

MAPPING VITICULTURAL POTENTIAL IN TEMPERATE CLIMATE AREAS. CASE STUDY: BUCIUM VINEYARD (ROMANIA)

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ABSTRACT. The paper presents the spatial distribution of ecological suitability for grape growing in Bucium vineyard (Romania), viticultural area with ecological characteristics representative for northern vineyards. The study is based on a complex methodology implying use of *remote sensing*, *Geographical Information Systems (GIS)*, *climatic data*, *topographic and pedologic maps*. Research reveal the low ecological potential of Bucium area, specialized, traditionally, in white table wines, sparkling wines and white quality wines. Data analysis shows that 30% of Bucium vineyard (281 ha of 928 ha) is inappropriate, in terms of climatic suitability, for *vinifera* varieties culture; 34% of the area (316 ha) has limited ecological potential, enough to produce white table wines and sparkling wines; 36% of the area (331 ha) is suitable for quality white wines. In the vineyard area was not registered suitable conditions for quality red wines production. Huglin's heliothermal index values shows that the vineyard has

climatic characteristics that allow culture of wine varieties with early and medium ripening. In terms of ecological suitability, it appears that the most favorable conditions offer Cetățuia wine land, the eastern slope of the Doi Peri hill, eastern slope of Vișani hill, south-western slope of Bucium hill and southern slope of Pietrăria wine land.

Key words: Vineyard; Geographic Information Systems; Site suitability; Climatic factors; Spatial distribution.

REZUMAT. Cartografierea potențialului viticol în arealele cu climat temperat. Studiu de caz: centrul viticol Bucium (România). Lucrarea prezintă distribuția spațială a favorabilității ecologice pentru cultura soiurilor de vin în centrul viticol Bucium-podgoria Iași, areal cu caracteristici ecologice reprezentative pentru podgoriile septentrionale. Cercetarea se bazează pe o metodologie complexă, în cadrul căreia se utilizează imagini din satelit, Sistemele Informaționale Geografice (GIS), date

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climatică, hărți topografice și hărți pedologice. Rezultatele cercetării relevă potențialul ecologic limitat al arealului viticol, specializat, în mod tradițional, în producerea vinurilor albe de masă, vinurilor spumante, vinurilor aromate și vinurilor albe de calitate. Din analiza datelor rezultă că 30% din suprafața analizată (281 ha din 928 ha) este improprie, din punct de vedere climatic, pentru cultura soiurilor *vinifera*; 34% din suprafață (316 ha) are potențial ecologic limitat, suficient doar pentru producerea vinurilor albe de masă și vinurilor spumante; 36% din suprafață (331 ha) are potențial pentru producerea vinurilor albe de calitate. În arealul viticol nu se înregistrează condiții favorabile obținerii vinurilor roșii de calitate. Valorile indicelui heliotermic Huglin, a cărui distribuție spațială este prezentată în lucrare alături de amplasarea zonelor afectate de înghețuri și brume, relevă faptul că, în areal, există condiții favorabile pentru cultura soiurilor cu maturare timpurie și mijlocie. Din punct de vedere al favorabilității ecologice pentru cultura soiurilor de vin, rezultă că cele mai valoroase microareale sunt: plaiul Cetățuia, versantul estic al dealului Doi Peri, versantul estic al dealului Vișani, versantul

sud-vestic al dealului Bucium și versantul sudic al plaiului Pietrăria.

Cuvinte cheie: podgorie; Sisteme Informaționale Geografice; potențial viticol; factori climatici; distribuție spațială.

INTRODUCTION

Bucium vineyard is located in the east of Romania and include vine plantations from the southern limit of Iași town. The vine plots are spread over a large area (928 ha) in which are individualized seven wine lands: Bucium, Bucium Monastery, Pietrăria, Vișani, Olteanu Cellar, Doi Peri and Cetățuia (*Figure 1*). The traditional products of Bucium vineyard are sparkling wines, white table wines, white quality wines and wine distillates. Regarding the climate conditions, Bucium is a northern vineyard, closed to the northern limit of vine culture (50°N), with a cold climate, frequently affected by winter frosts and white frosts.

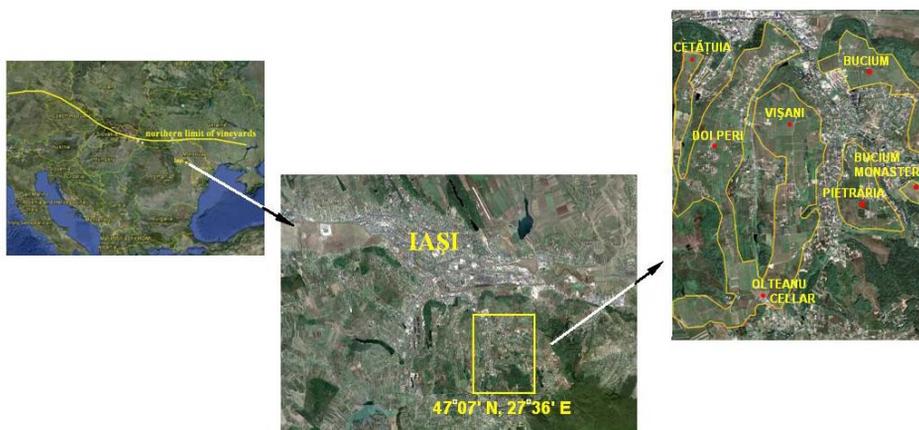


Figure 1- Bucium vineyard location

MAPPING VITICULTURAL POTENTIAL IN TEMPERATE CLIMATE AREAS

Although the vineyard has a long history (its wines were first mentioned in XVI century), her current situation is difficult, because of high real estate value that her lands acquired along with expanding living area outside the city. As a consequence, land owners abandon the vine culture and sell their terrains, situation that determine a gradual disappearance of vine plantations. As an attempt to prevent vineyard disappearance, we mapped the vineyard area, to identify the most suitable locations and submit the conclusions in order to maintain the traditional destination of the wine lands.

The study is based on a methodology implying remote sensing, GIS (Geographic Information Systems) and some ecological factors that influence growth and fruiting of wine varieties (Irimia and Patriche, 2009, 2010, 2011; Irimia and Rotaru, 2009). The GIS analyze of the vineyards is a rather new method, with certain specific characteristics depending on the methodology and the aim of the research (Smith and Whigham, 1999; Jones, 2004; Pythoud, 2006). To the GIS based methodologies, the suitability of the vineyards was assessed according to soil (Van Leeuwen *et al.*, 2004; Morlat and Bodin, 2006) and climate characteristics (Huglin, 1978; Smart and Dry, 1980; Teodorescu *et al.*, 1987; Jackson and Cherry, 1988).

MATERIALS AND METHODS

The identification and delineation of Bucium vineyard plantations, was

achieved using satellite images integrated in Google Earth. The digital terrain model (DTM), that represent the base for climatic and topographic factors modeling, has a 12,5 m resolution, and have been obtained by digitizing the contour of 1:25000 scale topographic maps. Climatic data were obtained from the FAO LocClim data base and the Iasi weather station. The soil data base is represented through 12 soil profiles, obtained by pedological study at 1:10000 scales, made by Pedological and Agrochemical Studies Office from Iași. A simple interpolation was performed to establish the local variation of clay content of the soil (inverse distance weighting – IDW) and a krigage after a regression with altitude for the humus content. The different operations were achieved using SIG ArcGIS 9.3 software.

The site suitability was assessed according to the values of 14 ecological factors and indicators, that are considered defining for quality of wine varieties production (Irimia and Rotaru, 2009): *the slope inclination, the slope exposure* (topographic factors); *annual average temperature, the hottest month average temperature, the sum of fractions of average daily temperatures above 10°C for the period from 1st April to 30 September (Σt_u °C), solar radiation, solar insolation, average rainfall for the period from 1st April to 30 September* (climate factors); *soil texture, humus content* (edaphic factors); *the length of bioactive period, the real heliothermal index (IHr), the bioclimatic index (Ibcv) and the index of oenoclimatic aptitude (IAOe)* (ecological indices). Spatial distribution maps were realized for each ecological factor analyzed.

The suitability of ecological factors and indices was noted by evaluation points (5, 8 and 10 points), depending on the influence that the factor exerts on the

growth and fruiting of wine varieties. By converting the ecological factors values in evaluation points a second series of maps was developed, as GIS raster layers. Within each layer, the points are distributed across the range of possibilities, with 5 points for low suitable values, 8 points for middle suitable values and 10 points for high suitable values. The areas where the ecological factors values are below the minimum threshold for grape-growing were noted with 0 points and were evaluated, in terms of economic efficiency, as unfavorable for viticulture. All 14 layers were added together and then divided by 14 to produce an average composite image which, by its construction, ranks sites numerically based on the combined attributes of the individual variables. Consequently, each pixel in the final ecological suitability map represents the average of the corresponding pixels of the ecological factors and indices maps. These average climatic suitability values were further grouped into the three classes of

suitability: 9-10 points = I class (high ecological suitability); 7-8 points = II class (moderate ecological suitability); 5-6 points = III class (low ecological suitability). The third class (III) reveals the potential for distillates, sparkling wines and white table wines; the second class (II) the ecological potential for white quality wines and red table wines; the first class (I) the ecological potential for quality red and white wines.

RESULTS

The local variation of ecological factors and indices was established using *digital terrain model* (DTM). For the ecological evaluation of the winegrowing area, the local variation of topographic, climatic and edaphic factors was analyzed. The climate study was completed with an analyze of *Huglin heliothermal index* local variation and with the frost exposed area mapping.

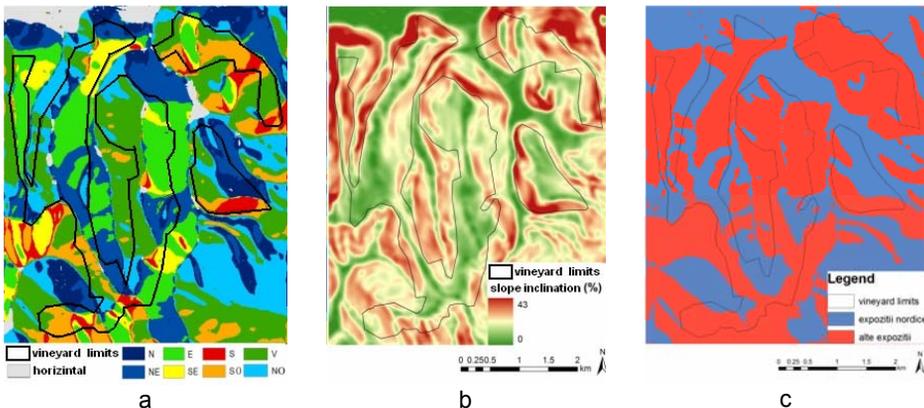


Figure 2 - Spatial distribution of topographic factors in Bucium vineyard: a. slope exposure; b. slope inclination; c. unfavourable exposures spatial distribution

Topographic factors. The slope inclination and slope exposure values

reveals the topographic complexity of the area (*Figure 2*). The high hills (up

MAPPING VITICULTURAL POTENTIAL IN TEMPERATE CLIMATE AREAS

to 349 m), with predominantly north – south orientation, and the north opened valleys limit the viticultural potential of the area. 30% of vineyard terrains has northern, north-eastern and north-western exposure, less favorable for grape growing in a northern vineyards as Bucium is. Regarding the exposure of the slopes, more than 58% of the vineyard area has eastern and western aspects, moderate favourable for grape growing, and only 11% south and south-eastern aspects, high favourable for grape growing.

Climate factors. The temperatures characterize the region as “cold”: the *annual average temperature* varies between 8,4°C at the hills level and rather 10°C on the valleys (*Figure 3*); the *July temperature* (the hottest month) varies between 19,5°C and 21,5°C, characterizing the region as favourable for quality white wines production. The *sum of fractions of average daily temperatures above 10°C for the period from 1st April to 30 September* (Σt_u °C) varying between 1086 and 1412 shows the potential for white wines production.

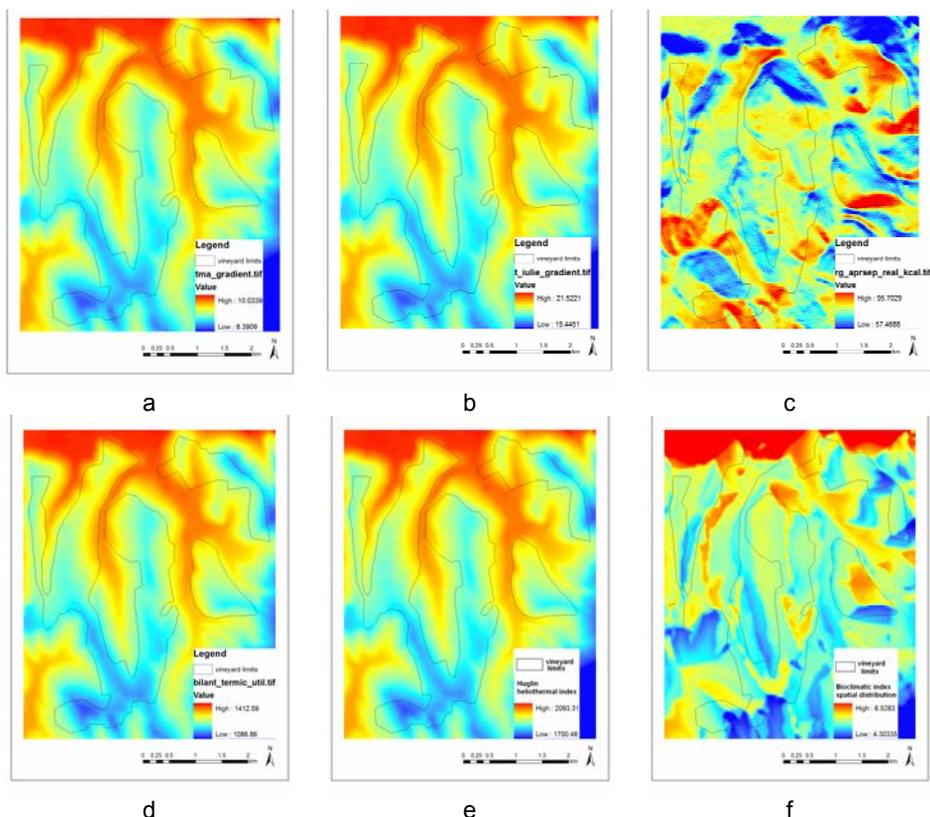


Figure 3 - Spatial distribution of climate factors in Bucium vineyard: a. annual average temperature; b. the hottest month average temperature; c. global radiation; d. solar insolation; e. Hugin heliothermal index (IH); f. bioclimatic index (Ibcv)

The *solar radiation* is highly favourable for wine varieties (>87 kcal/cm²/an) for more than 83% of the vineyard area, and unfavourable for grape growing (<83.9 kcal/cm²/an) for 17% of vineyard area. The *solar insolation* varies between 1076,3 and 1426,9 hours, less considered as less suitable for sugar, anthocians and aroma compounds accumulation. *Bioclimatic index*, with values varying between 4.5 and 6.5 characterize the vineyard climate as poor in heliothermal resources, as is the *Huglin heliothermal index*, whose values 1700 – 2093 define the topoclimate as temperate – cold (IH₂ – IH₃), suitable for early ripening (170 days) and middle ripening (180 days) grapevine varieties (i.e. Pinot gris, Chardonnay, Fetească albă, Sauvignon).

Edaphic factors. The soil type, texture and humus content are the three parameters considered to have a defining influence on wine quality. Concerning the *humus content*, the soils in the upper third of the slopes are less fertile, poor in humus (1,3 to 2%), with a clayey texture and fragments of calcareous rocks. These edaphic parameters are suitable for high quality white wines production. In the lower third part of the slopes, the soils have a higher humus content (up to 4,6%) and they are clayey. These characteristics reveal the aptitude only for table wines production.

The spatial distribution of the ecological suitability, according to topographic, climate and edaphic

factors. Combined analyze of the *topographic factors*, expressed through the average of evaluation points accorded to *slope inclination* and *slope exposure*, reveals that 34% of vineyard area is unfavourable for grape growing. This comprises northern, north-eastern and north-western slopes exposures and the frost exposed valleys (*Figure 4a*). Highest suitability for grape growing has the slopes with moderate inclination (8-15%) and south, south-eastern exposure that represent 28% of vineyard area: the eastern slope of Cetățuia wine land, the eastern slope of Doi Peri wine land, the eastern slope of Vișani wine land, the western slope of Bucium wine land, the southern slope of Pietrăria wine land and the plateau area closed to Olteanu Cellar. Must be noticed very reduced ecological suitability of the area around Olteanu Cellar (a natural amphitheatre with north, north-east and north-west exposure), of the north-eastern slope of Pietrăria wine lands and the entire western slope of Doi Peri wine land.

Concerning *climatic suitability*, 68% of the vineyard plantation fall in the II class, which means that it has favourable ecological conditions for producing white quality wines. In vineyard area are not registered values classified in the I-st class of suitability. The second class area cover the entire surface of Cetățuia and Doi Peri lands, the middle part of Vișani land, western slope of Bucium hill, and western and southern slopes of Pietrăria land (*Figure 4b*). The

MAPPING VITICULTURAL POTENTIAL IN TEMPERATE CLIMATE AREAS

lowest climatic suitability (III class) has the areas around Olteanu Cellar and Bucium Monastery.

In terms of *edaphic suitability*, 80% of analyzed area enter in the IIIrd class, that reveal the ecological potential for white table wines producing. A small percentage of the area (19,7%) enter, in terms of

edaphic suitability in II nd class. This area is situated at the southern limit of the wine growing centre, close to the Sarmatian limestones of Repedea Hill. These has a favourable influence on the wine quality. A small percent of these soils correspond to the southern slope of Pietrăria land, placed in that area (*Figure 4c*).

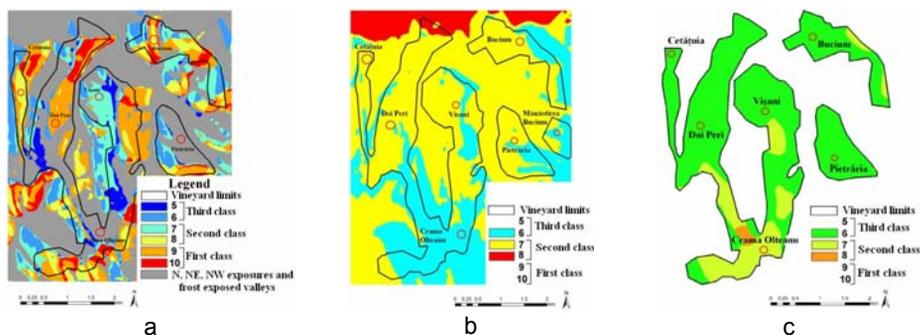


Figure 4 - The spatial distribution of suitability classes for ecological factors in Bucium vineyard: a. map of topographic suitability; b. map of climatic suitability; c. map of edaphic suitability.

The spatial distribution of viticultural potential defined by ecological conditions in their entirety. The study reveals that 30% of the surface (281 ha of 928 ha) is unfavourable for wine varieties, 34% (316 ha) fitted in the III rd suitability class and 36% (331 ha) in II nd ecological suitability class. In the winegrowing area were not recorded plots having I-st class viticultural potential characteristics, situation that limit the red wines production possibilities. As shown in *Figure 5*, the most valuable areas in terms of ecological suitability are Cetățuia wine land, the eastern slope of Doi Peri wine land, the eastern slope of Vișani wine land, the south-western

slope of Bucium wine land, southern slope of Pietrăria wine land and southern plateau of Olteanu Cellar wine land.

The satellite images (*Figure 6*) reveals that the most favourable plots from Cetățuia, Doi Peri and Bucium wine lands become gradually residential areas, which compromises the viticultural perspectives of Bucium vineyard. Areas less affected by urbanization perspectives are the western slopes of Vișani wine land, southern slope of Pietrăria plateau and the area from the south of Olteanu Cellar wine land. The most suitable area for grape growing in the entire Bucium vineyard is the southern slope of Pietrăria wine land which, in

addition to suitable climatic characteristics has calcareous soils, that have a favourable influence on

the quality of the grapes at wine varieties.

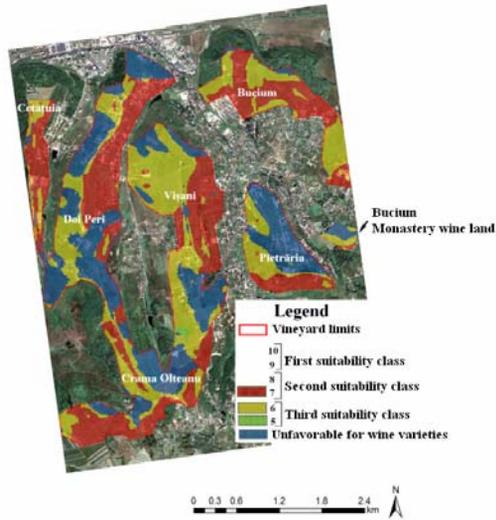


Figure 5 - The spatial distribution of ecological suitability for wine varieties growing in Bucium vineyard

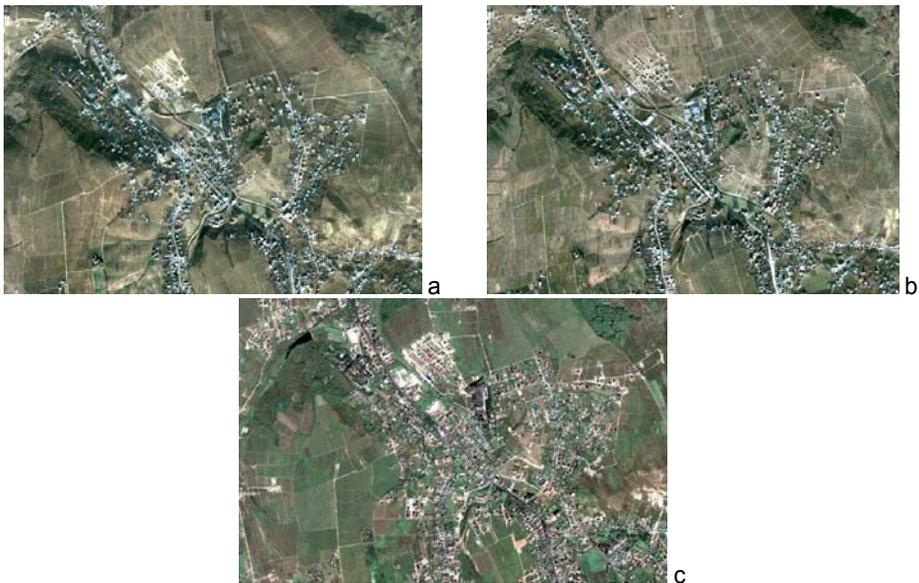


Figure 6 - Expansion of residential area into Bucium vineyard during the years 2003 – 2009: a. satellite image from 2003; b. satellite image from 2006; c. satellite image from 2009 (Google Earth source).

CONCLUSIONS

The aim of this study was to evaluate and map the most suitable areas from Bucium vineyard, through GIS analyze of topographic, edaphic and climatic conditions. The viticultural potential, expressed as average of cumulative influence of ecological factors, reveals that: 30% of the surface is unfavourable for grape growing; 34% has a limited potential, being suitable only for white table wines production; 36% has ecological suitability for producing quality white wines. The most suitable areas for grape growing, with a high potential for white quality wines production are Cetățuia wine land, the eastern slope of Doi Peri wine land, the eastern slope of Vișani wine land, the south-western slope of Bucium wine land, the southern slope of Pietrăria wine land and the plateau zone at the south of Olteanu Cellar wine land. The most favourable area for grape growing in the entire Bucium vineyard is the southern slope of Pietrăria land, which, in addition to high suitable climatic characteristics has calcareous soils, that exert a favourable influence on wine varieties, enhancing the quality of wines and giving them authenticity.

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