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New Technologies for Ecosystem Analysis Planning and Management

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1. Introduction

Planning the rural environment is one of the most intriguing examples of technical challenge where a multi-disciplinary approach plays a crucial role. The agricultural production, both food and non-food, the social role of rural settlements, the state and diffusion of the infrastructural networks, the rural architectonic heritage that in many countries constitutes a major positive value, should be appropriately considered and sinergically interlaced for a sound planning of agricultural biosystems.

Human activities impose a transformation of the extra-urban land that may lead to the modification of the frail equilibrium of whole ecosystems. Sound planning strategies should be therefore pursued, employing a multidisciplinary approach that should take into account geographical, environmental and landscape factors as variables interacting among themselves and with the social and economic aspects. In order to simultaneously analyse all these properties, tools able to manage, interpret and integrate several data are necessary.

Extra-urban land planning must pursuit, as a main goal, environmental sustainability, since sustainable development, in EU countries, has been perceived by social awareness and sensibility and is constantly been considered by new laws and regulations whose attempt is natural resources protection (Toccolini et al., 2006). In this scenario an accurate analysis of performing variations and a global monitoring of ecosystems is necessary in order to propose environmental protection politics. The farmer as a producer has traditionally been in focus when changes in agricultural landscapes are studied. Decisions on husbandry, rotational systems, machinery, fertilisation and pest management do indeed affect the landscape in crucial ways, and landscape dynamics cannot be understood if the farmer's decision making and the surrounding technology, socio-economics, and organisational structure are ignored (Primdahl, 1999). However, normally the farmer is not the only decision maker. Often he farms leased land and the owner may be an equally important actor concerning landscape changes.

Farmers are important agents in rural landscape management as they modify landscape elements to suit their needs (Kristensen et al., 2001). The industrialisation and intensification of agriculture over the last 50 years had a negative impact on landscape diversity and habitat values. During the last two decades, farmers have become increasingly engaged in landscape activities, to maintain or create habitats on their property: Kristensen (2003)

analyzed the value of traditional housing and settlements in the countryside. For the sustainable development of rural settlements at least four characteristics should be protected: balance between nature and built-up area; historic traditional entities; local communities; the countryside as an own culture (Ruda, 1998).

New leading technologies could be adequately introduced for an improved analysis of the rural environment. Remote sensing techniques could be employed for the monitoring of agricultural land variation. Geographical Information System (G.I.S.) are excellent tools for landscape modelling and three-dimensional analysis. They allow an easy digitalisation of geographical information and coverage structure, as well as facilitate graphical representation. An evaluation of the aesthetic impact produced on the rural environment becomes therefore possible, paving the way for landscape simulations and possible minimizations of the landscape impact.

G.I.S. allows an easy digitalisation of geographical information and coverage structure, as well as facilitating graphical representation (Hernández et al., 2004/a). Vigiak, Sterk, Warren, Hagen (2003) presented a model able to integrate windbreak shelter effects into a Geographic Information System (G.I.S.). The G.I.S. procedure incorporates the 1999 version windbreak sub-model of the Wind Erosion Prediction System (WEPS) (Hagen, 1991). Windbreak shelter is modelled in terms of friction velocity reduction, which is a function of wind speed and direction, distance from the barrier, windbreak height, porosity, width, and orientation.

A specific landscape analysis conducted by Capobianco, Tortora, Picuno (2004) by a G.I.S. approach has shown how positive results of the applied agronomic practises, in terms of CO_2 fixation, have been able to contrast heavy emissions of greenhouse effect gases in the atmosphere by urban settlements. Through the implementation of a Digital Terrain Model (DTM), enriched with the drape of land cover pictures, the authors evaluated in a scenic way the morphological and vegetation variations of agro-forestry landscape. The digitalization of historical cartography, moreover, simulated an hypothetical and virtual historical jump backwards (Tortora et al., 2006), enabling the analysis of the natural and anthropic changes of rural land, able to affect the structure of whole ecosystems. A similar approach, using a Geographical Information System and Image Processing techniques, was used by Tortora & Picuno (2008) in order to analyze the aesthetic impact that the use of plastic coverings produces on the rural environment, so enabling landscape simulation and examining possible minimizations of the landscape impact.

A wide spread of crops covered with plastic, can damage the visual landscape, although they are detectable through Remote Sensing techniques Remote Sensing techniques. Some scientific efforts were recently conducted in order to allow a better monitoring and planning of these uses. Using a field spectrometer, Levin et al. (2007). studied the spectral properties of a sample of polyethylene sheets and various nets used in Israel through the detection of three major absorption features around 1218 nm, 1732nm and 2313 nm. Carvajal et al. (2006) presented a methodology able to detect greenhouses from 2.44 m pixel size QuickBird image, based on an Artificial Neural Network algorithm. Thanks to the information introduced through training sites, they "teach" to the mathematical model to classify the image considering its radiometric and wavelet texture properties. Classification accuracy was evaluated using multi-source data, comparing results including and non-including wavelet texture analysis. The Authors concluded that some texture analysis can not improve classification accuracy but if one choose correctly parameters and texture model, it can become better.

The effectiveness of image processing application to the classification of crop shelter sites and its accuracy was verified by Arcidiacono & Porto (2008). An intensively-cultivated area located in South-Eastern Sicily (Italy) was selected to perform the localization of greenhouses and other type of shelters, like vineyards coverings. The chosen study area was pick out from a digital orthophotograph file of the Sicilian territory. This image was georeferenced and then analyzed by an image processing software. A methodology based on supervised classification of the image was found as the most adequate to the classification of crop shelters. According to this methodology, suitable classes were selected on the basis of signatures related to specific sample areas. The classification was then refined by using neighbourhood and contiguity analysis algorithms. The results of the analysis allowed to recognize and localize the crop shelters and to quantify their planimetric area. The latter was also compared with the attributes of georeferenced feature classes based on visual recognition.

Finally, Capobianco & Picuno (2008) implemented remote sensing techniques for an analysis of the rural land use with special attention paid to greenhouse and other application of plastics in protected cultivation, inside a study area located near the coast border between the Italian Regions of Basilicata and Apulia, where plastics in agriculture is widely used. The analysis was realized using Thematic Mapper of multitemporal Landsat images through Supervised classification, image processing, vectorialization and G.I.S. tools. For the study were used Band 7 (2.08 - 2.35 µm), band 5 (1.55 - 1.75 µm), and band 3 (0.63 - 0.69 µm) ion with other cartographic information. The results that were obtained enable the possibility to create a routine in IDL and ENVI software for the auto-detection of the plastic covers.

Solid modelling techniques, moreover, could contribute to the analysis and planning of the rural environment. The implementation of a Digital Terrain Model (DTM), enriched with the drape of land cover pictures, enables the evaluation in a scenic way of the morphological and vegetation variations of agro-forestry landscape. The digitalization of historical cartography, finally, allowed (Picuno et al., 2011) the simulation of an hypothetical and virtual historical jump backwards, so facilitating the analysis of the natural and anthropic changes of rural land, able to affect the structure of the agricultural biosystems.

2. Analysis of plasticulture landscapes in Southern Italy through remote sensing and solid modeling techniques

2.1 Foreword

The use of plastic covers for protecting cultivation in wide rural areas sets remarkable technical problems connected with the effects that large extensions of agricultural land covered with continuous cladding material may determine on aesthetic pollution of the rural landscape and on negative environmental impacts on water cycle, air and agricultural soil of the agro-ecosystem. The distribution of plastic cover for greenhouse or other protected cultivation applications has been analyzed using thematic mapping of multi-temporal satellite images with unsupervised classification, image processing, and vectorialization.

According to recent data (Scarascia-Mugnozza et al., 2008), the annual consumption of plastic film in Italy for protected cultivation amounts to more than 150,000 tons (Tab. 1). Protection from hail, wind, snow, or strong rainfall in fruit-farming and ornamentals,

together with the realization of a confined airspace with better microclimatic conditions, is the most common case. Plastic films are widely diffused for covering greenhouse, low and medium tunnel, and for soil mulching, while shading nets for greenhouses, or nets for a modification of the microenvironment, are employed.

ITALIAN REGION	Greenhouse	Middle/low	Covering	Mulch	TOTAL
Piedmont	977	528	0	1,481	2,986
Trentino	230	120	0	2	352
Lombardy	3,080	3,932	0	2,087	9,099
Friuli	345	96	0	209	650
Venetia	3,358	3,760	0	2,822	9,940
Liguria	805	288	0	283	1,376
Emilia-Romagna	2,875	4,152	0	7,375	14,402
Tuscany	2,185	960	0	1,746	4,891
Marche	1,334	600	0	1,073	3,007
Umbria	575	240	0	332	1,147
Latium	7,634	3,120	450	2,732	13,936
Abruzzo	780	600	1,050	1,538	3,968
Molise	85	54	20	427	586
Campania	8,520	3,040	90	4,355	16,005
Apulia	1,950	2,920	13,000	7,385	25,255
Basilicata	563	1,020	1,160	1,285	4,028
Calabria	713	360	200	1,946	3,219
Sicily	18,166	3,370	9,000	4,054	34,590
Sardinia	500	190	30	2,261	2,981
TOTAL (tons)	**54,675**	**29,350**	**25,000**	**43,393**	**152,418**

Table 1. Estimation of the agricultural plastic film (tons) used in the Italian Regions in Year 2002.

Film or net for the crop protection against meteorological agents, virus-vector insects and birds are used as standalone covers or in connection with typical structures for the growing of arboreal cultivation (e.g. vineyard or kiwi) as in Southern Italy, where the well-known technique of "tendone" growing is widely diffused. These large protected agricultural structures with continuous coverage can be studied (Picuno & Scarascia-Mugnozza, 1990) with reference to three different levels of analysis of their influence on the rural environment and the agricultural landscape:

- micro-scale: the influence on the microclimate of the air contained inside the envelop realised by the cover may modify environmental parameters, like temperature, relative humidity, carbon dioxide level, etc;
- meso-scale: the modification in the distribution of pollen, insects, birds, etc. may influence the global characteristics of the agro-ecosystem;
- macro-scale: the visual quality of rural landscape may be significantly altered by a heavy diffusion of artificial coverings.

The use of plastic covers sets significant problems connected with the effect that large extensions of agricultural land covered with continuous cladding material may determine on the visual perception of the rural landscape (Scarascia-Mugnozza et al., 1999), with significant landscape variations and negative consequences on the rural environment. In the present study both an application of remote sensing techniques for the detection of wide protected cultivation and a corresponding analysis enabling the realisation of a virtual model of a part of rural land through the suitable manipulation of the photographic image of the study area were conducted. The aesthetic impact generated by the plastic coverings was therefore evaluated, based on these results. On the same virtual model, moreover, it is possible to include further elements that could be successively introduced in the rural land, such as new tensile structures for arboreal cultivation covered with plastic sheets. The assessment of design parameters, like geometry, material and colour, able to minimize their aesthetic and environmental impact becomes therefore possible.

2.2 Materials and methods

The landscape analysis has been conducted in an area of Southern Italy, where structures for fruit farming covered with plastic net or film are widely employed.

2.2.1 Study area

The study area is located near the coastal border between Basilicata and Apulia Regions (Southern Italy, close to the Jonian Sea). The total surface of the study area covers about 3080 km², including the Jonian Coast from Metaponto to Taranto (40°39′41″ N; 16°58′15″ E; center area), the city of Matera at west, the town of Casamassima at North, and the town of Alberobello at East (Fig. 1). This area is characterized by a strong agricultural vocation, due to the wide diffusion of vineyards grown using the traditional "*tendone*" technique, a grape cultivation system similar to the pergola, with a supporting structure that may be covered with a plastic sheet. Other arboreal cultivation (i.e., kiwi, olive and fruit) and horticultural crops are widely diffused in this area too. Due to the need to limit numerical calculation, a smaller zone (about 100 hectares) inside this Study Area was selected in order to perform there the three-dimensional virtual simulations.

Fig. 1. The Study Area with the indication of the restricted area where the virtual solid modelling was performed.

2.2.2 Remote sensing of protected cultivation

The detection of the land use, with specific reference to greenhouse and other protected structures, has been obtained by Sabins (1996) using Thematic Mapping of multi-temporal Landsat images with Unsupervised classification, image processing, vectorialization and G.I.S. analysis. For the validation of the Landsat classification, a new approach using some SAR (Synthetic Aperture Radar) image (ERS 1 and ERS 2 satellite) was studied and experienced. In this study the multitemporal Landsat images used were: Year 1990; Year 1992; Year 1994; Year 1998; Year 2000.

The Landsat images were geographically corrected through an Envi's Registration procedure ("Image to Image", 20 Ground Control Point for each data). The Landsat data have been used for a correct vision of the band 7 (2.08 - 2.35 μm), band 5 (1.55 - 1.75 μm), and band 3 (0.63 – 0.69 μm) associated with other cartographic information and radiometric and thermal properties of greenhouse covering materials (Papadakis et al., 2000). In Fig.2a the three RGB visible bands referred to one of the images that were used for the experimental analysis are reported. The components in the infrared band reflective are showed, in Fig. 2b, by using false colour with reference to the same image as in Fig.2a. The difference between the two categories of coverage (greenhouse in blue and urbanized in purple) is here more evident. This aspect demonstrates the utility to have multispectral images with infrared components. The best combination to highlight this contrast on the display is the following: the Red colour represent the Band 7 (Spectral Resolution 2.08 - 2.35 μm), Green colour the Band 5 (Spectral Resolution 1.55 - 1.75 μm) and in Blue colour the Band 3 (Spectral Resolution 0.63 - 0.69 μm, visible red light). The Band 3, takes into account absorbed radiation of the chlorophyll that it can be helpful to highlight covers with net may be wrongly considered as a plastic film if observed in real colours (Jensen, 2005). Before carrying out the analysis and classification, it was necessary to monitor the field matching remote sensed information. In particular the following types of areas were investigated: wasteland; built environment; arable land; vegetation; plasticulture. Considering the agricultural activities inside the study area, in the category "plasticulture" both greenhouse and vineyard covered for advancing or postponing crop yield were included.

Fig. 2a. Landsat Image: True colours. Fig. 2b. Landsat Image: False colours (RGB: band 7,5,3).

The method for the acquisition of "spectral signatures" of different land use (Fig. 3) started at a stage when achieved knowledge on training areas is spent to know the spectral response of the different types of coverage. "Spectral signatures" are formed by the various statistical parameters (mean, covariance, etc.) related to the values of spectral components corresponding to the types of coverage of interest.
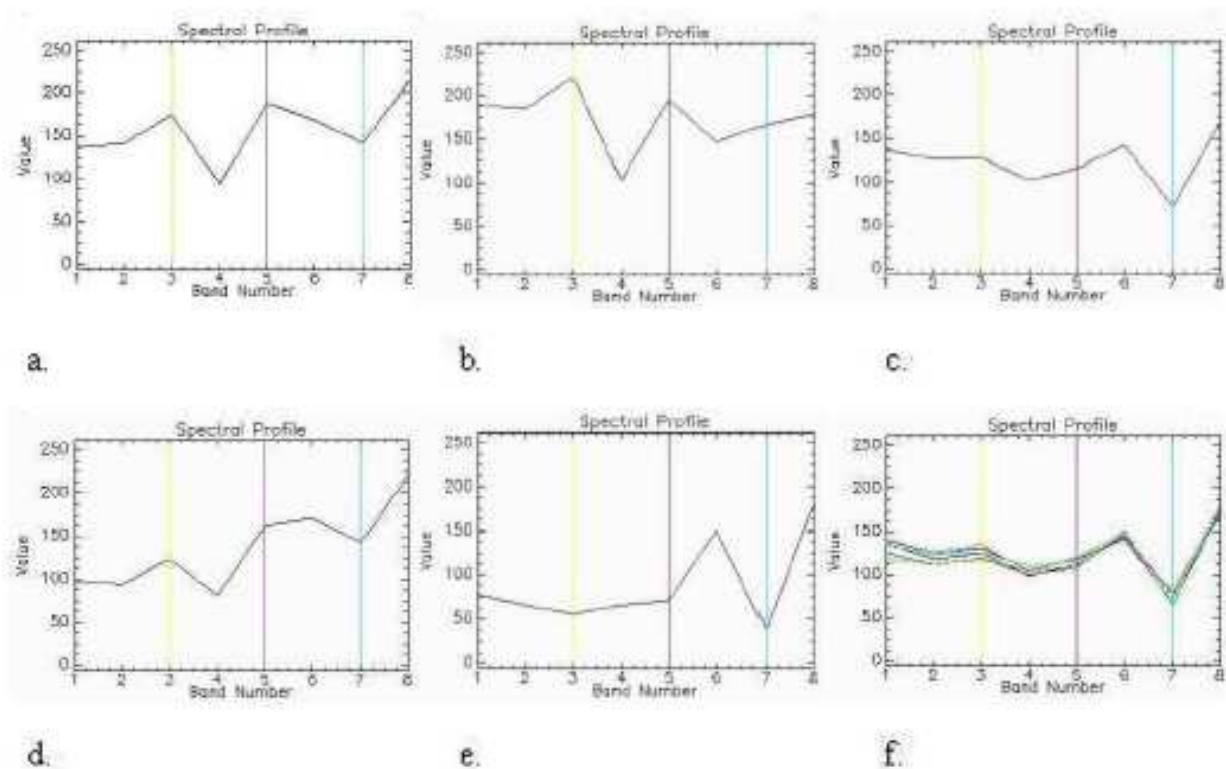
Fig. 3. Spectral signature of: a. wasteland; b built environment, c. greenhouse; d. arable land; e. vegetation; f. plasticulture. (Y-axis in a conventional RGB value).

In the present case Supervised classification techniques were used in order to classify, as a first attempt, the different land uses in ENVI Software. In Supervised classification, spectral signatures are developed starting from specific locations in the image. These specific locations are known as ROI (Region Of Interest), and they are defined by the user. The mathematical procedure assigns a label to each pixel in the image, according to their similarity to the class statistical signature. There are many different decision rules which can be applied in a Supervised classification methodology (Tso & Mather, 2009). In the present study the Parallelepiped method has been used. Parallelepiped classification uses a simple decision rule in order to classify multispectral data.

The decision boundaries form an adimensional parallelepiped classification in the image data space. The dimensions of the parallelepiped classification are defined based upon a standard deviation threshold from the mean of each selected class. If a pixel value lies above the low threshold and below the high threshold for all n bands being classified, it is assigned to that class. If the pixel value falls in multiple classes, ENVI assigns the pixel to the last class matched. The Maximum Standard deviation from the Mean used in the present work was 1,3 (expressed in the conventional RGB scale).

For the validation of the Landsat classification, in the present work a new approach using some SAR (Synthetic Aperture Radar) image (ERS 1 / ERS 2 satellite) was also studied and applyed with negative results. The data inferred by the classifications were then compared with SAR ERS PRI Type, ESA I-PAF images. The ERS-1, 2 satellites are devoted to global measurements of sea wind and waves, ocean and ice monitoring, coastal studies and land sensing using active and passive microwave remote sensing systems.

ERS-1 was launched in July 1991 and ERS-2 in April 1995. ERS-1 uses a synthetic aperture radar (SAR), an instrument able to acquire images of ocean, ice and land regardless of cloud and sunlight conditions. Unlike optical images, radar images are formed by coherent interaction of the transmitted microwave with the targets. Hence, it suffers from the effects of speckle noise which arises from coherent summation of the signals scattered from ground scatterers distributed randomly within each pixel. A radar image appears more noisy than an optical image. The speckle noise is sometimes suppressed by applying a speckle removal filter on the digital image before its display and further analysis. Single radar image is usually displayed as a grey scale image, such as the one shown in Figure 4.
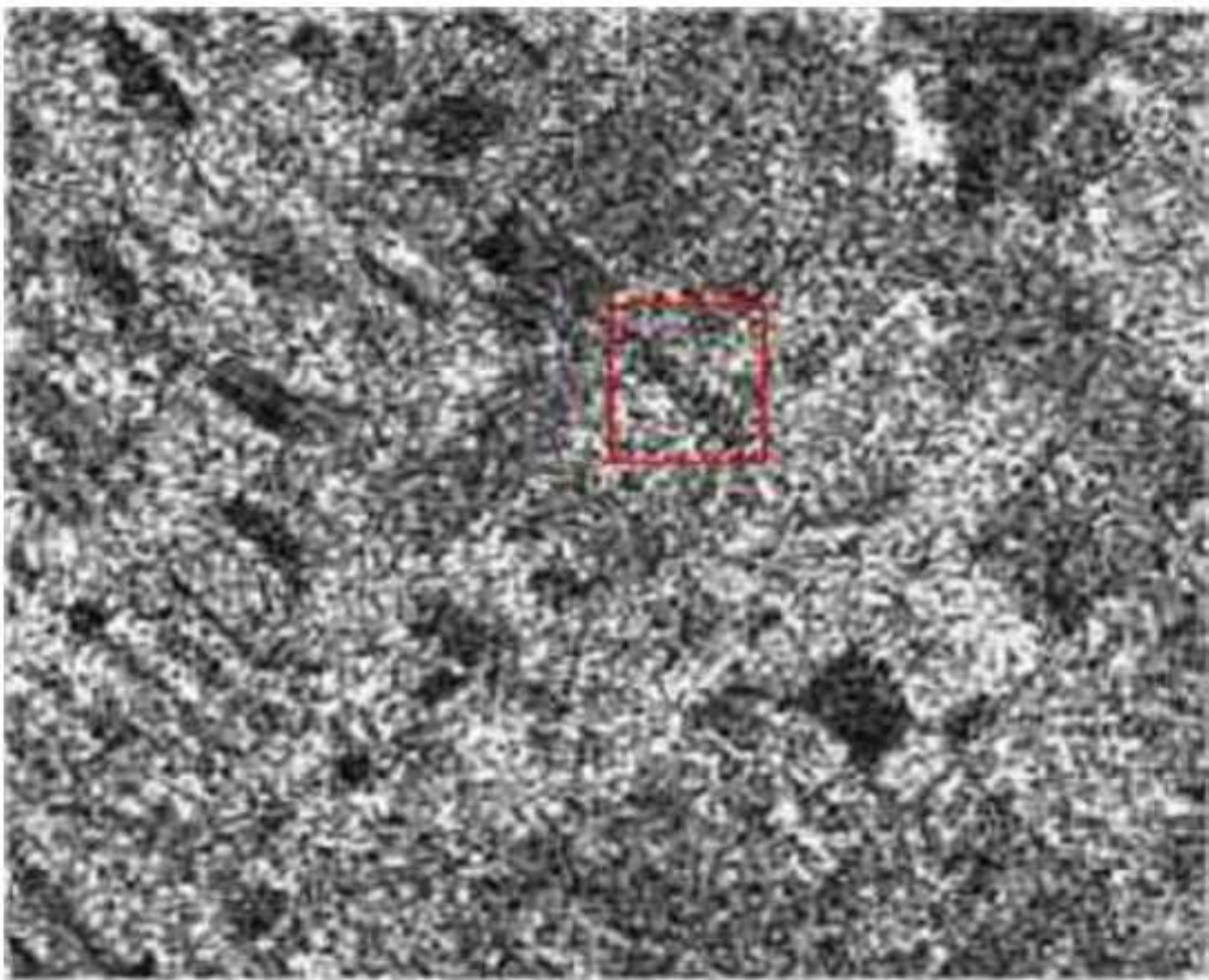

Fig. 4. SAR Image of the study area.

The intensity of each pixel represents the proportion of microwave backscattered from that area on the ground, which depends on a variety of factors: types size, shape and orientation of the scatterers in the target area; moisture content of the target area; frequency and polarisation of the radar pulses; incident angles of the radar beam.

Interpreting a radar image is not a straightforward task. It very often requires some familiarity with the ground conditions of the imaged areas. As a useful rule of thumb, the higher the backscattered intensity, the rougher is the surface being imaged. Flat surfaces such as paved roads, runways or calm water normally appear as dark areas in a radar image since most of the incident radar pulses are specularly reflected away. A more specific analysis was conducted on plastic coverings, but this analysis showed that these areas don't have a really significant interaction with the electromagnetic waves generated by the satellite ERS (c Band, Frequency 5.3 GHz, Wavelenght 6 cm). The plastic material is permeable to the electromagnetic waves so causing, as the only response, a reduction of real humidity detectable by the SAR. This phenomenon does not, therefore, support the use of radar for this type of investigation. After classification, the images obtained in GeoTiff, were imported and processed using a G.I.S. software (GeoMedia - Intergraph Corporation). The image has undergone a process of transformation and subsequent GRID elaboration in vector format (shp). With the Geoprocessing's "Dissolve" procedure it was possible to aggregate features based on specified attributes, then representing only shell plastic cover over the study area.

The result of the analysis of radar images is that you can are not applicable for this type of analysis.

2.2.3 Landscape impact simulations

The evaluation of the landscape impact produced by the tendone structures located in the area of study has been possible by implementing, through a G.I.S. procedure, a three-dimensional land modelling with the overlap of some photographic images where protected crops were clearly detectable. The Digital Terrain Model (DTM) was produced using the numerical cartography and extrapolating the graphic elements (contour and spot heights) that characterize the land altimetry. The individuation on the study area of the crops covered with plastic film or net was performed, followed by their location on the aero-photographic support (Scarascia-Mugnozza et al., 1999).This land three-dimensional virtual model is representing the real situation, proposed through the virtual photographic image of the study area (Fig. 5).

New plastic-covered structures were then inserted in the virtual model through solid extrusion, according to the crops that are currently grown in the study area and that would be potentially covered for an increase of the crop production. All data DTM, aerial images, tensile structures and extruded cover were analyzed through specific G.I.S. extensions, in order to visualize the virtual model of the study area with the agricultural structures. The cover was modelled using a specific "off-set" procedure, considering the height of the tensile structure equal to 3.0 m. The structure was modelled in a clear-grey (grey 20%) colour, considering the natural colour for this material (the posts are usually concrete-made). Regarding the covering material, in order to reproduce the hatch of the aerial image, a specific colour scale was implemented.

Fig. 5. Three-dimensional visualization of the restricted study area.

Among different conventional colour scales (i.e., RGB for PC monitor; CMY and CMYK for printer; RAL scale for paints; PANTONE, CIE and CIELAB for different use), considering the variability of the material colour, a colorimeter (Portable Colorimeter Minolta CR300) using the CIELAB scale for measuring the colour was finally selected. The scale colour used by the CIELAB colorimeter (Garcìa et al., 2003) was then converted in RGB value using the OpenRGB (Logicol 2008 version 2.10.91215), available from http://www.easyrgb.com/index.html.

The hatch of the structure was generated using the tendone real geometric characteristics, both for colour and for texture. The following cladding materials were considered for virtual simulation:

• UTILITY PRO 2.5". Anti-hail HDPE net, colour black or white, produced by TENAX (Fig. 6a).
• OMBRAVERDE 50". Shading net, warp in green colour, weft in black colour, produced by ARRIGONI (Fig. 6b).

The shading factor plays a central role in the virtual model; this has been implemented as the factor of transparency by calculating the inverse of the shading factor, obtained by the technical leaflet of the material (e.g., in case of UTILITY PRO 2.5, that has a shading factor of 6-12%, the factor of transparency was 91%).
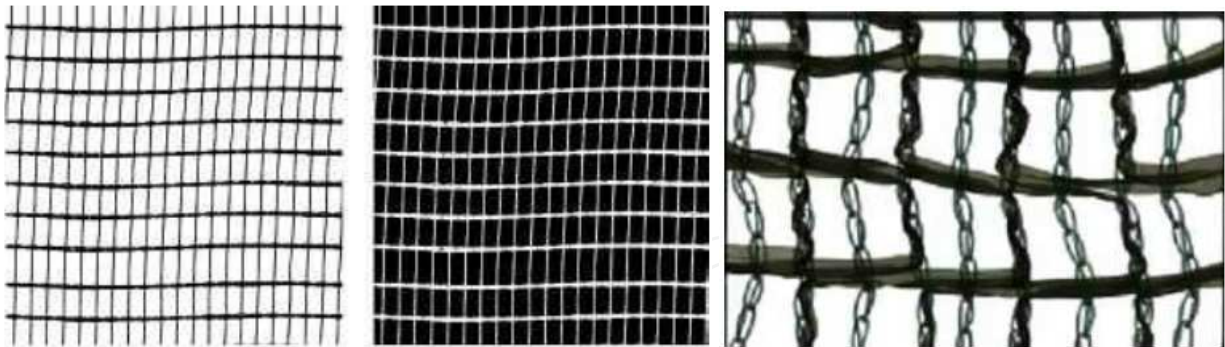
Fig. 6a. UTILITY PRO 2.5 black and white net. 6b. OMBRAVERDE 50 net.

2.3 Results and discussion

Whit satellite remote sensing analysis it was possible to obtain different multi-temporal thematic maps of surfaces covered with plastic film inside the study area. Comparing different chronological information, it is possible to deduce a sharp increase in the diffusion of protected crops in the study area, from about 65 Ha in Year 1990 to more than 680 Ha in Year 2000. In Figure 7 this trend is graphically shown, together with the formulation of a suitable interpolation equation. Most of the changes took place along the Jonian.

The impacts on agriculture of this wide use of plastics were evaluated using the method of Sorenson (CIE Cause/Impact/Effect), by filling the matrix of Leopold in simplified form through the application of coaxial matrices (Dal Sasso et al., 2007).
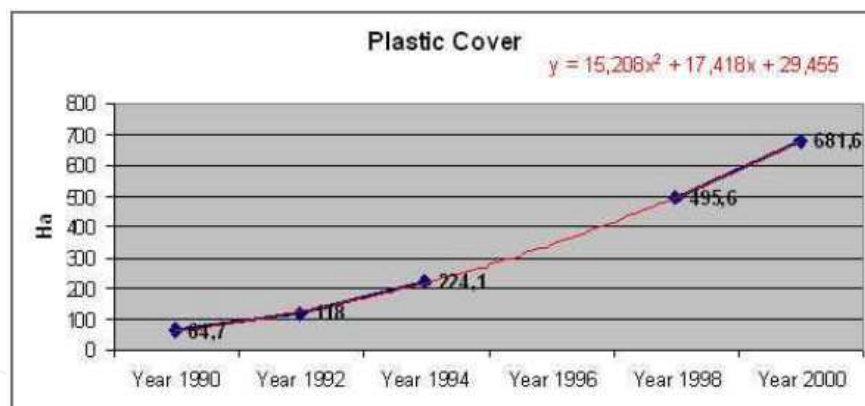

Fig. 7. Development trend of plastic-covered areas.

This method puts in relation and in logical sequence respectively the planning actions, the causal factors, the environmental components and mitigations, enabling a quick identification of the main impacts of the plastic covers and the evaluation of their effects on the agro-environmental system. In this way, a threshold range was identified as the value whose produced impacts are unacceptable, that was obtained through the calculation of the number of boxes resulting form the application of the matrix (Tab. 2, Tab.3, Tab. 4).

Assuming the actual status quo (i.e. a surface covered with plastic equal to ~ 3.3% of the total study area) as the unit value, the impact values corresponding to an increasing percentage of plastic cover were estimated: through an interpolation curve of data obtained from a coaxial matrices, was calculated as the threshold value, equal 10%, as a maximum

percentage value of the plastic cover above which the impacts on the agricultural landscape should be considered unacceptable.

PROJECT ACTIONS	Employment Land	Water Drawing	Removal of Natural Resources	Liquid Discharges	Solid Waste	Visual Obstruction	Atmospheric Emissions	Induced Traffic	Interference with the Flow of Water	Compaction and Soil Proofing	TOTAL
Supporting Structure						·		·	·	·	4
Coverage's Type			·		·	·	·		·		5
Irrigation or Fertigation		·	·				·	·			4
Shielding and Shadowing			·			·					2
Phytosanitary Treatments		·	·	·	·						4
Fertilization			·	·							2
Working Land			·			·		·			3
Transplanting and Harvesting					·			·			2
Maintenance			·		·			·	·		4
TOTAL	0	2	7	2	4	4	2	5	3	1	30
CAUSAL FACTORS											

Table 2. Coaxial matrices: Project Actions/Causal Factors

CAUSAL FACTORS	Employment Land	Water Drawing	Removal of Natural Resources	Liquid Discharges	Solid Waste	Visual Obstruction	Atmospheric Emissions	Induced Traffic	Interference with the Flow of Water	Compaction and Soil Proofing	TOTAL	ENVIRONMENTAL COMPONENTS
					·		·	·			3	Atmosphere
		·		·					·		3	Acquatic Environment (Surface and Groundwater)
	·	·	·	·	·				·	·	7	Soil and Subsoil
	·			·	·		·				4	Vegetation and Flora
	·			·	·			·			4	Fauna
	·			·	·		·		·		5	Ecosystems
				·	·			·			3	Public Health
								·			1	Noise and Vibrations
											0	Ionizing and not Ionizing Radiations
	·				·	·	·				4	Landscape
	·					·	·				3	Cultural and Historical Heritage
			·				·	·			3	Socio-Economic Context
TOTAL	6	2	2	6	7	2	6	5	3	1	40	**TOTAL**

Table 3. Coaxial matrices: Causal Factors/Environmental Components

ENVIRONMENTAL COMPONENTS	Compromising Ecosistems	Pollution of Surface Water	Groundwater Pollution	Reduction of Water Potential	Landscape-Environmental Degradation	Damage of Vegetation and Fauna	Atmospheric Pollution	Thermal Pollution	Waste and Scrap Outputs	Removal of Natural Resources	Health Risks	Socio-Economic Impact	Traffic Alteration	Loss of Open Spaces	TOTAL
Atmosphere	▪				▪								▪		3
Acquatic Environment (Surface and Groundwater)	▪	▪	▪	▪						▪				▪	6
Soil and Subsoil	▪				▪				▪	▪					4
Vegetation and Flora	▪	▪			▪	▪				▪			▪		6
Fauna	▪	▪			▪	▪	▪		▪	▪				▪	8
Ecosystems	▪	▪			▪		▪	▪	▪			▪	▪	▪	9
Public Health	▪	▪	▪				▪				▪	▪	▪		7
Noise and Vibrations													▪		1
Ionizing and not Ionizing Radiations															0
Landscape	▪	▪			▪		▪			▪				▪	6
Cultural and Historical Heritage					▪									▪	2
Socio-Economic Context		▪			▪							▪	▪		4
TOTAL	8	7	2	1	7	2	5	1	3	5	1	3	6	5	56

Table 4. Coaxial matrices: Environmental Components/Impacts

The corresponding solid modelling simulation are shown in figures 8-9-10-11. Figure 8 shows the solid modelling of the actual situation (3.3% of the total analyzed land surface), whereas the other pictures represent new protected structures, inserted on the basis of the hypothesis that in future some new crops, actually cultivated in this area, would be covered with a plastic material (anti-hail, shading, insect net or film, etc.) with covering percentages equal to 7% and 10% of the total surface (Picuno, 2005).

For each one of these virtual situations, the use of different covering plastic nets was also considered and the corresponding impacts on the visual quality of the agricultural landscape were evaluated.

Moving inside the model it has been therefore possible to evaluate the effects determined on the aesthetic properties produced by the structures covered with plastic material on the surrounding landscape, with a notable influence on the visual perception for an observer of the landscape (Fig. 12).

The use of coloured nets registered recently an increased spreading, thanks to their special radiometric characteristics able to specifically filter some components of the solar radiation. The consequent alteration of the spectrum of bright colours using very intense colorations (as the fiery red, electric blue, gold yellow, etc.) determines special positive effects on crop growth such as dwarfism or, conversely, gigantism effect. The use of such nets would further change the visual perception of the agricultural landscape (Fig. 13).

Fig. 8. Solid modelling of the study area in the actual real situation - i.e. about 3.3% of the surface covered with plastic net clear- gray (gray 20%) colour.
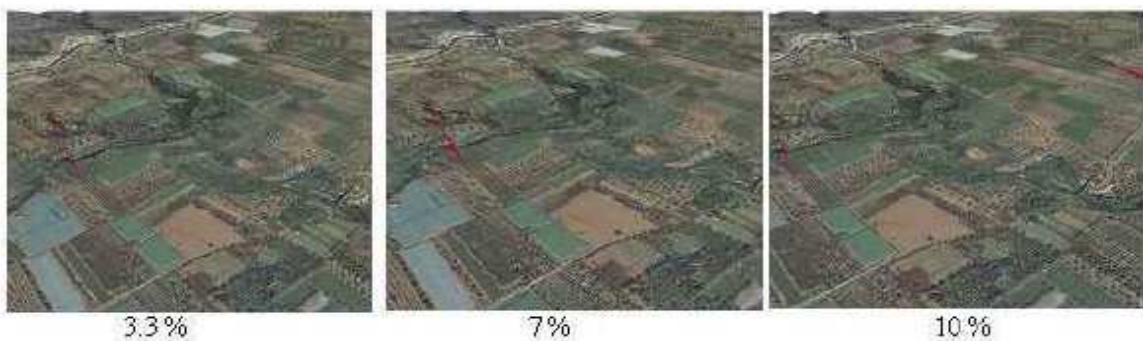

Fig. 9. Virtual solid modelling of the study area for different percentages of surface (3.3%, 7% and 10%) covered with plastic net OMBRAVERDE 50.
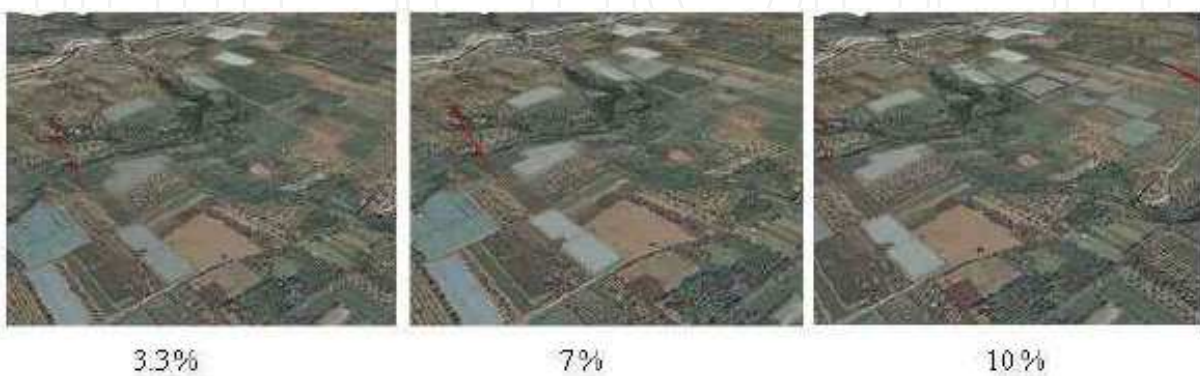

Fig. 10. Virtual solid modelling of the study area for different percentages of surface (3.3%, 7% and 10%) covered with plastic net UTILITY PRO 2.5 white.
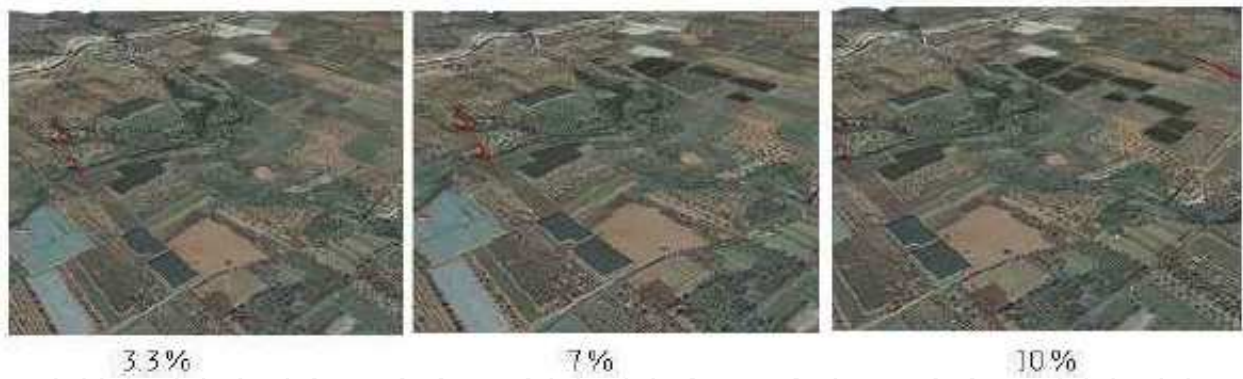
3.3%   7%   10%

Fig. 11. Virtual solid modelling of the study area for different percentages of surface (3.3%, 7% and 10%) covered with plastic net UTILITY PRO 2.5 black.

Fig. 12. Detail of the three-dimensional virtual view of the study area covered with 10% of plastic material.

Red   Blue   Yellow
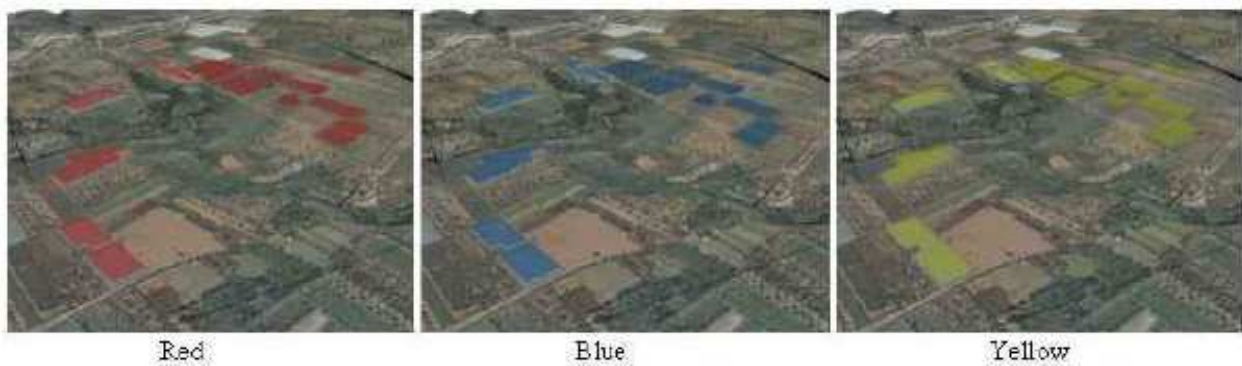
Fig. 13. Thee-dimensional simulation with three different ChromatiNet.coloured-nets.

3. Historical cartography and G.I.S. for the analysis of carbon balance in rural environment: A study case in Southern Italy

3.1 Foreword

An environmental analysis conducted by a G.I.S. approach shows how positive results of the applied agronomic practises, in terms of CO_2 fixation, could be able to contrast heavy emissions of greenhouse effect gases in the atmosphere by urban settlements. Using a geographic information system applied to historical maps in order to assess the environmental impact of land use transformation, with a special emphasis on the atmospheric carbon dioxide balance (Tortora et al., 2002). The analysis was focused on the transformation of a rural area in Southern Italy along the last 138 years, due to the change of land use through the introduction of corn and fruit orchards increasingly substituting olive trees and forested surfaces.

3.2 Materials and methods

The study area has been chosen, among other ecosystemically homogeneous regions, due to the availability of historical cartography starting from Year 1859, in order to assess land use change among a temporally long enough period.

This area, covering about 1500 ha, is located in Southern Italy, mainly in Bernalda e Pisticci municipalities of the Basilicata Region, nearby the Ionian Sea coastline (Fig.14). The thermoregulation effect of the sea, the aspect, the soil structure and the socio-economic context determined and still are determining the vegetation species pattern of this area.

Fig. 14. Study area

The morphology is mainly constituted by low hills, suitable for corn and olive production. The spread of mechanization technology for crop cultivation and harvesting together with, especially in the late '800, the development of industrial wheat transformation techniques serving the pasta and bakery products industry (Dal Sasso & Picuno, 1996), caused remarkable changes in the whole land asset.

3.2.1 Cartography

Land use change in the study area was examined over four different time periods: Years 1859, 1873, 1957 and 1997. The geographical information dated Year 1873 and 1957 was collected, in a 1:50.000 and 1:25.000 scale, using the historical maps of the Italian Geographic Military Institute (IGMI). Digital orthophotos - dated 1997 - were used together with a

1:5.000 scale technical map of Bernalda area obtained from a recent aerial photogrammetric survey.

The older time level (Year 1859) has been analyzed using an antique map created on Marquis Peres de Navarrete's demand (Fig. 15). This map represents most of Bernalda municipality land, especially the northern zone above the built-up area, within the borders of adjacent communal areas, describing the rural landscape of that time. It constitutes a complete and consistent cartographic support, endowed with planimetric coordinates and enriched with thematic information about the land use at that time.

Fig. 15. Historical Cartography (Year 1859) of the Study Area

Land use maps, chronologically based on different periods, have been obtained by the interpretation of the different cartographic supports recovered; every layer has been then classified in 9 classes: woodland, shrubland, arable land, orchards, olive groves, vineyard, meadows, urban, wasteland.

1997 land use classification was based on the interpretation of recent photographs; field data were collected, in order to obtain more accurate results and to localize the coordinates of control points, with the use of a GPS Mod. Garmin IIIplus.

Data retrieved have been implemented in a land information database and processed in a multi-temporal G.I.S. (GeoMedia - Intergaph) where each Year has been considered as an homogenous chronological layer. In this way, all the information about land orography and use were organized on four different layers (corresponding to Years 1859, 1873, 1957 and 1997), constitued by data characterized by the same time level. Then, through spatial overlay, the processed input layers sequence resulted in output vegetation temporal dynamism data.

Finally, two temporally different maps, one dated 1879 and the other being the contemporaneous one, have been also 3-D digitalized and processed, in order to analyse the different elevation attributes and vegetation cover condition between the two considered periods: morphological changes are strictly connected to the evolution of vegetation covers and, consequently, to different soil protection.

3.2.2 Image processing

In order to input the historical cartography, the maps were geo-referenced through a sequence of rectification and referencing procedures; especially for the iconographic map dated 1859, control points on the map at known locations were located and projected on the modern overlaid maps (Capobianco et al., 2004). The geographic framework has been achieved using georeferencing and pixel resampling tools through an affine transformation six-parameter dependent (Della Maggiore et al., 2002).

Using spatial analysis functions the map of Year 1859 was appropriately correlated to altimetry (DEM) of Year 1873; therefore, the land use here reported was associated with the visualization of land use as in the present orto-photos, so obtaining the historic reconstruction of Year 1859 landscape. This enabled an evaluation of the aesthetic changes of the study area in terms of both morphologic and vegetation variation of the agro-forestry landscape. Figure 16 shows three-dimensional reconstruction of 1859 landscape compared with the actual situation.
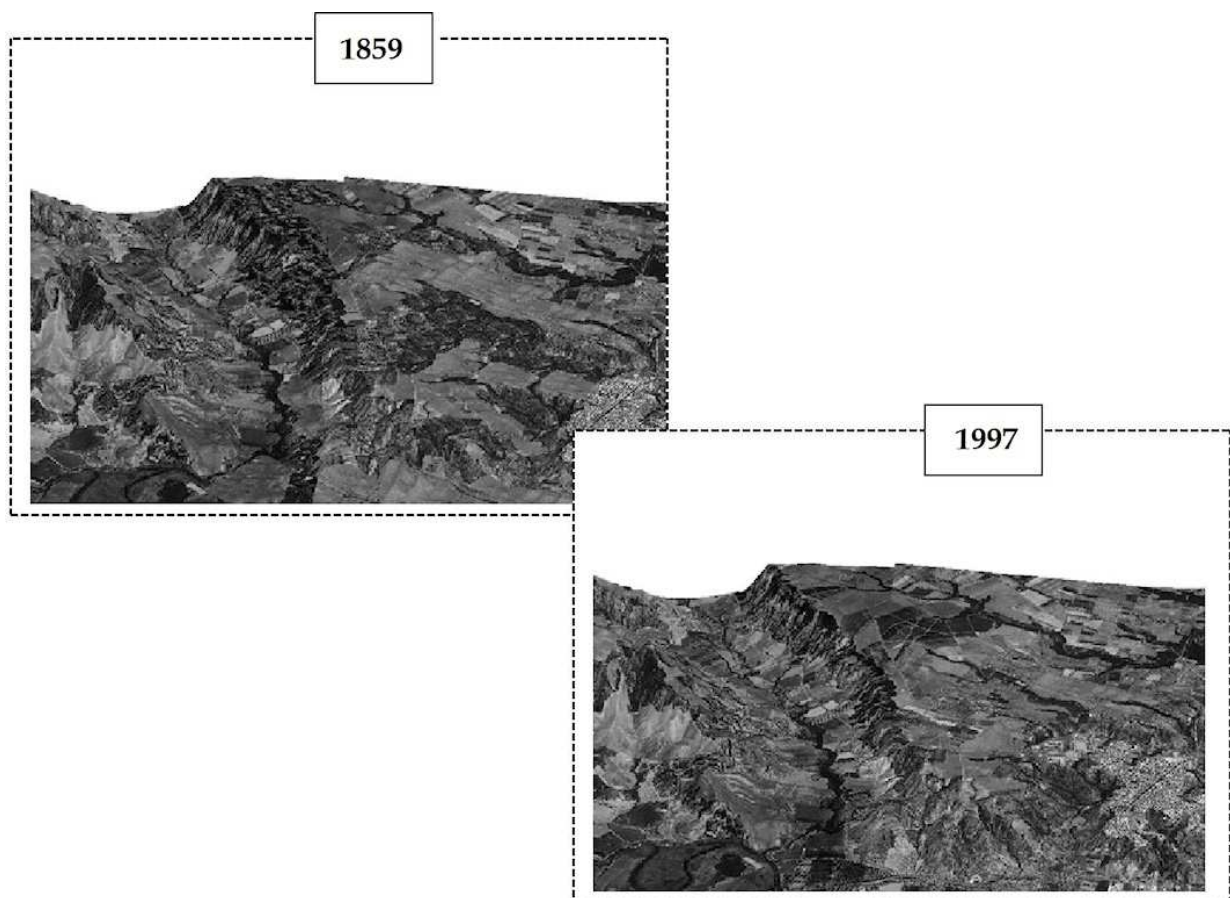
Fig. 16. Comparison of three-dimensionally reconstructed landscape (1859 – 1997)

3.3 Results and discussion

3.3.1 Land use

Figure 17 represents land use maps obtained for the four time periods produced on the basis of the thematic information contained in the historical maps that were retrieved. Based on polygonal topology, these maps represent for each data the state of landscape; the comparison obtained through a crossed over interpretation of the output maps has enabled the analysis of land changes from 1859 to present days, covering a time period of 138 years, giving information on historic persistence of soil use typologies along with their time-driven modifications. Dominant soil use typologies of the site have been grouped in order to better compare output data through a more evident highlighting of variations in time. Visualizing data in graphs (Graph 1) we can observe an increase of crop growing and a reduction of forested surfaces, that have now almost disappeared leaving their place to urban areas and fruit orchards.
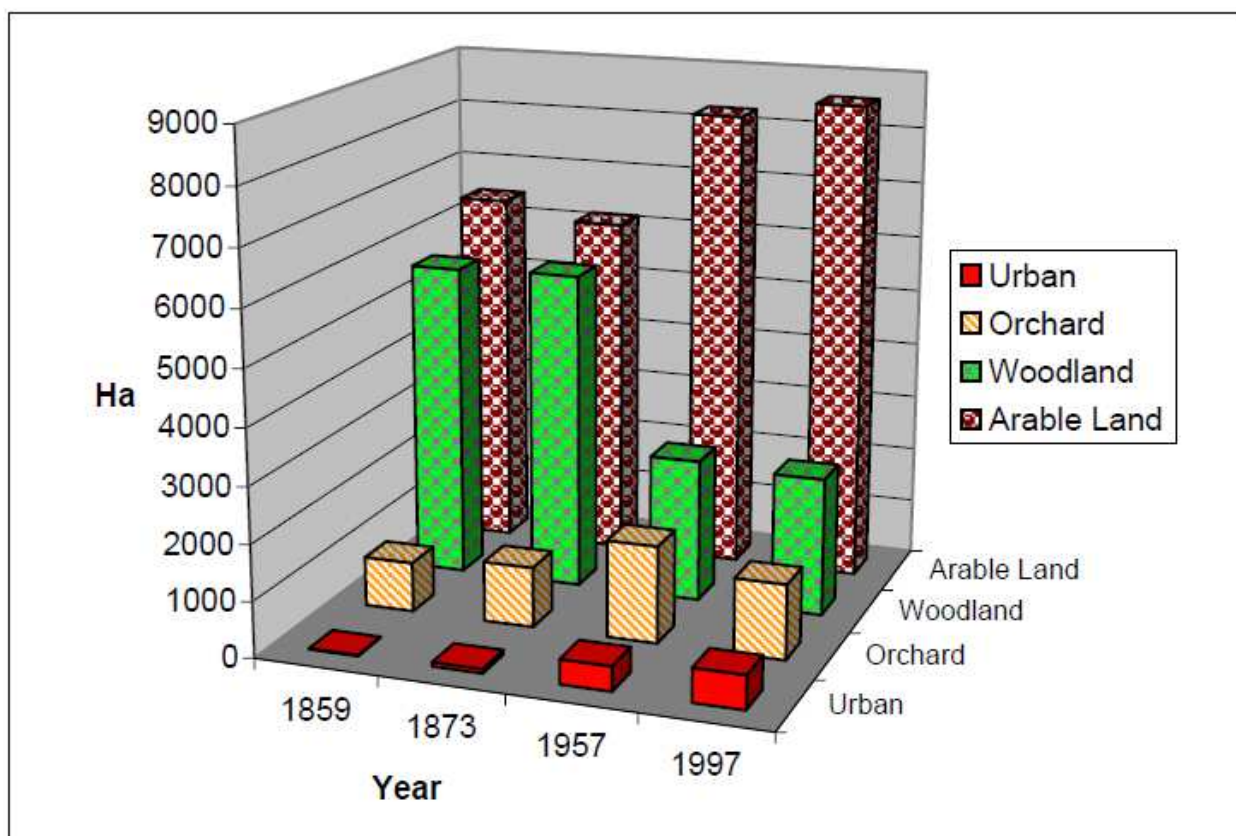
Graph 1. Evolution of principal land use over the four time periods

Historic dynamism of vegetation and morphology has evolved together with the effects of technology on cartographic production quality; this aspect is testified by the characteristics of the historical planimetric cartography of Year 1859, almost an iconography with very low metric precision, arriving to modern cartography, in paper or digital format, that has greater metric precision together with more accurate information.
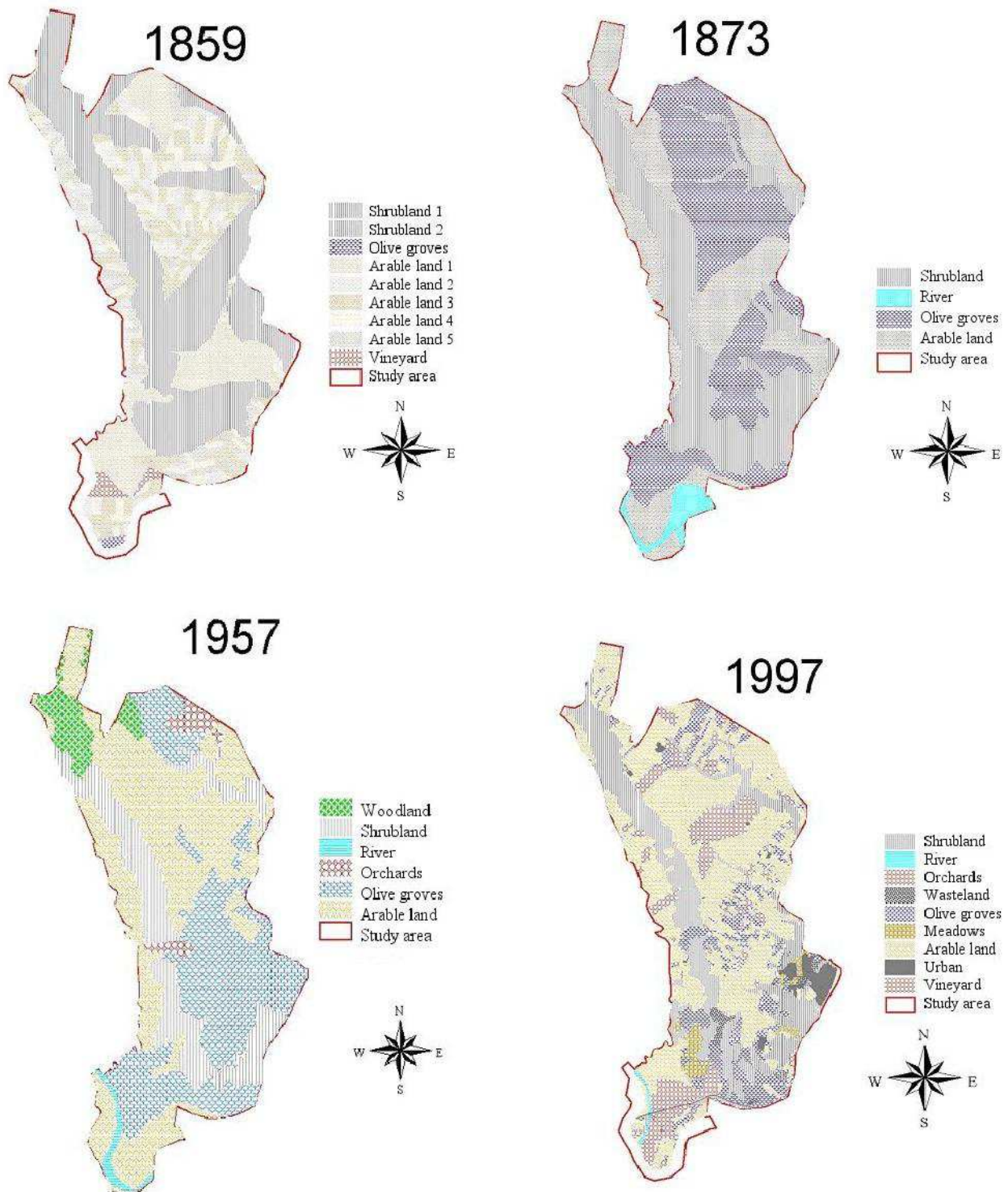
Fig. 17. Thematical land use maps for the four different time periods

3.3.2 Carbon dioxide balance

With the aim to quantify the effect of land use changes on the environment, with special emphasis on air quality, we estimated the CO_2 time variation connected with the use of the

crops (Woodland, Shrubland, Arable land, Orchards, Olive groves and Urban) in the study area reported in the different chronological informative levels (Years 1859, 1873, 1957 and 1997).

CO_2 sequestration rates were calculated through adopting the user-friendly CO2FIX V.2 model (Masera et al., 2003), tool for the dynamic estimation of the carbon sequestration potential of forest management, agroforesty and afforestation projects. CO2FIX V.2 is a multi-cohort ecosystem-level model based on carbon accounting of forest stands, including forest biomass, soils and products. Carbon stored in living biomass is estimated with a forest cohort model that allows for competition, natural mortality, logging, and mortality due to logging damage. Soil carbon is modeled using five stock pools, three for litter and two for humus. The dynamics of carbon stored in wood products is simulated with a set of pools for short, medium and long lived products, and includes processing efficiency, re-use of by-products, recycling, and disposal forms. The CO2FIX V.2 model estimates total carbon balance of alternative management regimes in both even and uneven aged forests, and thus has a wide applicability for both temperate and tropical conditions. (Masera et al., 2003). The CO2FIX model was developed as part of the "Carbon sequestration in afforestation and sustainable forest management" (CASFOR) project, which was funded by the European Union INCO-DC program. (Mohren et al., 1999).

CO2FIX V 2.0 is a carbon book-keeping model that simulates stocks and fluxes of carbon in (the trees of) a forest ecosystem, the soil, and (in case of a managed forest), the wood products. It simulates these stocks and fluxes at the hectare scale with time steps of one year. For an extensive description of carbon dynamics in forest ecosystems, and the role of forests in the global carbon cycle see Kauppi et al. (2001). Some of the results of CO2FIX have been used in the IPCC 1995 climate change assessment.

In order to initialise the model, different analysis parameters were used. The assumptions that were made were consistent with the software input characteristics (Mohren et al., 1999) and the local area characteristics (Capobianco et al., 2004). For forestry area the following characteristics were used: tree species, area, age, dominant height, standing volume, growth class and the coordinate of the stand.

Woodland in the study area is represented by highly degraded coppice forest with prevailing Quercus ilex. Rotation length is 30 years with maximum biomass in the stand equal to 130 Mg/ha. The allocation factor for foliage, branches and root production were copied from existing CO2FIX runs for comparable species. The turnover (annual rate of mortality of the biomass component) was evaluated in 0.3 for foliage, 0.06 for branches and 0.05 for roots. The soil organic matter compartment consists of dead wood, litter layers and stable humus in the soil. On the basis of this analysis, a total carbon stock ranging from 17 to 70 Mg/ha and an average atmospheric carbon sequestration approximately equal to 4.40 MgC/ha/yr were estimated.

In the study area, the orchard areas are generally orange groves with rare presence of apricot trees. For the purpose of CO_2 calculation, the orchard area was compared to coppice forest with a rotation of 20 years and periodical removal of organic matter through agronomic practices like pruning, comparable to a turnover (annual rate of mortality of the biomass component) of 0.3 for foliage, 0.07 for branches and 0.04 for roots. In an orchard,

carbon balance depends on the intrinsic structural and morphological characteristics of each species and it is also influenced by population density, rearing system, and especially on the canopy and aboveground and underground woody organisms. Moreover, in the case of young plantation, canopy has to provide for a relatively small amount of branches and roots and, consequently, primary production is net and the surplus of organic matter increases every year up to maturity when dry matter increases over time and subsequently tends to zero (Xiloyannis et al., 2005). Based on such a principle, it is possible to estimate the average yearly sequestration of atmospheric carbon as being equal to 7.25 MgC/ha/yr for the orchards, to 2.75 MgC/ha/yr for shrubland and to 3.6 MgC/ha/yr for arable land. On the other hand, urban areas represent a source of CO_2 emission from both municipal and industrial combustion; a yearly amount of 15.0 MgC/ha/yr of CO_2 release into the atmosphere was therefore estimated on the basis of a report on the environmental state of Basilicata Region (AA.VV., 2000). All the above-mentioned values of average atmospheric carbon sequestration were adopted for each one of the four time periods (Years 1859, 1873, 1957 and 1997). The data resulting from the implementation of the G.I.S. gave the values reported in Table 5 expressed in terms of areas occupied by the different vegetation typologies and, applying their respective CO_2 sequestration rates, in terms of absolute values of annual sequestration of CO_2. The balance of CO_2 does not include the effects of the agricoltural machinery, supplies and transportation on CO_2: in woodland these factors are almost absent, while in case of orchard and arable land they depend strongly by crop techniques, and in some cases are negligible.

Year	Woodland		Orchard		Arable land		Urban		Total	
	Area [Ha]	Annual balance of CO_2 [MgC/ha/yr]	Area [Ha]	Annual balance of CO_2 [MgC/ha/yr]	Area [Ha]	Annual balance of CO_2 [MgC/ha/yr]	Area [Ha]	Annual balance of CO_2 [MgC/ha/yr]	Area [Ha]	Annual balance of CO_2 [MgC/ha/yr]
1859	5638	24807	890	6452	6440	23184	17	-255	12985	54188
1873	5691	25040	1080	7830	6153	22150	79	-1185	13003	53835
1957	2555	11242	1731	12549	8270	29772	438	-6570	12994	46993
1997	2474	10885	1339	9707	8582	30895	598	-8970	12993	42517

Table 5. Annual balance of CO_2 in the study area.

Examining Table 5, in the investigated scheme it is clear that the greatest changes in land use occurred after the establishment of large orchard grown areas and mainly consisting of orange tree plantations. The percentage rise in arable land was equally considerable with increases as high as 30-40 %, to the detriment of woodland and shrubland. Olive groove reached its peak in the late 19th century until after the First World War, since it was one of the early livelihood sources of farm families at that time. As a result of the different performance in terms of CO_2 fixation and relative to the investigated study area, all these land changes caused progressive decrease in carbon dioxide sequestered by biotic agents embedded in the soil. We can argue that the sequestration of land carbon in Year 1859 was higher than in more recent periods, and that during time the land carbon balance worsened: the cultivation conversion occured during time caused a constant loss of CO_2 fixation value (Mohren et al., 1999), while heavy emission of greenhouse effect gas in the atmosphere by urban settlements were at the same time increasingly growing.

This pattern could be considered a typical situation also for many other areas located in Southern Italy or even elsewhere, and this approach seems that could be considered as a useful tool for the planning and management of rural landscape and environment: the study case showed that a sound planning in agricultural activities could significantly contrast the release in the atmosphere of CO_2 deriving from the diffusion of anthropic activities.

4. The optimization of the management of agricultural plastic waste in Italy using a geographical information system

4.1 Foreword

The extensive and expanding use of plastic material in the Italian agriculture for several diversified application (e.g., tunnel and greenhouse covering film, mulching film, silage bag, irrigation pipe, agrochemical containers, etc.), results in increased accumulation of plastic waste in rural areas (Scarascia-Mugnozza, 1995). It constitutes an environmental and economic problem (Sica, 2000), because agricultural plastic waste, if abandoned along rivers and/or in rural areas, may cause severe damages for the landscape environment, agricultural soil, air, shallow and deep water (Picuno & Scarascia-Mugnozza, 1994). If burnt in open and uncontrolled sites it may damage the human health because harmful substances could be released during the combustion: due to inefficiencies of open combustion, emissions from open burning are much greater per mass of material burned than emissions from controlled incineration (e.g., 20 times as for dioxin; 40 times as for particulate matter - Travis & Nixon, 1991). Plastic incineration produces anyway large CO_2 emissions (about 3 Kg of CO_2 per Kg of Polyethylene). Unfortunately, the abandonment and burning are practices still frequently in use in Italy, although they are against the law, while only a part of agricultural plastic waste is collected and recovered in a controlled way by the National Consortium "PolieCo", that has the task to collect, transport and direct them toward the final disposal, that is the mechanical recycling. In the year 2010, the Consortium recycled over 350,000 tons of post-consume PE (over the 35 % of the PE articles placed on the market) (PolieCo, 2010); they include APW, but it is very difficult to quantify them. The mismanagement of the agricultural plastic packaging waste (APPW) creates more acute problems because: they are not always properly cleaned before being disposed and the APPW management scheme has been established yet in many Countries. In order to analyze the current situation, to estimate APPW streams (quantity, temporal and spatial distribution, etc.) and existing technologies (specific disposal solutions applied) a Program called "Design of a common agrochemical plastic packaging waste management scheme to protect natural resources in synergy with agricultural plastic waste valorisation (acronym AGROCHEPACK), started in the 2010, under the frame of a Transnational Cooperation Programme Mediterranean (MED). The Program is carried out by Picuno & Sica , of the DITEC Dept., and other Project Partners of Italy, Greece, Cyprus, France and Spain. Fortunately, farmers are becoming more aware of two important problems: direct damage to the environment and reduction of non-renewable resources. Farmers must follow sound procedure for the collection and disposal of the agricultural plastic waste because they are "secondary raw material".

Since Geographical information systems are currently employed in order to optimize the flux of materials and goods, a Geographical Information System (G.I.S.) ad hoc designed may reveal as a tool suitable for the management both of the rural land and the agricultural

plastic waste flux (Scarascia-Mugnozza et al., 2006). In fact, many studies demonstrate the applicability of G.I.S. in the agricultural sector. A G.I.S. optimal routing model was proposed (Ghose et al., 2006) to determine the minimum cost/distance efficient collection paths for transporting solid wastes to the landfill. The model can be used as a decision support tool by municipal authorities for efficient management of the daily operations for transporting solid wastes, load balancing within vehicles, managing fuel consumption and generating work schedules for the workers and vehicles.

The disposal in landfill is the waste destination method with the largest demand for land, while land is a resource whose availability has been decreasing. Shortage of land for landfills is a problem frequently cited in the literature as a physical constraint. Leao et al. (2001) presented a method to quantify the relationship between the demand and supply of suitable land for waste disposal over time using a G.I.S. and modelling techniques. Based on projections of population growth, urban sprawl and waste generation the method can allow policy and decision-makers to measure the dimension of the problem of shortage of land into the future. The procedure can provide information to guide the design of programs to reduce and recover waste, leading to a better use of the land resource.

Basnet et al. (2002) developed a G.I.S.-based manure application plan for the specific application of animal waste to agricultural fields. Sites suitable for animal waste application were identified using a G.I.S. based weighted linear combination (WLC) model. The degree of land suitability for animal waste application was determined using a range of social, economic, environmental and agricultural factors.

In the agricultural sector, management strategies were planned through a G.I.S. approach since its attitude in synthesising complex land relations (Toccolini, 1998). The location in Almeria, a semi-arid Spanish region, of areas with best attitude for intensive horticultural production in greenhouses was analyzed in relation to risks connected with aquifer salinization caused by an indiscriminate use of underground water (Ayala et al., 1999). The analysis of agricultural-forestry land evolution phenomena and the related environmental impacts (Langaas, 1995) and the definition of several sustainable development indicators for the monitoring and planning process and the definition of land use and attitude (Manera et al., 2001) were investigated by means of G.I.S. procedure too.

The present section describes the implementation of a Geographical Information System, at regional scale, in order to contribute to the analysis of agricultural plastic waste production, flux, collection and disposal in Italy. The results enabled the analysis and planning of agricultural plastic waste fluxes, together with the possibility to investigate different development scenarios and to consider new planning strategies for the management of agricultural plastic waste.

4.2 Materials and methods

The amount of the post-consume agricultural plastic film, particularly mulching (LDPE) and greenhouse (LDPE and/or EVA) film, and the correspondent amount of the produced waste in one year in each Italian Region was estimated by analysis of statistical data. This result has been obtained considering the useful-life, expressed in years, of the different typologies without considering: a) the loss of material during the exercise and removal phases and b) the increase in weight, above all for mulching films, due to contamination (soil and sand,

organic material, humidity, etc.) during both their application and/or their collection and storing in the farm areas. Four Italian Regions were specifically analyzed; in particular, Campania and Sicily Regions have been chosen among those characterized by higher densities of protected structure (greenhouse and tunnel) while Apulia has been chosen both for its mulched areas (inside greenhouse or in open field) and wide diffusion of covering vineyards; the fourth Region (Emilia Romagna), chosen because characterized by medium-high amounts of greenhouse, meddle/low tunnel and mulching films. Actually, the study is proceeding, so the Regional data refer to an only zone, included in the province of Modena. In Apulia, Campania and Sicily Regions the total amounts of plastic consumption is respectively equal to 16.6 %, 10.5 % and 22.7 % of the total National consumption of film for protected cultivation. There, the survey has been carried out at provincial level through an identification of the main agricultural zones (Figg. 18, 19).
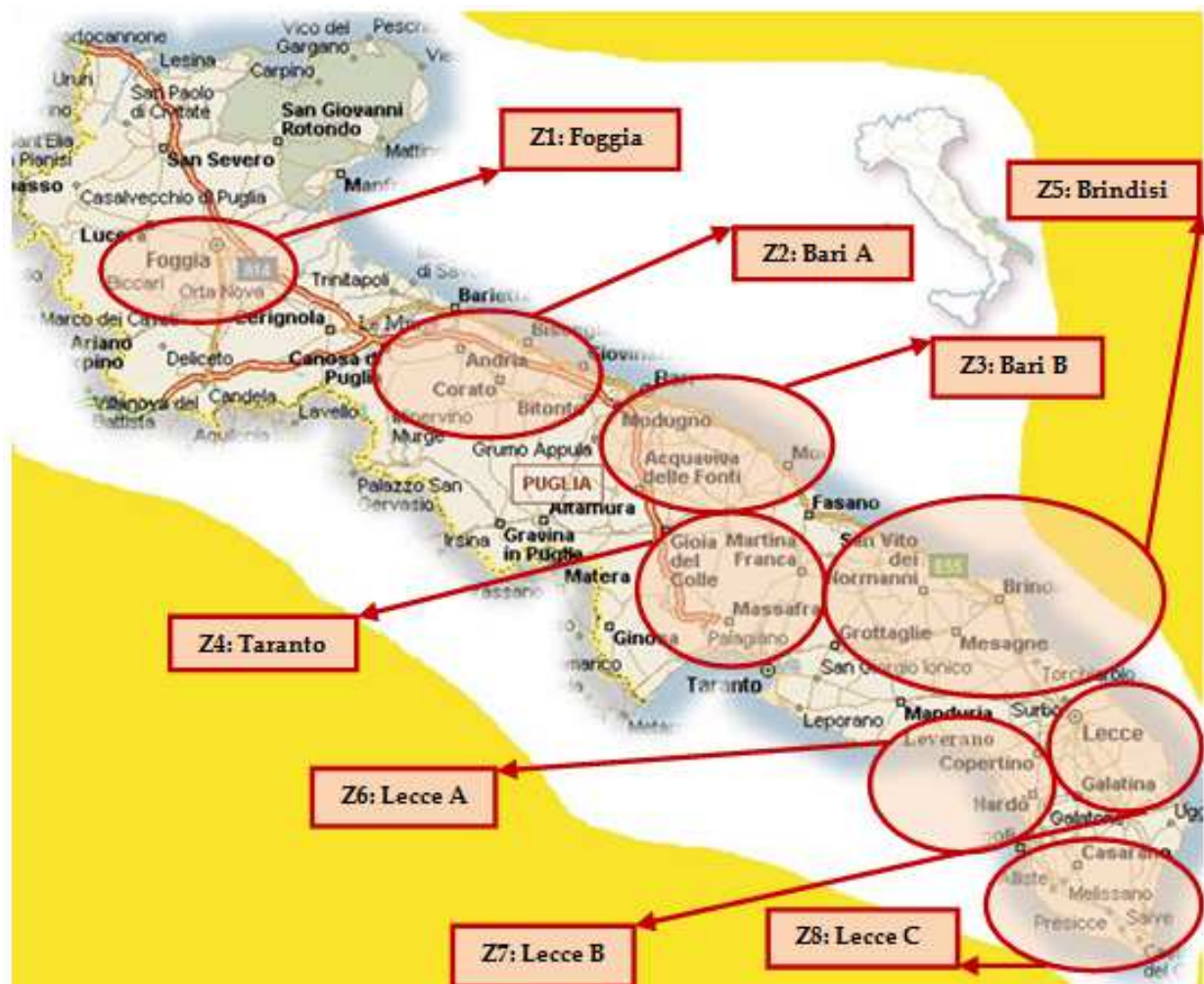
Fig. 18. Apulia Region and analyzed municipal farming areas.

The data that were collected regarded the plastic covered areas (hectares) according to the type of application (greenhouse, tunnel, mulching, etc.), the cultivation (vegetable, flower, fruit), the type of plastic (LDPE, EVA, PVC, etc.), the consumptions (tons) of these materials, the amount of agricultural plastic waste (produced and collected), the collection system (condition, transportation means, cost, dirtiness) These data were implemented in a relevant

database and processed in a G.I.S. (GeoMedia - Intergaph) assuming as a cartographic base a geographic map at European scale. The main agricultural zones of Apulia, Campania and Sicily Regions were geographically individuated in order to connect them to the first collection areas and recycling centres on the national territory.

Fig. 19. Campania Region and analyzed municipal farming areas.

4.3 Results and discussion

The results enabled the analysis and planning of agricultural plastic waste fluxes, together with the possibility to investigate different development scenarios and to consider new planning strategies for the management of agricultural plastic waste.

In the Geographical Information System at regional scale, implemented in order to contribute to the analysis of agricultural plastic waste production, flux, collection and disposal in Italy, it is possible, by pressing on an agricultural area, to examine the data introduced in the database relating to the area in consideration (Fig. 20). Three different layers were created: the first one is represented by the geographical basis, the second layer shows the main agricultural areas using a specific type of plastic materials (Fig. 21), the third layer reports indication about the number of the collection areas and the main plastic waste recycling firms, associated to the Consortium "PolieCo".

The implemented G.I.S. enables the followings possibilities:

- to localize the main agricultural areas characterized by intensive production with plastic material;
- to know both the quantities of surface (hectares) and the consumption (tons) of plastics;
- to analyse the specific type of plastic material and to know the generated type of agricultural plastic waste and the quantities in each zone;
- to study the stream of agricultural plastic waste from the farms to collection areas in order to transport the agricultural plastic waste towards those more close and/or more easily to reach;
- to propose the enlargement or the creation of a new collection areas in barycentric zone as regards to the areas that produce high amount of agricultural plastic waste, through a previous economic analysis;
- to direct the stream of agricultural plastic waste from the collection areas towards pre-established recycling firms in order to optimize the flow of material, avoiding the block of little recyclers due to lack of material, or the stop of the working process of big firms due to scarcity of plastic waste.
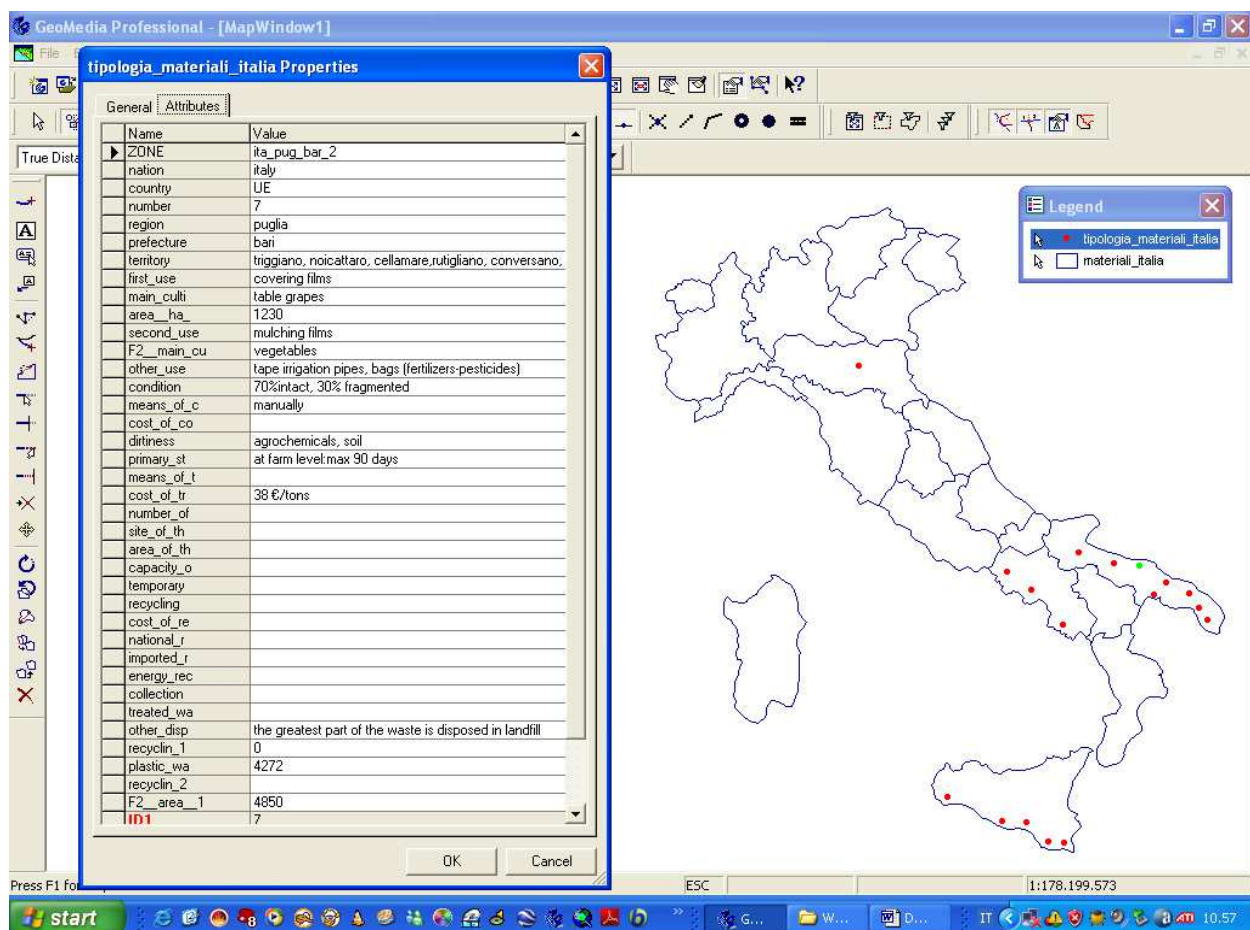
Fig. 20. Agricultural data included in the database of the G.I.S.
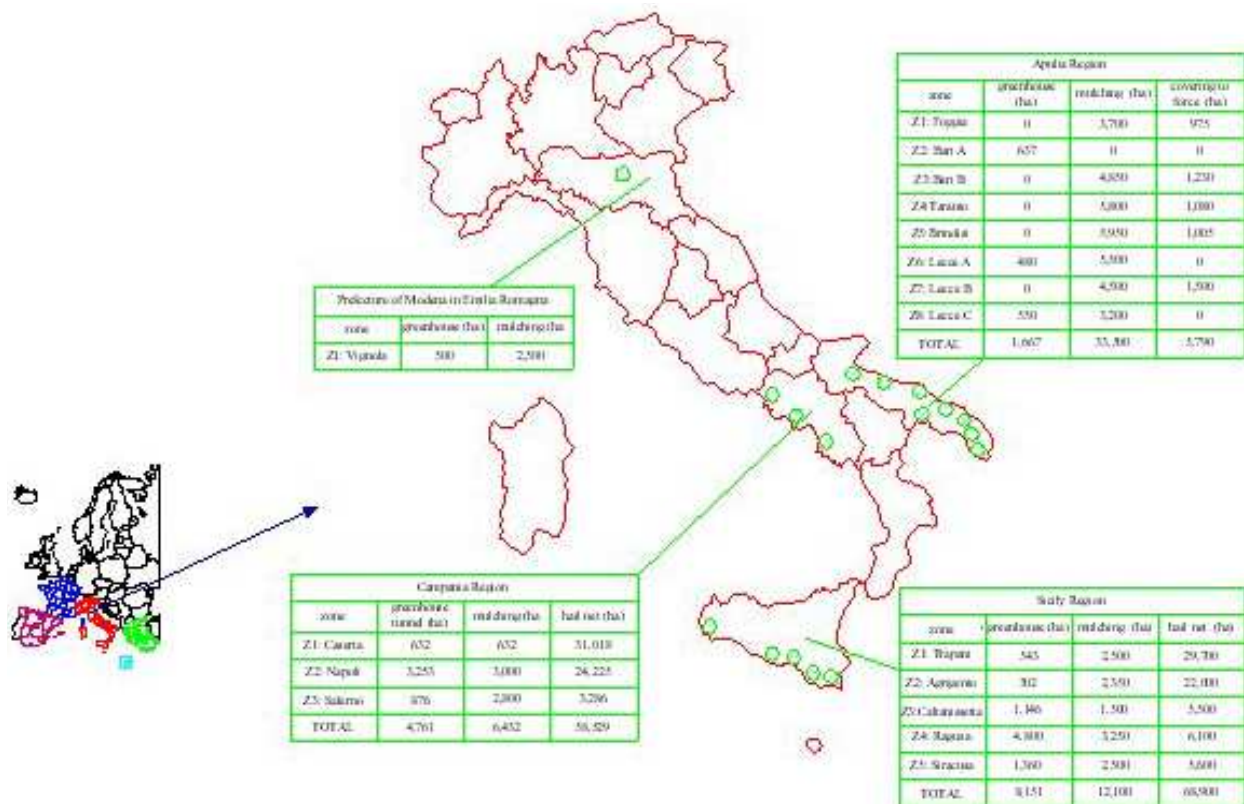
Fig. 21. Agricultural data included in the database of the G.I.S.

Different development scenarios may be therefore examined. Introducing the results in an optimal Decision Support System it would be moreover possible to analyse and plan agricultural plastic waste fluxes. Besides, different importance degree ("weighing" operation of informative levels) can be attributed both to each farm producing large amount of plastic waste and to the different parameters that characterise the viability net. For the attribution of weights to different informative levels the influence of each single factor should be preliminarily identified (Manera et al., 2001).

5. The utilization of a geographical information system (G.I.S.) for the valorisation of typical products from marginal areas

5.1 Foreword

The economy of marginal areas is frequently compromised by the inadequacy of the transport system, the lack of co-operation between farms, and by the insufficient distribution of their typical products, whose valorisation may be a factor of growth for lands that, due to orographical and geographical handicaps, are often delayed in their economic development. In those areas the problem that more frequently arises is difficulty in planning

land development due to the lack of or poor knowledge and classification of all possible information, together with the inadequate capability to get new information and possibility to simultaneously analyse many data.

From this point of view, the use of a Geographical Information System (G.I.S.) appears to be a very useful tool because it allows matching information of geographical level (terrain height, gradient, slope orientation, soil utilisation, structures and infra-structures etc.) with pasture characteristics (pasture aromatic herbs, grass percent coverage, nutritional values, etc.).

G.I.S. and image processing method was employed for an application in land use planning with reference to an internal area of Basilicata Region (Southern Italy), well known for its typical food products (sheep and goat cheese), with the aim to individuate new areas, that may be devoted to pasture, with the best characteristic and highest potential performance able to contribute for an increase of quantity and a standardisation of quality in production of Pecorino cheese.

The Geographical Information System that was implemented, through a crossing among its numerous informative levels, enabled us to obtain thematic maps with specific uses with the aim to locate areas destined to pasture. Through image processing, a different degree of importance both at any value of the single theme and to the different obtained themes has been attributed by weights, with particular care for pasture herbs and environmental load capacity of the different areas. The re-sampling of these informative level led to a final new thematic map named "Pasturage capability map" where areas with higher productive capabilities and with the best botanical characteristic are highlighted.

Sheep and goat raising plays a major role in animal breeding in Italy, not only in terms of economic weight of production but also of the related social aspects. Ewe's and goat milk products greatly differ in their characteristics - often original indeed – and their diversity is closely linked to the peculiarities of the growing areas and the production techniques in many cases related to old and consolidated traditions. In Basilicata region (Figure 1), in particular, most of cropping and livestock farms are located in mountain areas. On one hand, this further aggravates the problem of marketing, on the other hand, emphasises the different characteristics of production.

The G.I.S. (Geographic Information System) is a support tool increasingly applied in agricultural and forest land, for its analysis (Gomarasca, 1995; Manera et al., 2000; Zucca et al., 1998), planning (Brunschwig et al., 2000; Coulter et al., 2000) and management (Wade et al., 1998; Weber et al., 2001), and for the development of forecast models to support decision-making programming processes (Ayala et al., 1999).

Through the use of G.I.S. and image processing, have been identifying the main characteristics of the surfaces to be used for pasture by sheep and goat-raising farms producing Pecorino cheese in a study area (Fig. 22) situated north-west of the Province of Potenza. It covers 31 municipalities included in the specifications for the production of "Pecorino cheese of Filiano" where agriculture has been since long one of the major subsistence factors for the resident population.
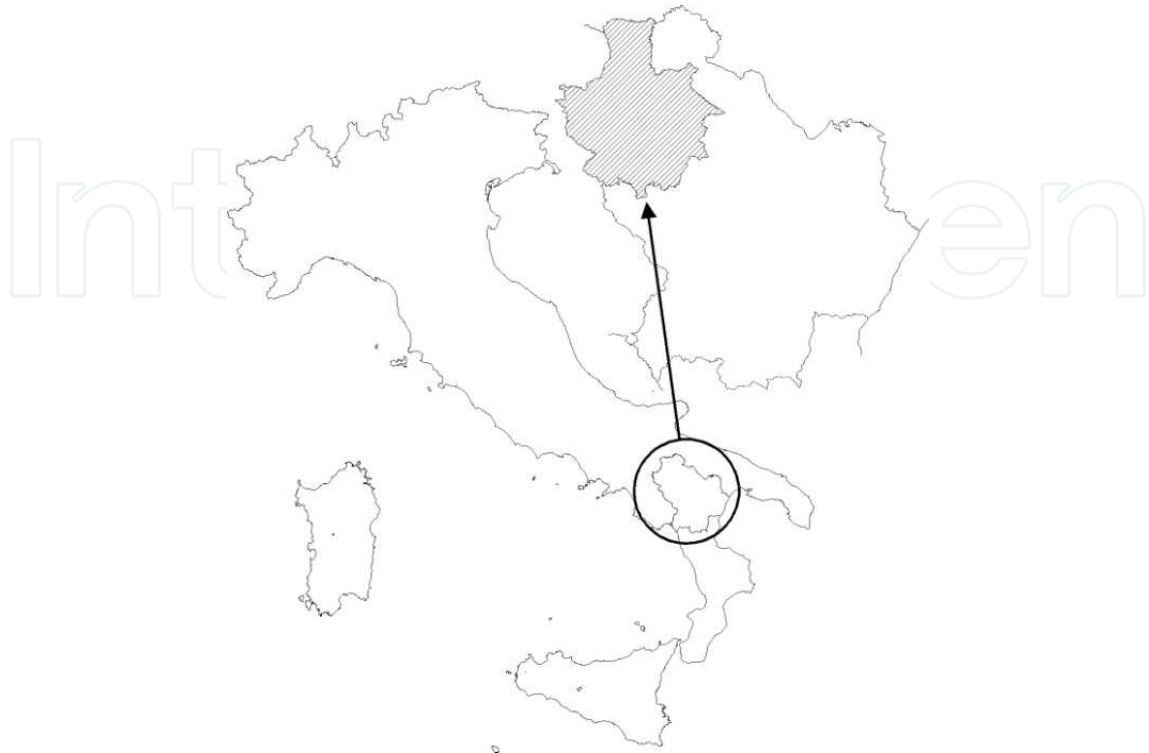
Fig. 22. Basilicata Region and study area

5.1.1 Materials and methods

A G.I.S. and image processing method was employed for an application in land use planning with reference to an internal area of Basilicata Region (Southern Italy), well known for its typical food products (sheep and goat cheese), with the aim to individuate new areas, that may be devoted to pasture, with the best characteristic and highest potential performance able to contribute for an increase of quantity and a standardisation of quality in production of Pecorino cheese.

1. This result was obtained by organising the operations into the following steps:
   - Identification and filing of basic informative layers;
   - administrative boundaries;
   - villages and towns;
   - road network;
   - geo-lithological data;
   - hydrological data;
   - altimetric data;
   - vegetational data;
   - temperature-rainfall data;
   - data on sheep-goat raising farms.
2. Homogenisation and integration of basic informative layers

LAYER	QUALITY
Elevation belt map (DEM – Digital Elevation Model) Slope map Exposure map	MORPHOLOGICAL
Permeability map Temperature-rainfall map Phyto-climatic belt map	CLIMATIC
Land use Map of the areas presently used for pasture	VEGETATIONAL
Farm distribution map	ANIMAL HUSBANDRY

3. Spatial overlay
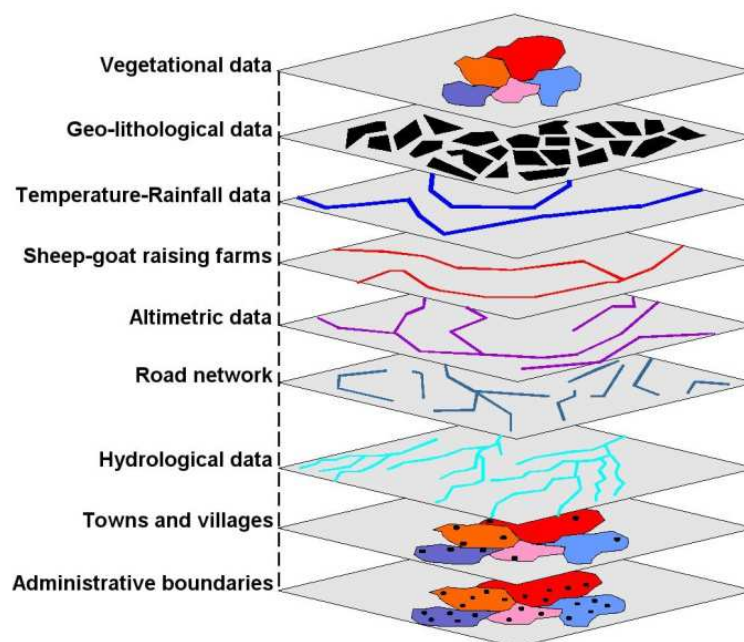
Filing being completed, the data were first sampled, attributing a different importance degree ("weighing" operation of informative levels) both to every class of each single theme and to the different thematic levels obtained, in order to characterise the area of higher yield capability. For the attribution of weights, the influence of each single factor was preliminarily identified and weights were thus attributed to the different informative levels, quantifying them according to the estimated fodder yield. The homogenisation and integration of data thus being completed, the layers were adequately processed to obtain a "capability" map, where the derived layers were gathered into distinct classes of "quality" subsequently used into new re-sampling operations where themes were processed through multiplicative algorithms (Manera et al., 2000). The result of simultaneous processing (Fig. 23) of informative levels is a summarising map called Grazing capability map.

5.1.2 Results and discussion

The reliability of the new informative level was first checked by overlaying the capability map with the location of the sheep-goat raising farms. Overlay highlighted that the highest number of small raising farms falls within areas belonging to lower capability classes, whereas farms with a greater number of heads are located in areas identified as having a greater parametric grazing capability value (Fig. 24).

Then, since the characteristics of more or less valuable pasture can be defined through agronomic and nutritional parameters, some of the said parameters were surveyed on a sample of farms falling within the study area in order to fully check the reliability of the proposed model.
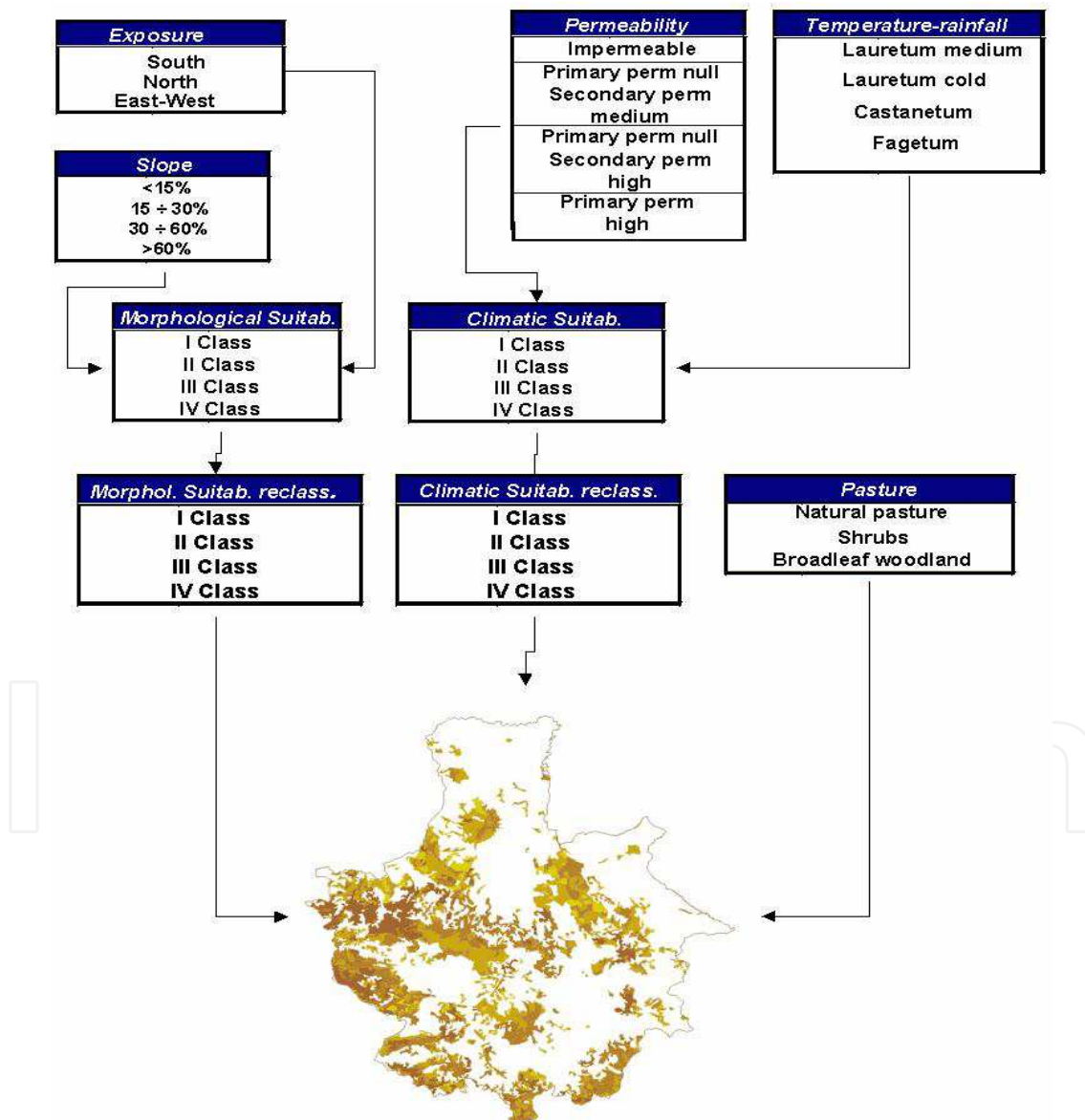
Fig. 23. Summarising scheme and grazing capability map
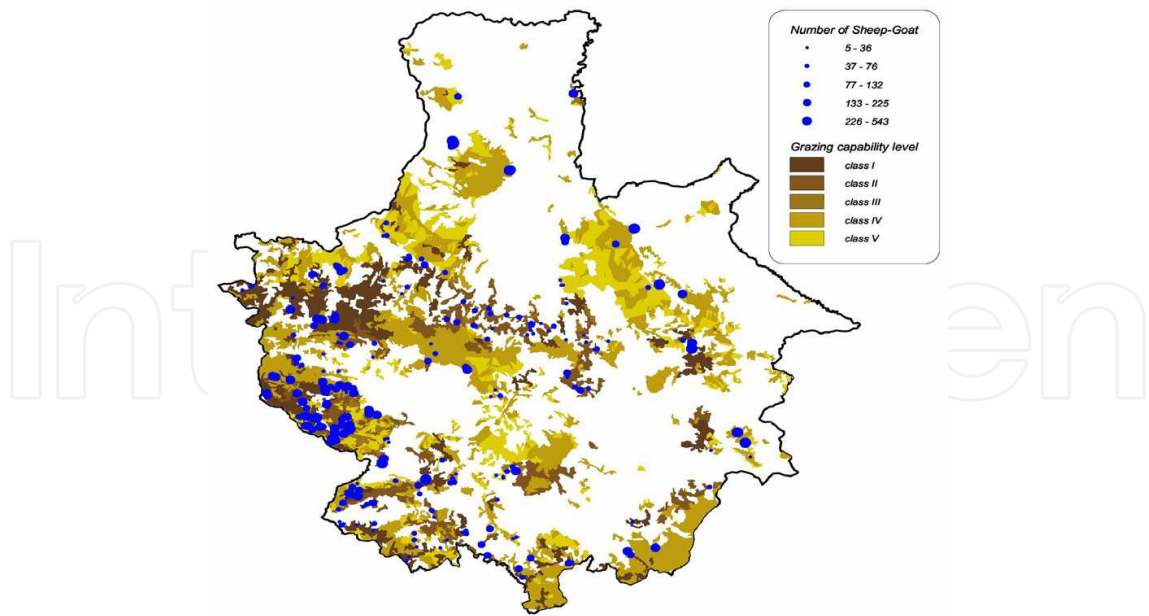
Fig. 24. Grazing capability and position of sheep-goat raising farms

These data were collected in collaboration with the Research Unit for the Extensive Animal Husbandry CRA-ZOE (Potenza), and concerned both some sheep-goat raising farms and the corresponding pasture they use. The agronomic data on pasture were grouped into five classes, in order to make them comparable with previous data treatments and overlay them with the grazing capability map.

Spatial overlay (Fig. 25), showed that the values of the FMU parameter (equal to the energy contained in milk produced from an intake of 1 Kg of standard barley) increases for higher
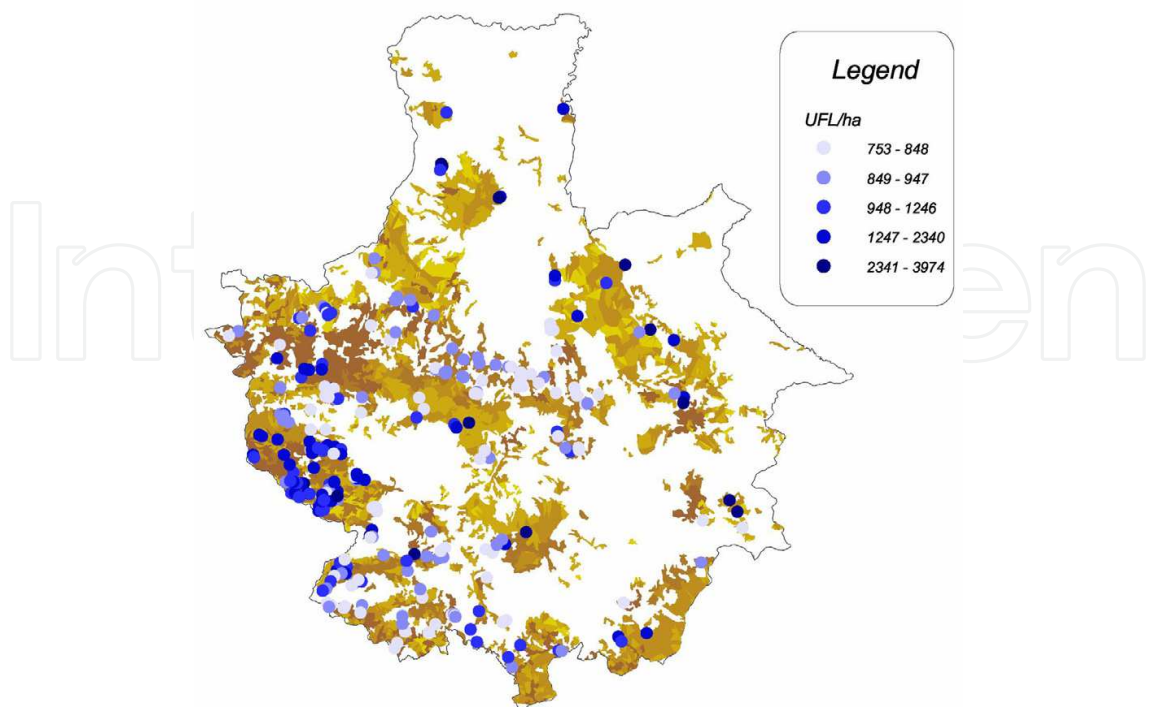
Fig. 25. Spatial overlay

capability classes, thus confirming the better grazing suitability of those areas identified as having higher capability.

Such processing was made by considering the distribution of qualitative parameters individually (dm, rp, rf) and it showed that, as for the FMU, also for dry matter the maximum values coincide with the classes of higher capability, whereas this was not the case for the two other parameters (rp, rf). Such a difference is probably due to the variability of the species present in the grazing turf and, in particular, in the associations of legumes and grasses.

Finally, also considering that the qualitative/quantitative characteristics of pastures were surveyed in a special period of the vegetative season and that the results of processing could be thereby disturbed, the parameter of the food supplement supplied to herds to make up any nutritional deficit independently of the vegetative season were analysed too (Graph 2).

Through the data analysis, the relationship between the types of food supplements and grazing capability classes was pointed out (Tab. 6).

	V CLASS	IV CLASS	III CLASS	II CLASS	I CLASS	TOT
Oat	6	6	0	5	0	17
Oat, barley, maize, broad beans	7	3	1	1	1	13
Oat, barley	4	1	1	3	3	12
Barley, maize, broad bean	0	4	0	3	0	7
Oat, barley, broad bean	0	2	1	0	0	3
Maize, barley	1	2	0	0	0	3
No food supplement	1	2	0	0	0	3
Oat, maize	0	0	0	2	0	2
Oat, maize, barley	1	0	0	1	0	2
Barley	2	0	0	0	0	2
TOT	22	20	3	15	4	64

Table 6. Farm distribution per grazing capability class on the basis of food supplements supplied

The wider diffusion of oat as food supplement, is because such fodder is more widely available in smaller farms with subsequently lesser heads, whereas in farms with a larger number of heads, combinations of oat and barley, maize and broad beans are more largely used.

Finally, based on the results obtained so far and considering that, on one hand, large agricultural surfaces are presently used for cereal growing and benefit from the economic compensation granted by the European Union that is supposed to cease in the near future and, on the other hand, pasture areas may increase due to the re-launching of Pecorino cheese, the "propensity to grazing" was assessed in the cereal-grown areas.

This further operation consisted in overlaying the grazing capability map (Fig. 23) with the data relative to climatic and morphological suitability of areas classified as predominantly cereal growing in the land use map.

% Kind of food supplements
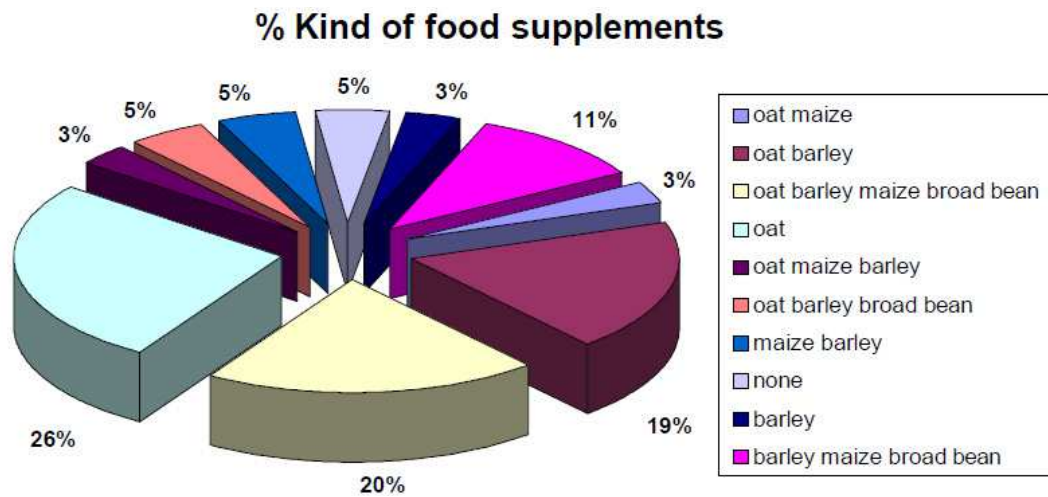
Graph 2. % distribution of farms per type of food supplement supplied

The result of such further processing, reported in Figure 26 as "grazing propensity map", allowed highlighting additional capability classes thereby confirming again that most of the study area shows a marked grazing suitability.
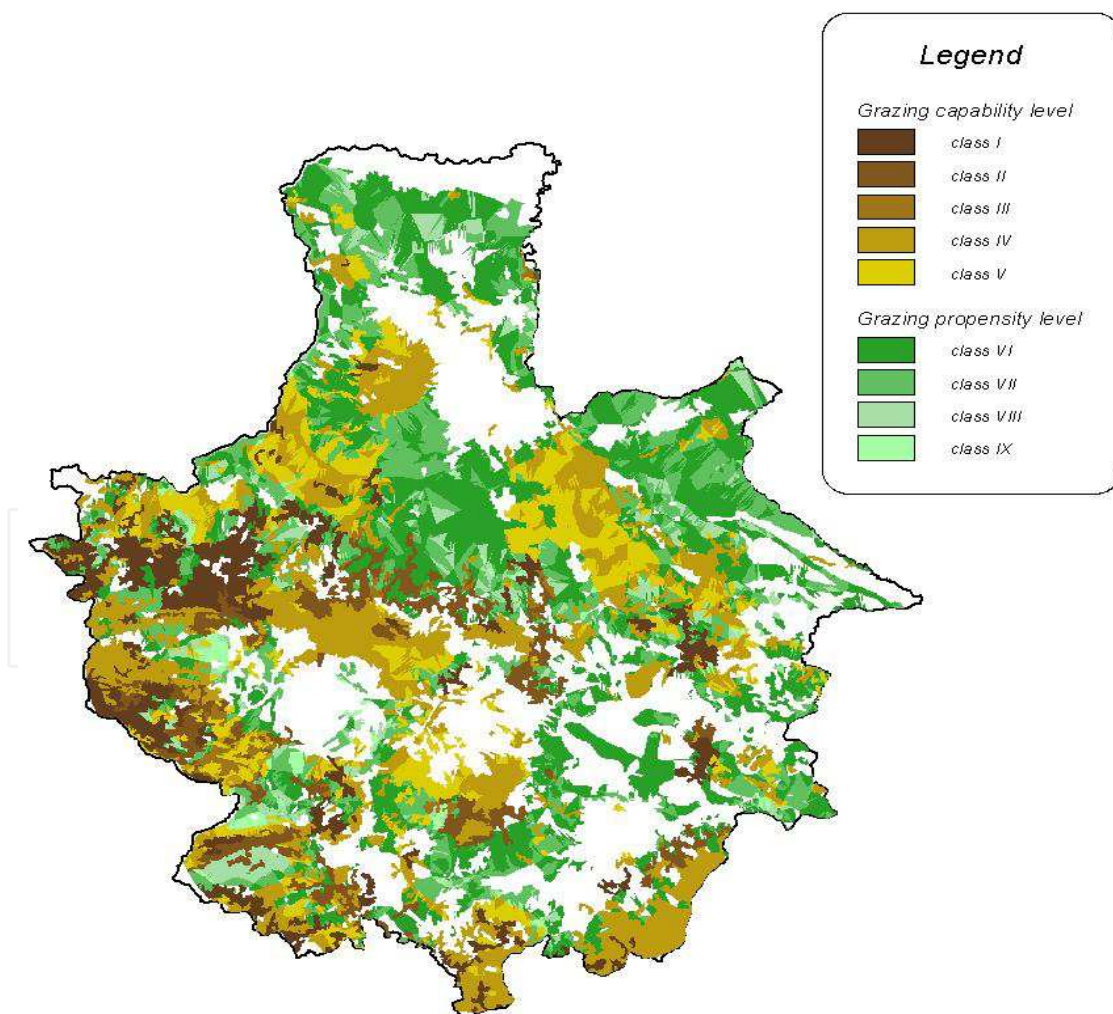

Fig. 26. Grazing propensity map

6. Conclusions

Agriculture constitutes in some areas of Europe the traditional and in most cases still the principal source for supporting the local economies; it plays, therefore, a central role, that should be adequately planned and managed, in order to avoid a confused and uncontrolled development of the rural land. The development of recent technologies for the automatic detection and positioning of greenhouse distribution enables an accurate analysis, that may be helpful for the definition of sound policies for the planning of the rural land and environment and a sound management of the agricultural landscape.

The results that were obtained in this paper enable the possibility to create a routine in IDL and ENVI software for an auto-detection of greenhouse and other protected structures. This tool can be used for monitoring the variation of rural land use and support better environmental and landscape planning policies. Moreover, through G.I.S., Image Processing techniques and landscape analysis procedures implementing coaxial matrices, areas that may be more environmentally endangered, in terms of the impact that large permeable coverings produce on natural cycles (water, soil, air, etc.) of the agro-ecosystem, could therefore be critically analyzed.

New structures for protected cultivation covered with wide surface of plastic material could alter in a significant way the agricultural landscape, that constitute one of the most important heritage of these fragile territories (Hernandez et al., 2004/b). If the phenomenon detected in the study area of the present research should continue with the same trend, an increase of the areas covered of more than 10% in the next years could be predictable. The present research showed how the impact of plastic-covered agricultural structures may be evaluated and potentially mitigated, so contributing to the preservation of the formal aesthetic characteristics of the rural landscape.

Finally, the concept of a "threshold" limit for the quantity of plastic-covered agricultural structures could also been considered in extra-urban planning: this limit would represent the maximum value that, from an aesthetic point of view, also incorporating shape and colour of the materials employed for crop protection, could be tolerated in an intensive agricultural context.

A Geographical Information System procedure for the analysis and planning of the collection and disposal of agricultural plastic waste, implemented at Italian level, may be enlarged introducing new fields and/or data of other Nations of the European Union, too.

Thanks to its attitude for synthesizing of complex land relations, the proposed G.I.S. may be improved including an analysis of the road network, in order to optimize the localization of the recycling centers, the optimal distances from them to the principal areas subject to intensive use of agricultural plastic films and the useful time and the average speed to cover these distances. Also the data regarding the distribution along different seasons of the year could be introduced in the G.I.S., in order to best fit the material flow towards the recycling centers.

The elaboration performed in this research work allowed producing a synthesis informative tool that reports the suitability of pasture for fodder production. (conclusion of the 2.4)

Extra-urban land planning must pursuit, as a main goal, environmental sustainability. A sustainable rural development, at least in European countries, has been perceived by social

awareness and sensibility and is constantly been considered by new laws and regulations whose attempt is the natural resources protection.

In this scenario an accurate analysis of performing variations and a global monitoring of ecosystems seem necessary in order to propose environment protection politics, crucial element for a sound planning of extra-urban land and for a sustainable growth of the civilized World.

This analysis has shown how the results of the applied agronomic practises, in terms of CO_2 fixation, would be able to contrast heavy emissions of greenhouse effect gases in the atmosphere by urban settlements, demonstrating how a correct rural-site management could efficiently balance environmental pollution determined by the human development. The use of this approach for other environmental factors, such as water, soil etc., would lead to a more comprehensive understanding of landscape development dynamics through its principal environmental components, contributing to the proposal of production oriented politics that achieve compensation of natural balance alterations, and a real application of the concept of sustainable development. The results showed that the cultivation conversion caused a loss of CO_2 fixation value, that was accompanied by heavy emission of greenhouse effect gas in the atmosphere by urban settlements too. A sound rural land management should efficiently balance environmental pollution determined by the economic development; the methodology employed in the present case study could properly be transported into other areas, and the resulting analysis extended to different rural context.

7. Acknowledgment

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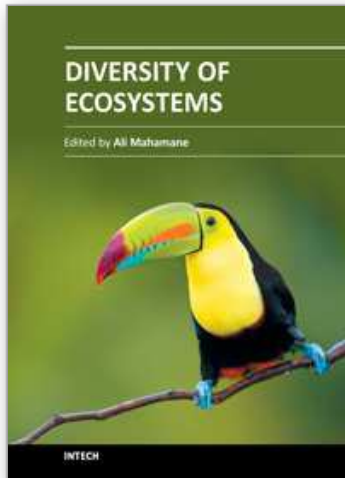
Diversity of Ecosystems

Edited by Prof. Mahamane Ali

The ecosystems present a great diversity worldwide and use various functionalities according to ecologic regions. In this new context of variability and climatic changes, these ecosystems undergo notable modifications amplified by domestic uses of which it was subjected to. Indeed the ecosystems render diverse services to humanity from their composition and structure but the tolerable levels are unknown. The preservation of these ecosystemic services needs a clear understanding of their complexity. The role of research is not only to characterise the ecosystems but also to clearly define the tolerable usage levels. Their characterisation proves to be important not only for the local populations that use it but also for the conservation of biodiversity. Hence, the measurement, management and protection of ecosystems need innovative and diverse methods. For all these reasons, the aim of this book is to bring out a general view on the function of ecosystems, modelling, sampling strategies, invading species, the response of organisms to modifications, the carbon dynamics, the mathematical models and theories that can be applied in diverse conditions.