International Journal of Information, Control and Computer Sciences
ISSN: 2517-9942
Vol:10, No:3, 2016

Solution of Logistics Center Selection Problem Using the Axiomatic Design Method

Fulya Zaralı, Harun Resit Yazgan

Abstract**—**Logistics centers represent areas that all national and international logistics and activities related to logistics can be implemented by the various businesses. Logistics centers have a key importance in joining the transport stream and the transport system operations. Therefore, it is important where these centers are positioned to be effective and efficient and to show the expected performance of the centers. In this study, the location selection problem to position the logistics center is discussed. Alternative centers are evaluated according certain criteria. The most appropriate center is identified using the axiomatic design method.

Keywords**—**Logistic center, axiomatic design, facility location, information systems.

I. Introduction

LOGISTICS centers are the regions, which are situated in the official institutions related to logistics and transport companies, in possession of active links to all kinds of modes of transport, the possibilities to perform activities such as storage, maintenance and repair, loading and unloading, handling, weighing, loads splitting, merging, packing, and low-cost, fast, secure, transfer areas and equipment between the transport modes. Due to the fact that the logistics centers play a major role in unifying the transport stream and the transport system operations, it is also important where these centers will be positioned. One of the factors affecting the choice of location is the requirement for the combined use of different transport modes in these centers. Considering the important logistics centers in Europe, it is seen that they are close to the main rail, the highway and the sea way. A logistics center established on a good location provides that the logistics processes are made better quality and the international trade services-more efficient, and all of the bureaucratic procedures are completed in one spot. Thus, productivity increases and contributes to the national economy [1].

When defining the design of the logistics center, client infrastructures, the post office/bank/insurance, offices, intermodal terminals, warehouses, and other public services should be defined. Infrastructure must be created for storage and integrated service. There should be sales and leasing areas of warehouse and office. Administration building should be for the management of the logistics center. The objectives of all businesses operating in the logistics centers should be to provide high quality such matters as the optimization of the logistics chain, the optimization of the level of use of trucks and warehouse, the optimization of labor organizations, reduction of total transport activities and total industrial costs with the personnel costs, the increase of total turnover of transport operators [2]. In this study, by using axiomatic design method, the most appropriate location selection is made.

Fulya Zaralı is with the Develi Vocational High School Logistics Program, Erciyes University, Kayseri/Turkey (e-mail: fzarali@erciyes.edu.tr).
Harun Resit Yazgan is with the Faculty of Engineering, Department of Industrial Engineering, Sakarya University, Sakarya/Turkey (e-mail: yazgan@sakarya.edu.tr).

II. Literature Survey

Determination of logistics centers can be evaluated as facility location problems. Facility layout can be also considered within the scope of the complex and multi-criteria decision-making problems. There is a need to further analysis to select the most appropriate location for a facility.

Many methods are used in the evaluation of logistics centers and in the selection of alternative locations. The appropriate location selection for logistic center from a lot of alternative places requires multi-criteria decision-making methods. Mathematical models are employed to select location selection problem in literature [3], [4].

Multi-criteria decision-making techniques are also often used [5]. The method of Fuzzy AHP and Electra is used also in the example of the specific values discussed as fuzzy [6], [7]. Kayikci Y. found the optimal location by combining Fuzzy AHP and the artificial neural network method for the logistics center location selection [8]. Li used a TOPSIS method for the logistics center location selection [9]. Liu employed an AHP method for the logistics center location selection [10]. A genetic algorithm method is applied by Wang [7]. Also unlike them, Liu identified several methods for the logistics center location selection. By using the method of center of gravity, location selection is made [11].

When examining studies on axiomatic design, we see that Suh and Do used the axiomatic design principles for software design and to create a large software system by starting out from the matters of software development for manufacturing firms in their study done by them in 2000 [12]. Chen established a decision support system based on knowledge to improve the performance of the location centers converted into a cell type created using the independence axiom in the study [13]. Jengaand Yango used the axiomatic design methods for the optimization of propeller design, the main engine selection, and barge design in the ship design [14].

Kulak, Kahraman employed together with AHP and axiomatic design method for selection of multi-criteria transportation company for an efficient supply chain in their study. The criteria for selection of the company (cost, time, damage/loss, flexibility, the ability of the documentation) have been determined. Software for axiomatic design and fuzzy axiomatic design to make the most appropriate choice has been developed [15]. Gu and Rao have combined the axiomatic design approach with the systematic design approach for product design in their study and adapted it to a furniture manufacturing system [16]. Kulak and Kahraman evaluated a production system according to pre-selected performance criteria based on axiomatic design principles in the studies and presented the results by applying a manufacturing company [17]. Kulak developed a decision support system (fuzzy multi-criteria material handling selection) considering such factors as efficient use of labor, ensuring system flexibility, increasing productivity, reducing lead times and costs for material handling selection. Finally, the final decision was given for selecting the most appropriate equipment from among the same type alternatives by using the information axiom of axiomatic design [18]. Due to the fact that transport costs and drive health significantly are affected depending on the selected route in this study, Murat and Kulak provided an approach using the information axiom in the evaluation and in the selection of the most appropriate route for drivers by considering criteria required for being taken into account in the choice of such route as travel time, the level of obstruction, safety and environmental factors. For precise (crisp) criteria values and also for the classical knowledge axiom and fuzzy criteria values, they performed an application including the fuzzy information axiom [19]. Özel and Özyörük compared the two methods using fuzzy axiomatic design and weighted fuzzy axiomatic design method for supplier selection problem for a company being white goods manufacturer in their study [20]. Durmuşoğlu and Kulak showed the axiomatic design method on an application including the actual data for the design of an effective office operation in their study [21]. Çelik used the axiomatic design and TOPSIS methods in order to determine the competitive conditions of the container ports in Turkey in the study. He also benefited from the SWOT analysis to evaluate data entry and the results. Besides, a hybrid approach was presented in order to contribute to the maritime sector in Turkey and applied to İzmir, Haydarpaşa, Mersin, Ambarlı, Gemport ports [22]. Kahraman and Çebi applied the hierarchical fuzzy axiomatic design method on the assistant selection problem by evaluating alternatives in a fuzzy environment in their study [23]. Pecka and Kum used the axiomatic design principles for the design and optimization of the health system in their study [24]. Kulak applied the fuzzy axiomatic design method for a bank to be compared the characteristics of IT systems [25]. Kulak, Cebi and Kahraman made a compilation by examining studies conducted about the axiomatic design in their study. They classified according to the methods and application fields [26]. Cebi and Kahraman used the axiomatic design principles for the design of the instrument paneling for vehicles in their study in 2010 and stated that they determined the most appropriate instrument paneling design using also the fuzzy axiomatic design method from among 18 alternatives [27]. Büyük and Özkan made an assessment of logistics vehicles under different criteria in their study [28]. Tatlı applied the fuzzy axiomatic design method for the selection of logistics companies [29]. Taha and others investigated the ergonomic design principles using axiomatic design principles in their study. Customer requests and suggestions were taken through questionnaires in the virtual environment and they developed the design principles of robotic manufacturing system [30]. Yazgan et al. used the fuzzy axiomatic design method to add the fuzzy values encountered in the solution of scheduling problems to the problem. The application was conducted for a company operating in the food industry [31]. Kannan et al. made a choice by using also the fuzzy axiomatic design method in order to make the best choice of green suppliers for a plastics company in their studies [32].

III. The Methods

A. Axiomatic Design

Axiomatic design is defined by the interaction of questions “What do we want to achieve?” and “How do we make it?” It is a design method developed by Suh. The design method with the axioms allows early destruction of the undesirable features of design, the focus on the intended purpose, and determination of the criteria used in the delivery of design decisions [33]. There are two axioms of design method with the axioms.

The first one is the Independence Axiom, and the second is the Information Axiom [33].

- Independence axiom: In a suitable design, a parameter of the design is the arrangement to provide the related functional requirement without affecting other functional needs. Normally, engineers are trying to independently solve by separating a problem into sub-problems.

When two or more functional are required, the design must ensure each functional requirements without affecting other functional need. This happens only with the selection of the correct parameter set.

- Information Axiom: A possibility to ensure a given functional need. Here is taken into account the information content. When functional of series of n is required, total information content is the sum of all these possibilities. If the total is equal to 1, information content is 0. If the sum of probabilities is greater than 1, the required knowledge is infinite. Data content is determined by the interaction between the tolerances specified by the designer. Information content is calculated according to:

$$I = \log_2\left(\frac{Common\ Range}{System\ Range}\right) \quad (1)$$

where, I: Information Content, A_S= System Area, A_C= Intersection Area. While A_c in this connection shows how much the properties possessed by the system provide the expected ones, A_s system area allows us only to know the properties of the system.

The Information Axiom being the second one primarily argues that the designs having the minimum information content from the designs providing the independence axiom are the best [26].

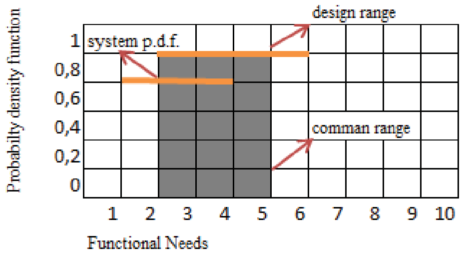

Fig. 1 System range Design range, common range and system probability distribution function of the functional needs

B. Fuzzy Axiomatic Design

Data being specific for certain is expressed with real numbers. But in real life, data can sometimes be represented by linguistic variables, not by numbers. Such data must be converted to digital form adhering to certain rule base. For this, fuzzy set theory is used.

Fuzzy Axiomatic Design allows us to make decisions even when data is qualitative. When data is given as a linguistic, triangular or trapezoidal fuzzy membership functions are used in the situations, where the probability density function is specific. The intersection area of triangular or trapezoidal fuzzy numbers is the common area in Fig. 2. Information content is calculated according to (2) [34]:

$$I = \log_2 \frac{\textit{Triangular Fuzzy Area of System Design}}{\textit{Common area}} \quad (2)$$

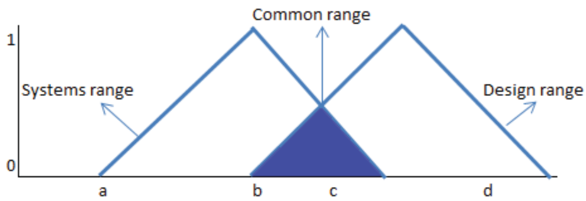

Fig. 2 Common area of system and design ranges

IV. The Proposed Approach

1- First, determination of the alternative lands is identified by forming a team of experts.
2- Treasury lands are selected by examining the ownership conditions of the determined lands.
3- A literature research for the evaluation of alternative locations are performed and 9 criteria are identified.
4- The axiomatic design method is employed to evaluate alternative locations.

V. An Application

Defining the location of the logistics center is very important for using the center efficiently. Having the possibility of using different transportation modes at the same time by choosing the location of the logistics center is one of the prior criteria. The connection to the railways, highways, airlines and maritime lines are taken into consideration by choosing the location of the center. In order to make a convenient decision and prevent facing irreversible difficult problems the choice criteria must be defined for making the decision [35].

Location choice are made within the context of this study in order to have an efficient and affective usage of the logistics center, which is being planned to be built in Kayseri. A model is developed for the choice of the location using axiomatic design method. By taking the expert opinions into consideration and by meeting firstly the managers of five logistics company in Kayseri, which are making international transportation and leading the setup of the center, Metropolitan Municipality of Kayseri Department of Settlement and Planning, Municipality of Melikgazi Department of Settlement and Planning and Vice President of UND, the locations are defined. Property conditions are searched together with Metropolitan Municipality of Kayseri Department of Settlement and Planning. Taking especially the public lands or the ones that are not being zoned for construction into consideration four alternative locations are defined as shown in the Fig. 3. Alternative locations are:

- ✓ Incesu Location
- ✓ Anbar Location
- ✓ Bogazkopru Location
- ✓ Mimarsinan Location

For the evaluation of these four locations literature search is made and thus nine criteria are decided. These criteria and their explanations are given in Table I.

In order to choose a location by axiomatic design, the first thing to do is to calculate the information content of each of the alternatives. Thus the design intervals of the functional needs are to be calculated. A questionnaire is prepared for this purpose and a survey is done to the 38 companies connected with the International Transportation Association of Kayseri and thus the design intervals of the functional needs are defined. Design intervals are given in the Table II. Questions of the questionnaire are given in the Appendix.

TABLE I
CRITERIA

Criteria	Explanation
Land	Expresses the land where a logistics center is to be setup.
Expansion Field	The part giving expansion possibilities to the logistics center except the setup area.
Infrastructure Possibilities	Cover ability of the needs such as electricity, water, internet etc for the lands that are chosen for the setup of the logistics centers.
Closeness to the Province	Closeness of the logistics center to the city as mileage, where the center is to be setup
Closeness to industry and trade zones	Closeness of the logistics center to the industry and trade zones as mileage
Closeness to the port	Closeness of the logistics center to the harbor as mileage
Closeness to the highways	Connection of the logistics centre to the highways
Connection to the railways	Connection of the logistics centre to the railways
Area costs	m^2 costs of the area where the logistics center to be built

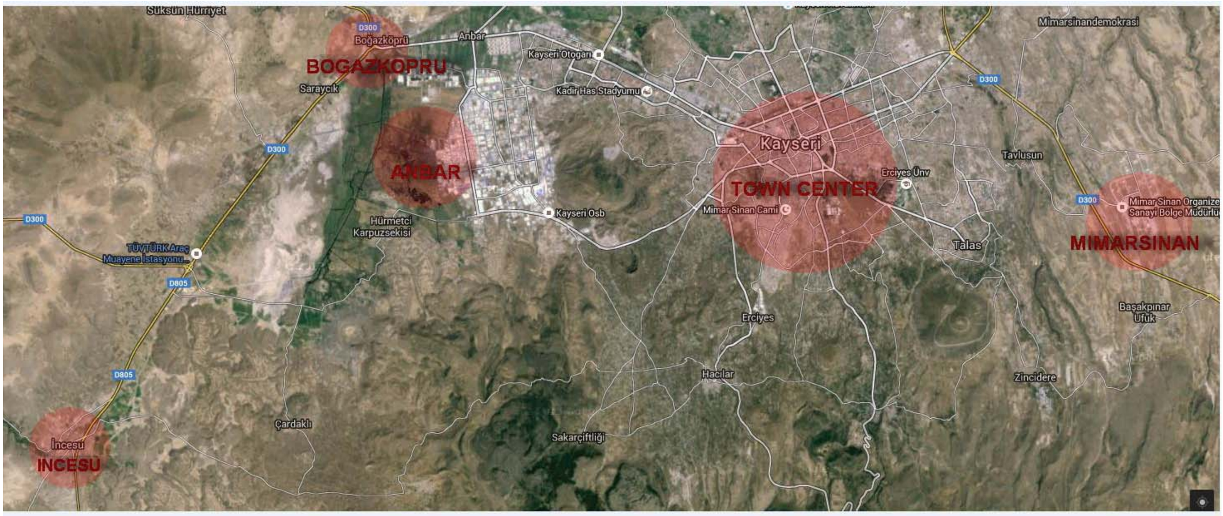

Fig. 3 Alternative Locations

TABLE II
DESIGN INTERVALS OF THE FUNCTIONAL NEEDS

Criteria	Design Intervals
Area	1000000-3000000
Expansion Field (%)	10-25
Infrastructure Possibilities	Very Good
Closeness to the province	10-30
Closeness to industry and trade zones	3-10
Closeness to the port	319-450
Connection to the highway	Very Good
Connection to the railway	Very Good
Area costs	50-100

The system characteristics of the criteria equals belonging to the alternative locations are given in the Table III. System data is expressed both as numeric and linguistic. Numeric system data is defined as minimum and maximum. Information and structure data and the center costs of the areas are received from Metropolitan Municipality of Kayseri Department of Settlement and Planning, Municipality of Melikgazi Department of Settlement and Planning. Other system characteristics are received via the results of the questionnaire applied to the 38 companies connected with the International Transportation Association of Kayseri.

System Intervals for the alternative locations are given in Table III.

The system data include the exact and linguistic information as seen in Table III. For the exact data "*Exact Data Axiom Approach*", and for the linguistic data "*Fuzzy Information Axiomatic Approach Method"* are used. The information content of the exact data is calculated by using (1) and the information content of the lingual data is calculated by using (2).

It will be expressed in this study how the information content is calculated for just one alternative location. İncesu Location is chosen for this purpose and shown in the following calculations. Area, expansion field (%), infrastructure possibilities, closeness to the province, closeness to industry and trade zones, closeness to the harbor, connection to the highway connection to the railway and area costs are the criteria taken into consideration, design and system intervals are uniform ranges included low and top values. Information content calculation methods are illustrated in figures.

TABLE III
SYSTEM INTERVALS FOR THE ALTERNATIVE LOCATIONS

Criteria	Incesu	Anbar	Bogaz Kopru	Mimarsinan
Area	500000-2500000	700000-2000000	500000-1500000	2000000-3500000
Expansion Field (%)	5-15	10-15	10-20	10-30
Infrastructure Possibilities	Very Good	Very Good	Good	Good
Closeness to the province	25-35	10-15	10-20	15-30
Closeness to industry and trade zones	8-15	3-5	4-6	7-15
Closeness to the port	300-425	315-440	315-446	300-430
Connection to the highway	Very Good	Very Good	Good	Good
Connection to the railway	Good	Good	Very Good	Poor
Area costs	80-120	50-70	60-100	80-150
Area structure	Very Good	Bad	Good	Very Good

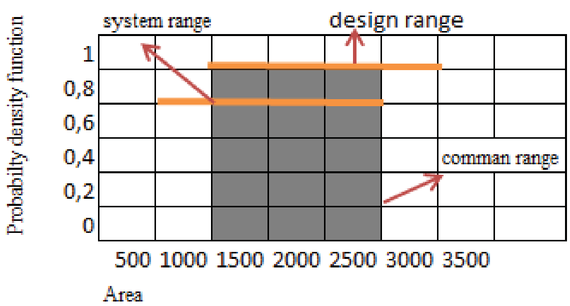

Fig. 4 Information content account for the criteria area

$$I_{iArea} = log_2\left(\frac{2500 - 500}{2500 - 1000}\right) = 0{,}411$$

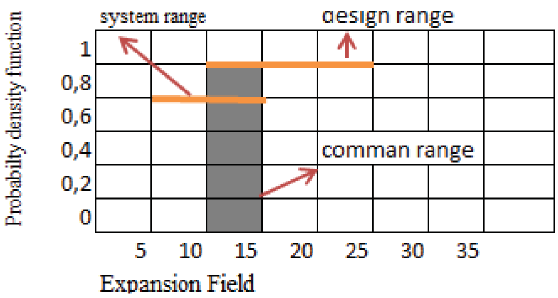

Fig. 5 Information content account for the criteria of the expansion space of İncesu location

$$I_{\dot{I}expan.f.} = log_2\left(\frac{15-5}{15-10}\right) = 1$$

Due to the fact that system range related to the expansion space is within the design range, the result is 1.

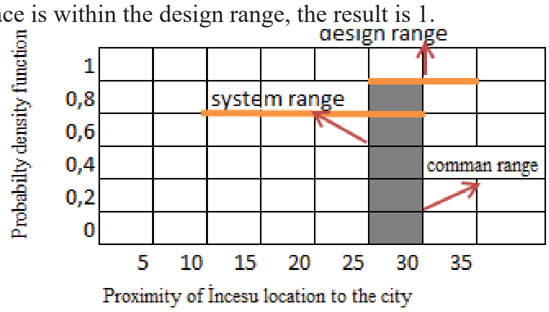

Fig. 6 Information content account for the criteria of proximity of İncesu location to the city

$$I_{\dot{I}prox.loc.} = log_2\left(\frac{35-25}{30-25}\right) = 1$$

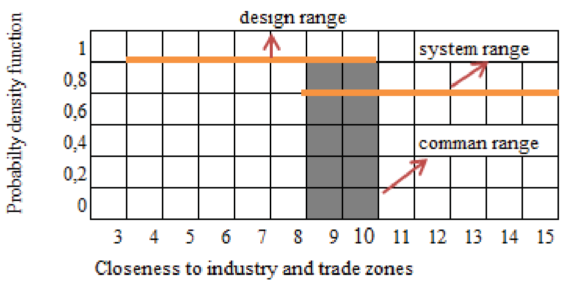

Fig. 7 Information content account for the criteria of proximity of İncesu location to the industrial and commercial center

$$I_{\dot{I}closness\ industrial} = log_2\left(\frac{15-8}{10-8}\right) = 1{,}807$$

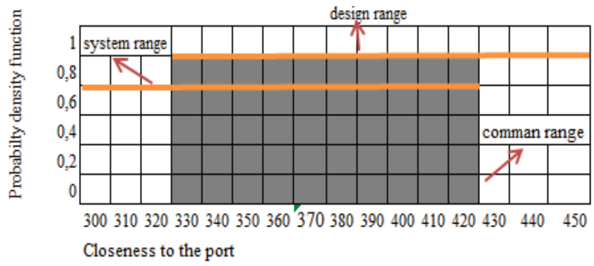

Fig. 8 Information content account for the criteria of proximity of İncesu location to the port

$$I_{\dot{I}closnessport} = log_2\left(\frac{425-300}{420-319}\right) = 0{,}258$$

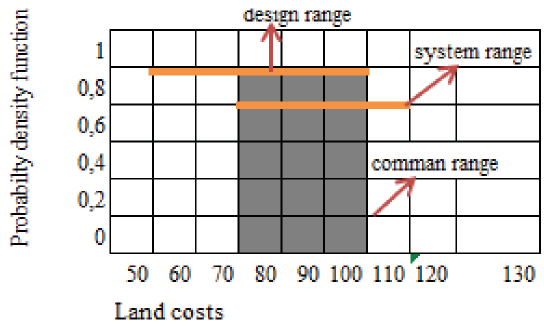

Fig. 9 Information content account for the criteria of proximity of İncesu location to the land costs

$$I_{\dot{I}landcost} = log_2\left(\frac{120-80}{100-80}\right) = 1$$

Infrastructure facilities, the highway connections and rail links for İncesu location, is expressed as linguistic. Linguistic expressions are defined as fuzzy data. Such data must first be converted into fuzzy numbers. The phrases used for conversion are given in Table IV and Fig. 10.

TABLE IV
NUMERICAL EXPRESSION OF THE LINGUISTIC VARIABLES

0	0	6	BAD
3	7	11	MEDIOCRE
8	12	16	GOOD
13	17	21	VERY GOOD
18	25	25	PERFECT

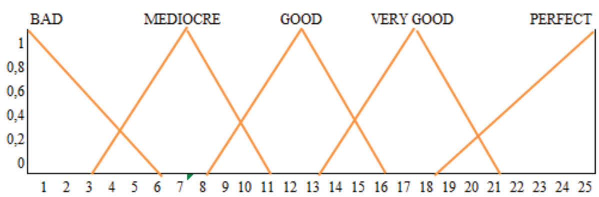

Fig. 10 Triangular Fuzzy Number

According to the survey, it is defined as triangular fuzzy numbers that the design range of infrastructure facility for Incesu is 14, 20, 25; the highway connection is 13, 21, 24 and the rail link is 8, 15, 22. The system ranges are also represented by the triangular fuzzy numbers and the information content is calculated for uncertain data. The common area being intersection of the design and system ranges gives the possibility of meeting the functional requirement. Information content is calculated using Fig. 11 and (2) and the common area is found.

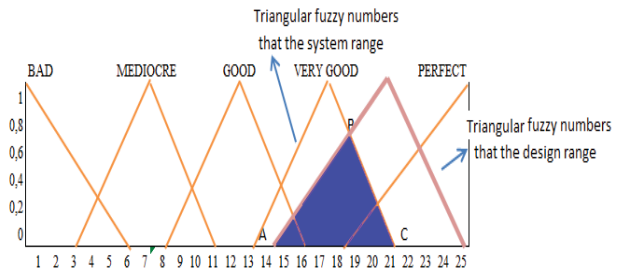

Fig. 11 Information content account for the criteria of the infrastructure facilities of İncesu location. The area of triangle ABC refers to the common area between the design and the system areas. A(ABC)=2.8

$$I_{iA} = log_2\left(\frac{(25-14)*1/2}{2.8}\right) = 0.971$$

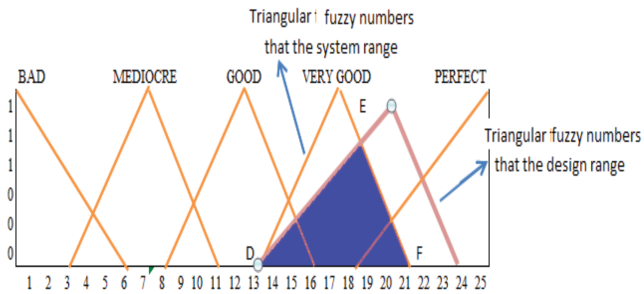

Fig. 12 Information content account for the criteria of the highway connection of İncesu location. The area of triangle DEF refers to the common area between the design and the system areas. A(DEF)=3.05

$$I_{Ihighway\ con.} = log_2\left(\frac{(24-13)*1/2}{3.05}\right) = 0.85$$

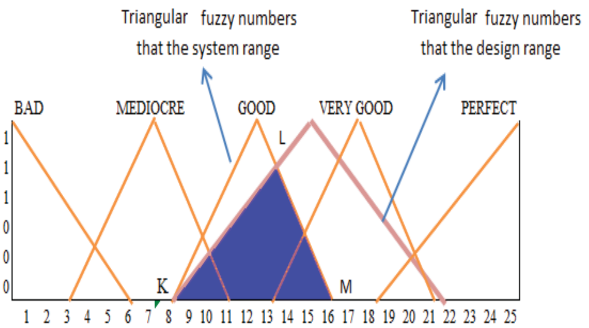

Fig. 13 Information content account for the criteria of the railway connection of İncesu location. The area of triangle KLM refers to the common area between the design and the system areas. A (KLM)=3.32

$$I_{Irailway\ con.} = log_2\left(\frac{(22-8)*1/2}{3.32}\right) = 1.075$$

Similar calculations have been made also for the other alternative places and the information content determined in Table IV is given.

TABLE V
INFORMATION CONTENT REPRESENTATION

CRITERIA	$I_İ$	I_A	I_B	I_M
Area	0,41	0,378	1	0,584
Expansion Area (%)	1	0	0	0,422
Infrastructure facilities	0,971	0,971	2,577	2,577
Proximity to the town	1	0	0,485	1,584
Proximity to the industrial and commercial center	1,807	0	0	1,42
Proximity to the port	0,238	0	0	0,226
Highway connection	0,85	0,85	3,67	3,67
Railway connection	1,075	1,075	0,799	3,896
Land Costs	1	0	0	1,807
Total	**8,352**	**3,274**	**8,531**	**16,18**

According to the results of the information content in Table V, warehouse location with minimum information content should be chosen. Because according to the axiomatic design principle, the design with less information content is the best design. The location with less information content is warehouse. The location of Mimarsinan with maximum information content is the last place to be selected.

VI. Results and Conclusion

Axiomatic design technique is one of the multi-criteria decision-making methods used in the evaluation together with the definite and indefinite data. It helps decision maker by evaluating precise and uncertain data. In our study four alternative locations for logistics center were identified and 9 criteria identified for the optimal location from among these four locations. Such criteria as area, expansion space, proximity to the city, proximity to industrial and commercial centers, and the cost of land were expressed in absolute terms and such criteria as the infrastructure facilities, highway connection and rail connection as fuzzy. The design ranges for criteria were determined by applying questionnaire to 38 logistics companies. When the design ranges and systems ranges change, the total of information content will be also change. The results minimizing the information content would be the most appropriate results. According to the data, the information content was calculated and the location with the minimum information content selected as the most suitable place.

Appendix

This survey study is being conducted by the logistic firm owners in order to model the most appropriate location which will be used as the center of the Logistics village/center being planned to be created in Kayseri. Thank you for your time.
Alternative locations
✓ Incesu Location

- ✓ Anbar Location
- ✓ Boğazköprü Location
- ✓ Mimarsinan Location

Firm Name and Address:

- Question 1. Which one of the alternative locations above would you prefer for the establishment of the Logistics center/village?
- Question 2. How many square meters should the logistics village/center cover?
- Question 3. How much should the enlargement area be after the logistics center/village is established? (In %)
- Question 4. Would you evaluate the infrastructure opportunities of a logistics center/village as bad, average, very good, perfect?
- Question 5. How many kilometers should the closeness of a logistics center be to a city?
- Question 6. How many kilometers should the closeness of a logistics center to industrial and commercial centers?
- Question 7. How many kilometers should the closeness of a logistics center to a port?
- Question 8.Would you evaluate the highway connection opportunities of a logistics center/village as bad, average, very good, perfect?
- Question 9.Would you evaluate the railway connection opportunities of a logistics center/village as bad, average, very good, perfect?
- Question 10.What should be the land area costs of a logistics center?

REFERENCES

[1] E. Akçetin, "Avrupa Birliğine üyelik sürecinde Küresel Lojistik üs olma yolunda Türkiye" Adıyaman Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, ISSN: 1308-9196 yıl:3 Sayı:5, 2010 (in Turkish).
[2] Logistics Centers Direction for use Euro Platforms, EEIG
[3] E Taniguchi, M Noritake, T Yamada, "Optimal size and location planning of public logistics terminals" Research Part E: Logistics, Elsevier, 1999.
[4] X.Wang, Z. Zheng, M. Li, "Dynamic dual-diamond evaluation of logistics center location". Journal of University of Science and Technology Beijing, 6, 2005.
[5] Y. Chen, Qu L. "Eveluating the selectin of logistics center location using fuzzy MCDD model based on entropy weight" The IEE Proceedings of 6th Congress on Intelligent Control and Automation, 2006.
[6] K. Ghoseiri, J. Lessn "Location selectin for logistics centers using a two-step fuzzy AHP and ELECTRE method. Proceedings of 9th Asia Pacific Industrial Engineering & Management systems Conference, Indonesia, pp.434-440, 2008.
[7] B. Wang, S. He, "Robust Optimization Model and Algorithm for Logistics Center Location and Allocation under Uncertain Environment", Journal of Transportation Systems Engineering and Information Technology, Volume 9, Issue 2, Pages 69-74, 2009.
[8] Y. Kayıkcı, "Conceptual model for intermodal freight logistics center location decisions", Procedia-Social and Behavioral Sciences, Elsevier, 2010.
[9] Y. Li, X. Liu, Y. Chen, "Selection of logistics center location using Axiomatic Fuzzy Set and TOPSIS methodology in logistics management", 2010, Journal homepage:www.elsevier.com/locate/eswa
[10] H. Liu, X. Zhang," Study on location selection of multi-objective emergency logistics center based on AHP, Procedia Engineering, Volume 15, Pages 2128-2132, 2011.
[11] X.Liu, X. Guo, X. Zhao, "Study on Logistics Center Site Selection of Jilin Province", Journal of Software, vol 7. No:8, pp.1799-1806, 2011.
[12] N.P. Suh, S. Do, "Axiomatic design of software systems", Annals of the CIRP, 49(1), pp. 95–100, 2000.
[13] S.J. Chen, L. Lin, "Knowledge-based Support for Simulation Analysis of Manufacturing Cells", Computers in Industry, 44, pp.33-49, 2000.
[14] B. Janga, Y. Yanga, "Axiomatic design approach for marine design problems", Marine Structures 15, pp.35–56, 2002.
[15] O. Kulak, C. Kahraman, "Fuzzy multi-attribute selection among transportation companies using axiomatic design and analytic hierarchy process" Information Sciences, 170, pp. 191–210, 2002.
[16] P. Gu, H. Rao, M.Tseng, "Systematic Design of Manufacturing Systems Based on Axiomatic Design Approach" Kyonggi-do, 467-711, South Korea Axiomatic Design Software, Inc. 221 N. Beacon Street, Boston, MA USA, 2002.
[17] O. Kulak, C. Kahraman, "Multi-attribute comparison of advanced manufacturing systems using fuzzy vs. crisp axiomatic design approach", International Journal of Production Research, 95, pp. 415-424,2005.
[18] O. Kulak, "A decision support system for fuzzy multi-attribute selection of material handling equipment", Expert Systems with Applications, 29, pp.310–319,2005.
[19] Y. Murat, O. Kulak, "Ulaşım ağlarında bilgi aksiyomu kullanılarak güzergah (rota) seçimi", Pamukkale Üniversitesi Mühendislik Fakültesi Mühendislik Bilimleri Dergisi, 11(3): pp.425- 435, 2005. (in Turkish)
[20] B. Özel, B. Özyürek, "Bulanık aksiyomatik Tasarım ile Tedarikçi Firma Seçimi" Gazi Üniv. Müh. Mim. Fak. Der. Cilt 22, No:3, pp.415-423, 2007. (in Turkish)
[21] M. Durmuşoğlu, O. Kulak, "A methodology for the design of office cells using axiomatic design principles", Omega,36(4), pp.633-652 2008.
[22] M. Celik, "A hybrid design methodology for an integrated environmental management systems for shipping business, Journal of Environmental Management, 90, pp.1469-1475, 2009.
[23] C. Kahraman and S. Cebi, "A new multi-attribute decision making method: Hierarchical fuzzy axiomatic design", Expert Systems with Applications 36(3), pp. 4848- 4861, 2007.
[24] J. Pecka, Nightingalea, S. Kim, "Axiomatic approach for efficient healthcare system design and optimization", CIRP Annals - Manufacturing Technology 59, pp.469–472, 2010.
[25] O. Kulak, "A decision support system for fuzzy multi-attribute selection of material handling equipment". Expert systems with applications, 29, pp.310-319, 2010.
[26] O. Kulak, S. Cebi, C. Kahraman, "Applications of axiomatic design principles: A literature review" Expert Systems with Applications, 37, pp. 6705–6717, 2010.
[27] S. Cebi, C. Kahraman, "Indicator design for passenger car using fuzzy axiomatic design principles", Istanbul, Turkey Expert Systems with Applications, 37, pp.6470–6481, 2010
[28] G. Büyüközkan, J. Arsenyan, D.Ruan "Logistics tool selection with two-phase fuzzy multi criteria decision making: A case study for personal digital assistant selection" Expert Systems with Applications, Volume 39, Issue 1, Pages 142–153, 2012.
[29] C. Tatlı, H. Yazgan, S. Kır, "Selection of a logistic firm by the axiomatic design approach", European Conference in Technology and society, 2013.
[30] Taha Z., Soewardi H., Dawai S., 2014 "Axiomatic design principles in analyzing the ergonomics design parameter of a virtual environment", International Journal of Industrial Ergonomics, Volume 44, Issue 3, Pages 368-373.
[31] H. Yazgan, S. Kır, S. Özbakır, E. Sezik, "Sıra Bağımlı tek makineli çizelgeleme probleminde erkenlik ve geçlik katsayılarının bulanık aksiyomatik tasarım yöntemi ile belirlenmesi", Endüstri Mühendisliği Dergisi, Cilt 25 Sayı 3-4, Sayfa 20-32, 2014. (in Turkish)
[32] D. Kannan, G. Kannan, R. Sivakumar "Fuzzy Axiomatic Design approach based green supplier selection a case study from Singapore." In: Journal of Cleaner Production, 2014.
[33] N.P. Suh, "Axiomatic design; advanced applications", Oxford University Press, New York, 2001.
[34] B. Özel, B. Özyürek, "Bulanık aksiyomatik Tasarım ile Tedarikçi Firma Seçimi" Gazi Üniv. Müh. Mim. Fak. Der. Cilt 22, No:3, pp. 415-423, 2014. (in Turkish)
[35] M. Elgün, "Ulusal ve uluslararası taşıma ve ticarette lojistik köylerin yapılanma esasları ve uygun kuruluş yeri seçimi" Afyon Kocatepe Üniversitesi, İİBF Dergisi C.XIII, S II, 2011. (in Turkish)