

A GIS – BASED METHODOLOGY FOR LAND SUITABILITY EVALUATION IN VENETO (NE ITALY).

Alba Gallo^{*}, Massimo Spiandorello, Claudio Bini

Dept of Environmental Science, Informatics and Statistics,
Ca' Foscari University of Venice, Italy

^{*}Corresponding author: email alba.gallo@unive.it

Abstract

Since almost ten years, the Soil Science Research Group in Venice is carrying out studies on the characterization of soils in the Veneto region and their suitability for specific uses. Several areas have been investigated with the aim to select the best land use for a sustainable environment. The scenarios taken into consideration range from the Alpine and pre – Alpine region to the alluvial plain. Attention has been focused especially on land suitability for forestry, typical and niche crops, pasture and vineyard. The land evaluation procedure has been applied by a GIS – based methodology. Today, the GIS techniques are essential for the success of a correct and fast work, concerning the interpretation and processing of soil data and its display in form of map. Integrating information with crop and soil requirements, by means of “matching tables”, it was possible to edit and manage land suitability maps for specific purposes. The applied methodology proved a useful and effective tool for sustainable land management.

Key words: *land suitability, GIS techniques, pedological data, crop requirements, matching tables*

Introduction

Nowadays, thanks to the use of the GIS technique, it is possible to manage the different territorial data. Land and soil data are stored in a database that can be relied to the geographic information (e.g. morphology, geology, climate and vegetation). This allows the interpolation of geo – referenced information and, consequently, easy, rapid interpretation and areal distribution of different pedo – landscapes in stratified layers. (Fotheringham and Rogerson, 2013). In particular, the GIS technique allows to edit land suitability maps for specific purposes (Costantini et al., 2002; Bucelli and Costantini, 2009). Knowledge of the land suitability is a very important instrument for sustainable land management, suggesting the correct land use and thus, avoiding the dispersion of essential environmental resources. For example, Zilioli et al. (2011) examined the Cortina territory (NE Italy) and evaluated the land suitability for niche crops (spelt, Prussian apple and truffle) in comparison to suitability for tourism. The results of the study allowed identification of different management systems of the examined area, including the recovery of traditional activities, aimed at the sustainable land use.

The objective of this study was to evaluate the land and soil features of different areas in Veneto region, with particular reference to ecological and agronomic aspects. The land evaluation was carried out following the FAO framework integrated with the GIS technique, in order to highlight the land suitability in relation to environmental (e.g. climate, soil characteristics, available water, etc.) and crop requirements (e.g. nutrients, fertilization, irrigation, etc.). A set of suitability assessment tables (“matching tables”) was prepared for a number of land uses (agriculture, forestry and pasture). For example, in the Sospirolo territory (Belluno province) we evaluated land uses for apple tree, potatoes and winter wheat.

Materials and methods

Current methods of land evaluation (FAO, 1976; Calzolari et al., 2009) were applied to create derived maps with the purpose to be used in land planning. The FAO guidelines provide a classification of soil suitability into four categories: order, class, subclass and unit (Table 1). The orders reflect the kind of suitability, the classes comprehend degrees of suitability within the orders, the subclasses include the types of limitation within the classes and the units group differences in required management within subclasses.

| | | |
|-------------------|--|--|
| ORDERS | <i>S</i> | Suitable. |
| | <i>N</i> | Not suitable. |
| CLASSES | <i>S1</i> | Highly suitable; without important limitations; high productivity (80-100%). |
| | <i>S2</i> | Moderately suitable; sensitive limitations; decrease in productivity (60-80%) or in profits; increase in required inputs. |
| | <i>S3</i> | Marginally suitable; very sensitive limitations, strong decrease in productivity (40-60%) or in profits; strong increase in required inputs. |
| | <i>NI</i> | Currently not suitable. |
| SUBCLASSES | Are indicated by lower-case letters; e.g.: m = moisture deficiency, e = erosion hazard, etc. | |
| UNITS | Are distinguished by Arabic numbers following a hyphen; e.g.: S2e-1, S2e-2, etc. | |

Table 1

The FAO guidelines for land evaluation.

Owing to the information included in the soil map, it was possible to classify the different soil units within the above categories considering the crop requirements.

Study areas

The investigated areas are located in different parts of the Veneto region. The land suitability was evaluated in the Northern part of the Treviso province (NW Veneto) for spelt, pasture, truffle and forestry areas. The extension of the studied area was about 2.750 km², mostly in the piedmont (PROVINCIA DI TREVISO AND ARPAV, 2008). Mesophile mixed forest is the prevailing natural vegetation cover, with agricultural land at more suitable sites. Due to its territorial conformation, in the Treviso province it is not possible to attribute a unique climatic class, and distinctive climatic characteristics can be found: the high rainfall area in the pre – Alpine zone and the foggy cold period in the plain.

Another application was to evaluate the suitability for “Prosecco” grapes, a very renowned and economically important crop, in the Conegliano – Susegana area, in the Central – Northern area of the Treviso province. This area is situated between the plain and the piedmont area with altitudes between 50 – 260 m. a.s.l. Climate is characterized in the winter season by temperatures above zero, whereas the spring period is determined by temperatures slightly below the regional average, about 20° C (Veneto Agricoltura, 2013). Soil are mostly Fluvisols, Cambisols and Regosols (ARPAV, 2008).

Another area in the Venice province was investigated for land suitability for both maize and soybean crops. The area is located in the Central – Eastern portion of the province, that extends from the Piave to the Livenza alluvial plain. This area is characterized by slow or difficult drainage, because of land reclamation occurred in the 20th century, and so many areas are currently below the mean sea level. Owing to drainage difficulties, soils are Gleyic Fluvisols and Cambisols, and the land use is generally agricultural (Provincia di Venezia and ARPAV, 2008).

A sector of the Sospirolo territory (Belluno province, N Veneto) was investigated to evaluate the best land use, in particular the suitability for winter wheat, potatoes and apple tree. Its extension is about 21.920 km² with an average elevation of 447 m a.s.l. Soil are mostly Cambisols and Regosols, followed by Chernozems and Luvisols (ARPAV, 2006). In this area the land use is mainly agricultural.

Results and discussions

Results obtained by means of specific “matching tables” allowed subdividing the investigated land into different land suitability classes. Moreover, a comparison among the suggested land uses allowed to produce a comprehensive map of the best land uses for each area investigated.

The examined land in the Treviso province presents the highest suitability (S1 and S2 classes, totally 69%) for forestry; the remaining areas being scarcely (S3, 28%) or not suitable (N, 3%) (Fig. 1a). Major limiting factors resulted: soil depth, slope and nutrient deficiency. The highest suitability for pasture (S1 and S2 classes) occupies the 48% of the examined area were 21% proved no suitable (Fig. 1b). Conversely, the land proved marginally suitable (S3) for spelt (43%), while only

31% is moderately suitable and 26% is not suitable (Fig. 1c). The major limited factors proved the soil chemical – physical parameters (pH, carbonate and particle size). The potential best land use in the examined territory is summarized in Fig. 1d.

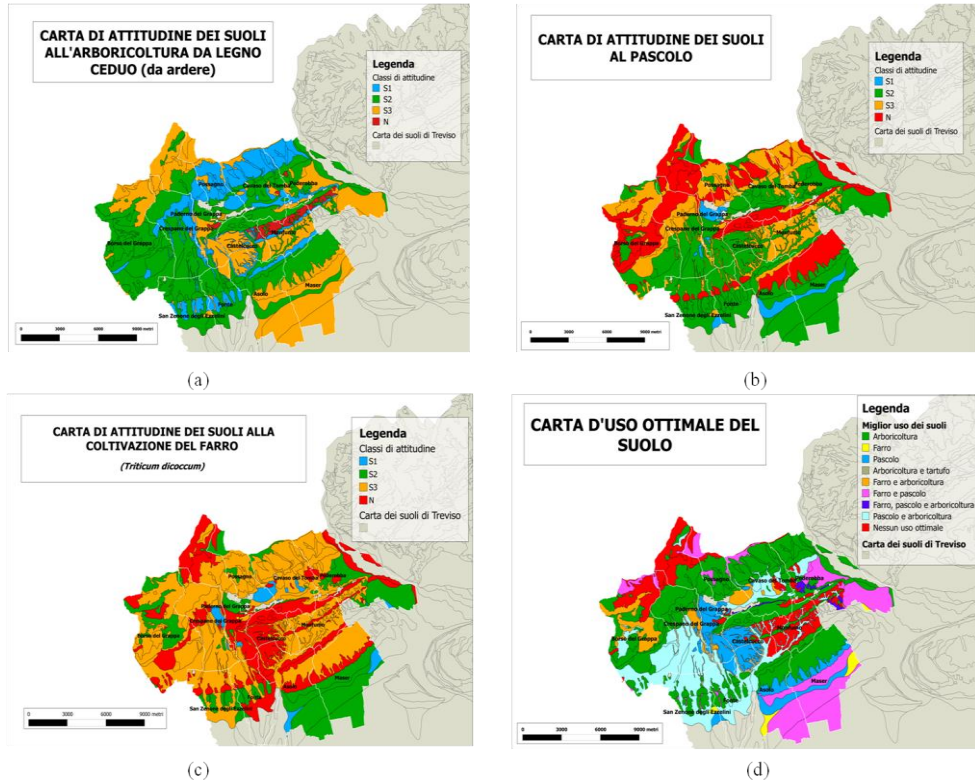


Figure 1. Land suitability maps for forestry (a), pasture (b), spelt (c) and best uses (d) (Treviso province, Veneto).

In the Conegliano – Susegana area the soils resulted moderately to scarcely suitable (S2 and S3) for “Prosecco” grapes; drainage and AWC being the most limiting factors (data not shown).

In the Piave and Livenza territory the main crops are maize and soybean. The evaluation of land suitability for these crops, unlikely expected, resulted very low for both of them (53% not suitable). Maize cultivation was marginally suitable (S3) in 47% of the surface, while soybean proved suitable (S1; 20%) and scarcely suitable (S2 and S3; 27%).

In the Sospirolo territory the results, related to land suitability for winter wheat, showed the territory to be highly and moderately suitable (S1=37% and S2=33%), while any area proved not suitable (Fig. 2a). Suitability for apple resulted very high

in most of the territory (S1=75%), where a local cultivation (Prussian apple) is grown (Fig. 2b). Conversely, suitability for potato resulted very low (N=33% and S3=42%) although a local cultivar of this crop (Giordano and Toffolet, 2006) is widely grown in the area (Fig. 2c).

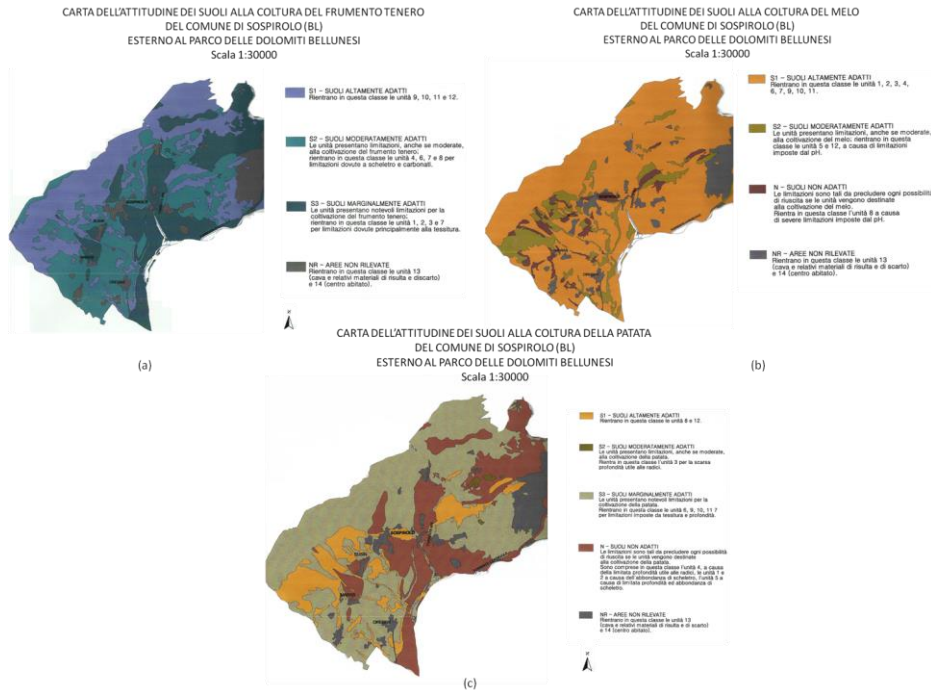


Figure 2. Land suitability maps for winter wheat (a), apple tree (b) and potato (c) (Sospirolo territory, Veneto).

Conclusions

Our research group studies have highlighted the importance of the GIS technique to create soil – derived maps and to organize data into database useful for land management. The utilization of these maps can be an effective tool to make pedological data understandable and applicable by stakeholders, in different environmental compartments.

The Veneto region is a typical case of territory in which the *Land evaluation* technique could be (and has been) applied. The evaluation and classification of soil and land, in the territories examined in this work, allow to find out more suitable land uses and to suggest different land management. The GIS technique, applied in this study, demonstrates how a sustainable land use could improve the ecological functionality of a pedolandscape. This methodology could be useful also in the urban development planning.

References

- ARPAV (2006) Inquadramento pedologico della provincia di Belluno, Documento interno predisposto per la pubblicazione, cap.6.
- BUCELLI P., COSTANTINI E.A.C. (2009) Wine grape and vine zoning. In: Manual of methods for soil and land evaluation (E.A.Costantini ed), Science Publisher, Enfield, pp. 353–400.
- CALZOLARI C., COSTANTINI E.A.C., UNGARO F., VENUTI L. (2009) Soil and land evaluation: history, definitions and concepts. In: Manual of methods for soil and land evaluation (E.A. Costantini ed), Science Publisher, Enfield, pp. 3–33.
- COSTANTINI E.A.C., BARBETTI R., RIGHINI G. (2002) Managing the uncertainty in soil mapping and land evaluation in areas of high pedodiversity, Methods and strategies applied in the province of Siena (central Italy), Proc. Int. Symp. on Soils with Mediterranean type of Climate, CHEAM – IAMB, Bari, pp. 45- 56.
- FAO (1976) A framework for land evaluation, Soil bulletin, 32, Rome.
- FOTHERINGHAM S., ROGERSON P. (2013) (Eds.), Spatial analysis and GIS, CRC Press., Boca Raton.
- KOPPEN W. P. (1918), Klassifikation der Klimate nach Temperatur, Niederschlag und Jahresablauf. Petermanns Geogr., Mitt., 64:193-203 and 243-248.
- GIORDANO D, TOFFOLET L. (2006) (Eds), Biodiversità coltivata nel Parco Nazionale delle Dolomiti Bellunesi, Industrie grafiche Belluno, Santa Giustina (BL).
- PROVINCIA DI VENEZIA, ARPAV (2008) Carta dei suoli della provincia di Venezia.
- PROVINCIA DI TREVISO, ARPAV (2008) Carta dei suoli della provincia di Treviso, L.A.C., Firenze.
- VENETO AGRICOLTURA (2013) Primi dati previsionali della vendemmia 2013 nel Nord – Est d’Italia, Veneto Agricoltura ufficio stampa, Padova.
- ZILIOLI D.M., BINI C., WAHSHA M., CIOTOLI G. (2011) The pedological heritage of the Dolomites (Northern Italy): Features, distribution and evolution of the soil, with some implication for land management. *Geomorphology*, 135(3–4):240–241.

UNE M THODOLOGIE BAS E SUR LE SIG POUR L' VALUATION DE L'APTITUDE DES TERRES EN V N TIE (NE ITALIE)

R sum 

Depuis pr s de dix ans, le group de recherch  du sol   l'Universit  de Venise a conduit des  tudes sur la caract risation des sols dans la r gion de la V n tie et de leur aptitude   des usages sp cifiques. Plusieurs domaines ont  t   tudi s dans le but de s lectionner la meilleure utilisation des terres pour un environnement durable. Les sc narios pris en consideration ont interess  le terroir   partir de la montagne et de la r gion pr alpine jusq'  la plaine alluviale. L'attention s'est port e en particulier   l'aptitude des terres pour la for t , les p turages, les cultures typiques et de niche et pour le tourisme. La proc dure d' valuation des terres a  t  appliqu e par une m thode bas e sur le SIG. Les techniques de SIG sont aujourd'hui essentielles pour la r ussite d'un travail rapide et correcte concernant l'interpr tation et le traitement des donn es relatives au sol et son affichage sous forme de carte. L'int gration de l'information pedologique avec les besoins des cultures et des sols au moyen de "tableaux correspondant", fait il possible d' diter des cartes d'aptitude des terres   des fins sp cifiques. La m thodologie appliqu e s'est r v l e un outil utile et efficace pour la gestion durable des terres.

Mots cl s: *aptitude des terres, techniques de SIG, donn es p dologiques, besoins des cultures, tables correspondantes*

IL METODO GIS APPLICATO ALLA VALUTAZIONE DELL'ATTITUDINE DEL SUOLO IN VENETO (NE ITALY).

Riassunto

Da quasi dieci anni, il gruppo di ricerca di Scienza del suolo all'Universit  di Venezia, sta effettuando studi sulla caratterizzazione dei suoli nella regione Veneto e la loro attitudine per usi specifici. Diverse aree sono state studiate con l'obiettivo di selezionare il miglior uso del suolo per un ambiente sostenibile. Gli scenari presi in considerazione vanno da quello alpino alla regione pre – alpina ed alla pianura alluvionale. L'attenzione   stata focalizzata in particolare sull'attitudine dei suoli per uso forestale, pascolo, vigneto, colture tipiche e di nicchia. Tale valutazione dell'attitudine   stata perfezionata grazie all'uso della metodologia GIS. Le tecniche GIS sono oggi essenziali per il successo di un lavoro corretto e veloce, riguardante l'interpretazione, l'elaborazione dei dati pedologici e la loro restituzione tramite mappe. Integrare le informazioni con i requisiti colturali e del suolo, per mezzo di "matching tables", permette la creazione di mappe di attitudine dei suoli per usi specifici. La metodologia applicata si   dimostrata uno strumento utile ed efficace per la gestione sostenibile del territorio.

Parole chiavi: *attitudine dei suoli, tecniche GIS, dati pedologici, requisiti colturali, tabella di confronto.*