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GIS TOOLS TO SUPPORT LANDSCAPE QUALITY ASSESSMENT AND ENHANCEMENT

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ATTRIBUTIONS
D. E. MASSIMO set up the research and authored paragraphs 1, 2, 5, 6, 7. M. MUSOLINO authored paragraphs 3 and 4. A. BARBALACE set up the General information system for valuation and appraisal (SGV), and coordinated the operational research. C. FRAGOMENI performed the multi criteria valuations.

ABSTRACT
Pollution, environmental disruption, oversized urban development and infrastructure new construction jeopardize landscape integrity and people's quality of life. Research deals with the landscape protection and enhancement providing governments and decision makers with a comprehensive Decision Support System to assess the quality of natural and cultural heritage and address planning measures and policy actions for landscape treasuring. Research set-up a sound methodology relying upon GIS tools, to spatially detect and define landscape units along with their endowment such as natural, ecological, historic, cultural, and urban resources then valuated with a GIS integrated multi criteria analysis tool set-up by the research team. Research developed a Case Study in the European Mediterranean Basin, validating the whole system and the performance and support of the GIS tools. Results achieved open the possibility to generalize the prototype application at regional, country and federation levels and therefore support the planning implementation for landscape enhancement.

Keywords: (1) Elements of agricultural landscape, (2) landscape assessment, (3) multi criteria analysis, MCA, (4) agricultural landscape protection; (5) landscape planning.

1. BACKGROUND
Countries are increasingly subjected to the pressure of "urban sprawl", infrastructure densification, soil impermeabilization, construction of new technological systems, whose "unplanned" localizations and combined and cumulative negative impacts are causing progressive ecological degradation.
As a result, the threat to agricultural areas, as well as to natural and agrarian landscapes, full of qualities, risks to turn them into unproductive and dangerous semi-urbanized lands.

To cope with this ongoing dramatic change, states, governments, international organizations, local and regional communities, have gradually built-up a framework or system of actions for the protection and improvement of the environment, territories, soils, agricultural areas, and forests.

2. GENERAL OBJECTIVE OF THE RESEARCH

Research goal is to outline and apply the frameworks of planning, protection and treasuring of local resources, through the definition of specific operational phases and the development of valuation and appraisal tools designed to support the mitigation of negative landscape and environmental impacts (such as the further destruction or decay of agricultural and forest areas) due to unplanned human actions, therefore uncoordinated, such as new construction and expansions.
Therefore, present research is addressed to all members of the Community and Institutional subjects to contribute to the definition of:

(a) new policies and strategies to prevent the destruction of agricultural and forest resources, promoting the treasuring of agricultural and natural landscapes;
(b) new ways to improve the infrastructure development with smaller impact on the landscape and new construction, preserving the Landscape Elements.

These features are implemented and verified in a specific and real Case Study.
A spatial information and valuation system has been built up to provide a possible answer to questions that are historically unresolved and related to the construction of a systematic knowledge and a multi-dimensional valuation of Landscape Areas (AdP), Landscape Units (UdP) as well as of Landscape Elements. This is derived from objective basis, both documentary and direct, through the structuring of an integrated tool to support landscape planning at the regional level, or a more complex General Information System for valuation and appraisal.

03. CONTENTS. FRAMEWORK FOR THE PROTECTION AND ENHANCEMENT OF LANDSCAPE RESOURCES

The framework for the protection and enhancement of resources contains logical sequences that foresee specific operational functions, including those summarized below.

- **Knowledge and total inventory function**: building a complete total knowledge of resources (so far fragmented and unsystematic), i.e., of agrarian, landscape and environmental assets, in the territories.
- **Geographic information function**: accurately spatialize the information directly acquired on the field to support landscape and urban planning, avoiding the overlapping of new constructions and transformations (destroying them) in sensitive areas, characterized by agriculture, forestry, ecological and landscape high –values.
- **Preventive conservation function**: outline through a rigorous spatialization and buffering the Landscape Elements and the agricultural areas characterized by high value.
- **Planning function**: include the information in the institutional tools of landscape programming and planning, at different scales, formalizing the presence and location of Landscape Elements to prevent conflicts and overlaps with the further expansions and new constructions, as well as spread their knowledge to society and to individual citizens, via the network.
- **Enhancement and promotion function**: create the institutional conditions as well as the operational and entrepreneurial *milieu* to promote actions of total and graduated

enhancement (preservation; existence; indirect use; subsidiary direct fruition, use) of the Landscape Elements and areas inversely proportional to their incorporated values, the latter estimated using assessment tools developed for specific categories of Landscape Elements.

04. LANDSCAPE KNOWLEDGE AND VALUATION

The mitigation of the “aggression” to the territory must therefore be one of the aims of landscape planning along with the enhancement of specific resources.
These objectives push the research to provide conceptual and operational tools to support and contribute to:

- classify and taxonomize per homogeneous clusters, as well as perform survey and make an inventory of all the areal goods and Landscape Elements;
- define per homogeneous clusters specific landscape features;
- define and outline homogeneous areas of landscape according to shared criteria;
- comparatively estimate with multiple criteria as well as with specific Multi Criteria Analysis tools Landscape Elements to derive hierarchical ranking and deploy actions of active protection and enhancement accordingly;
- estimate areal goods or landscape areas in their multi-functionality, as well as in the density and intensity of elements within them, finding an index of the current quality that becomes a point of reference to define the required "future landscape quality objectives";
- outline an agenda for the development of areal and elements in clusters and individual.

These are relevant because the Landscape Elements can vary and can be articulated in different objective categories, and for their protection and enhancement it is necessary to estimate their ranking value and attractiveness per homogeneous clusters. From the ranking derives the priorities of protection according to the built-in values. This hierarchical reading shows a strong need of valuation and information tools and framework. Valuation is the only approach that allows to outline an agenda of actions based on the actual characteristics and quality levels of the Elements.

5. VALUATION APPROACHES AND NEW MCA \ GIS SYSTEM

The valuation process to support planning, protection and enhancement of the landscape and land resources is divided into:

5.1. Identification-census of the resources in a specific area

The Landscape Elements are counted and valuated according to their relevance and subsequently categorized or grouped in homogeneous clusters for subsequent multi-criteria valuation and ordinal ranking for their protection and enhancement.
In particular, the quantitative assessment of the entity provides, through the total census on the territory, the numerical existence of entities, resources, objects. This becomes an element of measurement to:

- estimate and derive the intensity of landscape features;
- set up goals to pursue landscape quality;
- identify buildings and\or areas with particular quality to be protected;

- set up the knowledge to derive the perimeter-boundaries of Landscape Areas (AdP) and Landscape Units (UdP).

Furthermore, the discovery of excellent historical topographic maps led to a breakthrough in the accounts of landscape resources allowing the valuation of their existence on the basis of objective data.
The result is a Geodatabase within the General System of Valuation (SGV) in which all the landscape resources are documented and articulated in categories and sub-categories. The GIS tools allow to create layers of Landscape Elements to be then enriched with information related to their location, i.e., with the AdP and UdP.

5.2. Delimitation of AdP and UdP

The methodology developed indicates the criteria and operational stages for the identification and derivation of the AdP and related UdP, through a systemic and relational vision, with the "prevalence" of the typological \ morphological factors.
Therefore, the boundaries of these areas derive from the interweaving of historical, geographical, hydro-geo-morphological, ecological, settlement, landscape and identity features.
The result obtained with this synthetic-intuitive methodology consists in the identification and interpretation of landscape areas in which some elements \ factors have accentuated characteristics, while others are less “qualitative”, all for the purpose of a brief identification of areas, features, separate landscape units.

5.3. Weighted valuation system

It has been created a dual system of georeferenced information knowledge system integrated with a weighted valuation system of the "values" of the territories, for the landscape planning;

5.4. Sustainable enhancement

Potentials have been identified to promote a sustainable treasuring of areal elements through compatible activities, and harmonization of management plans including protection and ecological conservation.

5.5. Valuation approaches

In an articulated process applied to a complex topic as landscape is, the valuation approaches and instruments are necessarily diversified and of different types: categories; quantitative accounting; qualitative heuristic argumentation; regional economics (as for the objective analysis of potential agricultural commercial, recreational and tourism); and also analytical with multi criteria for the most sensitive landscapes valuation aiming to derive binomial hierarchical ranking of quality and attractiveness.

5.5. Approaches and tools

The case studies provides the opportunity for a coordinated experimentation of approaches and tools:

1. The definition of different types of landscape resources and elements is made with the systemic approach of Taxonomy.
2. The real census on the field is done with an accounting tool named “Taxonomic Inventory”, which populates the systematic scientific structure of Taxonomy.
3. The spatial system of knowledge and protection with the buffering is made with the information and valuation tool of the Geodatabase.

4. The specific valuation system to estimate the weighted "values" in the territories, to support landscape planning, belongs to the broader integrated "General information System for Valuation, SGV", which is an economic and urban tool for the territorial government of large areas (Massimo, Musolino, Barbalace, 2006). The analytical estimate with multiple criteria is made by adopting two comparative approaches, algorithms and related software, i.e., the Analytical Hierarchy Process by Thomas L. Saaty (AHP, 1970) and the Dominant Regime Method by Peter Nijkamp (DRM, 1974). It derives a high number of landscape elements to be valuated with multiple criteria, and the need to continuously monitor their location for their inclusion in the appropriate cluster. Also it derives the need for a MCA algorithm, more powerful as well as spatialized within the SGV and the Geodatabase. For this reason it has been built the new valuation system McaGis (Massimo, Musolino, Barbalace, Cefala, 2010) tested with the specific case study, and used to compare the results with those of the AHP and DRM systems, and resulting in a substantial and significant convergence of their hierarchical ranking.
5. The identification of potentials for the sustainable treasuring of areas and elements of agricultural landscape with compatible activities, is made with the tools of intuitive\heuristic\argumentative logical frameworks typical of business. The subsequent verifications of the original intuition, i.e., the analysis of potential targets respectively agricultural, commercial, recreational and tourist, and the resulting regional impacts, are carried out with statistical and econometric tools of Microeconomics (potential) and Regional Macroeconomics (impacts) and Regional Science.

06. CASE STUDY

The methodology has been tested in a specific case study in one of the most surprising area of Calabria: the so-called " Costa Viola landscape unit", already known to the poet Boccaccio.

The result is an extensive survey, classification and landscape valuation. The conservation priorities are derived through the multi-dimensional valuation and the consequent actions have been planned on the basis of the resource ranking, and progressively classified as:

- protection of areas with a higher value;
- conservation of high value areas;
- ecological conservation of medium value areas;
- treasuring of other parts within the " Costa Viola landscape unit";
- development of the remaining urban settlements.

The inventory of resources has confirmed the persistence of the characterizing Element of the "Costa Viola terracing."

The areal extent has been gradually reduced. Also, it has been carried out an analytical verification through a synoptic quantitative and comparative reading of the current aerial photo (2011 coverage), with two parallel detailed Topographic Maps produced by the Italian Military Geographic Institute (IGMI), respectively, in 1959 and 1993, finding out a significant reduction in acreage.

They are characteristic and typical terracing on the cliffs of the coast, from zero to 300 meters above sea level, which for over a millennium have been an extreme case of "heroic viticulture" and "heroic lemon trees", typically multifunctional because it has

both carried out an economic function and it has achieved the objectives of stabilizing geo-morphological and hydraulic control and regimentation.
For a thousand year the terracing have been made of dry stone walls. The overall impressive length is estimated to be over a thousand kilometers, and has made it possible to start up a high quality wine production and strongly characterized by the wine known as "Costa Viola".

FIRST CONCLUSIONS

Spatial information and the integrated multi-criteria assessment system (MCA) represent a decision support system in "landscape planning".
The availability of such a system provides decision makers with the ability to focus on the most significant landscape values, mitigating further urbanization in the most sensitive areas.
The integrated valuation MCA system estimates the density of landscape values, and processes the hierarchical comparative ranking of elements within homogeneous categories, providing society, actors, stake-holders, and decision-makers with important information about the prevalent elements on which focus the enhancement, so to then pull into the cluster other elements that are less attractive.
In the Costa Viola Case Study, the age-old terracing is indicated by the MCA as the first in the rank, therefore as the most interesting element of the area.
The coordinated enhancement actions, designed and valuated, start from the revitalization of the typical wine production, encouraged by the continuing success in the world of the Italian high-quality enology, and then integrates, coordinates and connects the first element of the rank order (terracing) to the dense and intense palimpsest of cultural and environmental assets (none of which is as extensive and significant as this feature) of the areal Costa Viola landscape, as well as at to tourism activities, organizing a system of economic actions which in fact represent an "eco-museum".
Protection, ecological conservation, agricultural production, cultural tourism can therefore be arranged in a synergistic way through the "landscape planning".
It has been finally activated on the network an experimental "landscape forum" as a point of meeting between public-private actors to foster cooperation between citizens, municipalities, provinces, regions and national government and trigger a more fervent participation in the cognitive processes related to the landscape elements.

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FIGURES

Detection of Elements and land marks for deductive identification of areas º figures º zones º units

Base = Physiographic map [Esri Community, sept. 2011]

Factors = costs; ridges; watersheds; *landmarks*

Figure 1 – Morphology - physiography

Detection of hills and plateaus perceptually significant

Base = Topographic Map [IGM: different years selection]

Factors = beaches, coastal ridges, plains, plateaus, high plateaus, hills, massive

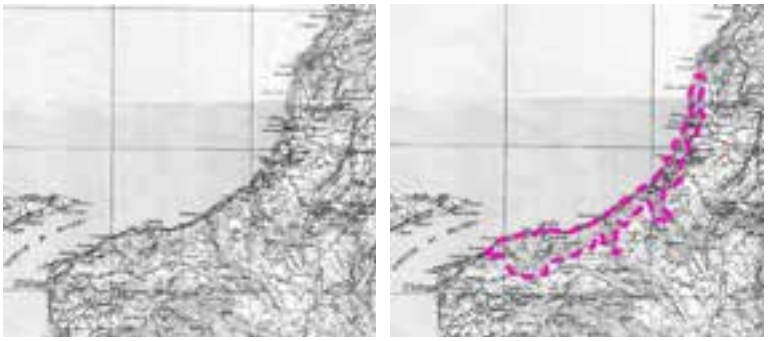

Figure 2 – Altitude

Detection of landscape features and coverage

Base = Ortofoto [sources: Google; Microsoft; Esri]

Factors = slopes orientation and consequent vegetation cover, signs of the territory; settlements

Figure 3 – Knowledge of the area

Detection of land use

Base = Corine Land Cover [source: European Union]

Factors = actual coverage of the soil; agricultural uses, urban settlements or their absence; historical infrastructure

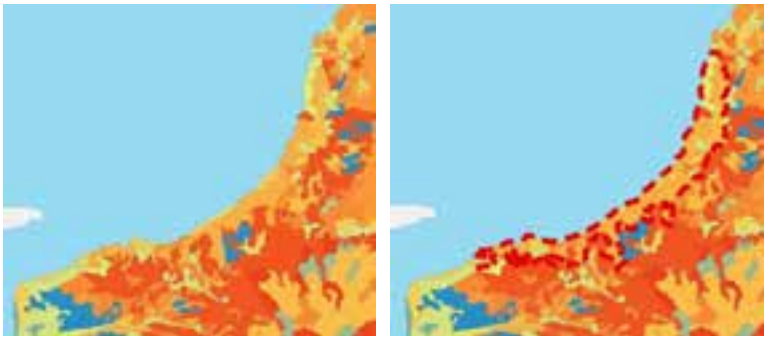

Figure 4 – Land use

Detection of the historical description of landscape and land use

Base = Rizzi-Zannoni 1788; Padre Eliseo 1783

Factors = territory's signs: agricultural landscape, swamps and wetlands, forests, lack of settlement;

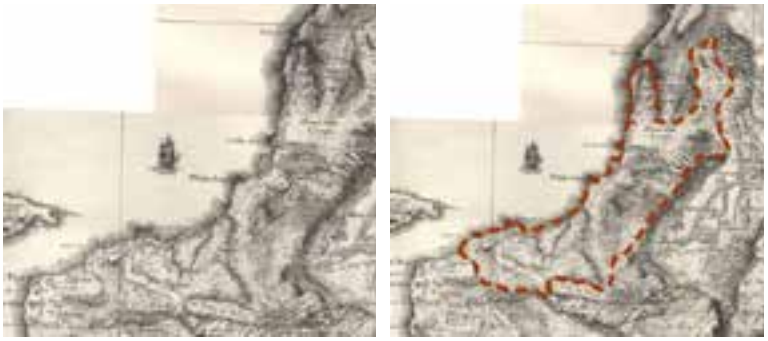

Figure 5 – Historical Maps

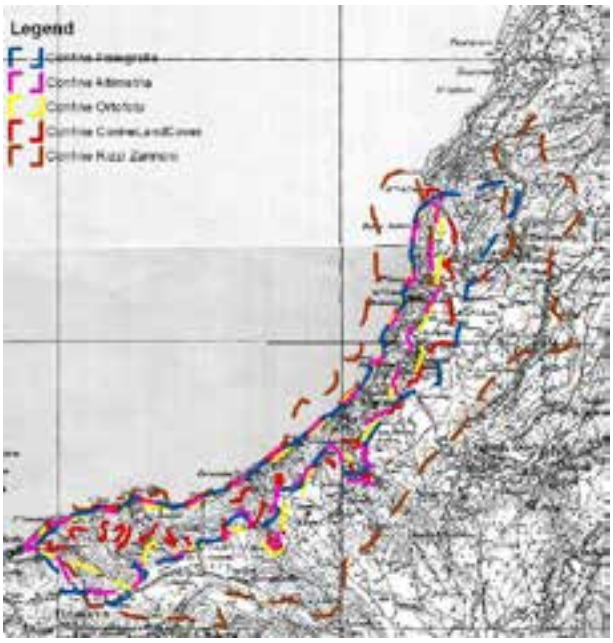

Figure 6 – Synthetic map of the structural analysis. Overlapping and identification of UdP

Figure 7. Mega 3D. Delineation of the landscape units for the provinces of Reggio Calabria and Vibo Valentia

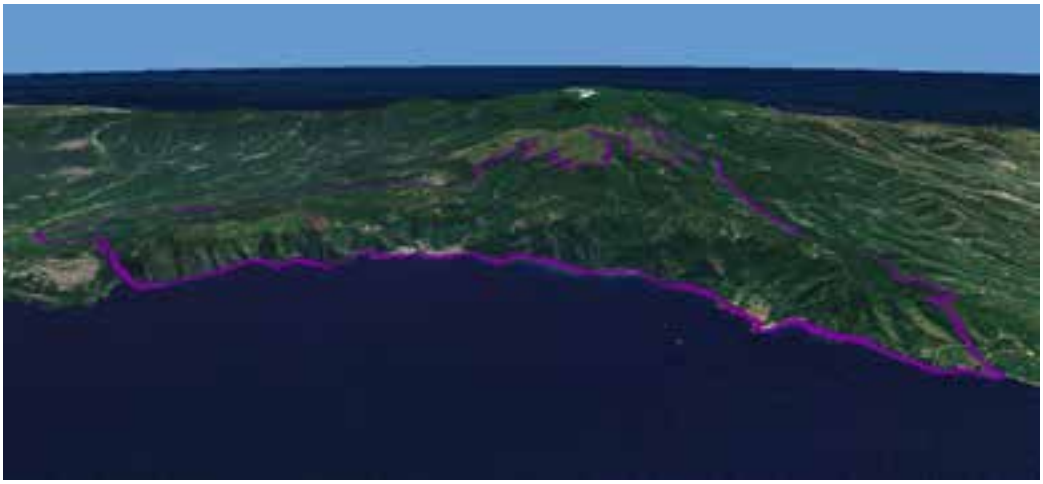

Figure 8. 3D. Case study: Landscape Unit "Costa Viola"

Figure 9. Case study: Landscape Unit "Costa Viola"

Figure 10. Case study: Landscape Unit "Costa Viola". Terracing

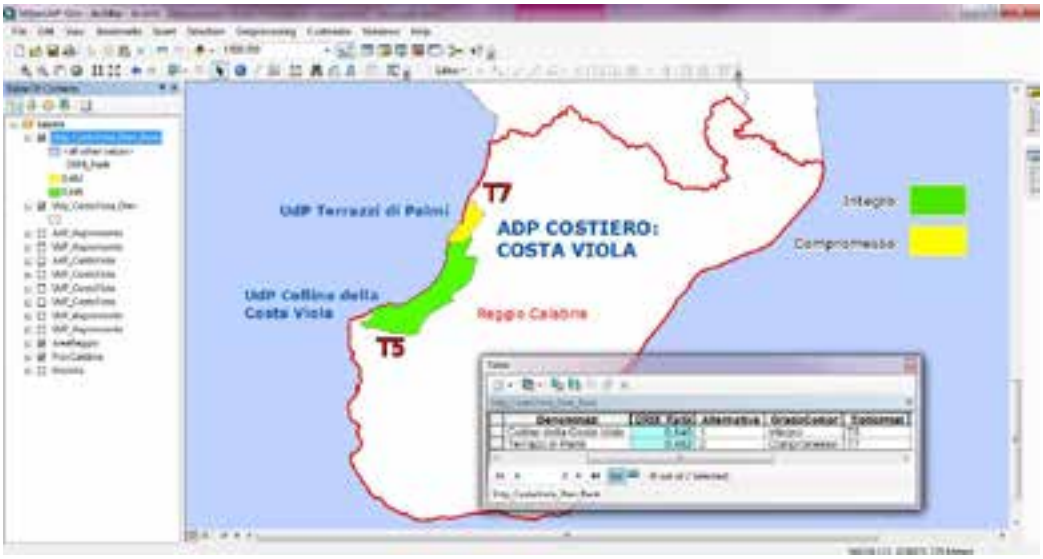

Figure 11. Case study: Landscape Unit "Costa Viola". Software "Spatial Multi Criteria Analysis." Thematic maps: rank order, degree of decay and law enforcement tools

Figure 12. Case study: Landscape Unit "Costa Viola". Software "Spatial Multi Criteria Analysis." Thematic maps: spatialized ranking