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THE ASSESSMENT MODEL OF REGIONAL SUSTAINABLE DEVELOPMENT THROUGH THE BENCHMARKING ANALYSIS OF THE ENVIRONMENTAL SITUATION FROM 2017 AND 2021

Abstract. *This study analyses the environmental changes that the South Muntenia region recorded in 2021 compared to 2017. The research has taken into account several aspects related to: climate change, sustainable waste management, water resources, and atmospheric pollutants. The analysis method used was the Benchmarking Analysis, following which we identified the main indicators for which the analysed region recorded improvements or, on the contrary, deterioration in one year compared to another year of analysis. The assessment of the aspects taken into account was based on both the information collected from the Environmental Registers and the opinions of specialists from the analysed region. The findings of the analysis have implications for decision-makers at the macro- and mezzo- economic level.*

Keywords*: Sustainable Development, Environment, Comparative Analysis, Pareto, Waste Management, Climate Change*

JEL Classification: C00, H12, K32, M54, O10

DOI: 10.24818/18423264/57.3.23.15

1. Introduction

Benchmarking is the process of continuous improvement of performance by identifying, understanding, adapting, and implementing the best practices found inside/outside the organisation and involves the creation of partnerships for the exchange of information regarding processes and assessments, resulting in the establishment of realistic objectives.

It is a valuable tool for company management, local administrations, and governments in their development strategies. Companies, localities, states that compare their performances with others and identify the best practices obtain strategic, operational, and economic advantages, leading to an increase in the degree of competitiveness. It can also be achieved by comparing two periods of time, taking the year with the best achievements as a reference.

Most benchmarking initiatives relate to financial and management aspects, but lately environmental benchmarking has recently become a major element in environmental management. Most of the time, environmental benchmarking is carried out for companies, but it can also be easily adapted to the needs of knowing the performances, at the level of localities, areas, regions, and states, being a tool for analysing practices related to the environment.

Environmental benchmarking is done by comparing the achievements of the analysed area with those of the best in class or the situation from another year of the same area, the fields of application assuming the assessment of: Environmental Management Systems, Performance Management, Quality of Ecological Products, Environmental Accounting, Waste Management, Environmental Education, Vocational Training and Customer Relations. This working method can be applied by analysing the following aspects: Causes of Climate Change, Ways to Reduce the Effects of Climate Change, Atmospheric Pollutants, Air Quality, Environmental Policy Instruments, Effects of Climate Change and Environmental Education, Sustainable Management of Resources, Water Resources.

The main objective of this study is to evaluate the environmental situation in the Southern Region of Muntenia in 2021 compared to 2017. It also aims to identify the environmental aspects that have registered substantial improvements or, on the contrary, the degradation of the identified situation. The aim is to rank the environmental aspects analysed according to the importance given by the specialists, but also to identify the main causes that lead to the result obtained.

Considering that sustainable development is a concern of the modern world, we considered that bringing to attention a model for evaluating the environmental situation at the regional level is necessary for the expansion at the macro- and mezzo-level.

2. Literature review

The environment includes all living species, natural resources, vegetation, microorganisms, rocks, atmosphere, and climate.

Air pollution harms the health of the environment. Emissions of many air pollutants have fallen substantially in recent decades, resulting in improved air quality, but pollutant concentrations remain very high (Penn World Table, 2020).

Studies carried out by scientists show how greenhouse gas emissions, mainly carbon dioxide, affect the way the planet's climate works (Gogu et al., 2021). The disruption of the cycle of the seasons also brings with it problems in the water cycle in nature, researchers observing a decrease in the amount of water that reaches the soil through rain or snow, and the increase in the plant population can represent the partial or even total elimination of moisture from the soil, which will lead to desertification (Zahid et. al., 2022).

The main problem of climate change is represented by carbon dioxide emissions and the effects they have on the atmosphere. Researchers show that, for the last 800,000 years, until the Industrial Revolution, the level of carbon dioxide was relatively stable, between 180-290 ppm parts per million (MacKenzie, 2003), but now the concentration of carbon dioxide has increased to 412 ppm, and in the year 2100 the level could reach up to 560 ppm (Alam and Murad, 2020; Menegaki, 2011).

Environmental problems can be understood and dealt with from an individual perspective, but we must take into account the fact that industrial activities and the private companies behind them are the ones that produce a large part of carbon dioxide emissions (Guanhua et al., 2022; Na-Ra, 2023).

A third of the carbon emissions worldwide, since 1965, are made by a group of 20 companies, the first five being (European Commission, 2011):

- Saudi Aramco (Saudi Arabia), which obtained 355.9 billion dollars from oil extraction in 2018, carbon emissions in the period 1965-2017 represent 4.38% of global emissions, and in the period 2018-2030 experts indicate an increase of 7.2% (Al-Mulali et al., 2015; Adeleye et al., 2022).
- Chevron (USA) operates in the oil field, with an annual profit of 158.9 billion dollars; during the period 1965-2017, it removed 3.3% of global production into the atmosphere, and in the 2018-2030 period specialists predicted a 20% increase in emissions.
- Gazprom (Russia) produced in the period 1965-2017, 3.19% of the total global emissions, and researchers' projections suggest that in the period 2018-2030, emissions will increase by 3%.
- ExxonMobil (USA) produced 3.09% of the amount of carbon produced between 1965-2017, and an increase in emissions of 35% is expected between 2018-2030 (World Bank, 2021).
- The National Oil Company of Iran produced 2.63% of the amount emitted between 1965-2017, and projections show an increase of 9.7% between 2018-2030 (Ergun et al., 2019).

After studying the specialised literature, we found that comparative analyses have been carried out, but not on the environment; therefore, we have not identified any source in which the benchmarking analysis can be applied. As a result, we consider it useful to apply this effective analysis method at the regional level. In order to more easily observe the results obtained from the benchmarking analysis, we correlated them with the Pareto analysis, as well as the graphical representation of the results obtained using the Spider Chart.

3. Research methodology

In this part of the study, we present the methodology for calculating environmental benchmarking at the level of a region. In the present case, the analysed region is South Muntenia, which includes the following counties: Prahova, Dâmbovița, Argeş, Ialomița, Călăraşi, Teleorman, Giurgiu. The proposed model analyses the environmental situation in the year 2021, a pandemic year, compared to the year 2017 prior to the outbreak of the Covid 19 pandemic. We chose the two periods trying to highlight the changes that appeared in the environmental situation as a result of the imposed restrictions.

The development of environmental benchmarking involves the following stages:

1) establishing the work team (of specialists);
2) documentation, gathering the information necessary for elaboration. This information can be gathered from the Annual Environmental Reports, which are drawn up both at the level of each county (from which data can be extracted for the main localities in the respective county) and at the level of the development regions.
3) assessment of the situation identified by developing the scorecard
4) interpretation of the results.

The assessment can be done using the following arrays 1 and 2 presented in Tables 1 and 2 as a tool.

Table 1. Array 1

Axis	**Axis content**	**Weight**	**Analytical weight**	**Maturity level**		**Weighted score**	
				Year 1	**Year 2**	**Year 1**	**Year 2**

Table 2. Array 2

Indicators groups	**Indicator subgroups**	**Indicator**	**Ranking subgroups**	**Importance level indicators**	**Analytical ranking**	**Maturity level**		**Weighted score**	
						Year 1	**Year 2**	**Year 1**	**Year 2**

The proposed model involves the comparative analysis of environmental aspects from the years 2017 and 2021, the necessary data were collected from the Environmental Reports of the counties of the South Muntenia Region and following discussions with specialists from the Environmental Protection Agencies.

Regarding the score awarded, both for Array 1 and Array 2, it is established in collaboration with a team of specialists from the same agency. Weights are given from 0 to 1000, depending on the importance assigned by the team to each individual axis, the choice of weights being subjective. Within this model, each axis will have an individual weight, their content having a certain degree of importance, thus giving them different weights.

Next, we calculate the analytical weights, which are obtained by multiplying the weight of the axes by the weight of each indicator within the analysed axis and dividing by 1000.

The maturity level can be from 1 to 5 when analysing organisations or from 1 to 10 when analysing products or in the development of environmental benchmarking:

- 1 shows a very weak situation,
- 5 reflects an average situation
- 10 a very good situation, which does not require any kind of improvements.

Also, the assessment can be done using instead of scores from 1 to 10, percentage criteria either 10%, 20%, 30%,....., 100% or 25%, 50%, 75% or 100% of the ideal situation.

The awarding of points is done according to the real situation, ascertained as a result of the documentation. Each aspect analysed will receive a grade for each year, locality, area, region, country considered. The weighted scores are calculated using analytical weights, which are multiplied by the maturity level of each aspect studied. Total weighted scores are obtained for each analysed year, their value must be between 1000 and 10000.

Regarding Array 2, the difference appears at the level of detail, analysing groups of characteristics or indicators, subgroups of characteristics or indicators, and indicators or characteristics. The weights given to the subgroups represent the importance of each subgroup in the total group, and the analytical ranking is done by multiplying the weight of the indicator in the subgroup by the level of importance given and dividing by 1000.

The created scorecard involves the comparative analysis of environmental aspects from 2017 and 2021, the necessary data were collected from the Annual Environmental Reports and following discussions with specialists from the National Agency for Environmental Protection. The awarded score was established in collaboration with a team of specialists from the same agency. Within the presented model, the following groups of indicators were analysed: Climate changes, Sustainable waste management, Water resources, Atmospheric pollutants, Ways to reduce the negative effects of climate change.

Table 3. Axis of interest 1: Climate change

Groups	Indicator subgroups	Indicator	Hierarchy of features-groups	Ranking features	Analytical ranking of features	Medium Level		Weighted Score	
						2017	2021	2017	2021
1. Climatic changes 250	1.1 Climate	Maximum /medium temperature	50	300	45	7	5	315	225
		Minimum/medium temperature	50	300	45	7	8	315	360

Groups	Indicator subgroups	Indicator	Hierarchy of features-groups	Ranking features	Analytical ranking of features	Medium Level		Weighted Score	
						2017	2021	2017	2021
		Medium annual amount of precipitation	50	400	60	7	8	420	480
	Subtotal		150	1000	150	-	-	1050	1065
	1.2 Actions to attract and adapt to climate change	1.2.1 Clean development mechanism	60	600	60	7	8	420	480
		1.2.2 International emissions trading	40	400	40	7	8	280	320
	Subtotal		100	1000	100	-	-	700	800
	Total		250	-	250	-	-	1750	1865

In the first group “Climate Changes”, the subgroups of indicators “Climate” and “Actions to Attract and Adapt to Climate Changes” were analysed, in which the indicators “Average Maximum Temperature”, “Average Minimum Temperature”, “Average Annual Quantity of Precipitations”. Following the analysis, we note that the group’s score in 2021 was 115 points higher than that of 2017, due to some changes in the average annual maximum temperature. The first subgroup has the largest weight, but we note an improvement regarding the situation of international trading of emissions (Table 3).

Table 4. Axis of interest 2: Sustainable waste management

Groups	Indicator subgroups	Indicator	Hierarchy of feature-groups	Ranking features	Analytical ranking of features	Medium level		Weighted score	
						2017	2021	2017	2021
2. Sustainable waste management 200	2.1 Municipal waste	2.1.1 Biodegradable waste	20	250	17,5	7	8	122,5	140
		2.1.2 Packaging and packaging waste	15	250	17,5	7	8	122,5	140
		2.1.3 Treatment and recovery of municipal waste	10	200	14	7	8	98	112
		2.1.4 Waste disposal	25	300	21	7	8	147	168
	Subtotal		70	1000	70	-	-	490	560
	2.2 Industrial waste	2.2.1 Industrial waste generation	30	400	28	6	8	168	224
		2.2.2 Industrial waste valorisation	40	600	42	5	7	210	294
	Subtotal		70	1000	70	-	-	378	518
	2.3 Waste streams	2.3.1 Waste batteries and accumulators management	20	300	18	4	6	72	108
		2.3.2 Equipment waste management	20	400	24	5	7	120	168
		2.3.3 Used oils Management	20	300	18	5	5	90	90
	Subtotal		60	1000	60	-	-	282	366
	Total		200	-	200	-	-	1150	1444

Source: Authors' work

Axis 2 "Sustainable Waste Management" has three subgroups, two with the same weight and the third with a slightly smaller weight. We find that in 2021 the situation has improved by approximately 300 points compared to 2017. The greatest improvement is registered by the first subgroup "Industrial Waste" in the aspects related to the generation of industrial waste, which received a score of 8 from a score of 6, as well as the disposal of industrial waste. We observe an improvement in the third subgroup, "Waste flows", which obtained 366 points in 2021, compared to 282 in 2017 (Table 4).

The situation of the management of used oils remained unchanged in the two years, although the management of this type of residue is not efficient, receiving the score 5 in both years of analysis.

Table 5. Axis of interest 3: Water Resources

Groups	Indicator subgroups	Indicator	Hierarchy of features-groups	Level of importance	Analytical ranking of features	Medium level		Weighted score	
						2017	2021	2017	2021
3.Water resources 150	3.1 Surface waters	3.1.1 Ecological status of water bodies	20	400	24	7	8	168	192
		3.1.2 Lake water quality	40	400	36	7	8	252	288
	Subtotal		60	1000	60	-	-	420	480
	3.2 Drinking water and waste water	3.2.1 The connected population	20	350	21	8	9	168	189
		3.2.2 The length of the sewage network	15	250	15	8	9	120	135
		3.2.3 Polluting substances and pollution indicators in clean waters	25	400	24	6	7	144	168
	Subtotal		60	1000	60	-	-	432	492
	3.3 Water resources management	3.3.1 Significant pressures on water resources	10	400	12	6	7	72	84
		3.3.2 Strategies for sustainable management of water resources	20	600	18	7	8	126	144
	Subtotal		30	1000	30	-	-	198	228
	Total		150	-	150	-	-	1050	1200

Source: Authors' work

Axis 3 "Water Resources" is the one that registered the smallest increase, of 150 points in 2021 compared to 2017. This axis has three subgroups, two with an equal weight of 60 points and one with a lower weight of 30 points. The first subgroup, "Surface Waters", registers an increase of 60 points in 2021 compared to 2017. Both analysed indicators registered a slight improvement, because in 2021 they were evaluated with one point more than in 2017.

The subgroup "Drinking water and waste water" registered an increase of 60 points from 432 in 2017 to 492 points in 2021, all indicators having a superficial increase from one year of analysis to another. The increase of the sewage network from 1244 km in 2017 to 2013 in 2021 is noted. The last subgroup, the one with the lowest weight, increased by 30 points in 2021 when it recorded 228 points compared to 2017, when it had 198 points. We find slight improvements for both analysed indicators (Table 5).

Table 6. Axis of interest 4: Atmospheric Pollutants

Groups	Indicator subgroups	Indicator	Hierarchy of features-groups	Level of importance	Analytical ranking of features	Medium level		Weighted score	
						2017	2021	2017	2021
4. Atmospheric pollutants 200	4.1 Gas emissions with an acidifying effect	4.1.1 SO2 emissions	20	400	24	8	6	192	144
		4.1.2 Nox emissions	20	300	18	6	8	108	144
		4.1.3 Ammonia emissions	20	300	18	8	8	144	144
	Subtotal		60	1000	60	-	-	444	432
	4.2 Emissions of heavy metals	4.2.1 Cadmium emissions	15	250	15	8	7	120	105
		4.2.2 Mercury emissions	15	250	15	8	5	120	75
		4.2.3 Lead emissions	30	500	30	6	7	180	210
	Subtotal		60	1000	60	-	-	420	390
	4.3 Emissions of persistent organic pollutants	4.3.1 Polycyclic aromatic hydrocarbons	15	350	21	8	8	168	168
		4.3.2 Emissions of polychlorinated biphenyls	15	350	21	7	7	147	147
		4.3.3 Hexo-clorbenzen	30	300	18	8	9	144	162
	Subtotal		60	1000	60	-	-	459	477
	4.4 Emissions of volatile organic compounds	4.4.1 NMVOC	10	700	14	8	9	112	126
		4.4.2 Total powders	10	300	6	7	9	42	54
	Subtotal		20	1000	20	-	-	154	180
	Total		200	-	200	-	-	1477	1479

Source: Authors' work

Regarding the situation of atmospheric pollutants, in 2021 the score obtained was 1479 points, and in 2017 1477 points.

This axis has four subgroups, three of them having equal weights, the third subgroup – "Emissions of Persistent Organic Pollutants" registering a slight improvement, having 477 points in 2021, 18 points more than in 2017. Within these subgroups, we note improvements regarding the emissions of hexachlorobenzene and polychlorinated biphenyls that received a grade with a higher point in the second year of analysis compared to the first year, which shows a slight improvement of the analysed situation. The first subgroup, "Emissions of gases with an acidifying effect", registers a decrease of 30 points in 2021 compared to 2017, based mainly on the increase in SO_2 emissions. We also note that NOx emissions have decreased and that the situation of ammonia emissions has remained relatively unchanged.

"Heavy Metal Emissions" represent the second subgroup and recorded a worsening of the situation by 30 points in 2021 when it was 30 points. The greatest deterioration can be seen in mercury emissions, which were rated 5 in 2021.

The last subgroup has an increase of 26 points in 2021 compared to 2010, when both analysed situations received a 9 grade from the 8 or 7 grades we had in the first year of analysis (Table 6).

Table 7. Interest axis 5: Ways to Reduce the Negative Effects of Climate Change

Axis	Axis content	Weigh t	Analytical weight	Maturity level		Weighted score	
				2017	2021	2017	2021
Ways to reduce the negative effects of climate change 200	Use of biomass-based energy sources	100	20	8	8	160	160
	Efficiency of the energy industry	100	20	6	6	120	120
	Improving the energy efficiency of thermal power plants	50	10	6	6	60	60
	Replacement of less polluting classic means of transport	100	20	7	8	140	160
	Protection and extension of forests	175	35	5	5	175	175
	Educating the public about sustainability	150	30	5	7	150	210
	Improving the national inventory of greenhouse gas emissions	100	20	8	9	160	180
	Implementing the commercialisation scheme of greenhouse gas emission certificates	100	20	8	8	160	160
	Improving the legislative framework	125	25	7	8	175	200
TOTAL		1000	200	-	-	1300	1425

Source: Authors' work

Within this axis, we did not use subgroups, because the aspects analysed do not allow the application of the unfolded array. We see an increase of 125 points in 2021 compared to 2017, obtained mainly from the improvement of concerns at all levels for educating the public in the sense of sustainability.

Also, the situation of the national inventory of greenhouse gas emissions, the legislative framework, as well as the implementation of the channelization scheme of greenhouse gas emissions certificates have also improved.

The situation remains unchanged in terms of the efficiency of the energy industry, the improvement of the energy efficiency of thermal power plants, as well as the protection and expansion of forests (Table 7).

Table 8. Total Weighted Scores

No.	AXE	Year 2017	Year 2021	Ip 2021/2117
1	Climate change	1750	1865	1,065
2	Sustainable waste management	1150	1444	1,255

3	Water resources	1050	1200	1,142
4	Atmospheric pollutants	1477	1479	1,001
5	Ways to reduce the negative effects of climate change	1300	1425	1,096
TOTAL		6727	7413	1,101

Source: Authors' work

$$\text{Performance Index}_{\text{RSM}} = \frac{SCP\ RSM}{SCP\ RSM} * 100 = \frac{7413}{6727} * 100 = 110{,}1$$

Following the environmental benchmarking of the South Muntenia Region, we note a general improvement in the situation, the score of 2021 being 7413 compared to 6727, which led to a performance index of 1.101 (Figure 1). It should be noted that for each analysed axis, the performance index indicates an improvement of the analysed situation.

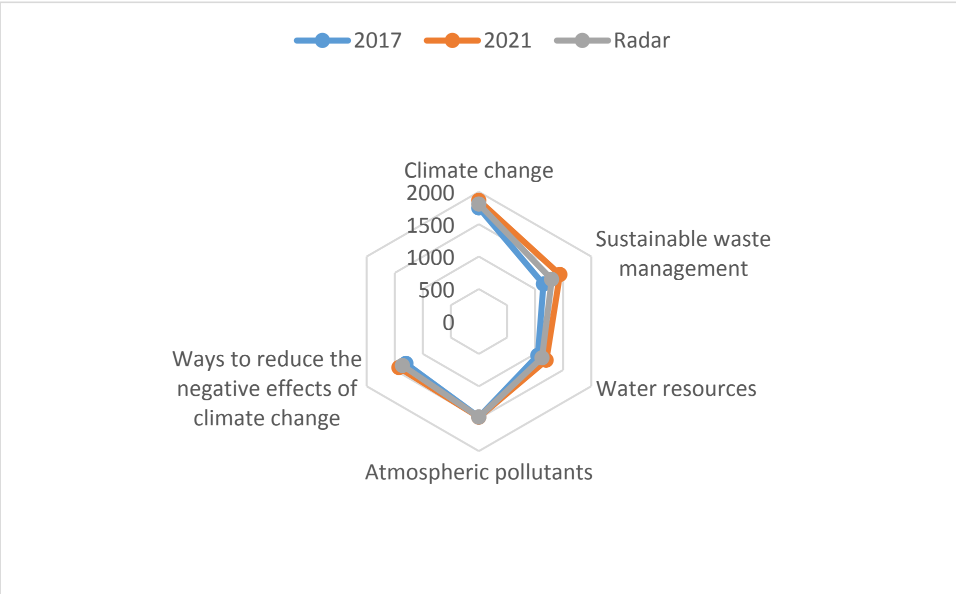

Figure 1. Radar

Source: Authors' work

In order to identify the indicators that have the greatest importance in the results obtained, the work continues with the PARETO analysis, which is done through three stages (Table 9):

- the descending ordering of the analytical characteristics and weights of each group;
- determining the relative frequency by dividing each analytical weight by 10;

• establishing the cumulative breeding frequency. The process is repeated until the characteristic that approaches the 80-20 rule. The rule describes the fact that in almost any problem, the little (20%) represents the essential, and the many (80%), represents the less valuable part (it depends from which angle the situation is viewed).

Table 9. Pareto Analysis

Indicator	Analytical weight	Frequency	Increasing cumulative frequency
Medium annual amount of precipitation	60	6	-
Clean development mechanism	60	6	12
Medium maximum temperature	45	4,5	16,5
Minimum-Medium temperature	45	4,5	21
Recovery of industrial waste	42	4,5	25,5
International trading of emissions	40	4,5	30
Lake water quality	36	3,6	33,6
Protection and expansion of forests	35	3,5	37,1
Lead emissions	30	3	40,1
Educating the public in the sense of sustainability	30	3	43,1
Waste generation	28	2,8	5,9
Improving the legislative framework	25	2,5	48,4
Polluting substances in water	24	2,4	50,8
SO2 emissions	24	2,4	53,2
Ecological state of waters	24	2,4	55,6
Equipment waste management	24	2,4	58
Polycyclic aromatic hydrocarbons	21	2,1	60,1
Emissions of polychlorinated biphenyls	21	2,1	62,2
The population connected to the water network	21	2,1	64,3
Waste disposal	21	2,1	66,4

Indicator	Analytical weight	Frequency	Increasing cumulative frequency
Use of energy sources based on biomass	20	2,0	68,4
Efficiency of the energy industry	20	2,0	70,4
Replacing classic means of transport with less polluting ones	20	2,0	72,4
Improving the national inventory of greenhouse gas emissions	20	2,0	74,4
Implementation of the commercialization scheme of greenhouse gas certificates	20	2,0	76,4
Battery and accumulator waste management	18	1,8	78,2
Strategies for sustainable management of water resources	18	1,8	80
Nox emissions	18	1,8	81,8
Ammonia emissions	18	1,8	82,4
Hexochlorobenzene	18	1,8	84,2
Management of used oils	18	1,8	86
Biodegradable waste	17,5	1,75	87,75
Packaging and packaging waste	17,5	1,75	89,5
The length of the sewer network	15	1,5	91
Cadmium emissions	15	1,5	92,5
Mercury emissions	15	1,5	94
Treatment and recovery of municipal waste	14	1,4	95,4
NMVOC	14	1,4	96,8
Significant pressures on water resources	12	1,24	98
Improving the energy efficiency of thermal power plants	10	1	99
Total powders	6	0,6	99,6
TOTAL	1000	100	–

Source: Authors’ work

The analysis shows that the first 25 indicators are the most important, having a weight of 80% of the total. Therefore, these indicators are the ones that require intervention to improve the environmental situation. The other indicators have a smaller weight of 20% and as such do not have a very important role in the final result.

4. Conclusions

Sustainable development is understood as a type of economic growth opposite to that which prevailed in the 19th and 20th centuries and which focused on the idea of using natural resources in parallel with protecting and preserving the environment (Ranju et al., 2023). The specialised literature, in addition to the four classic dimensions of sustainable development, economic, social, cultural, and environmental, also presents two other dimensions, namely temporal and digital.

Following the benchmarking analysis of the South Muntenia Region, we can say that the environmental situation is not very serious, but not very happy either. The score of 7413 points for the year 2021, i.e., a performance index compared to 2017 of 1.101, reflects a situation that requires some improvements, orienting the actions of decision-makers towards the promotion of environmental policies.

The ideal situation could be quantified in 10,000 points, which shows that the score of 7413 is above the average level, but far from a situation that no longer requires improvement. Compared to 2017 in 2021, the environmental situation improved by approximately 686 points.

In 2017, axis 1 “Climate change” was the best positioned, followed by axis four, “Atmospheric pollutants”, while axis three, “Water resources” obtained the lowest score. In 2021, the axis that placed the best was also axis 1, and the least was axis three.

We note that in 2021, all analysed axes recorded smaller or greater improvements compared to 2017. The biggest difference in 2021 compared to 2017 appears on axis two, “Sustainable waste management”, which in 2021 recorded 1444 points, 294 points higher than in 2017. Axis four saw a slight improvement in one year over the other, with a score difference of only 2 points.

In 2021, the management of waste oil saw no improvement, while the management of waste batteries and accumulators and waste equipment increased, being scored two points higher. Deterioration of the subgroup that assesses heavy metal emissions, with mercury emissions registering a substantial deterioration.

The main polluters in this region must focus their attention on reducing pollutant emissions by implementing “clean technologies” and prioritising aspects of environmental management.

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