SUMMARY OF PhD THESIS

Models of favorability and predictability for agricultural land use in the upper Somes Mic in the context of climate change

PhD student **Zanc (Săvan) Gabriela**

Scientific supervisor **Prof. univ. dr. Ioan Păcurar**

INTRODUCTION

The present study aims to contribute to the detailed knowledge of the agricultural potential of the land located in the study area, identifying the parcels of land that can be converted into arable land, taking into account a number of natural and anthropogenic factors, with emphasis on the natural and potential potential of the land, under the direct influence of soil characteristics, relief and climatic conditions

The main aim of the research is to carry out a comprehensive assessment of the soils in the upper catchment of the river Someș in order to determine their suitability for agricultural use (in particular for orchards, meadows, pastures and arable use).

This assessment is based on the agricultural land valuation method, which is based on a number of database resources and factors such as soil resources, morphometric relief characteristics and local climatic conditions.

The present study aims not only to contribute to a deeper understanding of the agricultural potential of the upper Someș river basin, but also to provide a useful tool for territorial planning and sustainable development of the region, the analysis being carried out both at the commune level (U.A.T. - Administrative Territorial Unit) and at the agricultural parcel level.

The research results will be used by local and regional authorities to make informed decisions on land use, rehabilitate polluted areas and promote sustainable and efficient agriculture. In addition, these results can contribute to the development of natural resource management strategies in the context of climate change and pressures on the environment from economic activities.

Keywords: soil favourability, land suitability, climate change, climate models

In order to achieve the main objective, a number of specific objectives were pursued as main lines of enquiry:

Objective 1. To provide a comprehensive characterisation of the study area in terms of pedological, climatic, geomorphological and hydrological factors in order to provide essential information on the soils of the area, climatic conditions, geomorphological structure and hydrographical network, as a basis for further analysis of the natural potential of the region.

Objective 2. To identify and physico-chemical analyse the soil types present in the study area for a detailed assessment of their physical and chemical characteristics. This analysis is intended to provide a clear picture of the carrying capacity of soils for various uses and will highlight possible limitations related to fertility or pollution.

Objective 3. Establish a database on ecological factors relevant for the assessment of land from a sustainable land use perspective. This database will serve as a fundamental resource for the realisation of a natural upgrading of land according to its capacity to support arable crops.

Objective 4. Application of a GIS model to classify the territory by classes of favourability and restrictiveness for specific crops including barley, maize, potato, wheat, beet, soybean, pea and sunflower and different land uses (fallow and grassland), orchards (taking into account apple, pear, plum, cherry, cherry, apricot and peach species) taking into account the current soil and climate characteristics.

Objective 5. To analyse the changes in favourability classes in the context of climate change, through statistical analysis of the impact of changes in mean annual temperature and precipitation projected for the period 2020-2100. The study thus contributes to the understanding of land use dynamics and to the assessment of land use potential in the context of climate change, providing valuable tools for planning the sustainable use of natural resources.

Objective 6. To identify areas suitable for the utilisation of exotic crops such as *Amaranthus sp*., Aronia (*Aronia melanocarpa*) and Chinese Curmal (*Ziziphus jujuba Li*).

STRUCTURE OF THE PAPER AND RESEARCH RESULTS

This study focuses on a GIS-based assessment of land-use suitability in the Apuseni Mountains, taking into account the evolving challenges posed by climate change. By assessing the suitability of different land parcels for different land uses this research aims to provide a scientifically grounded framework that can inform land-use planning and policy making in the region. The integration of climate scenarios into GIS-based assessment allows for future-oriented analysis, ensuring that land-use decisions are not only efficient under current conditions, but also resilient to future climate change.

A fundamental aspect of agricultural land valorisation is the maintenance of a sustainable ecological balance. This can be achieved by promoting sustainable agricultural practices, including the rational use of fertilisers and pesticides, crop rotation and the integration of agro-forestry elements to enhance biodiversity and protect soil against degradation processes. In this way, through proper planning and the optimal use of natural resources, agricultural land can be utilised efficiently, ensuring both agricultural productivity and environmental protection.

From an administrative point of view, the Upper Somes Small basin includes 23 administrative-territorial units, which are located either wholly or partially within the perimeter of this sector.

This paper is structured in three main parts:

The current knowledge study includes a detailed description of the study area in terms of soil characteristics, climate and anthropogenic pressure. The bibliometric analysis of the networks of relevant terms in research on soil survey, use of GIS technologies, climate change and soil erosion was part of this stage of the research as it involves examining the current state of knowledge in the mentioned fields through a detailed bibliometric analysis. In order to fulfil this objective, a systematic investigation of the scientific literature available on the Web of Science and Scopus platforms was carried out, identifying current trends and main research directions in the field.

Personal contribution, results and discussions

The present study aims at a comprehensive assessment of the agricultural potential of the land in the upper catchment of the Someş river, focussing on the identification and classification of plots suitable for various agricultural uses (orchards, meadows, pastures and arable). The main objective is to carry out a comprehensive land evaluation using the bontation method, integrating three major categories of factors: pedological characteristics, morphometric parameters of the relief and local climatic conditions.

Implementation of a GIS methodology for zoning the territory in classes of favourability and restrictiveness, with specific applicability for: cereal and technical crops (barley, maize, wheat, beet, soybeans, peas, sunflowers), permanent grassland (meadows and pastures), fruit crops (apple, pear, plum, cherry, cherry, apricot, peach) considering the current soil and climatic parameters.

Elaboration of a prospective analysis on the dynamics of favourability classes in the context of climate change, based on statistical modelling of the impact of thermal and rainfall variability projected for the 2020-2100 time frame, in order to inform sustainable land resource management strategies.

Climate prediction models under the SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0 and SSP5-8.5 scenarios for the period 2020-2099 were used to assess the variations in favourability and restrictiveness within the study area over time, based on projected changes in climatic conditions.

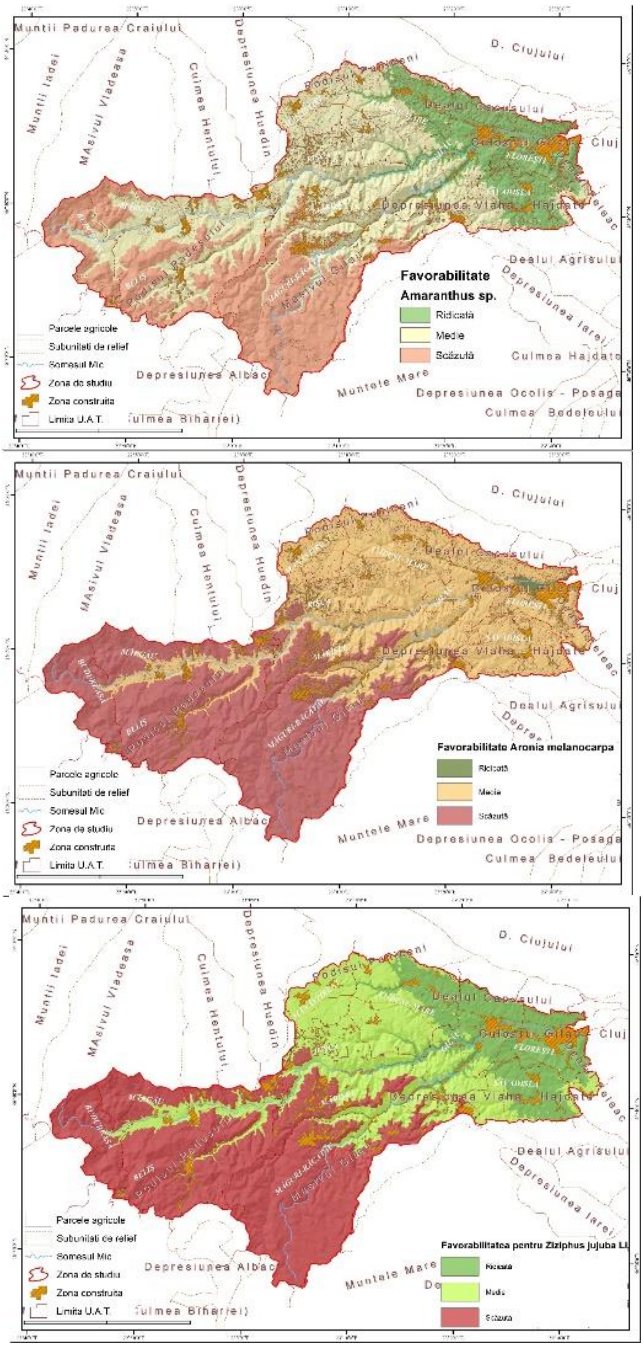

Figure 1. Favourability for Amaranthus sp., Aronia melanocarpa and Ziziphus jujuba Li
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Evaluation of the territorial potential for the introduction and cultivation of non-native species with high economic value, with focus on *Amaranthus* sp., *Aronia melanocarpa* (aronia) and *Ziziphus jujuba* Li (Chinese curmal)

Favourability class IV (low) for meadows, under current conditions occupies almost 42% of the surveyed area, while medium (III) occupies 20.54%, high (II) occupies 11% and very high (I) occupies 14.77%. This supports a medium favourability for this area considering the topography, soil and climatic characteristics.

According to the results of the GIS model, the favourability of grasslands varies between 11.7-100, being classified according to the methodology into 5 favourability classes.

The 11 administrative territorial units are covered with a percentage of 30.65% for favourability class III (medium), 25.65% for favourability class II (high) and 20.36% for favourability class (very high).

The utilisation of fruit trees is obtained by the arithmetic average of the maximum values of the six crops: apple, pear, plum, cherry, cherry, apricot and peach etc. This operation resulted in the map showing the low to very low favourability of this utilisation. The scores given to the use of fruit trees, as a result of the calculation, range from (0-50.1), which classifies the use of fruit trees into three favourability classes. Very poor favourability (class V) covers 82.48% of study area, followed by poor favourability (class IV) with 14.78%, while medium favourability (class III) occupies 3%.

Analyses of the climate scenarios for the period 2020-2099 highlight a number of substantial changes in the thermal and rainfall regime, with direct consequences for crop productivity and sustainability. Rising average temperatures may accelerate the rate of phenological development, leading to changes in the traditional agricultural calendar. High temperatures can induce heat stress at critical moments of plant development, affecting in particular pollination and fruiting processes.

The interdependence between temperature-rainfall amount and the effects on crops is indisputable. Thus, moderate changes in the temperature and rainfall regime are expected in the period 2020-2039, which would have a limited impact on existing agricultural crops but which imply the need to adapt agricultural practices at local level. These may involve the introduction of varieties with increased resistance to heat stress and varieties with higher ecological plasticity, a phased adjustment of the cropping calendar as well as an adaptation of conservative soil technologies.

The mean temperature for the study area is currently 5.51°C, and depending on the climate scenarios it can vary from 10.98°C in the period 2070-

2099 according to SSP1-1.9 to 15.40°C in the period 2070-2099 according to SSP5-8.5.

The mean annual precipitation for the study area is currently 967 mm/yr, but under the climate scenarios it may vary from 936.95 mm/yr in 2020-2039, according to SSP1-2.6, to 821.94 mm/yr in 2070-2099 mm/yr, according to SSP5-8.5.

In the long term, comparing the current situation with the climate projections for the period 2070-2099, there is a decrease in the high land favourability. Under the SSP5-8.5 scenario, which anticipates an increase in average temperature to 15.4°C and annual precipitation of 821 mm, the areas in the high-favourability class are projected to decrease by 4.7%.

Similarly, under the SSP3-7.0 scenario, which predicts an average temperature of 14.05°C and annual precipitation of 844 mm, the estimated decrease is 4.4%. Under the SSP2-4.5 scenario, with an average temperature of 12.7°C and annual precipitation of 895 mm, the reduction is more modest at 1.6%. These results emphasise the significant impact of climate change on the suitability of land for pasture use, indicating a progressive decrease in the optimal areas for pasture use under increasing temperatures and variations in the projected precipitation regime.

In the context of climate change, grassland land use will change significantly between 2020-2039 according to climate projections. The modelling based on the SSP1-2.6 scenario, which predicts an increase in precipitation to 936 mm and average temperature to 11°C, indicates a reduction of the area in the very low favourability class by 23.3%.

Similarly, under the SSP2-4.5 scenario, which assumes an average temperature of 12.75°C and annual precipitation of 895 mm, the decrease in this category is 18.8%. This increase in favourability is particularly relevant in the context of the projected increase in temperature, given that the assessment of favourability for orchards is made by averaging the favourability of species such as apple, pear, plum and cherry. In particular for cherry, peach and apricot species, which require higher temperature limits for optimal development and acceptable yields, the multiannual mean temperature increase has a beneficial impact.

Thus, some plots that were previously classified in the high-favourability class could move to the very high-favourability class. This qualitative leap will also be reflected in the statistical analysis of the suitability of plots for orchard use, emphasising the importance of adapting orchard management strategies to the new climatic conditions forecast.

Conclusions and recommendations

In this paper we have focused on the complex analysis carried out at the level of the territorial-administrative units in the upper catchment area of the Someș river, the main conclusions being the following:

The analysis of the suitability of land for different agricultural uses shows a heterogeneous distribution of land potential.

Climate projections for the period 2020-2099 indicate significant changes in climatic parameters, with average temperatures increasing from 5.51°C at present to potentially 15.40°C (scenario SSP5-8.5) and annual precipitation decreasing from 967 mm/year to possibly 821.94 mm/year. These changes will substantially influence the distribution of favourability classes for different agricultural uses.

The impact of climate change on grasslands indicates a decreasing trend in long-term high favourability, with reductions estimated between 1.6% (SSP2-4.5) and 4.7% (SSP5-8.5). For the period 2020-2039, a redistribution of favourability classes is projected, with significant reductions in the very low favourability zone.

For orchards, the projections suggest a potential improvement in conditions for some thermophilic tree species, with reductions in areas of very low favourability ranging from 3.4% (SSP1-1.9) to 6.4% (SSP2-4.5), accompanied by moderate increases in the higher favourability classes

The integration of alternative species with increased tolerance to heat and water stress (*Ziziphus jujuba Li, Aronia melanocarpa and Amaranthus sp.*) is a promising strategy for adapting farming systems to the expected climate change, providing opportunities for diversification and increasing the resilience of regional agriculture.

The results of the research emphasise the need for an adaptive approach to agricultural land management, with a focus on crop diversification and the implementation of climate resilient agricultural practices. These findings provide a sound scientific basis for the design of sustainable agricultural development strategies in the study region.

Thesis originality and innovative contributions

Specifically, the originality and innovative contributions of the thesis are the following:

8.1. Realisation for the first time of spatial analysis models of land classification by favourability classes for arable, fallow, orchards;

8.2. Identification of precipitation and temperature trends for the periods 2020-2039, 2040-2059, 2060-2079 and 2080-2099 according to climate models SSPA-1.9, SSPA-2.6, SSP2-4.5, SSP3-7.0 and SSP5-8.5 for the study area;

8.3. Run the favourability models for the current moment respectively for each moment of the 4 periods for which expected changes were modelled.

8.4. Running favourability models for the time periods 2020-2039, 2040-2059, 2060-2079 and 2080-2099 in order to highlight spatial, not just temporal, changes in the classification of parcels into different restrictiveness and favourability classes for different uses.

8.5. Identifying the suitability of the analyzed territory for alternative species with high tolerance to climate conditions: *Ziziphus jujuba* Mill., *Aronia melanocarpa* and *Amaranthus sp.*

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