DEVELOPMENT OF ECO-SUSTAINABLE AGRICULTURE THROUGH A SPATIO-TEMPORAL GIS ANALYSIS OF AGRICULTURAL CROPS. CASE STUDY: SOUTH-WEST OLTENIA REGION

Emilia CONSTANTINESCU (1), Ionuț-Adrian DRĂGULEASA* (2), Mirela MAZILU (3) Sorina NĂSTASE (NIȚU) (4)

(1) University of Craiova, 19 Libertății street, Craiova, Romania
(2) University of Craiova, Doctoral School of Sciences, Faculty of Sciences, Geography Department,13 A.I. Cuza street, Craiova, Romania
(3) University of Craiova, Faculty of Sciences, Geography Department,13 A.I. Cuza street, Craiova, Romania
(4) National Institute of Research – Development for Potato and Sugar Beet, No 2, Fundăturii street, Brașov, Romania

Corresponding author email: draguleasa.ionut.t7h@student.ucv.ro

Abstract

This research paper investigates the state of agricultural crops in the Oltenia Region.

We analyzed the main major agricultural crops (wheat, corn, sunflower and rapeseed) for the period 1990-2018, in Oltenia.

The study aims to answer the following research questions, such as: What are the counties with the largest agricultural cultivated area?, Can the cartographic method be useful in the comparative analysis of the areas of agricultural crops in Oltenia?, and What factors negatively affect the development of sustainable (ecological) agriculture?.

Using several research methods, such as document analysis, synthesis, comparison, statistical methods and referring to the available studies and statistical data series on the agriculture in Oltenia, this research paper highlights the position of the South-West Oltenia Region in terms of spatial-temporal dynamics and at the same time, the level of development of agricultural crops.

Key words**: **agricultural crops, eco sustainable agriculture, cartographic method – GIS, mechanization, region

INTRODUCTION

Romanian agriculture represents the most important sector in terms of the agricultural surface used by farmers, the contribution of this activity sector to Romania's GDP and especially the percentage of the population employed in agriculture (Hung, 2000; Restuccia et al., 2008; Popescu et al., 2021a). For an increase in the productivity of the agricultural sector, it is necessary to stimulate young students and small farmers, develop agricultural businesses and provide innovative equipment and modern, state-of-the-art laboratory facilities (Post & Terluin, 1997; Giampietro et al., 1999; Feuerbacher et al., 2020).

Employment in the agricultural sector represents a component of the sustainable (Tudor et al., 2022) and innovative rural development policy of the Romanian geographical space. That is why it is necessary to make appropriate use of the agricultural potential available to the Romanian regions and to stabilize the population of the rural area by constantly ensuring incomes (Popescu et al., 2021b; Popescu et al., 2021c) which may provide a quality and adequate well-being of life in the medium and long term. Romanian agriculture represents a turning point for any medium and long-term management strategy and plan for the local, county,

regional and national economy (Crecana & Crecana, 2019; Florea et al., 2021).

On the other hand, the agricultural sector in Romania is still underdeveloped, facing several negative factors as far as the sustainable development of agriculture is concerned. These factors are represented by: fragmentation of agricultural land, underdeveloped technological development, high share of the labor force with low productivity, inefficient production, low mechanization of agricultural crops (Aceleanu, 2016; Angearu et al., 2020), but also a social-demographic factor with a major impact on the development of ecological agriculture, i.e. the aging of the population (farmers with experience).

The main purpose of this study was to examine the dynamics of the agricultural crops of Oltenia for wheat, corn, sunflower and rapeseed, for the period 1990-2018, through the cartographic method of the GIS software.

The research objectives are: (1) the analysis of the concept of development concerning sustainable agriculture in Oltenia, (2) the research of the spatio-temporal evolution of the areas cultivated with cereals and (3) the investigation of the mechanization of agriculture in Oltenia.

The authors' remarks and assertions are derived from the practical reality of using GIS software and from the available official reports and data on this relevant topic. The development of the research is based on the aim of supporting this statement through the official data of the National Institute of Statistics regarding the dynamics and spatio-temporal distribution of the surfaces of cereal crops.

The perspective adopted in the present study is to analyze, visualize, edit and present the statistical data in an informational-innovative (cartographic) method so as to demonstrate that the mentioned observation, previously as a general hypothesis, can be scientifically supported and argued. The investigation and exploration, supported by collected data and scientific articles, starts from the finding that, in the South-West Oltenia Region, the dynamics and county distribution of agricultural areas is quite low, as compared to the potential for the exploitation of natural resources.

The research hypothesis is related to the results found in the specialized literature. Thus, the following hypothesis resulted: "*If there is a concern and at the same time a request of the population to buy eco or traditional products, then this desire can be supported through the development of sustainable agriculture in the South-West Oltenia Region".*

MATERIALS AND METHODS

The Geographic Information System (GIS) is a software which can provide all users with a combined mix of geospatial information management tools and methods that enable researchers to collect, analyze, store, edit and visualize geospatial data at different scales for any geographic space at the global level.

The spatio-temporal GIS evaluation of agricultural crops was carried out only in one of the eight development regions of Romania (Figure 1). Starting from the above statement, the research of the study addressed, thoroughly and in detail, the problem of the development of sustainable agriculture in Oltenia and the dynamic evaluation of the areas cultivated with agricultural crops.

Figure 1. Location of the regions in the national context and location of Romania in the European context

Source: authors processing of ArcGIS 10.7.2

As a result, an analysis was made on the basis of data sets compiled from the statistical database of the National Institute of Statistics of Romania, for the period 1990-2018. The maps for the South-West Oltenia region are based on the mapping of

areas cultivated with cereals and the number of tractors, starting from the series of data available for the researched time interval.

In order to intensify labor productivity and promote the sustainability of the natural environment for growing cereals in Oltenia, the main indicator (the number of tractors) that shows the degree of mechanization of agriculture for the counties of the region was analyzed (Drăguleasa et al., 2023).

RESULTS AND DISCUSSIONS

Sustainable development of the agriculture in Oltenia

Agricultural land is "the essential natural resource on which the food security of future generations depends" (Burja et al., 2020). Such fields are unexpectedly very fragmented and affected by soil erosion (Mihai & Minea, 2021), especially in hilly regions, which are also exposed to natural hazards or environmental pollution (Stângă & Grozavu, 2012; Ungureanu et al ., 2017; Vaculisteanu et al., 2015).

The development of sustainable agriculture in the Oltenia Region represents a paradigm at the beginning of socio-economic development, which focuses on the research of the most viable agricultural practices, such as high-performance technologies, raw material (seeds) with very productive genetic potential for fertile soils (Ionescu et al., 2020) and the rational use of natural resources.

The sustainable development of agriculture in the Southwest Oltenia Region can be supported through family farms, which address three dimensions: economic, social and environmental. The economic dimension is characterized by the growth, efficiency and stability of agricultural crops, while the social dimension is defined by equity and inclusion, and the third environmental dimension is oriented towards natural resources, environmental pollution and biodiversity (Radović et al., 2020; Micu et al., 2022).

Ecological agriculture determines in a beneficial way the population as well as producers` multiple benefits, for example: food safety, environmental protection, conservation of resources and the landscape specific to the toponymy of the analyzed region, employment capacity (Jităreanu et al., 2022) and the most important benefit – new options for establishing eco-farms through medium and long-term investments.

The development of sustainable (ecological) agriculture, for the Oltenia region, manifests decreases in terms of cultivated areas due to the following factors: fragmentation of agricultural land, weak systems of agricultural land recovery, reduced mechanization of agricultural crops (Angearu et al., 2020), the low scale technological implementation and aging farming population.

Cultivation of cereal varieties (wheat, maize, sunflower) with extended flexibility to soil conditions, climatic changes and technological conditions can significantly reduce the risks of fluctuation of the cereal crops in unfavorable years. Therefore, in order to minimize harvest losses caused by unfavorable pedoclimatic factors (Ionescu et al., 2020), local and regional promotion in Oltenia of cereal varieties with good adaptability to such unforeseen conditions during harvest seasons is required and, at the same time, the application of appropriate modern and innovative technologies.

The dynamics of agricultural crops in Oltenia

In the context of global climate change, the agricultural economic activity sector is one of the most seriously affected (Croitoru et al., 2020). Increased climate change extremes will periodically increase simultaneous losses in major food producing regions for the population (Campbell, 2022). For example: wheat, maize and rice are the three major crops that contribute to global food security. According to the authors Farooq et al., 2023 "cereals are a good source of minerals, carbohydrates, vitamins, proteins and micronutrients, essential for the proper functioning of the body". In the analysis of

the period 1990-2018 (Figure 2), Dolj county recorded the largest increases in the area (hectares) cultivated with wheat, followed by Olt and Mehedinți counties. The increases are due to the fertile soil and the favorable climate for the development and ripening of such grain.

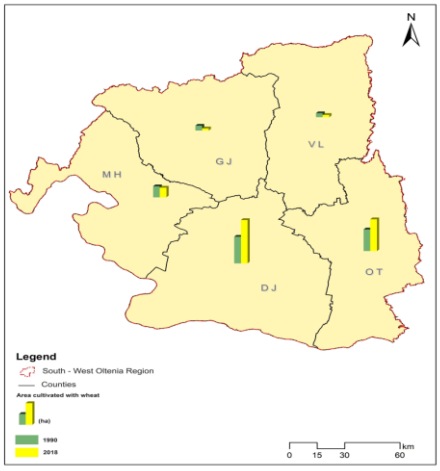

Figure 2 Regional distribution of areas cultivated with wheat - in hectares
Source: authors processing of INS data

Drought is a common phenomenon that can significantly reduce corn production in the southern counties of the Oltenia Region. This is the reason why maize breeding aims to find suitable forms, with high production capacity and at the same time stable (Bonea et al., 2009). In the central area of Oltenia, drought is very frequent, only two years out of ten are favorable for corn cultivation (Bonea et al., 2011).

The areas (hectares) cultivated with corn in the period 1990-2018, recorded different trends from one county to another, with Dolj county dominating with the largest used area in 1990, and in 2018 the same number of areas was recorded in Olt county. For both investigation years 1990-2018, Vâlcea was the county with the lowest number of areas cultivated with corn (Figure 3).

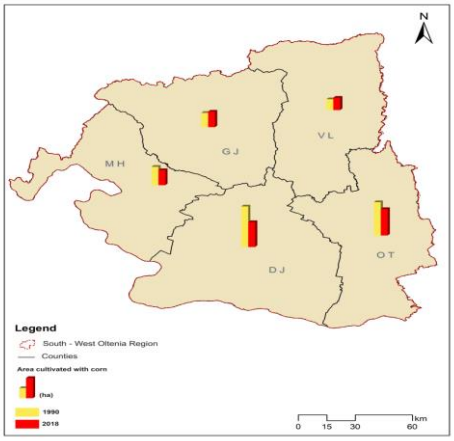

Figure 3 Regional distribution of areas cultivated with corn - in hectares
Source: authors processing of INS data

In the year 2018, Dolj and Olt counties recorded the largest area (hectares) cultivated with corn, as compared to 1990 (Figure 4). Regarding the smallest number of areas cultivated with corn, it can be observed in the counties of Gorj and Mehedinți, for both years of analysis (1990-2018).

As for the sunflower, compared to other phytotechnical plants, tolerates drought much better, which is primarily due to its better development of the root system, with a high capacity to absorb precipitation and nutrients from the soil, for a longer period of time, and secondly, it has the possibility of a rapid return of the leaves to the state of turgor (Ștefan & Constantinescu, 2022).

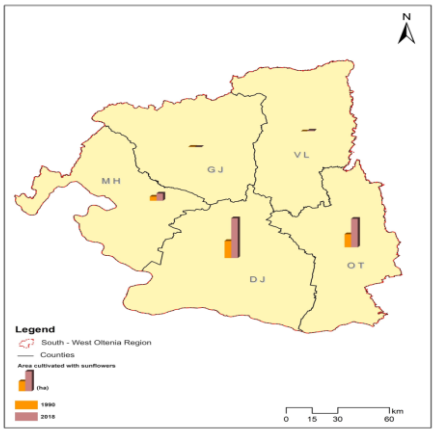

Figure 4 Regional distribution of areas cultivated with sunflower - in hectares
Source: authors processing of INS data

Rapeseed as a raw material in the production of oilseeds ranks second after

soybean. Also, improvements made to rapeseeds have made it possible to use rapeseed oil for feeding purposes, such as for instance animal feed (Banaś et al., 2023).

In 2018, the largest rapeseed areas were owned by the following counties in Oltenia: Dolj, Olt and Mehedinți (Figure 5). For the Oltenia region, it is noted that the areas cultivated with rapeseed increased after 1990, which means that farmers began to cultivate rapeseed, in addition to other agricultural crops.

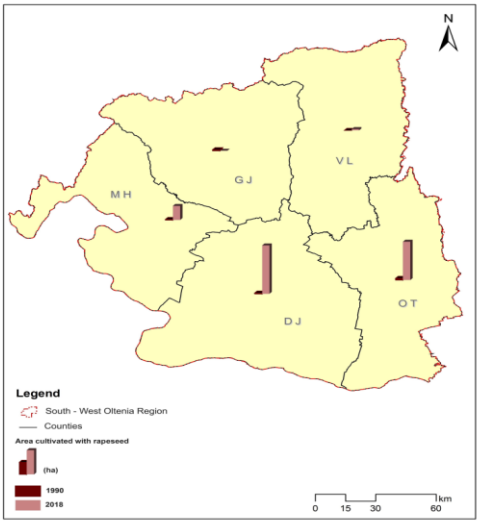

Figure 5 Regional distribution of areas cultivated with rapeseed - in hectares
Source: authors processing of INS data

Mechanization of agriculture

Agricultural mechanization is the process of using advanced agricultural machinery to equip the practice of agriculture and improve the conditions of production and exploitation of agricultural crops, thus continuously improving the economic benefits for farmers and the ecological benefits for protecting agriculture (Guan et al., 2023).

On the other hand, agricultural mechanization is an important factor for improving the total productivity of the green factors of the plant industry, thus, it is an effective way to achieve sustainable development and high-quality development of grain productions at the regional, national and international (Zhu et al., 2022).

In Oltenia, the mechanization of agriculture was analyzed by the number of tractors (Figure 6). The most tractors are in Dolj county, followed closely by Olt; at the opposite pole is Mehedinți county with the fewest tractors. In the south of the region, specifically in the Romanian Plain, where there are the most numerous non-irrigated arable lands. It should be noted that in Dolj and Olt counties there are also lands cultivated with rice.

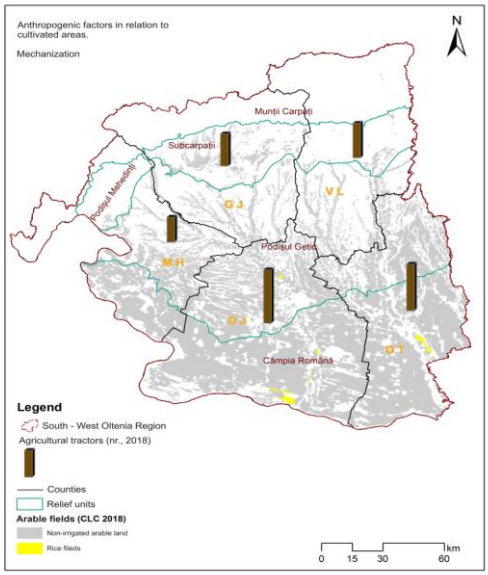

Figure 6 Mechanization of agriculture in Oltenia
Source: authors processing of INS data

CONCLUSIONS

Discovering the link between the issue of sustainable agricultural development and the concern or behavior of consumers related to eco or traditional Romanian products is not an easy matter to debate and analyze. Including at a theoretical level, the behavior and concern for eco foods is accepted by consumers, but in practice, it does not always produce a positive attitude for sustainable consumption (Mureșan et al., 2021). According to specialized literature, the organic food market in Romania has a positive trend, but on the other hand, the consumption rate is very low (Chiciudean et al., 2019). In this sense, the consumption of eco foods can be considered as a strategic direction for the development of a sustainable agricultural economy in the counties of Oltenia.

On the other hand, in order to determine sustainable consumption from organic farming, consumers of organic food must know that their purchasing behavior and attitude has a direct impact on ecological issues (Stoleru et al., 2019). Therefore, the increase in demand for eco products or food, for the sustainable agricultural sector, has led to the transformation of natural habitats into production fields, which is why sustainable agriculture imperatively requires an evolution from three perspectives according to the author Jeanneret & al. 2021 & Ecological Agricultural Projects: (1) as a production system to achieve food self-sufficiency, (2) as a management concept, (3) as a vehicle for supporting rural communities, to which the authors have added two more perspectives, namely: (4) as a traditional production system and (5) as a concept meant to protect the biodiversity of the Oltenia region.

In conclusion, the research results could represent an extremely useful tool for the interested parties in the field of economic activity - agriculture (farmers, researchers, suppliers of purchasing products based on seeds) and at the same time, for the local and county public authorities in the South-West Oltenia Region to improve the productivity of agricultural crops of wheat, corn, sunflower and rapeseed, mainly to think of a new sustainable development strategy for ecological agriculture, in accordance with local or regional climate changes.

Also, between 1990-2018, the largest areas cultivated with wheat, corn, sunflower and rapeseed were recorded in the counties of Dolj, Olt and Mehedinți.

ACKNOWLEDGEMENTS

Thank you to the editors of Annals of the University of Craiova – *Agriculture, Montanology, Cadastre Series* and anonymous peer reviewers for their helpful and developmental feedback.

REFERENCES

Aceleanu, M.I. (2016). Sustainability and Competitiveness of Romanian Farms through Organic Agriculture. *Sustainability*, 8(3), 245. https://doi.org/10.3390/su8030245

Angearu, C.-V., Ontel, I., Boldeanu, G., Mihailescu, D., Nertan, A., Craciunescu, V., Catana, S., & Irimescu, A. (2020). Multi-temporal analysis and trends of the drought based on MODIS data in agricultural areas, Romania. *Remote Sensing*, 12(23), 3940. https://doi.org/10.3390/rs12233940

Banaś, K., Piwowar, A., & Harasym, J. (2023). The potential of rapeseed (canola) oil nutritional benefits wide spreading via oleogelation. *Food Bioscience*, 103162. https://doi.org/10.1016/j.fbio.2023.103162

Bonea, D., Urechean, V., Constantinescu, E., & Deaconu, D. (2009). Aspects Regarding the Reaction to the Drought of Some Corn Inbred Lines Cultivated in SCDA Şimnic. *Bulletin of the University of Agricultural Sciences & Veterinary Medicine Cluj-Napoca. Agriculture*, 66(1). http://dx.doi.org/10.15835/buasvmcn-agr:3992

Bonea, D., Urechean, V., Constantinescu, E., Iancu, A., & Șandru, I. (2011). Researches on the suitability of some Corn (Zea mays L.) Hybrids for climatic conditions of Central Oltenia Area, Romania. Annals of the University of Craiova-Agriculture-Montanology-Cadastre Series, 41(1), 7-14.

Burja, V., Tamas-Szora, A., Dobra, I.B. (2020). Land Concentration, Land Grabbing and Sustainable Development of Agriculture in Romania. *Sustainability* 12(5), 2137. https://doi.org/10.3390/su12052137

Campbell, B. Climate Change Impacts and Adaptation Options in the Agrifood System—A Summary of the Recent Intergovernmental Panel on Climate Change Sixth Assesment Report. Rome,

Italy. 2022. Available online: https://www.fao.org/documents/card/en/c/cc0425en (accessed on 14 November 2022).

Chiciudean, G.O., Harun, R., Ilea, M., Chiciudean, D.I., Arion, F.H., Ilies, G., & Muresan, I.C. (2019). Organic food consumers and purchase intention: a case study in Romania. *Agronomy*, *9*(3), 145. https://doi.org/10.3390/agronomy9030145

Crecana, D.N., Crecana, C.D. (2019). Increasing the Performance of Agricultural Holdings in Romania -an Imperative for their Management. *Rev. Int. Comp. Manag. 20*, 112–121. https://www.rmci.ase.ro/no20vol2/01.pdf

Croitoru, A.-E., Man, T.C., Vâtcă, S.D., Kobulniczky, B., Stoian, V. (2020). Refining the Spatial Scale for Maize Crop Agro-Climatological Suitability Conditions in a Region with Complex Topography towards a Smart and Sustainable Agriculture. Case Study: Central Romania (Cluj County). *Sustainability* 12(7), 2783. https://doi.org/10.3390/su12072783

Ecological Agricultural Projects. A History of Sustainable Agriculture. Available online: https://www.eap.mcgill.ca/AASA_1.htm (accessed on 2 October 2023).

Farooq, A.; Farooq, N.; Akbar, H.; Hassan, Z.U.; Gheewala, S.H. (2023). A Critical Review of Climate Change Impact at a Global Scale on Cereal Crop Production. *Agronomy* 13(1), 162. https://doi.org/10.3390/agronomy13010162

Feuerbacher, A., McDonald, S., Dukpa, C., Grethe, H. (2020). Seasonal rural labour markets and their relevance to policy analyses in developing countries. *Food Policy 93*, 101875. https://doi.org/10.1016/j.foodpol.2020.101875

Florea, N.V., Duică, M.C., Ionescu, C.A., Duică, A., Ibinceanu, M.C.O., Stanescu, S.G. (2021). An Analysis of the Influencing Factors of the Romanian Agricultural Output within the Context of Green Economy. *Sustainability* 13(17), 9649. https://doi.org/10.3390/su13179649

Giampietro, M., Bukkens, S.G.F., Pimentel, D. (1999). General trends of technological changes in agriculture. *Crit. Rev. Plant Sci.* 18, 261–282. https://doi.org/10.1080/07352689991309225

Guan, N., Liu, L., Dong, K., Xie, M., & Du, Y. (2023). Agricultural mechanization, large-scale operation and agricultural carbon emissions. *Cogent Food & Agriculture*, 9(1), 2238430. https://doi.org/10.1080/23311932.2023.2238430

Hunt, R.C. (2000). Labour Productivity and Agricultural Development: Boserup Revisited. *Hum. Ecol.* 28, 251–277. https://doi.org/10.1023/A:1007072120891

Institutul Național de Statistică. Available online: http://statistici.insse.ro:8077/tempo-online/ (accessed on 14 July 2023).

Ionescu, R.V., Zlati, M.L., Antohi, V.M., Stanciu, S., Virlanuta, F.O., Serban, C. (2020). New Agricultural Model of Economic Sustainability for Wheat Seed Production in Romania. *Sustainability* 12(10), 4182. https://doi.org/10.3390/su12104182

Jeanneret, P., Lüscher, G., Schneider, M. K., Pointereau, P., Arndorfer, M., Bailey, D. et al. (2021). An increase in food production in Europe could dramatically affect farmland biodiversity. *Communications Earth & Environment*, *2*(1), 183. https://doi.org/10.1038/s43247-021-00256-x

Jităreanu, A.F.; Mihăilă, M.; Robu, A.-D.; Lipșa, F.-D.; Costuleanu, C.L. (2022). Dynamic of Ecological Agriculture

Certification in Romania Facing the EU Organic Action Plan. *Sustainability* 14(17), 11105. https://doi.org/10.3390/su141711105

Micu, M.M., Dumitru, E.A., Vintu, C.R., Tudor, V.C., Fintineru, G. (2022). Models Underlying the Success Development of Family Farms in Romania. *Sustainability* 14(4), 2443. https://doi.org/10.3390/su14042443

Mihai, F.C., & Minea, I. (2021). Sustainable Alternative Routes versus Linear Economy and Resources Degradation in Eastern Romania. *Sustainability*, *13*(19), 10574. https://doi.org/10.3390/su131910574

Muresan, I.C., Harun, R., Arion, F.H., Brata, A.M., Chereches, I.A., Chiciudean, G.O., Dumitras, D.E., Oroian, C.F., & Tirpe, O.P. (2021). Consumers' attitude towards sustainable food consumption during the COVID-19 pandemic in Romania. *Agriculture*, *11*(11), 1050. https://doi.org/10.3390/agriculture11111050

Popescu, A., Dinu, T.A., Stoian, E., Serban, V. (2021a). Efficiency of Labour Force Use in the European Union's Agriculture in the Period 2011–2020. *Sci. Pap. Ser. Manag. Econ. Eng. Agric. Rural. Dev. 21*, 659–672. https://managementjournal.usamv.ro/pdf/vol.21_3/Art75.pdf

Popescu, A., Tindeche, C., Marcuta, A., Marcuta, L., Hontus, A. (2021b). Labour Productivity in ROMania's Agriculture in the Period 2011–2020 and its Forecast for 2021–2025 horizon. *Sci. Pap. Ser. Manag. Econ. Eng. Agric. Rural. Dev. 21*, 673–678. https://managementjournal.usamv.ro/pdf/vol.21_3/Art76.pdf

Popescu, A., Tindeche, C., Marcuta, A., Marcuta, L., Hontus, A., Angelescu, C. (2021c). Labour Force in the European Union Agriculture—Traits and Tendencies. *Sci. Pap. Ser. Manag. Econ. Eng. Agric. Rural. Dev. 21*, 475–486. https://managementjournal.usamv.ro/pdf/vol.21_2/Art55.pdf

Post, J., Terluin, I. (1995). The changing role of agriculture in rural employment. In Proceedings of the International Symposium on Perspectives on Rural Employment, Coaticook, QC, Canada, 11–14 October 1995; Bollman, R.D., Bryden, J.M., Eds.; An International Perspective. CAB International: Wallingford, UK, 1997; pp. 305–326. https://www.cabdirect.org/cabdirect/abstract/19971803759

Radović, G., Petrović, M.D., Demirović Bajrami, D., Radovanović, M., Vuković, N. (2020). Can Proper Funding Enhance Sustainable Tourism in Rural Settings? Evidence from a Developing Country. *Sustainability* 12(18), 7797. https://doi.org/10.3390/su12187797

Restuccia, D., Yang, D.T., Zhu, X. Agriculture and aggregate productivity: A quantitative cross-country analysis. *J. Monet. Econ.* 2008, 55, 234–250. https://doi.org/10.1016/j.jmoneco.2007.11.006

Stângă, I.C., & Grozavu, A. (2012). Quantifying human vulnerability in rural areas: Case study of Tutova Hills (Eastern Romania). *Natural Hazards and Earth System Sciences*, 12(6), 1987-2001. https://doi.org/10.5194/nhess-12-1987-2012

Stoleru, V., Munteanu, N., & Istrate, A. (2019). Perception towards organic vs. conventional products in Romania. *Sustainability*, 11(8), 2394. https://doi.org/10.3390/su11082394

Ștefan, I.O., & Constantinescu, E. (2022). Research on the behavior of some sunflower cultivations in the specific conditions of the North Area of Olt county. Annals of the University of Craiova-Agriculture Montanology Cadastre Series,

52(2), 170-173. https://doi.org/10.52846/aamc.v52i2.1404

Tudor, V.C., Dinu, T.A., Vladu, M., Smedescu, D., Vlad, I.M., Dumitru, E.A., Sterie, C.M., Costuleanu, C.L. (2022). Labour Implications on Agricultural Production in Romania. *Sustainability*, 14(14), 8549. https://doi.org/10.3390/su14148549

Ungureanu, T., Iancu, G.O., Pintilei, M., & Chicoș, M.M. (2017). Spatial distribution and geochemistry of heavy metals in soils: A case study from the NE area of Vaslui county, Romania. *Journal of Geochemical Exploration*, 176, 20-32. https://doi.org/10.1016/j.gexplo.2016.08.012

Vaculisteanu, G., Niculita, M., & Margarint, M.C. (2019). Natural hazards and their impact on rural settlements in NE Romania–A cartographical approach. *Open Geosciences*, 11(1), 765-782. https://doi.org/10.1515/geo-2019-0060

Zhu, Y., Zhang, Y., & Piao, H. (2022). Does agricultural mechanization improve the green total factor productivity of China's planting industry?. *Energies*, 15(3), 940. https://doi.org/10.3390/en15030940