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SELECTS LOCATIONS FOR COLLECTION CENTER

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Abstract: With the rapid growth of the company, significant amounts of packaging waste are generated annually, in this regard, packaging waste defines any packaging or packaging material that cannot be used for its original purpose. The paper presents a model that was developed in the retail industry and represents the process of collecting packaging waste from the entire retail network and finding the optimal model for starting a waste collection center in order to achieve company profits and improve the environment. Simulation model was created that mimics the real system of a waste collection center with the application of eco-marketing in the function of ecological development of the economy, industry and society. The results obtained show that more packaging waste is collected by building a waste collection center that unites all locations in one place compared to collecting packaging waste from all locations. By creating a simulation model that included many years of warehouse operation, variables and operating conditions, insight was gained into the complexity and simulation of the system when it is maximally loaded during the peak season and when it is minimally loaded in the off-season.

Keywords: Recycling center, management, retail, eco-marketing, sustainability.

1. INTRODUCTION

Packaging waste is defined as any packaging or packaging material that cannot be reused for its original purpose, with the exception of waste generated in the packaging production process. Packaging waste includes excess material from the retail industry that is used to provide products or material that can no longer be used after use, primarily cardboard and foil. Collection centers are widely considered an effective countermeasure to mitigate economic and environmental challenges (Salgado, F.d.A., 2022; Hoang, N.H., 2021). The conventional way of producing packaging waste usually involves enormous energy

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consumption and greenhouse gas emissions, which directly contributes to environmental degradation and global warming.

In contrast, products produced from recycled waste represent a more sustainable alternative, as they reduce the need for raw material extraction, minimize energy consumption and lower greenhouse gas emissions (Kisku, 2017; Hossain, 2016). Preliminary, the amount of waste significantly exceeds storage capacities, which highlights the need to focus on eco-marketing and consolidation, compaction of packaging waste. Therefore, a well-designed waste collection center plan can effectively improve the packaging waste collection rate, increase collection volumes, and contribute to eco-marketing. However, the planning of these centers requires complex decisions that revolve around considerations of waste generation, transportation, and land use. High land acquisition costs and uncertain waste volumes are two major obstacles to waste collection center initiatives (Ma, 2020). In addition, the uncertain demand for recyclable materials is a critical factor affecting recycling rates (Rahimi, 2025). Accordingly, the waste collection center plan should carefully consider the quantities of packaging waste generated and the demand for recyclable materials under multiple scenarios. The ability to optimally manage eco-marketing as a function of environmental engineering is a complex, systemic problem, and industrial ecology is constantly searching for systemic solutions to the problem of anthropogenic impacts on the environment. The economic aspect is also included in the systemic analysis of industry/environment interaction. When designing industrial operations and processes, it is possible to improve the performance of system elements and optimize processes by cyclic material transformations (from raw material extraction to the final product and treatment of industrial waste). Establishing a unified waste management system in industries requires knowledge of the processes of generation, manipulation, storage, transport, treatment and disposal of waste. One of the general goals in the field of waste management is to reduce the amount of waste and ensure its reuse or disposal in a way that does not cause environmental degradation and allows for significant improvement of resource efficiency. Despite the importance of this endeavor, minimal studies have analyzed the design of a waste collection center in the context of stochastic scenarios, especially dealing with uncertainties in the supply of packaging waste and the demand for recyclable materials. Determining the location, method and maximum processing capacity are key decisions in the planning of a waste collection center that need to be taken due to varying degrees of uncertainty. In the meantime, further research is needed on company investments that affect the success of packaging waste collection.

The paper is structured as follows: goal, need and research problem, review and consideration of related literature, methodology, model formation, calculation elements, finally, the last part of this paper is a summary of our conclusions on determining the location for the collection center.

The goal of this paper is to determine the optimal location for the construction of a waste collection center in order to improve the recycling rate of packaging waste (cardboard and nylon). During the research, general methods were used, primarily analysis and synthesis, induction and deduction, methods of systemic analysis of eco-industrial networks of complex systems, as well as specific methods that are consistent with the subject of the research. Methods of global optimization, i.e. heuristic algorithms were applied to solve the problem of determining the location of a plant for collecting secondary raw materials.

The need for research arose after an analysis to improve processes in the company and an initiative was taken to increase revenue from the sale of baled cardboard and foil, all with the aim of improving working conditions in retail stores. With the launch of the collection center, it is expected that the collected quantities of recyclable materials will be up to 30%

higher than current records, which will lead to an increase in revenue and profitability of the investment.

2. LITERATURE REVIEW

Due to the increasing production of packaging waste and the negative effect on the environment, the company has shown its commitment to solving this challenge. Looking at extensive studies that have analyzed the recycling of packaging waste and offered recommendations for improving recycling rates. Recycled materials refer to cardboard and foil generated in the supply chain, which are reused in the production process through recycling, processing and treatment, including recycled paper, recycled foil and so on (Zhu et al., 2025). The use of recycled materials reflects the level of waste recycling, which is key to reducing dependence on natural resources, reducing the intensity and total amount of carbon emissions, promoting resource recycling, guaranteeing the safety of national resources and contributing to the achievement of sustainable development (Pan and Cai, 2024). From the point of view of source and processing method, recycled materials can be categorized into post-consumer recycled materials and packaging materials. This paper focuses on the recycling of post-consumer materials as well as packaging materials generated in the retail industry. After consumption, recycled foil and cardboard are sustainable raw materials that are formed by reconstructing waste plastic through closed-cycle recycling technology. The application of this type of material is appreciated for its contribution to waste reduction, environmental protection, eco-marketing and carbon emission reduction. The basic characteristics of foil and cardboard are reflected in the significant value of environmental protection, and energy consumption in the production plant is significantly reduced compared to untreated plastic or cardboard. The intelligent design of the fine sorting and high-quality palletizing plant of the zero-carbon digital packaging plant, which will be built by the company, will promote the closed process in the retail industry to cope with the challenges and provide high-value closed process solutions for the retail industry and promote the development of the recycling economy. Ulubeyli and others (Ulubeyli, S., 2016) gave a complete picture of the management problems of waste collection center facilities, which illustrated the lack of recycling facilities encountered in many countries around the world, such as Brazil, Turkey and China. In addition, the location and processing capacity for collection should be carefully planned, as transportation costs and initial investment play a decisive role in management. Inaccurate estimation of the amount of waste represents a threat to the process of the waste collection center and therefore it is necessary to provide as accurate estimates as possible and predict from the company's development strategy the future quantities.

Heuristic algorithms are widely used to solve strategic and operational planning problems in various industries (Wang, 2024; Yi, 2023; Zhu, 2022). Compared with multi-objective MILP (Mixed integer linear programming) models, they can solve multi-objective problems and overcome the discontinuity of objective and bounded functions (Yi, 2023; Wang, 2023). However, they require complex parameter settings and generate high computational costs. Swarm algorithm and GA-PSO algorithm have been successfully applied to balance different objectives, but they failed to optimize the capacity of recycling centers in uncertain situations (Cui, 2023; Wu, 2023; Song, 2024). From a life cycle point of view, Atta and Bakhoum used LCA (Lifecycle assessment) to identify environmentally acceptable recycling center locations (Atta, 2024).

3. IMPACT OF INDUSTRIAL SYSTEMS ON THE ENVIRONMENT

Industrial ecology (eco-marketing) is a scientific discipline based on the implementation of processes in natural ecosystems to industrial processes. The basic role of the food industry is to provide sufficient amounts of food with an ever-increasing living population. The increase in the distribution of products, on the other hand, also leads to an increase in waste materials and other pollution that arise from such production and end up in the environment, land, air or water. Contaminating substances in primary production reach the human food chain again through plants and animals. Industrial ecology deals with changes in industrial processes from linear (open-loop) compositions, in which resources and capital investments travel through the system eventually becoming waste, to closed-loop compositions where waste is used in new processes.

As a result, industrial systems are vertically connected to the company's business processes and horizontally connected to value chain networks in real time - from the moment of the order to immediate logistics. Such developments will differentiate industry from less important services as automation is linked to industrial products and services and hybrid products that are not purely goods or services. Environmental protection in the food industry is carried out in accordance with accepted principles. In order to achieve the aforementioned principle, most countries try to apply the principle of sustainable development in the process of food production. Concepts of environmental protection that were based on minimization, reuse and recycling of waste did not solve the issue of negative impact on the environment. As an aspiration to neutralize the negative impact of the food industry on the environment, the concept of zero emissions appeared. Zero emission requires optimization through an integrated process system and requires the food industry to redesign production processes for more efficient use of raw materials and waste.

To solve the problem of controlling industrial emissions and reducing waste, there are generally three concepts:

- The concept of applying technical solutions for pollution control, that is, pollution treatment technology at the end of the production process (End-of-Pipe Pollution Control Technologies);
- Cleaner Production Concept and
- Zero Emissions Concept

An environmental risk assessment should be done before and during the implementation of any significant technological breakthrough. Appropriate regulation is of crucial importance, as it can support and accelerate the process of establishing sustainable development in the industrial sector.

The European Union is passing ever stricter regulations on product packaging, transport, waste management, which indicates the fact that the increasing engagement of logistics will be precisely in the area of waste management and disposal. Integrated logistics systems usually enable the movement of products to consumers. However, logistics systems, in order to reduce pressure on the environment, must enable the reverse movement of products from consumers to other entities in the supply chain. Such a system is known as a reverse logistics system. Reverse logistics refers to logistics activities and management skills used to reduce, manage and dispose of waste from single-use packaging to various products.

Today, reverse logistics represents one of the most powerful tools for managing the flow of goods and information in companies, and this is a time when companies cannot rely on their own inventive and productive abilities (Ross, 2015). Today's competition is not only between

the organizations themselves - but its center of gravity has shifted to the entire supply chain (Hu, 2013).

A company's ability to successfully and effectively adapt to unexpected changes in the business environment is key to gaining a competitive advantage in the global market. Global competition in business operations has led to the fact that companies that are customer-oriented operate more successfully, but on the other hand, they must be more flexible and well organized (Ganguly, 2009).

The key to a company's survival in a volatile market is through "agility/flexibility" especially by creating responsible supply chains. A difference arose between the philosophy of "leanness" and "agility" where a distinction is made and the application of these ideas is discussed (Christopher, 2000).

Before proceeding with the improvement of the supply chain (reverse logistics), it is necessary to define business processes, as well as the current organization, but also to create an internal team that gathers the main managers of the company who have a vision and desire to improve business with a focus on the environment.

4. PROBLEM DESCRIPTION

The company where she worked is analyzing one of the world's leading retail chains worldwide with a large number of employees. In Serbia, it is a proud member of a large family, and on our market it stands out as one of the largest private business systems and largest employers. It has been building its leadership position on the Serbian market since the first store was opened. From then until today, through acquisitions and the opening of numerous new retail stores, it has fought for first place on the domestic market. It serves about a million different customers a month and, wanting to provide each of them with the best shopping experience, the business is based on different domestic brands. The company is very committed to eco-marketing, where it attaches special importance to environmental protection, and in this connection, a project was launched to improve environmental protection in the function of sustainable development by building a center for the collection of packaging waste.

The annual turnover of packaging waste (cardboard and foil) is in large quantities and represents a significant impact on the company's operations from the point of view of collection costs in all stores. Also, packaging waste is generated directly in the Distribution Centers for various types of unpacking and packaging.

The ratio of the observed amounts of cardboard in the total generation of packaging waste is 90% cardboard and 10% foil, and the focus is on the central collection of cardboard, but on the condition that the complete amount of foil is also delivered to the collection center.

Disposal of packaging waste can be divided into several processes:

- download from the comminent at the location,
- collection and download from specific locations (hybrid model),
- central download in one location.

The current model of disposal (taking over) of packaging waste is by the client at all individual locations.

For the displayed network of collection locations and collection method, it is necessary to determine the location of the collection center in function of the company's core business, taking into account all the parameters that lead to an increase in costs. Some of the parameters that directly destroy profitability are: the cost of manipulation, transportation, equipment, technology, method of release, etc.

5. MULTI-CRITERIA DECISION-MAKING BASED ON THE ANALYTICAL HIERARCHICAL PROCESS METHOD

The Analytical Hierarchy Process (AHP) method was presented by Tomas Saaty in the seventies, and developed by Saaty in 1980 (Ballou, 2007; Saaty, 1988) in order to solve decision-making problems with a larger number of decision-makers, criteria and in multiple time periods. The purpose of AHP is to organize human thoughts and judgments for making effective decisions (Liu, P. D., 2009; Liu , S., 2010). AHP is a systematic procedure for solving multi-criteria decision-making problems (Saaty R., 1987).

The criteria include an analysis of the available land in order to compare the cost situation and the economic benefit that the facility will bring after construction, if the company does not have its own land, the amount of its own land is insufficient or there is no leased land. Unemployment rate criteria is important in terms of locating the building in places where the unemployment rate is high, in order to reduce this rate and meet staffing needs (Kilincci O, Onal S., 2011; Koç, 2025). For the analysis of retail establishments, the variables for the selection of potential retail establishments are defined:

- K1 – Area of the building > 450m2,
- K2 – Amount of packaging waste > 100 t/year,
- K3 – Access to the facility (transportation challenges),
- K4 – Technical capabilities (electricity, layout, processes, workforce),
- K5 – Transportation costs.

6. RESULTS OF APPLYING THE AHP METHOD

Defining 5 priority criteria that are compared in pairs in relation to the goal:

Kriterijum	K1	K2	K3	K4	K5
K1	**1**	1	1/2	1	1
K2	1	**1**	3	2	1/2
K3	2	1/3	**1**	1	1
K4	1	1/2	1	**1**	1/2
K5	1	2	1	2	**1**
Suma kolona	6,000	4,833	6,500	7,000	4,000

The normalized matrix is obtained by dividing each value by the sum of the columns (eg for element 1 we have 1/6,000 = 0.167), then the mean value is calculated for each row:

Kriterijum	K1	K2	K3	K4	K5	Srednja vred.
K1	0,167	0,207	0,077	0,143	0,250	0,169
K2	0,167	0,207	0,462	0,286	0,125	0,249
K3	0,333	0,069	0,154	0,143	0,250	0,190
K4	0,167	0,103	0,154	0,143	0,125	0,138
K5	0,167	0,414	0,154	0,286	0,250	0,254

The mean values of the rows represent the weight coefficients of certain criteria.

Considered potential locations of the collection center was done with an assessment of all locations for each of the priority criteria.

Surface area of the object. It represents the possibility of packaging waste storage and manipulation in the facility itself:

	L1	L2	L3	L4	L5	L6	L7	L8
L1	1	5	5	2	3	2	3	1
L2	1/5	1	1/2	3	1	3	4	1/3
L3	1/5	2	1	4	1	4	5	4
L4	1/2	1/3	1/4	1	3	1	2	1
L5	1/3	1	1	1/3	1	2	3	1/2
L6	1/2	1/3	1/4	1	1/2	1	2	1/2
L7	1/3	1/4	1/5	1/2	1/3	1/2	1	1
L8	1	3	1/4	1	2	2	1	1
Suma kolone	4,067	12,917	8,450	12,833	11,833	15,500	21,000	9,333

The normalized Strategic Position matrix is obtained by dividing each member of the previous matrix by the sum of the columns:

	L1	L2	L3	L4	L5	L6	L7	L8	Average
L1	0,246	0,387	0,592	0,156	0,254	0,129	0,143	0,107	0,252
L2	0,049	0,077	0,059	0,234	0,085	0,194	0,190	0,036	0,115
L3	0,049	0,155	0,118	0,312	0,085	0,258	0,238	0,429	0,205
L4	0,123	0,026	0,030	0,078	0,254	0,065	0,095	0,107	0,097
L5	0,082	0,077	0,118	0,026	0,085	0,129	0,143	0,054	0,089
L6	0,123	0,026	0,030	0,078	0,042	0,065	0,095	0,054	0,064
L7	0,082	0,019	0,024	0,039	0,028	0,032	0,048	0,107	0,047
L8	0,246	0,232	0,030	0,078	0,169	0,129	0,048	0,107	0,130

Amount of packaging waste. A significant value is a quantity that determines the grouping of waste collection and shipment.

	L1	L2	L3	L4	L5	L6	L7	L8
L1	1	3	5	1/3	1/2	1/3	2	1/3
L2	1/3	1	1/3	2	1	2	3	2
L3	1/5	3	1	2	4	3	4	2
L4	3	1/2	1/2	1	1	1/4	1/5	1/3
L5	2	1	1/4	1	1	2	1	2
L6	3	1/2	1/3	4	1/2	1	2	3
L7	1/2	1/3	1/4	5	1	1/2	1	1/3
L8	3	1/2	1/2	3	1/2	1/3	3	1
Column Sum	13,033	9,833	8,167	18,333	9,500	9,417	16,200	11,000

Normalized demographic potential matrix:

	L1	L2	L3	L4	L5	L6	L7	L8	Average
L1	0,077	0,305	0,612	0,018	0,053	0,035	0,123	0,030	0,331
L2	0,026	0,102	0,041	0,109	0,105	0,212	0,185	0,182	0,056
L3	0,015	0,305	0,122	0,109	0,421	0,319	0,247	0,182	0,148
L4	0,230	0,051	0,061	0,055	0,105	0,027	0,012	0,030	0,114
L5	0,153	0,102	0,031	0,055	0,105	0,212	0,062	0,182	0,095
L6	0,230	0,051	0,041	0,218	0,053	0,106	0,123	0,273	0,107
L7	0,038	0,034	0,031	0,273	0,105	0,053	0,062	0,030	0,034
L8	0,230	0,051	0,061	0,164	0,053	0,035	0,185	0,091	0,114

Facility access (transportation challenges)

An access zone that has the possibility of approaching large trucks has an advantage over a zone that does not have enough access space:

	L1	L2	L3	L4	L5	L6	L7	L8
L1	**1**	5	5	2	1/2	5	5	1/3
L2	1/5	**1**	1/3	5	1/2	3	5	1/3
L3	1/5	3	**1**	4	3	2	1/2	2
L4	1/2	1/5	1/4	**1**	1	1/2	2	1/3
L5	2	2	1/3	1	**1**	1	1	2
L6	1/5	1/3	1/2	2	1	**1**	2	1/2
L7	1/5	1/5	2	1/2	1	1/2	**1**	1
L8	3	3	1/2	3	1/2	2	1	**1**
Suma kolone	7,300	14,733	9,917	18,500	8,500	15,000	17,500	7,500

Normalized object access matrix:

	L1	L2	L3	L4	L5	L6	L7	L8	Srednja vred.
L1	0,137	0,339	0,504	0,108	0,059	0,333	0,286	0,044	0,226
L2	0,027	0,068	0,034	0,270	0,059	0,200	0,286	0,044	0,124
L3	0,027	0,204	0,101	0,216	0,353	0,133	0,029	0,267	0,166
L4	0,068	0,014	0,025	0,054	0,118	0,033	0,114	0,044	0,059
L5	0,274	0,136	0,034	0,054	0,118	0,067	0,057	0,267	0,126
L6	0,027	0,023	0,050	0,108	0,118	0,067	0,114	0,067	0,072
L7	0,027	0,014	0,202	0,027	0,118	0,033	0,057	0,133	0,076
L8	0,411	0,204	0,050	0,162	0,059	0,133	0,057	0,133	0,151

Technical possibilities (stretch marks, layout, processes)

Technical capabilities have better existing and development conditions for equipment installation and capacity expansion:

	L1	L2	L3	L4	L5	L6	L7	L8
L1	**1**	3	5	5	1	3	5	1
L2	1/3	**1**	3	4	1	3	5	1
L3	1/5	1/3	**1**	2	4	2	5	1
L4	1/5	1/4	1/2	**1**	1/2	1/2	3	1
L5	1	1	1/4	2	**1**	3	1	3
L6	1/3	1/3	1/2	2	1/3	**1**	3	1/3
L7	1/5	1/5	1/5	1/3	1	1/3	**1**	1/5
L8	1	1	1	1	1/3	3	5	**1**
Suma kolone	4,267	7,117	11,450	17,333	9,167	15,833	28,000	8,533

Normalized matrix for technical conditions:

	L1	L2	L3	L4	L5	L6	L7	L8	Srednja vred.
L1	0,234	0,422	0,437	0,288	0,109	0,189	0,179	0,117	0,247
L2	0,078	0,141	0,262	0,231	0,109	0,189	0,179	0,117	0,163
L3	0,047	0,047	0,087	0,115	0,436	0,126	0,179	0,117	0,144
L4	0,047	0,035	0,044	0,058	0,055	0,032	0,107	0,117	0,062
L5	0,234	0,141	0,022	0,115	0,109	0,189	0,036	0,352	0,150
L6	0,078	0,047	0,044	0,115	0,036	0,063	0,107	0,039	0,066
L7	0,047	0,028	0,017	0,019	0,109	0,021	0,036	0,023	0,038
L8	0,234	0,141	0,087	0,058	0,036	0,189	0,179	0,117	0,130

A location zone with a greater amount of goods flows has an advantage due to the reduction of **transport costs**:

	L1	L2	L3	L4	L5	L6	L7	L8
L1	**1**	3	1/3	3	4	3	5	4
L2	1/3	**1**	1/3	5	1/3	3	5	1/2
L3	3	3	**1**	5	2	5	1/4	1/3
L4	1/3	1/5	1/5	**1**	1	1/2	3	1/5
L5	1/4	3	1/2	1	**1**	3	5	2
L6	1/3	1/3	1/5	2	1/3	**1**	3	2
L7	1/5	1/5	4	1/3	1/5	1/3	**1**	1/3
L8	1/4	2	3	5	1/2	1/2	3	**1**
Suma kolone	5,700	12,733	9,567	22,333	9,367	16,333	25,250	10,367

Normalized matrix of transportation costs:

	L1	L2	L3	L4	L5	L6	L7	L8	Srednja vred.
L1	0,175	0,236	0,035	0,134	0,427	0,184	0,198	0,386	0,222
L2	0,058	0,079	0,035	0,224	0,036	0,184	0,198	0,048	0,108
L3	0,526	0,236	0,105	0,224	0,214	0,306	0,010	0,032	0,207
L4	0,058	0,016	0,021	0,045	0,107	0,031	0,119	0,019	0,052
L5	0,044	0,236	0,052	0,045	0,107	0,184	0,198	0,193	0,132
L6	0,058	0,026	0,021	0,090	0,036	0,061	0,119	0,193	0,075
L7	0,035	0,016	0,418	0,015	0,021	0,020	0,040	0,032	0,075
L8	0,044	0,157	0,314	0,224	0,053	0,031	0,119	0,096	0,130

Relative scores for each objective. Calculating the mean values for each normalized matrix:

	L1	L2	L3	L4	L5	L6	L7	L8	težina kriterijuma
K1	0,252	0,115	0,205	0,097	0,089	0,064	0,047	0,130	0,169
K2	0,331	0,056	0,148	0,114	0,095	0,107	0,034	0,114	0,249
K3	0,226	0,124	0,166	0,059	0,126	0,072	0,076	0,151	0,190
K4	0,247	0,163	0,144	0,062	0,150	0,066	0,038	0,130	0,138
K5	0,222	0,108	0,207	0,052	0,132	0,075	0,075	0,130	0,254

Kriterijum	K1	K2	K3	K4	K5	5-ti koren proizvoda	Prioritetni vektor
K1	**1,000**	**1,000**	**0,500**	**1,000**	**1,000**	0,871	0,170
K2	**1,000**	**1,000**	**3,000**	**2,000**	**0,500**	1,246	0,244
K3	**2,000**	**0,333**	**1,000**	**1,000**	**1,000**	0,922	0,180
K4	**1,000**	**0,500**	**1,000**	**1,000**	**0,500**	0,758	0,148
K5	**1,000**	**2,000**	**1,000**	**2,000**	**1,000**	1,320	0,258
Suma reda	6,000	4,833	6,500	7,000	4,000	5,116	1,000
Prioritetni red	1,021	1,177	1,172	1,037	1,032		

Determination of the nth root of the product

The priority vector is the nth root divided by the sum of all locations

(n is the number of criteria = 5)

Row sum = sum of all columns

Priority queue = (queue sum value)*(priority vector)

LambdaMax = 5,438 = Sum of Priority Queues

Consistency Index (CI) = 0.110= (LambdaMax -n) / (n-1) = (5.440- 5) / (4)

Consistency Ratio (CR) =0.0978= (CI) / (Random Index) = 0.110 / 1.12

CR must be less than 0.10 (maximum can be tolerated up to 0.20)

The order of the location zones according to the set criteria is done according to the maximum values of the coefficients obtained on the basis of the relative results and the original weight coefficients of the criteria, which in our case represents the order **L1-0.258; L3-0.175; L8-0.130; L5-0.117; L2-0.107; L6-0.079; L4-0.078; and L7-0.055.**

The most suitable location for the construction of the collection center is Location L1.

In the field of research, it is crucial to systematically monitor the effectiveness of implemented regulations and evaluate the effectiveness of applied preventive measures. (Łusiakowski, K., & Gibowski, Ł., 2026).

7. DISCUSSION OF THE RESULTS OF THE APPLICATION OF THE MODEL

The proposed solution for finding the optimal location is primarily based on the use of waste management data. In this sense, the accuracy of the results of the application may be threatened by external factors related to the inaccuracy of the data on the amount of generated waste and the out-of-date records of the mentioned data.

Based on the analysis of the criteria and their quantification, it can be concluded that criterion group K5 (transportation costs) is more important than the other selected criteria. This approach enables a more comprehensive assessment of the impact of industrial activities on the environment.

The proposed hierarchy for AHP analysis can have a deeper structure in terms of the inclusion of a larger number of criteria and sub-criteria, which would require more extensive quantification of data and require the exponential engagement of decision makers. Increasing the number of criteria and sub-criteria often represents an extraordinary effort for the decision maker.

The results of the model verification indicate the applicability of the model for decision-making in concrete case studies, even when there are a large number of stakeholders in the reverse supply chain. By looking at the complete analysis and application of the methods, we have confirmed that the most suitable location for the construction of the collection center for recycling materials is location L1, and we have thereby confirmed the application of the location selection method.

8. CONCLUSION

Adequate management of industrial waste is of particular importance for preventive environmental protection and eco-marketing, where the formation of eco-industrial networks enables collaboration between representatives of different industrial sectors and the mutual use of secondary raw materials. The quantities of generated industrial waste (cardboard and foil), along with their increasing tendency, represent one of the key factors that contribute to the accelerated degradation of the environment. The existing burden on the environment can be reduced by implementing adequate solutions, that is, by establishing appropriate options for waste treatment, especially if you take into account the fact that waste materials must be viewed as a resource.

In our work, the most suitable location turned out to be the location marked L1, which indicates the optimal model from the point of view of all the mentioned criteria. The integration of product return flows into existing or planned logistics systems is a significant issue from both a theoretical and a practical point of view, because product return flows impose new requirements in the planning and management of logistics systems. Given the fact that the return of secondary products is one of the most important activities of reverse logistics, the paper presents one of the possible approaches to solving the problem of secondary materials.

For the purposes of model verification, the territorial scope of the project was analyzed, which includes waste generators in the company's retail stores in the region of Serbia, where two types of waste materials (cardboard and foil) are defined. Based on the input parameters, eight optimal locations were determined and the allocation of waste generators to the optimal locations was given. The mathematical model, implemented in this research, provides the possibility of determining the required number of optimal locations, as well as the allocation of available resources (secondary raw materials) to the located facilities. The application of the model points to the fact that the basic hypothesis of the research based on the subject, objectives and methodology of the research has been confirmed, i.e. that it is possible to create applicable location models for the optimization of transport costs when aggregating the necessary amounts of secondary materials to meet the capacity of processors by applying mathematical models that

support the decision-making process on macro-locations and capacities within the given eco-industrial network. In accordance with the above, the main goal of the research was achieved, which is the creation of a model for solving the location problem of a waste treatment facility (secondary raw materials).

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