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THE OPTIMIZATION OF ACCESSIBILITY AND INSTALLATION OF SMART DELIVERY LOCKERS IN THE TEPEBASI DISTRICT OF ESKISEHIR, TURKIYE

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Abstract. The increasing urban population density and rapid growth in e-commerce are exerting pressure on the efficiency and accessibility of delivery services. This has resulted in a substantial engineering challenge concerning the strategic positioning of urban delivery lockers. The objective of this study is twofold: firstly, to enhance the accessibility of smart delivery lockers, and secondly, to ascertain their optimal placement in order to meet the needs of individuals residing in the area. Subsequently, the model is to be implemented in the Tepebasi district of Eskisehir, Turkey. The designated area was subdivided into cells, with each cell defined as being within a walking radius. The problem is modelled as a clustering-based set covering problem. Furthermore, the decision-making process was informed by a comprehensive set of demographic and logistical data. Multi-criteria decision-making technique TOPSIS was utilised in order to define priorities of the neighborhoods. The study encompassed various demographic categories, including age groups, educational levels, and the mean monthly cargo traffic intensity across different neighbourhoods. It is evident that, upon the analysis of the obtained data, the implementation of coverage-based set covering optimization with TOPSIS was necessary in order to identify areas with high access potential.

Keywords. Optimization, Smart parcel lockers, Strategic location selection, Accessibility, Urban logistics, Set covering.

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1. Introduction

In the contemporary era, characterised by accelerated technological development and digitalisation, urban lifestyles and economic activities have undergone profound changes. The rapidly expanding domain of e-commerce has precipitated profound shifts in consumer behaviour, thereby necessitating a comprehensive reassessment of logistics and distribution networks. The increasing population density and the associated logistics demands have highlighted the need to make delivery systems in urban areas more efficient and accessible.

In order to address these problems, which are characterised by their economic, environmental and social dimensions, innovative and sustainable methods are required. Innovative distribution systems have been shown to hold significant potential for overcoming the aforementioned problems. To illustrate this point, consider the potential of smart delivery lockers to enhance urban distribution, alleviate traffic congestion, and reduce carbon emissions. However, for these solutions to be successful, appropriate management strategies must be developed and strategic positioning must be implemented. Thus, the restructuring of logistics systems plays a critical role in determining the future quality of life in cities. The present study therefore seeks to address these challenges with a view to creating more liveable, economically and environmentally sustainable cities.

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1.1. **Literature review.** Lachapelle, Burke, Brotherton and Leung [13] examines the locations of automated parcel delivery systems (Parcel Lockers) in car-centric cities and the potential impacts of these systems on urban planning and consumer travel access. The research analysed the micro-level characteristics of 45 parcel locker locations in five cities in Southeast Queensland, Australia. Hierarchical clustering analysis was used to determine the categories of these locations. The study also examined in detail a number of factors, including neighbourhood-level demographic and land use data, as well as proximity to transport infrastructure. The results indicated that parcel lockers are predominantly situated in areas that are accessible by car, with limited accessibility to alternative modes of transport. A survey of the existing literature on the matter revealed that parcel lockers are generally located in areas with high traffic density, such as shopping centres, supermarkets, and petrol stations, but with low accessibility by foot or public transport. This scenario has the potential to exacerbate car dependency, whilst concomitantly curtailing the utilisation of public transport and environmentally sustainable transport alternatives. Consequently, it has been stated that parcel locker systems, when properly planned, can have positive effects on cities' transport infrastructure and consumer behaviour. However, car-centric approaches may increase inequalities and environmental problems. The study emphasises the importance of integrating these systems with urban planning objectives and optimising them to contribute to sustainable transport goals.

Signak and Kuvvetli [18] developed a mathematical model to determine the optimal placement of bicycle sharing points on the Çukurova University campus. This study underscores the significance of sustainable transportation and engages in a discourse on the imperative of bicycle sharing systems in the context of urban planning. In this context, the set-covering algorithm was utilised to ascertain the most effective bicycle sharing points among the 54 buildings on campus. The model created 9 and 23 bicycle sharing points under two different scenarios. The study ensured the effective identification of bicycle sharing points by using different coverage constraints and made various recommendations, taking into account campus distances and building densities. The research emphasises the importance of capacity and the integration of bicycle lanes for future planning.

In addressing the need for innovative solutions in the context of rapidly expanding e-commerce, van Duin, Wiegmans, van Arem and van Amstel [19] examined the potential of parcel lockers to reduce the high costs of 'last mile' delivery processes. The study involved a pilot project in Amsterdam's De Pijp district, where three alternative design scenarios were evaluated, comparing the use of parcel lockers with the existing home delivery model. It was observed that the implementation of parcel lockers led to a reduction in delivery points and vehicle mileage, a decrease in fuel consumption and CO2 emissions, and the generation of cost savings amounting to €121,356 per year. Furthermore, it was emphasised that parcel lockers increased customer satisfaction, improved operational efficiency, particularly in high-density areas, and offered a sustainable delivery model. The study evaluated design alternatives using cost-effectiveness analysis, multi-criteria analysis, and simulation modelling, recommending the use of 'medium-sized' cargo lockers as the most suitable solution. However, it was stated that further optimisation of the positioning and dimensions of cargo lockers is required for the enhancement of operational efficiency.

An, Park, Song and Chung [2] examined the factors influencing consumers' adoption of parcel locker services within the framework of Protection Motivation Theory. The present study set out to investigate the influence that consumers' privacy concerns, perceived risks, perceived ease of use of the technology, and perceived benefits have on their preferences for such services. The findings of the study indicate that the rate of adoption of parcel locker services by consumers is predominantly influenced by the management of privacy concerns and the enhancement of perceptions regarding the service's ease of use. The authors emphasised that service providers should proactively address consumer privacy concerns and clearly highlight the benefits of the technology. The study proffers recommendations of considerable value to service providers, who may use these to develop strategies to increase consumer adoption rates.

Karabulut, Seyret and Avcı [11] examined the increasing complexity and rising costs of last-mile logistics activities. These developments are attributed to the growth of e-commerce and increased competition. In this context, the location selection problem for parcel lockers, one of the alternative delivery methods, is addressed. Parcel lockers have been demonstrated to reduce delivery costs whilst providing flexibility in terms of delivery time. However, due to high rental costs in central areas, they can only be installed in limited numbers. The study developed a mathematical model to determine the locations of five parcel lockers to be installed in the Buca district of Izmir. The model's objective is to optimize the total demand met through the implementation of a discount system that is based on the distance between the customer and the parcel locker. The discount system is structured into three tiers, with the discount rate varying according to the tier in which the customer is located. The mathematical structure of the model incorporates constraints such as the limited number of parcel lockers, capacity limits, and total discount budget, with an objective function that maximizes the total demand met.

Beyond simple geographical placement, the internal configuration of lockers—such as compartment size diversity—impacts location success. [10] investigate the viability of locker networks by combining facility location with layout optimization. They argue that a one-size-fits-all locker design leads to capacity inefficiencies. Their model uses a multi-objective genetic algorithm to determine both the location and the specific module mix (small, medium, large slots) for each site, resulting in a 12% reduction in failed delivery rates due to "locker full" scenarios.

The shift toward out-of-home delivery is extensively analyzed by Zzhang and Demir [21], who who have provided a systematic taxonomy of the Parcel Locker Location Problem. Their work identified that, while earlier models focused purely on cost minimisation, contemporary research must address the Amazon effect by balancing delivery speed with environmental sustainability. It was concluded that the utilisation of parcel lockers has the potential to engender a reduction in last-mile CO_2 emissions, with a maximum potential of 30$\%$, in high-density urban corridors. This is contingent upon the location density satisfying a critical mass of user proximity, with the objective of preventing incidental car trips.

Li and Li [14] proposed a data-driven optimization model that utilized ride-pooling and public transit data to identify optimal locker nodes. Employing a modified p-median algorithm, they demonstrated that placing lockers at transit hotspots minimizes the detour distance for both carriers and ride-pooling passengers. A transit-integrated approach has been demonstrated to enhance utilisation rates of lockers by up to 18$\%$ in comparison with standalone residential placements.

Wang [20] developed a hierarchical model in which the upper level is designed to minimise the total investment and operational costs for the logistics provider. The lower level of the model simulates user behaviour based on an improved gravity model, which quantifies the trade-off between maximum coverage and economic viability. This offers a Pareto-optimal set of locations that satisfy both corporate profitability and social accessibility.

The socio-technical dimension of the parcel locker location problem is explored by Knapskog et al. [12], who focused on multi-level governance. The physical placement of lockers was often constrained by municipal regulations and land-use policies. Logistics equity is a key variable in location models, ensuring that underserved or low-income neighborhoods are not excluded from the benefits of smart delivery. They identified a maximum walking comfort radius of 500–800 meters as the gold standard for access to urban lockers.

Mohammad et al. [15] introduced the notion of Mobile Automated Parcel Lockers. Utilizing a rolling horizon strategy, a dynamic location-allocation model is employed in which autonomous vehicles act as lockers and reposition themselves based on temporal demand shifts (e.g., near office hubs during the day and residential areas in the evening). It has been reported that this dynamic approach resulted in

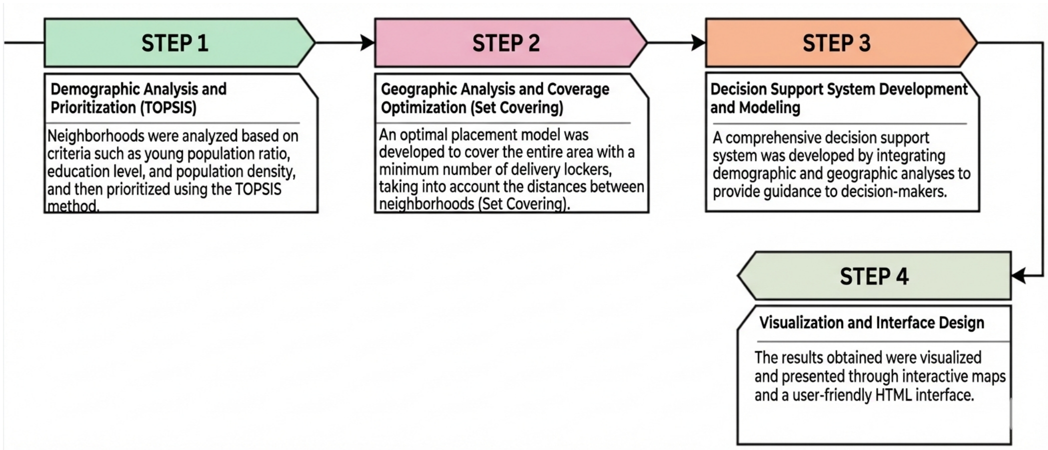

FIGURE 1. The flow chart of the methods

a 25% reduction in the total number of required locker units, while maintaining the same service level as a static network.

In this context, the study to be conducted in the Tepebaşı District of Eskişehir is significant in that it responds to regional needs while also developing solutions that meet the logistics demands of modern urban life. The central objective of this thesis is to enhance the urban delivery infrastructure and to increase accessibility through the strategic placement of smart delivery lockers. The objective of the study is to ascertain the most suitable delivery points within a walking distance. To this end, specific neighbourhoods in the Tepebasi district are divided into clusters.

This paper is organized as follows.

As elucidated in Section 2, the methodology is expounded, and subsequently, in Section 3, the computational outcomes that are derived from the implementation of the methodologies on the Tepebasi district of Eskisehir, Turkey, are presented. Finally, in Section 4, some conclusions are drawn.

2. Methods

In this section, the initial focus is on an explanation of the TOPSIS method, followed by a subsequent discussion of the Set Covering Problem (SCP). The sequence of events is illustrated in Figure 1.

2.1. The technique for order of preference by similarity to ideal solution (TOPSIS).

The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is a multiple criteria decision-making technique developed by Hwang and Yoon in 1981 [9]. The fundamental premise of this approach is the assumption that the alternative solution point is closest to the positive-ideal solution and farthest from the negative-ideal solution. TOPSIS procedure consists of the following steps(see e.g. [16]):

1. Construct the Decision Matrix
   Establish the initial decision matrix Y consisting of m alternatives and n criteria:

$$Y = [y_{ij}]_{m\times n} = \begin{pmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ y_{m1} & y_{m2} & \cdots & y_{mn} \end{pmatrix}$$

2. Calculate the Normalized Decision Matrix
   Normalize the matrix to ensure comparability between different units using vector normalization:
$$r_{ij} = \frac{y_{ij}}{\sqrt{\sum_{i=1}^{m} y_{ij}^2}}, \quad i = 1, \ldots, m;\ j = 1, \ldots, n$$
3. Calculate the Weighted Normalized Decision Matrix
   Apply the weights w_j to the normalized values:
$$v_{ij} = w_j \cdot r_{ij}, \quad \text{where} \sum_{j=1}^{n} w_j = 1$$
4. Determine the Positive and Negative Ideal Solutions
   Identify the Positive Ideal Solution (A^*) and the Negative Ideal Solution (A^-):
$$A^* = \{v_1^*, v_2^*, \ldots, v_n^*\} = \{(\max_i v_{ij} \mid j \in J), (\min_i v_{ij} \mid j \in J')\}$$
$$A^- = \{v_1^-, v_2^-, \ldots, v_n^-\} = \{(\min_i v_{ij} \mid j \in J), (\max_i v_{ij} \mid j \in J')\}$$
   where J represents benefit criteria and J' represents cost criteria.
5. Calculate the Separation Measures
   Calculate the Euclidean distance of each alternative from the ideal solutions:
$$S_i^* = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^*)^2} \quad \text{and} \quad S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2}$$
6. Calculate the Relative Closeness to the Ideal Solution
   Determine the closeness coefficient (C_i^*) for each alternative:
$$C_i^* = \frac{S_i^-}{S_i^* + S_i^-}, \quad 0 \leq C_i^* \leq 1$$
7. Rank the Alternatives
   Rank the alternatives in descending order of C_i^*. The alternative with the highest value is the preferred solution.

The TOPSIS method, a multi-criteria decision-making approach, has been utilised to assign a priority score to each neighbourhood, with the demographic characteristics of the respective neighbourhoods being given due consideration. The creation of these scores, has been informed by various criteria, including population density, the number of students, and the ratio of young and elderly populations. These scores are utilised to inform decision makers. Consequently, it is conceivable that they may elect not to construct a loader that possesses a lower level of confidentiality.

2.2. **Set covering problem (SCP).** The problem under consideration in this study has been modelled and solved within the scope of the Set Covering Problem (SCP), which is one of the classical covering problems (see e.g. [8]). SCP is an optimization problem that aims to select the minimum number of service points to ensure that all demand points on a given geographical or structural network are covered by at least one service point. The successful implementation of such problems is evident in numerous domains, including healthcare, emergency management, public services, logistics and retail distribution (see e.g. [1, 3, 4]). The Set Covering method is generally applied in the following steps:

1. The identification of demand points, denoted by the symbol $i \in I$ and candidate service points, denoted by the symbol $j \in J$.
2. The decision variable x_j is taken 1 if the candiate j is chosen as a locer point, otherwise it is taken zero.

3. The creation of the coverage matrix (a_{ij}) is pivotal in defining these coverage relationships.
4. The establishment of a mathematical model is initiated through the delineation of the objective function and the definition of coverage constraints.
5. The model is to be solved by means of a suitable solver (e.g. Python–PuLP, GAMS-CPLEX, Excel-Solver, Gurobi).
6. The following step involves interpreting the obtained solution and visualising it on a map.

The fundamental mathematical model of the Set Covering problem is expressed as follows:

$$\min \sum_{j \in J} x_j \tag{2.1}$$

$$a_{ij} x_j \geq 1 \tag{2.2}$$

$$x_j \in \{0, 1\} \tag{2.3}$$

The objective function (2.1) is to minimize the number of lockers. (2.2) is imperative that each neighbourhood is covered by at least one locator. (2.3) demonstrate that the decision variable is a binary variable.

3. Application

The Tepebası district of Eskisehir is experiencing increasing population density, construction rates and demographic diversity, which is putting pressure on the delivery infrastructure. In neighbourhoods with a high concentration of multi-storey apartment buildings, traditional cargo delivery methods are sometimes disrupted, resulting in problems such as delays, re-deliveries and customer complaints. Furthermore, delivery traffic during peak hours complicates urban transport and negatively impacts delivery times.

This study aims to maximise user access and increase operational efficiency by placing smart delivery lockers in the most suitable locations in the Tepebaşı district of Eskişehir. The proposed placement strategy aims to improve delivery processes and positively impact environmental and social factors, such as energy consumption, carbon emissions and traffic congestion.

3.1. **Data.**

In the course of the data collection process, alternative data sources were employed in lieu of direct access to field data, which was not feasible. The integration of neighbourhood-based population data, as furnished by Endeksa [5], with geographical coordinates obtained from OpenStreetMap [17], was undertaken for the purpose of establishing analysis units.

In location selection problems, access distance is a parameter that directly affects the success of the model. In this particular context, the distances between neighbourhoods were calculated as geodetic distances using the geopy library in Python [6], utilising coordinate information. The distances for each neighbourhood pair were measured in kilometres (see Appendix).

The neighbourhoods of Bahcelievler, Batikent, Cumhuriyet, Camlica, Ertugrulgazi, Esentepe, Eskibaglar, Fatih, Güllük, Hosnudiye, Kumlubel, Omeraga, Sütlüce, Sarhöyük, Seker, Sirintepe, Tunalı, Uluonder, Yenibaglar, Yesiltepe, and Zafer were selected as the analysis units for the study. Each neighbourhood centre was evaluated as a potential delivery cabinet location, and interactions between neighbourhoods were analysed based on geographical distance. In this context, coverage relationships were determined based on the decisions made by the decision-maker from the cluster radius options presented on the interface, and a data set was created for mathematical modeling.

The TOPSIS method, a multi-criteria decision-making approach, has been utilised to assign a priority score to each neighbourhood, with the demographic characteristics of these neighbourhoods being given due consideration. The criteria and their respective weights are delineated in Table 1.

TABLE 1. Criterias and their weights

Criteria Name	**Weight (w_j)**
Percentage of young people (0-24) (%)	0.40
Percentage of university graduates (%)	0.25
Population	0.20
Population density (people/km^2)	0.15
Percentage of middle age (25-59) (%)	0.10

3.2. **Decision support system.** The user interface has been designed to provide flexibility in spatial planning by allowing users to select from four predefined coverage radius: 0.8, 1.0, 1.2, and 1.5 kilometres. This range facilitates the system's adaptability to diverse urban densities and logistical requirements, thereby catering to both high-density pedestrian zones and more spread-out residential areas. Subsequent to user confirmation of their selection, the underlying optimization algorithm processes the spatial data in order to identify the most strategic delivery locker locations.

The decision supoort system's primary objective is to maximize the service area while ensuring that the selected neighbourhoods are covered efficiently within the specified distance constraints. Through the calculation of the intersection between potential locker sites and neighbourhood demand points, the system generates a localised delivery network that achieves a balance between accessibility and operational costs. This dynamic spatial allocation is visually represented in Figure 2, which illustrates how the algorithm clusters delivery points to provide seamless coverage across the target geography based on the specific radius parameter.

3.3. **Results.** The TOPSIS method was employed to facilitate multi-criteria decision-making. This entailed the consideration of criteria such as the age distribution, education level, population density and cargo demand of the neighbourhoods. The relative priority scores of these criteria were then calculated using a normalised decision matrix. The objective is twofold: firstly, to identify areas that provide coverage, and secondly, to identify high-priority and effective areas. The results can be found in Table 2. In the event of the TOPSIS core rating being in excess of 0.49, the neighbourhood is to be designated as high priority; conversely, should the rating fall below this threshold, the neighbourhood shall be classified as low priority.

The maps seen in Figure 3 below illustrate the extent to which the delivery cabinet centres proposed by the model cover the neighbourhoods according to the selected radius. Each map reflects the cabinet locations proposed by the model according to different threshold values and the neighbourhood areas they cover. The presentability of the solution to decision-makers is as critical as its feasibility. Consequently, interactive map outputs were generated using the Folium library [7] in this study. Folium is an open-source library based on Python that facilitates the addition of point, line, and area markings on maps. The delivery cabinets determined by the SCP model were marked on the interactive map and visualised in conjunction with the neighbourhoods to which they pertain. Concurrently, low-priority areas as determined by TOPSIS evaluations were designated by different colours, and Google Street View links were incorporated into the map. The chosen presentation format ensured that the model outputs could be evaluated technically as well as in terms of field use. The decision-makers were able to swiftly review both coverage and strategic alignment via the map.

4. CONCLUSION

The present study addresses a multi-criteria decision making, and location selection problem aimed at achieving coverage of each cluster with a limited number of smart parcel lockers, specifically in the

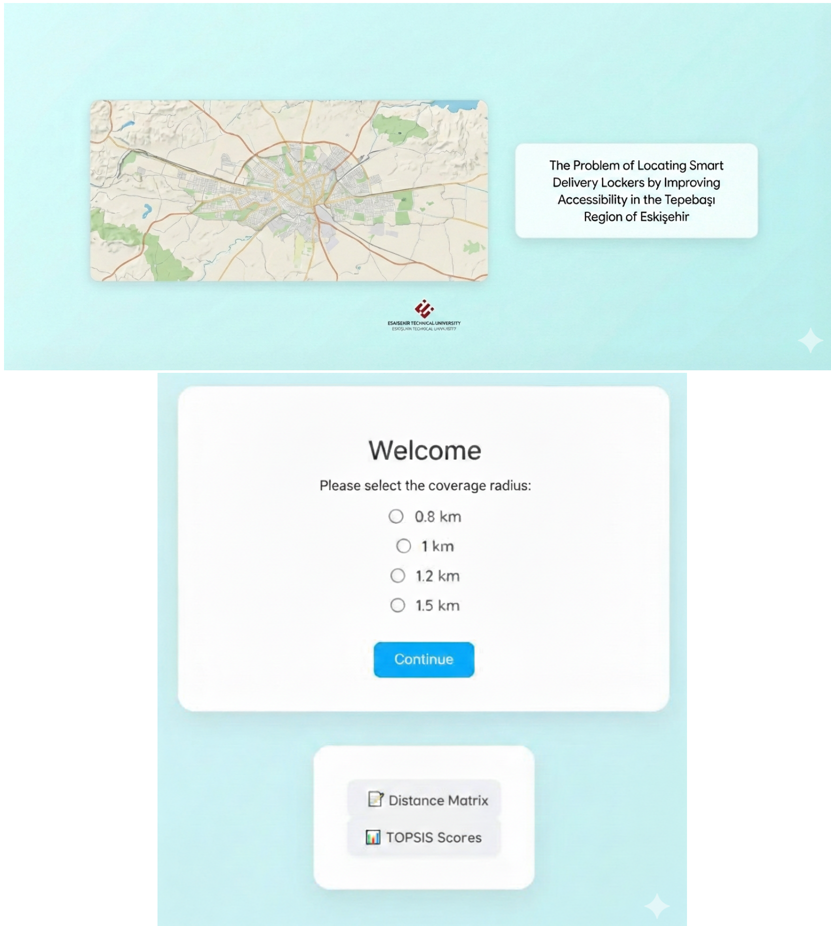

Figure 2. The welcome and selection screens of decision support system

Tepebasi district of Eskisehir, Turkiye. The Set Covering method was employed to optimize neighbourhood based accessibility in solving the problem, while neighbourhood prioritisation was carried out using the TOPSIS method. The integration of these two methodologies resulted in a multidimensional analysis, encompassing both the access distance and the demographic, socio-economic, and logistical characteristics of the respective neighborhoods. The objective of the applied method was to maximize the coverage of neighborhoods while minimising the number of lockers within the specified coverage radius. In light of the findings, the cargo companies may conduct pilot applications for the selected locker placement by SCP in neighborhoods that are found as high-priority by TOPSIS. Addition, this methods are applicable in similar urban logistics planning scenarios.

As a future research, the model can be rendered more sustainable and comprehensive by the addition of environmental and operational criteria, such as carbon emissions, traffic density, and delivery times, to the system.

FIGURE 3. Results based on 0.8km, 1km, 1.2km, and 1.5km, respectively

Table 2. TOPSIS Scores and Priorities of the Neighborhoods

Neighborhood	**TOPSIS Value**	**Priority**
Yenibaglar	0.683005	Yes
Camlica	0.635911	Yes
Batikent	0.612196	Yes
Fatih	0.608509	Yes
Sirintepe	0.562082	Yes
Seker	0.548795	Yes
Yesiltepe	0.540447	Yes
Sarhoyuk	0.530204	Yes
Eskibaglar	0.512458	Yes
Sutluce	0.505632	Yes
Bahcelievler	0.497998	Yes
Kumlubel	0.431954	No
Gulluk	0.420314	No
Zafer	0.395216	No
Omeraga	0.394444	No
Ertugrulgazi	0.393370	No
Hoşnudiye	0.360768	No
Cumhuriyet	0.351795	No
Tunali	0.346240	No
Esentepe	0.345436	No
Uluonder	0.300696	No

Statements and Declarations

The authors declare that they have no conflict of interest, and the manuscript has no associated data.

References

[1] T. Adamo, G. Ghiani, E. Guerriero, and D. Pareo. A surprisal-based greedy heuristic for the set covering problem. *Algorithms*, 16(7):Article ID 321, 2023.

[2] H. S. An, A. Park, J. M. Song, and C. Chung. Consumers' adoption of parcel locker service: protection and technology perspectives. *Cogent Business & Management*, 9(1):Article ID 2144096, 2022.

[3] A. Caprara, P. Toth, and M. Fischetti. Algorithms for the set covering problem. *Annals of Operations Research*, 98(1):353–371, 2000.

[4] L. S. de Pinho. Utilizing heuristics and metaheuristics for solving the set covering problem. *Universidade Porto Journal of Engineering*, 10(3):1–22, 2024.

[5] Endeksa. Endeksa: Real estate data analytics and neighborhood demographics, 2024. Accessed: 2025-06-20.

[6] K. Esmukov and contributors. geopy: Geocoding library for python, 2024. Python package for geocoding and distance calculations.

[7] F. Fernandes and F. contributors. Folium: Python data. leaflet.js maps., 2024. Accessed: 2025-06-20, https://github.com/python-visualization/folium.

[8] M. R. Garey and D. S. Johnson. *Computers and Intractability*, volume 29. Wh Freeman, New York, 2002.

[9] C.-L. Hwang and K. Yoon. *Multiple Attributes Decision Making*. Springer, Berlin, Heidelberg, 1981.

[10] M. Kahr. Determining locations and layouts for parcel lockers to support supply chain viability at the last mile. *Omega*, 113:Article ID 102721, 2022.

[11] O. A. Karabulut, M. K. Seyret, and M. G. Avcı. A mathematical model for the location selection problem of parcel lockers (in turkish). *Journal of Industrial Engineering*, 34(1):26–41, 2023.

[12] M. Knapskog, E. Caspersen, I. Briseid Kraft, H. Herheim, and S. A. Jensen. Policies on parcel lockers: multi-level governance networks for urban logistics. *Planning Practice & Research*, 40(4):932–953, 2025.

[13] U. Lachapelle, M. Burke, A. Brotherton, and A. Leung. Parcel locker systems in a car dominant city: Location, characterisation and potential impacts on city planning and consumer travel access. *Journal of Transport Geography*, 71:1–14, 2018.

[14] Z. Li and B. Li. The data-driven optimization of parcel locker locations in a transit co-modal system with ride-pooling last-mile delivery. *Applied Sciences*, 15(9):Article ID 5217, 2025.

[15] W. A. Mohammad, M. K. Hadid, A. Elomri, and L. Kerbache. Optimising last-mile delivery with mobile automated parcel lockers using rolling horizon strategies. In *Supply Chain Forum: An International Journal*, pages 1–28. Taylor & Francis, 2025.

[16] N. Omurbek, Y. Makas, and V. Omurbek. Selecting software programs for enterprise project management with ahp and topsis. *Journal of Suleyman Demirel University Institute of Social Sciences*, 1(21):59–83, 2015.

[17] OpenStreetMap contributors. Planet dump retrieved from https://planet.openstreetmap.org, 2024. Accessed: 2025-06-20.

[18] S. Signak and Y. Kuvvetli. The bicycle sharing point assignment problem using the cluster covering approach and an application (in turkish). *Nicel Bilimler Dergisi*, 2(2):60–70, 2020.

[19] J. R. van Duin, B. W. Wiegmans, B. van Arem, and Y. van Amstel. From home delivery to parcel lockers: A case study in amsterdam. *Transportation Research Procedia*, 46:37–44, 2020.

[20] M. Wang. A study on the location optimization of smart parcel lockers based on bilevel programming. In *2025 6th International Conference on Mechatronics Technology and Intelligent Manufacturing (ICMTIM)*, pages 531–534, Berlin, Heidelberg, 2025. IEEE, New York.

[21] Q. Zhang and E. Demir. Parcel locker solutions for last mile delivery: A systematic literature review and future research directions. *Frontiers in Future Transportation*, 6:Article ID 1654621, 2025.

APPENDIX

Distance matrix between neighborhoods

	Ertugrulgazi	Kumlubel	Zafer	Omeraga	Tunali	Sarhoyuk	Seker	Bahcelievler	Eskibaglar	Yenibaglar	Hosnudiye	Gulluk	Cumhuriyet	Uluonder	Sirintepe	Yesiltepe	Sutluce	Esentepe	Batikent	Camlica	Fatih
Ertugrulgazi	0.00	4.55	4.55	3.68	3.90	5.13	4.64	3.59	3.13	2.83	2.14	3.52	3.41	2.03	2.27	3.28	3.76	4.20	2.60	1.62	4.22
Kumlubel	4.55	0.00	0.63	1.38	1.01	1.33	1.82	0.99	1.62	1.72	2.50	1.34	1.76	3.10	3.70	2.01	1.30	0.69	5.21	5.55	0.52
Zafer	4.55	0.63	0.00	1.01	0.68	0.78	1.19	1.02	1.44	1.79	2.42	1.08	1.39	3.35	4.02	2.44	1.79	1.25	5.52	5.71	0.40
Omeraga	3.68	1.38	1.01	0.00	0.37	1.45	1.10	0.74	0.58	1.20	1.56	0.24	0.39	2.83	3.57	2.32	1.89	1.64	5.01	4.97	0.87
Tunali	3.90	1.01	0.68	0.37	0.00	1.26	1.17	0.55	0.77	1.23	1.77	0.40	0.76	2.85	3.57	2.17	1.65	1.32	5.04	5.11	0.49
Sarhoyuk	5.13	1.33	0.78	1.45	1.26	0.00	0.88	1.74	2.00	2.48	3.00	1.62	1.77	4.08	4.78	3.22	2.56	2.00	6.26	6.38	1.17
Seker	4.64	1.82	1.19	1.10	1.17	0.88	0.00	1.73	1.67	2.30	2.58	1.34	1.25	3.93	4.67	3.34	2.80	2.37	6.11	6.02	1.42
Bahcelievler	3.59	0.99	1.02	0.74	0.55	1.74	1.73	0.00	0.67	0.78	1.50	0.56	0.99	2.35	3.04	1.62	1.15	0.98	4.53	4.69	0.64
Eskibaglar	3.13	1.62	1.44	0.58	0.77	2.00	1.67	0.67	0.00	0.69	1.00	0.39	0.51	2.27	3.03	1.94	1.68	1.64	4.44	4.39	1.17
Yenibaglar	2.83	1.72	1.79	1.20	1.23	2.48	2.30	0.78	0.69	0.00	0.86	0.97	1.20	1.63	2.37	1.31	1.24	1.44	3.82	3.92	1.42
Hosnudiye	2.14	2.50	2.42	1.56	1.77	3.00	2.58	1.50	1.00	0.86	0.00	1.38	1.32	1.63	2.39	1.96	2.07	2.29	3.66	3.44	2.11
Gulluk	3.52	1.34	1.08	0.24	0.40	1.62	1.34	0.56	0.39	0.97	1.38	0.00	0.44	2.60	3.34	2.09	1.70	1.51	4.78	4.78	0.85
Cumhuriyet	3.41	1.76	1.39	0.39	0.76	1.77	1.25	0.99	0.51	1.20	1.32	0.44	0.00	2.76	3.52	2.44	2.12	1.95	4.90	4.77	1.25
Uluonder	2.03	3.10	3.35	2.83	2.85	4.08	3.93	2.35	2.27	1.63	1.63	2.60	2.76	0.00	0.77	1.35	1.99	2.55	2.19	2.51	2.96
Sirintepe	2.27	3.70	4.02	3.57	3.57	4.78	4.67	3.04	3.03	2.37	2.39	3.34	3.52	0.77	0.00	1.76	2.48	3.09	1.51	2.20	3.62
Yesiltepe	3.28	2.01	2.44	2.32	2.17	3.22	3.34	1.62	1.94	1.31	1.96	2.09	2.44	1.35	1.76	0.00	0.73	1.35	3.25	3.84	2.06
Sutluce	3.76	1.30	1.79	1.89	1.65	2.56	2.80	1.15	1.68	1.24	2.07	1.70	2.12	1.99	2.48	0.73	0.00	0.63	3.98	4.49	1.43
Esentepe	4.20	0.69	1.25	1.64	1.32	2.00	2.37	0.98	1.64	1.44	2.29	1.51	1.95	2.55	3.09	1.35	0.63	0.00	4.59	5.05	0.95
Batikent	2.60	5.21	5.52	5.01	5.04	6.26	6.11	4.53	4.44	3.82	3.66	4.78	4.90	2.19	1.51	3.25	3.98	4.59	0.00	1.47	5.12
Camlica	1.62	5.55	5.71	4.97	5.11	6.38	6.02	4.69	4.39	3.92	3.44	4.78	4.77	2.51	2.20	3.84	4.49	5.05	1.47	0.00	5.33
Fatih	4.22	0.52	0.40	0.87	0.49	1.17	1.42	0.64	1.17	1.42	2.11	0.85	1.25	2.96	3.62	2.06	1.43	0.95	5.12	5.33	0.00