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STUDIES OF BONITATION AND LAND EVALUATION IN MURFATLAR, CONSTANTA COUNTY, ROMANIA, USING GIS TECHNIQUES

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Abstract

This paper aims to present the land quality and productivity of the administrative territorial unit of Murfatlar, Constanța County, located in south-east of Romania, an area well known for its vineyards, while used for specific purposes, such as agricultural destinations. The assessment is based on the analyses of climate (temperature and precipitation), soil (type, texture, reaction, gleization, presence of microforms and water), relief (slope), as well as other aspects of land, and their interpretation in order to determine the fertility of the site and its suitability for cultures (such as wheat, canola, corn, etc.). For the results and discussions phase, the soil bonitation note was calculated and a qualitative classification map was made to illustrate the potential productivity level. However, due to the fact that the soil evaluation is developing under both natural and human-caused environmental changes, the bonitation note needs to be revised often.

Key words*: land quality and productivity assessment, bonitation, suitability, Geographic Information System, classification.*

INTRODUCTION

Land evaluation is a complex action of examining and analysing various factors to determine the productivity level of a particular site. The process is accomplished by calculating certain elements after each of them has been given a score (between 0 and 1) beforehand. These scores represent a numerical value to indicate the amount of benefit they provide.

Among the indicators usually taken into consideration, the following were studied, as they are more significant and more precisely measurable: temperature, precipitation, soil type and texture, gleization, slope, presence of water, affected surfaces.

The bonitation note is obtained by multiplying the result of the previously mentioned indicators by 100, as following:

$X = (a*b*\ldots*n) * 100$, where X is the bonitation note, while a/b/n are the indicators' value (Biali & Popovici, 2006).

The principle which is the basis of the bonitation note is that each characteristic is appreciated under the aspect of favourability. After the bonitation note was calculated, five classes were established to express the fertility of the site.

This article suggests a way to integrate the presented information using GIS (Geographic Information System) techniques for Murfatlar (known as "Basarabi" between 1924-1965 and 1980-2007), a city in Constanța County, Dobrogea, located in south-east of Romania. The administrative territorial unit is composed of Murfatlar (the residence) and the village of Siminoc.

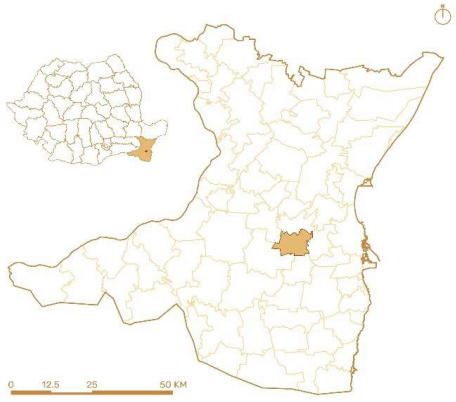

Figure 1. Map showing the location and outline of the study area. Source of vectors: geoportal.ancpi.ro

The area has an irregular shape, while the city was formed and developed in a complex natural region.

Murfatlar is very well known for its vineyards, with multiple varieties of vine, the site having certain particularities due to the geographical position. The vineyards are located between the Danube and the Black Sea, in the centre of Dobrogea Plateau, with predominantly southern and southwestern exposures.

The temperate continental climate, the diversity of the location of the vineyard plantations, the protective effect of the relief against the predominantly north-eastern cold currents, the favourable influence of excessive neighbourhood, offer the Murfatlar vineyard a particularly favourable microclimate for the production of a wide variety of wines.

The city also has a protected area of national interest corresponding to the IUCN (International Union for Conservation of Nature) category IV (floristic and faunal nature reserve). The Fântânița-Murfatlar nature reserve was placed under protection in 1932. Since 1962 the reserve has been protected by law and in 2000 was declared a protected area, identified with the site code ROSCI0083 in the Natura 2000 network.

Another attraction is represented by the monastic cave complex, one of the oldest places of worship in Romania, being excavated in a chalk hill located near the chalk quarry in Murfatlar.

For a better comprehension of the site, I realised a land use map for the administrative territorial unit which shows the variability of the functions.

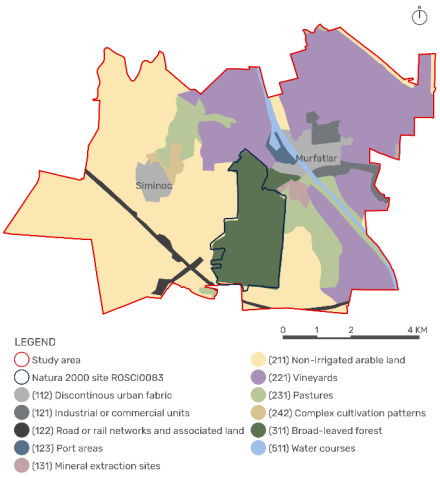

Figure 2. Land use map according to CORINE Land Cover 2018. Source of vectors: land.copernicus.eu

As shown above, the vineyards are on either side of The Danube - Black Sea Canal (represented as a "water course"), with a "port area" in vicinity. The broad-leaved forest assimilates with the Natura 2000 site. The south and south-east of the administrative territorial unit are composed of arable lands.

MATERIALS AND METHODS

Each characteristic (temperature, precipitation, soil type, texture, gleization, slope, affected surface) was analysed and received a score according to a bonitation scale (Figure 3).

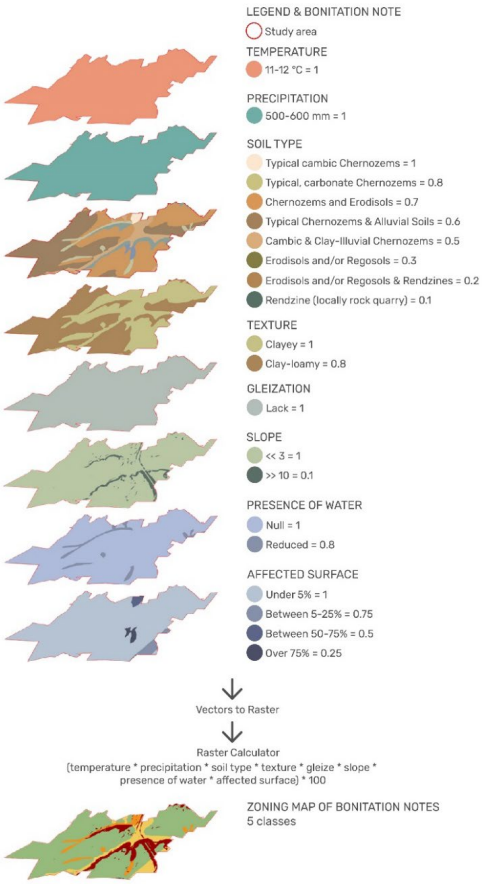

Figure 3. Diagram illustrating the map overlay process used to evaluate potential agricultural fertility

To determine the bonitation scale, multiple resources were taken into consideration, especially the methodology of pedological studies.

The study used only open-source materials (such as vectors and the EU-DEM from Land Copernicus), while the collected data was processed in QGIS and ArcMap software.
The vectors were transformed into raster in order to calculate the bonitation note and to make the qualitative classification map. Therefore, the interpretation of the results took place, to gain insights into the site's agricultural value and ecological status.
This type of information can be used for management planning or conservation strategies.
It's important to note that specific bonitation methodologies can vary depending on the purpose of the assessment and regional practices. Different countries and organizations may have their own guidelines and standards for conducting bonitation studies.

RESULTS AND DISCUSSIONS

The city's climate is part of central Dobrogea, characterised by continentality, with large diurnal and annual oscillations of air temperature, low amounts of precipitation.
The presence of The Danube - Black Sea Canal contributes to a permanent evaporation of water, ensures the humidity of the air and regulates the heating, while the relative proximity of the sea influences the circulation of air masses.
The frequent torrential nature of the rains, resulting in floods, is recorded as a specific phenomenon. However, the town benefits from a pleasant climate, determined by its geographical location and relief.

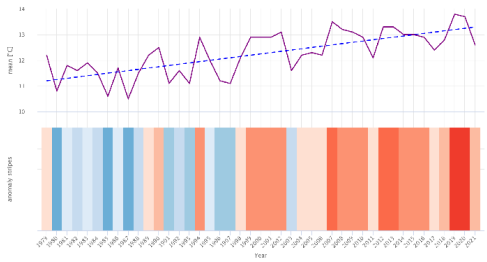

Figure 4. Mean yearly temperature in Murfatlar.
Source: meteoblue.com

The data above (Figure 4), provided by Meteoblue, show the trend and anomaly of temperature.
The blue dotted line represents the linear trend of climate change. As the trend line is upward from left to right, the temperature trend is positive and warming in Murfatlar due to climate change.
At the bottom, the graph shows the so-called anomaly stripes. Each coloured band represents the average temperature for a year, blue for colder years and red for warmer years. Thus, it is clear that in the past two decades the temperature has risen, the effects of climate change are already well visible through more frequent extreme weather events such as heat waves, drought, floods and storms.
As the average annual temperature for Murfatlar is higher than the mean for the country, with more than 11°C, it received the score 1 in the bonitation scale (Table 1).

Table 1. Bonitation scale for rating the temperature

Temperature (°C)			
11-12	10-11	9-10	8-9
1	0.9	0.8	0.7

For the precipitation, the trend (blue dotted line) is set at 533.5 mm, with clear ups and downs. As the line is horizontal, no clear trend can be determined. The below graph shows the anomaly stripes. Each coloured band represents a year's total rainfall, green for high rainfall and brown for drier years.

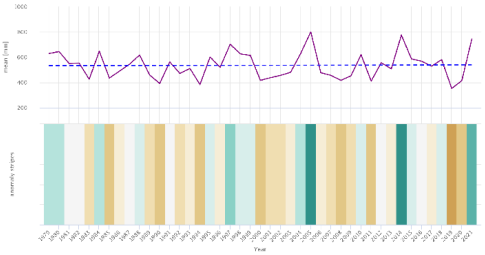

Figure 5. Mean yearly precipitation in Murfatlar
(Source: meteoblue.com)

The temperature and the precipitation are deeply correlated. In the warmer years, the rainfall registered was low, while in colder years the precipitation' quantity was higher.
As the precipitation' trend line is between 500-600 mm, and the listed values are more or less close, it got the score 1 in accordance with the bonitation scale (Table 2).

Table 2. Bonitation scale for rating the precipitation

Precipitation (mm)		
500-600	400-500	600-700
1	0.9	0.8

In Murfatlar there are numerous soil types, 11 to be precise (Figure 6).

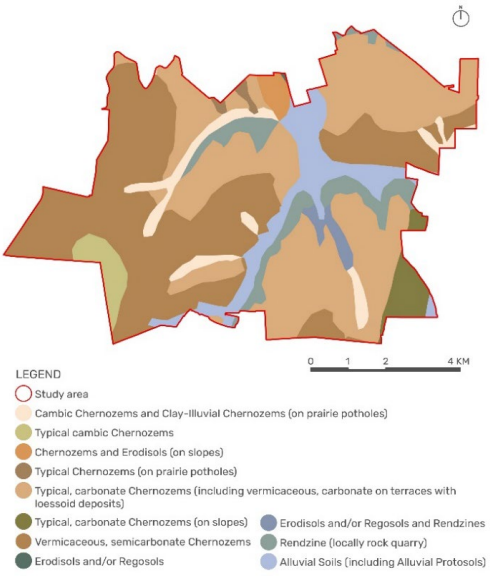

Figure 6. The soil map of the study area.
Source of vectors: geo-spatial.org

There are varieties of Chernozems, which are the most common and represent the fertility of the site. However, there are also Erodisols, Regosols and Rendzines, especially in the vicinity of the Danube - Black Sea Canal and the monastic cave complex.
The highest score of 1 in rating the soil type was received by typical cambic and vermicaceous, semicarbonate Chernozems.
The score of 0.8 was for Chernozems on slopes and on terraces. In-between (with 0.5-0.7) are the Chernozems on prairie potholes, while Erodisols and Regosols got 0.2-0.3.
The Rendzine (locally rock quarry) is the most unsuitable for agriculture, therefore it received the score 0.1 according to the bonitation scale (Table 3).

Table 3. Bonitation scale for rating the soil type

Soil type						
Chernozems	Cambic Chernozems	Brown Soils	Argilluvisols	Alluvial	Protosol	Gleic
1	1	0.8	0.7	0.7	0.5	0.1

Across the administrative territorial unit there are two main textures (Figure 7), clayey and clay-loamy.

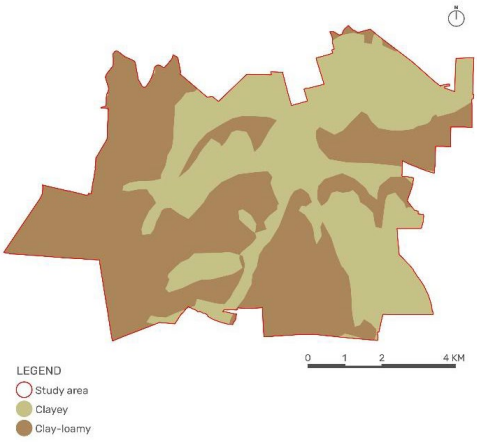

Figure 7. The texture of the study area

Conforming to the bonitation scale (Table 4) the clayey texture received a score of 1 and the clay-loamy texture received 0.8.

Table 4. Bonitation scale for rating the texture of soil

Texture					
clayey	clay-loamy	clay-sandy	loamy	sandy-loamy	sandy
1	0.8	0.7	0.6	0.5	0.4

Soil gleization represents a soil formation process which results in the development of glei horizon in the soil profile, due to poor drainage condition (depression land), impervious soil parent material, lack of aeration and more (Singh & Chandran, 2015, p. 76). This type of soil is inappropriate for agriculture.
In Murfatlar there is an absence of gleization, therefore it got the score 1 (Table 5).

Table 5. Bonitation scale for rating the gleization

Gleization				
lack	small	small -medium	medium	huge
1	0.8	0.6	0.4	0.1

The altitude in Murfatlar is low, of the plain, with values between 2.52 m and 121.40 m, as suggested by the EU-DEM, a digital surface model (DSM), shown below.

Murfatlar is located on the Pre-Balkan Dobrogean platform, the relief being formed by gentle slopes and valley confluences.
In Murfatlar, the valleys of Seacă, Basarabi, Șerpelea and Siminoc converge, all tributaries of the Danube-Black Sea Canal, with development works on the lower course and in the confluence area.
Here are three district forms of relief: hills 80-130 m (Maltezeanu), mounds 15-80 m (Siminoc), valleys (Carasu, Siminoc, Șerpelea).

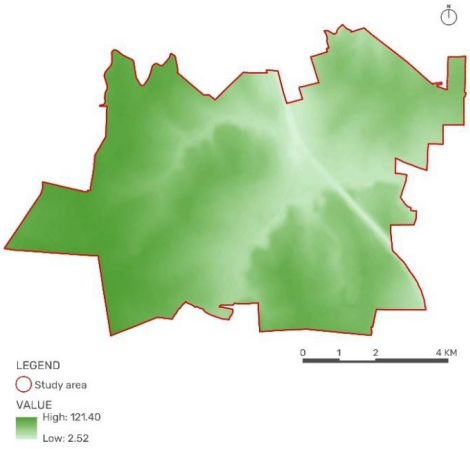

Figure 8. DSM (Digital Surface Model) of Murfatlar.
DSM source: EU-DEM - land.copernicus.eu

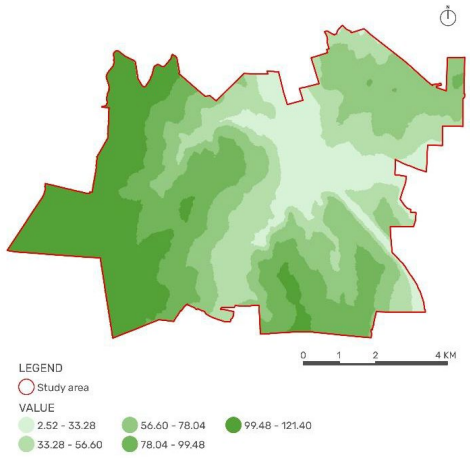

Figure 9. Classified DSM (Digital Surface Model) of Murfatlar using the ArcMap software.
DSM source: EU-DEM - land.copernicus.eu

The study area has a generally smooth slope, but it was categorized into two main classes based on the steepness of the terrain. Steeper slopes can potentially cause erosion and affect soil moisture levels.
The slope in Murfatlar (represented in Figure 10) in usually much less than 3 degrees, which means a score of 1.

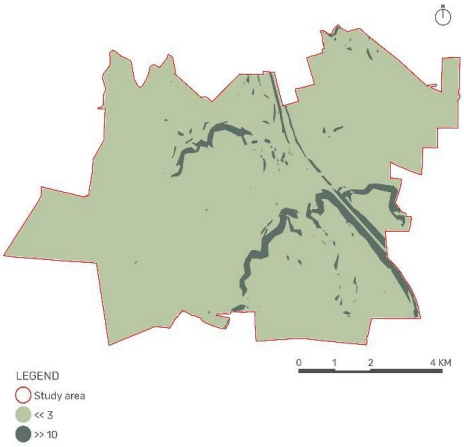

Figure 10. Slopes in the administrative territorial unit

However, along the Danube - Black Sea Canal, due to the excavations, as well as in the proximity of the chalk hills, the slope gets steep (much more than 10 degrees), meaning a score of 0.1 in accordance with the bonitation scale (Table 6).

Table 6. Bonitation scale for rating the slope

Slope (degrees)			
<< 3	3-5	5-10	>> 10
1	0.8	0.6	0.2

The presence of water (Figure 11) is mainly null, with some areas where it is reduced. These reduced zones are at the confluence of steeper altitudes and on specific Clay-Illuvial soils on prairie potholes.
The null area got the 1 score, while the reduced presence of water surfaces received the score 0.8 (Table 7).

Table 7. Bonitation scale for rating the presence of water

Presence of water			
null	reduced	big	huge
1	0.8	0.4	0.2

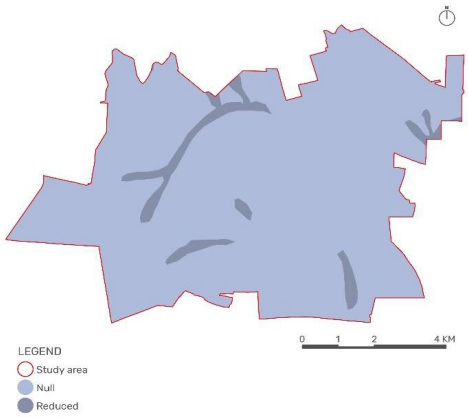

Figure 11. Presence of water in Murfatlar

The affected surface is presented below in the Figure 12.

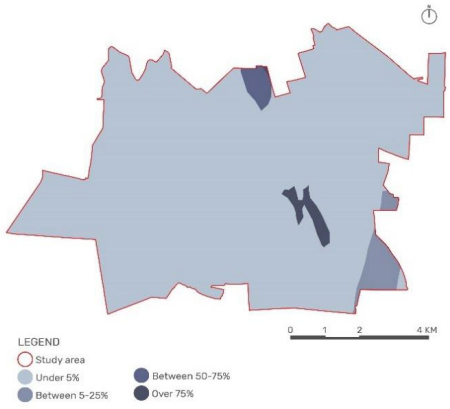

Figure 12. Affected surface around Murfatlar

The most affected surface (over 75%) is close to the chalk hills around the monastic cave complex and Murfatlar Chalk Lake, which received the lowest score of 0.25 (Table 8). In general, the study area is not affected and has 1. It is shown that the affected surfaces are on edges because of the lower altitude, between 5-25% in the south-east corner and between 50-75% in central-north (which assimilates with the Chernozems and Erodisols soil on slopes).

Table 8. Bonitation scale for rating the affected surface

Affected surface (%)			
0-5	5-20	20-50	50-70
1	0.8	0.6	0.3

After calculating the bonitation note of all the elements presented above, the next step was to use the Raster Calculator method in GIS to establish five pretability classes, colours represented from very low to very high pretability for cultures (wheat, canola, corn).
In the qualitative classification map (Figure 13) are also shown the circulations (roads and railroad), water courses and irrigation canals, for a better understanding of the surroundings.

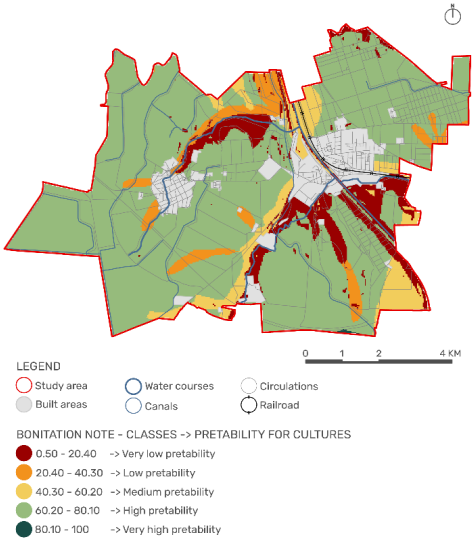

Figure 13. The qualitative classification map of Murfatlar based on the bonitation note

As graphically represented, Murfatlar has a high pretability (light green) across its surface which assimilates with the existing vineyards and arable lands. The very high pretability (dark green) is little represented in the south-east area. The in-between classes (low - orange and medium - yellow pretability) are almost equally illustrated.
The very low pretability (red) is pictured around built areas and the canal, as well as the chalk hills, which is well argumented with the slopes and anthropic surfaces.
For a more detailed interpretation, a map (Figure 14) picturing both the resulting qualitative classification layer and the CORINE land cover layer was made, to determine whether the current land use is fully exploiting the potential of the area regarding the specific crop cultivation.

The qualitative classification layer is represented with a stripped pattern to see through the land use characteristics.
It is shown that the current land cover takes advantage of the suitability of the site. For example, most of the surface of the vineyards and arable land has a high pretability, while the urban fabric shows a very low pretability.
Such analysis integrate spatial data and overlaying these layers could encourage management decisions and strategies.

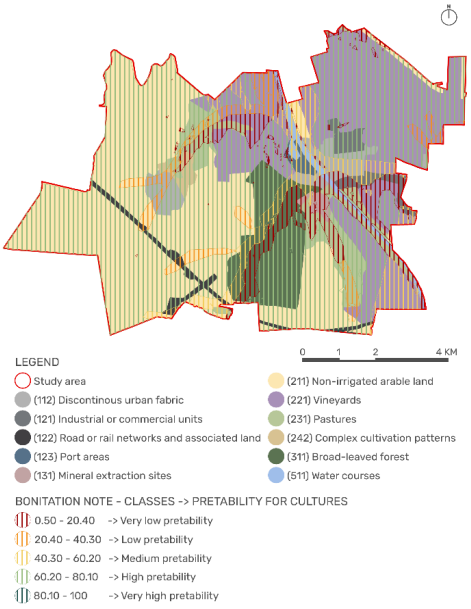

Figure 14. Map showing the overlay of land use and the qualitative classification

CONCLUSIONS

The administrative territorial unit of Murfatlar has multiple resources and benefits from the natural complex region. After making the qualitative classification map, the following step was to reclassify and convert the raster to vector (shapefile) in order to calculate the area.
The assessment of agricultural land and its suitability highlighted the classification (Figure 15), in a proportion of 10% in the first class - very low pretability, 5.3% for the second - low pretability, 9.4% in the third category with medium pretability and 74.8% with high (good) pretability, while just 0.05% has a very high (great) pretability.

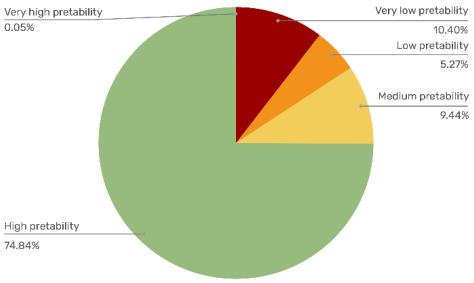

Figure 15. Statistical graphic to illustrate numerical proportion

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