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Waste management in Baltic States: Comparative assessment

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Abstract. In EU waste management policy the waste avoidance and reuse are under the highest priority and the recycling takes the third place while recovery and disposal are the least favourable options. The EU member states have to implement strict waste management policies based on this approach however though all countries have to prepare and implement waste management plants, their have achieved different results in waste management. The article aims to analyse the selected waste management indicators covering all stages of various wastes management ranging from prevention to recycling etc. available at Eurostat database and to present empirical comparative case study on waste management for Baltic. The different Multi Criteria Decision Making models were applied for comparing and ranking Baltic States based on their achievements in waste management in 2020. The case study revealed that the best performing country in waste management among Baltic States was Lithuania having the best indicators of waste generation per GDP and recycling rates of municipal waste and plastic packaging waste. Estonia was lowest ranked country according waste management due to very high overall total generated waste per capita and packaging and plastic waste per capita etc.

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1. INTRODUCTION

EU waste management policies aim to reduce the quantity of waste produced and increase waste recycling rate. This allows to implementation of cyclic economy principles and to reduce GHG emissions and other negative ecological and health effects of land waste and increase resource efficiency of EU Member States. The long-term goal for the European Union is to create a carbon-neutral and recycling society, avoiding waste and using unavoidable waste as a resource in all branches of the economy (Firle et al., 2023). In order to implement this ambitious goal, it is necessary to increase waste collection and it's recycling. Proper waste management is a key issue for implementing other environmental policies like climate change mitigation and implementation of the European Green Deal, Europe's new program for sustainable development, targets to achieve sustainable development and decoupling of economic growth from resource consumption as well as decoupling from pollution and resource usage (Pilota et al., 2021; Hajdukiewicz & Pera, 2023). Directive 98/2008 of 2008 introduced five five-stages in waste management, starting from prevention, followed by reuse, and recycling, and the landfill being the last option for waste management.

The European Commission in 2020 has introduced the latest action plan for circular economy progression. It is one of the most important constructs of the European Green Deal. The EU's progression towards circular economy principles allows for a reduction in the usage of natural resources and will ensure sustainable economic progress and the creation of green jobs. It is also a precondition for the realization of the EU target of reaching carbon neutrality by 2050 and stopping biodiversity losses.

EU waste management policies and measures have the objective to revert waste from lower locations in a waste management hierarchy, like landfill and incineration, to upper positions, like energy recovery and recycling (Sipos et al., 2007; Gharfalkar et al., 2015). However, the overall assessment of EU countries based on their achievement in waste management based on empirical evaluations is scarce. There are few studies (Karousakis, 2009; Halkos and Petrou, 2018; analysing EU member states and developed countries' environmental efficiency in waste generation). Klavenics and Blumberga (2017) developed a study on municipal solid waste (MSW) management in the Baltic States. Most of the studies in the waste management field deal with policies and measures of waste management (Reggiani and Silvestri, 2018; Vasa et al., 2018; Malek et al., 2023; de Weerdt et al., 2020; 2022; Apostu et al., 2022) and waste management behavior (Minelgaite and Liobikiene, 2019).

This paper aims to overcome this gap and provides a comparative assessment of Baltic States in their achievements in waste management. The case study of three Baltic States will be presented based on statistical data from Eurostat. Multi-criteria decision-making tools allow us to compare and rank selected countries. The rest of the paper is structured in the following way: section 2 on literature review, section 3 on study framework and data, section 4 presents case study results, and section 6 concludes.

2. LITERATURE REVIEW

Annually almost 2.2 billion tonnes of waste are produced in the EU. Almost 30% of all waste in the EU is municipal waste (Weghmann, 2023). Municipal waste is mainly generated by households and is collected and treated by municipalities. The volume of waste and the approach it is managed fluctuates among EU Member States though the EU has strict waste management policies in place. There are huge dissimilarities in the trends and amounts of municipal waste produced throughout the EU, though the average size of MSW per person was just slightly growing during 2005 - 2020 period. Denmark is the leader in municipal waste production per capita (845 kg per capita), while Romania produces the lowest volume of MSW per capita (282 kg per capita). This indicator is linked to the quality of life, lifestyles and economic development level of the country (Romano and Molinos-Senante, 2020; Chakraborty et al., 2022). The households' behavior in terms of waste collection and sorting also plays an important role (Czajkowski et al., 2014; 2019; Hage and Soderholm, 2008; Holotová et al., 2020). This is a positive trend that the awareness of food packaging and waste disposal has increased in recent years, especially among younger generations of consumers (Cichocka et al., 2020). In general, there is a strict relationship in waste management within the EU - higher efficiency is found in the more economically developed countries even though the amount of municipal waste generated in them is higher too (Ginevičius, 2022).

Plastic waste is growing very fast by creating real danger to the environment in the EU as well. (Chamas et al., 2023; Borrelle et al., 2020). The use of plastic as packing is the biggest cause of plastic waste, as 60% of plastic waste comes from packaging in the EU. It has increased by 30% since 2000 and Germany is the largest generator of plastic packaging waste and is responsible for almost 20% of its volume in the EU (Weghmann, 2023). There are new advanced technologies for sustainable solutions for biodegradable plastic waste management (Jung et al., 2023; Gadaleta et al., 2022).

Waste management in the European Union promotes waste treatment options according to a set hierarchy, particularly favouring prevention, arrangements for reuse and recycling over disposal like landfilling and incineration (van Ewijk and Stegemann, 2016). However, effectual policies and regulations are missing in the EU to promote waste prevention. Therefore, the priority is to reduce waste generation and reduce production and consumption. The growth of the sharing economy and the reduction of packaging are promising strategies for EU Member States to address these problems. It is also necessary first of all to implement the main principle of sustainable development - sustainable production and consumption. However, there are evident barriers to waste prevention as it brings no profits for all stakeholders. Progress toward sustainability principles sharing was not significant even in light of the pandemic new normal challenges and changes in the perception of well-being, connected with the environment (Mishchuk et al., 2023). Therefore, more public support and funding for new workplace creation in waste prevention areas is necessary like running educational campaigns and providing public support for repair services and all sharing economy services, etc.

In addition, waste collection improvements are essential to reduce waste contamination and ensure increased rate of recovery. The EU must enlarge its very localised recycling manufacturing. Reverse logistics can be an effective tool as well (Zielińska, 2020). This leads to lower dependency on the export of waste which is widely spread in the EU.

EU legislation introduces recycling targets for various types of waste, namely municipal, plastic, electronic, hazardous, construction and demolition wastes. There is a high potential to raise waste recycling levels in all waste streams. However, there are many barriers like price competition with virgin resources, infrastructure limits and high complexity of certain waste categories. This requires new policies and measures that are integrated into Europe's 2020 circular economy action plan.

According to EU policy documents circularity and sustainability need to be addressed in all phases of a value chain: from design to production and consumption. There are seven areas important for attaining a circular economy: plastics; textiles; e-waste; food, packaging; batteries and vehicles; buildings and building and construction. Bio-waste which is mainly food waste is the main municipal waste stream having huge potential for donating to a more circular economy (Petrariu et al., 2022). As occupation in the waste management sector was growing in line with the increase in the amount of waste, this can contribute towards the development of a more efficient waste collection system. This in the end allows to increase in the rate of waste recycling in the EU.

The decrease in commercial waste during the COVID-19 pandemic was not compensated by an increase in household waste. One of the potential sources of waste decreased during pandemic restrictions was tourism. Its sharp reduction was one of the most obvious economic sudden stops (Bilan et al., 2023). However, it had no significant positive impact on waste decrease either. However, COVID-19 has a negative impact on municipal waste management systems due to staff shortages which caused lower waste collection. The reduced municipal waste collection capacity provided for a lower sorting capacity and an increase in fly-tipping (WHO, 2020).

3. STUDY FRAMEWORK AND METHODS

The main approach followed in this paper is the use of MCD tools for ranking of Baltic States based on their waste management performance. As there are several indicators of waste management performance measured in different dimensions and in order to assess and compare countries based on these key indicators it is necessary to trade-off between different criteria expressed by waste management indicators as some indicators reveal positive trends and others are showing negative trends in waste management practice. In addition, countries are showing different achievements in waste management based on selected waste management indicators, therefore for comparative assessment of countries' achievement and ranking the MCDM tools are necessary. In order to ensure reliability of results, few MCDM tools having different approaches were applied for ranking Baltic States based on their achievements in waste management.

3.1. MCDM tools

SAW and EDAS MCD tools, having different approaches, were applied to ranking Baltic States based on waste management indicators.

The Simple Additive Weighting (SAW) method is also being named as weighted addition method and is very often used in various decision support studies. The main idea of the SAW method is to calculate a weighted sum of the performance scores for each option on all attributes (Ciardiello, 2023). The SAW method involves of normalization of the decision matrix (X) to a scale of other values that can be compared with all existing option scores according to all attributes (Ciardiello, 2023).

The SAW method necessitates the determination of the weight for each attribute. The total rating for the option is achieved by adding up all the multiplication results between the rating of attribute and the its weight. The score of each attribute should be dimension-free after matrix normalization (Ciardiello, 2023).

The following steps are necessary for SAW calculations:

a. Setting the criteria for decision-making and ranking of alternatives, namely Ci.
b. Defining the suitability rating of each alternative.
c. Producing the decision matrix based on the criteria (Ci).
d. Normalization of the matrix based on the specific equation in order to obtain a normalized matrix

The final result is by adding the values of the normalized matrix R multiplied by the weight vector and the highest obtained value allows selection of the best alternative (Ai) and ranking of all options.

The following formula 1 is applied for the normalization of matrix R:

$$R_{ij} = \begin{cases} \frac{X_{ij}}{Max\, X_{ij}} & If\ J\ is\ the\ benefit\ attribute \\ \frac{Min\, X_{ij}}{X_{ij}} & If\ J\ is\ the\ cost\ attribute \end{cases} \tag{1}$$

Where R_{ij} is a normalized performance score; X_{ij} is the attribute value of each criterion; Max X_{ij} is the highest value of each criterion; Min X_{ij} is the lowest value of each criterion; Benefit means that is the greatest value received is the best solution; Cost – mean the lowest value received is the best solution. Rij is the normalized performance scoring of options; Ai on attribute C_j; i=1,2,…, m and j=1,2,…, n.

The preference value for each option (V_i) is calculated according formula 2:

$$V_i = \sum_{j=1}^{n} W_j R_{ij} \tag{2}$$

Where V_i is the scoring of each option alternative, W_j is the weighted score of each criterion; R_{ij} is the normalized performance score. The larger value of V_i shows that option A_i is the best and it is preferred in decision-making

EDAS method was first introduced by (Ghorabaee at al., 2015). The EDAS method uses the positive and negative distances from the average value (AV) for assessing options with integration later of method to inventory classification.

The eight steps of EDAS method can be summarised by Ghorabaee et al. (2015).

In the first step, the attributes and options of the decision problem are defined.
In the second step, the decision matrix X is developed according to the following equation:

$$X = [x_{ij}]_{n*m} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ \vdots & \vdots & \vdots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \quad (3)$$

In this matrix, x_{ij} indicates the performance score of i^{th} option based on j^{th} attribute or criterion.

In third step the AV value according all criteria is calculated in the following way:

$$AV = [AV_j]_{1*m} \quad j = 1, \dots, m. \quad (4)$$

Here,

$$AV_j = \frac{\sum_{i=1}^{n} x_{ij}}{n} 1; \dots; m. \quad (5)$$

In fourth step, the PDA and the NDA matrices are developed based on the type (benefit or cost) of the criteria.

$$PDA = [PDA_{ij}]_{n*m}, \quad (6)$$

$$NDA = [NDA_{ij}]_{n*m}, \quad (7)$$

If criterion *j* is benefit criterion, the following equations are applied:

$$PDA_j = \frac{\max(0, (x_{ij} - AV_j))}{AV_j}; \quad (8)$$

$$NDA_j = \frac{\max(0, (AV_j - x_{ij}))}{AV_j}; \quad (9)$$

If criterion *j* is cost criterion, the following equations are used:

$$PDA_j = \frac{\max(0, (AV_j - x_{ij}))}{AV_j}; \quad (10)$$

$$NDA_j = \frac{\max(0, (x_{ij} - AV_j))}{AV_j}; \quad (11)$$

Here, PDA_{ij} and NDA_{ij} indicate the positive and negative distances of *i*th option from AV in terms of *j*th criterion, respectively.

Inn fifth step the weighted sum of PDA and NDA for all options are calculated by using following formulas:

$$SP_i = \sum_{i=1}^{m} w_j PDA_{ij} \quad (12)$$

$$SN_i = \sum_{i=1}^{m} w_j NDA_{ij} \quad (13)$$

Here, *wj* indicates the weight of *j*th criterion.

In sixth step for all options, SP and SN values are normalised by using following formulas:

$$NSP_i = \frac{SP_i}{max(SP_i)}, \quad (14)$$

$NSN_i = 1 - \frac{SN_i}{max(SN_i)}$. (15)

In seventh step the appraisal score (AS) for all options is evaluated based on equation 16:

$As_i = \frac{1}{2}(NSP_i + NSN_i)$. (16)

Here, $0 \leq AS_i \leq 1$.

In the final eight step, based on evaluated AS_s for all alternatives, the options are scored and ranked in descending order. The option with the utmost *AS* is the best option among the other options.

3.2. Indicators of waste management

The main waste management indicators are given in Table 1. These indicators were developed by Eurostat to measure results achieved by EU Member States in waste management.

Table 1

Waste management indicators

Indicator	Measure	Description
Total waste per capita	Kg/capita	The total waste produced per year in a country including major mineral wastes is divided by the average population
Food waste per capita	Kg/capita	The volume of food waste produced per year in the country divided by the average population. Food waste consists of all fresh mass within the food value chain.
Municipal waste per capita	Kg/capita	Solid municipal waste collected by or on behalf of municipal authorities per year and disposed of with the help of the waste management system divided by the average population.
Packaging waste per capita	Kg/capita	Packaging waste per year in the country divided by the average population. Packaging waste includes all products made from any materials used for the containment, protection, handling, delivery and presentation of goods.
Plastic packaging wate per capita	Kg/capita	Annual plastic packaging waste means packaging waste from all plastics per year in the country divided by the average population.
Waste excluding major mineral wastes per GDP unit	Kilograms per thousand euro, chain linked volumes (2010)	All waste generated in a country per year excluding major mineral wastes divided by GDP unit (kg per thousand EUR 2010).
Recycling rate of all waste excluding major mineral waste	%	The recycled waste per year divided by the total waste treated per year, excluding major mineral wastes, and multiplied by 100. Recycled waste is waste treated, which was sent to recovery. It covers hazardous and non-hazardous waste from all economic sectors, including the residential sector, incorporating secondary waste but excluding most mineral waste.
Recycling rate of municipal waste	%	The share of recycled solid municipal waste in the total municipal waste produced in the country per year.
Recycling rate of packaging waste	%	The share of recycled plastic packaging waste in all generated plastic packaging waste. Per year in the country. Packaging waste includes all products made from any materials used for the containment, protection, handling, delivery and presentation of goods
Recycling rate of plastic packaging waste	%	The share of recycled plastic packaging waste in all generated plastic packaging waste per year in the country. It considers just plastic packaging waste that is recycled back into plastic materials.

Source: created by author based on (EC, 2023)

4. BALTIC STATES CASE STUDY RESULTS

Waste management indicators were collected for the Baltic States and EU-27 average in 2020 based on the newest available data in Eurostat (EC, 2023). The data are presented in Table 2. The desirable trend of indicators is provided

Table 2

Waste management indicators of Baltic States in 2020

Indicator	Symbol	Estonia (A1)	Latvia (A2)	Lithuania (A3)	EU 27 average	Desirable trend
Total waste per capita, kg/capita	C1	12163	1501	2396	4815	Decrease
Food waste per capita, kg/capita	C2	125	145	137	130	Decrease
Municipal waste per capita, kg/capita	C3	383	478	483	729	Decrease
Packaging waste per capita, kg/capita	C4	154.7	142.8	136.8	177.9	Decrease
Plastic packaging waste per capita, kg/capita	C5	40.3	24.6	30.8	34.6	Decrease
Waste excluding major mineral wastes per GDP unit, kg/th EUR	C6	412	110	105	65	Decrease
Recycling rate of municipal waste, %	C7	28.9	39.7	45.3	48.9	Increase
Recycling rate of packaging waste, %	C8	71.4	61.4	61.8	64	Increase
Recycling rate of plastic packaging waste, %	C9	40.9	35.9	56.1	37.6	Increase

Source: created by author based on (EC, 2023).

The results of the case study on the ranking of three countries based on two three different MCDM tools are discussed below.

5.1. Ranking results by SAW

The process of the SAW technique is as follows in Tables 3-6.

The initial Matrix and minimal and maximal values matrix for each criterion according to SAW are shown in Table 3.

Table 3

The initial matrix and minimal and maximal values matrix for each criterion

Initial Matrix									
weights of criteria	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
kind of criteria	-1	-1	-1	-1	-1	-1	1	1	1
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**
A1	12163	125	383	154.7	40.3	412	28.9	71.4	40.9
A2	1501	145	478	142.8	24.6	110	39.7	61.4	35.9
A3	2396	137	483	136.8	30.8	105	45.3	61.8	56.1
MAX	12163	145	483	154.7	40.3	412	45.3	71.4	56.1
MIN	1501	125	383	136.8	24.6	105	28.9	61.4	35.9

Source: created by author

The normalized SAW matrix is provided in Table 4.

Table 4

Normalized matrix for ranking of Baltic States according to nine criteria

Normalized Matrix									
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**
A1	0.123	1.000	1.000	0.884	0.610	0.255	0.638	1.000	0.729
A2	1.000	0.862	0.801	0.958	1.000	0.955	0.876	0.860	0.640
A3	0.626	0.912	0.793	1.000	0.799	1.000	1.000	0.866	1.000

Source: created by author

The normalized weighted matrix is shown in Table 5.

Table 5

Normalized weighted matrix

Normalized Weighted Matrix									
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**
A1	0.014	0.111	0.111	0.098	0.068	0.028	0.071	0.111	0.081
A2	0.111	0.096	0.089	0.106	0.111	0.106	0.097	0.096	0.071
A3	0.070	0.101	0.088	0.111	0.089	0.111	0.111	0.096	0.111

Source: created by author

Table 6 shows the final Preference Value and ranking of countries.

Table 6

Final ranking of Baltic States based on final preference value

ALTERNATIVE	**Final Preference Value (Vi)**	**Ranking**
Lithuania (A1)	0.693	1
Latvia (A2)	0.884	2
Estonia (A3)	0.888	3

Source: created by author

5.2. Ranking results by EDAS

The calculations and results of EDAS application for ranking Baltic States according nine criteria are provided in Table 7-10.

In Table 7 the initial matrix for EDAS is presented based on the first data.

Table 7

Initial matrix for countries ranking according nine criteria based on EDAS method

Initial Matrix									
weights of criteria	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111
kind of criteria	-1	-1	-1	-1	-1	-1	1	1	1
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**
A1	12163	125	383	154.7	40.3	412	28.9	71.4	40.9
A2	1501	145	478	142.8	24.6	110	39.7	61.4	35.9
A3	2396	137	483	136.8	30.8	105	45.3	61.8	56.1
Average Solution	5353.333	135.667	448.000	144.767	31.900	209.000	37.960	64.867	44.300

Source: created by author

The Dij+ and Dij evaluation results are shown in Table 8.

Table 8

Dij+ and Dij evaluation results

D_{ij+}									
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**
A1	0.0000	0.0786	0.1451	0.0000	0.0000	0.0000	0.0000	0.1007	0.0000
A2	0.7196	0.0000	0.0000	0.0136	0.2288	0.4737	0.0457	0.0000	0.0000
A3	0.5524	0.0000	0.0000	0.0550	0.0345	0.4976	0.1932	0.0000	0.2664
D_{ij-}									
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**
A1	1.2720	0.0000	0.0000	0.0686	0.2633	0.9713	0.2388	0.0000	0.0767
A2	0.0000	0.0688	0.0670	0.0000	0.0000	0.0000	0.0000	0.0534	0.1896
A3	0.0000	0.0098	0.0781	0.0000	0.0000	0.0000	0.0000	0.0473	0.0000

Source: created by author

The PDA and NDA results are provided in Table 9.

Table 9

PDA and NDA evaluation results

PDA									
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**
A1	0.0000	0.0087	0.0161	0.0000	0.0000	0.0000	0.0000	0.0112	0.0000
A2	0.0800	0.0000	0.0000	0.0015	0.0254	0.0526	0.0051	0.0000	0.0000
A3	0.0614	0.0000	0.0000	0.0061	0.0038	0.0553	0.0215	0.0000	0.0296
NDA									
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**
A1	0.1413	0.0000	0.0000	0.0076	0.0293	0.1079	0.0265	0.0000	0.0085
A2	0.0000	0.0076	0.0074	0.0000	0.0000	0.0000	0.0000	0.0059	0.0211
A3	0.0000	0.0011	0.0087	0.0000	0.0000	0.0000	0.0000	0.0053	0.0000

Source: created by author

The final ranking of Baltic States based on EDAS method are shown in Table 10.

Table 10

Final ranking of Baltic States based on EDAS method

ALTERNATIVE	Rank	Si
Lithuania (A1)	1	0.977
Latvia (A2)	2	0.898
Estonia (A3)	3	0.101

Source: created by author

As one can see from the information provided in Table 10, Lithuania is ranked first based on the achievement of waste management in 2020. The same result was achieved by applying the SAW method (see Table 6).

Lithuania was highest ranked country in the achievement of waste management as the republic showed the lowest waste intensity by GDP, lowest packaging waste per capita, the highest recycling rate of municipal solid waste, and the highest rate of plastic waste recycling though according to other waste management indicators like total waste per capita, plastic waste per capita, Lithuania was in the middle position between Baltic States.

Estonia received the lowest ranking in municipal waste management due to very high total waste per capita, exceeding the level of Latvia almost 10 times and 3 times exceeding the EU 27 average level. Also, according to other indicators like plastic waste per capita, the waste intensity of GDP, and the recycling rate of packaging waste, Estonia showed the worst results among the Baltic States in 2020. The mineral waste and makes almost 74% of all waste in EU. When eliminating the waste from major mineral waste, Estonia was still the worst-performing country in EU due to extensive energy production from oil shale.

Such differences in waste management among the Baltic States show that countries have achieved different results, though all of them have prepared and implemented national waste management plans.

Estonia has developed the 2014–2020 National Waste Management Plan (NWMP). The Estonia has adopted decision in 2020 to prolong it's NWMP 2014-2020 until the approval of its new NWMP covering 2022-2028. Anew version of NWMP was developed in 2022. Estonia has been supporting waste prevention through the Environmental Investment Centre by offering support to waste prevention and reuse from circular economy program.

The first WPP of Lithuania came into force in 2014. However, it was difficult to see any clear effect of the program, especially since the municipal waste generation increased in 2015. Lithuania has prepared Integrated into National Waste Prevention and Management Plan for (2021-2027). The plan for 2021-2027 aims to diminish the volume of waste produced, promote rational use of material and energy resources, thus reducing environmental pollution and use of natural resources.

Latvian National Waste Management Plan 2021-2028 was adopted in the beginning of 2021. Latvian National Waste Management Plan 2021-2028 comprises also the Waste prevention plan Ch 9. "Waste prevention state programme", Ch 10 "Food waste prevention programme", Ch11 "Packaging waste prevention programme" and Ch 1"Programme for development of re-use of goods and repair services").

The analysis of the National waste management plans of Baltic States showed that though countries have set similar priorities for waste management and implemented similar policies for the improvement of waste management, the results are quite different. The Latvian waste plan and prevention program includes 10 quantitative indicators relating to the generation of household, industrial, and hazardous waste for the year 2028.

5. CONCLUSIONS

1. Waste prevention and re-use are priority stages of waste management addressed by EU legislation allowing to save natural resources and reduce negative the environmental and health impacts. Regrettably, the economic growth provides for the waste generation growth. In addition, there is no measures to quantify waste prevention and this is linked to the counteracts with economic interests of producers and retailers seeking to rise consumption and sales of their products and this is the main reason of increase in waste generation. In addition, waste management sector which very profitable will suffer if waste generation will decrease, and waste collectors, landfill operators, incinerators and recyclers, will have less revenue and turnovers.
2. The main policies to ensure waste prevention should be linked to promotion of sustainable production and consumption. Sustainable consumption plays the key role and such concepts like sufficiency are gaining more and more interests among scholars and decision makers. It aims to progress towards deliberate and structured reduction of consumption. In addition to a decrease, it influences uses and pushes for a change in behaviour, both on an individual and collective level.
3. In European Union the waste recycling rate was increasing during the recent years significantly, nevertheless, it is clear that there are definite limits for waste recycling, first of all linked to costs. 'For many types of wastes recycling can't compete with recovery, disposal or incineration. The limits of recycling are also imposed by the laws of thermodynamics. Though increased rates of waste recycling in EU Member States demonstrate environmental benefits, it also requires a lot of energy consumption and money and does solve the problem of growing waste generation itself.
4. Though EU member states were obliged to implement ambitious waste management policies and to develop and implement their National Waste Management Plans, the countries so far achieved different progress in waste management. The main indicators of waste management showing the rates of waste generation and recycling were selected from Eurostat database for comparative assessment of Baltic States achievements in waste management policies. Two different MCDM tools (SAW and EDAS) were applied to compare and rank Baltic States based on recent available statistical data (2020).
5. Empirical case study showed that Lithuania was the overall best performing country in waste management among Baltic States in 2020 based on both MCDM methods. These results were achieved due to the fact that country had the lowest waste intensity by GDP, lowest packaging waste generation per capita, the highest recycling rate of municipal waste, and the highest rate of plastic waste recycling though according to other waste management indicators like total waste per capita, plastic waste per capita, Lithuania was in the middle position between Baltic States.
6. Estonia was ranked as the worst performing in country in waste management among Baltic States and this is due the fact that Estonian waste generation per capita, in 2020 exceeded this indicator for Latvia almost 10 times and almost 6 times for Lithuania. Estonia is leader according to this indicator in EU because of its energy production based on oil shale. Estonia also showed the worst results in plastic waste generation per capita, the waste intensity of GDP, and the recycling rate of packaging waste in 2020. Such differences in waste management among the Baltic States show that countries have achieved very different results, though all of them have prepared and implemented national waste management plans having very similar policies and measures.
7. The study has limits as more in-depth waste management policy analysis is necessary to understand the differences in waste management achievements among Baltic States. Future research is necessary for linking waste management policies with waste management indicators and providing new targeted policies and measures for lagging waste management indicators.

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