SELECTION OF THE LOCATION OF THE DISTRIBUTION CENTER FOR AGRICULTURAL PRODUCTS

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ABSTRACT

The aim of the study was to use a multi-criteria decision-making method to make a rational choice for a new location for the distribution centre of agricultural products in the northeastern part of Bosnia and Herzegovina, specifically in five populated areas. The required criteria were selected based on experiences from previous research in this field, and decision-makers involved in the selection were engineers and technologists from the company in question. The results indicate that the criteria of construction cost and market connectivity gained the greatest importance, and Brčko was chosen as the location for the future distribution centre among the five populated areas. Additionally, the successful application of the used multi-criteria decision-making method, in this case, the CoCoSo method, was demonstrated. This could lead to improvements in making future business decisions within this economic sector.

Introduction

The selection of a distribution centre location is a crucial strategic issue for every company, particularly for those involved in the distribution of agricultural products. The need for transporting various goods has, undoubtedly, significantly increased as urban areas have become denser, and consumer demand has sharply risen (Sopha et al., 2018). As highlighted by Stević et al. (2022), distribution centres, whether urban or regional, emerge as the most popular alternative among potential interventions for

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reducing and/or enhancing the efficiency of urban traffic. De Carvalho et al. (2020) define distribution centres as places where products are transshipped, deliveries are consolidated, and the distribution process is efficiently executed. According to Okatan et al. (2019), a distribution centre represents a specific and designated location near markets and transportation hubs, facilitating well-organized storage and distribution based on the type and durability of the products. Kuo (2011) concludes that companies strive to increase economies of scale and reduce transportation costs, choosing a location that best facilitates these goals. The decision on the choice of a distribution centre location is influenced by a large number of factors. Supporting this, Mihajlović et al. (2019) note that the location selection problem plays a crucial role in logistics, making it very important to find the most desirable distribution centre location. The choice of location for distribution centres can expedite sales and procurement while reducing logistics costs, providing economic benefits to both suppliers and customers (Yang, Song, 2022). In essence, the selection of a distribution centre is a crucial strategic decision for every company (Agrebi, Abed, 2021).

Problem becomes even more complex when dealing with sensitive products, such as agricultural products. Whether of plant or animal origin, these products have specific characteristics that must be taken into account in their storage and transportation, so this is one of the main reasons for this type of research. The strong development of modern logistics for agricultural products is of great importance for improving the efficiency of agricultural product distribution, reducing costs, effectively solving problems, improving the lives of farmers, increasing agricultural production, and promoting rural prosperity (Mihajlović et al., 2019). Li Ma (2021) further states that a reasonable location and layout of agricultural product distribution centres can not only efficiently improve logistics, reduce costs, loss rates, and waste but also optimize the entire supply chain system.

Daily changes in the market conditions of the economy imposed the obligation of a serious approach to planning and organization of all business segments in agriculture and agribusiness, and making a decision has become something that is of crucial importance for every manager or business organizer. (Nedeljković et al., 2017) In support of the above, the number of factors that must be considered, and criteria that must be met, before making a rational decision, is growing day by day. Successfully overcoming complex organizational problems and making rational business decisions in agribusiness offer us multi-criteria decision-making methods that have been confirmed through some earlier research by individual domestic and foreign authors (Puška et al., 2023; Nedeljković et al., 2020; Maksimović et al., 2018 ; Durkalić et al., 2019; Kozlovskyi et al., 2018; Badr et al., 2018 ect.)

The choice of location is usually influenced by various qualitative and quantitative criteria (Kieu et al., 2021). Therefore, the effective resolution of location selection and evaluation for the establishment of distribution centres is achieved through the use of multi-criteria decision-making (Kuo, 2011). Specific multi-criteria decision-making methods play a crucial role in the evaluation and selection of distribution

centre locations, varying in their approaches. Hence, the aim of this study is to apply one such multi-criteria decision-making method to choose an appropriate location for an agricultural product distribution centre that best satisfies all specified criteria. The research focuses on planned distribution centres for agricultural products, specifically crops and vegetables, in the region of Bosnia and Herzegovina, namely four populated areas (Bijeljina, Ugljevik, Brčko, Zvornik, and Janja).

Literature review

As a result of the significant importance of selecting locations for distribution centres, numerous multi-criteria methods have been developed to assist decision-makers (Agrebi et al., 2017). In their earlier research, some authors concluded that choosing an appropriate location for a distribution centre can significantly impact a company's competitiveness, profitability, and sustainability (Ozerova et al., 2019; Taghikhah et al., 2019; Ehtesham Rasi, Sohanian, 2020; Kieu et al., 2021; Pantović et al., 2023). Supporting these claims is the fact that choosing the location for agricultural product distribution centres has become an important area of research in recent times. During the selection process, multiple criteria can be considered, sometimes conflicting with each other. Some of these criteria include transportation costs (Li, Zhou, 2021; Teng et al., 2021; Yonathan, Pujawan, 2021), proximity to markets (Van Der Lee et al., 2020; Xiong et al., 2020; Suman et al., 2021), and resource availability (Monzón et al., 2020; Milojević et al., 2020; Stock et al., 2020; Ilić et al., 2022; Baker et al., 2022).

Some of the earlier research has focused on the selection of locations for agricultural product distribution centres, utilizing multi-criteria analysis methods. For instance, Gergin et al. (2022) employed multi-criteria analysis methods to assess the location of oilseed warehouses in Turkey. They used a combined approach with AHP, TOPSIS, and the Delphi decision-making method, along with panel data, resulting in a comprehensive integrated approach used as a model for location selection. The results, as the authors conclude, are significant for shaping future policies in this economic sector. Nong (2022) proposed an integrated approach based on AHP and TOPSIS methods for selecting the most suitable location for a distribution centre. The model was suggested for the Dong Nai province in Vietnam and is advantageous for use in various industrial sectors. Additionally, Puška et al. (2023a) focused their research on the significance of location in establishing distribution centres. For their study conducted in the Brčko district, they employed multi-criteria decision-making methods, namely fuzzy set SWARA and CRADIS methods. Based on their research, they confirmed the hypothesis that this method can be successfully used for selecting the location of a future distribution centre. The aim of the study was to use a multi-criteria decision-making method to make a rational choice for a new location for the distribution centre of agricultural products in the northeastern part of Bosnia and Herzegovina.

Methodology

A multi-criteria decision-making model called CoCoSO (*Combined Compromise Solution*) has been proposed for the selection of distribution centre locations. Multi-criteria methods, including the CoCoSo method, have their strengths and weaknesses. Some authors argue that the choice of method depends on the decision-maker's preferences (Jansen et al., 2022; Schmitt et al., 2022), the characteristics of the problem (Mihajlović et al., 2019; Aytekin, 2021), and the availability of data (Kadoić et al., 2021; Mugiyo et al., 2021). The CoCoSo multi-criteria decision-making method has a wide range of applications. One reason for using this method in the study is its infrequent application by domestic authors, and this serves to popularize it. Essentially, the method is based on integrating simple weight additive and exponential weight product models (Lukić, 2021).

Yazdani (2019) outlines the following steps of this method:

1. *The determination of the initial decision matrix is carried out by the following statement:*

$$x_{ij} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}; i = 1,2,\dots,m; j = 1,2,\dots,n.$$

where m represents the number of alternatives, and n represents the number of specified criteria.

2. *Normalization of the initial decision matrix is achieved through the following equations:*

$$r_{ij} = \frac{x_{ij} - \min_i x_{ij}}{\max_i x_{ij} - \min_i x_{ij}}; \text{ (when it comes to benefit criteria),}$$

$$r_{ij} = \frac{\max_i x_{ij} - x_{ij}}{\max_i x_{ij} - \min_i x_{ij}}; \text{ (when it comes to cost criteria).}$$

3. *Establishing the sums of weighted comparable sequences () and the strengths of weighted comparable sequences () for each set alternative is based on the following formulas:*

$$S_i = \sum_{j=1}^{n} (w_j r_{ij})$$

$$P_i = \sum_{j=1}^{n} (r_{ij})^{w_j}$$

4. *Calculating the relative weights of alternatives with strategy aggregation is obtained using the following formulas:*

$$k_{ia} = \frac{P_i + S_i}{\sum_{i=1}^{m} (P_i + S_i)},$$

$$k_{ib} = \frac{S_i}{\min_i S_i} + \frac{P_i}{\min_i P_i},$$

$$k_{ic} = \frac{\lambda(S_i)+(1-\lambda)(P_i)}{(\lambda \max_i S_i+(1-\lambda)\max_i P_i)}.$$

5. *Ranking alternatives based on is obtained in the following way:*

$$k_i = (k_{ia}k_{ib}k_{ic})^{\frac{1}{3}} + \frac{1}{3}(k_{ia}k_{ib}k_{ic})$$

To obtain the weighting coefficients, the well-known AHP (Analytic Hierarchy Process) method was used, and the research results are presented in tabular and graphical form in the following text.

Research Results and Discussion

Due to the significance of choosing the location for the distribution centre, the following Table 1 provides a brief description of the economic and social criteria that will be used for evaluation by the selected experts of the company. The company in question is engaged in the sale and distribution of agricultural products intended for customers both domestically and internationally. Therefore, the existence of such a centre plays a crucial role in their operations. The company falls into the category of small to medium-sized enterprises, depending on the engagement of seasonal labour, and its headquarters are located in the municipality of Belgrade. With the development of business in the regional countries, the company plans to expand its distribution network beyond the borders of Serbia. Consequently, the selection of the location for the distribution centre for their products, which primarily consist of crops and vegetables (such as wheat, barley, corn, sunflower, beans, lentils, etc.), as well as certain products resulting from their processing, becomes crucial. The company comprises graduate engineers and several food technologists, five of whom, in this case, are considered decision-makers and evaluators of specific criteria.

Table 1. Research criteria

Criterion label (C)	Criterion	Description	Criteria type
C1	Construction cost	By choosing the location, reduce construction costs to a reasonable, minimal level that does not compromise quality.	Minimum
C2	Location accessibility	Choose a location that provides a place that is maximally available for further work activities.	Maximum
C3	Logistics costs	Reduce costs to a reasonable and minimal level.	Minimum
C4	Safety	By choosing a location, ensure reliability in every segment of functioning.	Maximum
C5	Market connection	Maximize connection with the main market entities.	Maximum

Criterion label (C)	Criterion	Description	Criteria type
C6	Distance from customers	By choosing a location, reduce the distance from potential customers to a minimum.	Minimum
C7	Distance from supplier	By choosing a location, reduce the distance from potential suppliers to a minimum.	Minimum
C8	Impact on the environment	By choosing the location, minimize the environmental impact through its operational activities.	Minimum

Source: Authors

As mentioned earlier, for alternatives, or potential locations of the distribution centre, five populated areas in Bosnia and Herzegovina were considered in the following regions: Bijeljina, Brčko, Zvornik, Ugljevik, Janja, and their brief descriptions can be seen in the following Table 2.

Table 2. Potential locations of the distribution centre

Alternative label (A)	Location	Short description
A1	Bijeljina	It occupies the northeastern part of Bosnia and Herzegovina; Proximity to the borders with Serbia and Croatia; Proximity to major transportation routes; Proximity to larger watercourses; Good terrain configuration; Proximity to markets and potential major suppliers.
A2	Brčko	It occupies the northeastern part of Bosnia and Herzegovina; Proximity to the borders with Serbia and Croatia; Good connectivity with the interior of Bosnia and Herzegovina; Proximity to the highway (M75); Proximity to major navigable watercourses and possession of a river port; Good terrain configuration; Proximity to markets and potential major suppliers. Good infrastructure equipment.
A3	Zvornik	It occupies the eastern part of Bosnia and Herzegovina; Good connectivity with major highways; Proximity to river watercourses; Proximity to major market centres; Good geographical position; Proximity to border crossings; Good connectivity with large supplier centres.
A4	Ugljevik	It occupies the northeastern part of Bosnia and Herzegovina; Proximity to the borders with Serbia and Croatia; Good connectivity with the interior of Bosnia and Herzegovina; Good connectivity with large and small supplier centres in Bosnia and Herzegovina. Accessible and quality workforce
A5	Janja	It occupies the northeastern part of Bosnia and Herzegovina; Proximity to the border with Serbia; Good connectivity with other parts of Bosnia and Herzegovina; Good connectivity with all main and local roads in the region; Good connectivity with potential customers and suppliers from Bosnia and the region; Good infrastructure; Good terrain configuration; Accessible and quality workforce.

Source: Authors

After individually considering all the criteria and proposed alternatives, a joint expert assessment was given based on a formed linguistic scale, whose quantitative values can be seen in the following Table 3.

Table 3. Linguistic scale of values

Evaluation of criteria	Linguistic scale
1	VP-Very Poor
2	P-Poor
3	M-Medium
4	G-Good
5	VG-Very Good

Source: Đalić et al., 2020

After determining the type of criteria based on the previous Table 1 and proceeding according to decisions, weight values for individual criteria were obtained from experts, where we observe that the criteria 'construction cost' and 'market connectivity' have the highest values (Table 4). The assessment was carried out based on the Analytic Hierarchy Process (AHP) decision-making methodology, which in this case provides the most favourable solution. The reason for the obtained ratings of individual criteria, specifically the significance of construction cost, should be sought in the increasing costs involved in it, while market connectivity, as stated by Koohathongsumrit & Meethom (2021), is crucial due to the fact that transport has become a key factor in international and domestic distribution centres.

Table 4. Expert assessment of criteria

	C1	C2	C3	C4	C5	C6	C7	C8
A1	3	4	3	3	5	5	4	5
A2	2	3	3	4	4	5	4	5
A3	2	2	3	3	4	4	4	4
A4	4	3	4	4	3	3	4	3
A5	4	4	4	4	3	3	3	2
Max.	***4***	***4***	***4***	***4***	***5***	***5***	***4***	***5***
Min.	***2***	***2***	***3***	***3***	***3***	***3***	***3***	***2***
C/B	**min.**	**max.**	**min.**	**max.**	**max.**	**min.**	**min.**	**min.**
Weight	**0,2**	**0,1**	**0,1**	**0,15**	**0,2**	**0,1**	**0,1**	**0,05**

Source: Authors' calculation

After the formation of the initial decision-making matrix, in further steps it was normalized (table 5), as well as the determination of its weights (table 6).

Table 5. Normalized decision-making matrix

	C1	C2	C3	C4	C5	C6	C7	C8
A1	0,5	1	1	0	1	0	0	0
A2	1	0,5	1	1	0,5	0	0	0
A3	1	0	1	0	0,5	0,5	0	0,33
A4	0	0,5	0	1	0	1	0	0,66
A5	0	1	0	1	0	1	1	1

Source: Authors' calculation

Table 6. Weighted normalized decision-making matrix

	C1	C2	C3	C4	C5	C6	C7	C8
A1	0,1	0,1	0,1	0	0,2	0	0	0
A2	0,2	0,05	0,1	0,15	0,1	0	0	0
A3	0,2	0	0,1	0	0,1	0,05	0	0,0165
A4	0	0,05	0	0,15	0	0,1	0	0,033
A5	0	0,1	0	0,15	0	0,1	0,1	0,05

Source: Authors' calculation

Further calculation established the sum of weighted comparable sequences of strings () and the strength of weighted comparable sequences (). (Table 7)

Table 7. Weighted and exponential comparability of sequences i

A1	0,5	0,2942
A2	0,6	3,641
A3	0,4665	3,703
A4	0,333	3,13
A5	0,5	3,994
Sum	2,3995	17,41
Min.	0,333	2,942
Max.	0,6	3,994

Source: Authors' calculation

Table 8 gives us the calculated relative weights of the alternatives, i.e., its aggregation, as well as their ranking order. In the last column of table 8, we see the final ranking of the alternatives values.

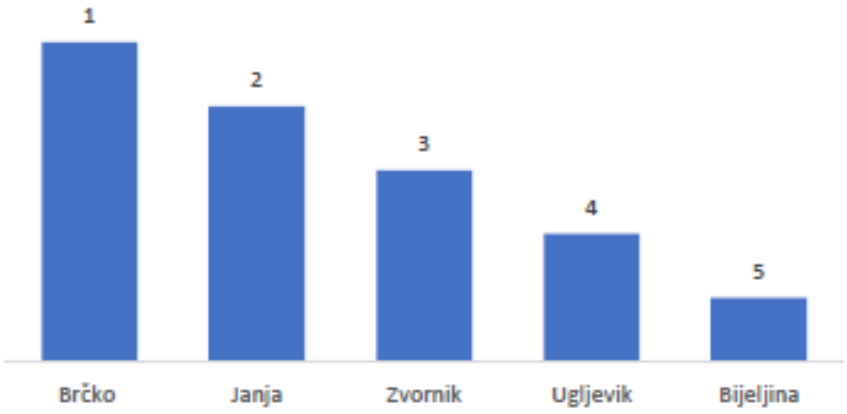
Table 8. Final aggregation and ranking

		Rank		Rank		Rank		Rank
A1	0,173755	5	2,501502	4	0,749238	5	1,13	**5**
A2	0,214089	2	3,039395	1	0,923161	2	2,22319	**1**
A3	0,21048	3	2,659568	3	0,907597	3	2,0457	**3**
A4	0,174815	4	2,063902	5	0,753809	4	1,6382	**4**
A5	0,226861	1	2,859081	2	0,978232	1	2,2015	**2**

Source: Authors' calculation

As seen in Figure 1, the chosen location for constructing the future distribution centre is Brčko, situated in the district of the same name in Bosnia and Herzegovina. Immediately following is the populated place Janja. Similar research results are found in the study by Puška et al. (2023), where the authors identify the settlement of Brčko as the optimal location for establishing a new distribution centre in their study. Advanced multi-criteria decision-making methods were also applied for this purpose.

Figure 1. Ranking of distribution centres



Source: Edited by the author

Conclusion

The selection of the distribution centre location represents a complex business decision-making problem in any company, especially one involved in the distribution of agricultural products. To address this, a multi-criteria decision-making method was employed, where experts, based on given economic and social criteria, identified the most favourable location from five proposed sites for distribution centres. The optimal location was determined to be the populated place Brčko, located in the Brčko District in Bosnia and Herzegovina. The undeniable significance of the location selection in this case is attributed to the use of the CoCoSo multi-criteria decision-making method, providing impetus for refining the research methodology in future studies. Future research should focus on further developing methods that assist in making rational decisions regarding the selection of locations for these centres, especially in the context of agriculture and agribusiness.

Conflict of interests

The authors declare no conflict of interest.

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