of the trail (if in bedrock or cover deposits, if in exposed, steep, or slippery portions). After the on-field recognition, they were edited on the map of all the geomorphological elements intersecting with the trail and which could constitute a hazard for hikers, such as crests, trenches, nivation hollows, landslide scarps, debris flow channels, avalanche tracks, gullies, glacial cirque, and selective structural scarps. All these elements have been traced according to the criteria established by the legend of “Quaderno 13 della Carta geomorfologica d’Italia 1:50,000—Servizio Geologico d’Italia, ISPRA” [36].

Thanks to the interoperability provided by the created database GIS, it has been possible to interpolate data assigning a level of risk for each portion of the trail (low, medium, high), considering all the above-mentioned critical elements (conditions of the path, exposure, geomorphological hazard, etc.).

The role of software GIS is considered essential for this work and, in general, for geotourism:

- It permitted the management of many different typologies of data, which is also helpful for spatial-temporal interpretations.
- It allows sharing and disclosing of information for security purposes through a webGIS.
- Thanks to its immediate versatility, it will represent a valuable tool to modify elements and communicate them in real-time, following the evolution of natural phenomena.

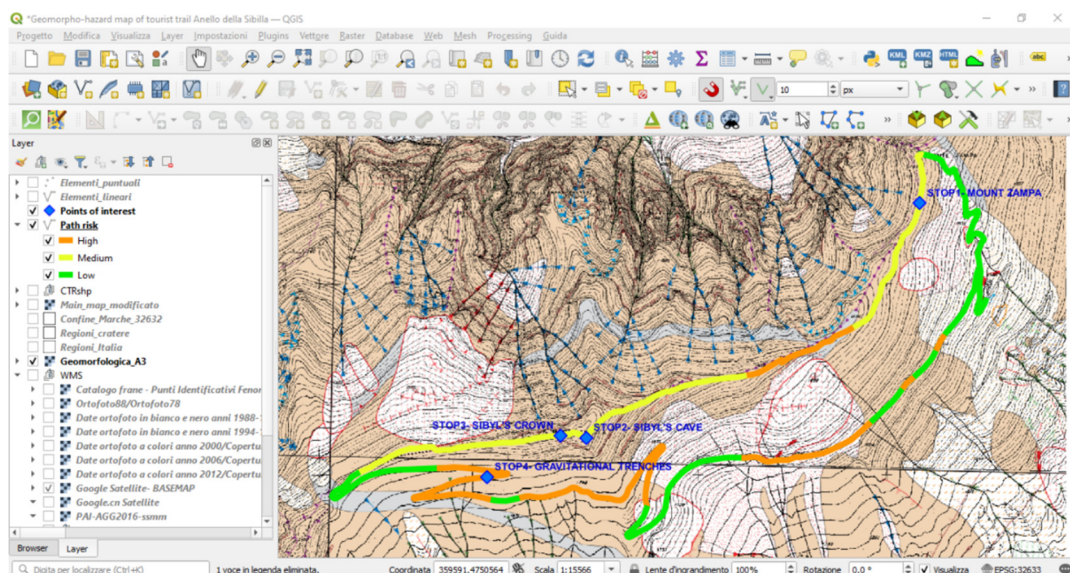


Figure 6. The “Anello della Sibilla” database GIS, with indicated geomorphological hazard elements, the stop of geological-cultural interest, and the level of risk for each portion of the trail (green = low risk, yellow = medium risk, orange = high risk).

7. Discussion and conclusions

The projects outlined so far have in common the goal of enabling individuals/communities/society to know they are part of the vital processes of a whole.

Man, as an organism, is to be considered in the same way as a complex ecosystem: what happens on a certain level of experience has repercussions on all the other levels [37]. In parallel, the physiographic configuration of a region characterizes territorial history and profoundly influences its development. A place is attractive for how it is perceived, and it is livable for the opportunities it offers: in many places afflicted by the abandonment syndrome, it is necessary to rebuild the structure of the community in an integrated way with the environment.

This delicate objective can be achieved by implementing policies that allow integration between social and geographical realities and looking for validation strategies by local communities, which allow everyone to acquire an informed knowledge of the territory where they live. The form of social organization is born to face and manage the difficulties and emergencies tied to the territory's survival. Thus, each type of planning can and must be based on appropriate knowledge tools that offer new opportunities for comparison between technicians and planners, the scientific community, and central and local government: the dialogue must be articulated on a shared code able to overcome old incomprehension. It is necessary to implement projects based on the new cultural identity of the territory, accessible only through the development of educational processes, which make the scientific heritage comprehensible and shared. It is essential to create new job opportunities and support communities by encouraging new investments and new forms of tourism that go beyond the simple visit.

The protection of the territory, the shared well-being, and the sustainable development are objectives attainable only through conscious knowledge; the acquisition of information can be significantly facilitated thanks to the cartographic representation and use of GIS, which allow to make it usable according to the different levels of complexity and adapted to the needs of different users.

The research in the field of Landscape Ecology indicates possibilities for fruitful experimentation: the new interpretive philosophy oriented to the integration of complexity stimulates new synergies, opening at the same time the panorama of skills (specific or overall) and creating new professional potentialities. The possible development paths start from the intent of launching the natural environment recognition of the area, making it productive in the context of the local economy, and reversing the risk-resource contrast in favour of the latter.

In this perspective, the reality of eco-tourism, already consolidated and enjoyed by many people, offers new opportunities: if it is understandable, it has so far been concentrated on the territories whose beauty is known, in some cases already placed under protection, can and must now open their power on unusual scenarios.

Once again, the unavailability of a valorization of eco-compatible activities inevitably emerges in a positive balance between conservation planning and sustainable development: a knowledge-based operation devoted to achieving, growing up, share. Modern technologies and experiences in various fields, through GIS and the WebGIS, encourage the validity of the proposed objectives and methodological paths undertaken.

It is necessary to acquire a new point of view, which interprets the Landscape as the result of all the anthropic and natural processes occurring in a complex mosaic of ecosystems, which can guide land planning and management processes toward the creation of places of collective identification. At

the same time, it is essential to activate sharing paths, which integrate educational processes, to harmonize individual psychophysical development and the natural environment.

The International Year of Planet Earth has fostered new steps in this direction. This UN/UNESCO initiative aims to share and make usable the wealth of knowledge related to Earth Sciences, using codes accessible to all, aiming at involving the whole society in environmental protection actions through the shared awareness of the realities that condition the evolution of our planet and humanity.

Khalil Gibran writes, “Your home is your greatest body”, and the environment is humanity’s home.

Conflicts of interest

All authors declare no conflicts of interest regarding this study.

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