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EVALUATING THE ECOLOGICAL SUITABILITY OF THE VINEYARDS, BY USING *GEOGRAPHIC INFORMATION SYSTEMS* (GIS)

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ABSTRACT – In this scientific paper are presented the preliminary results of the research having as goal to establish a methodology for the determination of the oenoclimatic potential and its spatial distribution in the viticultural areas. Data were obtained by means of GIS technology and disclosed a new, original model for analysing the viticultural ecoclimate. The evaluation presented in this scientific paper was the result of processing and interpreting data concerning spatial distribution, individual influence and total influence of four ecological factors that determine the quality of grapes: *slope, aspect, solar radiation* and *real insolation.* Investigations were carried out in three stages: I. *Determination of the spatial distribution of ecological factors in the wine growing region*; II. *Determination of the ecological factors suitability and their distribution in the wine growing region*; III. *Determination of the oenoclimatic potential of the wine growing region and the graphical representation of its spatial distribution*. The distribution of ecological factors is represented by digital maps. The ecological factor suitability for grape growing was assessed according to a new evaluation system, and its distribution was represented graphically on the region map. The oenoclimatic potential was expressed by *the sum and the average of evaluation points* given to the ecological factors. We found that the sum of *evaluation points* has generated a detailed representation of the oenoclimatic potential, while the average *of evaluation points* gave a much clearer synthetic representation, allowing the identification and delimitation of highly favourable *terroirs*. The evaluation of the Avereşti wine-growing centre – Huşi vineyard (Vaslui County) has shown that 94.37% of its area was favourable for producing high quality white wines, 4.40% for producing quality white and red wines, while 1.19% was less favourable for wine growing. The maps showing the distribution of the oenoclimatic potential highlighted the

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location of valiant *terroirs* in the Avereşti wine growing centre.

Key words: vineyard, Geographic Information System, ecological suitability, climatic factors, spatial distribution, insolation, solar radiation, temperature, slope

REZUMAT – Determinarea distribuției spațiale a favorabilității ecologice pentru cultura viței de vie, prin utilizarea *Sistemelor Informaționale Geografice* (GIS). În lucrare sunt prezentate rezultate preliminare ale unor cercetări având ca scop evaluarea potențialului oenoclimatic al arealelor viticole. Studiul utilizează informații obținute prin intermediul tehnologiei GIS şi conturează un model nou, original, de analiză a ecoclimatului viticol. Evaluarea prezentată în lucrare a rezultat în urma prelucrării şi interpretării datelor privind distribuția spațială, influența individuală şi influența însumată a patru dintre factorii ecologici, care determină calitatea producției viticole: *panta terenului, expoziția versanților, radiația solară* şi *insolația reală*. Cercetarea a parcurs trei etape: I. determinarea distribuției spațiale a factorilor ecologici în cadrul arealului viticol; II. determinarea favorabilității factorilor ecologici şi a distribuției acesteia în cadrul arealului viticol; III. determinarea potențialului oenoclimatic al arealului viticol şi reprezentarea grafică a distribuției acestuia. Distribuția factorilor ecologici este reprezentată prin hărți digitale. Favorabilitatea factorilor ecologici pentru cultura viței de vie a fost evaluată cu ajutorul unui sistem de bonitare, iar distribuția sa, reprezentată grafic pe harta arealului. Potențialul oenoclimatic a fost exprimat prin *suma* şi *media notelor de bonitare* acordate factorilor ecologici. S-a constatat că suma notelor de bonitare generează o reprezentare detaliată a potențialului oenoclimatic, iar media notelor de bonitare o reprezentare sintetică, clară, ce permite identificarea şi delimitarea *terroir*-urilor cu favorabilitate ridicată pentru cultura viței de vie. Evaluarea centrului viticol Avereşti-podgoria Huşi (jud. Vaslui) relevă faptul că 94.37% din suprafața acestuia este favorabilă pentru producerea vinurilor albe de masă şi de calitate, 4.40% pentru producerea vinurilor albe şi roşii de calitate, iar 1.19% este puțin favorabilă pentru cultura viței de vie. Hărțile cu distribuția potențialului oenoclimatic relevă amplasarea *terroir*-urilor valoroase din centrul viticol Avereşti.

Cuvinte cheie: areal viticol, Sistem Informațional Geografic, favorabilitate ecologică, factori climatici, distribuție spațială, insolație, radiație solară, temperatură, pantă

INTRODUCTION

The *oenoclimatic potential* shows the suitability of a certain region for wine growing. It results from the interaction between *climatic, soil, lithological* and *geomorphological factors* and it is valorised by grape growing and proper vineyard technologies. The oenoclimatic potential varies in the wine growing region according to the geomorphological factors (*relief, altitude, slope* and *slope orientation*). Its influence is so important because it determines a zonal differentiation of the product categories in the region: fertile fields at *the base of slopes* are valorised by growing table grape varieties and table wine varieties; *the middle third of slopes* with weakly fertile soils and high values of heliothermal factors is the most suitable for quality wine production; *the upper third of slopes* and the cooler plateaus are proper for growing

varieties for sparkling and table wines. Because of the variability of the geomorphological factors, some locations of the vineyard are improper for wine growing, while the others have the potential for producing high quality wines.

Because of its variability in the wine growing regions and its influence on yield quality, the oenoclimatic potential was the subject of many studies (Huglin, 1978; Jordan, 1980; Smart and Dry, 1980; Seguin, 1983; Teodorescu *et al*., 1987; Jackson and Cherry, 1988; Van Leeuwen *et al.,* 2004; Morlat, 2006). Most of these authors have noticed the individual influence of ecological factors on wine production. In the last years, new research methods have issued, allowing the global evaluation of the oenoclimatic potential, respectively of the result concerning the interaction of factors that determine the suitability of a region for wine growing (Carbonneau, 1994; Smith and Whigham, 1999; Pythoud, 2006; Jones, 2004; Antoce *et al.,* 2007; Irimia and Patriche, 2009).

This scientific paper shows the preliminary results of some investigations concerning the evaluation of the oenoclimatic potential in wine growing regions, by using *Geographic Information Systems (GIS)*. At the present stage of our studies, we have evaluated the feasibility of the methodology; therefore, these results concerning the Avereşti wine growing centre are not peremptory.

WORKING METHOD

The Avereşti wine growing centre has an area of 600 ha and is situated in the Huşi vineyard (Vaslui County), on an interfluve plateau with the mean altitude of 280 m. The parameters of topoclimate have resulted from the *digital elevation model* (DEM, SRTM – USGS, 2004), resampled at a spatial resolution of 10 m. Thus, we have calculated and represented graphically *slope, aspect, solar radiation* and *real insolation*. The radiation characteristics were determined in two stages: I. Derivation of radiation parameters, except the nebulosity; II. Correction of radiation parameters by using insolation fraction *(*Patriche *et al*., 2009).

The oenoclimatic potential was determined according to suitability, spatial distribution and interaction of four ecological factors: *slope, slope orientation, solar radiation and real insolation.* We have estimated their influence in relation with the *ecological evaluation system* for grape growing suitability (Irimia *et al.,* 2009). The recorded values of the four ecological factors in the studied region were classified into suitability classes (*the third class - less suitable; the second class - average suitable; the first class - very suitable)* and were valued with *5 points (for the first suitability class), 8 points (for the second suitability class) and 10 points (for the third suitability class).* Subsequently, by the representation of the given points on the map, we have obtained the spatial distribution of the suitability of ecological factors. By summing up the points corresponding to a *pixel* in the digital maps, resulted the *sum of factor suitability*. By dividing the sum to four, resulted the *average suitability of factors*. Both values were regarded as the

"*oenoclimatic potential"* of the territorial micro-unit represented by a pixel (100 m^2 in the field). The spatial representation of *sums and averages of evaluation points* given to each pixel in the map shows the distribution of the oenoclimatic potential in the vineyard.

RESULTS AND DISCUSSION

1. Analysis of the spatial distribution of ecological factors.

We have studied four ecological factors: *slope, slope orientation, global radiation and real insolation* (*Table 1*).

Table 1 - Values and distribution of slope, slope orientation, solar radiation and real insolation in the Avereşti wine growing centre - Huşi vineyard

Ecological factor	Values	Percentage of the total area (%)	Ecological factor	Values	Percentage of the total area (%)
Slope (%)	0-5	65.688	Solar radiation (kcal/cm^2/ year)	76-80	0.548012
	5-10	26.976		80-85	4.847247
	10-15	5.258		85-90	39.00667
	15-20	1.835		90-93	55.59807
	20-25	0.221		-	-
	25-27	0.020		-	-
Slope orientation	N	1.412	Real insolation (hours/April - October)	1277-1300	0.002877
	NE	7.499		1300-1400	0.74219
	E	42.825		1400-1500	2.499856
	SE	12.263		1500-1600	7.265117
	S	9.905		1600-1700	39.89701
	SW	13.103		1700-1772	49.59295
	V	10.464		-	-
	NW	2.525		-	-

The slope is relatively uniform: more than 65% of the area is plane, having slopes between 0 and 5 %, while 26.9% has low slopes, until 10%. As concerns the wine varieties, high grape yields, but of low quality were obtained on plane fields. Only 7% of the area has moderate slope areas, of 10–15%, where quality fields could be obtained (*Figure 1*).

Figure 1 - Map of the slopes

The slope orientation is favourable to wine growing: 78.0 % of the plantations were found in south, southeast, southwest and east exposure fields, which are characterized by high values of global radiation and real insolation; 12.4 % of vine plantations were found in north, northeast and northwest exposure fields, improper for wine growing (*Figure 2*).

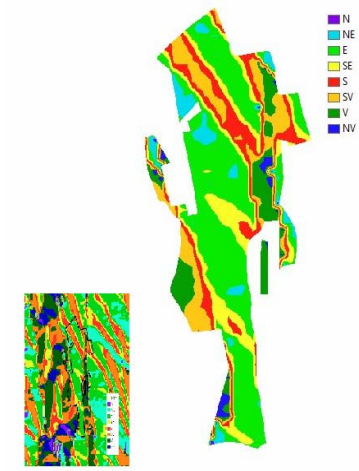

Figure 2 – The slope orientation map

Solar radiation. The wine growing region is situated in a high value area of solar radiation; on 55.59% of the area, radiation had values comprised between 90 and 93 kcal/cm^2/year, while on 39% of the area, between 85 and 90 kcal/cm^2/year (*Figure 3*). The highest values were recorded on south, southeast and southwest exposure slopes.

Real insolation. A percent of 89% of the area in the wine growing region had high insolation values, comprised between 1600 and 1773 hours (*Figure 4*). These are typical of the favourable regions for producing quality red wines. The highest values (1700-1773 hours) were recorded on south and east exposure slopes.

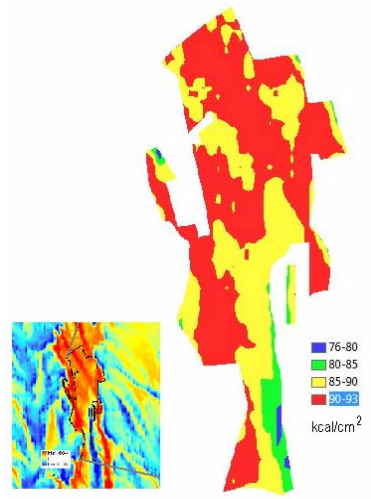

Figure 3 – Spatial distribution of solar radiation

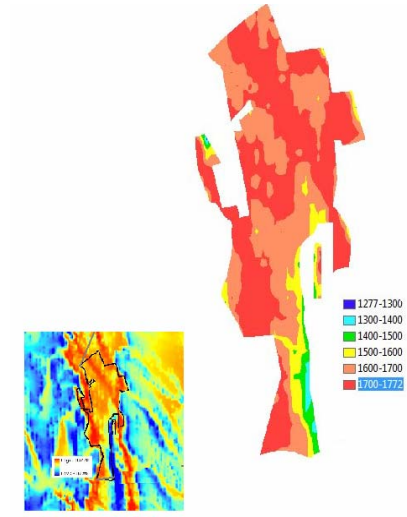

Figure 4 – Spatial distribution of real insolation

2. Evaluation of the suitability of ecological factors. The values of ecological factors were shown within the suitability classes established by the system of ecological classification of wine growing regions and evaluated by points (*Table 2)*.

By replacing values on maps with corresponding evaluation points, the spatial distribution of the suitability of the ecological factors was shown within the wine growing region (*Figure 5*).

Table 2 – Classification of the slope, slope orientation, solar radiation and real insolation, according to the ecological evaluation system for grape growing suitability (Irimia *et al.*, 2009)

Ecological factor	Suitability classes/ points		
	III/5	II/8	I/10
Solar radiation (kcal/cm^2, 1 April-30 September)	80 - 83.9	84.0 - 86.9	87.0 - 92
Real insolation (hours)	1300 - 1450	1451 - 1550	1551 - 1610
Slope (%)	< 8	> 15	8 - 15
Slope orientation	W	E, SW	S, SE

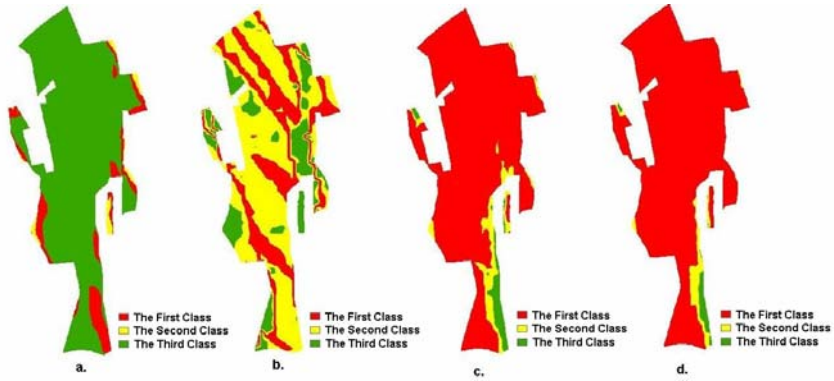

Figure 5 – Spatial distribution of the suitability of the ecological factors in the Avereşti wine growing centre:
a. slope; **b.** slope orientation; **c**. solar radiation; **d.** real insolation

Interpretation of the spatial distribution of the ecological factors suitability:

- *Slope*: more than 80% of the area, represented by plane lands, was found in the third suitability class, which allows obtaining table wines, wines used as raw matter for sparkling wines and for distilled beverages; a percent of 15% of the area, corresponding to moderate slope fields, was found in the first suitability class, while the difference of 5% (high slope fields), in the second class;

- *Slope orientation*: south and southeast oriented slopes, representing 22.16% of the region, were found in

the first suitability class; a percent of 55.9% of the area belonged to the second suitability class, while 10.46%, to the third suitability class. The difference of 11.48% is represented by north, northeast and northwest orientation fields, which are improper to wine growing;

- *Solar radiation*: a percent of 55.59 % of the area was found in the first suitability class that allows getting quality white and red wines; a percent of 39% of the area was found in the second suitability class, for getting quality white wines and table red wines; the 6% difference was partially found in the third suitability class, while a low percent was improper to wine growing.

The values of *real insolation* were also high, favourable for obtaining quality wines: about 96% of the area was found in the first suitability class, while the 4% difference, in the second class.

We found that by the individual evaluation, each factor, except the field slope, was very suitable to wine growing. However, the oenoclimatic potential being the result of interaction between the ecological factors, the evaluation of factor global action was required.

3. Spatial distribution of the *oenoclimatic potential* in the wine growing region. The *oenoclimatic potential* was expressed by *sum* and *average of evaluation points* given to a pixel ($100m^2$ in the field) of the digital map.

The sum of evaluation points generates a detailed graphic representation of the spatial distribution of the oenoclimatic potential in the Averesti wine growing centre (*Figure 6a*).

In this case, the first suitability class includes the fields having a score between 36 and 40 points; the second class includes the fields, which sum is between 28 and 35 points, while the third class, the fields having a sum comprised between 20 and 26 points. The fields that have a lower sum than 20 points are improper for wine growing, because at least one of these factors is restrictive for wine growing.

The average of evaluation points generates a synthetic representation of the spatial distribution of the oenoclimatic potential, allowing the clear delimitation of *terroir*s (*Figure 6b*). In that case, the first suitability class includes fields having the average of 9 – 10 points; the fields with the average of 7 - 8 points are found in the second class, while the fields with the average of 5 - 6 belong to the third class. If the average of classification points is lower than 5, the field is improper for wine growing, because at least one of the factors is restrictive (it cannot receive 5 points).

As concerns the *structure of the oenoclimatic potential* of the Avereşti wine growing region, estimated according to the interaction between four of the 15 ecological factors and indicators, used for the classification system, we noticed (*Table 3*):

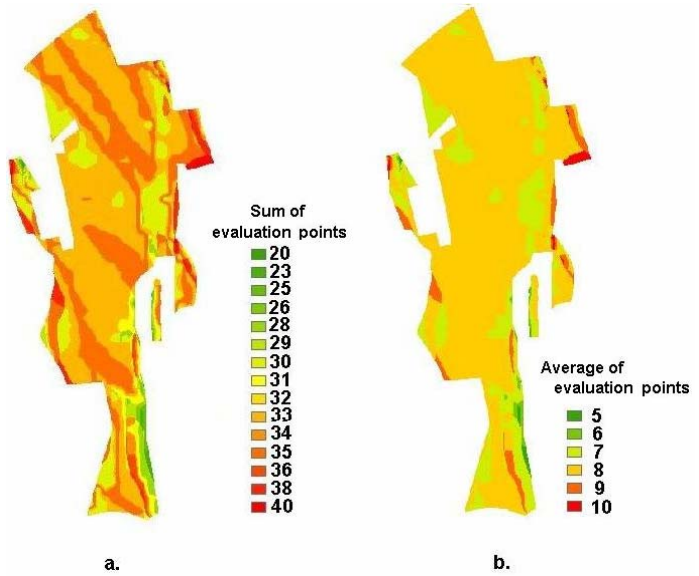

Figure 6 – Spatial distribution of the oenoclimatic potential in the Averesti wine growing centre: a. expressed evaluation by the sum of evaluation points; **b.** expressed evaluation by the average of evaluation points

Table 3 – Structure of the oenoclimatic potential in the Avereşti wine growing region, shown by the *sum* and the *average of evaluation points* given to four ecological factors (slope, slope orientation, solar radiation and real insolation)

Sum of points	Class	Percentage of the total area (%)			Average of points	Class	Percentage of the total area		
		%		ha			%		ha
20	III	0.0589	1.18	7.08	5	III	0.4084	1.18	7.08
23		0.3495							
25		0.3380			6		0.7896		
26		0.4516							
28	II	1.7504	94.3	565.8	7	II	17.858	94.3	565.8
29		0.9694							
30		11.654							
31		3.4836							
32		0.0632							
33		47.019			8		76.524		
34		1.0327							
35		28.408							
36	I	1.2772	4.40	26.4	9	I	3.6491	4.40	26.4
38		2.3718							
40		0.7695			10		0.7695		

- A percent of 94.37% of the area (565.8 ha) is found in the second suitability class, allowing the production of quality white wines and red table wines;
- A percent of 1.19 % of the area (7.08 ha) has a low oenoclimatic potential (the third suitability class) and it is proper for the production of white table wines and sparkling wines;
- A percent of 4.40 % of the region (26.4 ha) has high oenoclimatic potential (the first suitability class), appropriate for producing white and red quality wines.

CONCLUSIONS

The suitability distribution of ecological factors in the Avereşti wine growing centre was determined by the help of digital elevation model (DEM), resampled at a spatial resolution of 10 m.

The *system of ecological evaluation of the vineyard* allows the quantification of the influence of ecological factors on yield quality and data transfer to the *Geographic Information System* (GIS), for their processing, analysis and graphic representation.

The oenoclimatic potential was expressed by the *sum* and the *average of evaluation points* given to the ecological factors that interact within the wine growing area.

The *sum of evaluation points* generated a detailed representation of the oenoclimatic potential, while the *average of evaluation points* – a clearer synthetic representation, allowing us to view and delimit the most favourable *terroirs* for wine growing.

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