REPUBLIC OF TURKEY

ADANA ALPARSLAN TÜRKEŞ SCIENCE AND TECHNOLOGY UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

DEPARTMENT OF INDUSTRIAL ENGINEERING

FACILITY LOCATION DECISION USING FUZZY MULTI-CRITERIA DECISION MAKING : A CASE STUDY IN A FEEDMILL COMPANY

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MASTER OF SCIENCE

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ADANA 2019

I hereby declare that all information in this thesis has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all information that is not original to this work.

Emir GÜLDAL

ABSTRACT

FACILITY LOCATION DECISION USING FUZZY MULTI-CRITERIA DECISION MAKING :A CASE STUDY IN A FEEDMILL COMPANY

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The selection of facility location is very important for the sustainability and profitability of the enterprises. There is a possibility that the company will go bankrupt because of a wrong location. Appropriate methods should be used when making strategic decisions where the results can be so destructive. This study provides a suitable location for a new facility in eastern region for a feed company operating in different regions. The problem is formulated by using Fuzzy TOPSIS and Fuzzy VIKOR, which are the methods for MCDM problems. Ten criteria are determined based on expert opinions and five alternatives are investigated. Later the results are presented, and the obtained solutions from Fuzzy TOPSIS and Fuzzy VIKOR are compared.

Keywords: Facility location selection, Multi-Criteria Decision Making (MCDM), Fuzzy TOPSIS, Fuzzy VIKOR

ÖZET

BULANIK ÇOK KRİTERLİ KARAR VERME YÖNTEMİ KULLANILARAK TESİS YERİ SEÇİMİ; YEM SEKTÖRÜNDE BİR UYGULAMA

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Tesis yeri seçimi işletmelerin sürdürebilirliği ve karlılığı için çok önemlidir. Yanlış bir yere yapılan tesis nedeniyle şirketin iflas etmesi ihtimali vardır. Sonuçların bu kadar yıkıcı olabileceği stratejik kararlar alırken uygun yöntemler kullanılmalıdır. Bu çalışmada, Türkiye'de farklı lokasyonlarda üretim tesisleri bulunan bir yem firmasının, ülkenin doğu bölgesinde yeni bir tesis kurma kararı sonucunda ortaya konan alternatifleri değerlendirilerek, uygun tesis yeri belirlenmiştir. Çok kriterli karar verme (ÇKKV) yöntemlerinden olan Fuzzy TOPSIS ve Fuzzy VIKOR kullanılarak sonuçlar elde edilmiştir. Bu aşamada, uzman görüşlerinden faydalanılarak ortaya konan on kriter dikkate alınmıştır. Farklı iki yöntemle elde edilen sonuçlar tartışılmış ve en uygun tesis yeri ortaya konmuştur.

Anahtar Kelimeler: Tesis yeri seçimi, Çok Kriterli Karar Verme (ÇKKV) , Bulanık TOPSIS, Bulanık VIKOR

Dedication to my father Aziz GÜLDAL

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NOMENCLATURE

MCDM : Multi-criteria Decision Making

TOPSIS : Technique for Order Preference by Similarity to Ideal Solution

AHP : Analytical Hierarchy Process

VIKOR : Vise Kriterijumska Optimizacija I Kompromisno Resenje

FPIS : Fuzzy Positive Ideal Solution

FNIS : Fuzzy Negative Ideal Solution

1. INTRODUCTION

Adequate and balanced nutrition is one of the most important and invariable problems of human beings in the world. In this case, animal products are indispensable due to their inimitable biological properties and they are not substitutable with other types of nutrients.

Besides the human growth and survival, eight amino acids, which are vital for brain development, exist only in proteins of animal origin. According to World Health Organization (WHO) data, it is recommended that a healthy person should consume 1.0 gram of protein per kilogram of body weight per day and 42 percent of the protein should be animal origin. (General Directorate of Agricultural Enterprise [TIGEM], 2017)

The livestock sector, which has an important role in adequate and balanced nutrition of people, has important economic and social functions such as increasing national income and employment. It provides raw materials for meat, milk, textile, leather, cosmetic and pharmaceutical industries while making contribution to development and increasing foreign exchange revenues through exports. Also, one of the important criteria used to determine the development level of countries is the amount of animal food consumption per person. Within context, it is showed that there is a cause and effect relation between animal protein consumption and the development. (TIGEM, 2017)

At the present time, industries related with livestock sector such as, feed , meat and products, milk (diary) and products, leather and textile, veterinary drugs and livestock equipment industries create new employment areas and added value by processing animal products. The sector has a great contribution to the national economy by effecting a wide range of area. Feed is the main cost of animal farms in Turkey. Animal feed production industry has been operating in Turkey since 1950. The sector, which was initially limited in size and now reached a total cost volume of 27 billion TL. There are 151 different national and international companies in Turkey which have plenty of feed production plants and factories.

They have been upgrading their annual investments for increasing their production capacity and building new plants. Making the right decision in choosing the place during making new investments in the sector, where competition is so high, is one of the most important factors affecting the profit and existence of companies.

1.1. Problem Definition

Facility location selection is a multi criteria decision making problem. At the stage of selection of the facility location, the major aim is to optimize more than one parameter. For more than one plant location alternative, it is necessary to select the best installation location in accordance with the objectives and criteria. Nowadays, it has been seen that the problems of selection of facility can be solved more accurately and easily with the different applications of decision analysis, which is statedas a separate research field and takes place in the literature. At this point, the facility selection is one of the most important decision making processes for management of a company (Chen, 2001). In those studies dealing with the decision making process, primarily, a solution related to the cost saving is characteristically recommended (Lee, 1993), while there are also studies regarding to acquisition maximization (Hakimi & Kuo, 1991). Moreover the cost and profitability indicators, under increasing competing conditions, revealing customer service step and customer pleasure are also requested. In this case, Korpela and Lehmusvaara (1999) composed a customer based approach to evaluate alternative stocks and logistic services based on AHP and mixed integer programming method. For the facility selection decision, Korpela, Lehmusvaara and Nisonen (2007) used AHP and DEA methods together. When Ho and Emrouznejad (2009) created an application based on AHP and target programming enable to evaluate facility alternatives, many studies regarding to the facility selection decision in fuzzy environment also exist in the literature (Kuo, Chi and Kao, 2002; Tabari, Kaboli, Aryanezhad, Shahanaghi and Siadat, 2008; Chen, 2001; Kahraman, Ruan and Dogan 2003).

The decision making problem which is the application part of the study can be expressed in more specific way. Subject of this study involves the investment decision of the companies corresponding to their growth target providing advantage of the potential of east region and increasing animal feed demand of the place in 2016. As a result of the research, five different alternative facilities have been determined. In the decision for facility location selection, the evaluation criteria are selected and shown below:

- Number of cattle
- Number of small cattle
- Number of animals in neighboring provinces
- Transport facilities
- Characteristics of agriculture and pasture areas
- Distances of Alternatives to Company Existing Facilities
- Wheat production
- Distance to Ports
- Number of competitors
- Climate

1.2. Purpose, Scope and Contributions of The Study

In this study, the priority of the alternatives related to the new factory location selection was analyzed using Fuzzy TOPSIS & VIKOR methods which are two of the multi-criteria decision making (MCDM) methods. These methods are used to support the decision with calculated data and examine the effects of methods on the obtained results. It is pointed out in the study that the location selection has vital importance for the successful operation of a company.

The main purpose of the study is using the MCDM technique for the most appropriate facility selection for "X company" by reviewing and evaluating the most suitable alternative facility locations according to the convenient criteria.

Despite utilizing the MCDM techniques that is used in the application in most conditions, does not maintain any significante result, it might help to company executives up to great scope in concluding the most appropriate facility location and selecting among the proposed determined alternatives according to their own perspectives and assessments and to maintain them both a subjective and objective view points.

The companies should attain a vying benefit against their competitors by annihilating the suspenses in market conditions and environment as far as possible. To achive their goals, they have to support their management decisions with suitable scientific methods. In the study, the MCDM method has been utilized for simplifying the decision making process of the executives and presenting them an objective line of vision. Thus, it has been intended to make the most convenient facility location selection decision according to the most appointed criteria in a more objective way. (Erbıyık et al. 2012)

Area selection is the most complex stage of the decision to choose the optimum location. The factors affecting the selection of the region are many, as well as their measurement is quite difficult. It is very easy to determine the location or location of the plant where the plant will be established after the establishment region and location are determined. In the problem of selection of the new factory installation site in the feed sector, which is the subject of this thesis, the potentials and demands of the sector and the area to be selected are determined and criteria have been established. The investment decision problem of the factory was evaluated as a MCDM problem and a solution was sought.

2. LITERATURE REVIEW

In the literature, there are many different multi-criteria decision-making (MCDM) methods used in the solution of facility location issues. In one of these studies, Yang and Lee (1997) tried to solve the facility selection problem by using Analytic Hierarchy Process (AHP) method. Four main criteria and twelve sub-criteria have been determined for the evaluation of alternative establishment locations under the main headings of market, transportation, labor and community. In the study of Badri (1999), instead of using AHP management alone, he used a hybrid approach by using existing management with goal programming and looked for a solution to the problem of choosing a biochemistry facility location. Yang et al. (2008), evaluated the advantages and disadvantages of alternative facility location and proposed a three-stage model to assist decision makers in their work using the Analytical Network Process (ANP), which was developed by AHP. The three-stage model consists of determining the criteria, detailing the main criteria, and determining the sub-criteria. Erden and Çoşgun (2010), used AHP and Geographic Information System (GIS) methods, together and with this hybrid approach, they searched for the solution of the optimal facility location selection problem for pre-selected fire stations. In this study, GIS was used to determine geographic locations and then the main criteria was determined for the evaluation of positions determined by AHP method. Tibljas et al. (2010) used AHP method to select the most suitable place for a car park.

The increasing interest in environmental issues have been searched by Gündoğdu (2011). ELECTRE I method were used for solution for the location of the plants that considering the environmental priorities. In another study, Zhang (2011) aimed to find a solution to the problem of the location of a company that produces biofuels; used a GIS model consisting of two phases. In the first phase of the model, potential railways, highways and other modes of transport have been identified, and in the second stage, the most suitable location has been determined by considering the transportation costs. In another study, Doğan (2012) determined a solution by using Bayesian Networks and Total Cost of Ownership methods together for an international production facility. With the developed model, the decision makers have chosen the location that gives the minimum total cost.

Although mathematical models and traditional MCDM methods are frequently used in site selection problems, these methods have some drawbacks. Because these methods take into account either quantitative values or good / bad clear statements during the evaluation of alternatives. This makes it difficult for decision-makers to consider their assessment and judgments clearly in most cases. This difficulty is due to the fact that the evaluations and judgments of the decision-makers are not as clear like good/ bad as in any case (it is expressed “good“, “1“ ,”yes“ at one end; “ bad”, “0”, “no” at the other end and this is expressed as Aristo logic) in other words, these evaluations and judgments are expressed by the decision-makers in many cases by expressions such as ”very good“, “good “so so”, “bad”, “very bad”. In real life problems, it is not always possible to make conclusive judgments when evaluating alternatives. The failure to incorporate such uncertainty into the resolution process is the most frequently criticized of mathematical models, traditional MCDM problems, and the accuracy of the results (Uludağ and Deveci, 2013)

As a result of these debates and the search for alternative methods for solution, Fuzzy Logic theory, developed by Lüftü-zade in 1965, started to be used in conjunction with traditional multi-criteria decision-making methods. Thus, Fuzzy Multi-Criteria Decision Making Methods have taken its place in the literature. Fuzzy Logic is a mathematical form of behavior in everyday life and fuzzy set theory is based on it. Similar to Aristo logic, membership function [0, 1] is explained by the values; but, unlike him, intermediate values are taken into consideration in the membership relationship. Another important difference of fuzzy logic is that it is possible to determine the possibility of uncertainty situations (Vural, 2002).

In the literature, there are many studies conducted on different subjects where multi-criteria decision-making methods and fuzzy logic are used together. In one of these studies, Liang and Wang (1991) determined the weighting and evaluation of the criteria by using fuzzy set theory together with multi-criteria decision-making management. In the similar manner, Chen (2001) used triangular fuzzy numbers in order to include the linguistic expressions of the decision makers in the solution process and listed the alternatives. Kaboli et al. (2008) and Tabari et al. (2008) used fuzzy set theory and AHP method in order to solve the problems of facility location selection. Ulukan and Kop (2009) used trapezium fuzzy numbers to fuzzy linguistic expressions in solving the problem of establishment of a waste disposal facility location. Critical criteria and alternatives with the help of trapezoidal fuzzy numbers are included in the solution process. Finally, using the Fuzzy TOPSIS method, alternatives were listed and the most suitable location was chosen. The fuzzy method of the Blin has been used with four different multi-criteria decision making methods, including Fuzzy Synthetic Evaluation, Yager's Weighted Purposes and Fuzzy AHP, and pointed out the differences between the methods in the study of Kahraman (2003) to determine the solution of the choice of location problem for an engine manufacturer. In the study of Ozdagoglu (2011), location problem has been solved by using a combination of AHP's developed by the ANP method of fuzzy logic In another study, Ertugrul and Kasapoglu (2008), the method of Fuzzy TOPSIS was used to solve location selection problem for a company operating in the textile sector. Momeni (2011) extended the VIKOR method and combined the method with the fuzzy logic to find a solution to the location selection problem. The algorithm of the Fuzzy VIKOR method used to solve the problem is presented in eight steps.

The literature research on the topic showed that AHP is frequently used in the solution of such problems. This is due to the intelligibility and ease of implementation provided by AHP to users. Although AHP is commonly used in site selection problems, there is an increase in the number of studies seeking solutions to such problems using other multi-criteria decision-making methods.

Çınar (2009) showed that both fuzzy AHP and TOPSIS methods were able to be used as decision support structures by the organizations to make adequate decision on the bank branch area selection. In her study, FAHP and TOPSIS methods were used together. FAHP was utilized for determining the weights of the criteria while TOPSIS method was used for determining the ranking of the facilities possible to select for bank branch. In that application, the ranking result of the candidate cities was reached by considering their data obtained from Bank Association of Turkey, State Institute of Statistics and Union of Chambers and Commodity Exchanges of Turkey. As the weights of the criteria were determined by bank managers from different areas, the result indicates an overall performance ranking.

Boran (2011) claimed that the success of firms depends on their capability on making right key choices. Facility location selection is one of these key opinions, which it is a costly and hard to reverse movement for the companies. Therefore, this study has presented the integration of intuitionistic fuzzy preference relation and intuitionistic fuzzy TOPSIS approach for choosing the most enticing facility location. The decision factors expansion probability, availability of acquisition material, community considerations, distance to market and labour expense have been taken into consideration and candidate places have been evaluated by the nominated method with respect to the decision factors. The intuitionistic fuzzy choice relation has been applied to acquire the weights of criteria and intuitionistic fuzzy TOPSIS approach has been used to rank alternative. The integrated intuitionistic fuzzy multi criteria decision making method has enormous chances of success for multi-criteria decision making problems due to having great perfection on handling vagueness.

According to Ashrafzadeh (2012), a warehouse location choice is a multi-criteria decision-making issue including both significant and qualitative. In the paper, they presented a multi-criteria decision making method for warehouse location selection under fuzzy environment. The introduced approach in the study made of two steps. In step 1, the criteria for warehouse location selection were determined. Those criteria were labor costs, delivery costs, handling costs, area cost, skilled labor, availability of labor power, land availability, climate, existence of modes of transportation, telecommunication systems, quality and reliability of modes of transportation, quality and reliability of utilities, proximity to customers, proximity to producer, lead times and responsiveness. In step 2, the experienced personnel provided linguistic appraisal to the criteria and the alternatives. Fuzzy TOPSIS was used to aggregate the ratings and generate an overall performance score for measuring each alternative. The alternative with the best score was chosen as the best warehouse location selection. The warehouse location selection issue in his paper could be solved by fuzzy AHP and the obtained results could be benchmarked for further researches.

A.Zandi and Roghanian (2013), real world decision making issues are generally complicated, that’s why Fuzzy MCDM methods have found large implementations. ELECTRE is one of the most ordinarily used MCDM approaches in the list of alternatives. Even ELECTRE I is a simple method, it is not active in ranking. Therefore, they proposed a combination of ELECTRE and VIKOR method with respect to relationship between them, to solve their problem. Then, the executive procedure of that showed method was illustrated by implementing it to the issue of facility selection.

Güzel and Erdal (2015), nominated a comparative fuzzy multi-criteria analysis that exploits fuzzy TOPSIS and fuzzy VIKOR actions. The offered methods use fuzzy sets in determining uncertainties in the different criteria involved in selection of DC location. Since some uncertainties included in the decision process, each related factor is represented by a linguistic variable.

In the study of Şenvar et al. (2016), Using a proposition of technique via hesitant fuzzy TOPSIS with group determination-making using triangular fuzzy hesitant fuzzy sets (TFHFS) were presented by deciding the uncertainties inherent in decision-making movement for the assessment of the multi criteria hospital location selection problem. They carried out their proposed methodology for choosing a site of a new hospital in Istanbul. For that objective, they assessed the alternative places from multiple dimensions before selecting the best alternative site. Through comprehensive literature review and meetings with the management of hospital, a wide variety of criteria and sub-criteria were examined. For their implementation study, they mainly investigated four alternative locations, seven criteria and 24 sub-criteria deciding the perceptions of three decision makers from the executives.

3. MATERIALS AND METHODS

The main materials, methods, criteria and data of the study are described in this section.

3.1. Material

X company took a decision of building new feed factory investment in eastern anatolia region of Turkey. This company started operations in 1969 as the first private feed production factory in Denizli, Turkey.

The company operates in different ways in the food industry. These fields of activity are chicken meat production, egg production, feedmills, fish meat production, slaughter houses, and oil production.

The biggest share of the company's turnover is in feed production area. This company has operations in many business sectors. A total of all eight factories of the company is maintaining the convenience of factory production in Turkey's western and southern regions. The company will establish a factory in Southeast Anatolia or Eastern Anatolia where the potential for investment is high and where there is no factory.

Although the company has a 50-year history, it has grown rapidly in the last years by establishing 7 factories after the year 2000. It is one of the leading companies in the sector with its annual production of 1 million tons. It is a structurally institutional company next to a family enterprise.

The company's feedmills are located in Denizli, Çanakkale, Burdur, Manisa, Ankara, Mersin, Konya, and Samsun. The closeness to the market and proximity to the port are prominent in the factory location selection. The factor affecting the proximity to the market is due to the fact that the feed is perishable over time and the cost of logistics.

The company imports raw materials from abroad for the production of feed in terms of price and quality advantages. The main constraint in imported raw materials is the restrictions imposed by the state. The company establishes large storage areas in some locations and provides high price advantages by importing high tonnage raw materials. The Sixty percent of its raw material is an important criterion for the importing company.

3.1.1. Criteria and Data

In this thesis, an expert and experienced team has been formed. The criterias for the establishment of feed factory have been determined. The provinces of Sivas, Van, Malatya, Erzurum and Kars, which were determined as alternatives in line with these criterias, were evaluated. The evaluation was made by questionnaire method.

In the survey study, the factors affecting the choice of factory location were questioned. There are many factors affecting the location of the facility. These factors are proximity to the market and the presence of competitors, labor opportunities, proximity to raw materials and auxiliary substances etc.

The criteria identified for a new feed mill in Turkey's eastern regions are established in this thesis, criteria are as follows.

- Number of cattle
- Number of small cattle
- Number of animals in neighboring provinces
- Transport facilities
- Characteristics of agriculture and pasture areas
- Distances of Alternatives to Company Existing Facilities
- Wheat production
- Distance to Ports
- Number of competitors
- Climate

3.1.1.1. Number of Cattle

For a feed factory market, the first data that comes to mind is the number of bovines (cattles). It is one of the factors affecting the location of the plant. It is not possible to conduct an enterprise location analysis without considering the market factor. Because every production activity is performed to meet a need. Therefore, the producer must know where consumers are located and whether they should be close to the consumer. According to the type of product produced, if consumers are in bulk in a particular area, it is appropriate to select the location of the establishment near the consumers' collection

Besides, the fact that the product is one of the type of non-durable consumer goods also forces the selection of a location close to the market. Enterprises that produce food that is rapidly degradable or whose values fall short have the obligation to choose a location which is very close to the market. However, the fact that the transportation speed has increased in recent years and the possibility of transporting it too long distances without losing its values and losing it with refrigerated trucks has caused the importance of this issue to be decreased considerably.

Cattle Farming in Sivas; due to the geographical structure of Sivas province, animal husbandry is common. Especially cattle breeding are the main livelihood of the people in the region. Table 3.1 shows the number of bovine animals between the years of 2010-2018. When the table is examined, it was observed that there was no significant increase in the number of animals between the years of 2010-2018.

Cattle Farming in Van; where the industry is not well developed, the basic livelihood of people are animal husbandry. Although it has wide and high-quality pasture lands, cattle breeding in the province is much lower than expected. The number of cattle in Van between the years of 2010-2018 are given in Table 3.1.

Cattle Farming in Malatya is not at the desired level. However, the number of animals in the province has tended to increase in recent years. At Table 3.1, it is seen that the number of animals in Malatya province has increased by 72.3% in 2018 compared to 2010. This shows that the number of animals in the region tends to increase.

Cattle Farming in Erzurum; The main livelihood of Erzurum is cattle breeding (cattle farming). The number of animals in the region is as high as 768.997 according to 2018 data. In terms of the number of cattle, Erzurum comes after Konya in Turkey. In addition to the high number of animals, the number of animals also increases every year. According to the number of bovine animals in 2010-2018 of the alternative provinces given in Table 3.1, it is seen that the number of animals in Erzurum province increased by 42.9% in 2018 compared to 2010.

Cattle Farming in Kars; The livelihood of Kars is livestock, as it is in Erzurum, and it is in a good position with 456500 animals according to 2018 data. This number brings the city to the second position among the alternatives. According to the distribution of the number of cattle by years, it is seen that the number of animals in 2018 increased by only 13.4% compared to 2010. The rate of increase seems to be low, which can be considered as the market is close to reaching saturation. Table 3.1 shows the number of cattle from 2010-2018 in alternative provinces.

Table 3.1. Number of Cattles in Alternative Provinces (2010-2018)

Number of Cattles in Alternative Provinces					
Year	**Sivas**	**Van**	**Malatya**	**Erzurum**	**Kars**
2010	337.334	158.033	101.138	538.014	396.620
2011	342.907	198.049	125.824	588.007	432.499
2012	339.843	194.690	127.728	624.982	488.252
2013	352.227	192.843	130.375	670.683	519.645
2014	330.484	163.958	134.535	655.836	518.722
2015	265.355	167.388	130.371	641.811	442.575
2016	271.284	162.728	136.149	650.963	451.368
2017	337.471	186.099	171.963	731.282	467.362
2018	357866	177.346	174.321	768.997	450.101

Source: TUIK

3.1.1.2. Number of Sheep & Goat

The number of small ruminants (sheep & goats) is also a market indicator for a feedmill. The effect of the number of small ruminants is not as large as the number of bovine animals (cattle). The reason for this is that in our country and according to the general animal husbandry principle, small ruminant animals are weight-based feeding with grassland. Therefore, the rate of industrial feed consumption is small compared to bovine animals.

Sheep & Goat Farming in Sivas; According to other provinces in the region, Sivas province has small numbers of sheep & goat however the region is very suitable for animal husbandry. Along with the state supports in recent years, the number of small ruminants in the province is increasing. Table 3.2 shows the number of sheep in the last eight years of Sivas province. In the table, it is seen that the number in 2018 is increased by 79.3% compared to 2010.

Sheep & Goat Farming in Van; Van province's main livelihood is livestock. Breeding in terms of the number of animals after Konya province in Turkey in the 2nd position. Table 3.2 shows the number of small animals in Van in years of 2010-2018. Referring to the table, Van has 2,650,531 sheep&goat number corresponding to 5,52% of sheep livestock in Turkey. One of the main reasons for the high number is the large-scale, high-quality pasture structure in the region. Therefore, the number of sheep fed mainly in the pasture is high.

Sheep & Goat Farming in Malatya; According to 2018 data, Malatya ranks last among alternatives with its 338443 small cattles. Malatya province is lower than other alternative provinces due to the fact that its industry is more developed than other alternatives and the pasture areas are less developed. Table 3.2 shows the number of small cattles in the alternative provinces between years of 2010-2018.

Sheep & Goat Farming in Erzurum; The city of Erzurum, which is the fourth province in terms of surface area in turkey, is well developed in terms of pastures. Considering the number of small cattles in the year 2018, although it is a high number with 746733, it is well below its potential compared to the province of Van with similar geographic features. Table 3.2 shows the number of small cattles in the alternative provinces between years of 2010-2018. When the table is examined, it is observed that the number of animals in Erzurum in 2018 increased by 50.4% compared to 2010.

Sheep & Goat Farming in Kars; Although the province of Kars does not stand out among the alternative provinces in terms of the number of small cattles of 456500 according to the data of 2018, the number of small cattles in the provinces of 2010-2018 are given in Table 3.2 increased by 121% in 2018 compared to 2010. In terms of growth rate, it is ahead of other provinces.

Table 3.2. Number of Small Cattles in Alternative Provinces (2010-2018)

Number of Small Cattles in Alternative Provinces					
Year	**Sivas**	**Van**	**Malatya**	**Erzurum**	**Kars**
2010	322.485	2.332.697	238.981	496.350	206.540
2011	470.894	2.304.525	249.191	562.242	261.121
2012	486.575	2.372.499	265.254	574.213	363.212
2013	506.757	2.483.657	290.965	629.065	346.821
2014	458.077	2.691.934	295.580	717.843	499.500
2015	468.960	2.703.581	302.199	790.467	567.148
2016	468.220	2.658.215	285.991	705.953	563.927
2017	556.204	2.738.054	339.987	714.229	481.869
2018	578.436	2.650.531	338.433	746.733	456.500

Source: TUIK

3.1.1.3. Number of Animals in Neighboring Provinces

One of the factors in the feed sector market research is the market capacity and potential in the nearby region. The development of road transportation network in our country and the increasing number of new tunnels and roads have improved the physical characteristics of the existing roads and therefore the duration of transportation has decreased. For these reasons, the number of animals in neighboring provinces highly affects the market.

Number of animals in the neighborhood of Sivas; Due to the size of the area and the central location, the number of provinces adjacent to Sivas is high. It has developed in animal husbandry in Sivas's neighbors and Table 3.3 shows the number of bovine and ovine animals in these provinces in 2018.

Table 3.3. Number of Cattle and Small Cattles of the Neighboring Provinces of Sivas in 2018

Sivas		
Neighboring Provinces	**Number of Cattle**	**Number of Small Cattle**
Kayseri	349.696	647.093
Tokat	310.431	390.190
Giresun	112.481	106.101
Erzincan	114.915	434.457
Malatya	174.321	338.433
K.Maraş	215.223	837.589
Ordu	153.280	135.147
Yozgat	247.809	378.798
Total	**1.678.156**	**3.267.808**

Source: TUIK

Number of animals in the neighborhood of Van; the eastern part of the province of Van is entirely the Iranian border. Other neighboring cities; Hakkari, Şırnak, Siirt, Bitlis, and Ağrı. The number of bovine and ovine animals in 2018 is given in Table 3.4. The table shows that the number of cattle is not at the desired level in the provinces of the region. Although this situation may be a short-term problem, it may indicate a great potential for the future.

Table 3.4. Number of Cattle and Small Cattles of the Neighboring Provinces of Van in 2018

Van		
Neighboring Provinces	**Number of Cattle**	**Number of Small Cattle**
Hakkâri	44.443	668.041
Şırnak	71.120	1.138.629
Siirt	34.918	1.250.453
Bitlis	94.880	645.291
Ağrı	388.452	1.322.805
Total	**633.813**	**5.025.219**

Source: TUIK

Number of animals in the neighborhood of Malatya; Malatya region is the westernmost province of eastern Anatolia. There are 6 neighboring provinces around. These provinces; Erzincan, Elazığ, Diyarbakir, Adıyaman, Kahramanmaraş, and Sivas. The numbers of bovine and ovine animals belonging to these provinces in 2018 are shown in Table 3.5. When the table is examined, it can be said that the number of animals in the neighboring provinces of Malatya is in a good position, especially Diyarbakır, which is among the neighbors, has a high number of animals compared to other neighbors.

Table 3.5. Number of Cattle and Small Cattles of the Neighboring Provinces of Malatya in 2018

Malatya		
Neighboring Provinces	**Number of Cattle**	**Number of Small Cattle**
Adıyaman	129.194	343.577
Diyarbakır	589.462	1.834.639
Elazığ	187.418	698.745
Erzincan	114.915	434.457
K.Maraş	215.223	837.589
Sivas	357.866	578.436
Total	**1.594.078**	**4.727.443**

Source: TUIK

Number of animals in the neighborhood of Erzurum; Among the alternatives, Erzurum has the highest number of neighbors. There are 9 neighboring provinces of Erzurum; Rize, Artvin, Ardahan, Kars, Ağrı, Muş, Bingöl, Erzincan and Bayburt. Table 3.6 shows the number of cattle and small cattles in 2018 in neighboring provinces of Erzurum. When the table is examined, Erzurum province is in a better position than other alternatives in terms of the number of cattle in its neighbors. However, since the number of animals in the Black Sea provinces is very small, it is not the best alternative in terms of the total number of animals although it has the highest number of neighbors.

Table 3.6. Number of cattle and small cattles of the neighboring provinces of Erzurum in 2018

Erzurum		
Neighboring Provinces	**Number of Cattle**	**Number of Small Cattle**
Ağrı	388.452	1.322.805
Artvin	61.174	129.794
Bingöl	132.772	510.781
Erzincan	114.915	434.457
Kars	450.101	456.500
Muş	306.542	1.041.102
Rize	25.480	27.660
Bayburt	98.060	48.787
Ardahan	306.925	74.238
Total	**1.884.421**	**4.046.124**

Source: TUIK

Number of animals in the neighborhood of Kars; because Kars has a border with Armenia in its east, it has the lowest number of neighboring provinces. Kars has neighborhood with the provinces Ardahan, Iğdır, Ağrı, Erzurum and the number of cattle and small cattles in those neighbors are shown in Table 3.7. When the table is examined, it is observed that although the number of neighboring provinces is low, the number of animals in the province is high. If a comparison is made, the two-fold number of neighboring provinces of Kars named Sivas province; the number of animals in the neighborhood is close to the number of animals in the neighborhood of Kars. Although Kars has such a small number of neighbors, the presence of large numbers of animals in its neighbors will provide an advantage for Kars as a logistic cost.

Table 3.7. Number of Cattle and Small Cattles of the Neighboring Provinces of Kars in 2018

Kars		
Neighboring Provinces	**Number of Cattle**	**Number of Small Cattle**
Ağrı	388.452	1.322.805
Erzurum	768.997	746.733
Ardahan	306.925	74.238
Iğdır	150.633	1.028.322
Total	**1.615.007**	**3.172.098**

Source: TUIK

3.1.1.4. Transport Facilities

Almost all businesses are obliged to purchase the raw and auxiliary materials required for their production activities, to bring them to factory and to send the products to the market. This narrative reveals that businesses sometimes have to bear the costs of several transportation. After completing site inspections, a company can be located close to a source of raw materials. This means that the enterprise will not be able to bear the raw material transportation costs, but will bear the costs of transporting the goods to the market. Another business can choose a location close to the market. In this case, the transportation expenses to be incurred by the enterprise are completely contrary to the first one. In other words, while the expenses to be incurred to carry the raw material to the operation reach a large amount, the expenses required for the transportation of the product to the market will be neglected (Özer, 2005).

There are important developments in transportation services by the time and these developments have a significant impact on transportation time and cost. The fact that railway transportation is accelerated, turned into a door-to-door service with ancillary services, or truck transports reach large quantities in the form of truck transportation or air transportation begins to become cheaper in time may necessitate the replacement of the previously chosen means of transport (Gülerman, 1978).

Transportation in the feed industry is very important because there is a live animal feed and long-term stocking of the final product is not possible in the sector. In particular, large and professional farms keep industrial feed stock turnover low in quantity. In the feed sector, it is requested that the transportation leg is reliable and does not cause any delay in terms of time.

Another important transportation issue in the sector is the supply of raw material to the factory. The company that is the subject of the thesis and large firms in the sector import raw material supply. Firms keep the raw material purchase amount high in order to obtain a price advantage. For all these reasons, imported raw materials come with high tonnage by ships. Transportation costs are the biggest criterion for transportation of raw materials.

Sivas Region Transportation; when examined in Sivas, Turkey's location north - south and east - seems to be at the center of the road extending west direction. As many companies that are carrying freight and passenger transportation are required to pass through this route. Sivas is one of the most convenient cities in terms of transportation. The divided road network reached to 717 km within the provincial boundaries of Kayseri, Yozgat, and Erzincan. After the completion of the ongoing Black Sea - Mediterranean Highway Project, the transportation to the southern and northern provinces will become much more practical and more efficient commercial mobility will be achieved.

Van Region Transportation; It is located within the 11th Region boundaries of Van General Directorate of Highways. There are no motorways in the area. Main roads usually consist of divided roads in the last 10 years. Due to the Kapıköy border gate in the region, Van is an important route point. There is a total of 1084 km divided road in the area.

Malatya Region Transportation; Due to the renewed and shortened roads in Kayseri, Adana and Sivas directions and the location advantage, Malatya is now a very comfortable province in terms of road transport. Its proximity to the border gates, especially Mersin and Trabzon ports, is an indication of the high transportation potential of the province. According to the data of the General Directorate of Highways in 2019, there is 1162 km of state roads in the province of Malatya. It consists of 412 km of divided roads . General road transport in the province is good. It continues to expand and improve with new investments.

Erzurum Region Transportation; The opening of the OVIT tunnel between Erzurum and Rize will contribute to the mobilization of the economies of Erzurum and other provinces which are using this route will reach the Black Sea in a short time. With the completion of Kop Mountain Tunnel, which is an important crossing point connecting the Eastern Black Sea to the south and east, construction of Erzurum-Bayburt-Gümüşhane-Trabzon highway has been completed, Erzurum's connection with Trabzon Port will be ensured uninterruptedly in summer and winter. With the completion of Kop Mountain Tunnel, which is an important crossing point connecting the Eastern Black Sea to the south and east, construction of Erzurum-Bayburt-Gümüşhane-Trabzon highway has been completed, Erzurum's connection with Trabzon Port will be ensured uninterruptedly in summer and winter. According to the data of the General Directorate of Highways in 2019, there are 1724 km of state roads in Erzurum province. It consists of 596 km of divided roads. With the completion of the new tunnel investments, the province will be in the logistics position of the East Anatolian region. The primary factor that negatively affects the road transport in the province is the heavy winter conditions. Since the winter months are long and the conditions are heavy, the roads are covered with snow and transportation is hampered.

Kars Region Transportation; Kars, which is an important point of the Iron Silk Road, is not at the desired level in terms of road infrastructure. According to the data of the General Directorate of Highways in 2019, there is 945 km of state roads in Kars province. It consists of 233 km of divided roads. In terms of total road lengths, the province lags far behind other alternative provinces.

3.1.1.5. Characteristics of Agriculture and Pasture Areas

The feed sector is considerablybased on and intertwined with agriculture. The raw material of the factory operating in the feed sector is supplied from agricultural products while the products of the factory are sold to the livestock sector. The characteristics of agriculture and pasture areas in the area where a feed mill is located directly affect the raw material supply and market of the factory. Factors such as the distribution of crops that can grow in the size of the agricultural area, the feasibility of irrigated farming, and the rate of fallow affect the amount of agricultural products to be obtained.

Pasture area and its characteristics are directly affected by ovine livestock breeding in our country. Pasture areas, which are of great importance for the future of humanity and the continuation of biodiversity, are defined as natural resources that offer a large portion of nature piece covered with a blanket of herbaceous plants or high-quality roughage to produce animals in abundant and cheapest (Avcıoğlu et al. 1998). Turkey Statistical Institute has a total of 146167 km^2 of meadows and pastures in our country according to the 2001 Agricultural Census data (Table 3.8). In terms of meadow and pasture areas. When the data of total meadow and pasture areas are taken into consideration, Eastern Anatolia Region ranks first with a share of 37.53%, followed by Central Anatolia with 31.27% and Black Sea Region with 10.38%. Aegean Region has a share of 5.49% in total meadow and pasture areas with 8029 km^2.

Table 3.8. Grassland Areas in Turkey

Grassland	
Regions	**Area (km^2)**
Akdeniz	6757
D. Anadolu	54854
Ege	8029
G.D Anadolu	9962
İç Anadolu	45702
Karadeniz	15166
Marmara	5696
Toplam	**146167**

Source: TUIK

Usage of pasture decreases in winter due to the hard climate around Eastern Anatolia. In these regions, although the pasture area is high, the usage period is low. In the region, pastures are made in dry grass harvest for use in winter as well as for grazing in summer.

Sivas Region in terms of Agriculture and Pasture Areas Features; Approximately 55% of the province, which has a large surface area, consists of agricultural areas with an area of 15,700 km^2. Although there is such large arable area, agriculture has not developed sufficiently. Grain, legumes and industrial products are the main agricultural products while cereals comes first. The amount of agricultural products varies according to seasonal conditions. The main agricultural products are wheat, rye, beans, lentils, vetch, sugar beet and potatoes. Vegetables and fruit growing is not well developed. There are 7418 km^2 high quality pasture areas in Sivas. These areas are suitable for feeding cattle and sheep.

Van Region in terms of Agriculture and Pasture Areas Features; Although Van has large surface area, only 17% of its area can be cultivated. In addition, 27.2% of the total agricultural land, grain planting area, 28.1% of the forage crops cultivation area, 0.5% of other field crops cultivation, 1.2% of vineyard-fruit cultivation, 0%, 4 out of the open vegetable production area, 30.8% fallow field, and 11.8% of the agricultural lands that are not suitable for agriculture. The province is not in the desired place in agriculture. Van has an advanced level in terms of pasture quality and surface area. The province consists of 13590 km^2 meadows. This amount consists of 64.71% of the total area of the province.

Malatya Region in terms of Agriculture and Pasture Areas Features; According to the Provincial Directorate of Food, Agriculture and Livestock, Malatya has a total of 4254 km^2 of agricultural land, 1734 km^2 of which is irrigated, 2186 km^2 of which can be irrigated and 335 km^2 of which is waterless. However, the province has 7295 km^2 pasture and forest area. 54% of Malatya province's lands are covered with meadows and pastures and 31% is covered with cultivated and planted land. The forest area is small. Forest area is about 10% of the total area. The wide Malatya Plain looks like a steppe. River streams are covered with apricot (fruit) orchards that grow like forests. With the spread of apricot production, a decrease in grain production has been observed, but large farmland is quite suitable for grain production. Parallel to the increase in animal husbandry in recent years, forage crop production has become widespread. In addition to the large number of irrigation dams in the region, the amount of irrigable agricultural land will be substantially increased by the Recai Kutan Dam, which is under construction.

Erzurum Region in terms of Agriculture and Pasture Areas Feature; In Erzurum agriculture, animal husbandry comes before field crops. Because the climate is very harsh, the products grown are limited. Grows in wheat, barley, rye, vetch (animal feed), lentils, beets, sunflowers. Growing vegetables are not enough; most of the need comes from southern provinces. Fruit, apples, pears, plums, cherries, walnuts, quince, apricots, and cranberries are grown. Total agricultural land of the 20 existing districts of the province is 4602 km^2 of which 23.5% can be irrigated. Erzurum is 1170 km^2 of meadows and pasture, the total pasture area in Turkey has 11%. Although it is in a good position in terms of Erzurum pasture area and quality, pasture usage cannot be made in winter months due to the harsh winter months.

Kars Region in terms of Agriculture and Pasture Areas Feature; Nearly all of the land used as agricultural in Kars, is fields for growing cereals. The share of agricultural land for vegetable and fruit purposes is around 0.35%. The area where the field is cultivated is 3580 km^2 and constitutes approximately 99.65% of the used agricultural area. Approximately 35.48% of the province of Kars, spread over an area of 10127 km^2, is used as agricultural land. The majority of the province's land is 39% of the meadow-pasture area, the share of forests and heathlands in the province's land is 3.52%, and the share of the land which is not suitable for agriculture or used as a settlement area is 22%. Meadows and pastures have a high share in land use in Kars. Although these pastures are of high quality, they cannot be used for most of the year due to climatic conditions.

3.1.1.6. Distances of Alternatives to Company Existing Facilities

The market is one of the most important factors in the selection of facility location. The new facility investment is generally requested not to take the markets of existing plants and reduce the capacity of the existing plant. In this thesis, the company has 8 existing production facilities. The expectation is that the new facility will not affect the capacity of the existing facilities, so the distance from the new facility to existing facilities can be seen as an important factor. Table 3.9 shows the distances of the alternative provinces to the nearest existing facility.

Table 3.9 Distances of Alternative Provinces to the Nearest Facility

Alternatives	Nearest Available Facility (km)
Sivas	371
Van	932
Malatya	431
Erzurum	604
Kars	805

3.1.1.7. Wheat Production

Cereals are one of the main foodstuffs which has been consumed by humans since ancient times. The term grain is used to refer to all grains such as wheat, corn, rye, paddy, barley, oats, chickens, and millet which are the seeds of the "Graminae" family (Altan, 1990). Wheat, both in Turkey and in the plantation area ranks first in terms of the amount of cereals production, processed in different ways, in particular is of great importance as raw bread (Gül et al, 2015).

Wheat is the most essential nutrient in the human diet (bakery products, pasta, grits, biscuits, and bulgur)and more important than other agricultural products as raw materials. Share in the agriculture made in Turkey grains of wheat has 49% share in the total grain area.

Wheat is the raw material of flour which is the basis of “Bread“ and has the most important place in the basic nutrition of our country. The products such as bran, bonkalit, which are obtained during flour production, may be used as valuable raw materials for feed industry.

Sivas Region; The highest tonnage of wheat is obtained in agricultural production in Sivas. The products obtained from wheat in the feed plant are of critical importance. Wheat production in 2017 was 569.128 tons in Sivas and 2.65% of the total production in Turkey is provided fromthis city.

Van Region; the city of Van does not have a significant share in the production of field crops. 0.6% of Turkey's wheat production, 118,000 tonnes is performed in the city of Van.

Malatya Region; Malatya has a great importance in fruit production of Turkey especially in apricot production. While it is so developed in fruit production, it is not at the desired level in cereal production. According to the 2017 data of TUIK (Turkish Statistical Institution), 90799 tons of wheat is obtained. It is not at the desired level in terms of wheat production. Malatya province is in the last place in terms of production tonnage compared to alternative provinces.

Erzurum Region; Erzurum is one of the provinces affected by the decline in wheat production in recent years. According to TUIK data, wheat production in 2002 of 215567 tons of decreased by 8% in 2017 to 197047 tons. Although it is in the second position among the alternatives in terms of production tonnage, it is below its potential in terms of arable area.

Kars Region; According to 2017 data, Kars has 94801 tons of wheat production. Preferred Livestock production, rather than the production of field crops affected wheat production negatively.

3.1.1.8. Distance to Ports

The main products imported by the feed industry are soybeans, corn (imported when domestic production is not sufficient), soybean meal, sunflower seed meal, rapeseed meal, bran, corn derivatives (corn gluten, corn grizzles, etc.), food additives such as industrial pulp and residues (DDGS), fish meal and vitamins, minerals and premixes. 93,6 % of Turkey's imports are made by sea. Due to the fact that the raw materials are imported, their proximity to the port, the capacity of the port, and the distribution of the load are important.

The distance of Sivas to Ports; Although Sivas is in a central location, it is closer to the ports in the Black Sea coastal cities. It is 497 km away from Mersin port which is one of the central ports. Table 3.10 shows the distances of Sivas province to some ports.

Table: 3.10. Distances of Sivas to Some Ports

Sivas – Port Distances			
Fatsa Port	261 km	Antalya Port	815 km
Trabzon Port	423 km	Mersin Port	497 km
Giresun Port	288 km	Marmara Ereğlisi Ports	893 km
Samsun TCDD Port	339 km	İskenderun Ports	512 km

The distance of Van to Ports; In Turkey, Van in terms of distance to ports after the province of Hakkari has the most unfavorable position. The nearest port is Trabzon port with 676 km. The distance from the Mersin port is 962 km and the distance to some ports of Van is given in Table 3.11.

Table: 3.11. Distances of Van to Some Ports

Van – Port Distances	
Trabzon Port	676 km
Giresun Port	733 km
Samsun TCDD Port	928 km
Antalya Port	1485 km
Mersin Port	962 km
İskenderun Ports	876 km

The distance of Malatya to Ports; Malatya has a central location in our country. The province has access to Eastern Mediterranean ports and Karadeniz ports.Table 3.12 shows the distances of Malatya to some important ports.

Table: 3.12. Distances of Malatya to Some Ports

Malatya - Port Distances	
Mersin Port	461 km
İskenderun Port	376 km
Trabzon Port	512 km
Samsun TCDD Port	576 km
Giresun Port	473 km
Antalya Port	951 km

The distance of Erzurum to Ports; Erzurum province is located in the northeast of our country. Due to its proximity to the Black Sea region, it is easy to reach the ports of the Black Sea. It is far from the port of Mersin which is an important place in the feed sector. Table 3.13 shows the distances of Erzurum province to some important ports.

Table: 3.13. Distances of Erzurum to Some Ports

Erzurum – Port Distances	
Mersin Port	915 km
İskenderun Port	830 km
Trabzon Port	267 km
Rize Port	253 km
Samsun TCDD Port	553 km
Giresun Port	359 km
Antalya Port	1240 km

The distance of Kars to Ports; Kars is located at the eastern end of our country. The only possible alternative as a port is the ports just north of the Black Sea. Kars is the most restricted province in terms of distance to the port after Van. Table 3.14 shows the distances of Kars province to some important ports.

Table: 3.14. Distances of Kars to Some Ports

Kars – Port Distances	
Mersin Port	1119 km
İskenderun Port	1033 km
Rize Port	345 km
Trabzon Port	424 km
Samsun TCDD Port	755 km
Giresun Port	561 km

3.1.1.9. Number of Competitors

Competitive companies, while trying to prevent each other from living on the one hand, they also have some features that make it easier for each other to live. The production created by various companies in a specific region makes it attractive for many other organizations to operate in that region. The emergence of transportation facilities, the establishment and expansion of the settlement areas, the utilization of the labor force in expanding urbanization, the establishment of vocational and art schools in order to train the labor force needed by the industry, the selection of intermediaries in the region may be given as examples. The organization looking for a location can easily choose such a region that has matured in many respects as a place of establishment (Gülerman, 1978). Alternatively, feedmills and annual production capacities in the five provinces are given in Table 3.15.

Table: 3.15. Feedmill Numbers and Capacities in Alternative Regions

Province	# Feedmills	Capacity (Ton/Year)
Sivas	3	54000
Van	7	152000
Malatya	9	190000
Erzurum	5	130000
Kars	3	62000

Source: Ministry of Food, Agriculture and Livestock

3.1.1.10. Climate

Climatic conditions, such as temperature, precipitation, humidity, wind, in some cases may become a significant factor. Excessive heat difference and humidity are not only harmful to human health but also affect the working power and decrease the efficiency. Although measures can be carried out to eliminate these adverse effects of climate, it should be kept in mind that the measures will increase the costs. For example, in order to heat the establishments placed in cold regions, some side costs should be taken. For this reason, it is useful to select the places where the climatic conditions are normal as the site (Cemalcılar et al. 1993).

In the feed sector, humidity and temperature factors may cause negative effect on the stocking quality of feed and raw materials. The storage costs at high humidity and temperature changes may increase due to the risk of deterioration and the inventory turnover rate.

The climate of Sivas Region; Sivas has a continental climate. The winters are cold and hard, in the winter there is plenty of snow and the soil is covered with snow for about 3-5 months of a year. Summers are hot and dry, spring and autumn are rainy. Although winters are cold, in the northern part of the province, "Koyulhisar and Suşehri in the district" the typical climate of the Black Sea is seen . In these regions, the weather is mild compared to the interior. Table 3.16 shows the temperature distribution of Sivas province.

Table: 3.16. Temperature Distribution of Sivas

Sivas	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Ann.
Average Temperature (^oC)	-3,5	-2,1	2,7	8,9	13,5	17,0	20,0	20,2	16,1	10,8	4,7	-0,7	9,0
Average Max. Temperatıre (^oC)	0,8	2,5	8,0	15,2	20,0	24,0	27,8	28,5	24,5	18,4	10,7	3,5	15,3
Average Min. Temperatıre (^oC)	-7,4	-6,3	-2,1	3,0	6,9	9,5	11,7	11,7	8,0	4,1	-0,3	-4,5	2,9
Average Sunshine Duration (hr)	2,5	3,5	4,8	6,3	8,1	10,6	12,0	11,5	9,5	6,5	4,2	2,4	81,9
Average Nr. of Rainy Days	13,0	12,3	13,3	13,4	14,0	8,6	2,4	2,0	4,2	7,8	9,4	12,3	112,7
Average Monthly Rainfall (mm)	43,0	39,2	45,1	57,1	61,6	33,8	8,1	5,4	17,3	33,4	40,5	44,8	429,3
Maximum Temperature (^oC)	14,6	18,1	25,2	29,0	32,0	35,5	40,0	39,4	35,7	30,5	24,0	19,4	40,0
Minimum Temperature (^oC)	-31,2	-34,4	-27,6	-11	-5,5	-0,6	3,0	3,2	-3,8	-9	-24,4	-30,2	-34,4

*** Period 1930-2018**

The climate of Van Region; in the province of Van, continental climate prevails. Winters are long and hard. Although Van is geographically very high, the lake softens climate slightly. Close to 150 days in winter passes below 0 °C. In the summer about 20 days have + 30 ° C temperature. The soil is covered with snow for at least 80 days. Annual rainfall varies from 370 mm to 570 mm while summers are less rainy and very hot. The temperature range in the region is between -26.9 °C and + 36 ^oC. Table 3.17 shows the temperature distribution of the province of Van.

Table: 3.17. Temperature Distribution of Van

Van	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Ann.
Average Temperature (^oC)	-3,1	-2,6	1,6	7,7	13,1	18,2	22,3	22,2	17,8	11,3	4,9	-0,5	9,4
Average Max. Temperatıre (^oC)	1,9	2,6	6,5	12,8	18,5	23,9	28,2	28,5	24,3	17,3	10,2	4,4	14,9
Average Min. Temperatıre (^oC)	-7,6	-7,2	-2,9	2,6	7,0	10,8	14,6	14,6	10,7	5,6	0,3	-4,7	3,6
Average Sunshine Duration (hr)	4,6	5,4	6,0	7,3	9,3	11,7	12,1	11,4	9,8	7,1	5,5	4,2	94,4
Average Nr. of Rainy Days	10,1	9,9	12,2	12,3	11,1	5,2	2,0	1,3	2,4	8,4	9,0	9,8	93,7
Average Monthly Rainfall (mm)	34,6	33,5	46,6	55,7	46,3	18,1	5,3	3,7	13,4	47,1	46,8	36,6	387,7
Maximum Temperature (^oC)	12,6	14,3	22,7	27,2	28,3	33,5	37,5	36,7	34,0	28,8	20,1	15,4	37,5
Minimum Temperature (^oC)	-28,7	-28,2	-22,7	-17,5	-3,5	-2,6	3,6	5,0	0,9	-14,0	-20,5	-21,3	-28,7

*** Period 1930-2018**

The climate of Malatya Region; The harsh terrain climate prevails in the Malatya region. Winters are cold and long, summers are hot and dry. The temperature ranges from -22.2 ° C to + 41.8 °C. Three months of the year are above 30 °C and 2.5 months are below 0 °C. The average annual rainfall is about 376 mm. One month of the year is covered with snow. Malatya is the most suitable alternative because it is more temperate than other alternative provinces. Table 3.18 shows the temperature distribution of Malatya.

Table: 3.18. Temperature Distribution of Malatya

Malatya	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Ann.
Average Temperature (^oC)	-0,3	1,4	6,7	12,9	17,9	23	27	27	22,4	15,5	7,9	2,1	13,6
Average Max. Temperatıre (^oC)	3,1	5,4	11,6	18,4	23,9	29,5	33,9	33,8	29,1	21,3	12,5	5,4	19,0
Average Min. Temperatıre (^oC)	-3,4	-2,1	2,2	7,5	11,9	16,2	19,9	19,9	15,5	9,9	3,9	-0,8	8,4
Average Sunshine Duration (hr)	3,4	4,4	5,6	7,2	9,3	11,6	12,6	11,9	10,1	7,5	5,3	3,1	92,0
Average Nr. of Rainy Days	10,8	10,5	10,9	10,6	10,1	4,7	1,0	0,8	2,1	6,7	8,6	10,8	87,6
Average Monthly Rainfall (mm)	42,1	40,1	48,8	54,3	45,2	17,2	2,2	1,8	6,6	35,7	41,7	40,3	376
Maximum Temperature (^oC)	15,4	20,3	27,2	33,7	36	40	42,5	41,9	38,8	34,4	25,0	18,0	42,5
Minimum Temperature (^oC)	-19,5	-21,2	-13,9	-6,6	0,1	4,9	10	9,3	3,2	-1,2	-12	-22,2	-22,2

*** Period 1930-2018**

The climate of Erzurum Region; Erzurum is one of Turkey's highest altitude and the coldest cities. The harsh land climate prevails. Winters are very cold and snowy, summers are very hot and dry. About 150 days of the year the soil is covered with snow. The rainfall is 432 mm. Melting snow feeds the streams. Table 3.19 shows the temperature distribution of Erzurum.

Table: 3.19. Temperature Distribution of Erzurum

Erzurum	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Ann.
Average Temperature (^oC)	-9,2	-7,7	-2,4	5,4	10,7	14,9	19,3	19,5	14,7	8,1	1,0	-5,9	5,7
Average Max. Temperatıre (^oC)	-4,0	-2,4	2,6	10,9	16,8	21,7	26,5	27,2	22,6	15,1	6,8	-1,0	11,9
Average Min. Temperatıre (^oC)	-14	-12,6	-7,1	0,0	4,4	7,3	11,2	11,2	6,5	1,8	-3,7	-10,3	-0,4
Average Sunshine Duration (hr)	3,2	4,4	5,1	6,3	7,9	10,2	11,2	10,7	9,0	6,8	4,8	3,1	82,7
Average Nr. of Rainy Days	11,3	11,1	12,4	13,7	16,2	11	6,7	5,2	5,2	9,7	9,3	10,7	122,5
Average Monthly Rainfall (mm)	22,5	26,8	34,9	53,0	73,8	49,0	26,6	17,7	23,5	48,3	33,1	22,8	432,0
Maximum Temperature (^oC)	8,0	10,6	21,4	26,5	29,6	32,2	35,6	36,5	33,3	27,0	20,7	14,0	36,5
Minimum Temperature (^oC)	-36	-37	-33,2	-22,4	-7,1	-5,6	-1,8	-1,1	-6,8	-14,1	-34,3	-37,2	-37,2

The climate of Kars Region; Kars has a strong high plateau climate. It is under the influence of the Siberian high-pressure center. Winter lasts seven months. Nearly 50 days year snow falls and the soil is covered with snow for more than 100 days. Spring and autumn seasons last almost none. The annual amount of precipitation is 528 mm in some places and 252 mm in some places. Table 3.20 shows the Kars temperature distribution. In terms of climate, Kars is the hardest one among the alternative provinces.

Table: 3.20. Temperature Distribution of Kars

Kars	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Ann.
Average Temperature (°C)	-10,3	-8,6	-2,0	5,5	10,3	14,0	17,6	17,7	13,5	7,3	0,4	-6,5	4,9
Average Max. Temperatıre (°C)	-5,0	-2,9	2,8	11,3	16,8	21,0	25,5	26,3	22,2	15	6,7	-1,5	11,5
Average Min. Temperatıre (°C)	-16,4	-15	-8,4	-0,7	3,9	6,6	9,9	9,7	5,3	0,5	-4,8	-12	-1,8
Average Sunshine Duration (hr)	3,2	4,3	5,2	6,0	7,3	9,3	10,4	10,2	8,5	6,4	4,6	3,2	78,6
Average Nr. of Rainy Days	10,7	10,3	11,5	13,2	18,1	14,7	10,4	8,7	7,1	9,6	8,6	10,1	133
Average Monthly Rainfall (mm)	21,3	22,1	29,7	50,8	81,0	77,6	58,1	43,4	28,5	41,4	26,0	22,8	502,7
Maximum Temperature (°C)	8,4	12,0	19,1	25,0	27,0	31,6	35,4	35,4	32,6	26,8	21,2	15,9	35,4
Minimum Temperature (°C)	-36,7	-37	-31,5	-23	-7,0	-4,0	0,1	-1,9	-4,4	-17,5	-30	-35	-37

*** Period 1930-2018**

3.2. Method

Fuzzy Topsis and Vikor methods which are used frequently recently were performed in this thesis study.

3.2.1 Fuzzy TOPSIS Method

TOPSIS (Tecnique for Order Preference by Smilarity to Ideal Solution) is one of the Multi Criteria Decision Making (MCDM) methods. It was developed by Hwang and Yoon (1981) (Chen, 2000: 2). The TOPSIS method takes into account the proximity to the positive ideal solution and the distance to the negative ideal solution when finding the proximity required for the ideal solution. These distances are compared with the preferred ranking (Janko and Bernroider, 2005: 16)

A multi-criteria fuzzy decision-making method is needed to make different linguistic assessments, build weights and decide on the best choice (Chen, 2001). In TOPSIS method, the studies using fuzzy values were started with a doctoral thesis by Negi (1989) and a book by Chen and Hwang (1992). However, the Fuzzy TOPSIS algorithm was not completed (Chu, 2002). Different researchers have tried to complete the algorithm in the light of these studies. One of these researchers, Chen (2000), in his article, has corrected this deficiency.

A triangle fuzzy number is shown as "n" *(n_1 , n_2 , n_3)* and μ_n (x) membership function is expressed as follows, and as shown in Figure 3.1 (Chen, 2000):

$$\mu_n(x) = \begin{cases} 0\,, x < n_1 \\[2ex] \dfrac{x - n_1}{n_2 - n_1}\,, \quad n_1 \le x \le n_2 \\[2ex] \dfrac{x - n_3}{n_2 - n_3}\,, \quad n_2 \le x \le n_3 \\[2ex] 0\,, x > n_3 \end{cases} \tag{1}$$

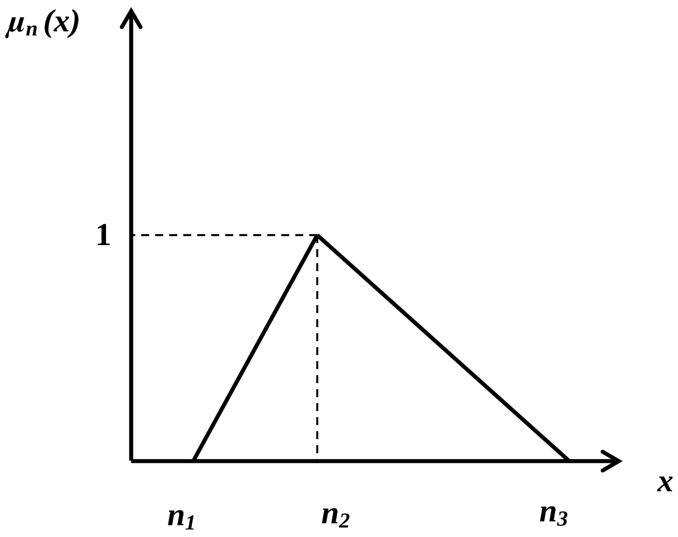

Figure 3.1. *n* Triangle Fuzzy Number (Chen, 2000: 3)

$m = (m_1, m_2, m_3)$ ve $n = (n_1, n_2, n_3)$ Let it be two triangular fuzzy numbers. The vertex method used to calculate the distance between them is defined as (Chen, 2000: 3):

$$d(m,n) = \sqrt[2]{\frac{1}{3}[(m_1 - n_1)^2 + (m_2 - n_2)^2 + (m_3 - n_3)^2]} \quad (2)$$

The linguistic variable is the variable whose values are the sentences in the native language (Zadeh, 1987). For example, beauty is a linguistic variable. Because values can be very ugly, ugly, middle, beautiful, very beautiful, as well as values. Linguistic values can be expressed with fuzzy numbers.

The Fuzzy TOPSIS method can be used to evaluate both qualitative and quantitative criteria. It has a very flexible structure (Chen et al. 2005). The Fuzzy TOPSIS method is very suitable for solving the problems that require decision of the group when decisions of decision makers vary. The importance of different criteria and criteria values are considered as linguistic variables. In order to calculate the importance of the criterion and the criterion values of alternatives according to different criteria, decision makers use linguistic variables. These linguistic variables can be expressed as positive triangle fuzzy numbers as in Tables 3.21 and 3.22 (Chen, 2000)

Table: 3.21. Linguistic Variables for Weight of Criteria

Very Low (VL)	(0,0,0.1)
Low (L)	(0,0.1,0.3)
Medium Low (ML)	(0.1,0.3,0.5)
Medium (M)	(0.3,0.5,0.7)
Medium High (MH)	(0.5,0.7,0.9)
High (H)	(0.7,0.9,1)
Very High (VH)	(0.9,1,1)

Table: 3.22. Linguistic Variables for Rating

Very Poor (VP)	(0,0,1)
Poor (P)	(0,1,3)
Medium Poor (MP)	(1,3,5)
Fair (F)	(3,5,7)
Medium Good (MG)	(5,7,9)
Good (G)	(7,9,10)
Very Good (VG)	(9,10,10)

$x^{K}{}_{ij}$ ve $w^{K}{}_{j}$ consisting of K decision makers; In a group where the K. (Kst) decision-maker shows the criterion value and significance, the criteria values of the alternatives and the significance weights of the alternatives according to each criterion are calculated as follows:

$$x_{ij} = \frac{1}{K}\left[\ x_{ij}^{1}\ (+)\ x_{ij}^{2}\ (+)\ \dots\ (+)\ x_{ij}^{K}\ \right] \tag{3}$$

$$w_{j} = \frac{1}{K}\left[\ w_{j}^{1}\ (+)\ w_{j}^{2}\ (+)\ \dots\ (+)\ w_{j}^{K}\ \right] \tag{4}$$

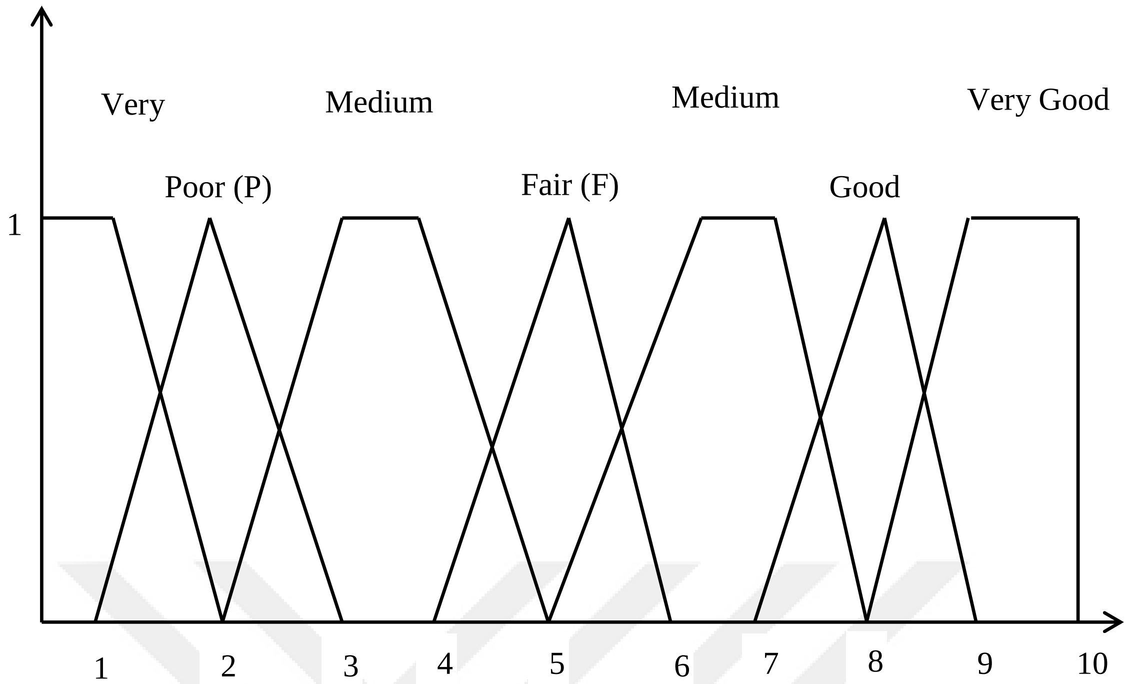

Figure 3.2. Membership Functions of Language Variables in Table 3.22

A fuzzy multi-criteria decision making matrix can be expressed as follows:

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ . \\ . \\ . \\ A_m \end{array} \begin{array}{c} \begin{array}{cccccc} C_1 & C_2 & . & . & . & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & . & . & . & x_{1n} \\ x_{21} & x_{22} & . & . & . & x_{2n} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ x_{m1} & x_{m2} & . & . & . & x_{mn} \end{bmatrix} \end{array}$$

Here, x_{ij} (∀i, j) ve w_j $j = (1,2,..., n)$ are linguistic variables. These linguistic variables can be defined as triangular fuzzy numbers with $x_{ij} = (a_{ij}, b_{ij}, c_{ij})$ and $w_j = (w_{j1}, w_{j2}, w_{j3})$

The normalized fuzzy decision matrix is indicated by R and

$$R = [r_{ij}]_{mxn} \qquad (5)$$

expressed as above. Here, B is a set of benefit criteria and is calculated as follows:

$$r_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right), \qquad j \in B; \tag{6}$$

$$c_j^* = max_i \, c_{ij} \;, \qquad j \in B$$

The above normalization method retains the characteristic that the normalized triangle fuzzy numbers are in the range [0,1].

A weighted normalized fuzzy decision matrix that takes into account the different importance of each criterion;

$$V = \left[v_{ij}\right]_{mxn} \qquad i = 1,2,\ldots,m \,; j = 1,2,\ldots,n \tag{7}$$

is created as in the form above. Here

$$v_{ij} = r_{ij} \;(\,.\,)\, w_j \tag{8}$$

is calculated with the formula.

According to the weighted normalized fuzzy decision matrix, the v_{ij} elements for $\forall i, j$ are normalized positive triangular fuzzy numbers and are in the range [0,1].

Fuzzy positive ideal solution (FPIS, A^*) and fuzzy negative ideal solution (FNIS, A^-)

$$A^* = (\, v_1^*, v_2^*, \ldots, v_n^* \,)$$

$$A^- = (v_1^-, v_2^-, \ldots, v_n^- \,)$$

Defined as above. Considered as $v^*_j = (1,1,1)$ * and $v^-_j = (0,0,0)$.

The distance of each alternative from A^* and A^- is respectively

$$d_i^* = \sum_{j=1}^{n} d\left(\, v_{ij}, \; v_j^* \,\right) \;, \qquad i = 1,2,\ldots,m \tag{9}$$

$$d_i^- = \sum_{j=1}^{n} d\left(v_{ij}, v_j^- \right) \quad , \; i = 1,2,\ldots,m \tag{10}$$

Calculated as this. Here d (.,.) Shows the distance between two fuzzy numbers.

The order of all alternatives is determined by the proximity coefficient. Proximity coefficient;

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-} \quad , \; i = 1,2,\ldots,m \tag{11}$$

Calculated as above.

While approaching 1, the value CC_i changes to alternating A_i , FPIS (A^*), while approaching alternative A_i FNIS (A^-) as it moves away from 1.

The algorithm of the Fuzzy TOPSIS method can be summarized as follows:

Step 1: A committee of decision makers is established and evaluation criteria are set.

Step 2: Decision makers determine the importance weight of decision criteria and evaluate alternatives with linguistic variables according to determined criteria.

Step 3: Measure the weight of the Cj criteria to obtain the total fuzzy weight w_j . The total fuzzy benchmark values of the Ai alternative under the Cj criterion are combined with the evaluations of the decision makers to obtain the x_{ij}.

Step 4: Fuzzy decision matrix and normalized fuzzy decision matrix are generated

Step 5: Weighted normalized fuzzy decision matrix is generated

Step 6: Accept FPIS (1,1,1) and FNIS (0,0,0).

Step 7: Calculate the total distances of each alternative from FPIS and FNIS.

Step 8: The proximity coefficient of each alternative is found.

Step 9: According to the proximity coefficient, the order of alternatives is made.

3.2.2 Fuzzy VIKOR Method

The VIKOR method was introduced as one applicable technique to be implemented within MCDM problem and it was developed as a multi criteria decision making method to solve a discrete decision making problem with non-commensurable (different units) and conflicting criteria. This method focuses on ranking and selecting from a set of alternatives, and determines compromise solution for a problem with conflicting criteria, which can help the decision makers to reach a final solution. The multi-criteria measure for compromise ranking is developed from the LP – metric used as an aggregating function in a compromise programming method. (Zhang and Wei, 2012)

Assuming that each alternative is evaluated according to each criterion function, the compromise ranking could be performed by comparing the measure of closeness to the ideal alternative. The various m alternatives are denoted as ; A1, A2, A3, …A_m. For alternative Ai,

the rating of the jth aspect is denoted by f_{ij}(i=1,2…,m_i j=1,2,…,n), i.e., f_{ij} is the value of jth criterion function for the alternative A_i, n is the number of criteria. Development of the VIKOR method is started with the following form of L_p- metric:

$$L_{p.i} = \left\{\sum_{j=1}^{n}\left[\frac{w_i\left(f_j^{*}-f_{ij}\right)}{(f_j^{*}-f_j^{-})}\right]^{p}\right\}^{\frac{1}{p}} \quad , \; 1 \leq p \leq \infty \tag{12}$$

In the VIKOR method $L_{1,i}$(as S_i) and $L_{\infty,i}$(as R_i) are used to formulate ranking measure. The solution obtained by min S_i is with a maximum group utility (‘‘majority’’ rule), and the solution obtained by min R_i is with a minimum individual regret of the opponent.

The compromise ranking algorithm of the VIKOR method has the following steps:

a) Determine the best f_j^{*} and the worst f_j^{-} values of all criterion functions j=1,2,…,n If the jth function represents a benefit then:

$$f_j^{*} = {}^{max}_{i} fij, f_j^{-} = {}^{min}_{i} fij \tag{13}$$

b) Compute the values S_i and R_i ; ,=1,2,…,m, by these relations;

$$S_i \ = \sum_{j=1}^{n} w_j \, \frac{\left(f_j^* - f_{ij}\right)}{(f_j^* - f_j^-)} \tag{14}$$

$$R_i \ = \ max_j \, w_j \, \left(f_j^* - \ f_{ij}\right)/\,(f_j^* - \ f_j^- \,) \tag{15}$$

Where w_j are the weights of criteria, expressing their relative importance.

c) Compute the values Q_i; i=1,2,…,mi, by the following relation:

$$Q_i \ = v(\,S_i \ - \ S^*\,)/\,(\,S^- - \ S^*\,) + \ (1 - v)(R_i - \ R^*\,)/(R^- - \ R^*) \tag{16}$$

Where,

$$S^* \ = \ min_i S_i \ , \quad S^- \ = \ max_i S_i \tag{17}$$

$$R^* \ = \ min_i R_i \ , \quad R^- \ = \ max_i R_i \tag{18}$$

Where v is introduced as weight of the strategy of ‘‘the majority of criteria’’ (or ‘‘the maximum group utility’’), here suppose v=0.5 Rank the alternatives, sorting by the values *S*, *R* and *Q* in decreasing order. The results are three ranking lists.

d) Propose as a compromise solution the alternative A0 , which is ranked the best by the measure *Q* (Minimum) if the following two conditions are satisfied:

C1. Acceptable advantage*: Q(A') - Q(A'') >=DQ*

where A'' is the alternative with second position in the ranking list by
Q. *DQ* = 1/(m-1), m is the number of alternatives

C2. Acceptable stability in decision making: Alternative A''must also be the best ranked by S or/and R. This compromise solution is stable within a decision making process, which could be ‘‘voting by majority rule’’ (when v > 0:5 is needed), or ‘‘by consensus v(apr)= 0:5, or ‘‘with veto’’ (v(apr)< 0:5). Here, v is the weight of the decision making strategy ‘‘the majority of criteria’’ (or ‘‘the maximum group utility’’).

If one of the conditions is not satisfied, then a set of compromise solutions is proposed, which consists of:

Alternatives A' and A'' if only condition *C2* is not satisfied, or

Alternatives A',A'',…., $A^{(m)}$if condition Cl is not satisfied; $A^{(m)}$ is determined by the relation Q($A^{(m)}$) - Q($A^{('')}$) < DQ for maximum M (the positions of these alternatives are ‘‘in closeness’’).

The best alternative, ranked by Q, is the one with the minimum value of Q. The main ranking result is the compromise ranking list of alternatives, and the compromise solution with the ‘‘advantage rate’’. VIKOR is an effective tool in multi-criteria decision making, particularly in a situation where the decision maker is not able, or does not know to express his/her preference at the beginning of system design. The obtained compromise solution could be accepted by the decision makers because it provides a maximum ‘‘group utility’’ (represented by min S) of the ‘‘majority’’, and a minimum of the ‘‘individual regret’’ (represented by min R) of the ‘‘opponent’’. The compromise solutions could be the basis for negotiations, involving the decision maker’s preference by criteria weights. (Zhang and Wei, 2012)

4. RESULTS AND DISCUSSIONS

4.1. Results

In this part of the thesis, the most suitable solution will be sought among the 5 alternative provinces determined in the eastern regions for the establishment of feedmill (feed factory). Fuzzy TOPSIS and Fuzzy VIKOR methods were used from MCDM methods to be able to find solutions among alternatives.

The first five stages of Fuzzy VIKOR and Fuzzy TOPSIS methods are the same in terms of the creation of the decision maker group, determination of alternatives and evaluation criteria, determination of linguistic variables for criterion weights and alternatives, calculation of fuzzy weights, creation of fuzzy decision matrix, methods from the sixth stage. In the fuzzy TOPSIS method, from the seventh stage, obtaining normalized fuzzy decision matrices, calculation of weighted normalized fuzzy decision matrix, calculation of fuzzy positive ideal solution for each alternative and calculation of fuzzy negative ideal solution, calculation of proximity coefficients, selection of the most appropriate proximity coefficient alternative While following the stages, in the Fuzzy VIKOR method, respectively from the seventh stage; determining the best and worst values of all criterion functions, calculating distance values to fuzzy best and worst values, performing other calculations, clarifying fuzzy numbers, checking acceptance conditions, selecting the smallest value of "*Q*" are followed.

The criteria used in the application and the abbreviations are given in Table 4.1

Table 4.1 Criteria and Alternatives

Criteria				**Alternatives**	
C1	Number of Cattle	**C6**	Distances to Company Existing Facilities	**A1**	Sivas
C2	Number of Sheep & Goat	**C7**	Wheat Production	**A2**	Van
C3	Animals In Neighboring Provinces	**C8**	Distance to Ports	**A3**	Malatya
C4	Logistics Facilities	**C9**	Competitors Existince	**A4**	Erzurum
C5	Characteristics of Agro. & Pasture Areas	**C10**	Climate	**A5**	Kars

4.1.1 Fuzzy TOPSIS Solving

Step 1: A group of decision makers is formed consisting of “n” experts with knowledge of alternatives and alternatives used to evaluate alternatives.

Step 2: “k” units evaluation criteri and “m” units of alternatives are determined.

Step 3: Forms filled in by the decision makers according to the linguistic variables given in Table 3.18; the significance level of the criteria and the linguistic evaluations on the basis of criteria for each alternative are given in Table 4.2 and Table 4.3

Table 4.2. Criteria Importance Level

DM	Criteria									
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**
DM1	VH	H	H	H	M	M	M	VH	H	M
DM2	VH	VH	H	VH	MH	H	M	VH	MH	M
DM3	VH	MH	H	VH	H	M	MH	H	M	M
DM4	H	H	H	MH	MH	H	MH	H	MH	M

Table 4.3. Evaluation of Alternatives based on Criteria

Alternative	DM	Criteria									
		C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**
A1	**DM1**	G	F	G	F	G	MP	VG	G	VG	F
	DM2	MG	F	G	F	MG	MP	VG	MG	VG	F
	DM3	MG	MP	MG	F	G	F	G	MG	G	MG
	DM4	G	F	MG	MG	MG	P	VG	MG	G	F
A2	**DM1**	MP	VG	F	MP	G	VG	MP	P	F	MG
	DM2	P	VG	F	MP	MG	VG	MP	P	F	MG
	DM3	F	VG	MG	MP	MG	VG	MP	MP	MP	F
	DM4	MP	VG	MG	F	G	G	F	P	MP	F
A3	**DM1**	MP	MP	VG	MG	F	F	F	G	F	G
	DM2	P	P	G	MG	F	F	F	MG	MP	G
	DM3	P	MP	G	G	F	MP	MP	MG	MP	MG
	DM4	MP	P	G	MG	MP	F	MP	MG	P	MG
A4	**DM1**	VG	G	VG	F	MG	G	MG	MG	F	F
	DM2	G	MG	VG	MG	MG	G	F	F	F	MP
	DM3	G	G	G	MG	MG	G	F	F	F	F
	DM4	VG	G	G	G	MG	G	F	MG	MG	F
A5	**DM1**	G	F	MG	MP	G	G	F	F	G	F
	DM2	G	F	MG	MP	MG	G	F	F	G	MP
	DM3	G	MG	G	MP	MG	VG	MP	MP	MG	F
	DM4	MG	MG	G	P	G	VG	MP	F	MG	F

Step 4: The fuzzy weights of each criterion and the alternative are calculated by formulas 3 and 4. Table 4.4 shows the fuzzy weight matrix. Table 4.5 also shows how to calculate fuzzy weights for characters.

Table 4.4. Fuzzy Weight Matrix of Criteria

Criteria	Fuzzy Weights (w_j)		
	l	m	u
C_1	0,85	0,98	1,00
C_2	0,7	0,875	0,975
C_3	0,7	0,9	1
C_4	0,75	0,9	0,975
C_5	0,45	0,7	0,875
C_6	0,4	0,7	0,85
C_7	0,3	0,6	0,8
C_8	0,8	0,95	1
C_9	0,45	0,7	0,875
C_{10}	0,1	0,5	0,7

Table 4.5. Fuzzy Weight Matrix Calculation Table of the Criteria

	C_1			C_2			C_3			C_4			C_5		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
DM1	0,9	1	1	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	0,1	0,5	0,7
DM2	0,9	1	1	0,9	1	1	0,7	0,9	1	0,9	1	1	0,5	0,7	0,9
DM3	0,9	1	1	0,5	0,7	0,9	0,7	0,9	1	0,9	1	1	0,7	0,9	1
DM4	0,7	0,9	1	0,7	0,9	1	0,7	0,9	1	0,5	0,7	0,9	0,5	0,7	0,9
Average	0,85	0,98	1,00	0,70	0,88	0,98	0,70	0,90	1,00	0,75	0,90	0,98	0,45	0,70	0,88

	C_6			C_7			C_8			C_9			C_{10}		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
DM1	0,1	0,5	0,7	0,1	0,5	0,7	0,9	1	1	0,7	0,9	1	0,1	0,5	0,7
DM2	0,7	0,9	1	0,1	0,5	0,7	0,9	1	1	0,5	0,7	0,9	0,1	0,5	0,7
DM3	0,1	0,5	0,7	0,5	0,7	0,9	0,7	0,9	1	0,1	0,5	0,7	0,1	0,5	0,7
DM4	0,7	0,9	1	0,5	0,7	0,9	0,7	0,9	1	0,5	0,7	0,9	0,1	0,5	0,7
Average	0,40	0,70	0,85	0,30	0,60	0,80	0,80	0,95	1,00	0,45	0,70	0,88	0,10	0,50	0,70

Step 5: Fuzzy decision matrix of each criterion is formed according to the alternative of "A_i". Table 4.6 shows a fuzzy decision matrix.

Table 4.6. Fuzzy Decision Matrix

Criteria	Fuzzy Decision Matrix According to Criteria Alternatives														
	A_1			A_2			A_3			A_4			A_5		
	l	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**
C_1	6,00	8,00	9,5	5,5	7,5	9	0,5	2	4	0,5	2	4	0,5	2	4
C_2	8,5	9,75	10	2,5	4,5	6,5	9	10	10	9	10	10	9	10	10
C_3	6	8	9,5	8	9,5	10	8	1,25	3	8	1,25	3	8	1,25	3
C_4	4	6	8	2,5	4,5	6,5	1,25	3	5	1,25	3	5	1,25	3	5
C_5	7,5	9,25	10	5	7	8,75	6	8	9,5	6	8	9,5	6	8	9,5
C_6	8,5	9,75	10	0	1	3	3	4,75	6,25	3	4,75	6,25	3	4,75	6,25
C_7	5	7	8,5	2,5	4,5	6,5	0,25	1,5	3,5	0,25	1,5	3,5	0,25	1,5	3,5
C_8	4	6	8	5	7	8,75	0	1	3	0	1	3	0	1	3
C_9	8	9,5	10	7	9	10	4	6	8	4	6	8	4	6	8
C_{10}	4	6	8	2,5	4,5	6,5	3	5	7	3	5	7	3	5	7

Step 6: Using the fuzzy decision matrix, a normalized fuzzy decision matrix is obtained with the help of formulas 5 and 6. This matrix is given in Table 4.7.

Table 4.7. Normalized Fuzzy Decision Matrix

Normalized Fuzzy Decision Matrix															
Criteria	**A1**			**A2**			**A3**			**A4**			**A5**		
	l	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**
C1	0,60	0,80	0,95	0,13	0,30	0,50	0,05	0,20	0,40	0,80	0,95	1,00	0,65	0,85	0,98
C2	0,25	0,45	0,65	0,90	1,00	1,00	0,25	0,15	0,30	0,65	0,85	0,98	0,40	0,60	0,80
C3	0,60	0,80	0,95	0,40	0,60	0,80	0,75	0,93	1,00	0,80	0,95	1,00	0,60	0,80	0,95
C4	0,38	0,59	0,81	0,16	0,38	0,59	0,59	0,81	1,00	0,54	0,76	0,95	0,08	0,27	0,49
C5	0,63	0,84	1,00	0,63	0,84	1,00	0,26	0,47	0,68	0,53	0,74	0,95	0,63	0,84	1,00
C6	0,13	0,30	0,50	0,85	0,98	1,00	0,25	0,45	0,65	0,70	0,90	1,00	0,80	0,95	1,00
C7	0,85	0,98	1,00	0,15	0,35	0,55	0,20	0,40	0,60	0,35	0,55	0,75	0,20	0,40	0,60
C8	0,59	0,81	1,00	0,03	0,16	0,38	0,59	0,81	1,00	0,43	0,65	0,86	0,27	0,49	0,70
C9	0,80	0,95	1,00	0,20	0,40	0,60	0,13	0,30	0,50	0,35	0,55	0,75	0,60	0,80	0,95
C10	0,37	0,58	0,79	0,42	0,63	0,84	0,63	0,84	1,00	0,26	0,47	0,68	0,26	0,47	0,68

Step 7: The weighted normalized fuzzy decision matrix, based on the weight of each criterion, is found in formulas 7 and 8. Table 4.8 shows the weighted normalized fuzzy decision matrix.

Table 4.8. Weighted Normalized Fuzzy Decision Matrix

Weighted Normalized Fuzzy Decision Matrix															
Criteria	A1			A2			A3			A4			A5		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
C1	0,51	0,78	0,95	0,11	0,29	0,50	0,04	0,20	0,40	0,68	0,93	1,00	0,55	0,83	0,98
C2	0,18	0,39	0,63	0,63	0,88	0,98	0,18	0,13	0,29	0,46	0,74	0,95	0,28	0,53	0,78
C3	0,42	0,72	0,95	0,28	0,54	0,80	0,53	0,83	1,00	0,56	0,86	1,00	0,42	0,72	0,95
C4	0,28	0,54	0,79	0,12	0,34	0,58	0,45	0,73	0,98	0,41	0,68	0,92	0,06	0,24	0,47
C5	0,28	0,59	0,88	0,28	0,59	0,88	0,12	0,33	0,60	0,24	0,52	0,83	0,28	0,59	0,88
C6	0,05	0,21	0,43	0,34	0,68	0,85	0,10	0,32	0,55	0,28	0,63	0,85	0,32	0,67	0,85
C7	0,26	0,59	0,80	0,05	0,21	0,44	0,06	0,24	0,48	0,11	0,33	0,60	0,06	0,24	0,48
C8	0,48	0,77	1,00	0,02	0,15	0,38	0,48	0,77	1,00	0,35	0,62	0,86	0,22	0,46	0,70
C9	0,36	0,67	0,88	0,09	0,28	0,53	0,06	0,21	0,44	0,16	0,39	0,66	0,27	0,56	0,83
C10	0,04	0,29	0,55	0,04	0,32	0,59	0,06	0,42	0,70	0,03	0,24	0,48	0,03	0,24	0,48

Step 8: The Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS) clusters of each alternative are calculated, respectively. Table 4.9 shows the weighted normalized fuzzy decision matrix.

Table 4.9. Fuzzy Positive and Fuzzy Negative Ideal Solution

Criteria	FPIS & FNIS									
	A1, A*	A2, A*	A3, A*	A4, A*	A5, A*	A1, A^-	A2, A^-	A3, A^-	A4, A^-	A5, A^-
C1	0,311	0,719	0,801	0,190	0,277	0,768	0,340	0,258	0,879	0,805
C2	0,628	0,226	0,803	0,349	0,514	0,442	0,839	0,211	0,745	0,566
C3	0,373	0,507	0,291	0,267	0,373	0,730	0,580	0,810	0,826	0,730
C4	0,508	0,679	0,356	0,392	0,760	0,575	0,394	0,749	0,702	0,310
C5	0,482	0,482	0,679	0,531	0,482	0,631	0,631	0,401	0,580	0,631
C6	0,787	0,432	0,702	0,475	0,446	0,275	0,659	0,372	0,632	0,650
C7	0,506	0,785	0,760	0,686	0,760	0,591	0,283	0,312	0,400	0,312
C8	0,331	0,829	0,331	0,445	0,575	0,779	0,236	0,779	0,645	0,501
C9	0,423	0,724	0,781	0,634	0,502	0,668	0,347	0,282	0,449	0,599
C10	0,738	0,720	0,659	0,775	0,775	0,361	0,387	0,473	0,309	0,309

The distance of each alternative from FPIS and FNIS was calculated by formulas 9 and 10, respectively. The proximity coefficients of the candidates after finding the distances were calculated by the formula (2). According to the information given by the decision makers, the result of the solution with the Fuzzy TOPSIS method is shown in Table 4.10. According to this; Erzurum 1st place and Sivas took the second place.

Table 4.10. Fuzzy Topsis Solution Ranking

Alternatives	D*	D^-	CC	Ranking
A1	5,086	5,820	0,534	2
A2	6,101	4,697	0,435	5
A3	6,164	4,646	0,430	4
A4	**4,744**	**6,166**	**0,565**	**1**
A5	5,463	5,413	0,498	3

4.1.2 Fuzzy VIKOR Solving

Facility location selection problem is solved by Fuzzy TOPSIS method. The first five steps of Fuzzy TOPSIS and Fuzzy VIKOR methods are the same. Therefore, "Step 6" have been started for the solution of Fuzzy VIKOR method.

Step 6: The best and worst values of all criterion functions, fuzzy values are calculated with formula 13 and are shown in Table 4.11.

Table 4.11. Best and Worst Values of Criteria

Criteria	F(*)			F(-)		
	l	**m**	**u**	**l**	**m**	**u**
C_1	8	9,5	10	0,5	2	4
C_2	9	10	10	2,5	1,5	3
C_3	8	9,5	10	4	6	8
C_4	5,5	7,5	9,25	0,75	2,5	4,5
C_5	6	8	9,5	2,5	4,5	6,5
C_6	8,5	9,75	10	1,25	3	5
C_7	8,5	9,75	10	1,5	3,5	5,5
C_8	5,5	7,5	9,25	0,25	1,5	3,5
C_9	8	9,5	10	1,25	3	5
C_{10}	6	8	9,5	2,5	4,5	6,5

Step 7: Using the formulas S_i (14) and R_i (15), the distances of each alternative to the best fuzzy and worst fuzzy values are calculated and shown in Table 4.12.

Table 4.12. Determination of S_i and R_i Values of Alternatives

Alternative	S_i			R_i		
	l	**m**	**u**	**l**	**m**	**u**
A1	2,064	2,564	2,497	0,700	0,700	0,850
A2	3,654	4,893	5,453	0,800	0,950	1,000
A3	3,147	4,411	5,031	0,850	0,975	1,000
A4	1,402	2,098	2,083	0,300	0,500	0,700
A5	2,805	3,542	3,522	0,750	0,900	0,975

Step 8: Maximum group benefit S_i , S^* (17) and minimum individual regret, R^* were Calculated using formulas (18) and shown in Table 4.13.

Table 4.13. S_i , S^* and R_i , R^* Values

	l	**m**	**u**
S^* **(min.)**	1,402	2,098	2,083
S_i **(max.)**	3,654	4,893	5,453
R^* **(min.)**	0,300	0,500	0,700
R_i **(max.)**	0,850	0,975	1,000

Step 9: In this last step, the Q_i (16) values are calculated. Also, fuzzy numbers can be clarified; S_i , R_i and Q_i index values were found. The results obtained are shown in Table 12. According to the index values, a small to large ranking was made among the alternatives. The index value represents the best alternative with the smallest. According to this method; The A4 region is the first and the A1 region is the second.

Table 4.14. Sorting Alternatives by Index

Alternative	Fuzzy Vikor Results								
	Q_i			Q_i		S_i		R_i	
	l	m	u	Index	Result	Index	Result	Index	Result
A1	0,511	0,294	0,311	0,372	2	2,375	2	0,750	2
A2	0,955	0,974	1,000	0,976	5	4,667	5	0,917	4
A3	0,887	0,914	0,937	0,913	4	4,196	4	0,942	5
A4	**0,000**	**0,000**	**0,000**	**0,000**	**1**	**1,861**	**1**	**0,500**	**1**
A5	0,721	0,679	0,672	0,691	3	3,290	3	0,875	3

The following two conditions have been checked to see if the A4 alternative was the best solution.

1st Condition: Acceptable advantage Q(a'') - Q(a')≥0,25 should fulfill the condition (0,372 – 0,000 ≥0,25).

Alternative A4 provides the acceptable advantage condition.

2nd Condition: Acceptable stability in decision-making

Alternative A' should be the best alternative in the order of S and / or R values.

When Table 4.14 is analyzed, it appears that *S* and *R* are in the first place according to index values. Thus, the alternative provides an acceptable condition of stability.

Compared to the results of Fuzzy TOPSIS and VIKOR methods; In both methods A4 region is the best one, 2nd place A1 region and 3rd place A5 region were found. In this context, it was deemed appropriate to choose Erzurum which is the A4 region as a result of the implementation of both methods.

4.2 Discussions

Facility location selection is an important multi-criteria decision making problem. After determining the experts having different area of expertise, company culture and point of view, the decision-maker determined the facility location criteria for the feedmill and evaluated them. This study is planned to establish a new feed mill (feed factory) in eastern Turkey. For this reason, Fuzzy TOPSIS and Fuzzy VIKOR methods were used. Alternative cities were evaluated with details and a solution was reached.

Fuzzy VIKOR and TOPSIS methods were chosen as the selection methods. These methods are effective in obtaining the optimum results by including the selection in the verbal criteria based on the experiences and knowledge of the decision-makers. In both methods, the results are close to each other and the methods could be used to determine the definition of the problem.

When Tables 4.2 and 4.4 are examined, it is seen that the most important criteria by decision makers is the number of cattle. The distance to the ports has the second priority. These are followed by transportation facilities, the number of animals in neighboring provinces, the number of small cattles, agricultural and pasture areas. Climate is the least important criteria of all. It is seen that Erzurum province is the best alternative of both Fuzzy VIKOR and TOPSIS methods. However in terms of distance to the ports. the decision makers located Malatya and Sivas in a better position and put Erzurum in the 3rd place. In addition, Erzurum was identified as the best alternative province in terms of the number of animals in neighboring provinces. Erzurum is the worst one among the alternatives in terms of climate.

5. CONCLUSIONS

With an increasingly competitive environment, firms need to select the most appropriate places to support their long-term competitive structures and provide high profit and customer satisfaction at minimum costs. In this study, considering the results, it is emphasized that the choice of place for the feed mill from the strategic decision types which cause the high costs to be incurred in the long term even if it is returned and therefore require the correct decision for the first time. The choice of site location, the interaction of many factors with each other and often conflicting the desired gains, the choice of methods to reach a conciliatory solution becomes more important than ever. Therefore, it is important that the methods used in reaching the solution should take into account many factors that influence the final selection decision.

For the evaluation of alternatives and selection of the best; cases that require multiple criteria and decision-based assessments and are frequently used in recent years; Multivariate Decision Making (MCDM) methods using the Fuzzy VIKOR and Fuzzy TOPSIS methods have been performed to show a different approach for the solution. For evaluation of alternatives; A total of 10 criteria were determined including the number of bovine animals (cattle), number of ovine animals (small cattle), number of animals in the neighboring provinces, transportation facilities, characteristics of agricultural and pasture areas, corn production, wheat production, distance to ports, number of competitors, and climate conditions. As a result of the study; The number of bovine animals (cattle) to the port was determined as the most important evaluation criteria by the decision-makers in the selection of the location. As a result of the solution of the selected site location problem by using Fuzzy VIKOR and Fuzzy TOPSIS methods, A4 region was chosen as the first among the other alternatives.

The order of the results obtained by Fuzzy TOPSIS and VIKOR method is very close to each other. As in the MCDM techniques, TOPSIS and VIKOR methods are both based on the “ideal solution closeness” reference point. These two methods are different from each other when analyzing alternatives. The VIKOR method uses the Q_i function while the TOPSIS method uses the C_j function. These two MCDM methods use different normalization techniques. When using VIKOR liner normalization, TOPSIS uses vector normalization (Opricovic and Tzeng). The field of application of these methods is not limited to the selection of the location

Facility location selection problems are one of the most strategic decisions faced by the companies. The sustainability of a facility that is established as a result of a wrong decision without any comprehensive analysis would be unrealistic. When making such an important decision, the criteria should be determined accurately. By using a few methods instead of a single method, more durable and reliable results can be obtained. Recently, fuzzy TOPSIS and VIKOR facility location are frequently used in MCDM methods. In these methods, a committee of decision-makers is established. This committee is of critical importance for the accuracy of the results, which have different perspectives and are experienced and expert in the field.

In this thesis, the eastern regions of Turkey are being planned by the company and previously selected five provinces on alternative plant location study was conducted. More objective results may be obtained if the number of decision makers and decision makers in the committee is increased.

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C.P Yem	Production Spv	2013-2017
Tosçelik Profil&Sac	Lojistic Engineer	2011-2012