Visual Impact Assessment Methodologies for Rural Building Design

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ABSTRACT

The progressive decline in rural building architectural design seen in Italy since World War II has led to an increased interest in the study of how to make these constructions appropriately blend into the landscape. Considering these phenomena, this study deals with the definition and calibration of a structured methodological path aiming at identifying and comparing design solutions to be adopted as a framework for the most widespread building typologies in rural areas.

Considering these general aims, the study has provided for several phases. A close investigation of the state of the art has been followed by a critical analysis of the main methodologies for visual project and landscape analysis, in order to work out a specific strategy. The authors developed a method that considers both landscape and agricultural characteristics, in order to investigate and compare different design variables that have significant consequences on the overall visual impact of the building, with reference to different landscape areas. This method allows the analysis of several design solutions, according to the environmental context, in an iterative revision process.

Some particular phases of the above-mentioned path, which is part of a wider national research project, have been tested in detail, including the analysis of study cases.

Key words: rural building design, landscape indicators, scenic significance, visual impact assessment, building typologies, landscape characters.

1. INTRODUCTION AND AIMS

Until around the time of the Second World War, trends in farming evolution caused gradual and barely perceptible territorial transformations. Since then, in Italy as elsewhere, several events, such as the transition to modern agriculture, the creation in the countryside of residential areas functionally linked with towns (the so-called "rururbanization"), the chaotic urban sprawl towards the country and the abandonment of areas unfit for modern agriculture, have given rise to significant transformations in both farming arrangement and rural land texture, causing a sudden and profound modification and simplification of the rural landscape.

To meet production requirements, the construction typology, shapes and materials of industrial buildings (as shown in figure 1) have been widely applied to rural and livestock building design and constructions. This widespread practice upset the balance that had previously remained undisturbed between man-made constructions and the natural landscape since the first half of the 19th Century.

The study and evaluation of landscape, which like every other scientific subject should assume unambiguous, absolute or conventional definitions, is instead marked by dissonance in the interpretation of the term “landscape” itself, caused by a stratification of contrasting meanings.

Two fundamental meanings, one *esthetical-perceptive* and the other *naturalistic* or *geo-ecological*, should be considered as complementary issues within the same cognitive process. According to the first, the term landscape indicates the image of reality and its perceptive and cultural relationship with people in terms of perception of shapes. According to the second, landscape indicates the sum of natural phenomena in a dynamic and mutual relationship.

Figure 1. Recent rural buildings.

This interpretative synthesis is well expressed by the definition given by the European Landscape Convention, according to which *“…"Landscape" means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors”*. So, visual resources represent only one of several parts, that all together connote landscape.

The study of landscape as an object of perception is reasonably useful, because geo-ecological analysis alone cannot lead to its overall comprehension, since there are also factors of human criteria, arising from man’s nature as a thinking being, and thus subject to his way both of living and of assessing landscape, which cannot be defined by geo-ecology. Moreover, a direct link is often found between conditions of ecological equilibrium of the landscape and positive aesthetic judgments about it, letting us grasp how nature seems somehow to give aesthetic information mirroring its own state of efficiency and stability.
In evaluating the quality and characters of the landscape, we must also include the assessment of potential impacts caused by building different kinds of structures, with reference to both historical-natural and aesthetic-perceptive components. This study aims to propose a methodology useful not only in pursuing landscape quality and impact assessment, but also in supporting the elaboration of a planning path for the definition of guidelines for rural buildings. The methodology has been drawn up specifically for the rural territory, with its peculiarities linked to farming activities and its landscape and environmental characteristics.
By adopting an approach based on incentives and on the voluntary application of norms and guidelines such as the ones described above, it is in fact possible to contribute to building quality improvement.

While Landscape Impact Assessment (included in the Environmental Impact Assessment procedure) is mandatory by law for some categories of buildings, its application is unthinkable for the smaller ones that are more frequently and commonly constructed in rural

areas, due to the excessive costs. Nevertheless, such structures, more than any, widely characterize the perception of extra urban areas, due in part to the well-established and not always virtuous uniformity of building typologies that has spread in recent decades.
If on the one hand it is advisable to protect rural areas from the excessive visual impacts caused by conspicuous constructions such as significant structural and infrastructural works, on the other hand it is equally important to guarantee an adequate level of quality in smaller but more widespread constructions. It therefore seemed valuable to seek a suitable analytical path which might support the iterative revision of the planning process: such research represents the *general aim* of this study. The above-mentioned path, then, being flexibly organized into a logical sequence of several properly connected and related interactive steps, may prove to be a very useful tool, amongst those used for the elaboration of the above-mentioned guidelines. The *specific goals* of the study are the identification, definition and characterization of each single step to be considered in the process, as well as designing the system of relationships among the steps themselves and testing some of them by means of case studies. This calls for the research and analysis of all the variables involved in the process, which are related to both the built system and the environment. The study aims to identify a methodological framework capable of comparing several design solutions for the most widespread countryside building typologies, in order to establish which best fit into the landscape.

Everything reported in this paper may be considered as the preliminary results of a wider national research project, of which this study is a part, undertaken by the research group the authors belong to: further results will be submitted for publication as soon as they become available.

The study started with a critical and comparative analysis of the methodological approaches to landscape assessment found in scientific literature, paying particular attention to the perceptive aspects, in order to define an original method, through the integration of other existing methods as well as the authors' personal revision.

Visual impact assessment, unlike other types of evaluation, is not always based on standardized, measurable objective parameters, which can easily be compared with widely shared reference standards. Instead it is sometimes based on qualitative assessments conducted by experts in the field. The aim of this study is therefore to render this approach as objective, systematic, structured and transparent as possible.

2. STATE OF THE ART

Careful analysis of the state of the art has highlighted the fact that, when landscape is analysed in order to plan or verify design hypotheses, studies collecting information and describing the landscape are not enough, albeit that they are complete and supplied with functional data, if their only objective is simply knowledge of the landscape. Rather, evaluation analyses are needed, which will accommodate both the importance and the aptitude to alteration of landscape elements, with reference to aspects such as their value and vulnerability.

The diversity of both conceptual bases and applicative possibilities of the investigated methods makes it difficult to identify suitable criteria for their classification, but the critical analysis led to the identification of some of their logical, procedural and applicative affinities.

Almost all of them consider point allocation for landscape components, by means of overlaying data and thematic maps, experts' opinions and consideration of public preference, and also of more or less sophisticated statistical techniques.

Visual analyses of large areas generally aim to guide design and territorial planning policies, while higher-scale and more detailed studies mainly aim to assess specific landscape contexts, including reference to the creation of particular projects.
Among the most common approaches to landscape visual quality assessment, some methodologies have been found which aim to make an aggregated evaluation of landscape components, whilst others seek to establish visual preferences for space units or single elements, and yet others are the result of the integration of these two categories (Galletta, 1994).

Visual contrast rating and visual absorption capability procedures (Smardon et al, 1986) are examples of systems useful not only for landscape knowledge and assessment, but also for assessing the impact of projects and the aptitude of landscape for bearing intrusions, relative to the various different quality levels.

All these methods can use indicators, which are generally very useful in studying environmental components: they allow a synthetic description of complex phenomena and, by quantifying environmental effects related to the implementation of projects, they also allow the results to be compared to shared reference standards or other indicative values.
Two methods developed in the U.S.A. by the *US Bureau of Land Management* (USDI Bureau of Land Management, 1980a and 1980b) and by the *US Forest Service* (Smardon et al, 1986), which are used for landscape visual trait and aesthetic quality preservation and conservation, can be included among the methods employed in landscape component aggregated analysis.
They divide the study area into elementary units, defined according to their landscape and visual homogeneity, or discretize it using a grid whose mesh size depends on both territorial characteristics and the scale of the project. The visual value of each area is the result of the sum of values assigned to different landscape components according to the analysis of their quality and quantitative characteristics and to their division into importance classes.

The main intrinsic factors considered are morphology, vegetation, water, colour, rareness and unicity, and anthropic modifications (see figure 2), together with another important factor, sensitivity, which depends on the presence of potential visual receptors and on the way in which they use rural areas (Smardon et al, 1986).

Only some of the range of landscape components considered by the two above-mentioned institutions are common, as descriptors used by the *US Forest Service* are specific for mountain landscapes characterized by a dense vegetation, while the ones used by the *US Bureau of Land Management* are suitable for semi-arid areas or areas with thin vegetation and open spaces.

COMPONENTS	CLASSIFICATION CRITERIA AND POINT ALLOCATION		
MORPHOLOGY	steep slope, such as cliffs, needles or compact rocks; sharp changes in morphology; highly eroded formations; uncommon and remarkable single dominant factors	steep ravines, isolated hills, relevant cases of erosion, variety in size and kind of elevation, interesting, but not dominant or remarkable, factors	low hills or slight undulations of ground; low part of hills or flat valley bottom; few or no single interesting factors
	5	**3**	**1**
VEGETATION	remarkable variety of vegetation types, interesting in terms of shape and texture	some variety of vegetation, but only of one or two types	little or no variety of vegetation
	5	**3**	**1**
WATER	pure, clear water, still or in rapid movement, either way a dominant factor in the landscape	still or slow-moving water, not dominant	no water, or water not visible
	5	**3**	**0**
COLOUR	rich assortment, variety and intensity of colours; pleasant contrast between the colours of the land, rocks, vegetation and water	little variety of colours; little contrast between land, rocks and vegetation, not a significant element in the scenery	minimal variety of colours, low contrast, usually toned-down colours
	5	**3**	**1**
RARENESS/ UNIQUENESS	memorable or very unusual landscape in the area; good probability of seeing extraordinary naturalistic environments	remarkable landscape but similar to other ones in the area	interesting landscape but very common in the area
	6	**2**	**1**
ANTHROPIC MODIFICATIONS	modifications improve landscape quality and visual quality	modifications add little or nothing to landscape variety and visual quality	modifications are so widespread that visual quality is substantially reduced
	2	**0**	**-4**

Figure 2. Example of table for point allocation to landscape components.

Visual preference methods divide the study area into landscape units, and assign them a value according to the quality and extent of their most meaningful views, considered as the prime elements to be evaluated, relative to individual landscape components. These methods, which consider large areas, are not well-suited to small scale studies.

Methods resulting from the integration of the two categories seen so far relate landscape element values, that can be objectively measured, and values assigned to landscape according to the visual preference analysis. The contribution of each component to total landscape value is defined by relating the visual preference scale (worked out for each landscape typology in the study area) with the quantitative measurement data for specific landscape components. The study area is discretized by means of a regular grid, and the ratio of land-use to total unit surface area is calculated for each landscape component; then the most significant components in determining visual quality are selected, and an importance factor is given to them. The sum of the values of selected components in each grid unit, each multiplied by the corresponding relative weight, represents the total visual quality value. Multiplying it by an intervisibility factor, defining the extent and depth of the views, gives the end landscape value.

The above-mentioned methods of the *US Bureau of Land Management* and the *US Forest Service* take different approaches to project landscape impact assessment.
Visual contrast rating methodology (Smardon, 1979) by the *US Bureau of Land Management*, which together with the above-mentioned inventory and evaluation phases represents the overall Visual Resource Management System (Smardon et al., 1984), determines whether the proposed project is consistent with the landscape, and allows the determination of necessary mitigation measures, according to both the visual resource management class in which it is located (defined in the inventory and evaluation phases) and the maximum tolerable visual intrusion.

The basic concept is that visual impact severity depends mainly on contrast and dominance levels between the proposed project and the existing landscape, assessed in relation to their components and to basic perception elements such as colour, shape, lines, texture, scale and space (Smardon, 1979). In order to conduct homogenous comparisons, the proposed project's components must be considered alongside the physical features of the landscape, which are essentially land, water, vegetation, and any existing construction.

The *US Forest Service* considers a *Visual Absorption Capability* (VAC) index (USDA Forest Service, 1974), measuring the physical, formal and visual capability of the area considered to absorb or hide the consequences of the project, whilst preserving its own characteristics.

However it gives no information about changes in landscape value caused by the project. The VAC index includes these kinds of factors, and their interaction gives a measure of the probable impact of the project: biophysical factors (site conditions), factors regarding the visual impact for observers (distance, position and number of viewers, duration of the view) and project-related factors (scale, type of project and aesthetic qualities).

Methods such as those of the *US Bureau of Land Management* and *US Forest Service*, which consider aesthetic qualities as inherent in the landscape itself, and believe that landscape quality level can be established by describing its characteristics, are classified as *formal aesthetic models* (Daniel and Vining, 1983).

This descriptive approach is generally based on standards established by experts. However it can be appropriate to use evaluation methods that consider the visual preferences of several people, the general public or experts, in order to limit subjectivity in visual judgments, or at least to consider them as systematically and scientifically as possible, and thus to standardise them as much as is feasible. The so-called *public preference model* methods (Arthur et al., 1977) study statistics on the reactions of representative samples of potential receptors, in order to identify the landscape components that contribute most to the judgement, and to quantify this influence (Tempesta and Crivellaro, 1999): schedules, visual preference evaluation and behaviour measurement systems can be used.

Romani, a landscape architect, considers a systemic approach to landscape analysis by means of matrixes having multidisciplinary, trans-disciplinary, dynamic, relational and multidimensional characteristics. Matrixes, considered not as static components but as processes that create the landscape with different dynamics and effectiveness, are classified as natural, anthropic or perceptive (Romani, 1994). Romani considers neither Lynch nor quantitative-geometric analyses, which are typical of the American school, as they have already been widely discussed elsewhere, and he defines four kinds of analyses: absolute visibility, relative visibility, intervisibility and semiologic. Absolute visibility analysis consists of the identification of those elements of the landscape which are visible from any viewpoint, of those which constitute a visible boundary, and of the so-called “visual emergencies” which are particularly dominant, representative and characterizing. Relative visibility analysis aims to study what is visible from established points or paths, examining view depth and obstructions, importance, dominance and continuity of perceived objects. Intervisibility analysis looks at other points that are visible from each considered point, and, reciprocally, from which the considered point is visible. Finally semiologic analysis studies signs and their meaning, considering both natural and anthropic perceived elements which give measurable information.

With specific reference to visual impact assessment, two other methodologies analyzed in order to develop the method which is the aim of this study are briefly outlined here.

The approach by Oneto, a landscape architect inspired by the principles and applications of so-called “environmental planning and design” (McHargh, 1969), is used to evaluate the consequences of new projects on landscape components, in order to promote projects following the natural rhythms and vocations of the landscape itself (Oneto, 1987).

In this method the aim of the first phase is to get to know generally the area concerned by the project, and this can be achieved by means of a screening procedure that uses thematic maps and data about natural and anthropic information levels to investigate areas characterized by hazards, development issues and natural or cultural resources. Matrixes, specific for the project typology, can relate landscape and project components, and highlight and quantify potential impacts. By overlapping this data with the thematic maps of the same landscape components, we can conceive a synthesis map of potential impact, allowing us to compare possible alternative solutions and choose the best location or layout for the project. The phase of description and definition of the project visual space uses maps of intervisibility, of landscape units and of existing visual and perceptive conditions; it is then possible to select the key viewpoints, and thus to simulate the visual perception of the project. This represents a very useful means to define design choices, as well as possible alternative solutions and corrective measures. Since careful site choice and scrupulous design are not always enough to totally exclude or prevent any potential negative impact, the method also allows the definition of protection, minimization, mitigation and compensation measures.

The *Landscape Institute of Environmental Management and Assessment*, a British professional institution, more recently defined a method (The Landscape Institute of Environmental Management and Assessment, 2002) made up of phases similar to those proposed by Oneto. It separately analyzes the physical landscape - evaluated considering both the site concerned by the project and the wider context, within which the character of the landscape may undergo changes due to the project itself - and the visual resource space, meaning the area from which the project may be seen (the so-called *visual influence area* or *viewshed*).

A detailed project description in terms of structure, design and material solutions, allows the assessment of the magnitude of impacts (entity of changes caused) and of the sensitivity of the landscape resources involved, which together determine overall impact severity.
Landscape management entails highly complex cultural phenomena, which make it extremely difficult to find variables suitable to assess the quality level of the landscape. Nevertheless, several indicators have been defined, partly in order to establish a methodology homogeneous with the study of other environmental components subject to impact assessments. Those indicators are meant as parameters suitable to define measurable or calculable characteristics, representative of the studied phenomenon.

The main indicators (Colombo and Malcevschi, 1999) can be classified into: physical-geomorphological, physical-hydrogeological, vegetation, faunistic, agricultural, built system, infrastructural, historical-cultural, ecosystem and perceptive. Perceptive indicators can be further divided into those referring to generic perceptive characteristics, or to characteristics which may be perceived from particular viewpoints, and those specifically referring to the insertion of new projects. The latter may be directly used to describe, classify and evaluate the effects of the proposed project and determine its perceptive compatibility level and the relative weight of the impact according to vulnerability and sensitivity. When indicators measure quality levels of landscape or visual resources, impacts can be derived as a differential measure, by forecasting the values for the indicators after the implementation of the proposed project.

This state of the art, which has concentrated on those parts which are considered most directly relevant for the aims of the study, has shown how several institutions and researchers have so far produced a sizeable scientific literature about methodologies for landscape and visual project analyses. Nevertheless, Italian environmental impact studies still often fail to consider visual and perceptive components with enough rigour, although they are universally acknowledged as important elements in determining landscape quality.

3. PROPOSED METHOD

As already stated in the aim section of this work, the study consisted in the elaboration of an original methodological path, useful in developing design solutions, which may be taken as a point of reference for the main kinds of projects to be produced in rural areas, in order for them to fit into the landscape. The authors, also referring to the scientific literature, planned a method specifically conceived for agricultural buildings and tested it using representative case studies. In order to calibrate the method, since the variables involved were numerous, a study area and several representative case studies (types of farms and built systems) needed to be defined. Some municipalities in the eastern part of the Bologna province (Emilia Romagna, Italy) were chosen, having both flat and hilly areas and different farming arrangements. The study area has a total territorial extent of 787 square kilometres and a total population of more than 121,000.

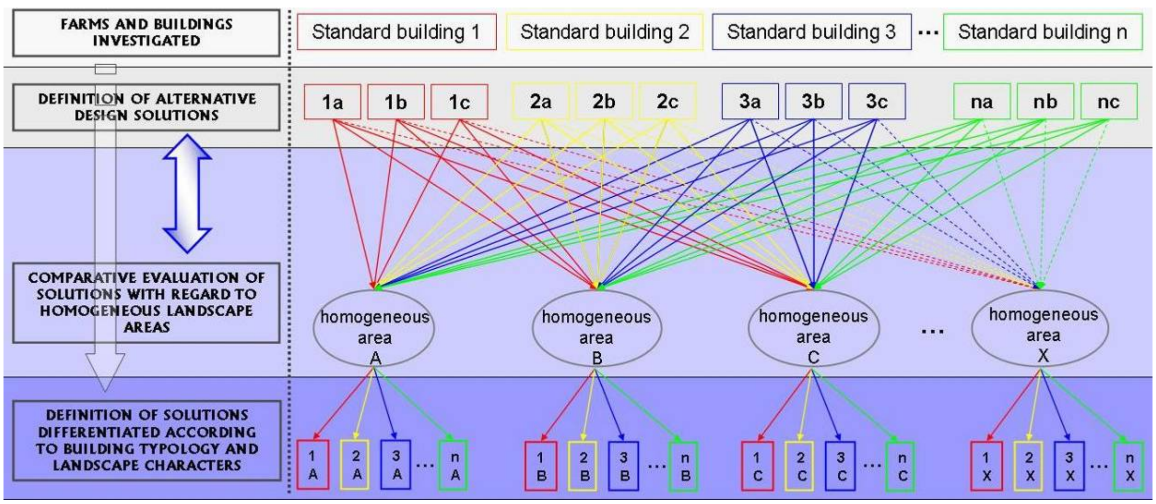

Figure 3. The architecture of the methodological path.

The method reflects some peculiarities of the study area, considering both its landscape and agricultural characteristics, but it can be conceptually extended to other geographic areas, with different sizes and landscape arrangements.

Figure 3 shows how the architecture of the methodological path was developed to investigate and compare the different design variables that can have significant consequences on the overall visual impact of the building, with reference to different landscape areas. This scheme allows the creation of design solutions differing from each other according not only to the building function, but also to the environmental context, in an iterative revision process.

3.1. Definition of Landscape and Farming Units

The first part of the proposed method provides for a close analysis of the study area, as regards geomorphological and farming issues.

The investigations described below call for the collection of a large amount of data by both

public and private institutions and by means of on-site surveys.
The analysis has been organized as follows:

a) the division of the study area into landscape units (below referred to as *environmental landscape units, ELU*), understood as homogeneous areas in terms of geomorphological, geographical and landscape issues, mostly by means of aerial and satellite ortho-rectified high-definition images and thematic maps;
b) the further division of these *environmental landscape units* into landscape sub-units (below referred to as *agricultural landscape sub-units, ALSU*), on the basis of homogeneity in terms of farming arrangements and agricultural systems;
c) the verification and, where necessary, detailed definition of the *ALSU*, by means of targeted on-site surveys.

For the definition of the *ELUs*, all the information layers available in the various archives should be collected. These need to be updated, integrated, and arranged in a GIS. The method provides above all for the discretization of the study area by means of a regular grid, whose mesh size has to be properly defined according to the level of fragmentation (continuity and discontinuity) of the anthropic and natural elements characteristic of the study area. This grid will represent the basis for the quality and quantitative analyses of both geomorphological and landscape issues. Above all, for these analyses, data and maps regarding altimetry, slope, aspect, geology, pedology, hydrography and derived maps have to be analysed, together with landscape components and characterizing elements, such as the presence and typology of vegetation, land use and land use capacity, anthropic elements, cultural, biological, geological, and historical heritage (including very important elements such as the agricultural hydraulic arrangements), and the main territorial invariants.

The method also provides for the analysis of the relationships between the information layers of each cell of the grid and among different cells, in order to define homogeneity criteria for clustering cells in wider macro-areas.

The definition of the *ALSU* comes from the integrated statistical analysis of information about the size and farming arrangement of all the farms of the study area.
Possible sources for this information include cadastral data and maps, agricultural censuses, as well as any other archive which may contribute, even indirectly, to gaining detailed information about the use of agricultural land. Databases compiled by institutions in charge of allocation of several kinds of funds for economic and financial support of farms may be quoted among useful sources of data.

The elaboration of such information should lead to the definition of the prevalent farming arrangement of each farm. Therefore the process of georeferencing all the farms allows the definition of areas as homogeneous as possible as regards agricultural issues.
It is a well-known fact that homogeneity in agricultural land-use plays an important role in creating homogeneity in landscape characters: this influence is closely linked to the territorial scale of the analysis, and generally speaking, the more prevalent the agricultural use of the area, the more direct the influence, whilst the less prevalent, the greater the level of naturalness.

It is important to note that, since it provides for the statistical analysis of data by means of assessing the farms as regards their prevailing farming arrangement, the method explained above may lead to the definition of areas which, homogeneous in principle, can sometimes

actually prove to be highly fragmented in terms of farming and landscape issues. This kind of limitation, which is strictly related to the level of fragmentation of landed property and of homogeneity of agricultural systems, should be properly verified according to the study area considered, and calls for specific in-depth analyses and scrupulous considerations, with the purpose of identifying and refining suitable criteria for clustering the farms in homogeneous classes, according to affinities in their farming arrangements.
Several tests of all these procedures have been performed using the GIS software by ESRI (Redlands, California), ArcGIS 9. Figure 4 shows some results for the definition of the *ELUs* described in phase *3.1a*.

Figure 4. Preliminary investigations for the definition of environmental landscape units.

3.2. Analysis of the Built System of a Sample of Farms

This phase aims to define the building typologies to be studied (for agricultural, agro-industrial and livestock activities), by analyzing the different patterns of the built system, on the basis of the main production arrangements. Specific considerations should be made about those agro-industrial buildings where products mainly cultivated on other farms are transformed.

This phase provides for selections in the following steps:

a) the identification of a sample of farms, representative of each one of the previously-defined *ALSUs*, in terms of size and farming arrangement;
b) on-site surveys of the farms in the sample, in order to define the main functional categories of rural and livestock buildings for each of the farms investigated;
c) their aggregation into classes of architectonically homogeneous buildings;
d) the definition of “standard buildings”, outlined in terms of general characteristics and size.

3.3. Building Design Criteria

For each *ALSU* defined in phase 3.1, the method provides for the selection of a number of sites, some of which are near to existing structures of farms from the surveyed sample, where the design of new buildings will be hypothesised.
As for the design of new developments, for each of these sites, representative of different landscape and territorial arrangements, this phase provides for:

a) the definition of parts of the study area which are visible from main roads and viewpoints, by means of computer simulation techniques (GIS intervisibility tools). Even if these systems need integrations and on-site surveys, they are objective methods, so they have been given preference over systems based only on visual investigations, which are often only able to give approximate results (Galletta, 1994);
b) the definition of criteria for planning the most suitable location of buildings, to be used in cases ranging from wide areas down to farm scale, which are the fruit of compromise between perceptive and functional needs of accessibility and feasibility;
c) the definition of alternative solutions, in terms of materials and building components,

to be used for the previously-defined building categories. The most common solutions available in the building components market have to be considered and, where necessary, new solutions should be defined, which may sometimes diverge from the most common existing trends, considering functional and aesthetical needs. Possible alternatives must be investigated, in order to reduce visual impact whilst retaining structural, performance and functional requirements. Data collection may benefit from the collaboration of a representative sample of firms producing building components. A closer investigation may also consider technical, economic and environmental characteristics of the products analysed;

d) the definition, for each standard building deriving from phase *3.2d*, of several alternative design solutions, in terms of typology, structural layouts, form, materials, and relative layout of the individual buildings making up the farm's built system;
e) the definition of the visual influence area for the site and projects under investigation;
f) the definition of the main viewpoints (also called key viewpoints), to be used in the impact simulations;
g) the classification of viewpoints according to parameters of specific relative importance and to criteria based on intensity, frequency and typology of use;
h) the elaboration of renderings and computer aided simulations, produced by superimposing each alternative design solution on suitable photographs taken from the previously selected key viewpoints; different lighting conditions and seasons also need to be considered in these simulations;
i) the comparative evaluation of alternative solutions in order to define those characterized by the lowest overall impact, by means of a detailed investigation of the main potential visual impacts and based mainly on the visual contrast rating theory and the use of specific indicators.

All the above phases would require some considerable discussion. For brevity's sake, we will only report phases *3.3e* and *3.3f* in detail here. The most common current techniques and procedures will be tested on case studies, intended as experimental test benches.

A process of this kind has also been defined for analyses supporting the mitigation of visual impact of existing built systems. Its main steps are: *i)* the definition of key viewpoints; *ii)* perceptive analysis to define inadequate elements; *iii)* the definition and comparison of alternative design solutions for correction.

4. PRELIMINARY RESULTS

4.1. Phase 3.3e

This phase, as mentioned, aims to define the visual influence area (which usually also covers the area where other effects on landscape receptors are registered). This area is made up of all the points in the study area from which the proposed project in question can be seen.

In this regard, a case study is reported here in which, in order to consider as many variables and conditions as possible, not only one building, but a hypothetical complex of buildings has been considered. This built system consists of several rural buildings (livestock, feeding and farm tools and machinery storage), arranged according to a specific layout.

First of all, a digital terrain model (DTM) was built using GIS tools for three-dimensional computer modelling, starting from elevation points and contour lines derived from technical maps of the Emilia Romagna Region (Italy). Other layers, to which information about elevation is not usually associated, proved useful in defining terrain morphology: layers such as roads and hydrographical networks, derived in vector two-dimensional format from technical digital maps, were used to refine the DTM. For these and subsequent computer simulations and elaborations the Spatial and 3D analyst extensions of the already quoted ArcGIS software by ESRI were used.

The simulation was then improved and made more suitable for the aims of the study, by means of more detailed modelling of the project area. Thus each building was three-dimensionally defined in order to allow simulations to include in the results even those parts of the study area from which the project is only partially visible.

In order include for consideration cases where this kind of analysis has to support the definition of corrective design solutions for existing built systems, the same modelling was elaborated for a case study, where the measurements of existing buildings needed for the calculations could be obtained from design drawings or measured on site.

A first rough assessment of these sizes was also worked out: technical maps were verified by means of high-definition aerial and satellite ortho-projected images as regards the layouts, and digital stereoscopic aerophotogrammetry was used for mean building heights.

The viewshed calculation, made by defining a set of observation points on the top of each building, gave the area visible from the considered location. This area in turn coincides with the part of the landscape from which the built system will be visible if it is placed in this location, i.e., the visual influence area (see figure 5).

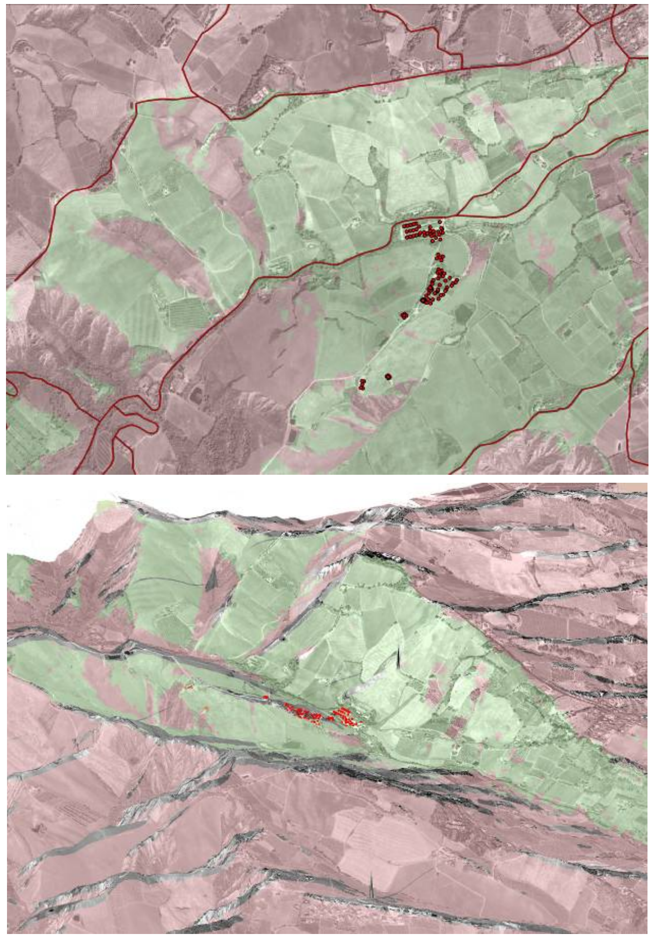

Figure 5. Visual influence area (viewshed), in green:
2D and 3D overlay on panchromatic satellite images.

In order to consider the maximum distance of perception significance (generally considered as varying from 3 up to 10 km), the viewshed was outlined using a circle centred on the project location, with a radius varying according to this distance.

Integration of computer simulations and on-site surveys allowed the calibration of the methodology according to the density of the built system and to geomorphological, farming and vegetation characteristics. The following specific issues were investigated: the relationship between the density of the DTM mesh needed for intervisibility simulations and achievable precision, model sensitivity to the heights of observation points and targets, and influence of vegetation and other obstructions (such as high-density built systems, scattered buildings, walls and fences).

The above issues were also investigated in relation to computational loads, both for the creation and elaboration of the DTM and for the viewshed simulation, due to the lengthy computing times often required, even on current generation workstations. The results of some of the DTM extraction sessions, using digital aerophotogrammetry, are shown in figure 6. The software used for the digital stereoscopic photogrammetry was RFD Evolution, by GEOPRO (Ancona, Italy).

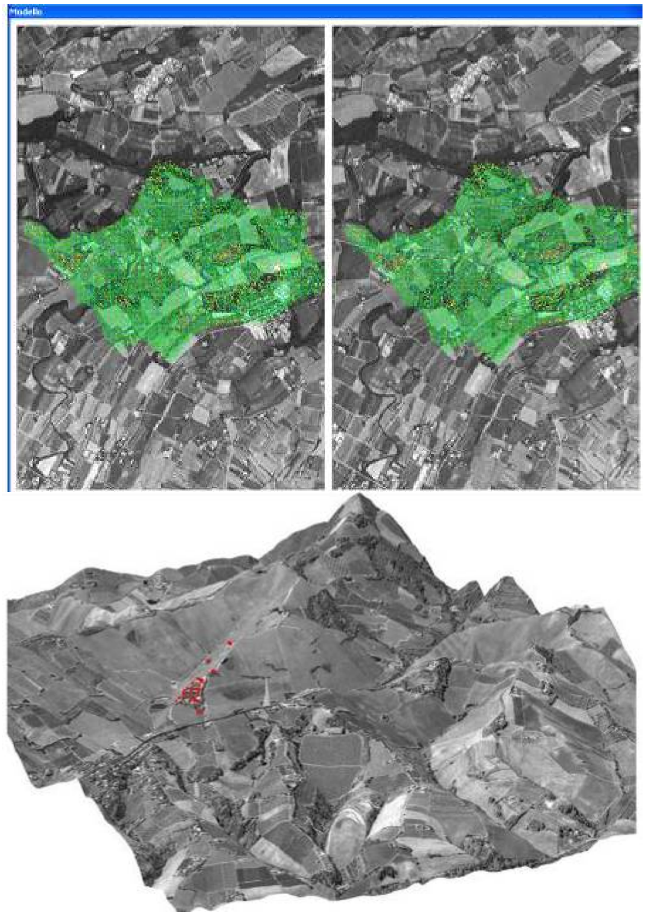

Figure 6. A stereoscopic model for the extraction of the digital terrain model.

4.2. Phase 3.3f

This phase used the overlay of the viewshed with the road network to establish the coverage area of all possible locations from which the built system in question is visible, with reference to most common and frequent access routes to the area. Given that the viewpoints within this coverage area are theoretically innumerable, and that viewing conditions vary with the observation point, the most critical and representative viewpoints were selected.

This selection was made using both physical-geometrical parameters based on quantifiable data obtained from the landscape's morphological conditions and from the observer's position, and also by considering environmental and usage mode parameters, calculated through simulations and on-site surveys.

Key viewpoints were marked on technical maps and corresponding views were illustrated using suitable means. It was found that the number of viewpoints needed varies with the typology and size of the project: for smaller ones the single most critical viewpoint may be enough, whereas for more complex ones more viewpoints are needed in order to get different views of the landscape and of the simulated alterations.

5. CONCLUSIONS

In Italy, it was only in the 'Eighties - very late compared to the manifestation of the progressive decline in architectonic quality of rural buildings, seen since the end of the Second World War - that regulations for environment and landscape protection focused their attention on the systematic safeguarding of the cultural identity and physical integrity of the land. More recently, national and local regulations have been promulgated to draw attention to matters such as the promotion of landscape quality and the appropriateness of buildings to the environment.

Considering these issues, the study has given rise to the definition and calibration of an articulated methodological process, devised so as to allow the definition of design solutions for built systems related to rural activities, differentiated according to building typology and landscape characters, and to provide a comparative characterization based on performance, aesthetic and functional issues and on local traditions in rural building.

Indeed, this study, of which figure 3 shows the process layout, established an original way to adopt, combine and apply a set of multiple logical criteria and elaboration, evaluation and comparison methods, each of which is usually approached separately in scientific literature, and with aims that cannot be directly extended to the subject of this study.

Particular attention was then paid to the detailed testing of two of the above phases: the definition of the visual influence area for the site and projects under investigation, and definition of key viewpoints to be used in the impact simulations. The techniques currently available for these processes are little-investigated in scientific literature. For this reason the current most common procedures were tested on case studies intended as experimental test benches, by means of both computer simulations and on-site surveys. Nevertheless the resulting method is flexible and can be applied in different contexts, after proper experimental validation.

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