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ASSESSING BIOMASS CHAINS FEASIBILITY AT LOCAL LEVEL

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ABSTRACT "Valle dei Latini" is one of the first examples of agro-energy district in Italy for the development of different bio-energy chains. A feasibility study, with the identification of all bio-energy resources available in the area has been carried out. A multidisciplinary approach, through which the analysis of the rural districts socioeconomic characteristics is integrated with information on the agroindustry sector, networks and land morphology has been developed. The collected and estimated data on biomass production, potential and energy consumption have been processed together and integrated via spatial analysis. A specially designed GIS has been used as a support tool for a feasibility analysis for different biomass chains. This paper describes the main results of the land suitability study for sunflower, an oil crop largely cultivated in Italy for the production of biooil and biodiesel. The designed methodology includes different analysis steps: data collection, geodatabase creation (by data integration about geomorphology, climate, land use, soil), sunflower suitability factors and constraints definition and GIS processing. The core processing is based on set up and resolution of a multi-criteria analysis of multi-attribute form. The methodology has been optimized to obtaining the maximum spatial resolution and analysis completeness related to the available data. The analysis result is a sunflower land suitability map characterized by the subdivision of the area in distinct land suitability classes. The spatial heterogeneity and the resolution of available data have been implied in the subdivision of the final result in two distinct maps with different levels of detail.

Keywords: agro-energy district, sunflower, land suitability, Spatial analysis

INTRODUCTION The European Union has set ambitious targets on the percentage of energy to be produced from renewable sources on the overall consumption of energy and electricity and on biofuels. Biomass energy production is going to have a major role to meet the upcoming energy requirements. The spreading of biomass use to produce energy will potentially both help reduce greenhouse gas emissions and create new opportunities for the agricultural sector. Nevertheless any strategy for the exploitation of the biomass potential has to take into account local land use, agricultural characteristics and energy

consumption patterns. Moreover non– technical barriers that could threat or affect the growth of a local bioenergy market have to be identified and overcome.

Feasibility studies on how and where to promote and to set up agro - energy rural districts in Central Italy, were carried out by ENEA.

Within an agro - energy development project in the Latium region, the Sacco Valley, South of Rome, has been specially investigated. The regional administration identified the area as a potential agro - energy district. Its agriculture is facing a deep crisis because of the progressive marginalization of land and pollution phenomena due to industrial activities carried out since the seventies. Severe water and soil pollution led the local authorities to ban food crop cultivation alongside the Sacco river.

Relevant analysis carried out within the project:

- current biomass potential for the area (farm residues, wood residues, cattle manure);
- potential land suitability for energy crops;
- land capability and potential production for energy crops;
- areas with higher biomass potential density;
- farm characteristics, size, distribution, ownership;
- energy pattern demand in the area;
- overlapping areas between biomass availability and energy demand;
- local stakeholders that could be involved in the district development.

THE STUDY AREA

The valley of the Sacco river, also known as Latin Valley, is situated between Roma and Frosinone in the Lazio region. The surface area is about 85000 hectares (Figure 1). The project of the agro–energy rural district, includes that part of the land is cultivated to energy crops to produce row material for three different agro-energy chains: wood, biogas, biolio/biodiesel. To start the biolio/biodiesel chain is necessary to introduce several thousand hectares of oil seed crop cultivation, particularly rapeseed and sunflower. With our work we tried to understand if it was possible to introduce the sunflower in traditional rotation. Morphology, pedology, climate, land use, and socioeconomic characteristics are the key components for a mulidisciplinary approach to analyse a cultivation suitability. Yet the data about Sacco Valley area are not collected in a complete database, we tried to exploit the available ones. In particular, climate analysis was focused to verify the compatibility of air temperature-rainfall area, with sunflower growth properties. The following table (Table 1) shows the characteristics of suitability that affect the growth of no-irrigated sunflower. The split of data in 3 different classes of decreasing suitability (S1, S2 and S3) and in one class “not suitable” (NS) is based on the level of productivity expected.

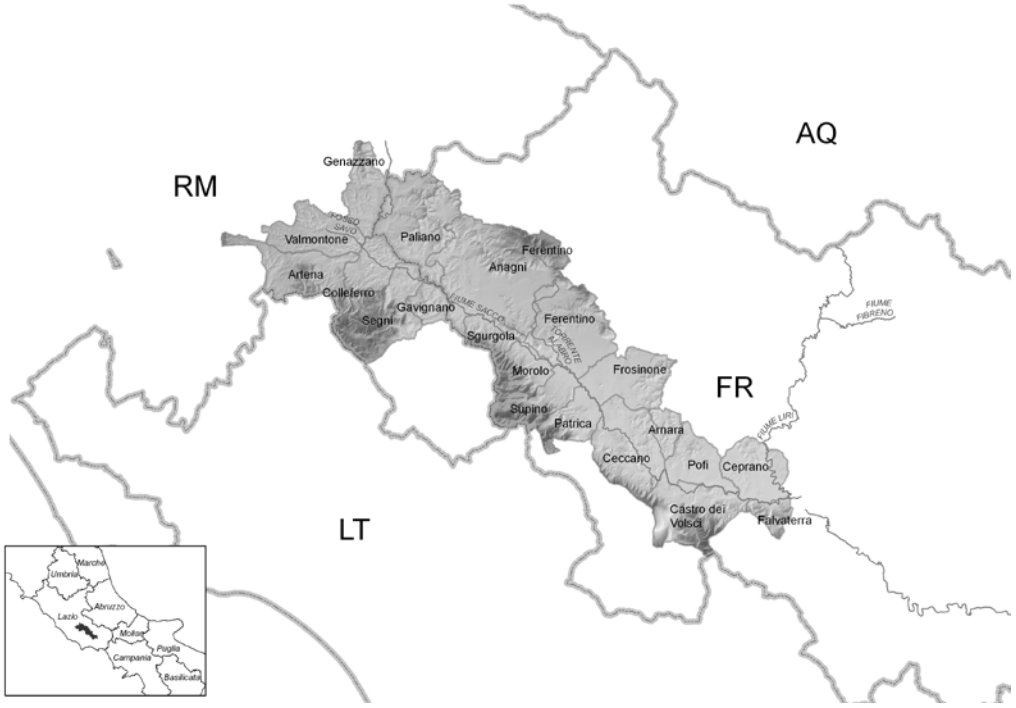

Figure 1. The study area

The geographic data for the area are characterized by a high spatial and temporal inhomogeneities and have sources, production methods and different resolution, so the creation of the database was preceded by a long pre-processing (harmonization, spatialization, georeferencing). The data were processed in GIS raster format with pixel of 25 m size according to the resolution of available altimeter data (DEM). The final scale of land suitability chart is given by the data at lower resolution that is 1:25.000 (pedological chart). The available soil data cover only 53% of the study area, therefore the analysis of vocations has been divided into two levels: in the First Level the analysis was performed on the entire district, using only the morphological characteristics, altitude and land use; in the Second Level the analysis was performed in sub-area covered by soil data (45.269 hectares), using all the features listed in Table 1.

Table 1. Morpho-pedological characteristics of the no-irrigated sunflower and related classes of suitability

CHARACTERISTIC	CLASS OF SUITABILITY				DESCRIPTION
	S1	S2	S3	NS	
Reaction (topsoil)	5.5-8.3	4-5.5 and 8.3-8.9	<4 and >8.9		Data obtained by spatialization IDW (*Inverse Distance Weighting* method) of the soil profile provided by ISNP[2]-Rome.
Texture[1]	SL-L-ZL-SCL-CL-ZCL-SC	LS-Z-ZC-C	S		
Organic carbon (topsoil)	>0.8	<0.8			
Morphology	Plain and	Valley	Medium	High	Data obtained by

	terraces	floor and slightly leaning slope <15%	leaning slope 15%-30%	leaning slope >30%	elaboration of DEM (*Digital Elevation Model*) with a ground resolution of 25 m (Source: Lazio Region)
Altitude (m.a.s.l.)	0-600	600-800	600-800	>800	

1 Texture: S (sand), LS (loamy sand), SL (sandy loam), L (loam), ZL (silt loam), Z (silt), SCL (sandy clay loam), CL (clay loam), ZCL (silty clay loam), SC (sandy clay), ZC (silty clay), C (clay)
2 ISNP - Experimental Institute for Plant Nutrition, Rome.

METHODOLOGY Our focus was the formulation and solution of a problem of decision making. Since the peculiarities and the different characteristics involved in the assessment of suitability, the problem has been formulated using the class of multy criteria decision making (MCDM). The main steps are:

- Defining of the decision problem: it is the definition of the objective analysis, or the determination of the best areas for cultivation.
- Definition of analysis criteria: it is the definition of the set of attributes used in the multi-criteria analysis. Each attribute is selected about its ability to directly influence the decision problem.
- Definition of alternatives: the alternatives are the territorial units characterized by its attributes. The territorial unit used in the analysis is the pixel.
- Definition and application of the *decision rule*: it is the definition of the resolution method and the calculation of the solution (suitability chart). The land suitability analisys is classified as a multi-attribute decision problem and it can be solved by the method of *linear weighted sum*. Analytically, the solution is obtained in a GIS environment through a weighted sum of the different layers representing different criteria.
The entire flow of operations is shown in Figure 2.

The most difficult step of the methodological approach is defining the weights associated with the various criteria in the weighted sum. They express the relative influence of each criterion on the objective of analysis. To make the process of allocating weights more rigorous has been applied the *AHP- Analytic Hierarchy Process* method (Saaty, 1977), in which the criteria are compared in pairs. For both levels of analysis, the chart of alternatives, obtained from the multicriteria analysis, was filtered through the classes of land use potentially usable from land use chart (LUC).The result of the two levels of analysis is shown in Figure 3.

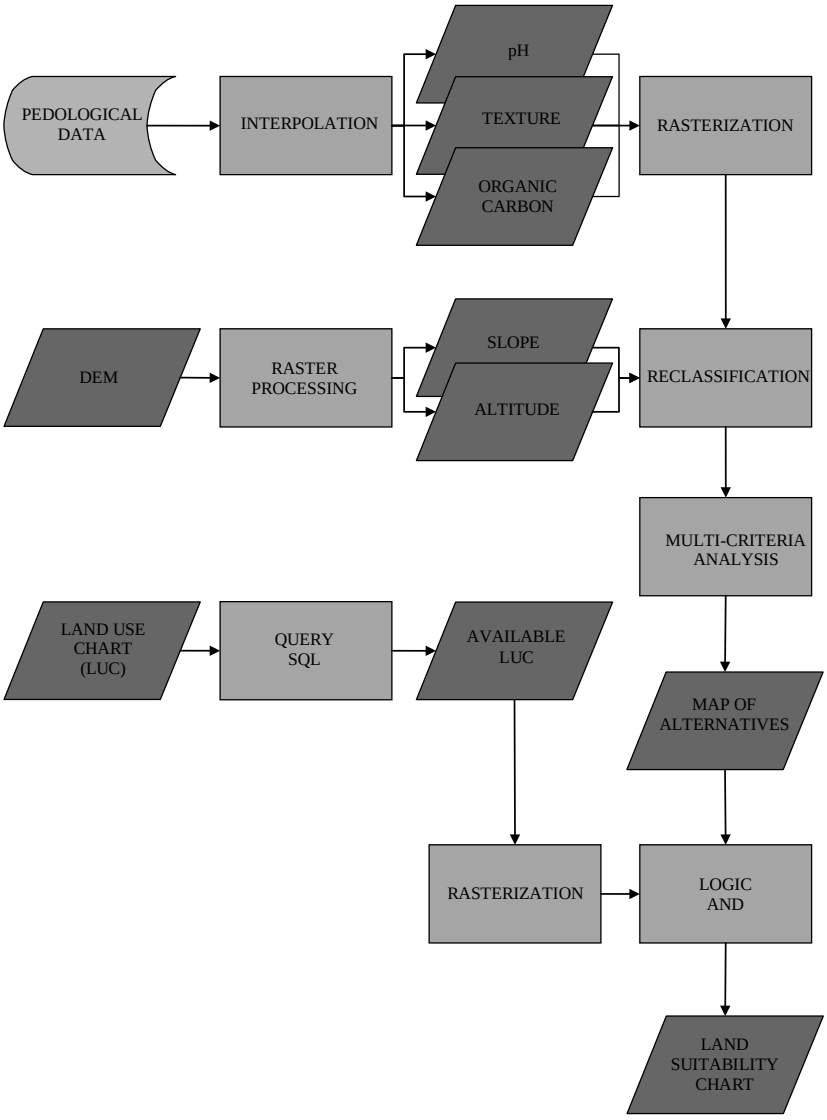

Figure 2. Flowchart for the assessment of sunflower land suitability.

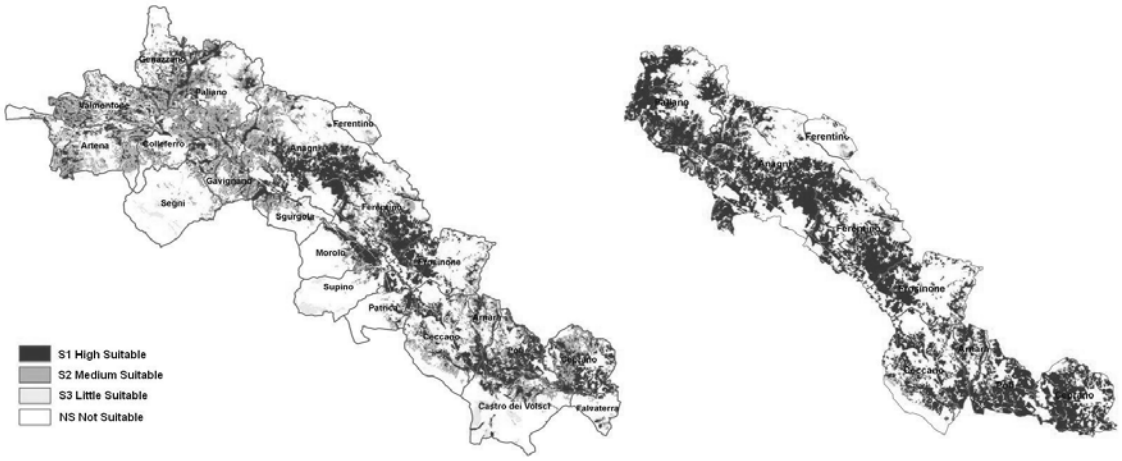

Figure 3. Sunflower land suitability maps for the two levels of analysis, I and II (from left to right).

CONCLUSION The results obtained with the resolution of a multi-attribute analysis, implemented entirely in a GIS tool, can be used by decision makers to identify the areas most suitable for the develop of various agrifuels chains.

However, the quality of this type of study are strongly influenced by the nature and accuracy of available data and the characteristics of the methodology used. Generally, the regional spatial database has massive gaps on some components of the climatic and soil conditions. In this case, through the functions of GIS, we have tried to remedy gaps in knowledge and spatial information. These gaps could be filled only with a long-term effort and a financial commitment of government authorities.

From the methodological point of view the limitations of the study are related to the definition of all criteria and constraints. It would be useful to verify the effectiveness of the model calculation by performing a sensitivity analysis to highlight the magnitude of changes in the final maps in relation to the selection criteria and constraints.

The quality and reliability of the results could be increased if the local authorities invest resources useful to systematize and the digitization of large amounts of data produced in their paper files.

REFERENCES

Saaty, T.L. 1977. A scaling method for priorities in hierarchical structures. Journal of Mathematical Psychology, 15: 231-281.

Francaviglia, R., G. Mecella. 2003. Studio dei processi di degradazione del suolo su scala territoriale. ISNP – Istituto per la Nutrizione delle Piante.

IPLA S.p.A. 2006. L'esperienza del Piemonte sulle colture bioenergetiche. Istituto per le Piante da Legno e l'Ambiente. Workshop Soil Indicators for the Soil Thematic Strategy

Support JRC – Ispra.
Regione Lazio. 2008. Studio di fattibilità di filiere agroenergetiche nel comprensorio della Valle dei Latini al fine di definire un distretto agroenergetico. Roma.