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# MODELLING AVERAGE ANNUAL TEMPERATURE THROUGH G.I.S. TEHNIQUES

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***Abstract***

*The temperature is one of the most important climatic factors when it comes to land reclamation. The aim of this paper is modelling the average annual temperature for the year 2015 in Romania, in order to have information regarding the recorded values within the perimeter of the Horticultural Research Station, Cluj-Napoca. For the study area, a complex database will be created using spatial analysis specific factors. Spatial distribution of air temperatures is influenced by altitude, respectively there is a dependency between these two factors: air temperature decreases as the altitude increases. Thus, utilizing the data from the meteorological stations, the analysis aims to realize with the help of G.I.S. (Geographic Information Systems) techniques a map containing the average annual temperature for the year 2015 within the study area. The results obtained by this study indicate a temperature between 9.9 and 10.7ºC.*

***Key words:*** *G.I.S., Horticultural Research Station from Cluj-Napoca, modelling, temperature.*

## INTRODUCTION

The temperature is one of the most important climatic factors when it comes to land reclamation (irrigation, drainage, soil erosion and landslides).
The factor with the highest share in the formation of excess moisture is the climate through its main elements, precipitation, temperature and evapotranspiration. According to Pleşa et al. (1980), Romania was divided, depending on these factors into three climatic zones: the wet zone(annual temperature between 4-9° C), sub-humid zone (8-11°C) and dry zone (values between 10-11.5° C).
From the factors which influence the size of the irrigation regime elements, the temperature is also included (Mureșan et al., 1992). The temperature can play a decisive role in triggering and the evolution of landslides, high temperature values generating soil water evaporation, which leads clay lands to crack. Temperature influences the erosion process in two ways: physically (by producing frost and thaw, the soil structure being affected) and chemical (rocks are favoured for decomposition). Thus, the temperature by sudden changes favour the phenomenon of disintegration, which prepares the material to be dislodged and to be transported by leakageand also helps to trigger the process of erosion by the sudden melting of the snow (Dîrja, 2000).
Also, the temperature is a determining factor in terms of the potential suitability of territory to different types of farming.
Modelling the temperature targeted a large surface (Romania) afterwards to determine the average annual temperature to a small surface (Horticultural Research Station Cluj-Napoca) (Figure 1).

Figure 1. Horticultural Research Station Cluj-Napoca (Source: Google Earth)

## MATERIALS AND METHODS

In order to obtain a characterization of the targeted area in terms of climate (temperature), were used the values recorded in the 23 essential meteorological stations of Romania, stations that measure in addition to air temperature, the atmospheric pressure, relative air humidity, rainfall, wind direction and speed, snow depth or duration of sunshine.

The 8395 records, provided by the National Meteorological Administration were processed, ultimately resulting the average annual temperature values (2015) related to each station. Regarding the modelling, the regression equation was identified by using the Microsoft Excel utility, describing with a high accuracy the relation between the temperature and the altitude. It was then integrated into the GIS environment using the Spatial Analyst toolbox of the specialized software ArcGIS 10.1. The used database within this study is presented in the following table:

Table 1. Database

| *Graphical* |
|---|
| Digital Elevation Model<br>Resolution: 25 m |
| Study area, National and county borders, Territorial Administrative Units |
| Meteorological station locations, County capitals |
| *Numerical* |
| The values of average annual temperature for each station (° C) |
| Station altitude (m) |

## RESULTS AND DISCUSSIONS

The data provided by the National Meteorological Administration contain records regarding the minimum temperature, maximum temperature and average temperature for each day. For each meteorological station the first values which were determined were the average monthly temperature values. The Cluj-Napoca station data are presented in Table 2.

Table 2. Average monthly and annual temperatures, Cluj-Napoca Station

| *Cluj-Napoca Station* | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Month* | | | | *Average Monthly Temperature($^0$C)* | | | |
| January | **-0.6** | April | **9.1** | July | **21.5** | October | **9.2** |
| February | **0.1** | May | **15.0** | August | **21.5** | November | **5.9** |
| March | **5.2** | June | **18.7** | September | **16.9** | December | **1.2** |
| *Average Annual Temperature(AAL) ($^0$C)* | | | | **10.3** | | | |

After processing the temperature values recorded in each of the 23 stations the average annual temperature was calculated (Table 3).

Table 3. Meteorological Stations

| *CODST* | *Name* | *County* | *ALT (m)* | *LAT* | *LONG* | *AAL2015 (° C)* |
|---|---|---|---|---|---|---|
| 15335 | Tulcea | TL | 4.36 | 45.1906 | 28.8242 | 12.6 |
| 15360 | Sulina | TL | 12.69 | 45.1622 | 29.7269 | 12.6 |
| 15480 | Constanța | CT | 12.8 | 44.2139 | 28.6456 | 13.3 |
| 15460 | Călărași | CL | 18.72 | 44.2058 | 27.3383 | 12.9 |
| 15310 | Galati | GL | 69 | 45.4731 | 28.0322 | 12.5 |
| 15090 | Iasi | IS | 74.29 | 47.1633 | 27.6272 | 11.6 |
| 15410 | Drobeta Tr.Severin | MH | 77 | 44.6264 | 22.6261 | 13.5 |
| 15420 | Buc-Băneasa | B | 90 | 44.5106 | 26.0781 | 11.9 |
| 15350 | Buzău | BZ | 97 | 45.1328 | 26.8517 | 12.6 |
| 15470 | Roșiorii de Vede | TR | 102.15 | 44.1072 | 24.9786 | 12.4 |
| 15200 | Arad | AR | 116.59 | 46.1336 | 21.3536 | 12.3 |
| 15020 | Botoșani | BT | 161 | 47.7356 | 26.6456 | 11.5 |
| 15150 | Bacau | BC | 174 | 46.5578 | 26.8967 | 11.0 |
| 15450 | Craiova | DJ | 192 | 44.3103 | 23.8669 | 12.4 |
| 15346 | Rm. Vîlcea | VL | 237 | 45.0889 | 24.3628 | 12.4 |
| 15230 | Deva | HD | 240 | 45.865 | 22.8989 | 11.4 |
| 15292 | Caransebeș | CS | 241 | 45.4167 | 22.2292 | 12.0 |
| 15120 | Cluj-Napoca | CJ | 410 | 46.7778 | 23.5714 | 10.3 |
| 15260 | Sibiu | SB | 443 | 45.7894 | 24.0914 | 10.4 |
| 15015 | Oc.Șugatag | MM | 503 | 47.7769 | 23.9406 | 9.7 |
| 15170 | Miercurea Ciuc | HR | 661 | 46.3714 | 25.7725 | 7.1 |
| 15108 | Ceahlău Toaca | NT | 1897 | 46.9775 | 25.9500 | 2.2 |
| 15280 | Vf. Omu | PH | 2504 | 45.4458 | 25.4567 | -1.0 |

The meteorological stations are evenly distributed all over Romanian territory (Figure 2).

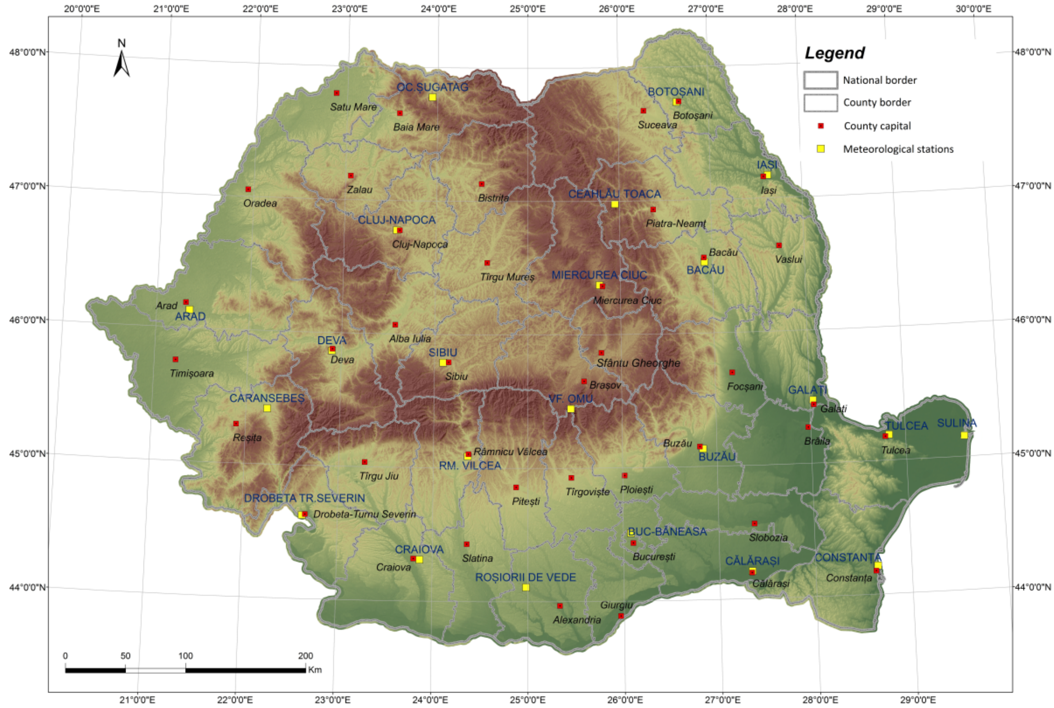


Figure 2. The location of the meteorological stations

The strength of the relationship between the altitude (x) and temperature (y) variables is expressed by the coefficient of determination, r2.

It is the proportion of the variation in the y variable that is explained by the variation in the x variable. r2 can vary from 0 to 1. Values near 0 meanthere is very little relationship between x and y, while values near 1 mean the y values fall almost right on the regression line (www.biostathandbook.com).

Regarding the temperature-altitude relation, several regression functions were applied by ensuring that the value of the coefficient of determination r2 is closer to 1.

Thus the following regression types were analysed:

- Linear regression ($r^2$= 0.9656)
- Polynomial, order 2 ($r^2$ = 0.9703)
- Polynomial, order 3 ($r^2$= 0.9704)
- Logarithmic ($r^2$= 0.5494).

By analysing the values ofr2, an order 3 polynomial function was chosen.

The dependency between the average annual air temperature and the altitude can be observed in Figure 3, where it can be noticed that the altitude explains 97.04% of the spatial variability of the temperature.

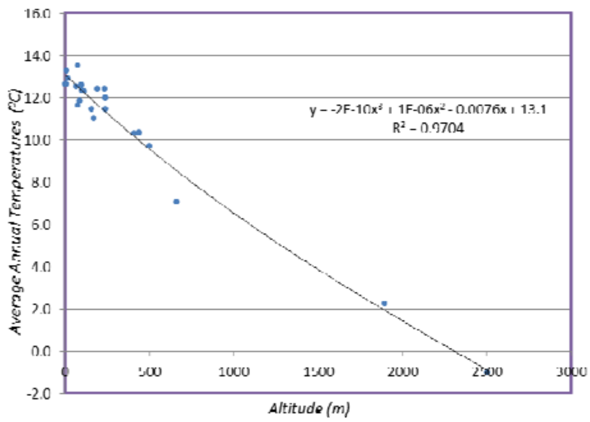


Figure 3. Graph (temperature-altitude)

The chosen equation has been implemented in G.I.S.environment using the Raster Calculator function (Figure 4).

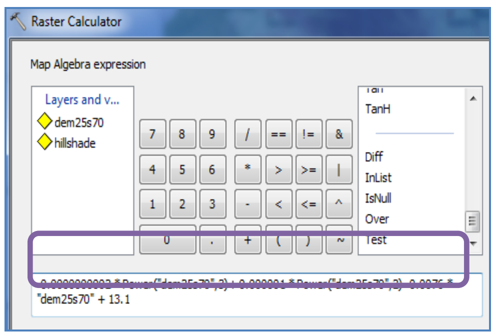


Figure 4. Implementing the equation in G.I.S.

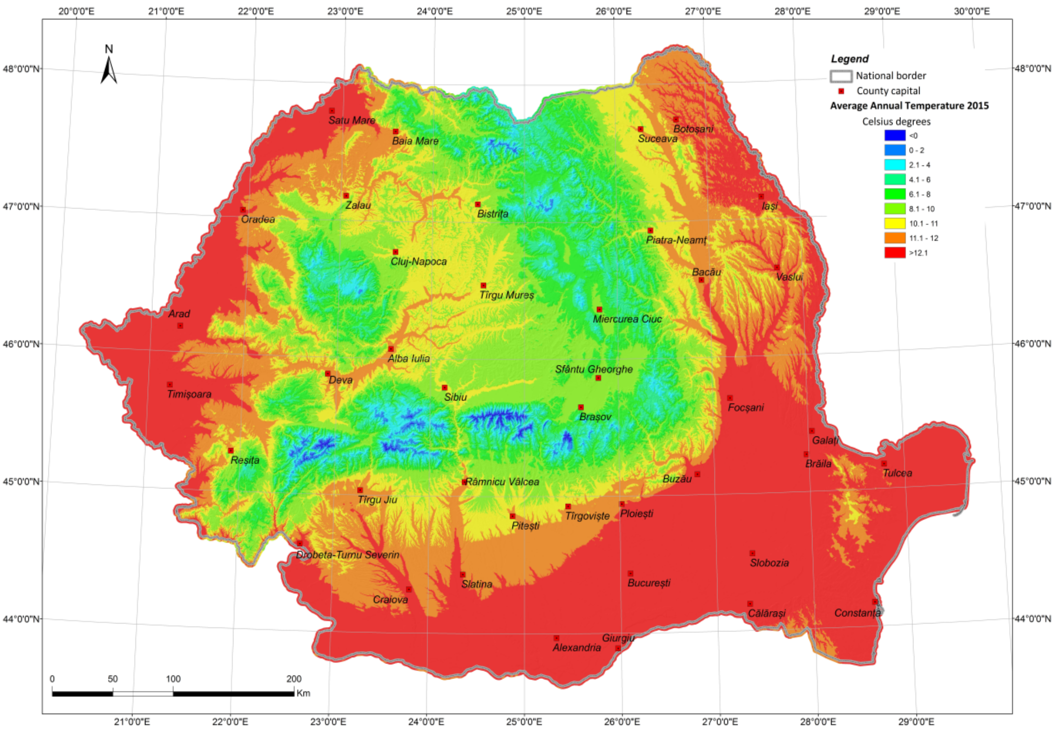


Figure 5. Average annual temperature map (2015)

The result takes the form of a map which presents the average annual temperature (Figure 5).

The resulting raster image from the analysis was cut after the limit of the study (Figure 6) so the temperature range corresponding to that area can be analysed. Thus, within the area of the municipality of Cluj-Napoca were obtained values between 7.39 and 10.87° C and in the perimeter in which the spatial analysis is performed, the average annual temperature for the year 2015 is between 9.9 and 10.7° C.

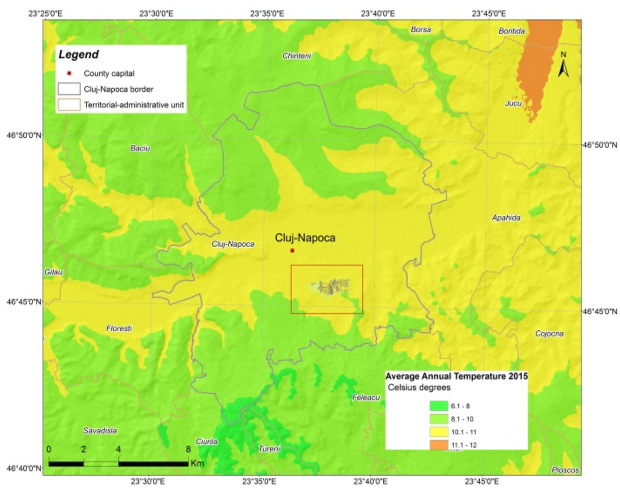


Figure 6. Average annual temperature map Cluj-Napoca, Red border – Study area (Horticultural Research Station Cluj-Napoca)

## CONCLUSIONS

Temperature is one of the climatic factors influencing soil erosion, landslides or excess moisture formation. It plays a decisive role in land reclamation works, but also in determining the suitability of land for certain species.

Since study performed at the Horticultural Research Station is a complex one it was deemed necessary to model the temperature.

The average annual temperature was modelled from point values from the meteorological stations using the following equation: y= -0.0000000002x3 + 0.000001x2-0.0076x+13.1yielding values between 9.9 and 10.7°C.

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***http://www.biostathandbook.com/linearregression.html