THE EVOLUTION OF ROMANIAN AGRICULTURE MECHANIZATION DEGREE
/
EVOLUTIA GRADULUI DE MECANIZARE IN AGRICULTURA ROMANEASCA

Ancuta MARIN, Vili DRAGOMIR*, Ruxandra POP, Marian BUTU
Institute of Research for Agriculture Economy and Rural Development, Bucharest / Romania

Tel: +40733839694; E-mail: Dragomir.vili@iceadr.ro
DOI: https://doi.org/10.35633/inmateh-71-61

Keywords: *sustainable agriculture, regional disparities, technology imports, mechanisation*

ABSTRACT
Mechanization is a fundamental aspect of agricultural sector modernization, bringing with it both benefits and challenges. The purpose of this study was to evaluate the degree of mechanization of Romanian agriculture and identify the major trends that marked the evolution of this process in the last ten years. Regional differences in the degree of mechanization were also explored, highlighting the particularities and challenges of each region. This analysis will provide a comprehensive perspective on the impact of mechanization in agriculture in Romania and will serve as a basis for the formulation of appropriate agricultural policies for the sustainable development of the country's agricultural sector.

ABSTRACT
Mecanizarea reprezintă un aspect fundamental al modernizării sectorului agricol, aducând cu sine atât beneficii cât și provocări. Scopul acestui studiu a fost evaluarea gradului de mecanizare al agriculturii românești și identificarea tendințelor majore care au marcat evoluția acestui proces în ultimii zece ani. De asemenea, au fost explorate diferențele regionale în ceea ce privește gradul de mecanizare, evidențiind particularitățile și provocările fiecărei regiuni în parte. Această analiză va oferi o perspectivă cuprinzătoare asupra impactului mecanizării în agricultura din România și va servi drept bază pentru formularea politicilor agricole adecvate în vederea dezvoltării durabile a sectorului agricol din țară.

INTRODUCTION

Mechanization in agriculture is the use of modern equipment and technologies to automate and optimize agricultural processes. This practice has significantly transformed the agricultural sector, bringing with it numerous benefits and challenges. Increased efficiency is one of the most significant advantages of mechanization in agriculture. The use of modern equipment and technologies is transforming the way agricultural activities are carried out, contributing to better and more sustainable production (*Peng et al., 2022, Partal et al., 2023*). In general, mechanization has been reported to bring with it considerable advantages in terms of increased efficiency in agriculture *(Arun et al., 2019).* This not only facilitates agricultural processes, but also contributes to increased productivity and reduced costs, all of which have a positive impact on the economic performance of the agricultural sector. However, it is important that mechanization is applied responsibly, also taking into account environmental and societal aspects, to ensure sustainable and balanced agriculture (*Emami et al., 2018*).

Mechanization in agriculture has not only increased efficiency, but also led to a considerable reduction in human effort in agricultural activities (*Peng et al., 2022, Grzelak et al., 2019*). This transformation has a significant impact on work and working conditions in the agricultural sector, for example by reducing the risk of accidents, optimizing the work schedule, reducing the physical effort of agricultural workers *(Duckworth et al., 2019, Yiorgos et al., 2022*).

Also, the increase in the degree of mechanization in agriculture was a determining factor in the increase in agricultural production, ensuring a greater amount of agricultural products in an efficient and sustainable way. By using modern equipment and technology, farmers can successfully manage crops over larger areas, applying fertilizers and pesticides with precision and achieving higher yields (*Ștefan et al. 2019, Grzelak et al., 2019*). The work of ploughing, sowing, harvesting and processing crops became much faster and more efficient, leading to a significant increase in production. Moreover, with the help of mechanization, farmers can optimize resources such as water and energy, contributing to greater efficiency in the production process. From fertilizer application to irrigation and harvesting, mechanization provides greater control over agricultural variables (*Onwunde et. al., 2016; Popescu et al., 2017*).

However, mechanization in agriculture also comes with challenges, such as high costs for purchasing and maintaining equipment, reliance on fossil fuels, and the risk of job losses in agriculture. It is important to balance the benefits with the impact on the environment and society, and develop solutions that lead to more efficient and sustainable agriculture. Mechanization in agriculture is a key factor in the evolution and modernization of the agricultural sector in Romania. Over the decades, the use of technology and agricultural equipment has become increasingly significant, having a significant impact on the efficiency, yields and sustainability of Romanian agriculture and in ensuring food security (*Popescu et al., 2017; Bădan, 2017*).

In this context, the present article focuses on the analysis of the degree of mechanization in Romania, investigating the evolution of this process over a period of ten years. The purpose of this study is to assess the degree of use of modern agricultural equipment and technologies, as well as to identify trends and major changes that have marked this evolution. The analysis will address both the general aspects of mechanization in agriculture and the aspects related to the different categories of agricultural machinery. In addition, regional differences in the degree of mechanization will be explored, highlighting the particularities and challenges of each region *(Vittis et al., 2022).* This analysis will provide a comprehensive perspective on the impact of mechanization in Romanian agriculture and provide a solid framework for understanding future trends and formulating appropriate agricultural policies to increase the competitiveness and sustainable development of Romanian agriculture.

MATERIALS AND METHODS

To carry out this analysis on the evolution of agricultural machinery in Romania, the statistical data available from the National Institute of Statistics for the period 2013-2022 were used. The data collected has been carefully analysed to understand trends and changes in the country's agricultural industry. Data analysis tools were used to calculate rates of increase or decrease and to identify patterns in the data.

Data for different categories of agricultural machinery such as tractors, ploughs, power cultivators, power planters, power-driven sprayers and dusters, self-propelled grain harvesters, self-propelled forage harvesters, potato harvesters and machines, balers for straw and hay balers and windrowers for fodder, were collected and analysed separately to obtain a complete picture of the evolution of each machine category. The analysis also included a comparison between different development regions in Romania to identify regional variations in the purchase of agricultural machinery. Annual growth rates were calculated and graphs were made to highlight the evolution over time of the number of machines.

For further study, the imports of agriculture machinery over a five year period were analysed. The data were extracted from trade map, by selecting the harmonised codes for agricultural machinery for soil works and harvesting, as follows:

'843229 Harrows, scarifiers, cultivators, weeders and hoes for use in agriculture, horticulture
'843210 Ploughs for use in agriculture, horticulture or forestry
'843239 Seeders, planters and transplanters (excl. no-till machines)
'843242 Fertiliser distributors (excl. sprayers and manure spreaders)
'843221 Disc harrows for use in agriculture, horticulture or forestry
'843231 No-till direct seeders, planters and transplanters
'843241 Manure spreaders (excl. sprayers)
'843351 Combine harvester-threshers
'843359 Harvesting machinery for agricultural produce (excl. mowers, haymaking machinery, straw)
'843352 Threshing machinery (excl. combine harvester-threshers)
'843330 Haymaking machinery (excl. mowers)
'843360 Machines for cleaning, sorting or grading eggs, fruit or other agricultural produce
'843353 Root or tuber harvesting machines

RESULTS

Mechanization in agriculture is a key factor in the evolution and modernization of the agricultural sector in Romania. Over the decades, the use of technology and agricultural equipment has become increasingly significant, having a significant impact on the efficiency, yields and sustainability of Romanian agriculture and in ensuring food security.

AGRICULTURAL TRACTORS

The agricultural tractor was and is the emblem of agricultural mechanization. With more than 100 years of history, it has been improved every time it was needed, adapting to various needs and expanding its range of applications. Analysing the tractor fleet over the last 10 years, based on data collected from the National Institute of Statistics, a nationwide increase of 53,494 units (+27.96%) is observed. By development region, the most tractors were purchased in the North-West region, followed by the South-Muntenia and Centre regions (Figure 1).

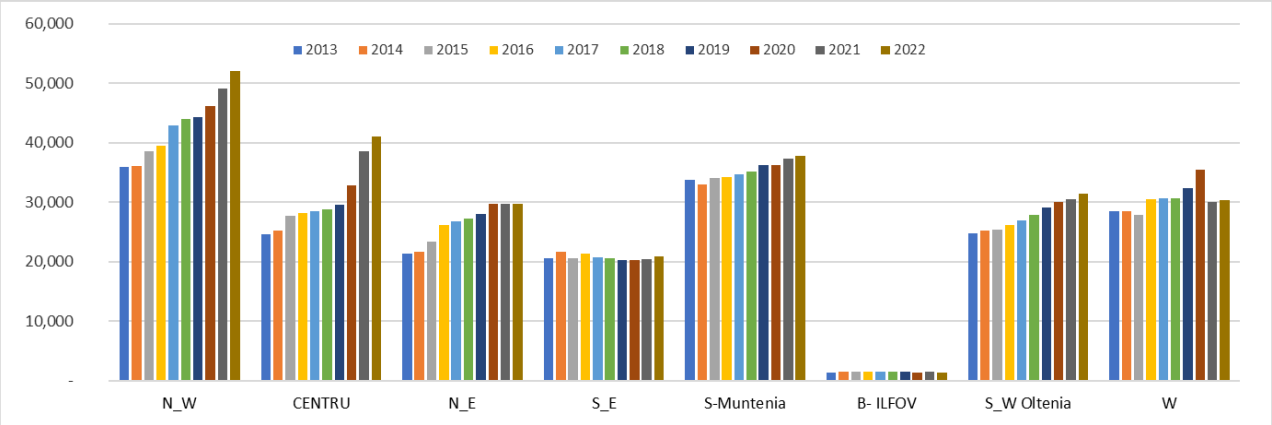

Fig. 1 – Endowments with tractors in Romania, during 2013-2022, by regions

At country level, the tractor fleet had an average of 215,672 units, during the analysed period, with a relatively homogeneous annual growth rate of +2.7776 per year.

PLOWS FOR TRACTOR

One of the most important works of the soil is ploughing, which has a quality directly proportional to that of the agricultural machinery used for this endeavour. Thus, the plough is the most needed work tool, ploughing consists of cutting and moving the furrow of land laterally, simultaneously with its overturning and shredding. This can be done at various depths, depending on the type of soil, the crop that is on it, the surface you have to plough. These aggregates can be attached to tractors or motor cultivators, having 2-5 furrows or even more, depending on the needs (*Petcu et al., 2023*).

Analysing the data available at the INS for the period 2013-2022, an increase, at the country level, of 9,969 pieces (+6.56%) is observed. By development region, in the North-West, the most ploughs for tractors were purchased, followed by the South-Muntenia and Central Regions, in the same order as that of tractors (Figure 2).

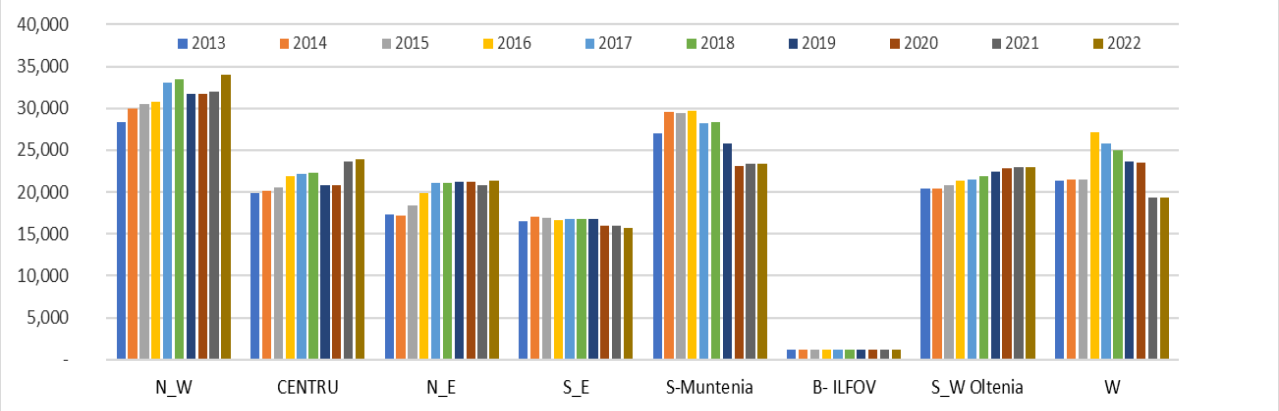

Fig. 2 – Endowments with ploughs for tractors in Romania, during 2013-2022, by regions

MECHANICAL CULTIVATORS

The cultivator is a special tool that prepares the soil for sowing and facilitates harvesting, simplifying manual work and saving time (*Stavytskyy et al., 2017*).

Analysing the data available at the INS for the period 2013-2022, the existence of two sub-intervals 2013-2020 and 2021-2022 can be observed. During the first interval, the number of mechanical cultivators, at the level of the farm, increased by 4,188 pcs (+14.16%), while during the second interval the decrease is accentuated, their number being reduced by 8,681 pcs (26%) compared to maximum. At the country level, the annual rate of decrease was -1.815 per year.

By development regions, growth rates between +0.257 and +2.114 per year were recorded in the Centre Region, the Bucharest-Ilfov Region and the South-West Oltenia Region. In the other regions of the country, the rates were decreasing, the values being between -0.357 and -6.451 per year, much more pronounced than the increases, so that at the country level there is a decrease in these machines (Figure 3).

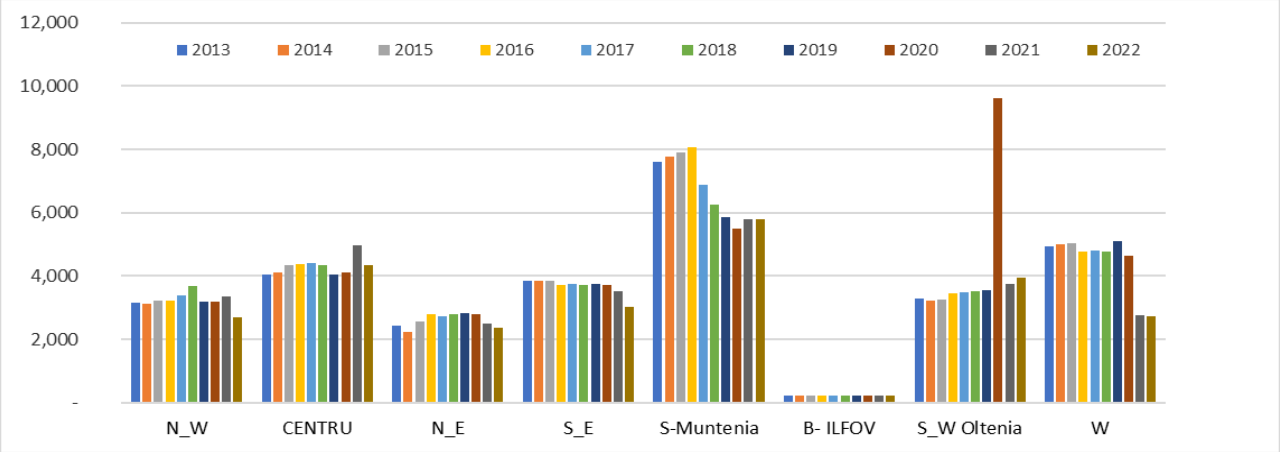

Fig. 3 – Endowments with mechanical cultivators, during 2013-2022, by regions

MECHANICAL SEEDERS

Mechanical seeders are devices that plant seeds for crops by measuring and placing them in the soil at equal distances and covering them to a certain depth. The use of mechanical seeders leads to an improvement in crop yield (seeds harvested/seeds planted) up to 9 times.

Analysing the data available at the INS for the period 2013-2022, the existence of two sub-intervals 2013-2016 and 2017-2022 can be observed. During the first interval, the number of mechanical seeders at field level increased by 6,450 pcs (+8.62%), while during the second the decrease is accentuated, their number decreasing by -11,549 pcs (-14.21%) compared to maximum. At the country level, the annual rate of decrease was -0.7814 per year (Figure 4).

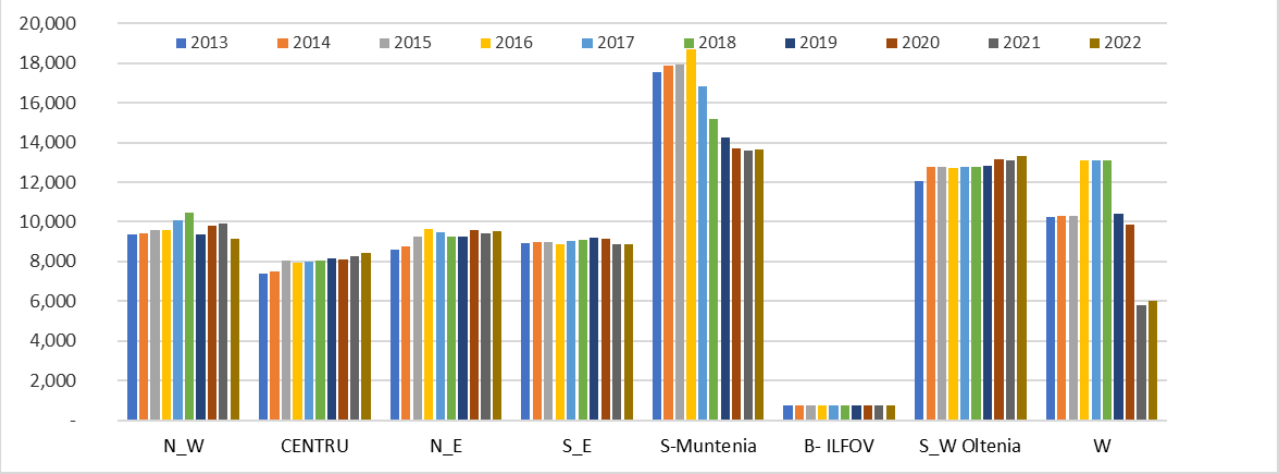

Fig. 4 – Endowments with mechanical seeders in Romania, during 2013-2022, by regions

SELF-PROPELLED COMBINES FOR HARVESTING CEREALS

Self-propelled combines for harvesting grassy cereals are used for direct harvesting of plants from the field and for split harvesting. In this case, the plants are harvested with windrowers and left in the furrows, the combine (equipped with a plant lifter) carrying out their lifting and threshing.

Analysing the data available at the INS for the period 2013-2022, it is observed that the number of self-propelled combines for harvesting grassy cereals decreased by -1,938 pieces (-7%) compared to the maximum recorded. At the country level, the annual rate of decrease was -0.0151 per year. (Figure 5).

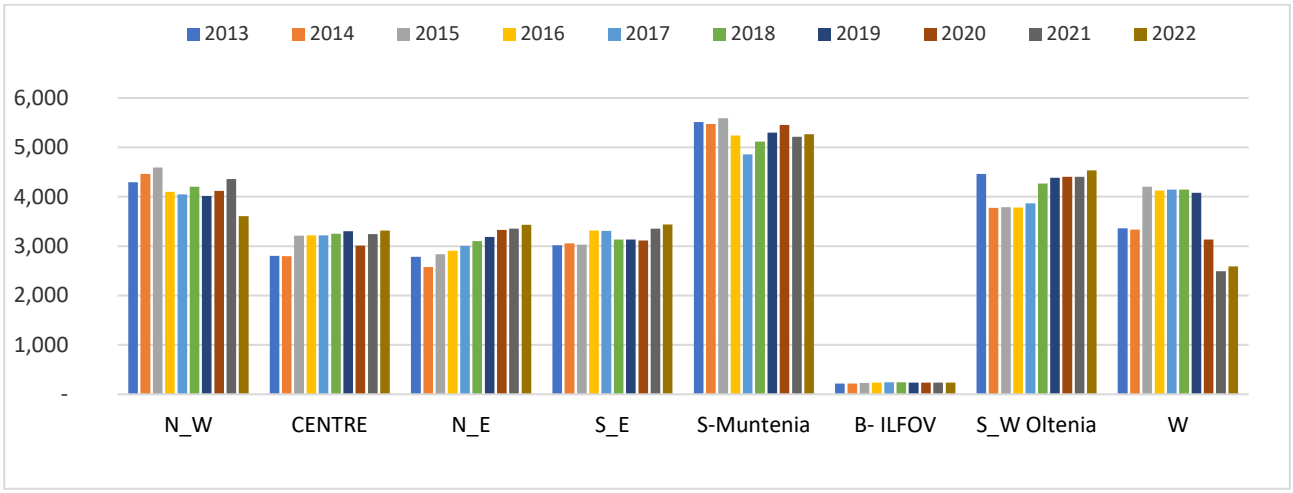

Fig. 5 – Endowments with p self-propelled combines for harvesting cereals in Romania, during 2013-2022, by regions

SELF-PROPELLED COMBINES FOR FORAGE HARVESTING

The self-propelled forage harvester is intended for the harvesting of silage forage plants, grasses and silage corn. It performs operations of cutting, chopping and loading the material into a means of transport. The combine is equipped with a grass harvesting equipment, a furrow gathering equipment and a corn silage harvesting equipment.

Analysing the data available at the INS for the period 2013-2022, there is an increase in the number of self-propelled forage harvesters by 374 units (+7%), followed by a slight decrease in 2022, by 57 units (4.75%) compared to the maximum registered. At country level, the annual growth rate was relatively homogeneous, of +3.6750 per year. By development region, the most self-propelled forage harvesters were purchased in the North-East, followed by the South-East and South-West Oltenia Region (Figure 6)

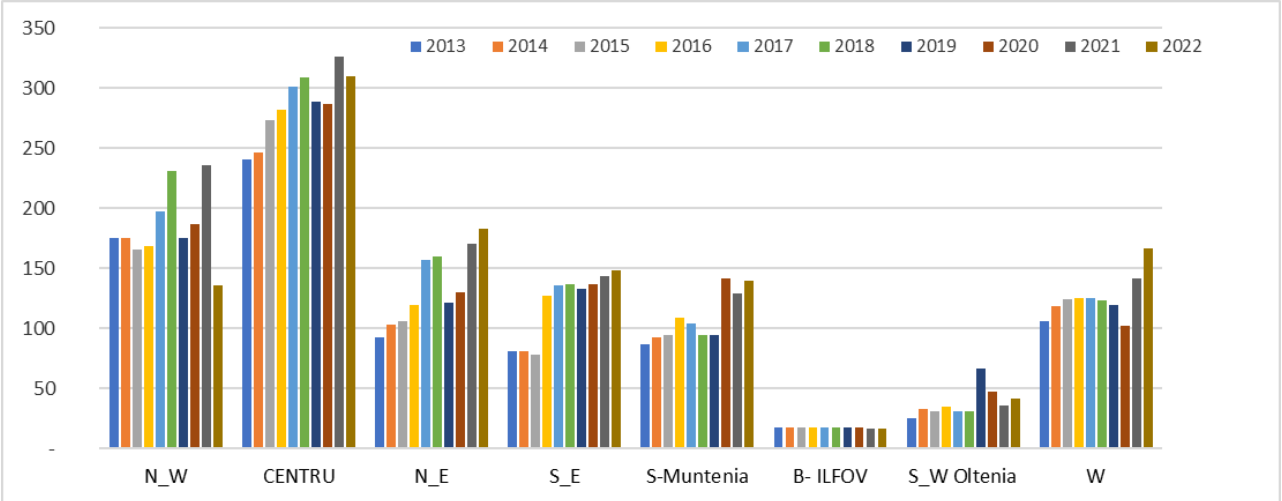

Fig. 6 – Endowments with self-propelled forage harvester in Romania, during 2013-2022, by regions

COMBINES AND MACHINES FOR HARVESTING POTATOES

Combines and potato harvesters are specially designed for digging up potatoes and their subsequent harvesting. These are machines aggregated by the tractor's power take-off cardan.

In order not to distort the analysis, only the areas of potato cultivation were taken into account, the southern regions being excluded. Analysing the data available at the INS for the period 2013-2022, it can be said that the situation of combines and machines for harvesting potatoes was relatively constant because the increase of 852 pcs (+16.14%) recorded in the period 2013-2020 was almost entirely annualized by the sharp decrease from 2021-2022, respectively – 810 pcs (-13.21%), the annual growth rate at the country level was +0.0881 per year (Figure 7).

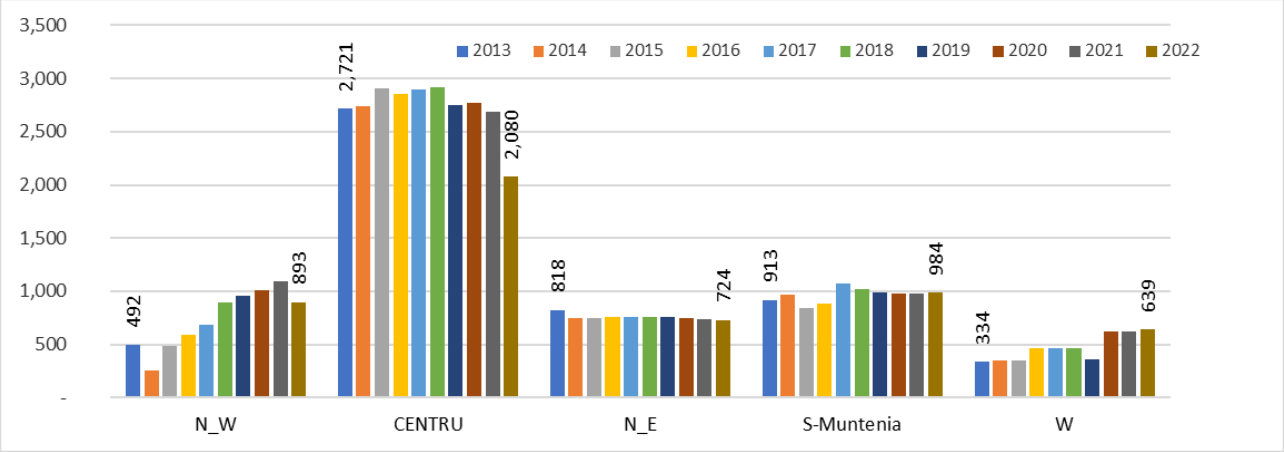

Fig. 7 – Endowments with combines and machines for harvesting potatoes ploughs for tractors in Romania, during 2013-2022, by regions

STRAW AND HAY BALING PRESSES

Straw and hay balers are agricultural machines capable of forming cylindrical or rectangular bales, very well compressed, making them very easy to handle, even manually. Straw and hay balers are equipped with automatic knotters, using twine for tying.

Analysing the data available at the INS for the period 2013-2022, a doubling of the number of presses for baling straw and hay, of 9,691 pcs (+94.77), can be observed at country level. By development region, the most straw and hay baling presses were purchased in the Central Region, followed by the North-West, South-West Oltenia and North-East Regions (Figure 8).

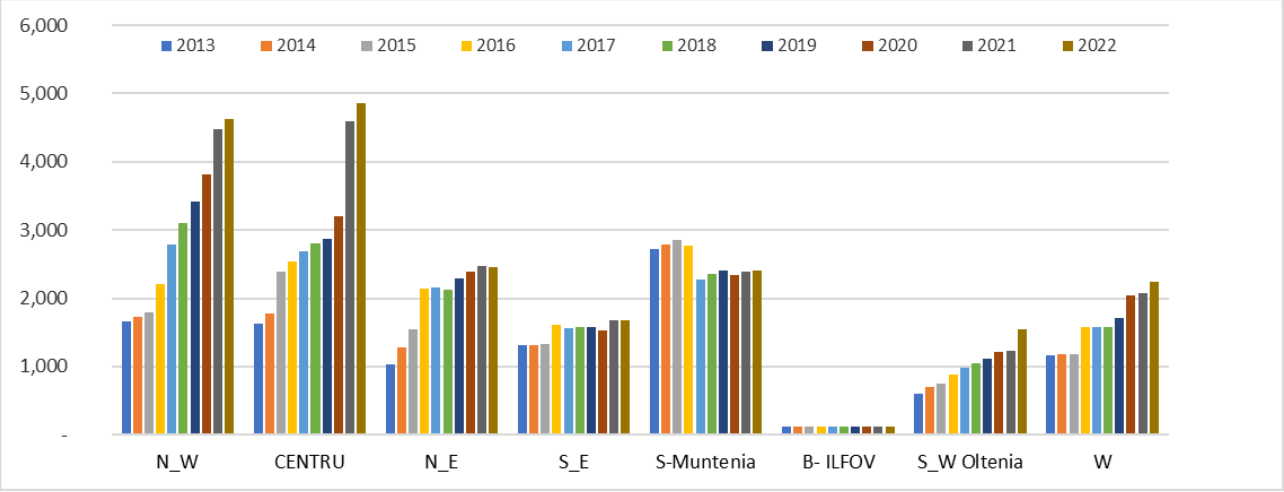

Fig. 8 – The quantitative situation of the baling presses for straw and hay, during 2013-2022, by regions

Although there is more and more talk about Agriculture 4.0 and digital and precision agriculture and data driven agricultural systems these concepts are more difficult to apply in the case of small and medium-sized farms due to limited resources and specific constraints.

Small and medium-sized farmers are often faced with an overload of human and financial resources, and these resources are often directed towards the basic needs of the agricultural operation, such as the purchase of seeds, fertilizers and crop treatments. Allocating funds for the purchase of precision agriculture equipment or technologies can be difficult, because they may not be seen as urgent or immediate investments (*Hadelan et al., 2022*). It is also important to mention that some small and fragmented agricultural lands can make it difficult to use technologies such as large tractors or agricultural combines. Moreover, access to technical expertise and consulting services for precision agriculture is limited in many rural areas, which can make it difficult to implement these technologies. Small and medium-sized farmers may face difficulties in finding and hiring qualified personnel to assist them in the adoption and efficient use of these technologies (*Zhang et al., 2022*). Despite these obstacles, there are initiatives aimed at making precision agriculture more accessible to small and medium-sized farmers, including through subsidies and financing for the purchase of equipment, training programs and consultancy, as well as collaborations between farmers to share costs and resources. With proper support and an attentive approach to the specific needs of these agricultural holdings, precision agriculture can become a reality for small and medium-sized farmers, bringing them significant benefits in terms of increasing productivity and efficiency, as well as reducing the impact on the environment.

Modern agricultural machinery is a crucial factor in increasing the efficiency, productivity and sustainability of Romanian agriculture. The import of agricultural machinery is motivated by the need to replace old and obsolete equipment, as well as to meet the new technological requirements of contemporary agriculture. For example, it is widely recognized that manure and other by-products can be effectively repurposed within soil-crop systems, serving as a valuable nutrient source while also enhancing the physical structure of the soil. It is imperative that land application is conducted with precision and care to minimize any adverse environmental impacts, and this is why manure spreaders are becoming so popular (*Ștefan et al, 2019*).

In Romania, imports of agricultural machinery in Romania cover a wide range of equipment, from tractors and agricultural combines to specialized machinery for agricultural work, such as seed drills, ploughs or irrigators. Imports of agricultural machinery are also an indicator of Romanian farmers' willingness to adapt to modern agricultural technologies and improve their farming practices. Most marketed harvesting machinery are the haymaking machinery (excluding mowers). Interesting is that in 2018, a peak of combine harvester-thresher imports was registered (over 15.000 units) compared to other years (8-900 units per years between 2019-2022) (Figure 9.)

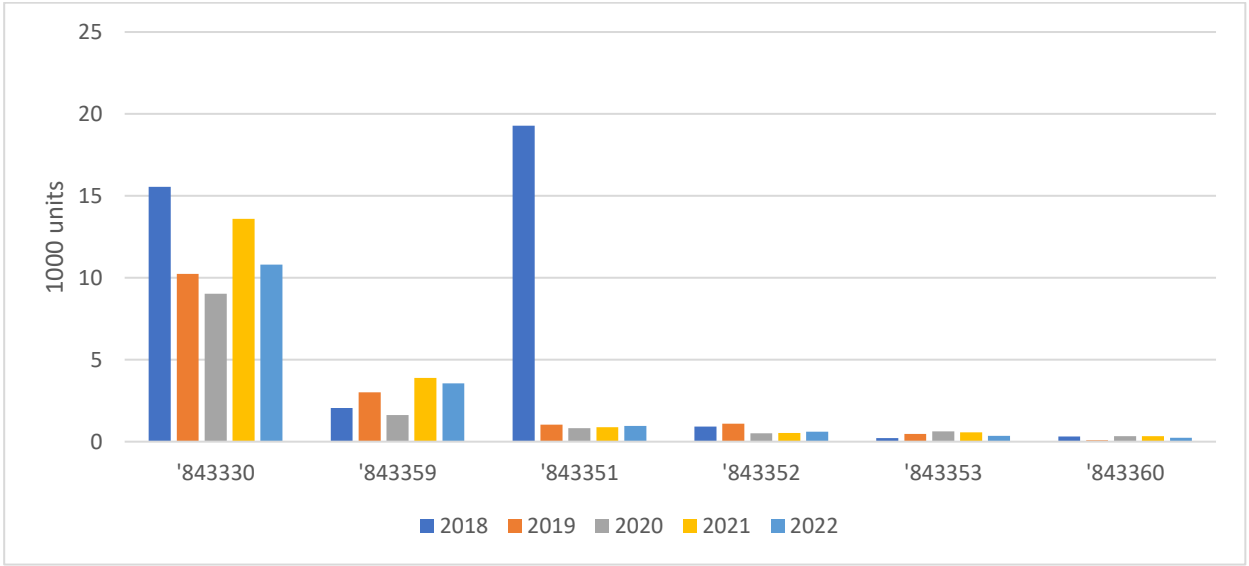

Fig. 9 - List of products imported by Romania detailed products in the following category:
8433 Harvesting or threshing machinery, incl. straw or fodder balers; grass or hay mowers; machines for cleaning, sorting or grading eggs, fruit or other agricultural produce

'843330 Haymaking machinery (excl. mowers); '843359 Harvesting machinery for agricultural produce (excl. mowers, haymaking machinery, straw; '843351 Combine harvester-threshers; '843352 Threshing machinery (excl. combine harvester-threshers); '843353 Root or tuber harvesting machines; '843360 Machines for cleaning, sorting or grading eggs, fruit or other agricultural products;

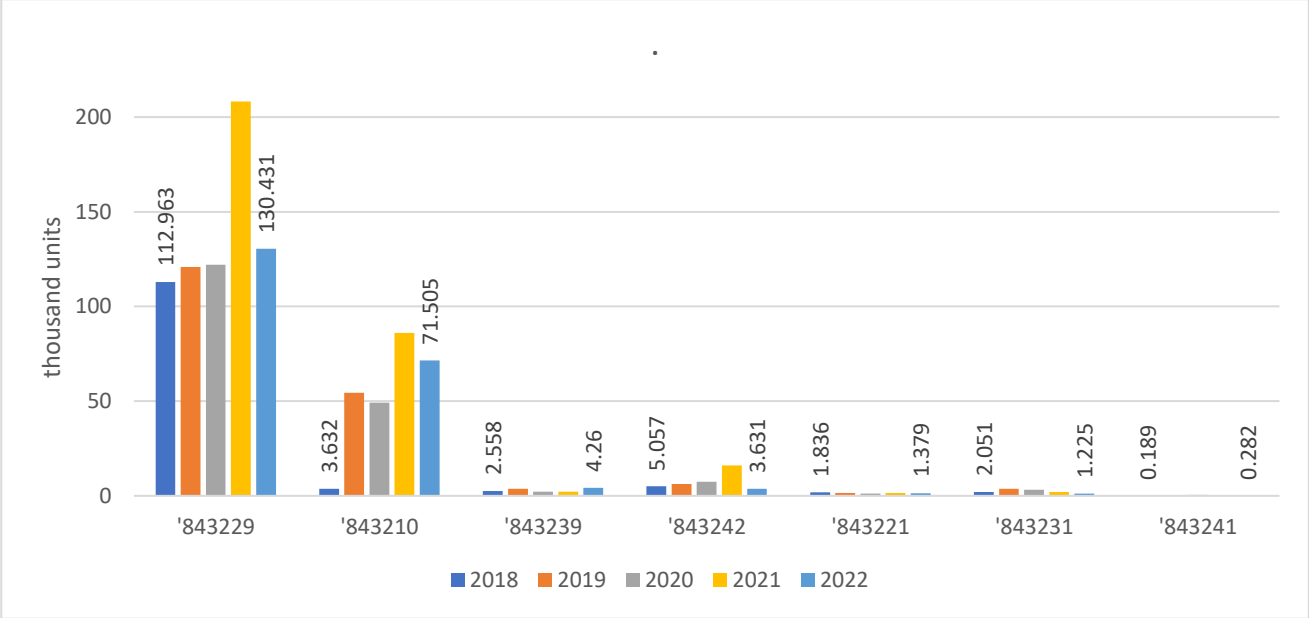

Fig. 10 - List of products imported by Romania, detailed products in the following category: 8432 Agricultural, horticultural or forestry machinery for soil preparation or cultivation (excl. sprayers and dusters); lawn or sports-ground rollers; parts thereof

'843229 Harrows, scarifiers, cultivators, weeders and hoes for use in agriculture, horticulture or forestry (excl. disc harrows); 843210 Ploughs for use in agriculture, horticulture or forestry; 843239 Seeders, planters and transplanters (excl. no-till machines); 843242 Fertiliser distributors (excl. sprayers and manure spreaders; 843221 Disc harrows for use in agriculture, horticulture or forestry; 843231 No-till direct seeders, planters and transplanters; 843241 Manure spreaders (excl. sprayers)

Romania imports agricultural machinery from several countries, each of them offering specific products and agricultural technologies. Among the main countries supplying agricultural machinery for Romania are: Germany, Italy, Poland and China (Figure 11).

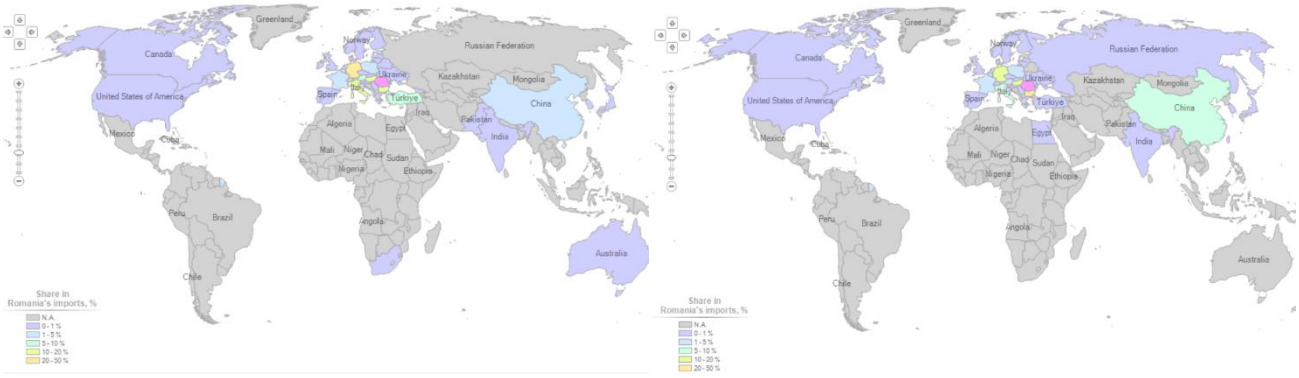

Fig. 11 - Romania's imports of agriculture machinery, by country (left -code 8433, right – code 8432)

Germany is a major supplier of tractors, agricultural combines, harvesters and other high-quality equipment. Italy is known for the production of precision agricultural machinery, including viticulture and horticulture equipment. Poland is an important supplier of tractors and agricultural equipment for the Romanian market. The Netherlands specializes in the production of precision agricultural machinery, including planting and harvesting machinery. These are just a few examples of countries supplying agricultural machinery for Romania. Imports of agricultural machinery from these countries reflect the needs and preferences of Romanian farmers and offer solutions for the modernization and development of the country's agricultural sector.

The level of endowment of Romanian agriculture has evolved significantly in the last decades, reflecting the efforts to modernize and adapt to European standards. Agriculture has remained an essential pillar of the Romanian economy, and investments in agricultural equipment and technologies have played an important role in increasing the efficiency and competitiveness of the sector.

However, there are still significant differences in the level of farm equipment, with large and medium-sized farms being better equipped with modern farm machinery and precision technology, while small farmers may experience difficulties in purchasing and using this equipment. Continued agricultural policy development and government support for technology accessibility and sustainable agricultural development remain essential to ensure that all farmers in Romania benefit from the appropriate level of equipment and technology to increase their efficiency and productivity.

CONCLUSIONS

In conclusion, the detailed analysis of the evolution of agricultural machinery in Romania reveals significant trends in the mechanization of the agricultural sector. The agricultural tractor, with over a century of history, has continued to evolve and adapt to the changing needs of agriculture. In the last 10 years, the number of tractors has increased significantly, reflecting an increase in efficiency and productivity in agriculture. Tractor ploughs also became more common, with an increase of 6.56%, indicating an improvement in soil preparation. In contrast, the number of mechanical cultivators has seen a significant decrease in the last two years. Mechanical seeders and power-driven sprayers and dusters also showed significant fluctuations over the same period. Self-propelled hay and forage harvesters saw slight declines, while straw and hay balers saw a significant increase of almost 95%. Forage windrowers had a relatively constant evolution with minor fluctuations. Overall, these data reflect the adaptability of farmers to the changing demands of the agricultural sector and the need to continue to explore technological innovations and improvements to increase the productivity and sustainability of Romanian agriculture.

ACKNOWLEDGEMENT

This research work was carried out with the support of Ministry of Agriculture and Rural Development, financed from Project ADER 22.1.1 *Designing technical-economic analysis models for the resilience and sustainability capacity of agricultural sector and the production processes optimization*.

REFERENCES

1. Arun, G.C., Yeo, Jun-Ho, Y., & Kiran, Ghimire. (2019). Determinants of Farm Mechanization in Nepal. *Turkish Journal of Agriculture - Food Science and Technology, 7(1), 87–91. https://doi.org/10.24925/turjaf.v7i1.87-91.2131*
2. Bădan, D. N. (2017). Analysis regarding the fleet and the farm equipment in Romania compared to the European Union. In *Agrarian Economy and Rural Development-Realities and Perspectives for Romania. 8th Edition of the International Symposium, November 2017, Bucharest* (pp. 69-73). Bucharest: The Research Institute for Agricultural Economy and Rural Development (ICEADR).
3. Duckworth, A. L., Quirk, A., Gallop, R., Hoyle, R. H., Kelly, D. R., & Matthews, M. D. (2019). Cognitive and noncognitive predictors of success. *Proceedings of the National Academy of Sciences*, *USA*, *116*(47), 23499–23504. https://doi.org/10.1073/pnas.1910510116
4. Emami, M., Almassi, M., Bakhoda, H. *et al.* Agricultural mechanization, a key to food security in developing countries: strategy formulating for Iran. *Agric & Food Secur* **7**, 24 (2018). https://doi.org/10.1186/s40066-018-0176-2
5. Grzelak, A., Guth, M., Matuszczak, A., Czyżewski, B., & Brelik, A. (2019). Approaching the environmental sustainable value in agriculture: How factor endowments foster the eco-efficiency. *Journal of Cleaner Production*, *241*, 118304.
6. Hadelan, L., Zrilić, M., Rogelj, M. J., & Sušac, M. Z. (2022). Enhancing the productivity of small farmers in Croatia through the agricultural fund for rural development. *Economics of Agriculture*, *69*(4), 1043-1059.
7. Onwude, D.I., Abdulstter, R., Gomes, C. and Hashim, N. (2016), Mechanisation of large-scale agricultural fields in developing countries – a review. *J. Sci. Food Agric., 96: 3969-3976. https://doi.org/10.1002/jsfa.7699*
8. Partal, E., Oltenacu, C. V., Paraschivu, M., Cotuna, O., Dima, M., & Contescu. (2023). Effects of different soil tillage on soil moisture, weed control, yield and quality of maize (Zea mays L.). *Number 40/2023, 1-8*
9. Peng J, Zhao Z and Liu D (2022) Impact of Agricultural Mechanization on Agricultural Production, Income, and Mechanism: Evidence from Hubei Province, China. *Front. Environ. Sci. 10:838686. doi: 10.3389/fenvs.2022.838686*

10. Petcu, V., Bubueanu, C., Casarica, A., Săvoiu, G., Stoica, R., Bazdoaca, C., ... & Horhocea, D. (2023). Efficacy of trichoderma harzianum and bacillus subtilis as seed and vegetation application combined with integrated agroecology measures on maize. *Romanian Agricultural Research*, (40).
11. Popescu A., Dinu T., Stoian E., Mituko Vlad I. (2017), Trends in agriculture endowment with machinery in Romania 2007-2015, *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 17, Issue 2, 2017, p. 291-300,* available at the address: http://managementjournal.usamv.ro/pdf/vol.17_2/Art40.pdf
12. Stavytskyy, A. and Prokopenko, O. (trans.) (2017) Investments in Agricultural Machinery and its Efficiency in Ukraine. *Ekonomika*, *96(1), pp. 113–130. doi:10.15388/Ekon.2017.1.10667.*
13. Ștefan, V., Cârdei, P., Popa, L., David, L., & Ciupercă, R. (2019). Influence of the manure spreading machines' working parameters on the qualitative performances of the fertilization process. *INMATEH-Agricultural Engineering*, *58*(2), 115-120.
14. Vittis,Y., Godfray, C., Obersteiner, M., et al. (2022). Agricultural mechanisation could reduce global labour requirements by hundreds of millions of agri-food workers, 22 February 2022, *Preprint (Version 1) available at Research Square [https://doi.org/10.21203/rs.3.rs-1344105/v1]*
15. Zhang, H., Li, J., Shen, J., & Song, J. (2022). Measurement of supply-and demand-side endowment effects and analysis of their influencing factors in agricultural land transfer. *Land*, *11*(11), 2053.