



Research article

Landscape analysis as a tool for risk reduction

Francesca Romana Lugeri^{1,2,*}, Piero Farabollini² and Nicola Lugeri¹

¹ ISPRA Institute for Environmental Protection and Research, Italy

² UNICAM University of Camerino, Italy

* **Correspondence:** Email: francesca.lugeri@unicam.it; Tel: +393396140338.

Abstract: We live in an era defined as postmodern. Socio-economic developments require a knowledge that keeps pace with the dizzying speed of technological evolution. The disconnect between progress, society, and environment triggers unpredictable side effects on the planet: that is the Anthropocene paradigm. How can this be changed? Shared awareness seems to be the only possible solution that can be only reached through knowledge, which is provided by science. Landscape, as the perceivable expression of our planet, becomes a strategic tool in communicating Territorial Sciences, aiming at involving society in a common action toward a sustainable future. The awareness of being part of an ecosystem is achieved through the knowledge and the experience of the environment. The risk prevention must necessarily be based on cognitive processes that activate in society conscious knowledge, as well as virtuous practices. Knowledge is wisdom, the first step towards the so-called “civil self-protection”. A lot of initiatives have been started in the last years, all around the world. Most of them are devoted to the school activities. However, the facies sociale of the decision makers is not enough involved in the topics we have talked about. So the voters, the policymakers, the territorial planners, are more interested in those problems related to the “here and now”. They have to be sensitized on what prevention means, on environmental protection, on territorial valorization. The landscape encompasses a lot of meanings and trigger emotions, thus it provides us with the most effective tools to share the essential concept of Earth Sciences, especially those ones that can help individual/community/society to better behave, toward a healthier planet and a shared well-being.

Keywords: landscape analysis; society; risk reduction; GIS

1. Introduction

In Italy, a country highly exposed to hydrogeologic and seismic hazards, the natural disasters that often occur, cause disasters to settlements, society, and infrastructures.

It is not destiny, of course, but unbelievably, it's always the same old story. Looking at the pictures taken after the terrible Messina earthquake in 1908, it is puzzling to find almost the same images as the last Italian big earthquake (2016/2017), showing destruction, death, desperation.

Indeed, a big earthquake is an extremely dramatic event, wherever it manifests. However, there are some steps between drama and tragedy. All around the world, it is easy to understand the direct link between the worst effects of a seismic event, and local- economic development. But also the reverse is true: excepting few countries/states such as Japan, Alaska, New Zealand (maybe California?), those at high hazard exposure are characterized by a not balanced social and economic situation.

Despite the unquestionable efficiency of a modern system of Civil Protection, the prevention is not yet deeply rooted.

Why? Lot of activities are continuously realized in the field of communication, education, and divulgation. Where to find an answer to this question, we have to consider a lot of components, most of which not easily assessable, nor, in many cases, even detectable.

2. The Italian country

Let us start from the geographical and geological context. Just at a glance, the position in the middle of the Mediterranean Sea, the millennial history and culture; the climatic component is essential in establishing new settlements, and the sea exposed the peninsula to hostile attacks. Due to such risk (here is the crucial term) a myriad of little towns founded in the inner areas, thanks to the presence of the Apennine chain.

Sea, coasts, cliffs, islands, rivers, mountains, plains and so on: physiography and morphology: barriers or corridors, these components play an essential role in the history of societies and cultures. Geological processes have molded Earth's surface over time, giving each territory its shape, its history, its own life.

Geology and geography are so deeply linked to history: thanks to these branches of knowledge, and using a multi-scale reference in observing reality, we are able to access to all the information needed to understand the territory where we live. So we all should be able to manage our lives and our social participation as well. In this sense, we all have the tools to sustainably develop the territory, and prevent risks [1]. However, despite the progress in researches and technologies, nothing in the Anthropocene shows reassuring signs in this direction.

3. Anthropocene, postmodernity, late modernity

Every human being interacts with the environment in which it lives, but the feeling of being part of the environment is not always perceived. The difficult journey towards harmonization between humankind and Environment unfolds on a complex path, guided by scientific knowledge. Knowing

and recognizing: keywords of an essential process in the development of community/society. The attainment of awareness, through experience and knowledge, assumes a leading role for the purpose of survival itself. If a Nobel Prize in chemistry comes to attribute a new name, Anthropocene, to the times in which we are living, it is appropriate to reflect.

Anthropocene is, in fact, the term coined by Paul Jozef Crutzen, to define the first geological Era in which human activities have been able to alter the atmospheric balance [2].

Moreover, the same Era can be defined as Postmodernity, characterized by technology and virtual reality, where all is superficial and fragmented as a broken mirror surface.

The part of this Era which we are living is also defined as Postmodernity. A plethora of tools and sources offer everyone around the world the possibility of participating in social dynamics, a side effect of which is an inclination to constant change, and a related fragility, temporariness, vulnerability. Characteristic of the so-called “liquid modernity” is a growing conviction that change is the only permanence, and uncertainty the only certainty. Too often good ideas and innovations die out; mediocre practices persist, sometimes genuine advances occur [3].

4. Environment and society

Environmental protection and personal growth should be a only objective naturally pursued: instead it has become almost a utopia.

In these last weeks, we are observing an intense youth’s movement against the inconsiderate exploitation of our planet.

The charismatic figure of this new social trend is the young Danish Greta Thunberg who, with the clear awareness of a teenager of extraordinary intelligence, affected by Asperger’s syndrome and other behavioral discomforts she declared, started a series of students’ demonstrations (spread soon all over the world) against political inactivity towards the climate changes, and then participated in the UN CC Conference, pronouncing a speech that is the manifesto of this amazing social revolution. “You only speak of a green eternal economic growth because you are too scared of being unpopular. You only talk about moving forward with the same bad ideas that got us into this mess, even when the only sensible thing to do is pull the emergency brake. You are not mature enough to tell it like it is. Even that burden you leave to us children”. “And if solutions within the system are so impossible to find, then maybe we should change the system itself”. So climate changes are at the forefront of the social attention to risk scene. Their global character increases their evocative potential. However, beyond public attention and talks, it is worrying to note the difficulties in applying the Kyoto agreement on carbon dioxide emissions. Nor the subsequent conference on climate change (Paris 2015) made any progress in the necessary establishment of the reduction of greenhouse gas emissions, despite the alarm confirmed by the scientific models; the last, recent congress in Katowice (December 2018) reiterates and reinforces the provisions, thus confirming in this way the lack of effectiveness of the decisions, the insufficiency of the agreed regulation [4].

Rich countries tried to buy the shares of the poorest countries, to continue to pollute as before. “Washington does not want the cause-effect relationship between climate change and disasters to be made explicit. If it were official, since the link between US consumption and global warming is now established, the US would be considered the main perpetrators of future disasters... What is never

found in the United States is the attribution of some responsibility to the institutional structures.” [5]. Other industrial major powers joined the United States in the global market, greatly increasing the burden of harmful emissions, with damaging effects in exponential growth, with a non-linear trend and distribution.

In terms of scientific research, Climate Changes are object of debate, with strange reveries towards their own definition which, on some scientist’s opinion, contradicts the correct concept of climate, being it considered the statistics of weather over long periods of time (whose standard average period is 30 years). However, by evidence, it is possible to state that the frequency in the occurrence of exceptional events has increased in recent decades, with effects that are difficult to predict in their progress but whose severity is proved. It, therefore, can happen that even those areas of high naturalness, although cared for and respected to preserve their economic potential as a tourist resource, suffer the consequences of these exceptional events. Such delocalization of the dangerous effects on the exposed value translates in fact into an extension of the vulnerability that cannot be controlled according to the usual parameters.

5. Landscape

Territory identity is a fascinating combination of geological, geomorphological, environmental and anthropic elements: nature and culture. The link between Earth and society is a surprising resource that, if correctly activated by using appropriate tools, favors sustainable development. New approaches to the knowledge of territory are the basis for designing new models of growth, based on resources, renewal, creativity that comes from the ecosystemic integration between land and living beings. Claude Levy Strauss [6], in his “Tristes Tropiques”, shows us how dangerous is the loss of the landscape, referring to the symbolic value that Landscape encompasses in every culture. The attractiveness of an environment is based on how it is perceived: it is necessary to protect it and favor a balanced fruition of it. In many cases, the most fascinating landscapes are also the most hostile. Those projects aimed at performing sustainable development must necessarily be based on the cultural identities of the territory. It is necessary to save such places from the ancient abandonment syndrome, which has impoverished all the lands that, due to their geographical position, were marginalized, excluded from a socio-economic context that, for better or for worse, proceeds quickly, following (and at the same time creating) the times of progress. It is essential to start a new participation, especially in the field of new styles in tourism, such as those that overcome the moment of the simple visit: in some cases the travelers even decide to elect as new home, places with high naturalness degree with the aim of enjoying the harmony between humankind and environment. The most rational and desirable way to achieve the objectives of balanced territorial management and sustainable development is always to run initiatives and programs that allow integration between the different socio-geographical realities: to practice a hospitality policy, sharing it with the local population. The new interpretative philosophy oriented towards the integration of complexity, stimulates new synergies, opens at the same time the panorama of skills, and creates new professional chances.

6. Danger and risk

The concept of risk is never so clear when we talk about it. The term, in common sense, is not univocal and is often used as a synonym of danger. The difference instead is substantial, with extremely significant implications in terms of individual and social responsibility. It is proper to define the meaning of risk using the scientific definition of risk:

$$\text{Risk} = \text{danger} \times \text{vulnerability} \times \text{exposed value} \quad (1)$$

The term danger expresses the probability that in a certain area, a destructive event of a certain intensity within a certain time frame (that can be the “time lapse”) will take place. So the danger is a function of the frequency of an event. Vulnerability indicates the predisposition of a certain “environmental component” (human population, buildings, services, infrastructure, etc.) to bear the effects of an event depending on its intensity; it expresses the degree of losses of a given element or a series of elements resulting from the occurrence of an event of a certain intensity. The exposed value or exposure indicates the element that has to bear the event and can be expressed by the number of human inhabitants or by the value of the natural and economic resources present that are exposed to danger.

The risks are not the same in countries: the physiography and the geographical position condition the natural hazard of the places, the distribution of the population and the infrastructures determine the risk. In the European context, where current geopolitical configurations have been structured on ancient cultures, we can see that the countries with the highest seismic hazard (Greece, Portugal, Italy) have a “low economic stability” condition.

It is also quite surprising to see that some low-risk countries, even for the distribution of the population and goods exposed, have a very diversified view of the danger. For example, Sweden has distributed to the population a manual on the war emergency. It is remarkable that such initiative was the subject of the official report by the Swedish delegate at the UN EFDRR conference (United Nation European Forum Disaster Risk Reduction) recently held in Rome: the whole demonstrates how complex is the concept of risk, how is it perceived in different geographical, political, social, cultural areas.

7. How to analyze and monitor the territory

The study and assessment of the territory is a complex operation. By an epistemological point of view, the holistic approach, that integrates all the components of nature’s complexity, should be the answer to the unsolved questions due to the extreme superficiality and fragmentation of knowledge. By a methodological perspective, such kind of approach provides a multiscale vision, allowing a complete analysis of the “territorial patches” identified at each of the scales of investigation [4].

Concurrently, the most proper parameters are identified, to be integrated into appropriate algorithms that summarize the value and variability in positive indexes.

The “Carta della Natura” (Map of Nature), is an Italian nation-wide project stated by national law, pointing at the knowledge and evaluation of the environment and territory, realized following the Landscape Ecology, approach, holistic and multiscale [7–9].

8. Landscape physiographic types and units

The Map of Italian physiographic Units (Figure 1), created at the 1:250,000 scale, identifies in the Italian territory 2155 areas, characterized by homogeneous physiography, and by a characteristic geographic connotation as well. Each of these physiographic units is classified referring to a list of 37 types of landscape, identified and reported at a national level [10]. The physiographic units are described referring to physical components, selected as emergent at the scale analysis, such as altitude and relief roughness, hydrographic network, lithology, physical, morphological components, land cover.

The spatial arrangement of these characteristics allows us to identify the territorial pattern, where each “patch of the mosaic” is distinguishable from the surrounding ones; the so-called “Physiographic Units” are thus defined by typological properties, referred to the above-described landscape approach, by following an inductive process. In parallel, the unit has a precise and univocal denotation, about the geographical context in which it is located: such topological property is highlighted by following a deductive process [11]. The procedure is intended for the calculation of ecological value, ecological sensitivity and anthropic pressure referring to each unit (biotope at the scale of analysis 1:50,000, the physiographic unit at 1:250,000 scale). Environmental fragility is the result of a further combination of ecological sensitivity and anthropic pressure. The indicators are selected according to availability and homogeneity throughout the national territory [12]. The places where the landscape encompasses resources and risks, are located in Basilicata, a region in the South of Italy (Figures 1 and 2). The charm of Basilicata is evoked by a series of images, light, and shadows, such as those that outline the landscape that the region offers to the observer’s gaze [4].

9. Geographical information systems

The contemporary technology offers us the chance to realize GIS and maps, useful tools at different complexity. Flexible, updatable, friendly, they can start new dialogues between society and policy makers, in the shared aim reaching a more balanced territorial management [14–17].

The map and the related tables, converted to digital format, form a database that is part of a Geographical Information System (GIS); in fact, GIS’s are considered to be the most logical choice for structuring an ecological database [18,19].

The integration process of the landscape unit map into the GIS was quite standard. We only preferred an automatic vectorization process (Laserscan VTRAK) rather than manually digitizing the handwork of the interpreters. The tolerances of the output were chosen according to the 1:250,000 scale.

The description of types and units is managed in a twofold manner: A “short” description is stored in the Polygon Attribute Table linked to the map, to be visualized by the default tools in the specially designed project (originally, within ArcView, then migrated to a Web-GIS. The more detailed units and types descriptions are instead stored in text files and visualised by a personalised Graphical User Interfaces of the GIS, where the links to the 1:50,000 maps of habitats, the second main layer of the “Carta della Natura” Project [12], are also provided.

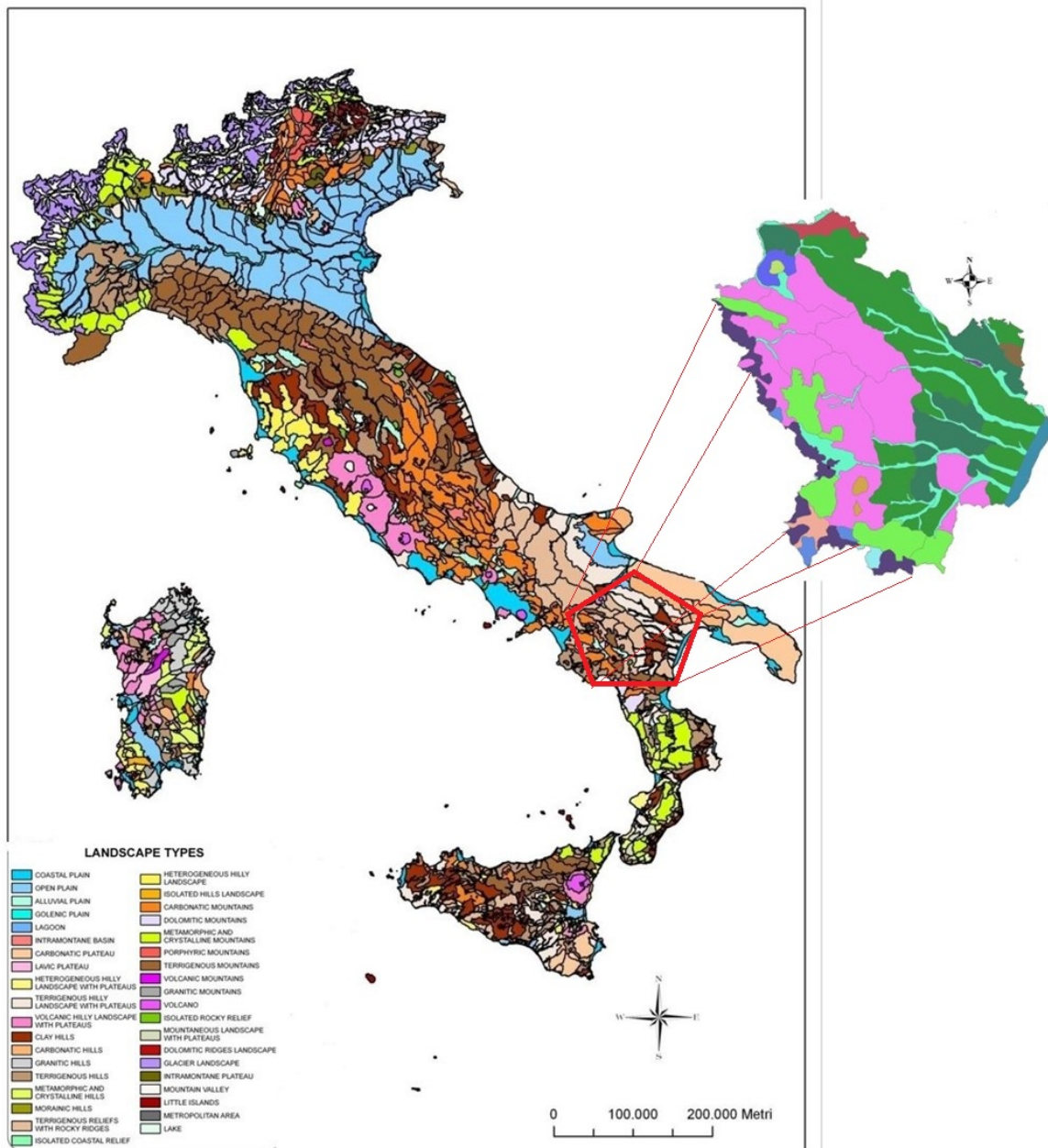


Figure 1. Italian Map of Landscapes Units scale 1:250,000, with the Units of the Basilicata Region highlighted [20].

10. The assessment

The landscape units identified in the entire Italian territory represent the set of features for environmental quality and territorial vulnerability assessment, the fulfillment of the “Carta della Natura” Project main goal [11]. The attribution of environmental quality to a landscape unit is based on some ecological and institutional criteria. Different hierarchical levels were considered to derive the ecological criteria, namely the “unit” level, the “habitat” level and the “habitat composition of the unit” level. Concerning institutional criteria, the presence of natural parks, reserves or protected areas

was taken into account [21]. The evaluation of the territorial vulnerability aims at estimating the sensitivity of habitat to perturbations or to conditions that assure their spatial and temporal persistence. Two additional parameters were also considered: the contextual sensitivity that evaluates the landscape structure where a certain habitat is found, and the intrinsic sensitivity that examines the characters of the habitat [11,22]. The evaluation of the landscape physiographic units consists in the definition of the indexes of “Ecological value”, “Ecological sensibility”, “Human pressure” (calculated by using specific indicators for each unit) and of an overall index resulting from the combination of those indexes. The indicators of value consider essentially the composition of the unit, those of sensibility consider its structure, while the human pressure indicators are related to the anthropogenic agents operating inside the unit [23]. In brief, the evaluation procedure is divided into the following phases: implementation of the “Map of Ecological Systems”, necessary to calculate various indicators, using the “Map of Habitat at the scale 1:50,000” [13]; normalization of values of each indicator, which allows bringing back the values on a continuous scale between 0 and 1, comparing values originally uneven; development of standardized indicators, calculating the value of three synthetic indexes (“Ecological value”, “Ecological sensibility”, “Human pressure”) through the application of the TOPSIS statistical method for each unit [19]; classification into five classes of values calculated for each index; definition of an overall index, called “Environmental Profile”, which provides an approximate measure of the risk of environmental degradation for each landscape physiographic unit.

The fundamental principles, the indexes and the procedure followed by this evaluation methodology are similar to those defined for the 1:50,000 scale, but they are calibrated for the 1:250,000 scale. This choice allowed to maintain an overall consistency in the “Map of Nature” project.

11. The total ecological value of the habitat

The total value of the habitat (Figure 2) is the result of the superposition of environmental, economic, social and cultural values. The ecological value of an ecosystem in a bio-centric perspective is built through structures and processes. The considered parameters are related to structural and institutional aspects, biodiversity, rarity, as shown in Table 1.

Table 1. The ecological value of the habitat: indicators.

Institutional Indicators	Structural Indicators
Value from Bioitaly List (NATURA 2000)	Value from the presence of Vertebrates
Value from Bird Directive	Value from valuable floral species
Value from Ramsar Convention	Value from rarity
Value from Annex 1 of CEE Habitat Directive (now priority)	Value from ratio habitat area/average area of that type
	Value from ratio perimeter/area



Figure 2. Satellite image of the assessed areas (Basilicata Region, Bradano Basin) [20].

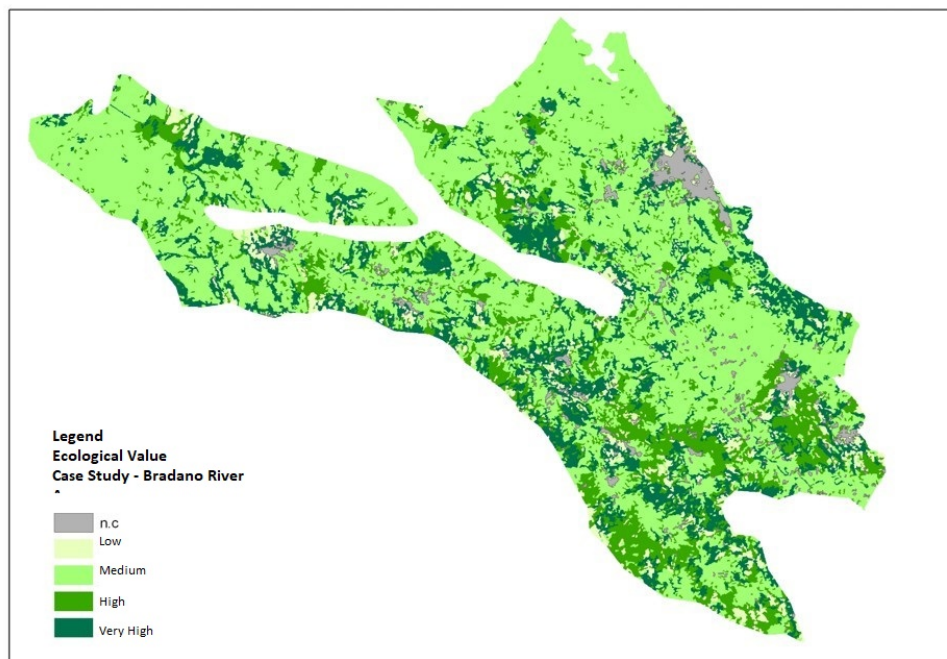


Figure 3. The ecological value of the habitat [20].

12. The anthropic pressure

Disturbance may concern both structural and functional characteristics of habitat, including any process altering the birth/death rates of the individuals present in a patch [24]. The considered parameters are related to the fragmentation of the habitat (risk of habitat of tearing up by a linear anthropic feature); the constriction of the habitat (proximity of the habitat to an environmental detractor); the demographic pressure (present/potential demographic evolution in the area), (Figure 4).

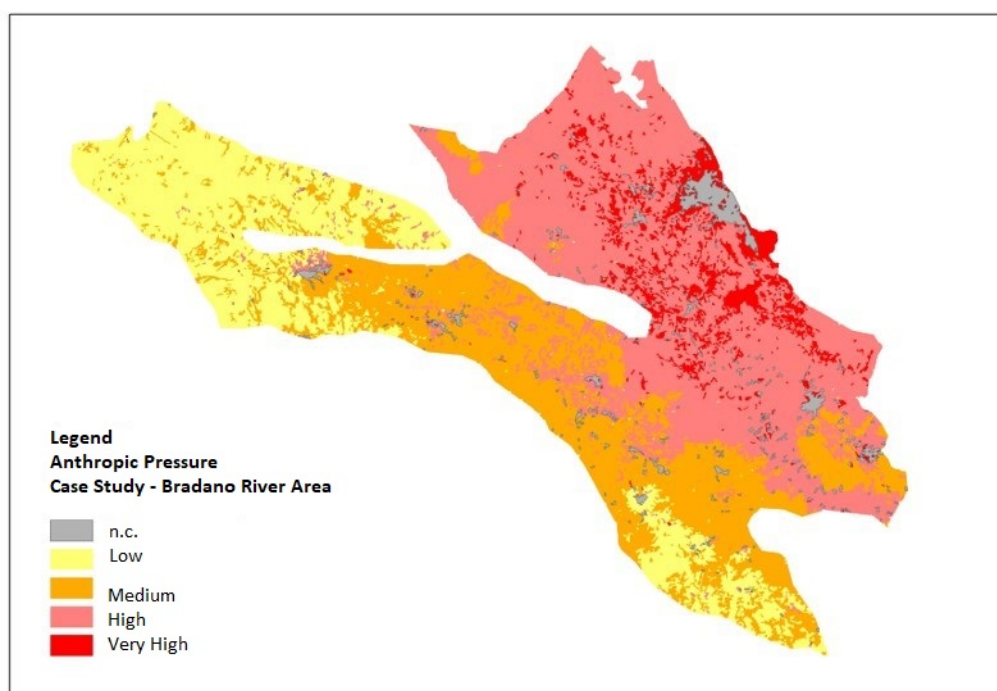


Figure 4. The anthropic pressure of the habitat. [20].

13. The environmental sensitivity

It is intended as the potential hazard of a habitat to be degraded or lose its own identity from external pressures [25]. The considered parameters related to compositional aspects such as endangered species; structural aspects; Institutional aspects; isolation (Table 2).

Table 2. Environmental Sensitivity.

Hazard from CEE Directive (priority)
Hazard from the presence of endangered Vertebrates
Hazard from endangered Flora
Hazard from rarity
Hazard from isolation
Hazard from ratio habitat area/total area of that type

14. The territorial vulnerability (fragility)

By combining in a multicriteria analysis Sensitivity and Anthropic Pressure, we can obtain the map of the Fragility of the habitats [26] (Figure 5).

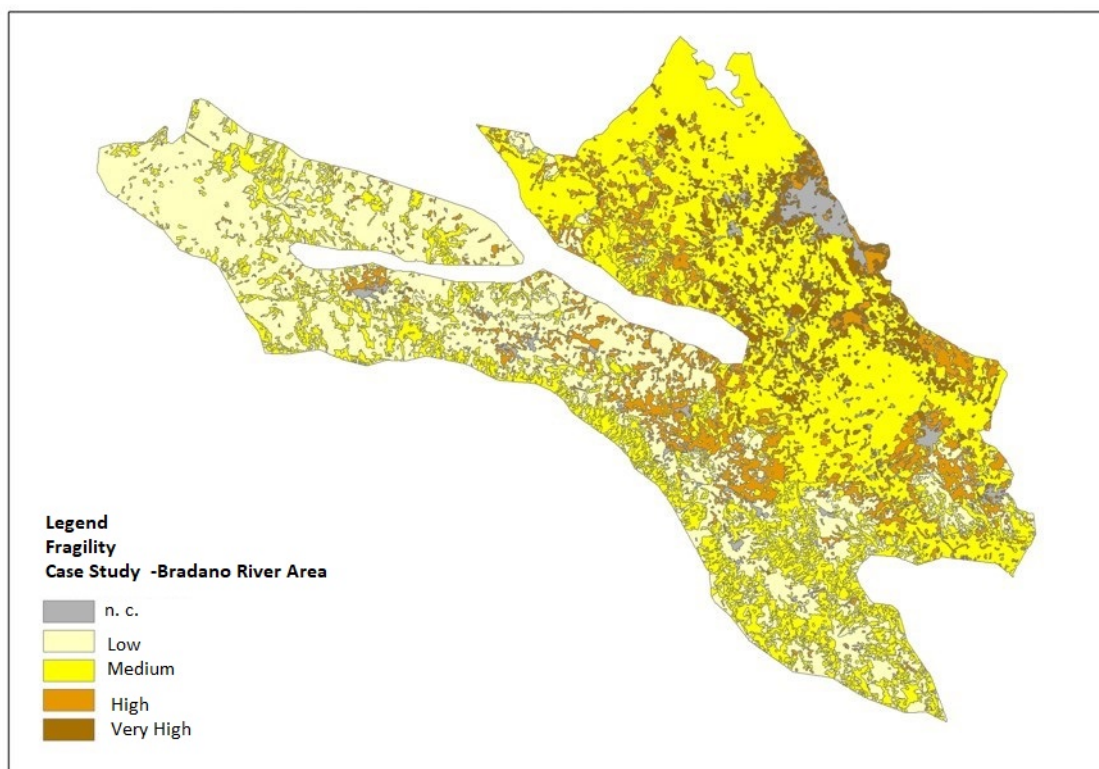


Figure 5. The Territorial Fragility [20].

15. Discussion and conclusions

Nature escapes predictions, often just because of human action. Such political and social problem is deeply rooted in history: unfortunately still today Humankind does not seem to have yet matured either instinct or wisdom needed to balance the tendency to presumption. It seems unbelievable that too often those settlements affected by calamities due to high exposure to natural hazards, are rebuilt in the same place as to demonstrate a stubborn supremacy. Rather than dealing with the laws of nature—not always completely understandable—and respecting them, humankind prefers the way of intervention “a posteriori” often re-establishing the previous risky conditions.

It is this same logic that, in many cases, succeeds in shaking scientific research itself. Science aims at reaching knowledge, but on too many occasions this is almost subordinate to intervention, even if chronologically subsequent. The action in some way resizes the dissonance between the human presumption of control and the consciousness of reality. If the sense of belonging prevailed, as a foundation in the lives of individuals/communities/society, perhaps a more healthy and comforting sensation would be obtained. Humankind modifies the environment, to adapt it to his

needs: but nature, which unites the planet and its inhabitants, teach us that humanity must adapt itself to the environment, and not vice versa.

Beyond the due diversification in the concrete management of environmental protection, when a catastrophic event happens, there is a widespread tendency to separate its causes from its effects. It is quite logical that this “trick” makes it easier to forget about the human responsibility, direct or not, in altering the environmental balance. It happened: so it’s time to repair the damage. Recovery, restoration, reconstruction: humankind likes to build: it is clear that too often economic and corporatist interests are affecting most of the activities related to land management.

How can we prevent the risks associated with extraordinary natural phenomena? Spreading information: clear, constant and shared is essential. Communication must be able to activate the awareness of risks.

From this point of view, a key function is performed by Landscape: what man perceives, what man interacts with a source of emotions, of resources, of risks. Landscape Ecology offers a new scientific approach to the study of Landscape, while on the socio-political front, the European Landscape Convention, establishes its important role on the cultural, ecological, environmental and social level. The landscape is “everywhere an important element of the quality of life of the populations, cooperates in the elaboration of local cultures and represents a fundamental component of Europe’s cultural and natural heritage”.

The Landscape Ecology approach, which considers the characteristics of natural and artificial ecosystems as parts of a diversified system, is an essential basis for any correct planning hypothesis that pursues the protection of the territory’s aesthetic resources as well as the opportunities for social and economic promotion. All this in a harmonious relationship with the natural resources’ safeguarding and the fruitful interaction with cultures.

A new awareness is directed to the active social participation transforming Landscape, being it a usable resource if supported by new ways in territorial planning, aimed at increasing the qualities of the landscape itself and the related social well-being. A correct management policy entails rights and responsibilities for each one.

Prevention of environmental risk, as an extension of public health, must be taught and widely proclaimed. Prevention is a combination of knowledge, conscience, and action. Until it is assimilated and transformed into behavior, it is essential to work on many fronts. Information is the first and most vital step. The importance of communication in the field of prevention, is only apparently a shared concept. The old tradition in the “mainstream” communication styles, testifies the habit of using spectacularization and fatalism, which is put into a narrative context that focuses on catastrophic events, with emphasis only on the harmful effects suffered by people and infrastructures, often setting aside the analysis of other fundamental aspects, like prevention, exposure, vulnerability, resilience. By continuing on this path, it is difficult to set up a fruitful dialogue with the audience, within educational projects aimed at risk prevention. New approaches address non-conventional communication techniques, based on the emotional and experiential involvement of the individual/community/society in a process of behavioral evolution. While scientific communication must be simple, scientific information must not be simplified; it is a question of language that must be rendered comprehensible. The presence of information must be constant and offered to the general

public without it having to seek it out, and at the same time, it must be very good to instill trust and familiarity.

Acknowledgements

The authors are grateful to Patrick O' Brien for reviewing the English text.

Conflict of interest

All authors declare no conflicts of interest in this paper.

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