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Communes' Expenditure on Municipal Waste Management in Terms of Sustainable Development

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Abstract

Theoretical background: As we work towards achieving sustainable development under Goal 12, which entails promoting sustainable consumption and production patterns, one of our key tasks is to minimize waste generation through prevention, reduction, recycling, and reusing. Local government units (LGUs) have a significant role to play in implementing this task. By investing in municipal waste management, LGUs can influence the behavior of residents toward responsible waste collection and management, including hazardous waste.

Purpose of the article: This article aims to evaluate how local government spending affects municipal waste management in different voivodeships. The hypothesis of this paper is that local government expenditure improve waste management effects. To achieve effective spending that supports sustainable development, public authorities at the regional level must coordinate their activities and adapt to EU standards.

Research methods: This article used literature and statistical analysis to adopt dynamics indicators and correlation coefficients. Data on selected variables for the study came from the Local Data Bank of the Central Statistical Office and Eurostat.

Main findings: According to the analyses conducted, there has been a positive development in municipal waste management in Polish communes. This suggests that the government's policies are contributing

towards achieving the sustainable development goal of responsible and sustainable waste management, especially when it comes to hazardous waste. These findings could be utilized to recommend to public authorities the necessary changes to fiscal instruments that would promote sustainable public finances.

Introduction

Practicing sustainable consumption involves using natural resources, goods, and services in a conscious, responsible, and optimal manner, at various levels ranging from individuals to supranational structures like governments. In particular, sustainable food consumption is crucial, and it is important for market participants, especially consumers, to understand and respect the connections between the natural environment, economy, and society. To achieve this, we need to expand educational systems that promote shared respect for values and raise awareness of the link between human life quality and healthy human-nature relationships (Goryńska-Goldmann & Gazdecki, 2020, p. 3).

In the last five years, the European Commission has issued some essential documents, taking up many commendable policies with the primary aim to prevent the generation of waste while tackling the problem at its root and maximizing the recovery of raw materials and energy from waste. At the same time, these policies pose a daunting challenge for many EU Member States in implementing new environmental protection regulations (Badura, 2021, p. 18).

The task of ensuring sustainable consumption and production patterns, as stated in Goal 12, presents various challenges for sustainable development. One of the objectives is to minimize waste generation through prevention, reduction, recycling, and reuse. Local government units (LGUs) are expected to take a leading role in implementing this objective. In particular, LGUs' spending on municipal waste management can significantly influence residents' behavior toward selective waste collection and management, particularly hazardous waste. There is no sustainable development without sustainable consumption and recycling. Waste management is crucial here to reduce the amounts of toxic materials which are dangerous for natural environment and for future generations so on. Effective waste management is a part of sustainable development conception.

The study aims to evaluate how local government spending affects municipal waste management in different voivodeships. The hypothesis of this paper is that local government spending improve waste management effects. Therefore, it should be outlined that waste management is one of necessary factor in achieving sustainable development. Efficient spending instruments require coordination among public authorities at the regional level and must adhere to EU regulations. This article uses literature and statistical analysis, including dynamic indicators and correlation coefficients. For the first part of research to show the correlation with municipal waste management expenses in different voivodeships in Poland there are chosen the following data: the amount of

collected municipal waste for recycling, selective waste collection (including hazardous waste, batteries, and accumulators), commune revenue from the municipal services management and environmental protection department, and population of municipalities. To examine the effectiveness of local government spending at improving waste management, there were used some indicators of sustainable development. These are indicators of 12th goal of sustainable development related with waste management applied in research: total mass of waste generated in kg per capita, mass of hazardous waste generated in kg per capita and material intensity in circular economy in %.

Literature review

In global terms, environmental initiatives are implemented in the areas of climate change, biodiversity protection, use of resources and waste storage as well as spreading knowledge about the situation of the natural environment. Through environmental initiatives at the micro-level, Wassmer, Cueto, and Switzer understand activities aimed at reducing the negative impact on the natural environment in the areas of energy efficiency, pollution prevention, reduction of waste generated, use of clean energy, use of environmental management systems and offering green products and services (Fura & Bonga, 2020, p. 9).

One of the negative aspects of the economy is waste generation. Not only do consumers contribute to this by disposing of excess packaging or used goods, but it is also produced at every stage of manufacturing, across all industries. In the past, waste was viewed as a danger to public health and removed from urban areas as quickly as possible, with most of it being sent to landfills. However, with growing environmental awareness, there is a greater focus on the sustainable use of our limited natural resources (Jelonek & Walentek, 2022, p. 41).

Waste can be classified according to several criteria by its source (who generated it?), substances (what is its composition?), hazardous properties (is it dangerous or not?), management (who deals with it?), or a combination of these concepts. The most common classification of waste is its impact on the environment, where waste is classified into two main groups hazardous and non-hazardous (Vasiljeviki-Shikaleska et al., 2022, p. 374).

Under the Regulation of the Minister of the Environment of December 11, 2018, on the annual rates of recovery and recycling of packaging waste from households, Poland was obliged to meet the following requirements by 2020 (Zarębska & Lewicka, 2020, p. 50):

- reducing the mass of biodegradable landfilled municipal waste to 35%,
- increasing by at least 50% the recycling level of the paper, metals, plastics, and glass, preparing for reuse and recovery by other methods,
- at least a 70% increase in recycling, preparation for re-use, and recovery of non-hazardous construction and demolition waste.

Waste that poses particular threats to the environment and human health is hazardous waste found in the municipal waste stream. In recent years, an upward trend has been observed in the hazardous waste stream generated by the inhabitants/residents of developed countries, including Poland. This is one of the key challenges for the municipal waste management system (Lorek, 2015, p. 118).

Companies introducing prepackaged products to the Polish market have a legal obligation to ensure that their packaging materials are recycled after use. This responsibility can be fulfilled by the companies themselves or by external organizations dedicated to packaging recovery. The Polish public register, which is a part of the Database on Products and Packaging and Waste Management (known as “BDO”), shows that there are currently 25 recovery organizations in Poland that are obligated to carry out extended liability on behalf of businesses in 2021. However, since only 42% of plastic packaging waste in the EU is recycled, additional measures need to be taken to increase this percentage, such as implementing a collection and recycling deposit system. This is especially important considering that over 6.3 million tons of packaging were used in the Polish market in 2020, which is a significant increase compared to previous years. The growth in packaging use is due to the packaging industry’s continuous development and e-commerce has become very popular (Cholewa-Wójcik et al., 2022, p. 10).

Waste management can be considered in a process and substantive approach. Waste prevention is preferred in waste management processes, and landfill is the least desirable. In the substantive framework, types of waste are distinguished – among them municipal waste generated by households and business entities, mainly service ones, if this waste is similar in terms of composition and nature to that generated by households and does not contain hazardous waste (Pawlik & Dziekański, 2022, p. 119).

The EU plays a significant role in global efforts to protect the environment. The European Green Deal of the European Commission development strategy assumes the main goal of achieving climate neutrality by 2050. It is an ambitious plan to transform Europe into a modern, economic, and sustainable society and move away from a consumer economy based on non-renewable sources. This area assumes the transition to a circular economy, in which the consumption of raw materials and waste and emissions and energy losses are minimized by creating a closed loop of processes. Poland’s membership in the European Union obliges it to implement EU priorities and plans in the field of environmental protection. However, implementing the transition to a circular economy with a minimum amount of waste generated requires both time and significant financial resources (Dziawgo, 2022, p. 42).

Sustainable development is a strategy that defines the orientations and limitations resulting from the exploitative approach to natural resources, including raw materials and ecosystems (Sobczak et al., 2021, p. 8). The European Union reaffirmed its commitment to implementing the 2030 Agenda for Sustainable Development to protect the environment, reduce land degradation and prevent biodiversity loss by reducing

dependence on natural resources. Regarding product durability, the European Commission promotes, among others, the following activities (Rybczewska-Błażejowska & Mena-Nieto, 2020, p. 122):

- increasing the recyclable content in products,
- remanufacturing and high-quality recycling,
- reducing the carbon and environmental footprint.

The idea of sustainable development, even though correct as to its basic tenets, is not a cure-all to the global issues of scarcity of natural resources or degradation of the natural environment. The paradox of sustainable development consists of preserving the linear economic model without enabling reuse of resources characteristic for mass production, consumption or waste generation. The problem is, however, that natural resources have been used up beyond their recovery levels already, meaning that such linear paradigm is destructive and futile, not related to sustainability in the east (Raftowicz-Filipkiewicz, 2016, p. 111).

Waste is defined as any substance or object which the holder discards, intends, or is required to discard (Directive 2008/98/EC, 2008). Directive 2008/98/EC establishes the following waste hierarchy: prevention, preparation for reuse, recycling, another recovery (e.g. energy recovery), and disposal. This hierarchy also applies in Poland, as each EU Member State has to transpose Community law into national law. According to the established hierarchy, the key method of waste management should be the possibility of reducing or completely preventing the generation of waste. It follows from this principle that any organization whose activities generate or may generate waste should plan, design and carry out these activities appropriately. To this end, appropriate forms of handling, production, or use of resources and materials should be considered to prevent or reduce the volume of waste and limit the negative impact on the environment. Unavoidable waste should undergo recovery processes (Nycz-Wróbel, 2022, p. 444).

European Union legislation governs the reverse logistics and waste management guidelines in the following documents:

The waste package consists of four directives: Directive 2018/851 amending Directive 2008/98/EC on waste, Directive 2018/852 amending Directive 94/62/EC on packaging and packaging waste, Directive 2018/850 amending Directive 1999/31/EC on landfilled waste, Directive 2018/849 amending Directives 2000/53/EC on end-of-life vehicles, 2006/66/EC on batteries and accumulators and waste batteries and accumulators, and 2012/19/EU on waste electrical and electronic equipment,

– Directive 2019/904 on the impact of certain plastic products on the environment,

- Communication. A European Strategy for Plastics in a Circular Economy.

Directive 2018/851, amending Directive 2008/98/EC on waste, increased the degree of municipal waste preparation for reuse and recycling (Zielińska, 2020, p. 175):

- by 2025 to a minimum of 55% by weight,
- by 2030 – 60%,

- by 2023 – 65%,
- by 2035, the amount of landfilled municipal waste must be reduced to 10% of the total amount of municipal waste generated.

Under national regulations governing the general principles of municipal waste management, the commune owns the waste. Therefore, it is obliged to develop rules for maintaining cleanliness and order, which is an act of local law, which defines (Łajewski, 2021, p. 139):

- requirements for selective collection of municipal waste,
- operation of the Municipal Waste Selective Collection Points (PSZOK),
- collection frequency of selective and mixed waste from owners of inhabited and uninhabited real estate,
- container and bag capacities used in single and multi-family housing,
- optional requirements for biodegradable waste composting.

The commune may oblige the residents to self-equip with containers and bags or transfer this task to the service contractor (Łajewski, 2021, p. 139).

Local governments generate revenue and incur expenses through municipal waste management. Revenue comes from waste collection fees, while expenditures include the costs of operating the waste management system. The financial flow varies for each local government unit due to factors like the land area and development method used for waste collection, the amount and type of waste collected, and the real estate covered by the waste management system. Some factors are beyond the control of local government authorities, while others are influenced by them, such as the fees charged and system operating costs. The number of entities included in the municipal waste management system affects both revenue and expenditure. According to the Act on maintaining cleanliness and order in communes (Art. 6c sec.), owners of inhabited real estate must be covered by the system, while owners of uninhabited premises may be included at the local government unit's discretion. This decision is made by the unit's decision-making body (Kotlińska, 2021, p. 254).

In the legal aspect, public expenditure constitutes the implementation of public functions, goals and tasks resulting from applicable legal provisions, public sector financial plans and adopted state social and economic policy programs. From a legal point of view, the following problem areas are important: the method of making decisions on the titles and sizes of expenses, legal forms of making expenses, normative division of expenses, legal activities in the implementation of expenses and persons responsible for the condition of public expenses and their implementation (Szołno-Koguc, 2015, p. 194).

Sustainable socio-economic growth is not possible without investments, and well-planned and implemented investments at the level of local government voivodeships will have an impact on poviats and communes. It should also be remembered that investments will favor:

- providing jobs and income that allow for what we feel is necessary
- social standard of living, ensuring conditions of material existence,

- providing conditions for spiritual development,
- providing a sense of security and prospects for the future,
- preserving the natural environment for future generations (Filipiak, 2017, p. 96).

Research methods

The research approach in this work is based first on conducting a literature review, then formulating a hypothesis and then verifying it. In this part of the work, after reviewing the literature, a statistical analysis will be performed to verify the hypothesis formulated at the beginning of the study. To achieve our research goal and verify the hypothesis, we conducted a statistical analysis that involved calculating dynamics indicators and correlation coefficients for specific variables. We looked at data from the Local Data Bank of the Central Statistical Office, which included information on municipal waste management expenses in different voivodeships in Poland, the amount of collected municipal waste for recycling, selective waste collection (including hazardous waste, batteries, and accumulators), commune revenue from the municipal services management and environmental protection department, and population of municipalities. Sustainable development indicators for waste management were obtained from the Eurostat international database. First, we calculated dynamics indicators for each variable. Our research method allowed us to test the hypothesis that active state policy on public expenditure is key to effective waste management and that effective expenditure support for sustainable development requires coordination of public authority activities at the regional level while adhering to EU requirements. In the second stage the coefficient indicator was used as in followed formula. This coefficient was used to examine the correlations between chosen variables. It helps to check the link between financial and nonfinancial data in research period.

$$r_{xy} = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^n (x_i - \bar{x})^2} \sqrt{\sum_{i=1}^n (y_i - \bar{y})^2}},$$

Figure 1. Formula for Pearson's correlation coefficient

Source: (Ostasiewicz et al., 2003, p. 310).

Results

Between 2017 and 2021, Podlaskie, Lubelskie, and Warmińsko-Mazurskie voivodeships experienced the greatest surge in recyclable municipal waste mass at 78%, 73%, and 72%, respectively. The Łódzkie Voivodeship saw the highest

year-on-year increase at 66% in 2020 but experienced a significant reduction on the previous year at -28% in 2019.

Table 1. Mass dynamics of recyclable municipal waste in 2017–2021

| | on the previous year | | | | on the base year | | | |
|-----------|----------------------|-------------|------------|------|------------------|------|------|------------|
| | 2018 | 2019 | 2020 | 2021 | 2018 | 2019 | 2020 | 2021 |
| Poland | 2% | -2% | 10% | 5% | 2% | 0% | 9% | 15% |
| Dol. Śl. | 8% | -6% | 8% | 12% | 8% | 1% | 9% | 22% |
| Kuj.-Pom. | 16% | -15% | 12% | -1% | 16% | -1% | 11% | 9% |
| Lubel. | 21% | 18% | 20% | 2% | 21% | 42% | 71% | 73% |
| Lubus. | -8% | 2% | 36% | 3% | -8% | -7% | 27% | 31% |
| Łódz. | -9% | -28% | 66% | -2% | -9% | -34% | 9% | 7% |
| Małop. | 1% | -7% | 31% | -2% | 1% | -6% | 23% | 21% |
| Mazow. | -7% | 15% | 20% | -7% | -7% | 7% | 28% | 19% |
| Opol. | -3% | 19% | -23% | 21% | -3% | 15% | -12% | 7% |
| Podkar. | -1% | 7% | 21% | 9% | -1% | 6% | 28% | 39% |
| Podlas. | 20% | 14% | 26% | 3% | 20% | 36% | 72% | 78% |
| Pomor. | -3% | 8% | 11% | 21% | -3% | 5% | 17% | 41% |
| Śląs. | 2% | -5% | -18% | 7% | 2% | -3% | -21% | -15% |
| Święt. | 11% | 10% | -3% | 18% | 11% | 22% | 19% | 40% |
| War.-Maz. | 2% | 4% | 51% | 7% | 2% | 6% | 60% | 72% |
| Wielk. | 17% | -16% | 11% | 11% | 17% | -2% | 8% | 20% |
| Zach. | -9% | 1% | -14% | 12% | -9% | -9% | -22% | -12% |

Source: Author's own study based on: (www1).

Between 2016 and 2021, the Mazowieckie Voivodship saw the greatest growth in local government spending under Chapter 90002, with a 221% increase in 2020 and a 189% increase in 2021. Notably, no voivodship has experienced a decrease in spending under this chapter in recent years. In terms of year-on-year growth, Łódzkie and Mazowieckie voivodships reported the largest increases at 53% and 52%, respectively, in 2020.

Table 2. Expenditure dynamics under Chapter 90002 on municipal waste management in 2016–2021

| | on the previous year | | | | | on the base year | | | | |
|-----------|----------------------|------|------|------------|------|------------------|------|------|-------------|-------------|
| | 2017 | 2018 | 2019 | 2020 | 2021 | 2017 | 2018 | 2019 | 2020 | 2021 |
| Poland | 5% | 10% | 26% | 37% | 10% | 5% | 16% | 46% | 99% | 120% |
| Dol. Śl. | 3% | 6% | 8% | 20% | 13% | 3% | 9% | 18% | 41% | 60% |
| Kuj.-Pom. | 3% | 14% | 6% | 23% | 26% | 3% | 18% | 24% | 53% | 92% |
| Lubel. | 5% | 6% | 18% | 29% | 18% | 5% | 12% | 32% | 70% | 102% |
| Lubus. | 6% | 9% | 21% | 26% | 19% | 6% | 15% | 40% | 77% | 111% |
| Łódz. | 0% | 7% | 35% | 53% | 21% | 0% | 7% | 44% | 120% | 166% |
| Małop. | 6% | 8% | 26% | 34% | 15% | 6% | 15% | 45% | 94% | 124% |
| Mazow. | 3% | 13% | 80% | 52% | -10% | 3% | 17% | 111% | 221% | 189% |
| Opol. | 6% | 12% | 19% | 27% | 13% | 6% | 19% | 41% | 78% | 101% |
| Podkar. | 2% | 24% | 19% | 42% | 8% | 2% | 27% | 51% | 115% | 132% |
| Podlas. | 2% | 19% | 10% | 27% | 30% | 2% | 22% | 35% | 70% | 121% |

| | on the previous year | | | | | on the base year | | | | |
|-----------|----------------------|------|------|------|------|------------------|------|------|------|------|
| | 2017 | 2018 | 2019 | 2020 | 2021 | 2017 | 2018 | 2019 | 2020 | 2021 |
| Pomor. | 11% | 15% | 5% | 40% | 9% | 11% | 28% | 34% | 88% | 105% |
| Śląs. | 5% | 10% | 18% | 37% | 16% | 5% | 16% | 36% | 86% | 115% |
| Święt. | -3% | 11% | 17% | 40% | 27% | -3% | 8% | 26% | 76% | 124% |
| War.-Maz. | 3% | 10% | 22% | 18% | 16% | 3% | 13% | 37% | 62% | 87% |
| Wielk. | 18% | 0% | 12% | 34% | 15% | 18% | 19% | 33% | 78% | 106% |
| Zach. | 4% | 9% | 16% | 20% | 25% | 4% | 14% | 32% | 59% | 99% |

Source: Author's own study based on: (www1).

The most significant increase in the mass of selective waste collections in comparison to 2017 was recorded in Lubelskie (116%) and Warmińsko-Mazurskie (118%) voivodships. All voivodships reported a rise in the variable on a year-by-year basis. The most significant increases were recorded in Mazowieckie (41%) and Warmińsko-Mazurskie (37%) voivodships in 2020.

Table 3. Mass dynamics of selected waste collected in a year in 2017–2021

| | on the previous year | | | | on the base year | | | |
|-----------|----------------------|------|------------|------|------------------|------|------|-------------|
| | 2018 | 2019 | 2020 | 2021 | 2018 | 2019 | 2020 | 2021 |
| Poland | 11% | 10% | 25% | 9% | 11% | 23% | 54% | 68% |
| Dol. Śl. | 14% | 16% | 22% | 15% | 14% | 32% | 61% | 86% |
| Kuj.-Pom. | 16% | 9% | 23% | 7% | 16% | 27% | 56% | 66% |
| Lubel. | 22% | 26% | 29% | 8% | 22% | 54% | 99% | 116% |
| Lubus. | 4% | 18% | 25% | 16% | 4% | 23% | 54% | 78% |
| Łódz. | 24% | 10% | 23% | 5% | 24% | 37% | 69% | 77% |
| Małop. | 15% | 3% | 26% | 8% | 15% | 18% | 48% | 59% |
| Mazow. | 2% | 2% | 41% | 8% | 2% | 3% | 46% | 57% |
| Opol. | 7% | 11% | 25% | 7% | 7% | 18% | 48% | 58% |
| Podkar. | 20% | 11% | 23% | 11% | 20% | 34% | 65% | 83% |
| Podlas. | 14% | 31% | 21% | 7% | 14% | 49% | 80% | 92% |
| Pomor. | 9% | 18% | 28% | 11% | 9% | 28% | 65% | 83% |
| Śląs. | 13% | 3% | 18% | 3% | 13% | 16% | 37% | 42% |
| Święt. | 6% | 21% | 16% | 8% | 6% | 29% | 49% | 61% |
| War.-Maz. | 13% | 12% | 37% | 26% | 13% | 26% | 73% | 118% |
| Wielk. | 9% | 14% | 22% | 15% | 9% | 24% | 51% | 74% |
| Zach. | 2% | 18% | 18% | 15% | 2% | 21% | 43% | 64% |

Source: Author's own study based on: (www1).

The most spectacular increases in selectively collected hazardous waste tonnage were recorded in the Mazowieckie (304%) and Warmińsko-Mazurskie (426%) voivodships in 2018. The Warmińsko-Mazurskie Voivodship reported the collection volume decreased by 48% in 2020 compared to 2019.

Table 4. Mass dynamics of hazardous waste selective collection in a year in 2017–2021

| | on the previous year | | | | on the base year | | | |
|-----------|----------------------|------|-------------|------|------------------|------|------|------|
| | 2018 | 2019 | 2020 | 2021 | 2018 | 2019 | 2020 | 2021 |
| Poland | 68% | -11% | 9% | 33% | 68% | 50% | 63% | 116% |
| Dol. Śl. | 145% | -16% | 7% | 56% | 145% | 105% | 120% | 242% |
| Kuj.-Pom. | 47% | 12% | -16% | 12% | 47% | 64% | 38% | 54% |
| Lubel. | 28% | 60% | -9% | 70% | 28% | 104% | 86% | 217% |
| Lubus. | 6% | 18% | 5% | 68% | 6% | 24% | 31% | 120% |
| Łódz. | -7% | 51% | -27% | 83% | -7% | 40% | 2% | 88% |
| Małop. | 13% | 7% | 26% | 18% | 13% | 21% | 51% | 78% |
| Mazow. | 304% | -48% | 0% | 2% | 304% | 111% | 111% | 114% |
| Opol. | -24% | 17% | -12% | 66% | -24% | -11% | -21% | 31% |
| Podkar. | 18% | 11% | 24% | -11% | 18% | 31% | 62% | 44% |
| Podlas. | -10% | 17% | -5% | -70% | -10% | 6% | 1% | -70% |
| Pomor. | 150% | 7% | -5% | 24% | 150% | 167% | 154% | 216% |
| Śląs. | 17% | -12% | 20% | 62% | 17% | 3% | 24% | 101% |
| Święt. | -32% | 35% | -14% | 25% | -32% | -9% | -21% | -1% |
| War.-Maz. | 426% | -36% | -48% | 0% | 426% | 234% | 75% | 75% |
| Wielk. | 7% | 41% | 40% | 70% | 7% | 50% | 109% | 255% |
| Zach. | 176% | 1% | 3% | 9% | 176% | 180% | 189% | 215% |

Source: Author's own study based on: (www1).

According to the data, the category of hazardous waste, specifically batteries, and accumulators, saw a significant increase in the Świętokrzyskie Voivodeship by 955% compared to 2017. The largest jump was reported between 2019 and 2020 at 827%. However, other voivodeships, such as Małopolskie and Mazowieckie, noted a decrease in this variable. The Małopolskie Voivodeship saw the most significant decline at -77% compared to 2020, and the Mazowieckie Voivodeship saw a decrease of 82% compared to 2019.

Table 5. Mass dynamics of accumulators and batteries collected in 2017–2021

| | on the previous year | | | | on the base year | | | |
|-----------|----------------------|------|------|------|------------------|------|-------------|------|
| | 2018 | 2019 | 2020 | 2021 | 2018 | 2019 | 2020 | 2021 |
| Poland | -46% | 22% | -18% | -8% | -46% | -34% | -46% | -50% |
| Dol. Śl. | 12% | 3% | -38% | 19% | 12% | 15% | -29% | -15% |
| Kuj.-Pom. | -1% | -33% | -37% | 40% | -1% | -34% | -58% | -42% |
| Lubel. | -3% | 2% | -36% | -10% | -3% | -2% | -37% | -44% |
| Lubus. | -74% | 22% | -18% | 1% | -74% | -68% | -74% | -73% |
| Łódz. | 260% | 32% | -78% | 8% | 260% | 376% | 5% | 14% |
| Małop. | -43% | 9% | -24% | -52% | -43% | -38% | -52% | -77% |
| Mazow. | -81% | -3% | 0% | 62% | -81% | -82% | -82% | -70% |
| Opol. | 11% | 120% | -40% | 12% | 11% | 145% | 47% | 64% |
| Podkar. | -10% | 34% | -51% | 7% | -10% | 22% | -40% | -36% |
| Podlas. | -11% | 34% | -47% | 15% | -11% | 19% | -36% | -27% |
| Pomor. | -23% | 27% | -31% | -18% | -23% | -2% | -32% | -45% |
| Śląs. | -31% | 24% | 4% | -25% | -31% | -15% | -11% | -33% |

| | on the previous year | | | | on the base year | | | |
|-----------|----------------------|------|-------------|------|------------------|------|-------------|------|
| | 2018 | 2019 | 2020 | 2021 | 2018 | 2019 | 2020 | 2021 |
| Święt. | 25% | -9% | 827% | -61% | 25% | 14% | 955% | 310% |
| War.-Maz. | -6% | 105% | -61% | 4% | -6% | 94% | -24% | -21% |
| Wielk. | 28% | 35% | -38% | 18% | 28% | 72% | 6% | 26% |
| Zach. | -17% | 185% | -62% | -21% | -17% | 136% | -11% | -29% |

Source: Author's own study based on: (www1).

In Section 900, communes in Podkarpackie (144%), Mazowieckie (141%), and Łódzkie (140%) reported the highest revenue increases compared to 2017. However, the Opolskie Voivodeship witnessed a significant decline in revenue for the municipal services management and environmental protection department in 2021, recording a decrease of -20% compared to 2020.

Table 6. Revenue dynamics of communes in Section 900 on the municipal services management and environmental protection in 2017–2021

| | on the previous year | | | | on the base year | | | |
|-----------|----------------------|------|------|-------------|------------------|------|-------------|-------------|
| | 2018 | 2019 | 2020 | 2021 | 2018 | 2019 | 2020 | 2021 |
| Polska | 31% | 16% | 21% | 12% | 31% | 52% | 85% | 108% |
| Doł. Śl. | 24% | 3% | 10% | 15% | 24% | 27% | 40% | 62% |
| Kuj.-Pom. | 26% | 4% | 17% | 17% | 26% | 31% | 54% | 80% |
| Lubel. | 96% | 5% | -1% | 4% | 96% | 105% | 103% | 111% |
| Lubus. | 57% | 16% | 20% | -5% | 57% | 83% | 120% | 109% |
| Łódz. | 23% | 35% | 22% | 18% | 23% | 67% | 103% | 140% |
| Małop. | 23% | 22% | 33% | 12% | 23% | 49% | 99% | 122% |
| Mazow. | 19% | 19% | 45% | 18% | 19% | 41% | 104% | 141% |
| Opol. | 31% | 18% | 53% | -20% | 31% | 54% | 136% | 90% |
| Podkar. | 76% | 47% | -6% | -8% | 76% | 159% | 144% | 125% |
| Podlas. | 32% | 8% | 11% | 28% | 32% | 43% | 59% | 103% |
| Pomor. | 37% | 4% | 30% | 6% | 37% | 42% | 84% | 95% |
| Śląs. | 25% | 10% | 23% | 31% | 25% | 38% | 70% | 122% |
| Święt. | 39% | 53% | -12% | 9% | 39% | 112% | 87% | 104% |
| War.-Maz. | 32% | 15% | 17% | 5% | 32% | 51% | 77% | 86% |
| Wielk. | 17% | 18% | 24% | 7% | 17% | 38% | 71% | 82% |
| Zach. | 16% | 11% | 32% | 5% | 16% | 29% | 69% | 78% |

Source: Author's own study based on: (www1).

In terms of population growth, the Mazowieckie Voivodeship had the highest increase, with 2.8% based on the base year and 1.7% on the previous year. Conversely, the Świętokrzyskie Voivodeship saw a significant population decline. Between the start of the analyzed period and 2021, the population decreased by 5.2% compared to 2020 and 2.8% compared to 2019.

Table 7. Population dynamics in Poland in 2016–2021

| | on the previous year | | | | | on the base year | | | | |
|-----------|----------------------|-------|-------|--------------|-------|------------------|-------|-------|-------------|--------------|
| | 2017 | 2018 | 2019 | 2020 | 2021 | 2017 | 2018 | 2019 | 2020 | 2021 |
| Poland | 0.0% | -0.1% | -0.1% | -0.8% | -0.5% | 0.0% | -0.1% | -0.1% | -0.9% | -1.4% |
| Dol. Śl. | 0.0% | 0.0% | 0.0% | 0.3% | -0.4% | 0.0% | -0.1% | -0.1% | 0.2% | -0.2% |
| Kuj.-Pom. | 0.0% | -0.2% | -0.3% | -2.0% | -0.7% | 0.0% | -0.3% | -0.6% | -2.5% | -3.2% |
| Lubel. | -0.3% | -0.4% | -0.4% | -2.4% | -0.9% | -0.3% | -0.7% | -1.2% | -3.6% | -4.5% |
| Lubus. | -0.1% | -0.2% | -0.3% | -1.8% | -0.8% | -0.1% | -0.3% | -0.6% | -2.4% | -3.1% |
| Łódz. | -0.4% | -0.4% | -0.5% | -1.6% | -0.9% | -0.4% | -0.8% | -1.2% | -2.8% | -3.6% |
| Małop. | 0.3% | 0.3% | 0.3% | 0.6% | -0.1% | 0.3% | 0.5% | 0.8% | 1.5% | 1.4% |
| Mazow. | 0.3% | 0.3% | 0.4% | 1.7% | -0.1% | 0.3% | 0.7% | 1.1% | 2.8% | 2.7% |
| Opol. | -0.3% | -0.4% | -0.4% | -2.7% | -0.8% | -0.3% | -0.7% | -1.0% | -3.7% | -4.5% |
| Podkar. | 0.1% | 0.0% | -0.1% | -1.5% | -0.5% | 0.1% | 0.1% | 0.0% | -1.5% | -2.0% |
| Podlas. | -0.2% | -0.3% | -0.3% | -1.8% | -0.7% | -0.2% | -0.4% | -0.7% | -2.5% | -3.2% |
| Pomor. | 0.4% | 0.4% | 0.4% | 0.6% | 0.0% | 0.4% | 0.8% | 1.2% | 1.8% | 1.9% |
| Śląs. | -0.2% | -0.3% | -0.4% | -2.3% | -0.8% | -0.2% | -0.6% | -0.9% | -3.2% | -4.0% |
| Święt. | -0.4% | -0.5% | -0.6% | -2.8% | -1.0% | -0.4% | -0.9% | -1.5% | -4.3% | -5.2% |
| War.-Maz. | -0.2% | -0.3% | -0.4% | -2.6% | -0.8% | -0.2% | -0.5% | -0.9% | -3.5% | -4.3% |
| Wielk. | 0.2% | 0.1% | 0.1% | 0.2% | -0.2% | 0.2% | 0.4% | 0.5% | 0.7% | 0.5% |
| Zach. | -0.2% | -0.3% | -0.3% | -2.1% | -0.7% | -0.2% | -0.4% | -0.7% | -2.8% | -3.4% |

Source: Author's own study based on: (www1).

Discussion

In the following analysis stage, we proceeded to calculate correlation coefficients between different variable combinations. Initially, we examined the correlation between the expenditure and revenue of communes in municipal services management. The results showed a very strong positive relationship in eleven voivodeships, with three voivodeships having a relatively strong correlation as well. This indicates that an increase in revenue leads to a corresponding increase in expenditure on municipal services management. All the relevant indicators have been summarized in Table 8.

Table 8. Correlation coefficients for selected variables

| Region | Communes' expenditure and revenue in municipal services management | Collected selective waste mass and communes' expenditure on municipal services management | Hazardous waste mass from selective collections and communes' expenditure on municipal services management | Population and communes' expenditure on municipal services management |
|-----------|--|---|--|---|
| Dol. Śl. | 0.949997914 | 0.993610048 | 0.799615508 | -0.96488995 |
| Kuj.-Pom. | 0.979229225 | 0.957618836 | 0.480659391 | -0.160045747 |
| Lubel. | 0.614787272 | 0.976016464 | 0.910996275 | -0.970189363 |
| Lubus. | 0.849044396 | 0.99917284 | 0.907971695 | -0.991369297 |
| Łódz. | 0.977514544 | 0.959268662 | 0.713566823 | -0.983621252 |
| Małop. | 0.994111592 | 0.982109768 | 0.987905315 | -0.990245944 |
| Mazow. | 0.920731175 | 0.8892262 | -0.132223893 | 0.95349312 |
| Opol. | 0.864913849 | 0.995752011 | 0.510068512 | 0.970621098 |

| Region | Communes' expenditure and revenue in municipal services management | Collected selective waste mass and communes' expenditure on municipal services management | Hazardous waste mass from selective collections and communes' expenditure on municipal services management | Population and communes' expenditure on municipal services management |
|-----------|--|---|--|---|
| Podkar. | 0.709433643 | 0.994288933 | 0.912638323 | -0.983215604 |
| Podlas. | 0.979992624 | 0.933706782 | -0.809082533 | -0.947993495 |
| Pomor. | 0.972970542 | 0.989896311 | 0.72056649 | -0.973422105 |
| Śląs. | 0.975519918 | 0.973126096 | 0.839267626 | 0.955093697 |
| Święt. | 0.682830478 | 0.965171268 | 0.233709571 | -0.994325423 |
| War.-Maz. | 0.958345464 | 0.980235046 | -0.310252139 | -0.983041344 |
| Wielk. | 0.957865909 | 0.98784358 | 0.964298456 | -0.970799093 |
| Zach. | 0.956563209 | 0.991536351 | 0.68004748 | 0.795146201 |

Source: Author's own study based on: (www1).

During the analysis of dependencies, the mass of selectively collected waste and the expenditure of communes in the field of municipal waste management were examined. Results showed a strong correlation in fifteen voivodships, suggesting that an increase in commune expenditure on municipal waste management corresponds with an increase in the amount of waste collected through selective collections. This means that more waste is collected selectively and recycled, which undoubtedly helps to confirm the hypothesis put forward at the beginning. The lack of correlation between these variables or its opposite direction could indicate that some of the waste not collected will not be recycled and will harm the environment. therefore, this relationship should be assessed positively.

Another investigation analyzed the expenditure of communes for waste management, as well as the quantity of hazardous waste that was collected. The majority of voivodships displayed a positive correlation, with only five of them exhibiting a very strong or fairly strong correlation. This implies an increase in hazardous waste gathered through selective collections as municipal expenditure rises. Only the Podlaskie Voivodeship showed a reverse trend, with a significant correlation coefficient. This also proves that public expenditure contributes to effective waste management and positively verifies the hypothesis about the impact of public expenditure on municipal waste management.

In the analyzed scope, the population and expenditure of communes were examined. The data revealed a strong negative correlation (of 11) in most voivodships, indicating that local government expenditure is increasing while the population is decreasing. However, three voivodships displayed a positive correlation between the variables. This relationship can already be observed from the basic data used for the analysis.

To properly analyze Poland's adherence to the 12th sustainable development goal regarding waste management, it is crucial to evaluate the allocation of public funds. The analysis focused on three key indicators linked to waste generation: the total mass of waste generated in kilograms per capita, the mass of hazardous waste generated in

kilograms per capita, and the percentage of material intensity in a circular economy. Since most of the indicators are listed in the bi-annual Eurostat database, the data were examined in this timeframe. All indicators are conveniently presented in Table 9.

Table 9. Sustainable development indicators for Poland in waste management

| Sustainable development indicators in waste management | 2014 | 2016 | 2018 | 2020 | 2021 |
|--|-------|-------|-------|-------|---------|
| total mass of waste generated in kg per capita | 1,979 | 2,090 | 2,120 | 1,940 | no data |
| mass of hazardous waste generated in kg per capita | 32 | 27 | 79 | 46 | no data |
| material intensity in circular economy in % | 12.6 | 10.2 | 9.8 | 7.5 | 9.1 |

Source: Author's own study based on: (www2).

The data showed that the mass of waste generated per person had been steadily increasing until 2018, but in 2020, it decreased significantly by 180 kg, which is a positive development. The level of hazardous waste varied over time, but the most important finding is that it decreased by 33 kg in the last year compared to the previous year. To provide a complete picture, data for 2021 are included for the third indicator, which is calculated annually. This indicator measures material intensity in a circular economy, and a high value indicates good recycling management. In Poland, this indicator had been decreasing until 2020, but in 2021, it increased by 1.6 pp, which is somewhat puzzling given the previous trend. Taking into account the increasing tendency of public expenditure in the field of municipal waste management and the improvement in most indicators of the implementation of objective no. 12, it can be concluded that the hypothesis has been verified.

Conclusions

This work can contribute to the field of sustainable development, in particular municipal waste management in the context of its financing at the local level. There are few studies in Poland dealing with this topic in detail. However, the literature on sustainable development and indicators of its implementation is very extensive in theoretical terms, but does not include practical financial analyses.

Across most surveyed voivodeships, the mass of municipal waste being recycled has been on the rise since 2017. This is a positive development in terms of achieving sustainable development goals. Local government spending on municipal waste management in communes under Chapter 90002 has also increased from 2016 to 2021, with Mazowieckie and Łódzkie voivodeships leading the way in funding. The only exception was the Świętokrzyskie Voivodeship, which saw a slight one-time decrease (-3%) in municipal waste financing during the second year of analysis. On the other hand, there were also increases in municipalities' revenue in Łódzkie and Mazowieckie voivodeships. The mass of selectively collected waste also increased

between 2017 and 2021, with the most significant improvements seen in Lubelskie and Warmińsko-Mazurskie voivodeships. In nine voivodeships, hazardous waste was collected selectively, with gains exceeding 100%. Only two voivodships (Podlaskie and Świętokrzyskie) saw decreases in this area. It is concerning to see a decline in the collection of hazardous waste, specifically batteries, and accumulators, in thirteen voivodeships. However, the Świętokrzyskie Voivodeship stands out as an exception, with a significant increase of 310% compared to the first year of observation. A study of various dependencies revealed strong correlations in many cases. Notably, fourteen voivodeships showed a positive correlation between expenditure and revenue in municipal services management, while almost all voivodeships showed a strong correlation between expenditure and the collected mass of selective recyclable waste. This suggests that increasing expenditure on municipal services management leads to an increase in selectively collected waste. However, when comparing the mass of hazardous waste from selective collections with municipal expenditure, results varied. In most voivodeships, the hazardous waste collection increased with higher municipal expenditure, but the Podlaskie Voivodeship showed the opposite trend. Hereby, when assessing the impact of public expenditure on municipal waste management in the light of the implementation of indicators of objective no. 12, it should be concluded that the objective of the work has been achieved.

Based on the analysis results, it appears that the management of municipal waste in Polish voivodeships has improved. Therefore, it can be concluded that the hypothesis has been positively verified however, at the local level, differences were identified in the dynamics of increases in the mass of municipal waste intended for recycling, the mass of selective collections, hazardous waste and municipal expenditure. This suggests that the state policy is aiding in achieving the sustainable development goal of sustainable and responsible waste management, especially for hazardous waste. The downward trend in waste generation indicators supports this conclusion. These findings could be used to suggest changes to fiscal policies that will promote sustainable public finances. Overall, the current policies seem to be working effectively, so there is no need for a change in direction.

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