Vol. 5 No. 3, 2024
DOI: https://doi.org/10.30525/2661-5169/2024-3-4

EVALUATING EFFICIENCY IN ORGANIZATIONAL MODELS INTERACTING POPULATION WITH SMALL AND MEDIUM-SIZED ENTERPRISES IN WASTE PROCESSING*

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Abstract. The *purpose* of the article is to analyze assessing the effectiveness of organizational models of interaction between the population and small and medium-sized enterprises in the field of waste processing. *Methodology.* In the study of the interaction between the population and small and medium-sized enterprises (SMEs) in the field of waste processing, it is necessary to use methods that allow for a deeper understanding of the problem and its aspects. The main methods that were applied are: literature analysis: this method provided for the study and systematization of scientific articles, studies, reports and publications related to the topic of waste processing, interaction between the population and SMEs. Literature analysis helped to identify existing theoretical concepts, approaches and models that can be used to understand the specifics of the problem under study. Content analysis – this method involved the analysis of documents, reports, media materials and other information related to the research topic. Comparative analysis – the use of comparative analysis made it possible to compare different organizational models of interaction in different regions or countries. *Results.* The article examines the international experience of countries such as Germany, Sweden, Japan, South Korea and the Netherlands, which are implementing different models of waste management. Germany demonstrates the effectiveness of separate collection, Sweden – financial incentives for the population, Japan focuses on thermal treatment technologies, South Korea – on educational programs, and the Netherlands is implementing the concept of "circular economy". The article emphasizes that the adaptation of these international practices to Ukrainian realities can significantly improve the efficiency of the waste management system. The introduction of innovative solutions, strengthening legal regulation and active participation of the population can ensure sustainable development and reduce negative impact on the environment. The highlighted recommendations provide a basis for further research and development of strategies aimed at improving the interaction between the population and enterprises in the context of waste processing in Ukraine. The main elements of assessing the effectiveness of organizational models of interaction between the population and small and medium-sized enterprises (SMEs) in the field of waste processing are considered, and international experience in this area is also analyzed. It is determined that public awareness, community involvement, social responsibility of SMEs, economic efficiency, technological innovation, feedback, legal regulation, information support and infrastructure development are key elements that contribute to successful waste management. Each of these aspects contributes to the formation of active public participation in the processes of waste collection and recycling, which is the basis for sustainable development. *Practical implications.* An approach to assessing the effectiveness of organizational models of interaction between the population and small and medium-sized enterprises in the field of waste recycling is presented. The use of an integral index, multi-criteria analysis

[1] The research is supported by the budget of the Ministry of Education and Science of Ukraine (research topic 0123U100112 "Post-war recovery of the energy industry of Ukraine: Optimization of waste management taking into account the health of the population, environmental, investment, tax determinants"; and the Executive Agency for Education and Culture of the European Union (Jean Monet module, project No. 101047530 "Healthy economy and policy: European values for Ukraine")

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(AHP method) and statistical methods (correlation and regression analysis) is proposed to identify key factors of influence and compare models.

Keywords: evaluation of the effectiveness of organizational models, interaction of the population with SMEs, small and medium-sized enterprises in waste processing, the field of waste processing, principles of effective interaction.

JEL Classification: A10, J23, M21

1. Introduction

In the modern world, the issue of the effectiveness of organizational models of interaction between the population and small and medium-sized enterprises (SMEs) in the field of waste processing is gaining particular importance. With the growth of the volume of waste generated as a result of consumer activity, there is a need to optimize the processes of their treatment and disposal. Organizations involved in waste processing are leading elements of the economy, as they not only contribute to reducing the negative impact of waste on the environment, but also stimulate the development of the local economy by creating jobs and introducing innovative technologies.

Assessing the effectiveness of organizational models of interaction is a complex task that requires a systematic approach that includes the analysis of both economic and social aspects.

Proper organization of cooperation between the population and enterprises can provide more effective communication, which will help to raise public awareness of the importance of waste recycling. In turn, small and medium-sized businesses, being flexible and adaptable, can respond more quickly to changes in market requirements and public needs.

Assessment of the effectiveness of organizational models of interaction between the population and SMEs in the field of waste recycling is a relevant area of research that can offer new solutions for improving management processes, increasing the social responsibility of business and ensuring sustainable development of regions.

2. Highlighting Previously Unresolved Parts of the Overall Problem

In the field of interaction between the population and small and medium-sized enterprises (SMEs) in the context of waste recycling, there are several aspects that remain insufficiently researched and require attention. The first issue concerns the lack of awareness among the population about the need for waste recycling and mechanisms for its utilization. Many citizens are not aware of how their actions affect the environmental situation and, accordingly, may not provide adequate support for initiatives aimed at improving recycling processes. This creates a gap between the consumer habits of the population and the entrepreneurial strategies of SMEs.

The second unresolved part is the lack of effective communication mechanisms between enterprises and the community. Enterprises often do not have the opportunity to receive feedback from the population about their services, which limits the possibilities of adapting business models to the real needs of consumers. This, in turn, leads to under-equipped or inefficient use of resources, as well as low involvement of the population in recycling processes.

The third aspect is related to regional specificity: the lack of unified standards and methodologies for assessing the effectiveness of interaction models in different regions makes it difficult to compare and adapt them. This leads to the fact that some regions may suffer from insufficient attention to specific problems that require an individual approach. For example, in urban areas there may be one challenge associated with large volumes of waste, while in rural areas there may be another problem associated with the lack of infrastructure for its collection and processing. Insufficient funding for programs and projects that stimulate cooperation between the population and SMEs is also an obstacle to effective interaction. Without adequate investment in technology and infrastructure, enterprises cannot develop innovative solutions necessary to improve recycling processes.

3. International Experience

In the context of modern challenges associated with the growth of waste volumes, the topic of the effectiveness of organizational models of interaction between the population and small and medium-sized enterprises (SMEs) in the field of waste processing is becoming increasingly

relevant. The real need to optimize waste processing processes requires a new approach to understanding the role of both the population and enterprises in this system. SMEs play a key role in ensuring sustainable development of regions, because it is these organizations that are able to implement innovative solutions and effectively use local resources for waste processing, but their success largely depends on the active participation and support of local residents. The effectiveness of interaction between the population and SMEs in this area can be assessed according to various criteria that take into account both economic and social aspects.

International experience in the field of waste processing demonstrates a variety of approaches and models that can be useful for improving waste management systems in Ukraine. Countries with developed economies are actively implementing innovative strategies that not only contribute to reducing waste, but also ensure efficient use of resources. Studying international experience allows us to identify best practices, adapt them to local conditions and increase the level of recycling of secondary raw materials.

This experience includes the introduction of modern technologies, effective models of partnership between the state, private and public sectors, as well as active participation of the population in the processes of waste collection and recycling. Countries that have successfully implemented these strategies demonstrate a high level of environmental awareness, which in turn has a positive impact on the quality of life of the population and the state of the environment (Table 1).

Germany is one of the leaders in waste management thanks to the implementation of innovative strategies, in particular the separate waste collection system and the concept of the "green point". This system, which involves the segmentation of waste by category, allows for the efficient collection, recycling and disposal of secondary raw materials. In particular, the "green point" system provides all participants in the process – from consumers to businesses – with clear instructions on separate collection, contributing to the reduction of waste going to landfills. Sweden has become a model in the field of waste management thanks to an effective system of stimulating the population through financial benefits for recycling. This system was designed to encourage citizens to actively participate in the recycling processes of secondary raw materials and reduce the amount of waste going to landfills.

Japan is an example of a country that has achieved significant success in the field of waste management through the introduction of modern technologies for thermal waste treatment and the introduction of strict environmental standards. This approach, in particular, involves incinerating waste in specialized facilities, which allows reducing its volume and converting it into energy, while ensuring effective management of hazardous waste.

The introduction of environmental standards in Japan also contributes to the reduction of pollutant emissions. Strict emission control standards and an effective monitoring system ensure a high level of safety for the population and the environment. Japan focuses on innovations and technological solutions that allow not only to reduce the negative impact of waste, but also to improve the quality of life of citizens.

South Korea demonstrates an effective approach to waste management, emphasizing the

Table 1
International experience in waste recycling

Country	Strategy description	Main results
Germany	Implementation of a separate waste collection system and a "green point".	Waste reduction by 40% in 20 years, high recycling rate (about 70%).
Sweden	A system of stimulating the population through financial incentives for recycling.	High level of recycling (more than 50%), reduction of waste in landfills.
Japan	Use of thermal waste treatment technologies and implementation of environmental standards.	High processing efficiency (about 80%), significant reduction in pollutant emissions.
South Korea	Active public participation through educational programs and innovative collection technologies.	Increasing public awareness, reducing waste by 30% in 5 years.
Netherlands	The "circular economy" system and legislative regulation of waste recycling.	Reducing waste volumes by 20%, implementing new business models in the recycling sector.

active participation of the population through educational programs and the introduction of innovative waste collection technologies. The country's government believes that the main factor in achieving success in this area is the awareness of citizens about the importance of recycling and sustainable use of resources.

The Netherlands is actively implementing the concept of a "circular economy", which is aimed at maximizing the use of resources and reducing waste. This system assumes that products, materials and resources should remain in circulation as long as possible, and waste that does arise should be recycled and reused.

International experience in waste management from countries like Germany, Sweden, Japan, South Korea, and the Netherlands offers valuable insights for Ukraine in developing effective strategies. Implementing separate waste collection, financial incentives, modern processing technologies, and environmental standards can reduce waste volumes and boost recycling rates. Emphasizing the "circular economy" concept and engaging the public through educational programs can foster environmental awareness among citizens and enterprises. A comprehensive assessment of interaction models, analyzing environmental, economic, and social aspects, helps identify problems and improve cooperation between communities and SMEs, contributing to sustainable development in waste recycling (Wattanapruttipaisan, 2002).

Public awareness of waste recycling's importance significantly influences the effectiveness of interaction between communities and SMEs. Understanding environmental challenges and the role of enterprises enhances people's willingness to engage in waste collection and recycling (Audretsch et al., 2023).

Community involvement in waste collection, recycling, and disposal processes is a leading indicator of the effectiveness of organizational models of interaction between the population and small and medium-sized enterprises (SMEs).

The activity of the population in these processes is necessary not only to achieve environmental

Table 2
Key elements for assessing the effectiveness of organizational models of interaction between the population and small and medium-sized enterprises in the field of waste processing

Element	Description
1. Public awareness	The level of knowledge and understanding of the population about the importance of recycling, environmental problems and the role of businesses in solving them. This includes awareness of recycling programs and their benefits to the community.
2. Community involvement	Level of population activity in waste collection, recycling, and disposal processes. Includes participation in volunteer programs, participation in seminars, educational campaigns, etc.
3. Social responsibility of SMEs	Business initiatives aimed at having a positive impact on the community and the environment. This may include environmental education projects, collaboration with local organizations, and cleanup campaigns.
4. Economic efficiency	Assessing the financial performance of SMEs in waste recycling processes, including the costs of collecting, processing and selling secondary raw materials. It is also important to consider the economic benefits to the population from reducing waste disposal costs.
5. Technological innovation	Using the latest technologies and methods in waste processing processes. This may include process automation, innovative cleaning and treatment technologies, and the introduction of new waste collection methods.
6. Feedback	Communication mechanisms between the public and businesses that allow for community feedback. This could include surveys, meetings, a platform for sharing ideas and complaints.
7. Legal regulation	The regulatory framework that defines the rules and standards for waste processing. Includes waste management legislation, environmental regulations, and government support programs for SMEs in the environmental sector.
8. Information support	Availability of information to the public about waste recycling programs, as well as the role and opportunities of SMEs in this process. This may include websites, newsletters, social media, etc.
9. Infrastructure	The availability and quality of infrastructure for waste collection, processing and disposal, including containers for collecting secondary raw materials, recycling stations and their accessibility to the population.
10. Partnership	Cooperation between businesses, local governments, and civil society organizations. This may include agreements on joint projects, sharing resources, and experiences to improve recycling processes.

goals, but also to create awareness of a responsible attitude towards the environment. Volunteer programs that involve the active participation of citizens in garbage collection, cleaning up areas, or conducting environmental education activities can significantly increase awareness of environmental problems.

The social responsibility of small and medium-sized enterprises (SMEs) is a factor that determines their impact on the community and the environment. The initiatives that enterprises implement in this context are aimed at creating positive changes in the social environment, improving the quality of life of the population and ensuring environmental sustainability.

Environmental education projects are essential for promoting social responsibility. SMEs can organize workshops and seminars to raise awareness about environmental issues, recycling, and resource efficiency, fostering conscious waste disposal habits and encouraging public participation in environmental programs (Deineha et al., 2021). Economic efficiency in waste processing is vital for SMEs' sustainability. This involves analyzing costs of waste collection, processing, and sales, along with the economic benefits communities gain through reduced waste disposal expenses (Dwyer & Kim, 2003).

Technological innovation drives the efficiency and competitiveness of SMEs in waste processing. Advanced methods improve recycling quality, cut costs, and promote sustainable enterprise development while reducing environmental harm (Lombana, 2006). Feedback mechanisms between SMEs and the population enhance sustainable interaction models. Surveys and other communication tools allow enterprises to adapt strategies based on community needs, increasing trust and cooperation (Skawińska, 2002). Legal regulation plays a key role in defining the framework for SME activities in waste processing. This includes legislative acts that establish rules and standards for effective waste management, environmental compliance, and sustainable development (Spivak et al., 2020). Information support is essential for fostering collaboration between the population and SMEs in waste processing. Providing information about recycling programs and SMEs' roles raises public awareness and promotes active participation (Wattanapruttipaisan, 2002). Infrastructure for waste collection, processing, and disposal is critical to the efficiency of waste management systems at the SME level (Miroshnyk & Prokop'ieva, 2020).

Partnerships between enterprises, local governments and public organizations play a role in the development of effective waste recycling models. The cooperation of these participants provides an integrated approach to solving environmental problems arising from waste management and helps to maximize the results of joint efforts.

4. Stages of Evaluating the Effectiveness of Organizational Models

Based on the analyzed data, a set of indicators reflecting various aspects of efficiency is used to develop an approach to assessing the effectiveness of organizational models of interaction between the population and small and medium-sized enterprises (SMEs) in the field of waste processing. The use of methodology and mathematical apparatus ensures the structure of the evaluation process and the objectivity of the results. The main stages of this approach include the formation of a set of indicators for each element, the development of an integral efficiency index and the application of multi-criteria analysis.

Stages of assessing the effectiveness of organizational models:

1. Formation of a set of indicators for each element – based on the table "Main elements of assessing the effectiveness of organizational models of interaction between the population and small and medium-sized enterprises in the field of waste processing", a set of key indicators for assessing each element was determined (Figure 1).

2. Development of an integral efficiency index – to ensure a comprehensive assessment of all indicators, an integral efficiency index (IE) is used, which combines various indicators. The formula for calculating the index is developed as follows:

$$IE=w1\times A+w2\times B+w3\times C+\ldots+wn\times N$$

where:

A, B, C, …, N – the values of the indicators for each element of the assessment (public awareness, community involvement, economic efficiency),

w1, w2, w3, …, wn – weight coefficients that determine the importance of each indicator in the overall efficiency.

Weight coefficients are determined based on expert assessment or using correlation analysis, which allows you to identify the most significant indicators for assessing efficiency.

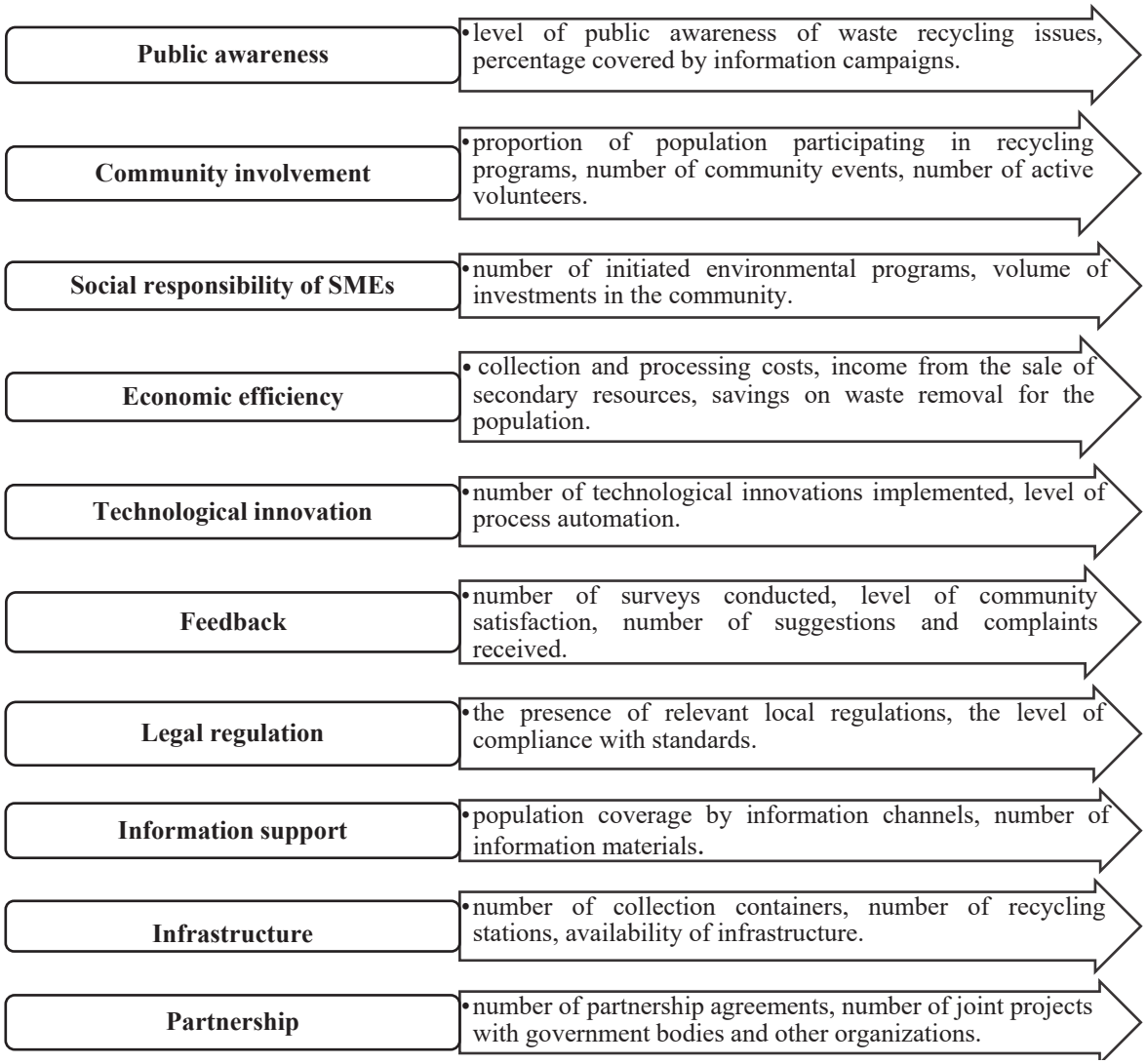

Figure 1. Key indicators of waste management efficiency

3. Correlation and regression analysis – correlation analysis to determine the relationship between various indicators and their impact on the efficiency of the organizational model, which allows you to identify key factors that most affect overall efficiency, for example, the level of public awareness and its impact on economic indicators.

Regression analysis allows you to predict efficiency based on specific indicators, such as the dependence of economic efficiency on the level of community involvement. The resulting model estimates changes in efficiency when a certain indicator changes, using the following dependencies:

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_n X_n + \epsilon$

where:

Y – dependent variable (revenue from processing),

Xn – independent variables (population involvement indicators),

βn – regression coefficients,

ϵ – error.

4. Multi-criteria efficiency analysis (AHP method) – to determine the importance of various criteria (economic, social, environmental efficiency) and make an optimal decision on choosing an organizational model of interaction, the analytical hierarchy process (AHP) method was used;

– formation of a hierarchical structure: the upper level – the general goal (effective interaction), the middle level – criteria (economic, social, environmental effect), the lower level – alternative organizational models;

– determination of weight coefficients for criteria: based on expert assessments, weights are determined for each criterion, which allows objectively comparing organizational models according to a set of criteria.

The AHP method allows calculating the priority index for each model, which contributes to the selection of the most effective interaction model.

5. Integrated Performance Assessment Methodology – to systematize the assessment process, an integrated performance assessment methodology has been proposed, which includes the following stages:

– data collection: covers information on population participation, financial indicators of SMEs, analysis of information and infrastructure elements.;

– indicator normalization: is used to bring indicators to a single scale in order to ensure the correctness of the calculation of the integral index;

– calculation of the integral index: is carried out on the basis of weighted indicators to calculate the overall performance index, which allows comparing different organizational models.

For an applied study, an organizational model can be taken in which the main emphasis is placed on informing and involving the community. To assess the effectiveness of the model, several key indicators can be selected:

1. Population awareness – the level of coverage of the population by information campaigns.

2. Community involvement – the share of active participants in recycling programs.

3. Economic efficiency – reducing the cost of garbage collection.

Using the proposed approach, it is possible to calculate an integral efficiency index and compare it with the indices of other models (for example, models with an emphasis on infrastructure or partnership) to determine the most effective organizational model.

The proposed approach to assessing the effectiveness of organizational models of interaction between the population and SMEs in the field of waste processing provides a comprehensive analysis taking into account various criteria and optimization of the organizational model in accordance with the specific needs of the community and enterprises.

5. Conclusions

International experience presented by different countries demonstrates how effective organizational models can be implemented in practice. For example, Germany shows how separate waste collection can reduce waste and increase recycling rates, while Sweden uses financial incentives to encourage the population. Japan focuses on thermal treatment technologies, South Korea on educational programs, and the Netherlands implements the concept of a "circular economy".

Adapting this international experience to Ukrainian realities can significantly increase the efficiency of waste management in the country. Involving the population in active actions, introducing innovations and strengthening legal regulation will create a favorable environment for the development of sustainable practices in waste recycling, which will ultimately lead to a reduction in the negative impact on the environment and an improvement in the quality of life of citizens.

The main elements of assessing the effectiveness of organizational models of interaction between the population and small and medium-sized enterprises (SMEs) in the field of waste recycling are key components for achieving success in waste management. They include public awareness, community involvement, SME social responsibility, economic efficiency, technological innovation, feedback, legal regulation, information support and infrastructure. Each of these elements plays a role in creating a system that allows for active participation of the population in the processes of waste collection and recycling, as well as improves interaction between the public and enterprises.

The evaluation process includes several stages: defining a set of indicators, developing an integral index, conducting correlation and regression analysis to identify key factors of influence, as well as applying multi-criteria analysis (AHP method) to assess efficiency according to a set of economic, social and environmental criteria. To ensure the correctness of the calculations, data normalization and an integrated evaluation methodology are used, which involves systematization of data, calculation of the index and analysis of the results.

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Received on: 09th of October, 2024
Accepted on: 23th of November, 2024
Published on: 27th of December, 2024