DYNAMICS OF AGRO-ENVIRONMENTAL INDICATORS AT THE LEVEL OF ROMANIA IN THE PERIOD 2014-2023

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Abstract. *The agricultural sector is the main user of natural resources, with agricultural production generating negative environmental impact and problems, both inside and outside the agricultural holdings. This situation increases the sensitivity of agriculture to risks that can cause serious economic losses. Considering the environmental problems facing the agricultural sector today, it is necessary to study the impact of agricultural activities on the environment, through an analysis of agro-environmental indicators. Over the past 20 years, numerous agri-environmental indicators have been developed by agronomist engineers, ecologists and economists to assess the impact of agricultural practices on the environment and to monitor the effects of agri-environment policies. This paper aims to present the dynamics of agro-medium indicators at the level of Romania in the period 2014-2023, based on the data provided by the National Institute of Statistics (INS). Eight series of indicators were taken into account in this work: the area equipped with irrigation works and the irrigated agricultural area, the area equipped with drainage works, the area equipped with improvement works and combating soil erosion, the area on which fertilizers were applied chemical and natural, the amount of chemical fertilizers by category of fertilizers used in agriculture, the amount of natural fertilizers used in agriculture, the surface on which pesticides were applied, the amount of pesticides applied in agriculture.*
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JEL*: Q10, Q15, Q57*
UDC*: 631.95(498)*

Introduction. The agricultural sector, responsible for satisfying the demand for agricultural products and implicitly of food security, is the main user of natural resources. Agricultural production generates significant impacts and problems on the environment, both inside and outside agricultural holdings. This context increases the vulnerability of agriculture to the risks that can cause serious economic losses (Abdou & Yilmaz, 2020; Ion & Petre, 2023).

In order to measure the impact of agricultural activities on the environment, as well as the effects that the climatic changes have on the agriculture and sustainable development of the rural environment, sets of agri-medium indicators have been

established. These indicators were also proposed in Romania, regarding the relevance for the evaluation of the policies, the response capacity, the analytical basis, the accessibility and the measureability of the data, the interpretation facility and the cost-effective report. Following several researches, it was concluded that only part of these indicators can be calculated, the rest of the indicators being estimated by mathematical modeling, due to the high diversity of physical-geographical conditions and agricultural systems, which depend on a wide range of features specific local (Toma, 2015; Bergez et al. 2022).

The intensification of agricultural systems has a visible impact on agro-economic services. Thus, the adoption of more sustainable agricultural practices, such as diversification of crops and reducing external inputs, is an alternative strategy to minimize the impact of intensive agricultural systems (Vano et al. 2022).

Research methodology. The research method used in the elaboration of this work is represented by the empirical research and quantitative research, focused on the collection, processing and analysis of data on the indicators of Agri-Medium provided in the TEMPO ONLINE of the National Institute of Statistics. Among the analyzed agri-medium indicators are: the areas arranged with irrigation works and the irrigated agricultural area; *the surfaces arranged with desert works*; surfaces arranged with improvement works and combating soil erosion; the surfaces on which chemical and natural fertilizers were applied; the amount of chemical fertilizers, on categories of fertilizers used in agriculture; the amount of natural fertilizers used in agriculture; The surfaces on which pesticides have been applied, on pesticide categories and the amount of pesticides applied in agriculture.

Main results. Between 2014-2023, the areas arranged with irrigation works in Romania presented slight growth trends. Regarding the irrigation arrangements, ***the total arranged area*** recorded the highest growth (+0.87%), from 3,149 thousand hectares in 2014 to 3,177 thousand hectares in 2023, followed by ***the arranged agricultural area*** (+0.76 %), from 3,046 thousand hectares in 2014 to 3,069 thousand hectares in 2023 and by ***the arable land*** (+0.70%), from 2,893 thousand hectares in 2014 to 2,913 thousand hectares in 2023. As for ***The agricultural area actually irrigated with at least one watering***, significant increases were registered, both for the arranged agricultural area (+254.02%) and for the arable land (+252.43%) during the analyzed period (table 1).

Table 1. **Dynamics of the areas developed with irrigation works and the irrigated agricultural area, by land use category in the period 2014-2023 (thousands of hectares)**

Land improvements	Mode of use	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2023/ 2014
Arrangements for irrigation -	The total landsca	3.149	3.149	3.149	3.149	3.149	3.152	3.166	3.170	3.166	3.177	0,87 %

total	ped area											
	Arranged agricultural area	3.046	3.045	3.045	3.045	3.045	3.048	3.061	3.065	3.060	3.069	0,76 %
	Arable land	2.893	2.893	2.893	2.893	2.893	2.896	2.905	2.909	2.904	2.913	0,70 %
The agricultural area effectively irrigated with at least one watering	Arranged agricultural area	145	173	153	212	267	287	473	345	528	515	254,02%
	Arable land	145	173	153	209	266	284	469	344	526	512	252,43%

Source: INS, TEMPO AGR102 A, accessed on 19.07.2024

From the analysis of the dynamics of the surfaces arranged with delays, a slight tendency to decrease them was observed. The total area arranged with delays reached 3,144 thousand hectares in 2023, registering a decrease of 0.18%, compared to the area registered in 2014. Analyzing according to the use of land, the arable land was noted by the most significant decrease (-0.45%), from 2,505 thousand hectares in 2014 to 2,493 thousand hectares in 2023, followed at a difference of 4 percentage of the agricultural area (-0.41%), from 2,902 thousand hectares in The year 2014 at 2,890 thousand hectares in 2023 (Table 2).

Table 2. **Dynamics of the areas developed with drainage works, by land use category in the period 2014-2023 (thousands of hectares)**

Mode of use	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2023/2014**
The total landscaped area	3.150	3.150	3.150	3.150	3.150	3.150	3.150	3.150	3.144	3.144	-0,18%
Arranged agricultural area	2.902	2.901	2.901	2.901	2.901	2.901	2.901	2.898	2.893	2.890	-0,41%
Arable land	2.505	2.504	2.504	2.504	2.504	2.504	2.504	2.501	2.496	2.493	-0,45%
Natural pastures	259	259	259	259	259	259	259	259	259	259	-0,08%
Natural hay	111	111	111	111	111	111	111	111	111	111	-0,31%
Vineyards, wine nurseries and wineries	15	15	15	15	15	15	15	15	15	15	-
Orchards, nurseries, fruit trees	12	12	12	12	12	12	12	12	12	12	-

Source: INS, TEMPO AGR 102B, accessed on 19.07.2024

As for the area Arraged with Drying Works, for the Living Categs, Wine Nurseries and Hameists, respectively Tree Orchards, Nurseries and Fruit Bushes, The Area Constant Throughout the Analyzed Period, Being 15 Thousand Hectand and 12 Thousand Hectes, Respectively (Table 2).

With regard to the ***arraged with improvement work and combing soil***, the dynamics reminded relatively constant for all land categories. In the period 2014-2023, The Total Landscaped Area Values Between 2,280 Thousand Hects in 2022 and 2,291 Thousand Hectes in 2018, Registering An Average of 2.289 Thousand Hecti A standard deviation of 4.48 Thousand hectes. For the Developed Agricultural Area, The Variation Was Between 2,134 Thousand Hectes in the Years 2022 and 2023 and 2,146 Thoousand hectes in the period 2015-2018, The Average Being 2.143 Thousand hectes with a standard deviation of 4.70 thousand (Table 3).

For Arable Land, The Area Arranged with Improvement Works and Combating Soil Erosion Constant Constant Throughout the Analyzed Time, 194 Thoousand Hects (Table 3).

Table 3. **Dynamics of the areas developed with improvement works and combating soil erosion, by land use category in the period 2014-2023 (thousands of hectares)**

Land improvements	**Mode of use**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Works to combat erosion and land improvement - total	The total landscaped area	2.289	2.291	2.291	2.291	2.291	2.291	2.291	2.291	2.280	2.280
	Arranged agricultural area	2.143	2.146	2.146	2.146	2.146	2.145	2.145	2.145	2.134	2.134
	Arable land	1.226	1.228	1.228	1.228	1.228	1.227	1.227	1.227	1.222	1.222
	Natural pastures	517	518	518	518	518	518	518	518	514	514
	Natural hay	200	201	201	201	201	201	201	200	200	201
	Vineyards, wine nurseries and wineries	83	83	83	83	83	83	83	83	82	81
	Orchards, nurseries, fruit trees	117	117	117	117	117	117	117	117	116	116
Drainage works - total	The total landscaped area	253	254	254	254	254	254	254	253	253	254
	Arranged agricultural area	250	250	250	250	250	250	250	249	249	250
	Arable land	195	195	195	195	195	195	195	194	194	195

Source: INS, TEMPO AGR 102C, accessed on 19.07.2024

From the Analysis of the Areas on Which Chemical and Natural Fertilizers Were Applied, in the Last Decade, Significant increaSes Were observated in the agricultural arrow on which potassium fertilizers were administred (+98%), from 1.024 thoousand hectes in 2014 to 2.032 thoousandandandandandandand. in the year 2023. A sign in the increasing Was Also Recorded in the Areas Where Phosphate Fertilizers Were Applied (+46%), FROM 2,627 Thousand hectes in 2014 to 3.824 thousand hectares in 2023. The Largest Areas Have Were Registered in the Category of Nitrogen Fertilizers , These Being 6,864 Thousand hectares in 2023, 3% more than the area registered in 2014 (Table 4).

Table 4. **Dynamics of the surfaces on which chemical and natural fertilizers were applied in the period 2014-2023 (thousands of hectares)**

Categories of fertilizers	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2023/2014
Chemistry	**6.676**	**6.575**	**6.491**	**7.273**	**6.928**	**7.374**	**7.522**	**8.400**	**6.838**	**6.864**	**3%**
Nitrous	4.708	4.660	4.837	5.218	5.491	6.104	6.054	6.352	5.738	5.686	21%
Phosphorous	2.627	2.612	2.684	2.765	3.128	3.727	3.665	4.445	3.742	3.824	46%
Potash	1.024	1.057	1.180	1.279	1.421	1.915	1.995	2.155	1.775	2.032	98%
Naturally	**795**	**864**	**862**	**708**	**778**	**817**	**952**	**878**	**963**	**904**	**14%**

Source: INS, accessed on 19.07.2024

Regarding the surfaces on which natural fertilizers were applied, in the analyzed period a 14% increase was observed, from 795 thousand hectares in 2014 to 904 thousand hectares in 2023 (Table 4).

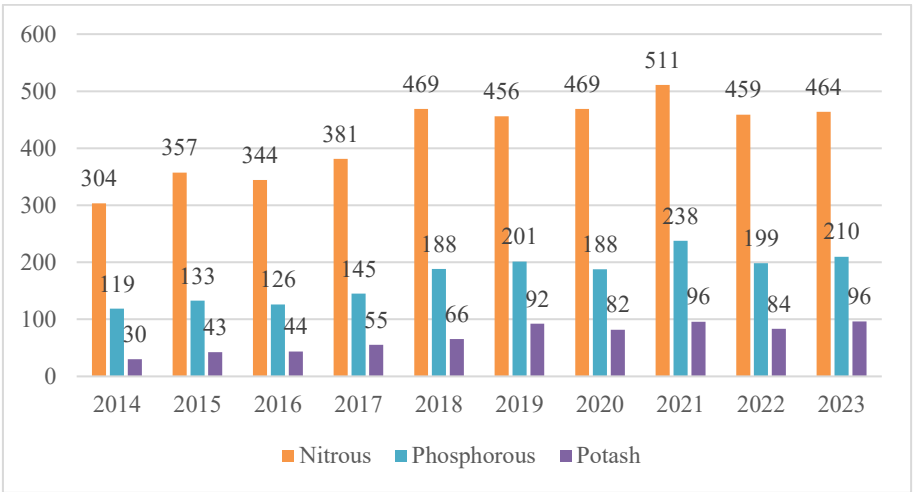

Figure 1. **Dynamics of the amount of chemical fertilizers, by categories of fertilizers used in agriculture during 2014-2023 (thousands of tons 100% active substance)**
Source: INS, AGR104A, accessed on 19.07.2024

In the period 2014-2023, the amount of chemical fertilizers varied between 452 thousand tons of 100% active substance in 2014 and 770 thousand tons of 100% active substance in 2023, registering a significant increase of approx. 70% By category of fertilizers, the nitrogenous ones stood out with the largest amounts, 464 thousand tons of 100% active substance in 2023, increasing by approx. 53% compared to the amount recorded in 2013, respectively 304 thousand tons of 100% active substance. A significant increase (+220%) in the amount of potassium fertilizers was noted, from 30 thousand tons of 100% active substance in 2014 to 96 thousand tons of 100% active substance in 2023 (Figure 1).

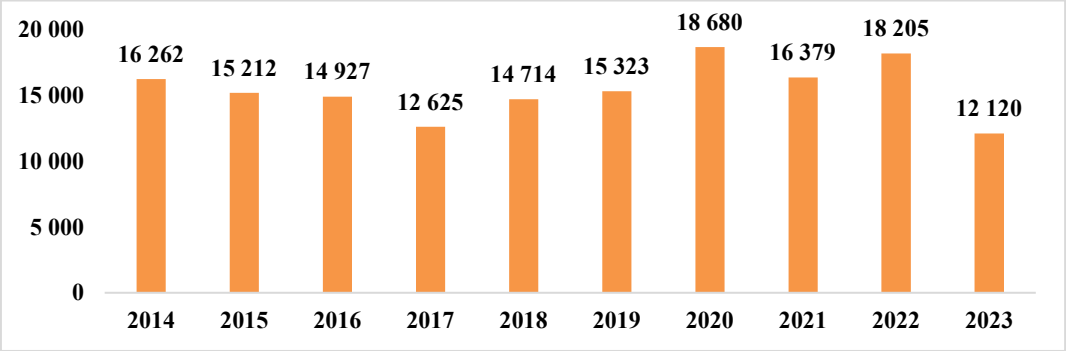

Figure 2. **Dynamics of the quantity of natural fertilizers used in agriculture during 2014-2023 (thousands of tons 100% active substance)**

Source: INS, AGR104A, accessed on 19.07.2024

Regarding the quantity of natural fertilizers used in agriculture, during the analyzed period a downward trend was noted (-25%), from 16,262 thousand tons of 100% active substance in 2014 to 12,120 thousand tons of 100% active substance in 2023 (Figure 2).

Table 5. **Dynamics of the areas on which pesticides were applied, by category of pesticides, in the period 2014-2023 (thousands of hectares)**

Categories of pesticides	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2023/2014
Insecticides	1.696	1.732	1.882	2.218	2.367	2.270	2.343	2.844	2.784	3.012	78%
Fungicides	2.028	1.845	2.082	2.395	2.478	2.454	2.395	2.982	3.028	3.229	59%
Herbicides	3.584	3.476	3.475	3.606	3.305	3.779	3.887	4.063	3.938	4.521	26%

Source: INS, AGR107A, accessed on 19.07.2024

The surfaces on which pesticides were applied registered an evolution trend in the analyzed period for all categories of pesticides analyzed. The greatest increase (+78%) was observed in the category of insecticides, from 1,696 thousand hectares in 2014 to 3,012 thousand hectares in 2023. Also, the largest area was the one on which herbicides were applied, 4,521 thousand hectares in 2023 with 26% more

compared to the area registered in 2014, respectively 3,584 thousand hectares (Table 5).

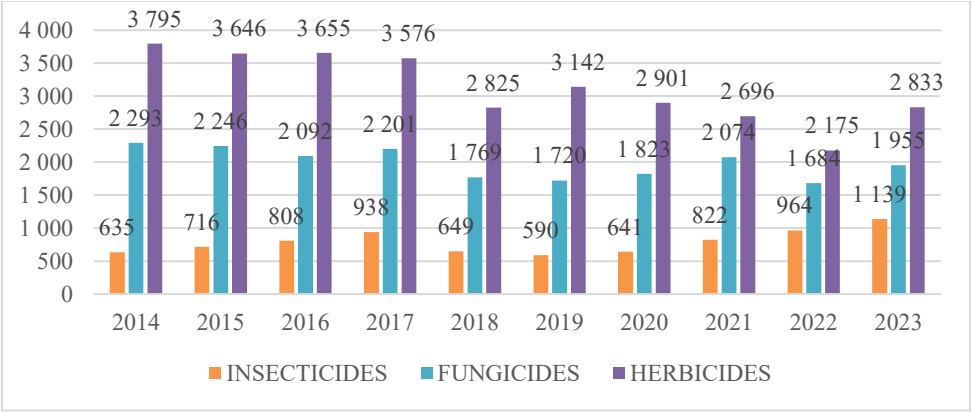

Figure 3. **Dynamics of the amount of pesticides applied in agriculture during the period 2014-2023 (tons of active substance**
Source: INS, accessed on 19.07.2024

Regarding the quantity of pesticides applied in agriculture, at the level of the reference period, a sharp increase (+79%) in the quantities of insecticides was noted, from 635 tons of active substance in 2014 to 1,139 tons of active substance in 2023. In time as for the quantities of fungicides, respectively herbicides, the trend was one of decrease. For fungicides, the quantities registered a decrease of 15%, from 2,293 tons of active substance in 2014 to 1,955 tons of active substance in 2023, and for herbicides, the quantities registered a decrease of 25%, from 3,795 tons of active substance in 2014 to 2,833 tons of active substance in 2023 (Figure 3).

Discussion and conclusions. From the analysis of the agri-environmental indicators at the level of the period 2014-2023, the following were concluded:

- the areas landscaped with irrigation works showed increasing trends. The most significant increases were observed in the developed agricultural area (+254.02%), as well as in arable land (+252.43%).
- the surfaces arranged with drying works showed a slight downward trend. The most significant decrease was recorded by arable land (-0.45%), from 2,505 thousand hectares in 2014 to 2,493 thousand hectares in 2023.
- the areas arranged with improvement works and combating soil erosion, the dynamics remained relatively constant for all land categories.
- the surfaces on which chemical and natural fertilizers were applied registered significant increases. In terms of chemical fertilizers, the agricultural areas treated with potash fertilizers registered the highest increase (+98%), and the areas treated with natural fertilizers increased by 14%.
- the amount of chemical fertilizers showed a significant increase of approx. 70% By category of fertilizers, the nitrogenous ones stood out with the largest amounts, 464 thousand tons of 100% active substance in 2023, increasing by

approx. 53% compared to the amount recorded in 2013, respectively 304 thousand tons of 100% active substance. Regarding the amount of natural fertilizers used in agriculture, a downward trend (-25%) was noted during the analyzed period.

- the surfaces on which pesticides were applied registered an evolution trend in the analyzed period for all categories of pesticides analyzed. The biggest increase (+78%) was observed in the category of insecticides.
- the amount of pesticides applied in agriculture stood out through a sharp increase (+79%) in the amount of insecticides. While for the quantities of fungicides, respectively herbicides, the trend was one of decrease.

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