TERRITORIAL DISPARITIES OF THE WASTE GENERATION AND RESOURCE PRODUCTIVITY IN SUSTAINABLE DEVELOPMENT

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Abstract
Sustainable development is not only a desideratum but also a pressing necessity of modern economies. Its efficient use of resources and reduction of waste generation are priority objectives in both the EU and most countries. Therefrom, based on two groups of indicators which characterize on the one hand the intensity of waste generation and on the other hand the level of development and use of resources, the paper presents the results of a cluster analysis which included 30 European states. The level of disparities between the states included in the analysis is highlighted by the results obtained on the resource's productivity and the level of waste generation. Thus, the highest values of GDP and Resource productivity are reported in Luxembourg, and the lowest in Serbia. Regarding the indicators Generation of municipal waste per capita and Generation of waste excluding major mineral wastes either per domestic material consumption or per GDP unit the highest levels are recorded in Norway, Belgium and Bulgaria while Romania, Latvia and Norway record the lowest levels. The conclusion is that sustainable waste management and treatment options aim at both regional environmental management and efficiency and a waste trade between regions and countries which is in line with the sustainable development.

Key words: *sustainable development, territorial disparities, waste generation, resource productivity, clusters.*

JEL Classification: *C20, C38, Q01, Q52, Q56*

I. INTRODUCTION

The economic and social development, increasingly incisive urban agglomerations and developments, as well as the continuous increase of population consumption have led, in recent decades, to the generation of increasing amounts of waste at municipal and regional level with direct consequences. on the environment and implicitly on the health of the population. This growing trend of municipal waste has also become a problem for decision makers in Romania [Târțiu, 2011; Marcu, 2018] the gaps compared to most EU countries, although reduced, are significant. Thus, if in 2010, the share of municipal waste landfilled in Romania was 94% [Iacoboaea, Luca and Petrescu, 2013] compared to 38% EU average (a difference of 56 percentage points), in 2017, the share decreases at 71% compared to 24%, the EU average (a difference of 47 percentage points), and waste recycling rates compared to other EU countries continue to be low [Jigani, Delcea and Ioanăș, 2020].

Of course, the economic development will lead to the continuous increase of municipal solid waste production, expecting that in 2025 it will reach 2.2 billion tons / year [Indrawan et al., 2018]. For efficient and sustainable management, most developed countries have implemented efficient ways to manage them, but low-income countries face serious problems due to inadequate infrastructure [Sharma and Jain, 2020].

The improper waste management can lead to environmental degradation and create hazards for the residents [Singh et al., 2011]. There can also be negative effects on the tourism development by affecting the natural heritage and protected areas, especially since in relatively small local communities (villages and communes) there are a number of features [Mihai, Oiste and Chelaru, 2014].

Although there are controversies about the economic growth and waste generation, there are studies which show in a certain model of economic growth that the long-term waste stream can be a positive factor of economic growth [Desmarchelier, Djellal and Gallouj, 2011], as well as the lack of a short-term causal link within the EU between GDP, energy consumption and waste generation [Gardiner and Hajek, 2020] leading to the conclusion of sustainable waste management in the EU.

Given the imperatives of sustainable development, the waste management process has a new trajectory given the changes in consumption patterns manifested both in trade and at the household level [USEPA, 2011; Osra, F.A. et al., 2021]. Thus, the waste management chain, with a priority of solid waste, is based on processes

aimed at collecting, disposing of, storing waste and treating and recycling it. They can be grouped into five levels of evolution: generation, handling and storage, collection, transfer - transport and disposal. The approaches to the sustainable development of resource management are based on five basic pillars: reduction, recycling, recovery, reuse and disposal [Karak, 2012].

Of course, the waste management is closely linked to the attitude of the population towards this aspect in the conditions of the circular economy. In this regard, studies have been conducted in Romania on the existence of positive relationships between the consumer's attitude, awareness and intention to recycle e-waste and between the intention and behavior [Delcea et al., 2020] study which highlights the role of the demographic and socio-economic variables in defining the consumer's behavior, on students' knowledge, attitudes and behavior on different approaches to waste management [Kolbe, 2014] as well as the attitude of different generations on reducing resource consumption, waste management, recycling and reuse [Lakatos et al., 2018].

Taking into account these aspects, the main objective of the paper was to highlight the similarities and disparities between the European states in terms of the results obtained on the resource productivity and the level of waste generation.

The article has been structured in four parts and begins with an introduction in which the objectives addressed are presented and argued. The second part presents information through which the work data and the applied methodology aimed at the clustering process are specified. The third part addresses the results which explain how to obtain and use the group in the context of an analysis of the average values of the five variables, as well as the ranking of the component countries by clusters. The paper concludes with a section of conclusions which summarizes the results with a perspective on the sustainable development.

II. METHODOLOGY AND DATA

30 European states were included in the analysis. Based on their choice, the availability of data as well as their comparability were taken into account. In these conditions, only 26 of the 27 Member States of the European Union were included, Estonia not being able to be included due to the fact that in the case of the Generation of waste excluding major mineral wastes indicator, high value for Estonia results from including waste from energy production.

Taking into account the existential conditions (criteria and the data comparability), the Non-UE countries which were included are: UK, Norway, North Macedonia and Serbia.

The analysis was based on five indicators (Table 1): Generation of municipal waste per capita, Generation of waste excluding major mineral wastes per domestic material consumption, Generation of waste excluding major mineral wastes per GDP unit, Real GDP per capita and Resource productivity.

Table 1. Significances and units of measurement of the indicators used

Variables	Significances	Units
MWC	Generation of municipal wastes per capita	Kilograms per capita
WDMC	Generation of waste excluding major mineral wastes per domestic material consumption	The indicator is defined as all waste generated in a country (in mass unit), excluding major mineral wastes, divided by the domestic material consumption (DMC) of a country. The ratio is expressed in percent (%) as both terms are measured in the same unit, namely tones.
WGDP	Generation of waste excluding major mineral wastes per GDP unit	Kilograms per thousand euro, chain linked volumes (2010)
GDP	Real GDP per capita	Chain linked volumes (2010), euro per capita
RP	Resource productivity	Gross domestic product (GDP) divided by domestic material consumption (DMC). Euro per kilogram, chain linked volumes (2010)

Source: Authors elaboration

The main characteristics of the data series corresponding to the indicators included in the analysis are presented in Table 2.

Table 2. The main characteristics of the analyzed variables

	Mean	Standard Error	Median	Standard Deviation	Kurtosis	Skewness	Confidence Level (95.0%)
MWC	496.37	25.48	480.50	139.59	0.12	0.65	52.12
WDMC	11.38	1.19	9.45	6.54	1.79	1.55	2.44
WGDP	92.07	16.69	69.50	91.41	11.39	3.24	34.13
GDP	27656.67	3486.19	22830.00	19094.62	1.48	1.22	7130.05
RP	1.77	0.21	1.51	1.14	-0.40	0.69	0.42

Source: Authors elaboration

The two characteristics Kurtosis and Skewness, which define the shapes of the distributions of the variables used, show that four of the five variables MWC and RP have normal distributions, WDMC and GDP have approximately normal asymmetric and leptocurtic distributions, and WGDP has no normal distribution. This means that for WDMC and GDP most of the values recorded are lower than the average. The same feature is recorded for the WGDP variable. Taking this into account, the values recorded by the respective variables, at the level of the analyzed states, show significant differences from one state to another.

In order to highlight the similarities and disparities between the states included in the analysis, in terms of the five indicators, a hierarchical cluster methodology was used. Wards 'method was used to determine the proximities matrix squared Euclidian Distance and z score transform, and to generate clusters.

The Levene test with statistical hypotheses was used to test the homoscedasticity of the data series dispersions:

H0_1: The data series dispersions are homoscedastic (homoscedasticity hypothesis is accepted)

H1_1: The data series dispersions are heteroskedastic (the homoskedasticity hypothesis is rejected)

In case of accepting the homoskedasticity hypothesis for testing the statistical meanings of the mean values, at cluster level, of the analyzed variables, the ANOVA methodology and the F test can be applied. Otherwise,we can apply the Welch test (Robust Test of Equality of Means) with the statistical hypotheses:

H0_2: the cluster-level averages of the analyzed variables do not differ significantly (they are not statistically significant)

H1_2: the cluster-level averages of the analyzed variables differ significantly (are statistically significant).

For testing statistical hypotheses a significance threshold $\alpha = 0.05$ (Confidence level 95%) was used. The data series processing was performed with SPSS.

III. RESULTS AND DISCUSSIONS

The analysis of the territorial disparities based on the 5 indicators (MWC, WDMC, WGDP, GDP, RP) to highlight the intensity of the waste generation and the level of productivity, considers primarily the construction of the dendrogram (figure 1).

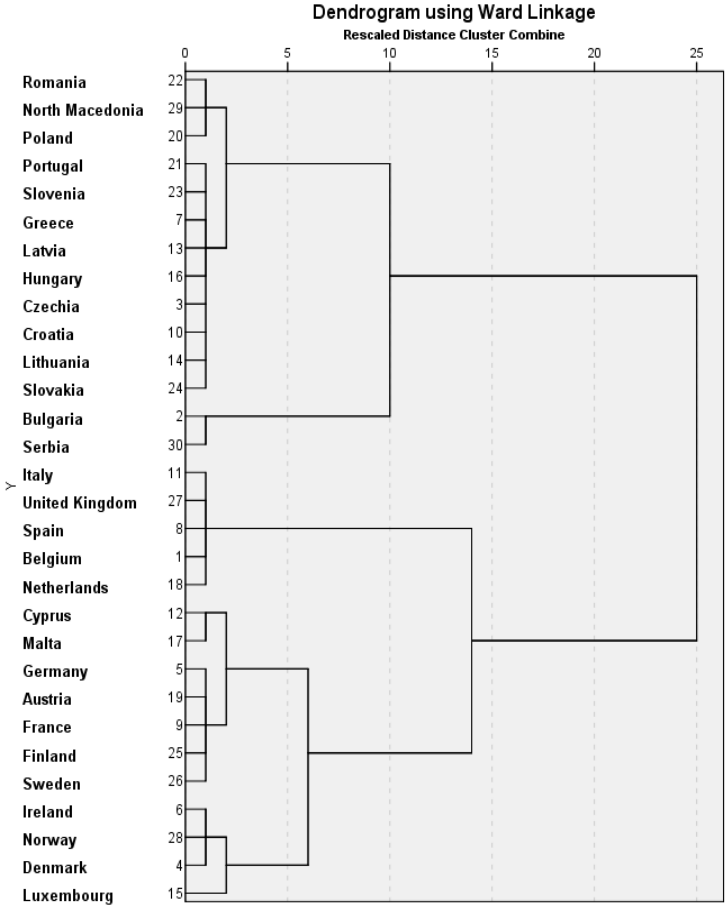

Figure 1 Dendrogram

According to the dendrogram, the states included in the study form six clusters whose structure is presented in table 3.

Table 3 - Cluster structure determined by MWC, WDMC, WGDP, GDP, RP

Cluster	Clusters structure	
	EU Countries	*Non EU Countries*
A	Bulgaria,	Serbia
B	Poland, Romania,	North Macedonia
C	Czechia, Greece, Croatia, Latvia, Lithuania, Hungary, Portugal, Slovenia, Slovakia	
D	Germany, France, Cyprus, Malta, Austria, Finland, Sweden	
E	Denmark, Ireland, Luxemburg,	Norway
F	Belgium, Spain, Italy, Netherlands,	United Kingdom

The homoscedasticity test of the data series dispersions was performed by applying the Levene test taking into account the results in table 4.

Table 4. Test of Homogeneity of Variances

	Levene Statistic	df_1	df_2	Sig.
MWC	1.150	5	24	0.362
WDMC	1.290	5	24	0.301
WGDP	24.204	5	24	0.000
GDP	4.217	5	24	0.007
RP	2.700	5	24	0.045

The results of applying the Levene test are not all insignificant (only SigMWC and SigWDMC are higher than the significance level of 0.05), which indicates that not all dispersions within the groups are homogeneous. In this context, the Welch test is still applied.

Table 5. Robust Tests of Equality of Means

		Statistic[a]	df_1	df_2	Sig.
MWC	Welch	24.333	5	6.572	.000
WDMC	Welch	7.998	5	6.113	.012
WGDP	Welch	20.485	5	5.930	.001
GDP	Welch	35.676	5	8.398	.000
RP	Welch	40.689	5	8.569	.000

a. Asymptotically F distributed.

Given that, for all variables, the statistical values of the Welch test are significant (Sig <0.05), it can be seen that the averages of the variables at the level of each cluster differ significantly.

Table 6. Average values of the indicators used

Cluster	Means (95% confidence level)				
	MWC	**WDMC**	**WGDP**	**GDP**	**RP**
A	363.00	12.60	400.00	5875.00	0.31
B	296.00	7.03	135.33	8416.67	0.50
C	439.67	8.86	81.11	15512.22	1.10
D	572.71	9.26	51.00	33225.71	1.86
E	738.50	7.63	29.00	64805.00	2.69
F	471.40	24.04	70.60	32258.00	3.47

Taking into account the averages of the analysis indicators (table 6), the study is mainly based on an analysis of the disparities at internal level between the component states of the clusters, and in conclusion presents comparatively, by hierarchy, their situation between clusters.

Cluster A, regardless of the analyzed indicator (MWC, WDMC, WGDP, GDP, RP) is characterized by the highest value levels compared to the determined averages (Table 6) for Bulgaria. At the level of this country, the highest value of WGDP (473 kg per thousand euro) is registered, being the maximum registered compared to all the states included in the analysis.

In this context, it can be highlighted that Serbia is the component country of this cluster with a favorable situation for the process of sustainable development, compared to Bulgaria, based on the low values of the

specific indicators. At the same time, Serbia has the lowest resource productivity of 0.3052 euros per kg and the lowest GDP of 5875 euros per capita, as determined minimums, compared to the values calculated for all other countries.

In relation to the average values determined for each indicator, the ranking of the component countries of cluster B places Poland at the top of the ranking with the values of above average variables: 315 kilograms per capita per MWC, 10.9% WDMC, 168 kilograms per thousand euro, 12420 euro per capita GDP and 0.65 euro per kilogram RP. If for Poland all the variables were at a maximum level, compared to those of the other two component states of cluster B, for Romania the situation is reversed, recording the lowest values for all variables (below the average values). Romania, due to the low values of the indicators (272 kilograms per capita at MWC, 4.8% WDMC, 127 kilograms per thousand euro, 8700 euro per capita GDP and 0.38 euro per kilogram RP) is positioned at the end of the ranking (except for the GDP which positions on the second place) but has positive prospects in regard to the sustainable development process. A middle position in the ranking is occupied by North Macedonia with 5 kilograms per capita above average for MWC. The rest of the variables of this country have values below the average: 5.4% WDMC, 111 kilograms per thousand euro, 4130 euro per capita GDP and 0.48 euro per kilogram RP.

In regard to cluster C, which includes most of the analysed countries (9 states: Czechia, Greece, Croatia, Latvia, Lithuania, Hungary, Portugal, Slovenia, Slovakia), it can be noted that, compared to the values of the indicators of the other countries, Greece ranks first for three significant variables in the link between waste and sustainable development: MWC, WDMC, RP.

Thus, for Greece at MWC there is an additional difference of 75.33 kilograms per capita compared to the average of 439.67 kilograms per capita, at WDMC the value is 4.54 percentage points above the average of 8.86%, while for RP, compared to the average of 1.10 euro per kilogram, the indicator is higher by 0.51 euro per kilogram. Lithuania with 23.89 kilograms per thousand euro above the average of 81.11 kilograms per thousand euro is dominant among the other countries of cluster C in the WGDP, while in GDP at the top of the ranking of this cluster is Slovenia with 4687.78 euros per capita more than the average of 15512.22 euros per capita. The fluctuations of indicators from one country to another highlight the different situation of the ranking in terms of occupying the last place, ie the states with the lowest values of variables.

Thus, the Czech Republic is on the last place with 88.64 kilograms per capita below the average of the MWC indicator. Latvia is the last country for both the WDMC, with 4.06 percentage points less than the average value, and the WGDP for which there have been determined values with 23.11 kilograms per thousand euro less than the average corresponding to this indicator. Croatia with 12040 euros per capita is on the last place in GDP, while Lithuania, which ranks first in WGDP, compared to other countries, has the lowest RT with 0.75 euros per kilogram.

The fourth cluster (D) also has a fairly consistent composition, including 7 states (Germany, France, Cyprus, Malta, Austria, Finland, Sweden), the values of the indicators showing quite low oscillations. Taking into account the values of the indicators of the states of the analyzed cluster, Malta represents the country with the highest value of MWC (with 90.29 kilograms per capita higher than the average of 572.71 kilograms per capita) and the lowest for GDP, with 11685.71 euros per capita compared to the average value of 33225.71 euros per capita. The situation reported for Sweden in terms of the two indicators analysed fro Malta, is reversed, occupying the reversed extreme positions in the ranking. Thus, with 138.71 kilograms per capita below the MWC average, we can observe Sweden which has the lowest value of the indicator, compared to the other states, occupying the last place in the ranking. For GDP this country is on the first place, with 10534.29 euros per capita above the average corresponding to this indicator. Compared to other countries, France is in first place both in terms of the WDMC variable by 13.1%, the value being 3.84 percentage points higher than the average. of 9.26%, as well as the variable RP by 1,005 euro per kilogram above the average 1.86 euro per kilogram Cyprus is the component of cluster D which presents both the lowest WDMC by 5.1% and the lowest WGDP by 39 kilograms per thousand euro, compared to the values of the other countries which form cluster D.

The most significant value of the WGDP indicator belongs to Finland (70 kilograms per thousand euro) occupying the first place and has the lowest value of the RP indicator (1,066 euro per kilogram) which occupies the last place in the ranking among the other countries of this cluster.

Denmark, Ireland, Luxembourg, Norway are the four countries which form cluster E. The length of the range of variation of the MWC indicator is 216 kilograms per capita, the lower limit being represented by Ireland with 598 kilograms per capita, and the upper limit by Denmark with 814 kilograms per capita. Denmark remains at the highest level of the ranking with 37 kilograms per thousand euro at WGDP and at the last level by the GDP value of 48530 euro per capita. Luxembourg holds the supremacy of the WDMC indicators by 10.00%, GDP by 83470 euros per capita and RP by 3.67 euros per kilogram. Norway stands out with the lowest values of the indicators WDMC (6.3%) and WGDP (24 kilograms per thousand euro)

Cluster E includes five countries (Belgium, Spain, Italy, Netherlands, United Kingdom) of which, Italy is in the middle of the ranking regardless of the indicator included in the analysis. The other countries occupy extreme places by the lower and upper values of the indicators. Belgium is the country that ranks last at MWC

with 409 kilograms per capita and is at the top of the ranking for WDMC with 29.30% and for WGDP with 99 kilograms per thousand euro. Spain is at the lower limit for WDMC indicators by 17.70%, GDP by 24910 euros per capita and RP by 2.75 euros per kilogram. The Netherlands represents the country which has supremacy over the indicators: MWC with 511 kilograms per capita, GDP with 41450 euro per capita and PR with 4.42 euro per kilogram. United Kingdom with only 58 kilograms per thousand euro is at the end of the WGDP indicator ranking. The average values of the indicators represent benchmarks in completing the analysis, taking into account the absolute amplitude of their variation. GDP is the indicator with the highest absolute amplitude of variation, the length of the range of 5893 euros per capita, Denmark, Ireland, Luxembourg, Norway, the components of cluster E having the highest values of this variable, and Bulgaria and Serbia (cluster A) the lowest.

According to the GDP, Generation of municipal waste per capita (MWC) registers oscillating values over a length of 442 kilograms per capita, the most significant values belong to the component countries of cluster E (Denmark, Ireland, Luxembourg, Norway), and the smallest to Poland, Romania, North Macedonia (cluster B). With a variation of 371.00 kilograms per thousand euro, Generation of waste excluding major mineral wastes per GDP unit (WGDP) is the indicator with inverted limits to GDP in the sense that it includes in cluster A the countries with the highest values, while the cluster E holds the states with the lowest values of the indicator. The value oscillation of the Generation of waste, excluding major mineral wastes, per domestic material consumption (WDMC) indicator of 17.01% will be among the highest values recorded in cluster F in Belgium, Spain, Italy, Netherlands, United Kingdom and the most reduced from cluster B registered at the level of the three countries, Poland, Romania, North Macedonia. A small amplitude of 3.16 euro per kilogram is given by the low values of the Resource productivity indicator which oscillate between the minimum values of Bulgaria and Serbia (cluster A) and the maximum values of Belgium, Spain, Italy, Netherlands, United Kingdom (cluster F).

IV. CONCLUSIONS

The sustainable development remains a topical process due to the global economic and social situation. The significant increase in the amount of waste in recent years has led to a special focus on its management and treatment, in the direction of sustainable development. In this context, the article was elaborated in which, two categories of indicators were used, aiming at the efficient use of resources and the reduction of waste generation. One category addresses the intensity of the waste generation through the variables MWC, WDMC, WGDP. The second category considers the level of development and use of resources through the variables GDP and RT.

The application of the cluster analysis methodology began with collecting the data from 30 states (26 EU states and 4 nonmember EU states: United Kingdom, Norway, North Macedonia and Serbia) and aimed at highlighting the disparities which occur between countries. The reflection of the disparities was detailed internally, between the component states of the clusters through the average values of the indicators used in the analysis. Thenceforth, it can be highlighted, as a conclusion, a comparative ranking of the fluctuation of the average values of indicators between clusters.

Summarizing the results of the indicators which measure the intensity of the waste generation through the variables Generation of municipal waste per capita (MWC), Generation of waste, excluding major mineral wastes, per domestic material consumption (WDMC), Generation of waste excluding major mineral wastes per GDP unit (WGDP) there are quite significant disparities between countries.

Compared to the other states included in the analysis, the components of cluster E (Denmark, Ireland, Luxembourg, Norway) have the highest average level of Generation of municipal waste per capita (738.50 kilograms per capita). Poland, Romania, North Macedonia have the lowest values of the indicator, determining an average MWC of 296 kilograms per capita, thus cluster B is on the last place. Regarding WDMC, the supremacy is held by the countries Belgium, Spain, Italy, Netherlands, United Kingdom which form cluster F with 24.04%, and on the last hierarchical stage there are all three countries of cluster B with 7.03%. The situation changes for the third indicator, the maximum Generation of waste excluding major mineral wastes per GDP unit (WGDP) being reported in the first cluster A. With an average of 400 kilograms per thousand euro of WGDP, Bulgaria and Serbia are dominant, while the states of cluster E have on average only 29.00 kilograms per thousand euros.

The analysis of disparities with respect to the other two indicators, Real GDP per capita (GDP) and Resource productivity (RP) brings to the fore cluster A (Bulgaria, Serbia) with the lowest average values of the indicators (5875.00 euro per capita and 0.31 euro per kilogram). For these two indicators, the first place is occupied by the countries of cluster E for GDP (64805.00 euro per capita) and those of cluster F for RT (3.47 euro per kilogram).

The countries of clusters C and D include values of indicators which do not place them at the extremities of the ranking, which represents an attitude and activity maintained at about the same levels, with insignificant fluctuations in terms of the waste generation intensity and the level of development and use of resources in the context of sustainable development.

The process of improper waste disposal causes significant problems which lead to the pollution of air, water and soil, sometimes leading to the blockage of the drainage system. Currently, technological and IT developments could be applied to the waste management issues. The contribution of innovation to the waste management plays a key role, tackling the potential for innovation is a resource of strategic importance. Given this aspect, a future direction of research will be the extension of the analysis taking into account indicators aimed at innovation.

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