SUMMARY OF PhD THESIS

Research on the situation of agricultural lands and the effects of their management on the sustainable development of agriculture in the North-West Development Region of Romania

PhD student **Ing. Sergiu-Bogdan Pop**

Scientific coordinator **Prof. dr. Teodor Rusu**

INTRODUCTION

Agricultural land has a very important strategic role in ensuring food security, which has become a very important issue in meeting the food demand of a growing global population. (PAWLAK and KOŁODZIEJCZAK, 2020).

Agriculture plays a very important role in Romania's economy, which leads to the search for solutions to maximize production and increase economic yield (RODINO et al., 2023).

The doctoral approach highlights the use of agricultural land at the level of the North-West Development Region of Romania and the profile of their owners. The data used in the study were collected uniformly at the level of the region by the sociological survey method based on a questionnaire, with a number of 35 questions relevant to the present study, for the current characterization of agricultural land use and the future intentions of farmers.

Precision agriculture often uses digital techniques such as satellites, UAS (unmanned aerial systems) and sensors to optimize agricultural production processes while reducing the negative impact on the environment. Smart agriculture is data-driven, so a UAS can receive and accurately distribute this information, allowing producers to take action based on individual soil circumstances. The paper aims to highlight the main advantages of UAS used in agriculture, depending on the type of wing (single-rotor, multi-rotor, fixed-wing and VTOL) and the sensors used. Also, within the work, the stages of making a digital orthophoto plane at the Hoia farm, belonging to the USAMV Cluj-Napoca, were analyzed, with a view to further analyzes regarding the state of the vegetation, using a DJI Phantom 4 Pro UAS model.

With the help of GIS (Geographic Information System) thematic maps were made that help to characterize the area under study.

The research carried out in the framework of this doctoral thesis is up-to-date and brings useful information in making decisions regarding the management of agricultural land at the regional level and encourages the development of the use of modern technologies in order to make production more efficient quantitatively and economically.

STRUCTURE OF THE PhD THESIS

The doctoral thesis entitled "Research on the situation of agricultural lands and the effects of their management on the sustainable development of agriculture in the North-West Development Region of Romania" is structured in two parts and 8 chapters.

The first part, entitled THE CURRENT STATE OF KNOWLEDGE, is structured in 3 chapters that present important aspects from the specialized literature studied.

The second part represents the PERSONAL CONTRIBUTION, which is made up of 5 chapters that present the research methodology, the results obtained, the conclusions and recommendations, respectively the originality and innovative contributions of the thesis. The work ends with 145 bibliographic titles and a number of 4 appendices.

1. AGRICULTURAL LAND RESOURCES, POLICIES AND REGULATIONS

Chapter 1 comprises three sub-chapters in which current information on the importance of agricultural land is presented; agricultural land resources and legislative regulations on agricultural resources.

2. CURRENT STATE OF AGRICULTURAL LAND USE

Chapter 2 includes four sub-chapters that represent the situation of agricultural land use at the level of the European Union, the situation of land at the level of Romania, the price of agricultural land and the lease, respectively the irrigation of agricultural land.

3. APPLICATION OF UAS TECHNOLOGY IN AGRICULTURE

Chapter 3 comprises three sub-chapters that are an introduction to UAS technology in agriculture, classification of UAS platforms and sensors used.

4. RESEARCH OBJECTIVES

The main objective of this paper is to present the situation of agricultural lands and the effects of their management in the North-West Development Region of Romania, which includes the counties of Bihor, Bistrița-Năsăud, Cluj, Maramureș, Satu Mare and Sălaj. It is desired that, following the investigations carried out, recommendations can be outlined on how to practice agriculture in the region in order to outline some strategies that will help to improve it.

From the general objective of the research derive the following specific objectives aimed at:

- Carrying out a sociological survey based on a questionnaire in the Northwest Development Region of Romania, with specific questions for the characterization of agricultural farms;
- Outline the profile of agricultural farm owners;
- Characterization of agricultural areas from the point of view of the way of use;
- Characterization of the decision to work the agricultural land and the future intentions of the farm owners;
- Characterization of the support offered for the practice of agriculture;
- Creation of thematic GIS maps for monitoring the studied agricultural area;
- The main advantages for the use of different types of drones in the optimization of agricultural processes;
- Application of UAS technology in agriculture by creating a photogrammetric map of the Hoia farm lands, belonging to USAMV Cluj-Napoca, in order to monitor them.

5. MATERIAL AND METHOD

Chapter 5 presents the methodology applied for the characterization of the research area, which is represented by the agricultural lands in the Northwest Development Region of Romania. In this sense, we used the sociological investigation method based on a questionnaire. It includes a number of 35 questions, with multiple answer options, relevant for the characterization and observation of current and

future trends regarding the sustainable development of agricultural land in the studied area.

The questionnaires were distributed uniformly within the analyzed region (276 questionnaires), at the level of each component county: Bihor county 47 respondents from 39 localities, Bistriţa-Năsăud county 50 respondents from 37 localities, Cluj county 44 respondents from 34 localities, Maramureș County 46 respondents from 37 localities, Satu Mare County 49 respondents from 34 localities, Sălaj County 40 respondents from 25 localities.

The questionnaires were filled out directly by the owners of the agricultural holdings under the guidance of the PhD student, through the Payments and Investments Agency for Agriculture at the level of each county within the North-West Development Region of Romania.

6. RESULTS AND DISCUSSION

Chapter 6 is divided into 4 sub-chapters that present the realization of the GIS database in order to create thematic maps of the studied area, results and discussions following the application of the sociological survey, the statistical interpretation of the results and a case study on the agricultural farm Hoia, belonging to USAMV Cluj-Napoca, with the aim of applying UAS technology.

Realization of the GIS database

Agriculture represents a favorable sector for the use of GIS, due to specific data that mostly have a spatial component, and thus maps can be made to highlight data from the field more easily (SIPKA and MARKOVIC, 2022). When creating the GIS database, the data collected through the questionnaire-based sociological survey at the level of the North-West Development Region of Romania were used.

Results and discussions regarding the use of agricultural land in the Northwest Development region of Romania

After analyzing the data, it can be seen that the largest percentage is represented by farmers over 40 years old (63.8%). It is also observed that most farm owners have high school education (42.1%), followed by higher education with 39.5%, professional and technical education 10.9%. Relatively low percentages are recorded among farmers who have only completed primary or secondary education (5.8%), respectively non-university tertiary education (1.8%). The specialized studies in agriculture, acquired in high schools with an agricultural profile or higher agricultural education, represent 26.1% of the total number of farmers studied.

The total area of land owned by an agricultural holding in the region of interest is mostly, over 50%, between 50-99 ha (33.7%) and 100-149 hectares (20.7%). It is observed that more than 25% of agricultural lands have areas between 150 ha and more than 500 ha, i.e. 150-199 ha (6.2%), 200-299 ha (7.2%), 300-399 (6 .5%) and larger than 500 ha (5.8%). The smallest areas of agricultural land are those smaller than 5 ha (1.1%) and those between 400 ha and 500 ha (1.4%).

The main types of crops (table 1) fall into three distinct groups at the regional level: field crops, horticulture and permanent crops.

Table 1.

Types of agricultural crops at the level of the North-West Development Region of Romania

The type of culture		Number of farms owning the crop	Percentage of farmers owning the crop (%)
Field crops	Cereals	231	83.70
	Technical plants	76	27.54
	Medicinal and aromatic plants	3	1.09
	Fodder plants	172	62.32
Horticulture	Fruits and vegetables	61	22.10
	Seeds, planting material	6	2.17
	Viticulture/winemaking	6	2.17
	Flowers	2	0.72
Permanent crops	Fruit trees	62	22.46
	Hop	1	0.36
	Fruit bushes	3	1.09
	Nurseries (vineyards, fruit trees, forestry)	2	0.72
	Permanent grasslands	173	62.68

At the level of the Northwest Development region of Romania, it is observed that there is a very small number of subsistence farms of only 0.7%, most farms fall into the category of medium-sized commercial ones (42.4%). Small commercial farms have a significant percentage of 26.1%, followed by semi-subsistence farms with a percentage of 18.5%. Farms with incomes greater than 250,000 euros, i.e. large commercial ones, have a relatively small percentage at the regional level of 12.3%.

According to the type of agriculture practiced in the North-West Development Region of Romania, it is observed the practice of conventional agriculture (52.2%), followed by the use of mixed agriculture (35.9%), which indicates a moderate-low involvement in the use of ecologically certified alternative methods of treating crops against pests.

Agricultural techniques applied in the studied area are mostly based on annual plowing, a technique used by 72.1% of farmers, followed by the application of manure as fertilizer, a technique applied by 71.7% of farmers. The least used techniques are without chemical plant protection (12.7%) and without chemical fertilizers (17%), which leads to the conclusion that farmers in the region largely use conventional agriculture, based on chemical fertilizers in optimal doses , technique applied by 54.3% of respondents and chemical plant protection (48.9%). Other farming techniques used are: minimum tillage (37%), direct seeding (41.7%), annual cover crops (29.7%) and periodic cover crops (23.9%).

Regarding the price of agricultural land, the highest percentage of almost 60% is represented by the categories under 2,000 euros and between 2,000-4,999 euros with 31.9% and 27.9% respectively. The categories 5,000-7,999 euros and 8,000-10,999 euros represent a total of 36.2%, and between 11,000 euros and over 20,000 euros is a percentage of only 4% of the total farms.

In the studied region there is medium-high fragmentation, 25% of the farms fall into the 10%-39% category with medium fragmentation, and 23.9% fall into the 40%-70% category with high fragmentation. The two categories add up to almost half of the agricultural holdings, i.e. 48.9%. A number of 38 analyzed farms fall into the category of excessive fragmentation, representing 13.8% of the total. The lowest fragmentation, below 10%, is found in a number of 103 farms out of the total of 276 analyzed, representing 37.3% of the total and being the largest registered category.

Most of the agricultural lands in the Northwest region of Romania are not irrigated (88.8%) and do not have facilities for this operation.

Agricultural farms are involved to a small extent in associative forms, only 31.9% of them.

Most of the products are sold directly from the farm (62%), through intermediaries (40%) and in agro-food markets (29%). At least the products are marketed through processing units and agricultural cooperatives, totaling 2.4% of farms.

At the level of the studied farms, a series of land improvement works were carried out (33%), in order to increase the quality of agricultural land exploitation. Drainage and drainage facilities have the highest percentage and were carried out in 42 farms (45.7), followed by specific works to combat soil erosion in 25 farms (27.2%), irrigation facilities in 23 farms (25%), dams and regularization of watercourses of local interest in 16 farms (17.4) and forest curtains in 14 farms (15.2%).

From the point of view of modern technologies for a digital agriculture, a very low use is observed, only 20%, which represents a number of 55 farmers out of the total analyzed of 276. Among the applied technologies, precision farming systems such as used for fertilization, sowing, treatment and watering represent the highest percentage at 12%, followed by GPS monitoring systems applied to agricultural machinery (11.6%). The least used technologies are agricultural drones (2.9%), used in crop monitoring and treatment, having multiple advantages especially for crops where traditional techniques are difficult to use, reducing their possible destruction.

Depending on the forms of support accessed, all the surveyed farmers benefited from subsidies from the Agency for Payments and Investments for Agriculture (APIA). A relatively small percentage of 69 farmers (25%) received support from the Rural Investment Financing Agency. The fewest farmers accessed funds from imputation providers through advisory services (4.7%), respectively through farmers' associations (4%). European funds for the establishment of the farm, its development or other investments, were accessed by 107 interviewed farmers out of a total of 276, meaning a percentage of 38.8% of the total.

Statistical interpretation of the results

In order to make statistical interpretations, the linear numerical scale type questions with answers from 1 to 10, where 1 means very little and 10 means a lot, were taken for analysis. The 5-point Likert scale question was also analyzed where 1 means total disagreement, up to 5 total agreement.

The SPSS program was used to perform the statistical interpretations, and the results are presented in tabular form (table 2, table 3, table 4).

Table 2.

The decision on the variables related to the support provided by the associative forms

Variables	Average	σ	Decision
Protecting common interests	7.24	2.383	High perception
Accessing funding	6.76	2.514	Low perception
Exchange of best practices and information	6.91	2.257	High perception
Access to national and EU policies on development strategies	6.59	2.466	Low perception
Joint purchase of goods and services	6.41	2.689	Low perception
Easier access to markets for product marketing	6.91	2.462	High perception

Note: N=88, σ= standard deviation, Decision-weighted average= 6.803

Table 3.

Decision on labor force variables in agriculture

Variables	Total agreement (%)	Agree (%)	Neutral (%)	Disagreement (%)	Totally disagree (%)	Average	σ	Decision
Specialized studies	107 (38.8)	114 (41.3)	51 (18.5)	3 (1.1)	1 (0.4)	4.17	0.789	High perception
Age	61 (22.1)	148 (53.6)	61 (22.1)	4 (1.4)	2 (0.7)	3.95	0.751	High perception
Job security	53 (19.2)	145 (52.5)	71 (25.7)	6 (2.2)	1 (0.4)	3.88	0.746	Low perception
Work schedule	50 (18.1)	152 (55.1)	67 (24.3)	7 (2.5)	0 (0.0)	3.89	0.717	Low perception
Social acceptance, prestige, community respect	40 (14.5)	136 (49.3)	83 (30.1)	14 (5.1)	3 (1.1)	3.71	0.815	Low perception
Environmental sustainability	47 (17.0)	142 (51.4)	75 (27.2)	11 (4.0)	1 (0.4)	3.81	0.774	Low perception
Work autonomy and independent activities	61 (22.1)	151 (54.7)	56 (20.3)	8 (2.9)	0 (0.0)	3.96	0.735	High perception
Maintaining family values and traditions	73 (26.4)	162 (58.7)	34 (12.3)	5 (1.8)	2 (0.7)	4.08	0.721	High perception

Note: N=276, σ= standard deviation, Decision-weighted average= 3.931

Table 4.

The decision on the variables related to the influence of agricultural activities

Variables	Average	σ	Decision
The motivation for agriculture	7.73	1.947	High perception
Economic performance	7.17	1.860	High perception
The influence of climate change	7.12	2.008	Low perception
Conservation of natural landscape elements	6.93	2.066	Low perception
The influence of labor migration	6.45	2.557	Low perception
Accessibility to the farm grounds	7.42	2.028	High perception

Note: N=276, σ= standard deviation, Decision-weighted average= 7.136

Case study: Land monitoring using UAS technology

The use of the UAS photogrammetric method helps to map large areas of land, at relatively low costs and in a short time. Compared to the classic methods of making digital plans, digital maps can be made at very good resolutions, for making further observations and analyzes regarding the use of agricultural land (SCHENK, 2005).

The area of interest studied is represented by the Hoia farm, belonging to USAMV Cluj-Napoca. The DJI Phantom 4 Pro drone was used to perform the photogrammetric flight. The technological flow used to obtain a digital plan (orthophotoplane) is presented in figure 1.

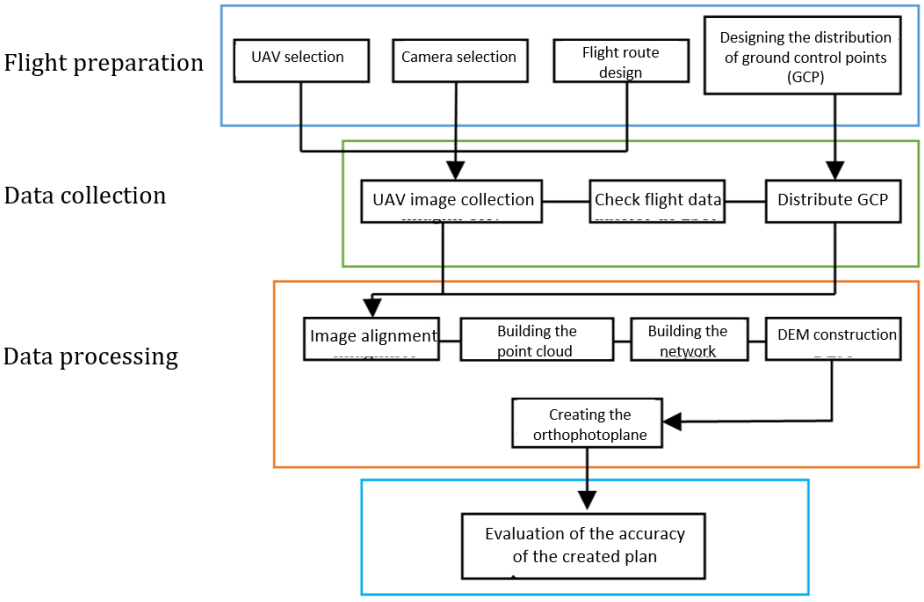

Fig. 1. The technological flow of obtaining digital orthophoto planes

Figure 2 shows the image resulting from processing the photograms.

Fig. 2. The resulting plan after image processing

7. CONCLUSIONS AND RECOMMENDATIONS

Based on the research carried out on the use of agricultural land in the North-West Development region of Romania, a series of conclusions and recommendations emerge:

- The Northwest Development Region of Romania is characterized by a rich agricultural area with an average area of 150 hectares per agricultural holding, represented by the presence of the main agricultural areas: arable area (98.4% of farms), pastures (56, 88 of farms), hayfields (38.76% of farms), vineyards and wine nurseries (5.43% of farms), fruit orchards and nurseries (25% of farms);
- The agriculture practiced is conventional and mixed, based in particular on the technique of annual plowing, fertilization with manure and the use of chemical plant protection;
- With a view to the sustainable development of agriculture in the region, there is a lack of irrigation systems in 88.8% of agricultural lands, due to high costs, lack of water and a low association among farmers of only 31.9%.
- Another problem identified is the fragmentation of land, which leads to difficult use with additional costs, especially for the transport of machinery and labor;
- Farmers in the region prefer to lease land (48.2% of the total owning more than 70% of leased land), the purchase being relatively low, due to prices, legislation and farmers' uncertainty regarding the future of farms;
- The land owned by the farms is tabulated on average a little over 25%, which indicates another factor in the low number of traded lands;
- Most lands have prices below 2,000 euros due to the lack of completion of their cadastre, poor access and low demand in many areas of the region;
- With a view to the sustainable development of agriculture, we observe the practice of conventional agriculture (52%), with great potential for the growth of a

mixed and ecological agriculture (48%), through the use of minimally invasive substances and techniques on crops;

- Investments in land improvement works are relatively low, being present in 33% of the analyzed farms. Most of the work focused on flood control of agricultural land through drainage and drainage, soil erosion control and irrigation systems.
- The age of workers in the agricultural sector is relatively high, most of them being in the category of 30-39 years (26.8%), 40-49 years (33%) and over 49 years (30.8%). Most farmers consider age to be an important factor in the decision to work in agriculture, due to the ever-increasing labor migration;
- Most of the owners of agricultural farms have high school (30%) and university (25%) studies in fields other than agriculture, a field in which only 26% of farmers fall;
- Almost 60% of farmers have an increased motivation to carry out agricultural activities, the main reason being related to maintaining family values and traditions;
- Modern technologies in agriculture, which can improve productivity, are used by only 20% of farmers. Most attributed the low use to a lack of knowledge of how to use the equipment. Another impediment to the use of equipment such as precision agriculture systems (for fertilizing, sowing, treating, watering), agricultural drones and GPS monitoring systems applied to agricultural machinery, are high acquisition costs;
- UAS technology does not cause soil entrainment or impact that would occur with a ground mechanism and can operate on terrain that traditional agricultural machinery cannot (eg terraced, paddy fields, swamps);
- The use of UAS technology contributes to improved human safety due to reduced contact with agricultural chemicals compared to human-operated land-based equipment.;
- GIS technologies facilitate the creation of databases for the creation of digital maps that facilitate access to spatial data, providing precise positioning of agricultural land and monitoring of crops for sustainable agriculture in terms of costs and production yield.

Recommendations:

- For the development of agriculture in the region, it is recommended to merge the land surfaces in order to combat their fragmentation, which leads to poor exploitation due to factors such as: lack of access to subsidies, limited access, increased cost of transporting agricultural machinery, lack of interest from investors for small areas of land;
- It is recommended to increase public and private investments in irrigation systems. Agriculture being a strategic field of national interest, it is recommended to make significant investments from the state for irrigation (only 11% of all farms have irrigated areas). At the same time, the association of farmers is suggested for the realization of water adductions to farm lands, through the establishment of agricultural associations or through existing ones;
- The majority of farms sell only about 50% of the total production, due to the lack of a common strategy to encourage the market entry of small and medium-sized farms that sometimes have insufficient quantities to associate with large

hypermarkets. In this sense, association in agricultural cooperatives is recommended, currently being below 25%.

- Due to the small number of agricultural farm owners who hold specialized studies in agriculture, it is recommended to complete some specialized university courses, in order to improve their managerial performance;
- To cover the high costs of purchasing equipment, some solutions could come from national or European funding and through the joint use of equipment by farmers;
- Increasing the labor force by promoting the technologies used in agriculture among young farmers, pupils and students, in order to change the perception of the practice of agriculture;
- It is proposed to replace the unskilled and insufficient workforce with modern agricultural technologies, such as agricultural drones that can cover large areas of land autonomously, GPS systems applied to agricultural machinery or other precision systems for fertilizing, sowing, treating, watering, etc. , which can be programmed remotely by a single operator.

8. THE INNOVATIVE AND ORIGINALITY CONTRIBUTIONS OF THE THESIS

The originality of the thesis is given by the application of a series of questions designed specifically to achieve the proposed objectives in combating the phenomenon of agricultural land abandonment. The survey was applied directly to farmers in the studied area and discussed with them. The questions were grouped so that they could outline three essential directions: the profile of agricultural farm owners, the current use of agricultural holdings and future trends. Previously, the specialized literature does not record the application of a survey of such complexity in the region under study.

SELECTIVE REFERENCES

1. SCHENK T., 2005. Introduction to Photogrammetry, Department of Civil and Environmental Engineering and Geodetic Science, *Ohio State University, USA, Columbus, 106(1).*
2. ŠIPKA, M.; MARKOVIĆ, M., 2022. Use of GIS in agriculture. *Practical Guide for the Use of ICT in AET, 50-62.* https://af.unmo.ba/media/1834/wp2-6_practical-guide-for-the-use-of-ict-in-agriculture-english-version.pdf
3. RODINO, S., POP, R., STERIE, C., GIUCA, A., & DUMITRU, E.,2023, Developing an Evaluation Framework for Circular Agriculture: A Pathway to Sustainable Farming. *Agriculture, 13(11), 2047.*
4. PAWLAK, K., & KOŁODZIEJCZAK, M., 2020, The role of agriculture in ensuring food security in developing countries: Considerations in the context of the problem of sustainable food production, *Sustainability, 12(13), 5488.*
5. ****https://www.madr.ro/dezvoltare-rurala.html*