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GIS INTEGRATION OF CLIMATE CHANGE THROUGH FAST CALCULATION OF TEMPERATURE AND PRECIPITATION MAPS FOR USE IN AGRICULTURAL LAND QUALITATIVE ASSESSMENT. CASE STUDY: ICLOD COMMUNE, CLUJ COUNTY, ROMANIA

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Abstract

Global warming in the past 30 years had serious effects on agricultural land and its crop suitability in the Iclod Commune, whose agricultural land evaluation database still uses old temperature and precipitation averages. Using WorldClim monthly temperature and precipitation distribution maps, History+ simulated archive database and SRTM's slope steepness and orientation, raster calculations were performed in GIS for a fast update of temperature and precipitation distribution maps which were then used to update the OSPA's agricultural land qualitative assessment database.
The results show that the last 30 years hot and dry tendencies substantially modify Iclod Commune's land evaluation database, suggesting that new crops are more suitable than the old ones in face of the current accelerated climate change tendencies.

Key words*: climate change, GIS, land evaluation, crop suitability.*

INTRODUCTION

FAO (1976) defines land evaluation as „the process of assessment of land performance when used for specified purpose involving the execution and interpretation of surveys and studies of landforms, soils, vegetation, climate and other aspects of land in order to identify and make a comparison of promising kinds of land use in terms applicable to the objectives of the evaluation". In Romania, agricultural land quality classification is made depending on crop production potential, which is appreciated based on rating marks in natural conditions for arable use (Zisu, 2016).
The most dynamic factors taken into account when a land evaluation is performed are climate resources, namely temperature and precipitation. Although land evaluation maps are constantly being updated, the national land evaluation methodology uses averages of temperature and precipitation over the past 30 – 50 years (OSPA Cluj, 2014). The current tendencies of climate variability are not being taken into account, thus giving a reason to run climatic scenarios for accurate land evaluation of Iclod`s Commune agricultural fields. The use of current temperature and precipitation distribution in land evaluation is a common practice in the past years (Mitrica et al., 2015; Niacsu et al., 2015; Rosca et al., 2015; Moldovan, et al., 2016; Bilasco, et al., 2016; Oprea et al., 2016).

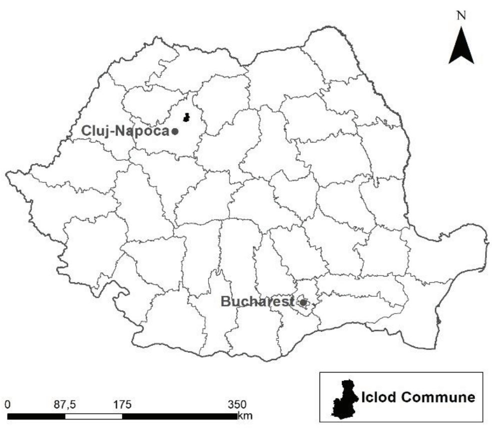

Figure 1. The geographical location of Iclod Commune within Cluj County and Romania

Iclod Commune is located in north western Romania, near Cluj Napoca municipality, in Cluj County (Figure 1). Most of its land is currently being occupied by field crops.

MATERIALS AND METHODS

The climate data was extracted from WorldClim monthly temperature and precipitation distribution maps (Fick & Hijmans, 2017) and Meteoblue History+ (2018) daily temperature and precipitation acquired tabular data.
For slope and aspect calculations, the SRTM's 30 m maps were used
According to WorldClim version 2 for the 1970 – 2000 interval the yearly temperature for Iclod is 9.3°C and the yearly rainfall is 600 mm. In the Meteoblue History+ the yearly temperature and rainfall values vary according to the chosen intervals (Table 1).

Table 1. Temperature and precipitation averages

	1988-2017	1993-2017	1998-2017	2003-2017	2008-2017	2013-2017
Temp. (°C)	11.14	11.17	11.26	11.29	11.52	11.64
Precip. (mm)	526	518	508	503	477	441

From the 30-year interval to the last 5 years averages the temperatures increases while the precipitation decreases as shown in figure 2.

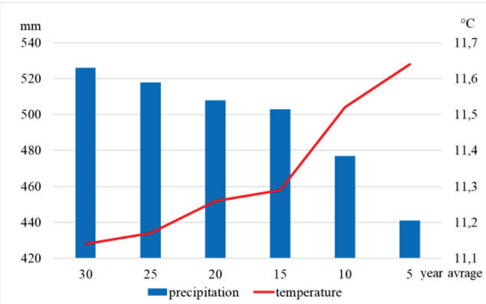

Figure 2. Precipitation and temperature evolution on a 30 years course

The highest yearly rainfall amount of 717 mm was recorded in 2004, while the lowest quantity of 308 mm was registered in 2011. The highest yearly temperature of 12.17 was recorded in 2002 and the lowest of 10.02 was recorded in 1997. For 2017 the average rainfall amount was 373 mm, and the average temperature was 11.42.
Temperature and precipitation corrections were applied on slope steepness and aspect in the case of temperature (Figure 3) and slope steepness and soil texture for rainfall (Figure 4).

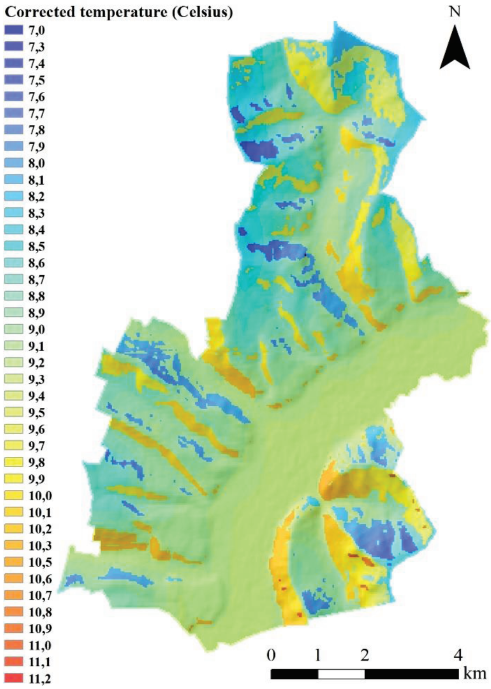

Figure 3. Average corrected temperature distribution in Iclod commune (after Worldclim version 2)

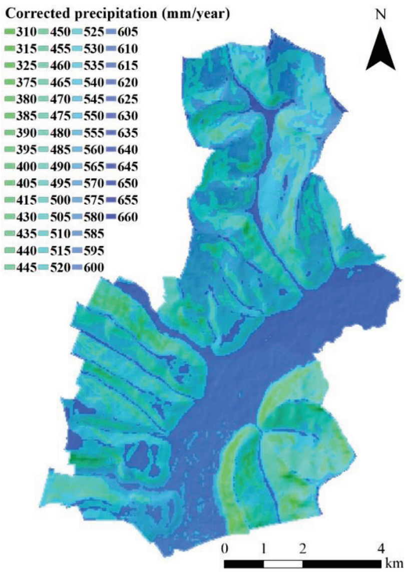

Figure 4. Average corrected precipitation distribution in Iclod commune (after Worldclim version 2)

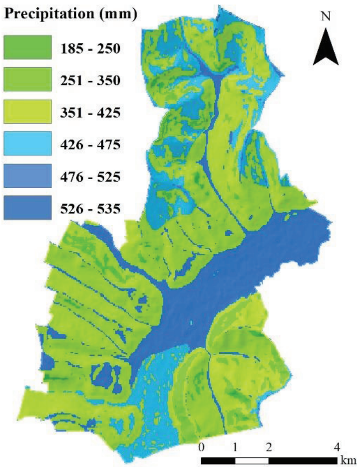

Figure 5. Precipitation distribution in the first scenario

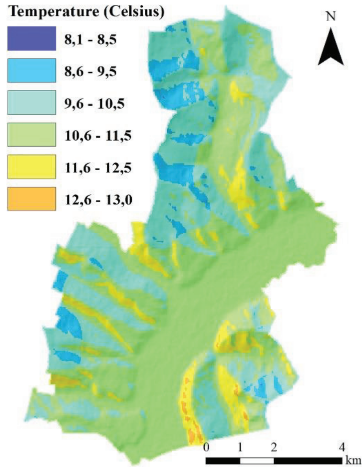

Figure 8. Temperature distribution in the first scenario

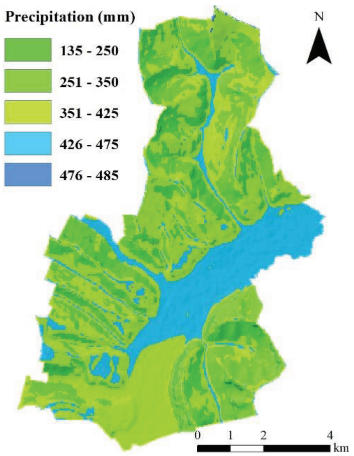

Figure 6. Precipitation distribution in the second scenario

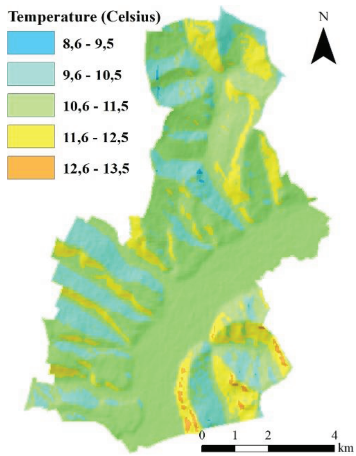

Figure 9. Temperature distribution in the second scenario

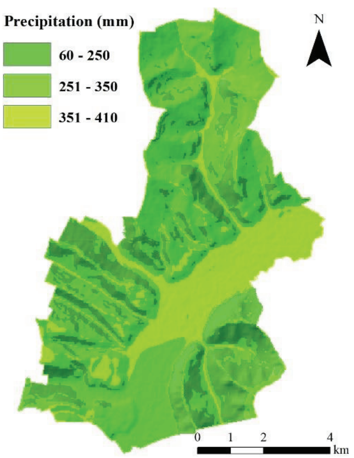

Figure 7. Precipitation distribution in the third scenario

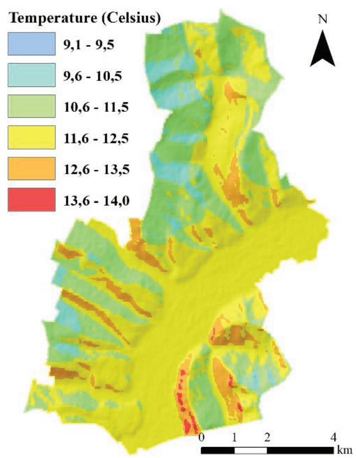

Figure 10. Temperature distribution in the third scenario

The climate data was processed in ArcGIS 10.4 software, where WorldClim's 1km^2 data was resampled to match SRTM's 30m resolution map (Pasca and Nasui, 2015; Zisu and Nasui, 2015).

RESULTS AND DISCUSSIONS

Based on temperature and precipitation trend values, three scenarios were compiled. The first scenario uses the last thirty years average temperatures: 11^{0}C and the last ten years average rainfall: 475 mm. For the second scenario a temperature of 11.5^{0}C (last 10 years average) and a rainfall amount of 425 mm (last 5 years average) were used. The last scenario uses the highest recorded temperature of 12^{0}C and an average of the most arid two years (in the analysed interval) of 350 mm.

The first step was to correlate the Meteoblue History+ tabular data with WorldClim version 2 spatial distribution maps. In ArcGIS Raster Calculator a constant was added or subtracted to the corrected temperature and precipitation maps depending on the scenario used. For the 1st scenario 1.7^{0}C was added (Figure 8) and 125 mm was subtracted (Figure 5), for the 2nd scenario 2.2^{0}C was added (Figure 9) and 175 mm was subtracted (Figure 6), and for the 3rd scenario 2,7^{0}C were added (Figure 10) and 250 mm were subtracted (Figure 7).

The second step was the identification of the most suitable crops for the climatic scenarios, obtained by multiplying temperature with precipitation in raster calculator. Although quite a few crops are suitable for the three scenarios (such as: peas/beans, alfalfa, sunflower, apricot tree, vineyard for wine, beetroot or soy) only four reach the highest degree of suitability: wheat (Figure 11), flax (Figure 12), vegetables (Figure 13), and barley (Figure 14). In the national land evaluation methodology the most suitable four crops are being taken into account when calculating the arable land quality rating marks, which is an average of the four.

The climate marks distribution maps for the four crops were calculated for each scenario. Their multiplication within each scenario gave the arable land climate quality rating marks distribution maps, which after reclassification gave the arable land climate favorability classes.

1st scenario is represented in Figure 15.

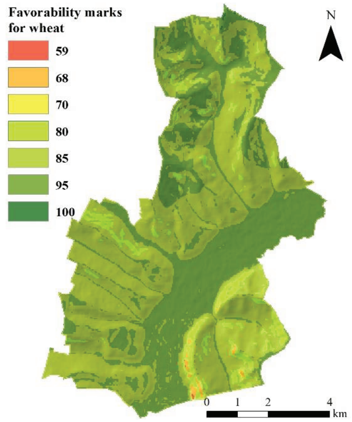

Figure 11. Wheat marks distribution in the first scenario

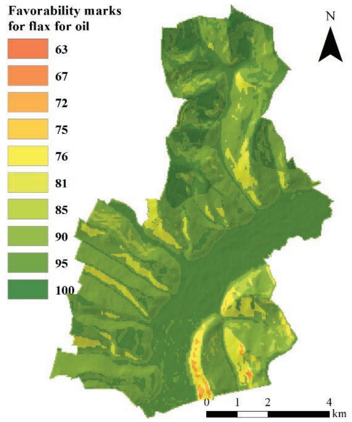

Figure 12. Flax marks distribution in the first scenario

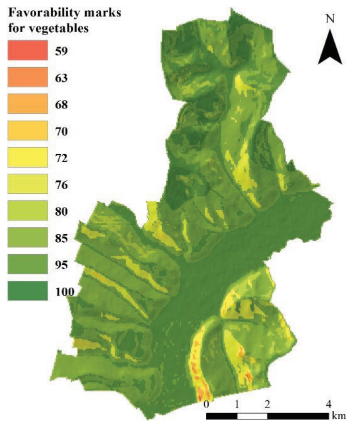

Figure 13. Vegetable marks distribution - first scenario

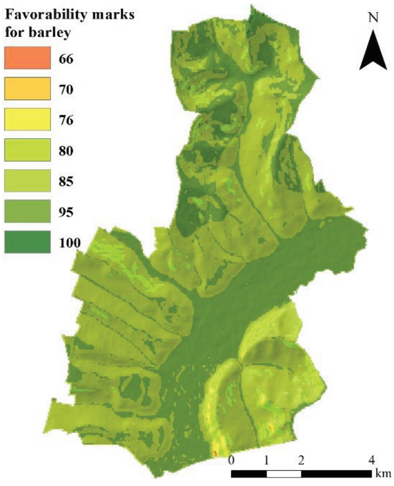

Figure 14. Wheat marks distribution in the first scenario

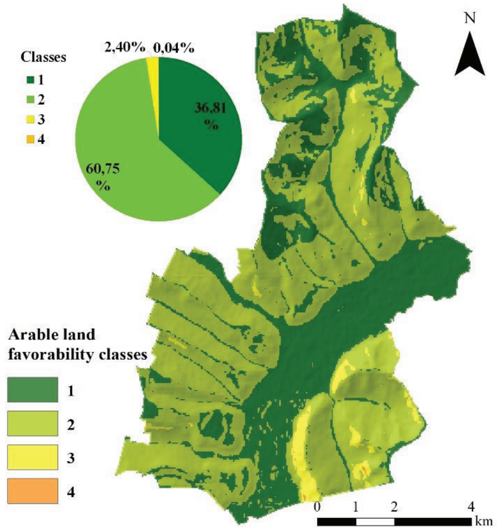

Figure 15. Arable land favorability in first scenario

The 2nd scenario is represented in Figure 16 and third scenario in Figure 17.

The climate favorability in the 1st and 2nd scenarios shows a very good distribution of 1st class (in the floodplain and valleys). It encompasses the current situation (past 5 years), in which the commune's land owners cultivated mostly maize crops, with lesser yields than in previous years (due mainly to maize vulnerability to low precipitation values).

The replacement of maize with wheat or barley could prove beneficial in the long run. The 3rd scenario shows the lack of the 1st class and a domination of the 3rd class in the floodplain, while the best favorability is held by the apricot tree (if seeded in the second class slopes).

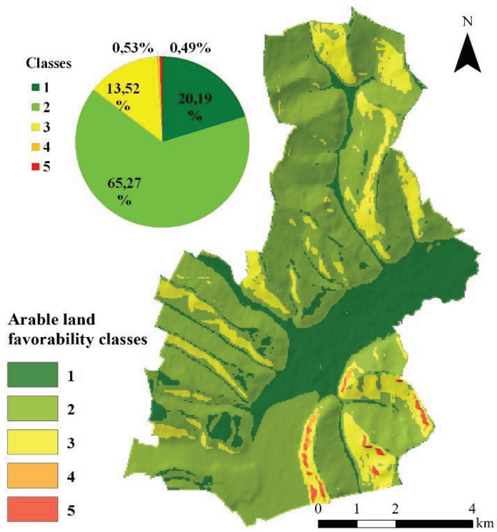

Figure 16. Arable land favorability in second scenario

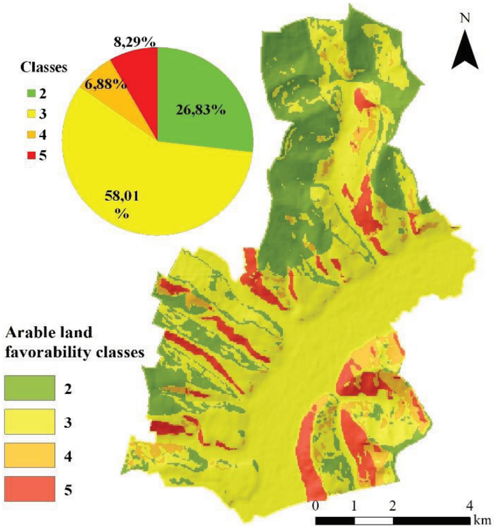

Figure 17. Arable land favorability in third scenario

CONCLUSIONS

When used in conjunction, WorldClim version 2 spatial data and Meteoblue History+ tabular data show a quick and clear distribution of temperature and precipitation trends. The current climate trends in Iclod Commune show a significant increase in temperature and an acute decrease of precipitation amounts. The scenarios used show that even if other crops are used, the overall crop yields will decrease if the existing trends continue.

REFERENCES

Bilasco S., Rosca S., Pacurar I., Moldovan N., Bot A., Negrusier C., Sestras P., Bondrea M., Nas S., 2016. Identification of Land Suitability for Agricultural Use by Applying Morphometric and Risk Parameters Based on GIS Spatial Analysis, Not Bot Horti Agrobo, 2016, 44(1):302-312.

FAO, 1976. A framework for land evaluation, FAO Soils Bulletin 32, FAO Rome, pp. 66.

Fick S.E. and R.J. Hijmans, 2017. Worldclim 2: New 1-km spatial resolution climate surfaces for global land areas. International Journal of Climatology.

INCDPAPM - ICPA (Florea, N., Balaceanu, V., Rauta, C. and Canarache, A. coord.), 1987. Metodologia elaborarii studiilor pedologice (Soil Studies Development Methodology), part II, Methods, Reports, Guidelines, 20, pp. 350.

Meteoblue® History+, 2018. Iclod climate simulated archive database, www.meteoblue.com.

Mitrică B, Mateescu E, Dragota CS, Grogorescu I, Dumitrascu M, Popovici EA., 2015. Climate change impacts on agricultural crops in the Timiș plain, Romania. Romanian Agricultural Research, 32, 93-101.

Moldovan N., Pacurar I., Rosca S., Bilasco S., 2016. Land favorability to crops in intercommunity association for development Alba Iulia, Geographia Napocensis Anul X, nr. 1, 75-84.

Niacsu L., Ionita I., Curea D., 2015. Optimum agricultural land use in the hilly area of eastern Romania. Case-study: Pereschiv Catchment. Carpathian Journal of Earth and Environmental Sciences, Vol. 10, No. 1, 183 – 192.

Oprea R., Cuculici R., Nedelea A., Ene M., Mihailescu D., 2016. The land use in the Dobrogea Plateau and the relationship with ecological groups of soils. 16th International Multidisciplinary Scientific GeoConference SGEM 2016, www.sgem.org, SGEM2016 Conference Proceedings, ISBN 978-619-7105-67-4 / ISSN 1314-2704, June 28 - July 6, 2016, Book5 Vol. 3, 661-668.

OSPA Cluj, 2014. Land suitability and capability factors for Iclod Commune, physical database, http://ospacluj.ro.

Pasca A., Nasui D., 2015. Soil Erosion Estimation in Suciu de Sus Commune, Maramures County, Romania. ProEnvironment Promediu 8 (22), 302-307.

Rosca S., Bilasco S., Pacurar I., Oncu M., Negrusier C., Petrea D., 2015. Land Capability Classification for Crop and Fruit Product Assessment Using GIS Technology. Case Study: The Niraj River Basin (Transylvania Depression, Romania). Not Bot Horti Agrobo, 2015, 43(1): 235-242.

Zisu I., 2016. Correlations between the quality of the agricultural land from Lugoj Hills and its current way of use. Carpathian Journal of Earth and Environmental Sciences, Vol. 11, No. 1, 167 – 179.

Zisu I., Nasui D., 2015. Using Universal Soil Loss Equation for soil erosion assessment in agricultural land from Lugoj Hills. Geographica Timisiensis 24 (2), 13-23.