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CREATION OF A GIS DATABASE FOR THE ANALYSIS OF AGRICULTURAL LAND MANAGEMENT IN THE NORTH-WEST DEVELOPMENT REGION OF ROMANIA

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Abstract

The agricultural sector has been suffering in recent years from a decrease in the workforce, especially young farmers. In this regard, it is necessary to rethink agricultural holdings by practicing intensive and financially sustainable agriculture in order to be able to provide food for the entire growing population. In the framework of this work, a number of 276 agricultural farms belonging to the North-West Region of Romania were studied in 2024, from the point of view of the way agriculture is practiced, through a large survey that was applied directly to farm owners, with a number of 14 relevant questions with multiple answer options. Following statistical interpretations and the creation of GIS maps, it can be observed that the area under study benefits from a rich agricultural area with a great diversity of crops, but with a slightly aging workforce that uses very little new techniques and modern technologies to intensify the productions obtained. Field crops are present in 88.4% of farms, followed by permanent crops (67%) and horticultural crops (25.7%). The conclusions of the study show an increased potential in the use of ecological, intensive and economically sustainable agriculture by applying modern technologies in agriculture such as GIS systems for the spatial tracking of agricultural land.

Key words*: sustainable agriculture, NW Development Region, agricultural farms, sociological survey, GIS.*

INTRODUCTION

Agricultural land is the most valuable capital for food production, enabling territorial development and population growth (Wigier & Andrzej, 2018; Paz et al., 2020). To maintain a satisfactory level of global food supply, this continues to increase the very important way of exploiting agricultural resources in the most efficient way possible (Foley et al., 2011; Castillo et al., 2021). To obtain higher and better quality production, it is essential that modern crop monitoring techniques, namely irrigation and fertilization treatments, are used on the exploited area (Postek et al., 2019; Godfray et al., 2010; Wu et al., 2014).

At the European Union level, agricultural land is highly complex due to a series of factors such as: soil structure, geographical position and climatic conditions (Bański, 2017; Călina et al., 2015). In addition to physical-geographical factors, labor is very important (Adenuga et al., 2021; Cummings et al., 2006). The Member States of the European Union have been facing a considerable decline in the workforce in recent years, which is leading to the search for modern technological solutions that require a significantly reduced number of workers (Salimova et al., 2020; Eurostat, 2024). Romania at the European Union level has a very large agricultural potential, with rich land and favorable climatic conditions for agriculture. (Constantin, 2017). Over 60% of Romania's territory can be used in agricultural activities for growing plants and raising animals (Feher et al., 2017).

Geographic information systems (GIS) have recently become a very efficient way to create spatial databases for highlighting and monitoring works in a multitude of fields, including agriculture. These GIS systems can be correlated with remote sensing and GPS positioning systems, in order to collect and use spatial data with very good resolutions for observing the objects of interest subject to analysis (Merchant et al., 2009).

Agriculture represents a favorable sector for the use of GIS, due to the specific data that mostly have a spatial component and thus maps can be made to highlight data from the field more easily

(Šipka & Marković, 2022). For agricultural lands, spatial data plays an important role in investigating the spatial links between factors such as environmental, physical and agroecological factors, respectively, studying the influence of these factors on sustainable agriculture (Mathenge et al., 2022). The collected geospatial data can be displayed and analyzed at different scales thanks to specific methods and tools available in the ArcGis program (Goodchild, 2011).

GIS technologies help in agriculture to create dynamic agricultural databases and interactive systems (Nie et al., 2010). These systems facilitate farmers to access real-time spatial data, providing accurate positioning that helps in making favorable decisions regard-ing the sustainable use of agricultural land (García-Berná et al., 2020). The new fields in agriculture where GIS applications are used are: precision agriculture, automated agricultural systems, crop yield estimation, climate change and production monitoring, with the aim of im-proving food security (Weiss et al., 2020; Dunaieva et al., 2019).

MATERIALS AND METHODS

To create the GIS database for the analysis of management regarding the exploitation of agricultural land in the North-West Region of Romania, a survey was created based on a questionnaire specially designed to reflect the reality on the ground. The survey analyzed 11 questions relevant to the creation of the GIS database and statistical interpretation, which were distributed through the Payment and Investment Agencies for Agriculture uniformly to farmers in the 6 counties analyzed, namely 47 in Bihor County, 50 in Bistrita Nasaud County, 44 in Cluj County, 46 in Maramures County, 49 in Satu Mare County and 40 in Salaj County, totalling 276 farms analyzed. The questions addressed to farmers with answer options referred to the county in which the farm is located, the locality in which the farm is located, the age of the farm owners, the area of agricultural holdings, the use of land by land use category, the types of crops held, the economic size of farms, the execution of land improvement works. Two questions were also asked on a linear numerical scale with answers from 1 to 10 regarding the factors that influence the involvement of farms in associative forms, respectively the factors that influence the conduct of agricultural activities. A 5-point Likert scale was used to analyze the factors that influence the labor force in agriculture.

The GIS database (Figure 1) was created in the Excel editing program and reported in the ArcGIS Pro program to create thematic maps that highlight the situation of the study area.

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909	Point	MADARAS	BIHOR	5	1	H	<N	1	49	99	5	99	0	0	0	5	0	99	10999	0
2698	Point	TAUTEU	BIHOR	5	<N	A	<N	2	39	149	149	0	0	0	0	149	0	0	7999	0
1883	Point	TILEAGD	BIHOR	5	1	S	ne	1	60	199	99	99	0	0	0	99	0	99	7999	0
1881	Point	SACUENI	BIHOR	5	1	S	<N	2	60	149	149	0	0	0	0	149	0	0	10999	1
1879	Point	STEI	BIHOR	4	1	S	nu	3	49	99	99	0	0	0	0	99	0	0	7999	0
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1495	Point	SALONTA	BIHOR	4	1	S	<N	2	60	149	149	0	0	0	5	149	0	5	7999	0
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910	Point	CEFA	BIHOR	5	1	A	<N	1	39	99	29	99	0	0	0	29	0	99	7999	0
858	Point	BIHARIA	BIHOR	5	1	S	<N	2	49	99	99	29	0	0	0	99	0	29	13999	0
904	Point	HOLOD	BIHOR	5	2	S	<N	3	29	99	29	99	0	0	0	29	0	99	7999	0
895	Point	LUNCA	BIHOR	5	<N	A	<N	1	49	99	29	49	0	0	0	29	0	49	7999	0
877	Point	NOJORID	BIHOR	5	1	H	<N	1	49	149	149	0	0	0	0	149	0	0	7999	0
876	Point	OSORHEI	BIHOR	5	1	S	<N	1	39	99	5	99	0	0	0	5	0	99	10999	0
862	Point	BALC	BIHOR	5	1	H	<N	1	39	99	5	99	0	0	0	5	0	99	7999	0
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850	Point	CHISLAZ	BIHOR	5	<N	A	<N	1	39	149	149	0	0	0	29	149	0	29	10999	0
848	Point	ABRAMI	BIHOR	5	1	S	<N	1	60	149	49	99	0	0	0	49	0	99	7999	0
843	Point	CURTUISENI	BIHOR	5	1	H	<N	1	49	99	99	0	0	0	0	99	0	0	4999	0
912	Point	CIUMEGHIU	BIHOR	5	1	S	<N	4	49	99	99	0	0	0	0	99	0	0	7999	0
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2707	Point	OLCEA	BIHOR	5	<N	A	<N	2	60	99	5	99	0	0	0	5	0	99	7999	0
2715	Point	LAZURI DE BEIUS	BIHOR	5	1	A	<N	2	39	99	99	0	0	0	29	99	0	29	7999	0
1887	Point	HERINA	BISTRITA-NAS	5	<N	A	<N	1	61	99	49	49	5	0	0	54	0	49	7999	0
1886	Point	CETATE	BISTRITA-NAS	5	<N	A	<N	3	60	149	99	29	29	0	5	128	0	34	4999	0
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750	Point	TEACA	BISTRITA-NAS	5	<N	A	<N	4	49	149	99	29	5	0	5	104	0	34	4999	0
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1712	Point	REBRA	BISTRITA-NAS	5	<N	A	<N	2	49	99	5	99	29	0	0	34	0	99	4999	0
745	Point	SANMIHAIU-DE-CAMPIE	BISTRITA-NAS	5	1	M	<N	5	60	199	149	49	5	0	29	154	0	78	4999	0
1501	Point	SANGEORZ-BAI	BISTRITA-NAS	4	1	S	<N	1	60	29	5	0	5	0	5	10	0	5	2000	1
747	Point	SIEU-MAGHERUS	BISTRITA-NAS	5	1	H	nu	1	39	99	5	99	0	0	0	5	0	99	2000	1
1500	Point	NASAUD	BISTRITA-NAS	4	1	S	<N	1	29	99	5	99	5	0	0	10	0	99	10999	0
2056	Point	MILAS	BISTRITA-NAS	5	<N	A	<N	1	29	49	49	29	5	0	5	54	0	34	4999	1
557	Point	ROMULI	BISTRITA-NAS	5	1	H	<N	1	60	29	5	29	29	0	0	34	0	29	2000	0
2545	Point	MATEI	BISTRITA-NAS	5	<N	A	<N	3	39	199	149	49	29	0	0	178	0	49	4999	0

1 (0 out of 163 Selected)

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Figure 1. GIS database

Statistical analyses were performed with SPSS software. The program has a well-structured and intuitive interface that allows for the entry of existing data from other programs such as Microsoft Excel or manual entry. Compared to Microsoft Excel, SPSS has an additional tab that allows you to set some parameters used in the statistical analysis of the data set: variable names, their type, width, number of decimal places, label, values, alignment (left, right, center), measure (scale, ordinal, nominal), role (input, target, input and target, none).

RESULTS AND DISCUSSIONS

Following the collection of data from farmers and their introduction into the GIS database, a series of thematic maps were generated that highlight the distribution of agricultural land use in the North-West region of Romania.

In a first stage, a GIS map was created showing the uniform distribution of farms and their number in each locality (Figure 2).

Regarding the age of farm owners, we can see that this is relatively high, with most being over 40 years old, which represents 63.8%. The category of young people under 30 is reduced by only 9.4% (Figure 3). The agricultural areas owned vary from one farm to another, with the average being between 50 ha and 99 ha (Figure 4). At the regional level, 88.4% of farmers own arable land, followed by permanent pastures (Figure 5). Field crops, mostly represented by cereals, are present in 83.7% of the farms analyzed (Figure 6).

Agricultural land prices vary from county to county, depending on the distance of the land to urban areas. Almost 60% of these fall into the category of under 2,000 euros per hectare, followed by the category between 2,000 euros per hectare and 4,999 euros per hectare (Figure 7).

Within the analyzed region, the application of various land improvement works to increase and improve agricultural performance is observed. The most common works were those of desiccation and drainage, being present in 42 farms (45.7%), followed by specific works to combat soil erosion in 25 farms (27.2%), irrigation arrangements in 23 farms (25%), damming and regularization of watercourses of local interest in 16 farms (17.4%) and forest curtains in 14 farms (15.2%).

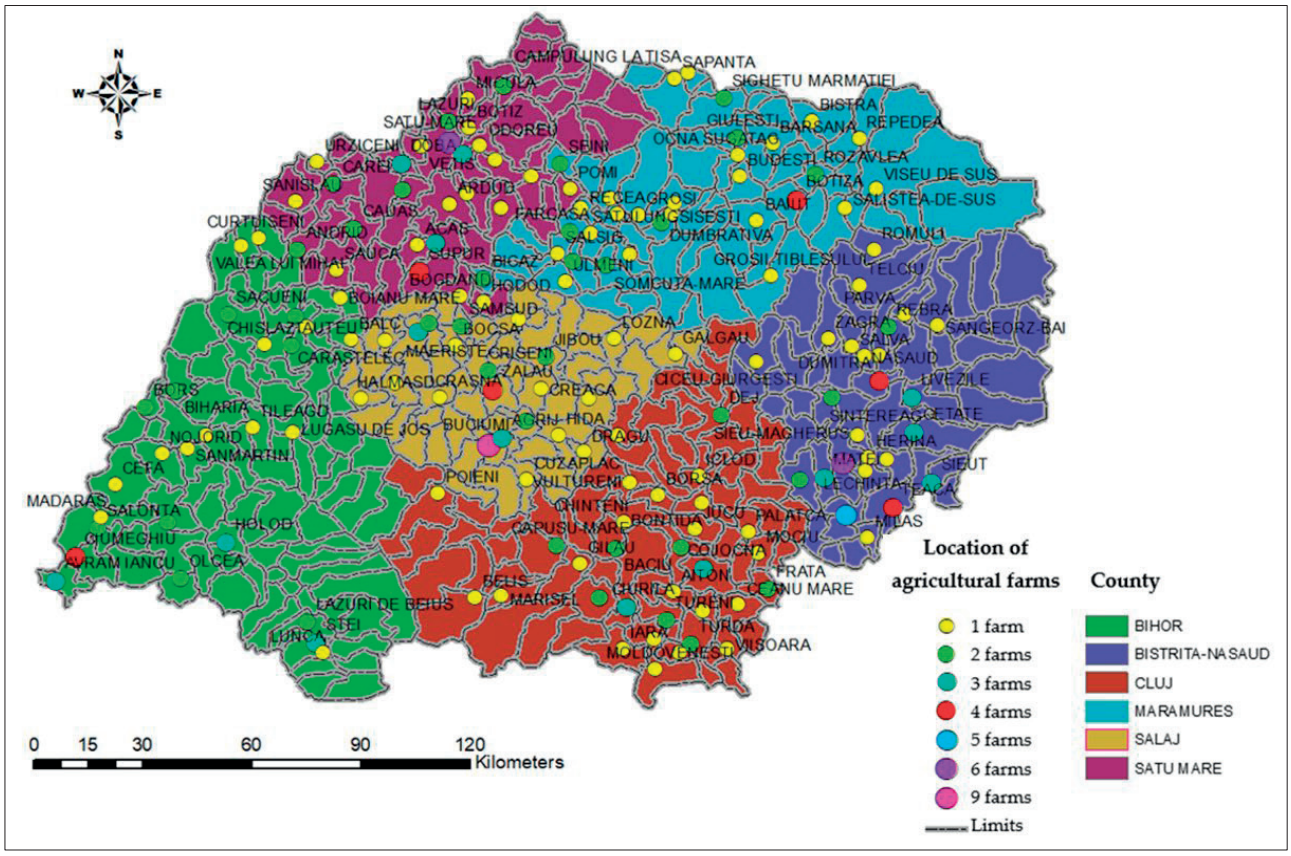

Figure 2. Locations of agricultural farms

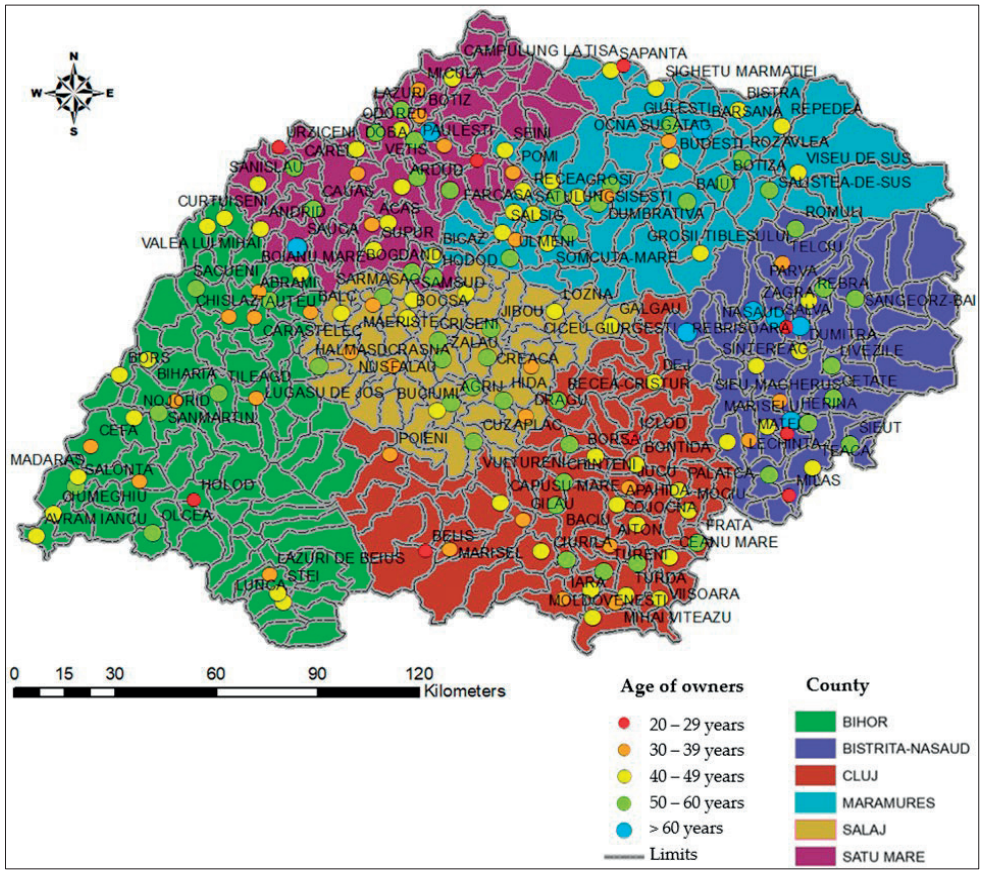

Figure 3. Farm owners by age

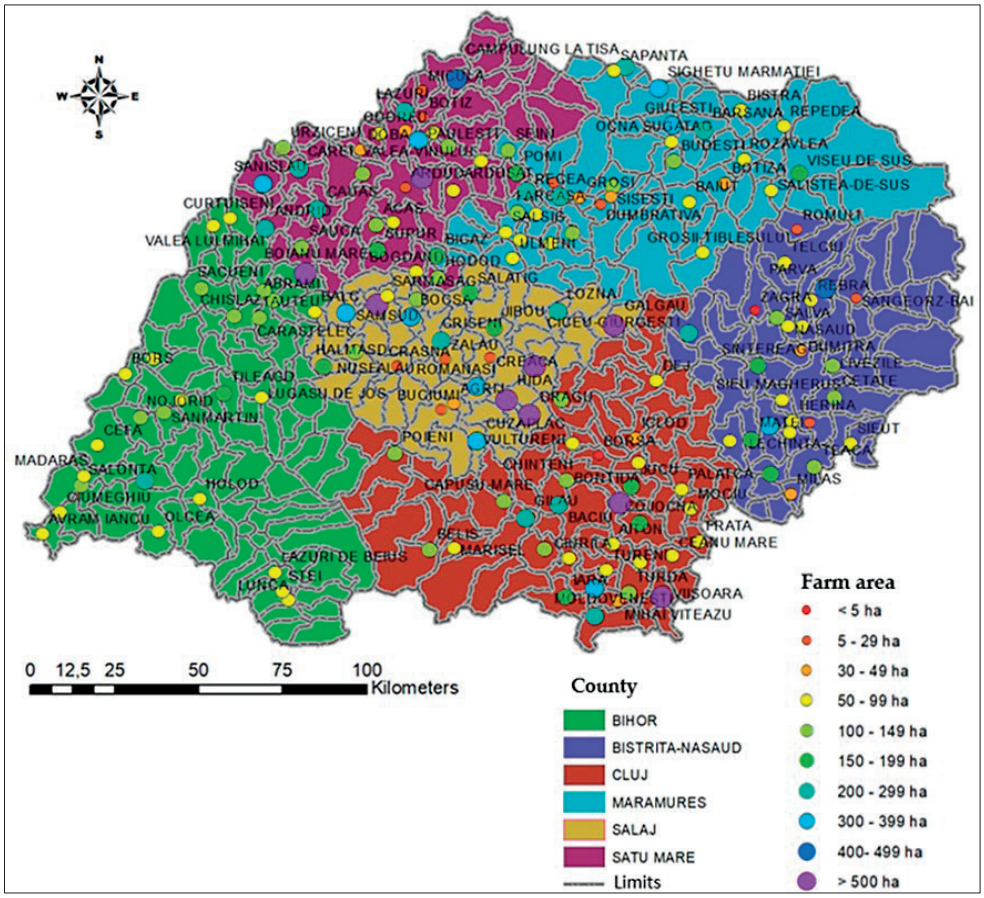

Figure 4. Size of agricultural farms

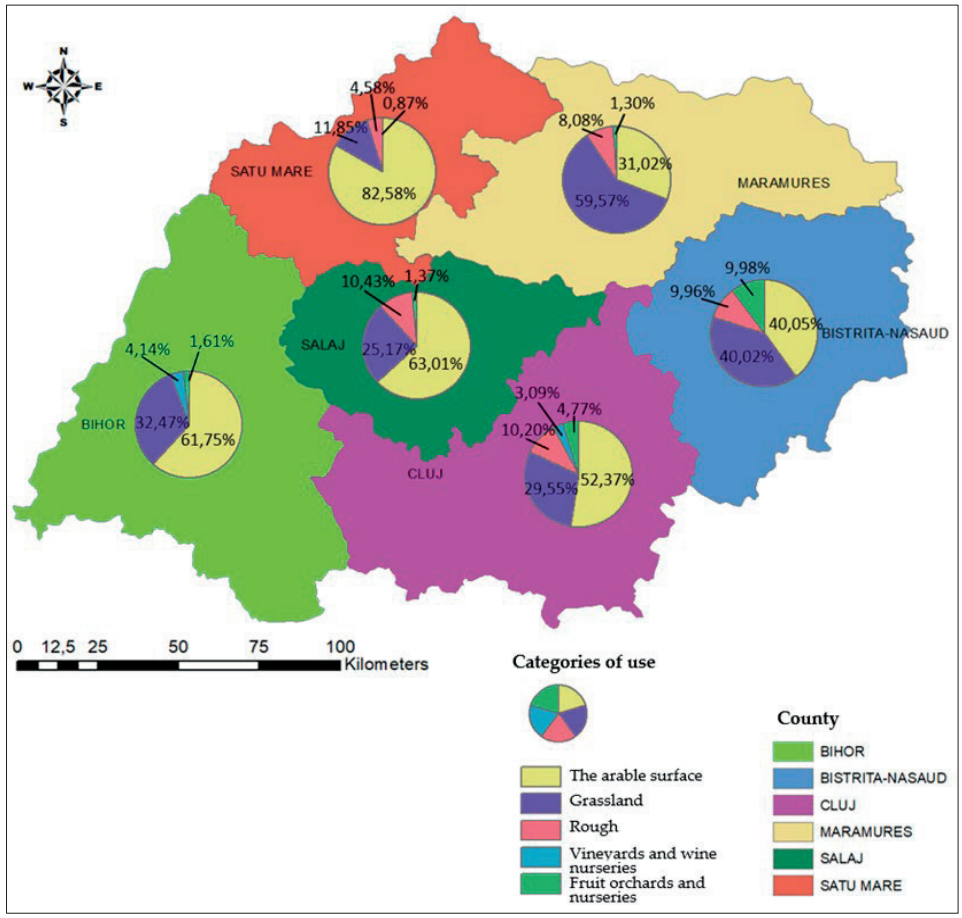

Figure 5. Agricultural land use categories

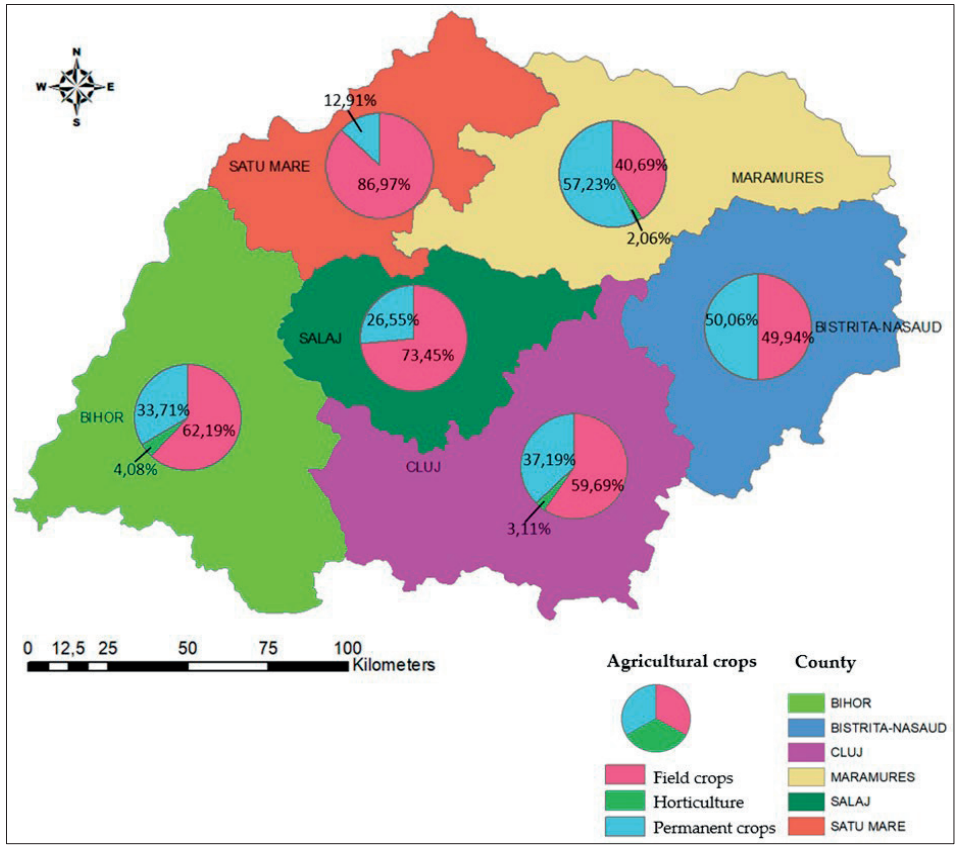

Figure 6. Main agricultural crops

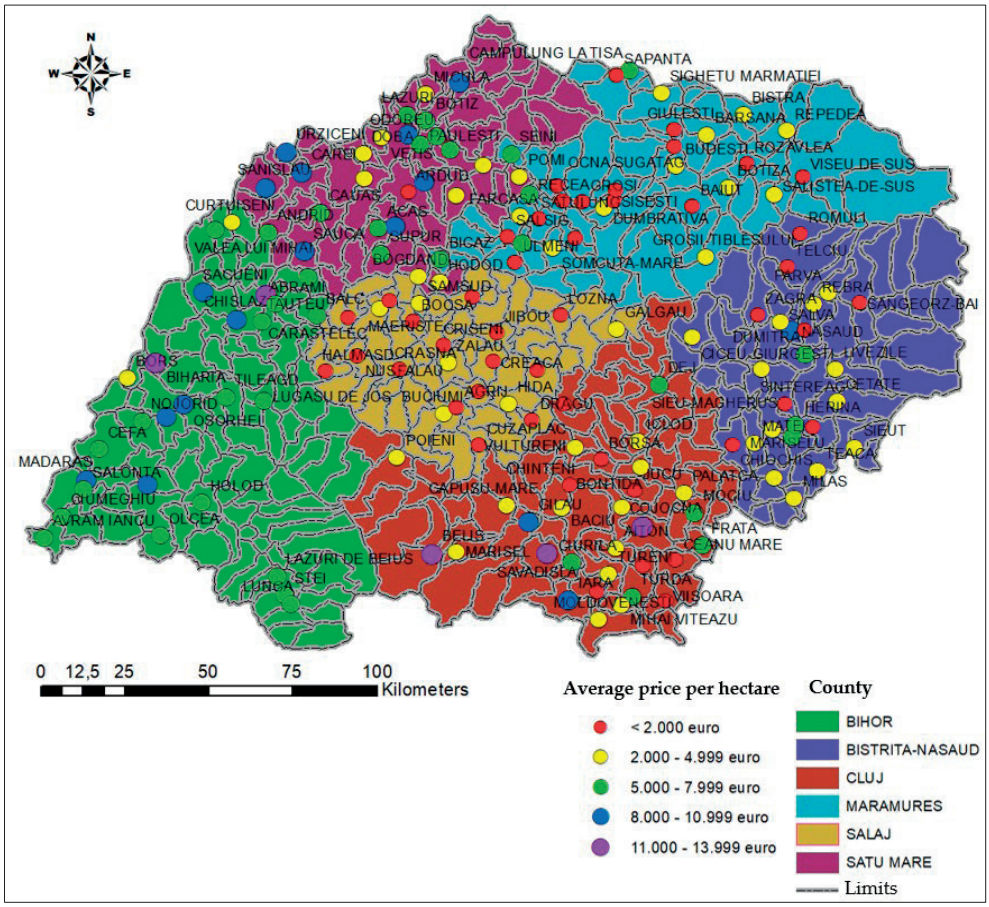

Figure 7. Agricultural land price

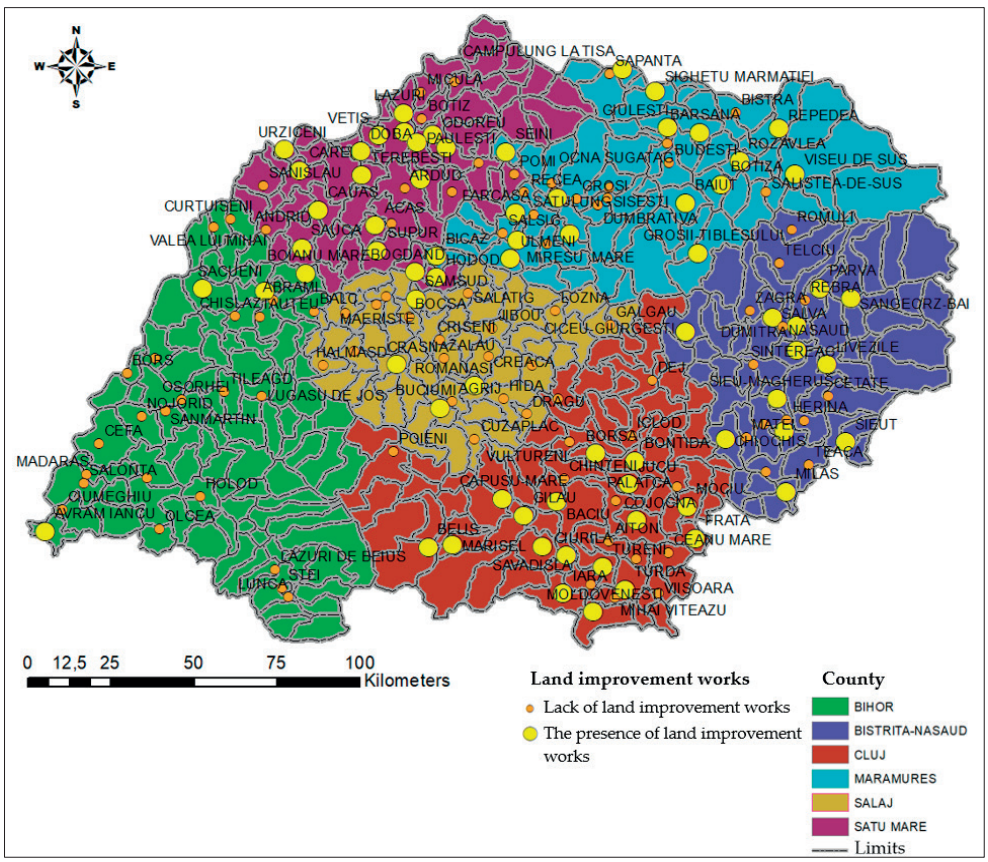

Figure 8. Land improvement works

Following the statistical analysis of the perception of the support offered by the associated forms of which they are part, a high perception is observed for the protection of common interests, motivated in fact by the fact that when problems arise that a large number of farmers face, they are more easily visible and resolved by decision-makers. The exchange of best practices between farmers enjoys a high perception, thanks to working groups at the level of farmers' associations that try to find the best solutions that are sustainable in terms of environment and financial return. Farmers believe that by joining forces they can more easily sell their products in large quantities to supermarket chains, specialty stores, or agri-food processing plants. Access to financing, access to EU policies and joint procurement of goods and services are characterized by farmers as being insufficiently promoted and used among the associative forms they belong to, due to a perception of distrust regarding accessing joint projects or the joint use of agricultural equipment and services (Table 1 and Table 2).

Table 1. The support provided by associative forms

Variables	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)	8 (%)	9 (%)	10 (%)
Protecting common interests	2 (2.3)	2 (2.3)	2 (2.3)	6 (6.8)	8 (9.1)	13 (14.8)	11 (12.5)	10 (11.4)	14 (15.9)	20 (22.7)
Accessing funding	3 (3.4)	3 (3.4)	7 (8.0)	4 (4.5)	8 (9.1)	10 (11.4)	13 (14.8)	16 (18.2)	10 (11.4)	14 (14.9)
Exchange of best practices and information	1 (1.1)	0 (0.0)	5 (5.7)	9 (10.2)	13 (14.8)	8 (9.1)	12 (13.6)	16 (18.2)	9 (10.2)	15 (17.0)
Accessing EU policies and strategies	3 (3.4)	1 (1.1)	4 (4.5)	9 (10.2)	18 (20.5)	9 (10.2)	8 (9.1)	13 (14.8)	7 (8.0)	16 (18.2)
Joint purchase of goods and services	5 (5.7)	4 (4.5)	5 (5.7)	9 (10.2)	9 (10.2)	7 (8.0)	17 (19.3)	9 (10.2)	8 (9.1)	15 (17.0)
Easier access to markets for product marketing	3 (3.4)	4 (4.5)	3 (3.4)	1 (1.1)	12 (13.6)	12 (13.6)	15 (17.0)	13 (14.8)	7 (8.0)	18 (20.5)

Table 2. Deciding on variables related to the support offered by 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
Accessing EU policies and 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

There is a high perception of motivation for agriculture due to the good economic performance of the farms studied. It is also observed that most farmers have good access to agricultural land, which can lead to increased performance in terms of its use.

On the other hand, climate change, the preservation of natural landscape elements and the influence of labor migration are characterized by a statistically low perception among farmers (Table 3 and Table 4).

Following the statistical analysis of the factors influencing the decision to work agricultural land, an increased perception among farmers of specialized studies is observed, thanks to high schools and faculties with an agricultural profile that help to learn the correct way to efficiently exploit agricultural land. Age is another important factor in terms of working in agriculture, due to specific activities that require increased physical effort.

The people surveyed also consider that work autonomy and maintaining family values and traditions are very important factors in the decision to work in agriculture. Factors such as job security, working hours and environmental sustainability are perceived as negative factors by most farmers in deciding to farm their farmland. Also, people working in agriculture have a low perception of social acceptance, prestige and respect from the community in which they work (Table 5).

Table 3. Number of respondents for variables related to agricultural activities

Variables	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)	8 (%)	9 (%)	10 (%)
The motivation for agriculture	1 (0.4)	2 (0.7)	6 (2.2)	5 (1.8)	24 (8.7)	37 (13.4)	40 (14.5)	45 (16.3)	52 (18.8)	64 (23.2)
Economic performance	0 (0.0)	1 (0.4)	8 (2.9)	14 (5.1)	33 (12.0)	40 (14.5)	55 (19.9)	49 (17.8)	45 (16.3)	31 (11.2)
The influence of climate change	0 (0.0)	4 (1.4)	7 (2.5)	18 (6.5)	35 (12.7)	42 (15.2)	41 (14.9)	48 (17.4)	44 (15.9)	37 (13.4)
Conservation of natural landscape elements	5 (1.8)	5 (1.5)	7 (2.5)	14 (5.1)	37 (13.4)	36 (13.0)	45 (16.3)	65 (23.6)	35 (12.7)	27 (9.8)
The influence of labor migration	14 (5.1)	12 (4.3)	16 (5.8)	20 (7.2)	33 (12.0)	32 (11.6)	37 (13.4)	43 (15.6)	37 (13.4)	32 (11.6)
Accessibility to the farm grounds	0 (0.0)	6 (2.2)	7 (2.5)	11 (4.0)	25 (9.1)	36 13.0)	44 (15.9)	48 (17.4)	51 (18.5)	48 (17.4)

Table 4. Number of respondents for variables related to 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: σ = standard deviation, Decision - weighted average = 7,136

Table 5. Number of respondents and decision for variables related to agricultural work

Variables	**Totally agree (%)**	**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
Independent work	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

CONCLUSIONS

At the level of the North-West Development Region of Romania, the presence of small (26%) and medium-sized (42%) farms is observed, this fact is due to the commercialization of only approximately 50% of the production, the rest being used on their own by the members of the agricultural holdings.

There is an increasing trend in the age of workers in the agricultural sector, with 26.8% being under 30 years old, with the rest being

over 30 and even over 40. The category of owners under 20 years old is missing, as they work occasionally and are not owners of agricultural holdings.

Only 26% of the farm owners analyzed have specialized studies in agriculture. High school education is held by 30% of farmers, followed by university studies in fields other than agriculture (25%).

Conventional agriculture, given the use of specific substances for treatment and production stimulation, is used to the greatest extent (52%). The studied area has a high potential for practicing organic and mixed agriculture, currently many farms have small areas cultivated exclusively organically and certified by the authorities. In this regard, modern technologies such as automated, minimally invasive irrigation and fertilization treatment systems can help maintain optimal plant parameters.

GPS monitoring systems mounted on agricultural machinery and the use of agricultural drones represent an efficient way to practice agriculture, unfortunately a small percentage of farmers use them, due to high costs and the lack of programs to train them on how to use them, especially for farmers who do not have specialized studies.

Due to the efficiency of monitoring in the agricultural field, it is recommended to use GIS technologies that facilitate the creation of spatial databases for assessing the situation regarding agricultural crops, allowing for economically efficient decisions to be made.

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