

**WAREHOUSE LOCATION SELECTION FOR 3PL COLD CHAIN SUPPLIERS
IN GULF COUNTRIES USING NEUTROSOPHIC FUZZY EDAS**

(BULANIK NÖTROSOFİK EDAS YÖNTEMİ İLE KÖRFEZ ÜLKELERİNDEKİ
3.PARTİ SOĞUK ZİNCİR TEDARİKÇİLERİ İÇİN DEPO YERİ SEÇİMİ)

by

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Thesis

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

MASTER OF SCIENCE

in

LOGISTICS AND FINANCIAL MANAGEMENT

in the

GRADUATE SCHOOL OF SCIENCE AND ENGINEERING

of

GALATASARAY UNIVERSITY

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July 2020

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**WAREHOUSE LOCATION SELECTION FOR 3PL COLD CHAIN SUPPLIERS
IN GULF COUNTRIES USING NEUTROSOPHIC EDAS**

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ACKNOWLEDGEMENTS

I would like to express my gratitude to my thesis supervisor Assist. Prof. Dr. M. Levent Demircan for his guidance, support and time. His guidance and agile time management was the most important driving factor all the way through this study.

I would also like to express my gratitude to my managers Mr. Recep Ulu and Mr. Zafer Yıldırım. Their support and understanding to make time for study at the same time with business was priceless.

Last but not the least, I would like to thank my family, especially my wife Hatice Işık for providing me necessary environment during this study. Their understanding and encouragement was huge.

July 2020

Berkay Özcan

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LIST OF SYMBOLS

ÇKKV	: Çok Kriterli Karar Verme
EDAS	: Evaluation based on Distance from Average Solution
AS/RS	: Automated Storage and Retrieval System
MCDM	: Multi Criteria Decision Making
3PL	: Third Party Logistics
4PL	: Fourth Party Logistics
IT	: Information Technology
UAE	: United Arab Emirates
SCM	: Supply Chain Management
SC	: Supply Chain
AHP	: Analytic Hierarchy Process
GB	: Great Britain
TOPSIS	: Technique for Order Preference by Similarity to Ideal Solution
NZ	: New Zealand
VIKOR	: VišeKriterijumska Optimizacija I Kompromisno Resenje
FST	: Fuzzy Set Theory
GMP	: Good Manufacturing Practices
GDP	: Good Distribution Practice
GWP	: Global Warming Potential
VIKOR	: VišeKriterijumska Optimizacija I Kompromisno Resenje
QC	: Quality Control
BFFF	: British Frozen Food Federation
IFFI	: Italian Frozen Food Institute
EFSA	: The European Food and Safety Authority
FDA	: The U.S. Food and Drug Administration
USA	: United States of America
FIFO	: First In First Out
FEFO	: First Expired First Out
FDA	: The U.S. Food and Drug Administration
IVN	: Interval-Valued Neutrosophic
IVNN	: Interval-Valued Neutrosophic Numbers
IVNS	: Interval-Valued Neutrosophic Sets
AV	: Average
IVNWAA	: Interval-valued neutrosophic weighted arithmetic average
DM	: Decision Maker

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ABSTRACT

From past to present, logistics processes have been analyzed as one of the most important expense items for companies. And the companies that failed to manage their logistics processes well, cannot reach the desired growth rates and some even disappeared. Logistics management without process optimizations can be time and money consuming for the companies. So as it is clear, logistics processes have a significant influence on organizations' efficiency. That's why the process flow quality should be kept at a certain level and some decision problems should be analyzed and answered well. Location selection of a warehouse is one of the most important decision problems of supply chain and logistics management. Since different alternatives need to be analyzed, MCDM techniques are used to solve this problem. And alternatives are evaluated in terms of both quantitative and qualitative criteria to decide the best location alternative by using scientific MCDM techniques. Over the years different kinds of scientific methods have been developed and used to solve this problem.

As for this study, the aim is to investigate a more specific topic of warehouse location selection. This specific topic is the warehouse location selection of third-party cold chain logistics suppliers. Recently, the importance of keeping perishable products under right conditions increased, since it is realized that cold chain warehousing and transportation prevent the product/food spoiled. So organizations can save their money and time by having an effective cold chain management. The main scope of this study is to give a new scientific point of view for warehouse selection in cold chain logistics. MCDM technique of Interval Valued Neutrosophic EDAS method has been used to evaluate important criteria and to choose the best alternative. And some important cities of Gulf Region countries have been handled and evaluated as alternatives in the computational study of this project.

RÉSUMÉ

Du passé au présent, les processus logistiques ont été analysés comme l'un des postes de dépenses les plus importants pour les entreprises. Et les entreprises qui n'ont pas bien géré leurs processus logistiques ne peuvent pas atteindre les taux de croissance souhaités et certaines ont même disparu car ces processus peuvent prendre du temps et de l'argent si les optimisations de processus n'ont pas été faites. Il est donc clair que les processus logistiques ont une influence significative sur l'efficacité des organisations. Étant donné que différentes alternatives doivent être analysées, les techniques MCDM sont utilisées pour résoudre ce problème. Et les alternatives sont évaluées en termes de critères quantitatifs et qualitatifs pour décider de la meilleure alternative de localisation en utilisant des techniques scientifiques MCDM. Au fil des ans, différents types de méthodes scientifiques ont été développés et utilisés pour résoudre ce problème.

Quant à cette étude, elle vise à étudier la sélection de l'emplacement des entrepôts pour la logistique de la chaîne du froid. Récemment, l'importance de conserver les produits sensibles à la température dans de bonnes conditions a augmenté, car l'entreposage et le transport dans la chaîne du froid empêchent le produit / l'aliment de se gâter. Ainsi, les organisations peuvent économiser leur temps et leur argent en ayant une gestion efficace de la chaîne du froid. L'objectif principal de cette étude est de donner un nouveau point de vue scientifique pour la sélection des entrepôts dans la logistique de la chaîne du froid. La méthode EDAS neutrosophique à valeurs d'intervalle a été utilisée pour évaluer des critères importants. Et la région du Golfe a été traitée dans l'étude informatique de ce projet.

ÖZET

Geçmişten günümüze lojistik süreçler firmaların en önemli gider kalemlerinden biri olarak değerlendirilmiştir. Lojistik süreçlerini doğru yönetmede başarılı olamayan firmalar istenen büyüme oranına erişememiş hatta kimi iflas etmiştir. Süreç optimizasyonları yapılmayan bir lojistik yönetimi firmalar için zaman ve para kaybına neden olabilir. Dolayısıyla, lojistik süreçlerin firmaların verimliliği üzerinde ciddi bir etkisi olduğu açıktır. Bu yüzden lojistik süreçlerin kalitesi belli bir seviyede tutulmalı ayrıca lojistik karar problemleri iyi analiz edilip sonuçlandırılmalıdır.

Bir önceki paragrafta belirtildiği üzere firmalar lojistik hizmetleri en düşük maliyetle, en hızlı ve en güvenli şekilde sağlayabilmek için sürekli bir gelişim içerisinde. Bir siparişin verilmesinden teslimat noktasına erişmesine kadar geçen sürenin azaltılabilmesi için; toplama, elleçleme, katma değer, paketleme, yükleme, transfer, taşıma ve teslimat gibi süreçler minimize edilmeye çalışılıyor. Dönemin değişen şartlarına karşı hızlı reaksiyon alma hatta dönemin ötesinde düşünmeyi bir kurum kültürü haline getirmeye çalışmaktalar. Bu vizyona sahip kurum ve kuruluşlar yere daha sert basmakta ve pazardaki rekabetçi duruşunu koruyabilmekte.

Bilgi sistemlerini alanında küresel anlamda yaşanan gelişmeler, iyi altyapıya sahip lojistik servis sağlayıcıları için ciddi bir avantaj sağlamakta, günümüzde son tüketici ya da ara müşteriler verdikleri siparişleri anbean takip etme ve haberdar olma isteği içerisinde. Bu da bilgi sistemlerinin doğru kullanımı ile son tüketici tarafında başarılı bir izlenebilirlik sağlıyor.

Tedarik zinciri ve lojistik yönetiminde en önemli karar verme problemlerden biri “Depo Yeri Seçimi”dir. Bu problemlerin çözümünde farklı alternatiflerin değerlendirilmesi gerektiğinden ÇKKV (Çok Kriterli Karar Verme) tekniklerinden yararlanılır. ÇKKV

teknikleri kullanarak en iyi depo yeri seçimini yapmak için farklı alternatifler nitel ve nicel kriterlere göre değerlendirilir. Bu tarz problemlerin çözümü için yıllar içerisinde birbirinden farklı bilimsel ÇKKV tekniği ortaya çıkmış ve kullanılmıştır.

Bu projeye gelince, depo yeri seçiminde daha spesifik bir konunun araştırılması amaçlanmıştır. Bu spesifik konu ise “ Üçüncü Parti Soğuk Zincir Lojistiği Tedarikçileri için Depo Yeri Seçimidir”. Son zamanlarda sıcaklık toleransı olan rejimli ürünler doğru koşullarda tutmanın önemi arttı çünkü soğuk zincir depolama ve taşıma faaliyetlerinin ürünlerin bozulmasını engellediği görüldü. Dolayısıyla üretici ya da tedarikçi firmalar, etkili bir soğuk zincir yönetimiyle paralarını ve zamanlarını kurtarabilir. Bu çalışmanın ana kapsamı da soğuk zincir lojistiğinde depo yeri seçimine bilimsel bir bakış açısı sunmaktır. Kriterlerin değerlendirilmesi ve doğru alternatifin tespit edilmesinde ÇKKV tekniklerinden biri olan Interval Valued Neutrosophic EDAS yöntemi kullanılmıştır. Son olarak, projenin sayısal hesaplamalı kısmında Arap Körfezi ülkelerinin bazı önemli şehirleri alternatif olarak ele alınmış ve değerlendirilmiştir.

1. INTRODUCTION

We all have different kind of needs during the day. These needs can be a material, an information or money and somehow they have to reach us. So somebody should provide or supply this needs to us or to related ones. These providers can be a producer or can be a dealer. In such an ecosystem, a good management is needed to ensure correct integration of the elements. This management is called as supply chain management and according to Mentzer et al. (2001) supply chain evaluated as a group of entities which has three or more member and all these members are included in downstream or upstream flows of information, product, money and services from point of source to point of customer.

As for logistics processes are played an important role in the different stages of supply chain. Physical supply and distribution stages involve logistics processes. Logistics is not just a shipping or transportation. Shortly, logistics is the delivery of right product;

- to right place,
- with right quantity,
- in the right time,
- with the minimum cost,
- with the maximum flexibility,
- as undamaged.

In fact, logistics emerged in the process of meeting military needs and it has been developed based on this fundamental over the years. Planning is the key factor of linking logistics chains. So it is pretty difficult to achieve any retail, production or marketing organization without logistical support.

It is known that the history of warehousing is almost as old as humanity. In the early stages of humanity, life was being maintained by hunting and gathering. After then, the storage problem of this gathered or hunted things has occurred. Therefore, people began to store the crops and animals in their own way. For example, animals were not killed because the meat spoilage quickly. And they have been kept by storing alive. That's why, in English, synonymous of herd is named as "livestock". Thus, primitive warehousing has been started (Derman, 2010). Then, products have begun to move one place to another. And this process brought along the needs of storage till shipped or storage at transfer centers. With industrial revolution, harbour warehouses hadn't sufficed. And the storage need has occurred for the products which produced in ateliers that transformed to factory.

In the early 1990s, packaging showed up to speed up loading, unloading, putaway and picking processes which take much time during storage. For example, in 1931, while a truck which loaded 13.000 boxes of canned food could be unloaded in 3 days, today it reduced to 4 hour if we palletised same amount of product. As palletized production increased, vehicles and machines that allow palletized products to be easily handled within the warehouse began to emerge. At the same time, thanks to these machines and vehicles, height / floor concepts have emerged in the warehouse and the warehouses have started to be used with maximum capacity. The last milestone of storage was the emergence of AS/RS warehouses (Derman, 2010).

From past to present, logistics processes have been analysed as one of the most important expense items for companies. Companies that cannot manage their logistics processes well, cannot reach the desired growth rates and some even disappear. Since logistics is a process with a lot of input and output, it is necessary to make accurate analyses in order to reach maximum efficiency. To this end, scientific studies have been conducted with different methods from past to present. The outputs were applied to the processes and a

certain knowhow was obtained. In addition, companies that do not have sufficient logistics knowhow have applied to expert companies to manage their logistics processes. The concepts of 3PL and 4PL have emerged for this reason.

As it is mentioned above parts, logistics processes have significant influence on efficiency of organizations and logistics has different kind of optimisation/decision problems. In a logistics system optimisation, proper warehouse location selection is an important problem (Raut et al., 2017). One fundamental of supply chain is warehouses and it has great effect on the success or failure of a business. (Ashrafzadeh et al. 2012).

Warehouse location selection is an MCDM problem that should be evaluated according to some criteria. This criteria can be both qualitative and quantitative. And best alternative is chosen by comparing this alternatives by using MCDM techniques. Such decisions are all important to companies because they are costly and difficult to fix and start over (Ashrafzadeh et al. 2012). In the past years, hundreds of study have been done related to warehouse selection problem. As for this study, it is aimed to investigate a more specific topic of warehouse location selection. So, this specific topic is warehouse location selection in cold chain logistics.

Every year, tons of food spoil since they haven't kept under correct temperature or humidity conditions. For example, every year the vegetables and fruits that are valued almost 75 billion ¥ are spoiled in shipping in China. This is corresponding to 370 million tons of vegetables and fruits which are thrown can meet the needs of a town of 200 million populations (Lan et al., 2008). So this is a huge number that should be considered. We need to achieve real-time monitoring of some important parameters to keep this products not to be spoilage in the warehouse operations or during delivery. New tech solutions and IT systems provide useful methods to monitor this parameters (such as track and trace services, temperature, invoice, etc.) (Stragas et al., 2014).

The main scope of this study is to give an alternative point of view for warehouse location selection in cold chain logistics of Arabian Gulf Region that consists of seven states. These are Qatar, Oman, Kuwait Bahrain, Saudi Arabia, Iraq and UAE. Cold chain warehousing and cold chain transportation has an important role to provide successful

supply chain of perishable goods in this region. Because annual average temperature is around 37 °C. Considering the very high temperature and humidity levels, cold chain logistics have become important more than ever in order to maintain a profitable and a suitable shelf life for perishable goods and products.

In Chapter 1, general scope of the study has been explained. In Chapter 2, literature review has been done about the topics of Supply Chain, Logistics, Warehouse Location Selection, Cold Chain Logistics, 3PL concept and Interval Valued Neutrosophic EDAS. In Chapter 3, it is mentioned about important criteria and sub-criteria which is a must to evaluate, calculate and comment location alternatives. In Chapter 4, alternatives have been determined and stated. In Chapter 5, there are some theoretical information related to scientific method (interval valued neutrosophic EDAS) which has been used in computational study of the project. Chapter 6 provides the details regarding how numerical example was performed and what are the results of this study. Chapter 7 contains a brief conclusion on what happened throughout the project. Final and eighth chapter provides potential researches that can be done in the future.

2. LITERATURE REVIEW

This part of the study provides some information about the subjects which has close relationship with the title of this study. Topics such as supply chain, logistics management, warehouse location selection, cold chain concept, third party logistics concept and EDAS method have been handled and investigated. In addition to researches have been done in the past, the information which is available on the web was also investigated. Web sites such as Google Scholar, Web of Science and Yöktez have been used to reach related articles or researches.

2.1. Supply Chain Management

In the early 1980's, SCM word has first been mentioned by subject matter consultants (Lambert et al., 2000). And then researchers and authorities have tried to draw the correct structure of the supply chain. Thanks to these investigations and analysis, supply chain structure has been developed. The disciplines and subjects which has a direct or indirect relationship with SC have been identified. Also challenges and benefits have been listed. Because when the organizations have experienced a challenge or problem, then it has solved by supply chain experts or researchers. So experiences ended up with new developments and investigation. Since the conditions change constantly over the years, new inputs brought new outputs.

The popularity of the supply chain concept increased over the years. Some specific factors of this popularity are global sourcing facilities, the importance of quality and on time-based competition, ease of access to different manufacturers and dynamic global economy. Global sources have started to preferred more by the organizations day by day. Most organizations try to find alternative sources from all over the world for their needs. The globalization effect forced organizations to find a much more efficient way to manage

their material flow. The supplier relationship can be evaluated as a key factor for this management. Also time and quality can be other parameters which companies compete for. End-users demand services or products continually delivered on time, faster and delivered with no damage. Plenty of different definitions have been made for supply chain management over the years. And Mentzer et al. (2001) summarized them all in their study as Table 2.1 below.

Table 2.1: Definitions of SCM

Riley D.W. et al (1985)	Supply chain management deals with the total flow of materials from suppliers through end users.
Stevens G. C et al. (1989)	The objective of managing the supply chain is to synchronize the requirements of the customer with the flow of materials from suppliers in order to effect a balance between what are often seen as conflicting goals of high customer service, low inventory management, and low unit cost.
Masters M. et al. (1994)	Supply chain strategy includes; - two or more firms in a supply chain entering into a long-term agreement - the development of trust and commitment to the relationship; the integration of logistics activities involving the sharing of demand and sales data - the potential for a shift in the locus of control of the logistics process
Cooper M.C et al (1997)	An integrative philosophy to manage the total flow of a distribution channel from supplier to the ultimate user.
Handfield R. et al. (1998)	SCM requires traditionally separate materials functions to report to an executive responsible for coordinating the entire materials process, and also requires joint relationships with suppliers across multiple tiers. SCM is a concept, “whose primary objective is to integrate and manage the sourcing, flow, and control of materials using a total systems perspective across multiple functions and multiple tiers of suppliers.

As it is seen in Figure 2.1 supply chain has different members such as supplier, suppliers' supplier, producer, distributor, customer, customer's customer etc. (Mentzer et al., 2001) And products, services, information, financial resources, demand and forecast can flow between this members. And different management disciplines such as marketing, sales, logistics, purchasing etc. should be run effectively to keep this chain smooth and effective because supply chain management cannot be left to chance

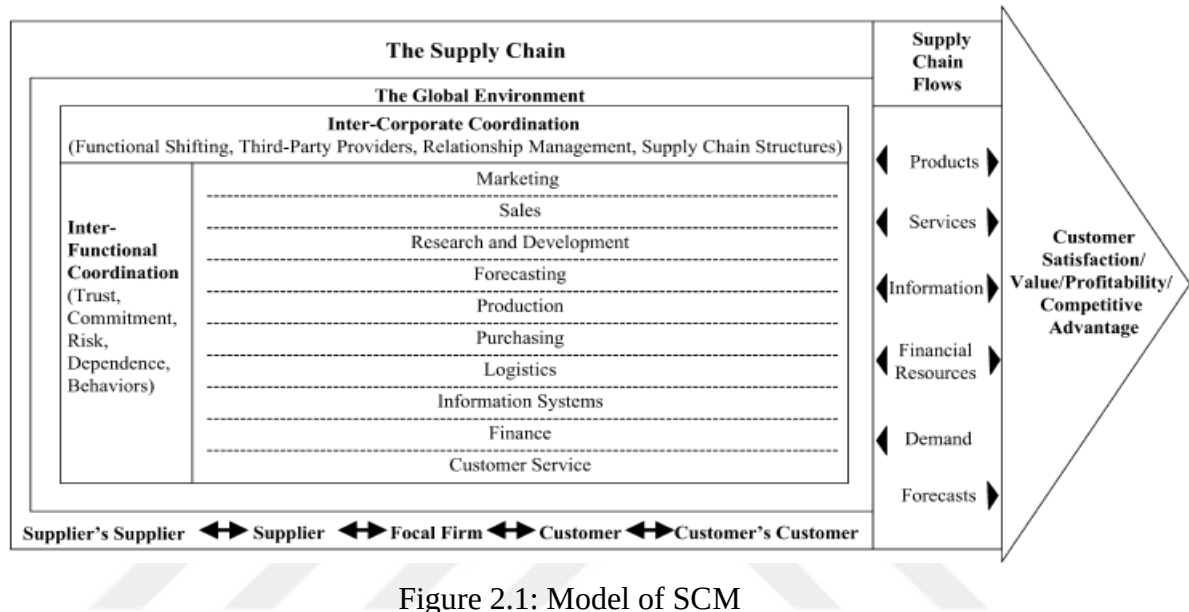


Figure 2.1: Model of SCM

2.2. Logistics Management

One of the best definition of logistics term can be strategic process of managing the movement, handling, storage and the acquisition of finished product, spare part or intermediate product and raw materials throughout the operation and its marketing ways. The aim is to fulfil orders in most cost effective way to maximise profitability (Gattorna et al., 1991).

Logistics consists of the communication, transportation, storage/warehousing and material handling processes. However the concept is mainly based on the effective, secure, real-time movement activity. And this material and information flow has been described in Figure 2.2 (Gattorna et al., 1991).

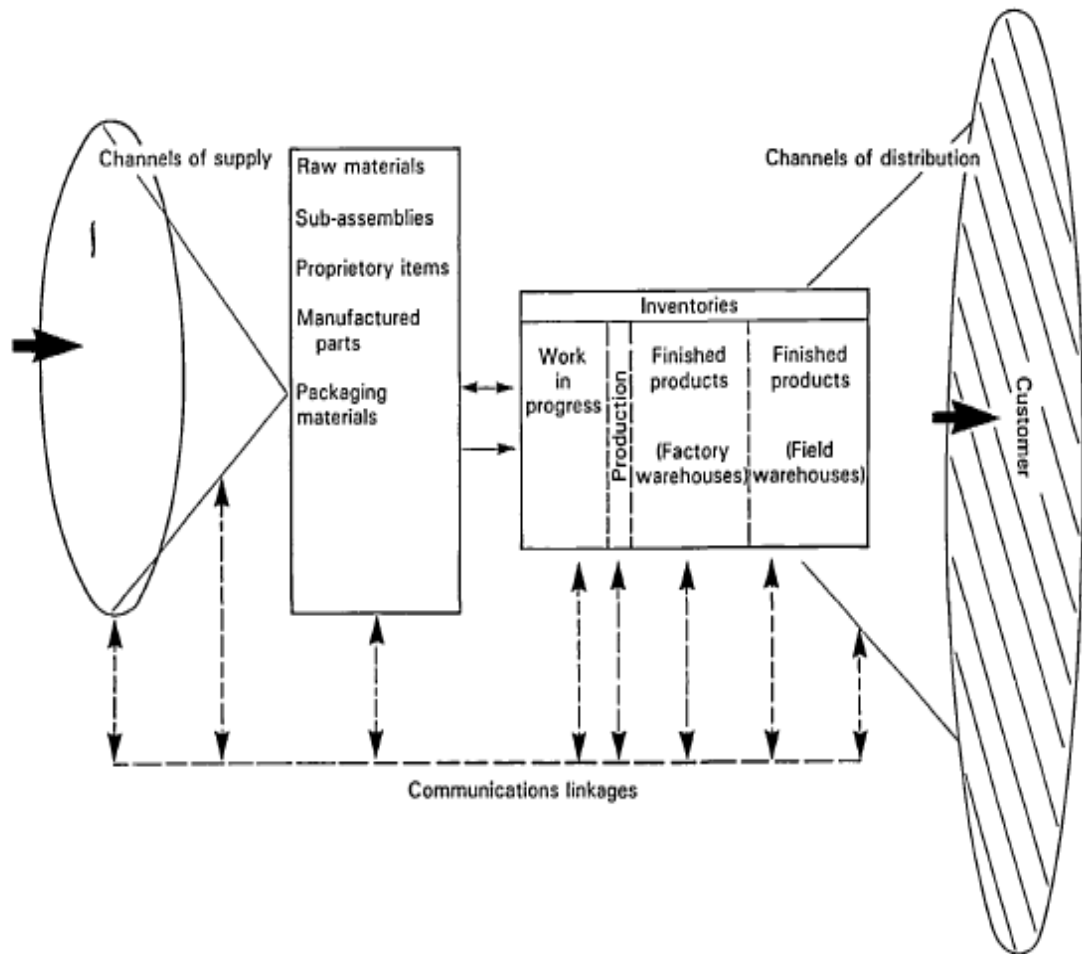


Figure 2.2: Logistics flow

On the other hand, logistics is built on some fundamentals. And its efficiency is changed depending on how many of them are fulfilled. These fundamentals are stated in Figure 2.3 below. While some of them such as minimum cost, flexibility affect efficiency, rest of them directly affect success. Because you have to provide right product to right place otherwise this attempt will be a fail. Right quantity is another important measurement because production lines or production places are fed by means of logistics. Time factor is crucial for healthcare sector and so on. As we can see, logistics affects our daily lives directly or indirectly.

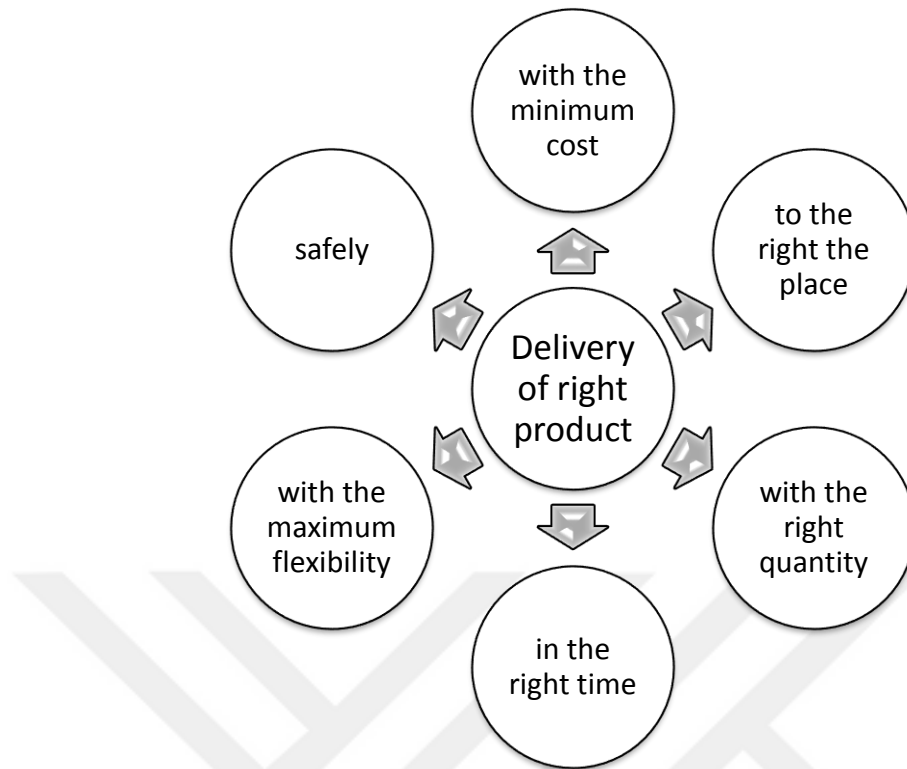


Figure 2.3: Fundamentals of logistics

This delivery can be performed in different transportation types. These are; road, rail, air, express freight, and maritime. After intermodal revolution companies started to use any combination of this transportation types together to reduce unit cost, to reduce delivery time, to reduce CO₂ emission. Transportation type of any load mainly depends on density, monetary value, seasonality, shelf-life, perishability, location and volume.

2.3. Warehouse Location Selection

In today's world, most of the organizations avoid to make a strategic decision that get them lost money/time and reduce their service level. Because they all try to achieve making more profit/benefit with lower cost and time. So supply chain and logistics management plays an important role on it. It influences organizational performance in context of quality, cost and flexibility (Chai et al., 2013).

Warehouse location selection is one of the most important decision problems for the organizations which need to store any kind of material. That's why, this topic is found

very attractive by MCDM researchers. So, hundreds of research have been done over the years. While some use MCDM methods, some combined different discipline's methods to solve this problem.

The selection of an efficient warehouse is a difficult task as it involves qualitative and quantitative factors and changes in operation environment makes the selection process a tedious one (Raut et al., 2017). The initial phase of research on warehouse location selection focused mainly on the cost reduction and slowly it got shifted to facilities of transportation, infrastructure and labor (Raut et al., 2017).

Raut et al. (2017) performed a study regarding warehouse selection of an Indian chemical product company which would like to aggressively expand its services through Middle East and East Africa. It is not possible to take this high level decision by using conventional methods. That's why, Raut et al. (2017) has used one of the most used MCDM technique called Analytic Hierarchy Process. To use AHP or other MCDM techniques, factors/criteria should be selected firstly. Raut et al. (2017) have used eleven criteria in their study and these are; governmental policies and the regulations, climatic conditions of the region, technology availability strategic location, availability of skilled sustainable workforce, safety measures availability, a provision for storage and disposal of toxic substances, provisions for energy saving, other organizations using the facility, availability of parking facilities, provision for water management.

Warehouse location selection problems are not only valid for 3PL's or production companies. It is also an important strategic decision for charities. Öztayşi et al. (2016) has performed a study on warehouse selection for charity foundations. Because, the warehouse location in humanitarian logistics has high importance since it determines the success of the disaster response after an event (Öztayşi et al., 2016).

As mentioned in previous paragraph, the conventional decision making tools which is used for a warehouse location selection problem are in tendency to be less efficient to overcome the loose or uncertain nature of the verbal assessments (Öztayşi et al., 2016). That's why, Öztayşi et al. (2016) have used MCDM techniques as well. In this study, hesitant fuzzy sets were used together with Hesitant Fuzzy AHP model. Five main criteria

have been determined by Öztayşi et al. (2016) and these are; geographical location, transport connectivity, cost, stable government, labor availability. All main criteria has different kind of sub criteria. For example, geographical location has four sub-criteria determined as “proximity to disaster areas”, “logistics experts” availability”, “warehouse security”, “proximity to urban facilities”, and “closeness to other warehouses”. Transport connectivity includes the sub-criteria “airport and seaport availability”, “proximity to beneficiaries”, “sufficient warehouse infrastructure”, “sufficient warehouse facility” and “warehouse accessibility”. Cost has sub-criteria as “storage cost”, “cost relate to logistics”, “land cost”, “labor price”, and “replenishment cost”. Stable Government, The stable government attribute has four sub-criteria “cooperation with logistics agents”, “political and economic stability”, “existence of other agents (NGOs)”, and “IT/Communication”. Finally, the sub-attributes of labor availability are “skilled and educated personnel”, “flexible customs regulations”, “population density”, and “climate” (Öztayşi et al., 2016).

Dey et al. (2016) is another researcher that has tried to bring a new perspective to warehouse/plant location selection. They have used Group Decision Making (GDM) method with MCDM techniques which is defined as a process of finding and reaching a common decision according to consensus, political or rational mechanism (Dey et al., 2016). Decisions which is beyond the one single decision makers’ thoughts can be made in this method. And the most important parameter of GDM method can be heterogeneity. Because it has huge impact on realistic evaluation of criteria and alternatives. Pair wise comparison matrix is used to determine importance for heterogenic degrees of expertise. As it is quite clear that there can be a biasness in this method, that’s why the consistency check control of AHP is used to cope with this biasness. Dey et al. (2016) have handled a case study for an auto company in India and this company wish to spread to other countries to gain competitiveness advantage against its competitors in the automobile market. That’s why the company need to decide appropriate location of its new plant. Four different selection criteria have taken into consideration. These are; availability of markets, transportation facility, space availability and cost. First, criterions were ranked, then well-known MCDM methods are used to make proper selection. The rank values or scores of the options according to SAW, VIKOR, COPRAS and PROMETHEE methods have found same under homogeneous conditions. The top ranking results of the

alternatives for SAW, TOPSIS, VIKOR, and ELECTRE I methods remain same under heterogenic conditions.

The most important feature of the subjective/qualitative criteria is that they are unproven, uncertain, and indefinite quintessentially. Also this criteria are mostly defined by verbal factor that can be measured by individual's experience, sense and perception. The availability of skilled and educated labour or proximity to both markets and customers can be counted as subjective/qualitative criteria in the warehouse location selection problem. As for objective/quantitative criteria, these are exemplified with speed, cost, lifecycle and weight or etc. As it is clear that these criteria are quantitative and measurable (Dey et al., 2015).

As we can see above, subjectivity and objectivity is another important parameters that can be affect the result of MCDM studies. Dey et al. (2015) have proposed three fuzzy MCDM techniques that are able to handle both objective and subjective criteria. The main purpose of the study was to select best warehouse location option for a reputed South East Asian company. Six appropriate selection criteria were used to evaluate and select best warehouse location. These are; availability of markets, transportation facility, availability of land, political stability, proximity to customers, cost. While first five criteria is subjective, last criteria (cost) is objective. As a result of this study, same rankings were found by using FTOPSIS, FSAW and FMOORA methods.

Roh et al., (2013) have conducted a study related to humanitarian relief logistics. And they have tried to find crucial criteria for locating warehouse which has been relatively ignored in humanitarian logistics as compared to commercial logistics (Roh et al., 2013). Five main criteria have been used in this study, these are; location, logistics, national stability, cost, cooperation. This main criteria have some sub-criteria. Proximity to potential beneficiaries, geographical position or location, donor's opinion, availability of location with no disaster, climate, proximity to other warehouse locations, closeness to potential disaster area have been evaluated within location main criterion. Airport, seaport, road, warehouse were evaluated within Logistics. Political, social and economic stability within National Stability. Labor, land, storage, replenishment, logistics within

Cost. Host government, International NGO, Local NGO, UN, neighbour countries, logistics agents within Cooperation.

Dey et al. (2013) have published a paper that propose alternative warehouse selection approach to assist decision makers. In this paper, he has integrated SAW (simple additive weighting) method with FST (fuzzy set theory) and FRS (factor rating system). Four criteria have been taken in to account, these are; transportation availability, availability of skilled workforce, climatic conditions, investment cost.

As it is mentioned in most of the papers, the location of a warehouse is generally one of the most important and strategic decision in the optimization of logistic systems (Ashrafzadeh et al., 2012). The procedure of making location decisions generally covered by following four steps which is demonstrated in Figure 2.4:

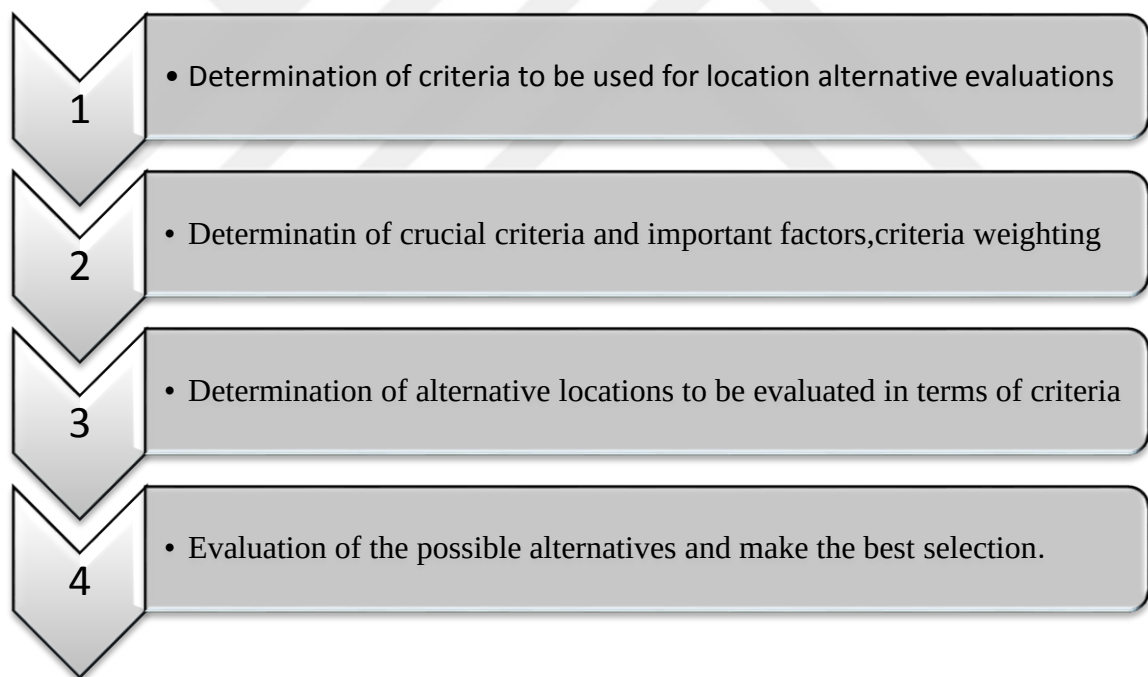


Figure 2.4: Location decision steps

Ashrafzadeh et al. (2012), have chosen 15 important criteria in their study. These are; labor costs, transportation costs, handling costs, land cost, skilled labor, availability of labor force, land availability, climate, mode of transportation availability, reliability and quality of different modes of transportation, telecommunication system infrastructure,

quality and reliability of utilities, closeness to customer, closeness to supplier, lead time and responsiveness. Then they have used Fuzzy TOPSIS method to aggregate the ratings and generate an overall performance score for measuring each alternative.

Özcan et al. (2011) have conducted a comparative analysis of the three most widely used basic methodologies, namely AHP, TOPSIS and ELECTRE. As for criteria of this study; capacity, cost and customer related criterions were evaluated. These are; movement flexibility, average distance to shops, unit price, average distance to main suppliers and stock holding capacity. AHP is useful technique on criteria weights' calculation and TOPSIS and ELECTRE are also useful to rank alternatives. To make paper aimed to give optimization point of view, Grey Theory has been used. When TOPSIS and ELECTRE methods were used, similar results have been obtained.

Singh et al. (2018) have mentioned vague nature of human decision making and have tried to overcome this difficulty by using Fuzzy AHP methodology since conventional methods were not sufficient. In their study, three main criteria has been used these are infrastructure, government and market. Infrastructure covers three sub-criteria named as transport and connectivity, electricity and water supply, IT communication setup. Government has three different sub-criteria named as cost of land, taxation policies, and incentives. Market has also three different sub-criteria named as market size, proximity to main market, scope for market growth.

Demirel et al. (2010) and Ismat et al. (2012) have used Choquet Integral method to make relatively best warehouse location selection and best bike purchasing. Choquet integral proposed by Auephanwiriya et al. (2002) will be used, in which measurable evidence is represented in terms of intervals, whereas fuzzy measures are real numbers, is an extension of the standard Choquet integral. Demirel et al. (2010), have used followings as main criteria of their study. Cost, labor characteristics, infrastructure, markets, macro environment. And they have also evaluated following sub-criteria within under single main criteria. Cost main criterion consists of handling costs, labour costs, transportation costs, tax costs and financial incentives, Labour Characteristics main criterion consists of skilled and trained labour, adequate labour force. Infrastructure main criterion consists of mode of transportation availability, reliability and quality of different modes of

transportation. Market main criterion consists of near to supplier, near to customer, responsiveness and lead time. Macro environment main criterion consists of construction and zoning plan, industrial regulations, and government policies. The benefits of using Choquet Integral is that it takes account the relationship between criteria. And also it is additive operator extension of the MCDM problems, but it considers interactions between criteria (Demirel et al.2010).

Kaboli et al. (2007) experienced a MCDM methodology for the correct and effective location selection problem. Fuzzy AHP methodology has been used to evaluate criterions. These criterions are stated as climatic condition, work culture, housing facility, transportation availability, recreational facility. Actually this study is kind of old world because new technologies and more complex methodologies has been found in today's developing world. This study can be used to find weight of criteria that belongs to any MCDM study.

According to Chu (2002), selecting a facility location is important to industrial organizations in maximizing resource utilization and minimizing cost. TOPSIS is one of MCDM technique which is based on alternatives that are evaluated by n criteria and this best alternative can be said as a single point somewhere over n -dimensional space. Geometric relationships can be established between m location points. The most optimum and ideal alternative has the best values in terms of all considered criteria, while the negative ideal solution has the worst calculation values. TOPSIS methodology determines selection as point or location which are closest to the ideal point and farthest from the negative-ideal point at the same time (Chu, 2002). Availability of skilled workers, power availability, transportation availability, investment cost, and community attitude have been defined as criterions of the study.

In short, plenty of study have been done from past to present as stated in Table 2.2 below. While some of them have a characteristics of methodology comparison, others aim to make best decision for warehouse location selection by using proven scientific methodologies such as; AHP, TOPSIS, PROMETHEE, MAUT, CBR, DEA, FST, SMART, GP, ELECTRE and SAW (Velasquez et al. 2013). As for this study, a new scientific method called Interval Valued Neutrosophic EDAS has been used.

Table 2.2a: Literature review

#	Year	Author(s)	Research Problem	Application Field	Technique	Purpose of Study
<u>1</u>	<u>2019</u>	Banaz N.	Cold Chain Applications in Supply Chain and a Vehicle Routing Problem Solution	Cold Chain	Investigation	To solve vehicle routing problem
<u>2</u>	<u>2019</u>	Karasan A. et.al	Social Responsibility Projects Prioritization using IVN EDAS	Social Responsibility	EDAS	To make optimum prioritization for social responsibility
<u>3</u>	<u>2018</u>	Singh R.K et al.	Warehouse Location Selection for a Global Supply Chain	Logistics	Fuzzy AHP	To deal with vague nature of human decision making
<u>4</u>	<u>2018</u>	Karasan A. et al.	United Nations sustainable development prioritization. A novel using IVN EDAS method:	Sustainability	EDAS	To prioritize US sustainable goals
<u>5</u>	<u>2017</u>	Kahraman C. et al.	Intuitionistic fuzzy EDAS method: an application to solid waste disposal site selection	Waste Disposal	EDAS	To choose solid waste disposal site
<u>6</u>	<u>2017</u>	Ghorabae M.K. et al	Supplier evaluation and order allocation by considering environment effect. Using type-2 IFS and EDAS method	Supplier Selection	EDAS	To make the best supplier selection
<u>7</u>	<u>2017</u>	Raut R.D. et al.	Multi-criteria decision making approach: a sustainable warehouse location selection problem	Chemical Industry	AHP	To identify the crucial, sustainable selection criteria for the chemical industry warehouse,
<u>8</u>	<u>2017</u>	Singhal R. et al.	Performance Assessment of the Storage and Warehousing Industry in India	Cold Chain	Investigation	To analyse the performance of the storage and warehousing (S&W) Industry in India
<u>9</u>	<u>2017</u>	Singh R.K. et al.	3PL selection for cold chain management by using TOPSIS and Fuzzy AHP	Cold Chain	Investigation	To illustrate a hybrid approach for selection of 3 PL for cold chain management under fuzzy environment
<u>10</u>	<u>2017</u>	Degirmenci I.T. et al.	Cold chain logistics for frozen food at tourism destinations	Cold Chain	Investigation	To explore possible distribution system models of cold chain logistics.

Table 2.2b: Literature review

#	Year	Author(s)	Research Problem	Application Field	Technique	Purpose of Study
<u>11</u>	<u>2016</u>	Öztayşi B. et al.	Warehouse Location Selection for Humanitarian Logistics by using Hesitant Fuzzy AHP approach	Humanitarian aid	Fuzzy AHP Hesitant Fuzzy	To solve the HL warehouse location selection problem
<u>12</u>	<u>2016</u>	Dey B. et al.	Group Heterogeneity in Multi Member Decision Making Model	Automotive Sector	All methods	To select an appropriate warehouse location
<u>13</u>	<u>2016</u>	Singh R.K. et al.	Location allocation decision making for a cold chain: using value deterioration big data coordination, approximation	Cold Chain	Investigation	To improve coordination between shippers and customers
<u>14</u>	<u>2015</u>	Dey B. et al.	Warehouse Location Selection by Fuzzy Multicriteria Decision Making Methodologies Based on Subjective and Objective Criteria	Logistics	Fuzzy TOPSIS Fuzzy SAW Fuzzy MOORA	To solve warehouse location selection problem
<u>15</u>	<u>2015</u>	Fredriksson A. et al.	A research agenda and literature review	Logistics	Logistics Research	Logistics Research
<u>16</u>	<u>2015</u>	Deli I.	Research on IV-N sets	Research	Fuzzy sets	Research on IV-N sets
<u>17</u>	<u>2015</u>	Ghorabae M.K et al.	Multi-criteria inventory classification	MCDM	EDAS	Inventory classification problem
<u>18</u>	<u>2015</u>	Arduino G. et al.	Comparison of refrigerated vs bulk	Cold chain	Investigation	Evidence from the banana cold chain
<u>19</u>	<u>2014</u>	Stragas N. et al.	Basic principles for effective warehousing and distribution of perishable goods in urban environment: Current status, advanced technologies and future trends	Food Industry	Investigation	To provide to the readers some basic principles for effective warehousing and distribution of perishable goods in urban environment
<u>20</u>	<u>2013</u>	Chai J. et al.	A rule-based group decision model for warehouse evaluation	Analysis	MCDM	To solve warehouse location selection problem
<u>21</u>	<u>2013</u>	Rodrigue J.P. et al.	The Geography of Transport Systems	Book	Analyse	Logistics book
<u>22</u>	<u>2013</u>	Roh S.Y et al.	Warehouse Location Decision Factors in Humanitarian Relief Logistics	Humanitarian aid	AHP	To identify the key factors considered to select humanitarian relief warehouse location as criteria in AHP

Table 2.2c: Literature review

#	Year	Author(s)	Research Problem	Application Field	Technique	Purpose of Study
23	2013	Dey B. et al.	Warehouse location selection for supply chain in a utopian conditions.	Logistics	Fuzzy Set AHP, TOPSIS ANP	to enhance warehouse location selection methodologies by developing
24	2013	Velasquez et al.	An Analysis of Multi-Criteria Decision Making Methods	Analysis	MCDM	To analyze scientific MCDM methods
25	2013	Kitinoja L.	Use of cold chains for reducing food losses in developing countries	Cold Chain	Investigation	To reduce food losses in developing countries
26	2012	Ashrafzadeh M. et al.	Fuzzy TOPSIS approach for the warehouse location selection	Logistics	Fuzzy TOPSIS	To solve warehouse location selection problem
27	2012	Prakash G. et al.	RFID based mobile cold chain management system for warehousing	Cold Chain	Investigation	To monitor and adjust temperature in warehousing
28	2012	Beg I. et al.	Multi-criteria of Bike Purchasing Using Fuzzy Choquet Integral	Purchasing	Choquet Integral	To make best purchasing via using scientific methods
29	2012	Zhang Q. et al.	Information construction for third-party cold chain warehousing.	Book	Book	To provide a more effective network infrastructure and development platform for logistics and service operations.
30	2011	Ozcan T. et al.	Comparative analysis of MCDM methodologies and implementation for warehouse location selection.	Retail	TOPSIS ELECTRE Grey Theory	To solve warehouse location selection problem
31	2011	Sarsoy G.	Cold chain logistics for food	Food Industry		To classify goods according to transportation and warehousing
32	2011	Subin R.	India's Cold Chain Industry	Cold Chain	Investigation	To analyze Indian cold chain
33	2011	Zimmerman H.J.	Fuzzy set theory research	Logistics	Fuzzy Set	Fuzzy set theory analysis
34	2010	Demirel T. et al.	Multicriteria warehouse location selection using choquet integral	3rd Party Logistics	Choquet Integral	To solve warehouse location selection problem
35	2010	Salin V.	2010 Global Cold Storage Capacity Report	Cold Chain	Investigation	To provide an update on global cold storage capacity
36	2010	Turcu C.	Sustainable Radio Frequency Identification Solutions	Cold Chain	Investigation	To provide RFID solution

Table 2.2d: Literature review

#	Year	Author(s)	Research Problem	Application Field	Technique	Purpose of Study
37	2010	James S.J. et al.	The food cold-chain and climate change	Cold Chain	Investigation	To improve the cold-chain without any increase in CO ₂
38	2010	Derman A.	History of warehousing	Warehousing	Investigation	Warehousing history
39	2010	Torra V.	Hesitant fuzzy sets	Logistics	Fuzzy set	Research on hesitant fuzzy sets
40	2008	Lan W. et al.	A Research on Related Questions of Chinese Food Cold Chain Development	Food Industry	Investigation	To introduces some theories of the food cold chain, then studies the questions which is in the Chinese food cold chain development, and analyzes deeply the reason of these questions
41	2008	Singh R. P.	Benchmarking Study of the Refrigerated Warehousing Industry Sector in California	Food Industry	Investigation	To benchmark cold chain logistics in California
42	2008	Aguezoul A.	An analysis on 3PL selection	Logistics	Analysis	To analyse 3PL selection
43	2007	Kaboli A. et al.	A New Method for Plant Location Selection Problem: A Fuzzy-AHP Approach	Logistics	Fuzzy AHP	To propose a new mathematical model with the aid of the (FAHP) to make the plant location decision.
44	2007	Flores S. E.	Electricity usage in the Australian cold chain	Cold Chain	Investigation	To investigate Australian cold chain
45	2007	Jol S. et al.	The Cold Chain of food safety initiatives in Canada	Cold Chain	Investigation	To investigate Canadian cold chain
46	2007	Gol H. et al	3PL Provider Selection	Logistics	Selection	To select 3PL provider
47	2006	Samarandache F.	Generalization of the intuitionistic fuzzy set	Research	Fuzzy sets	To generalize intuitionistics fuzzy sets
48	2005	Bogataj M. et al.	Stability of perishable goods in cold logistic chains	Cold Chain	Investigation	To evaluate of the retarded changes in temperature
49	2005	Hamprecht J. et al.	Mobitoring food supply chain sustainability.	Cold Chain	Investigation	to address this particular gaps in cold chain
50	2003	Zhang G. et al.	Structure of deep frozen and chilled food chain with tabu search procedure	Cold Chain	Investigation	To Improve the structure of deep frozen and chilled food chain
51	2002	Chu T.C.	Fuzzy TOPSIS Approach Under Group Decisions, application for Facility Location Selection.	Logistics	Fuzzy TOPSIS Group Decision	To solve warehouse location selection problem

Table 2.2e: Literature review

#	Year	Author(s)	Research Problem	Application Field	Technique	Purpose of Study
52	2002	Auephanwiriya S. et al.	Generalized Choquet fuzzy integral fusion	MCDM	Choquet Integral	To analyze Choquet Fuzzy Integral
53	2001	Mentzer J.T et. al.	Defining supply chain management	MCDM	Investigation	To define supply chain management.
54	2000	Lambert D. M. et al.	SCM Issues and Industrial Marketing Management	Supply Chain	Investigation	To analyse supply chain management.
55	1996	Korpela J. et al.	A decision aid in warehouse site selection	Logistics	AHP	To solve warehouse location selection problem
56	1986	Atassanov K.	Intuitionistic fuzzy set study	Research	Fuzzy sets	Research on fuzz sets
57	1975	Zadeh L.	Linguistic variable concept	Research	Investigation	Approximate reasoning application
58	1975	Grattan G. I.	Fuzzy research	Research	Fuzzy sets	Fuzzy research on interval and many-valued quantities
59	1975	Sambuc R.	Function flows	Research	Investigation	Function flows
60	1975	Jahn K.	Interval valued EDAS research	Research	Investigation	Research on Intervals
61	1965	Zadeh L.	Fuzzy sets research	Research	Fuzzy sets	Research on fuzzy set theory

2.4. Cold Chain Logistics

The main subject of this study is on Cold Chain Logistics. In this part, there are some information about the emergence and developments of the Cold Chain.

2.4.1. Emergence of Cold Chain

Temperature sensitive goods have been first experienced by British fishermen in 1797. Natural ice has been used to keep hunted stock fresh while they are at sea for a long fishing. Following, dairy products which produced in rural areas have been sent to markets in urban areas in the late 1800s (Rodrigue et al. 2013).

Cold storage also had an important role on intercolonial food and derivatives trade. For instance, in the late 1870s and early 1880s, frozen mutton carcasses and meat have been shipped to France from South America. On the other hand, Great Britain (GB) has met their beef need by importing it in frozen form from Australia and also they have met needs of pork and derivatives from New Zealand (NZ). Thus was promoted to ship surpluses in developing countries to Europe where shortage of meat happened. (Rodrigue et al., 2013).

In 1902, United Food Company used temperature controlled (reefer) ship for the first time. And the ship has been used for banana trade. Thanks to this development, top consumed and preferred fruit of the world has been banana.

As for the temperature controlled movement of pharmaceuticals and medical products is a much more recent activity than the shipping of refrigerated or frozen food. Since the 1950s, logistical third party companies began to find and implement new methods for successfully transporting these goods. Before this developments, cold chain processes were mostly managed in-house by the manufacturer's own self (Rodrigue et al., 2013).

It is quite clear that the management of cold chain should be evaluated as a factor that has direct impact on community health. Fungal, bacterial and microbial shipment contamination can be reduced by using refrigerated and cooled transportation equipment. Moreover, to have effective transport and distribution system for medicals such as vaccines, this will make a huge impact on solving urgent health problems (Rodrigue et al., 2013).

Nowadays, temperature sensitive product producer began to become self-aware of importance of temperature controlled logistics. While some specialize themselves in cold chain logistics by getting consultancy, some give this management to 3PL or 4PL companies which are already specialized in this area. Thus, organizations make their logistics management much more productive and reduce their spoilage based costs. On the other hand, to prevent wasting food or other products is started to evaluate as social responsibility.

2.4.2. Cold Chain Concept

The importance of to protect temperature sensitive goods is increasing day by day. Because researches show that movement of temperature sensitive goods under right conditions is crucial to keep them fresh and long-lived. The fact that freshness in these products has a direct impact on human health makes the issue more important. That's why, regulations and legislations is prepared by governments or standards such as Good Manufacturing Practices (GMP), Good Distribution Practice (GDP) and Global Warming Potential (GWP) are prepared by other authorized organizations to standardize the processes of this business. As it can be seen easily, the cold chain is not one of the simple logistics activities. From production to consumption, while dry products can be managed by using some simple standards and conditions, cold chain required more complex standards and conditions. The difference of cold chain from other logistics processes emerges right this point.

Cold Chain refers to all processes such as storage, transportation and so on that must be applied in order to maintain its properties at every stage from the production of frozen/cold food to consumption. That's why, it is important that the receive dock, shipment dock, preparation and loading area, packaging area are all maintained in such way that product maintains its temperature. Because, what happens if the cold chain breaks? Microorganisms start to reproduce rapidly in the product. It may even reach levels that threaten human health. As it is seen, cold rooms has an important role to keep products fresh. Cold room can be defined as spaces which are cooled under suitable conditions and controlled humidity condition and insulated against heat and moisture gain from the external atmosphere in order to store foodstuffs for longer periods than they can be stored in normal conditions. The main function of cold room is to provide constant temperature and relative humidity

Cold warehouses are structures that can be constructed as reinforced concrete or prefabricated. Heat insulation and vapour diffusion of cold warehouses are made accordance with insulation standards. In cold warehouses, moisture control is designed to be adjusted according to the type of foodstuff. The whole cooling system can be designed with fully automatic control and overload protection. Vehicles have platforms suitable for

loading and unloading. There are cooling and freezing rooms which can be used independently. Fast freezing (shocking) rooms are available in accordance with standards. The cold rooms have a homogeneous ambient temperature. Cold storages are designed with the infrastructure that can be cleaned quickly and easily. According to official gazette, temperature increasing tolerance cannot be more than 3oC. During storage, storage and transport of fast-frozen foods, ambient temperature is recorded frequently and regularly using appropriate measuring and recording equipment. All measuring and recording devices used for monitoring the temperature must comply with TS EN 12830, TS EN 13485 and TS EN 13486 standards. Food operators are required to have documents showing that these devices comply with the relevant TSE standards. All this standards and conditions make cold chain a specific warehousing method.

Cold chain is a concept that provide temperature control in supply chain and it is pretty important for management of both food and pharmaceutical sectors (Banaz, 2019). The cold chain includes the transportation and distribution of temperature sensitive goods throughout a supply chain via using heat keeping and refrigerated warehousing, picking, packing, packaging and distribution methods. Temperature controlled cargo ships, railcars, trucks, air cargos and reefers can be evaluated as means of cold chain transportation. This shipment methods allow the cold chain to be protected.

Also we need temperature controlled warehouses for correct storage of temperature sensitive products. According to Rodrigue et al. (2017), the main elements of cold chain have been stated in Figure 2.5;

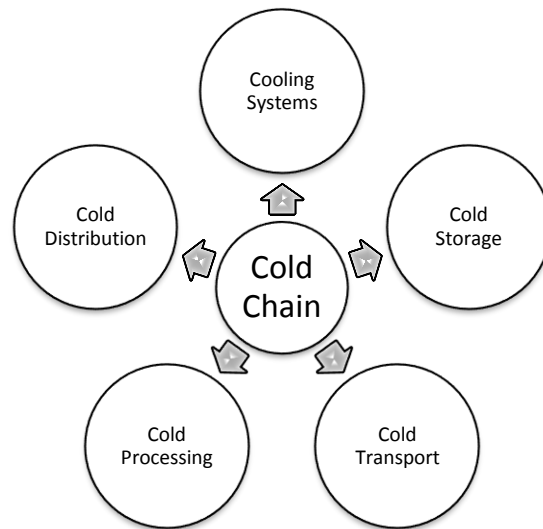


Figure 2.5: Elements of cold chain

Cold chain has five fundamentals; these are “cooling systems”, “cold storage”, “cold transportation”, “cold processing”, and “cold distribution”.

- Cooling Systems provides foods to be kept under right temperature during different process (e.g. storage, processing or transportation).
- Cold storage provide facilities or warehouses for the correct storage of foods or goods.
- Cold transport is used to deliver temperature controlled food or goods under right humidity and temperature conditions. And also it tries to protect integrity of them.
- Cold processing provides necessary equipment and materials to ensure correct sanitary and health conditions.
- Cold distribution plays an important role to deliver right product to right place in right temperature conditions.

According to Singhal et al. (2017), the number of cold stores and total cold storage capacity has increased by nearly 50% and 60% respectively between 2004 and 2014.

Singh et al. (2017) have stated in their studies that almost 30% of vegetables and fruits go for nothing because of ineffective management of cold chain, in India. To manage the value chain of temperature sensitive foodstuffs or pharmaceuticals has been defined as cold chain, in their study (Singh et al 2017). Purpose of the study was to decide for best 3PL company. Ten criteria have been determined to evaluate this study by using Fuzzy

TOPSIS and AHP methods together. These are; warehousing and transportation cost, facilities of warehousing, facilities of infrastructure, customer service management and reliance, management of network facilities, capabilities for material handling processes , quality control (QC) and inspection check, process automations, innovations and cold chain process effectiveness, application for track& trace and process flexibility rate.

Failure to keep the temperature of the food during the logistics process, or breakage of the cold chain, is a huge risk for both the supplier and the buyer. It will reduce the economic value of the products or make the products completely unusable. Loss of economic value or making products unusable is a huge financial burden for producers (Degirmenci et al., 2017). Nutritious and healthy food demand is increasing day by day in developing and developed countries. And also it is announced that frozen product demand was reached US\$224.74 billion in 2018 and it hit US\$293.75 billion in 2019 (Singh et al., 2016).

Zhang et al. (2012) stated that global world faced with shortages of third party Logistics Company for temperature sensitive products. And this happened because of;

- Low capacity value and space use rate.
- Low annual utilization value because of season factor.
- Faced difficulties to provide and keep quality of product.
- Low efficiency because of manual works timeless updates.

The safety and quality of foods can be ensured by temperature control. There are three classification groups of foods. If the temperature of a product or food is below minus eighteen degree Celsius, then it is a frozen product or food. If the room temperature is best for a product or food, then it is ambient product. Lastly, products are evaluated as chilled, if they need to be kept between zero and fifteen degree Celsius according to classification provided by Fredriksson et al. (2015).

In Germany, cold storage is classified in four groups as below:

1. Plant cold stores with 20 products and temperature is below minus twenty.
2. Central cold stores with 80 product and temperature is below minus twenty-four.
3. Distribution cold stores with 200 products and temperature is below minus twenty.

4. Freezing cabinets with 210 products and below minus eighteen degree Celsius.

Temperature conditions and rules have been determined differently by each country. This happened because of different measurement units of temperature, different feeding habits. And this increases misinterpretations and complexity of coordination (Singh, 2016).

- The British Frozen Food Federation (BFFF) has classified frozen foods when the temperature ranges between minus twenty and minus twenty-eight and it should have the temperature tolerance to reduce 3 degree Celsius to eighteen.
- According to American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the temperature of frozen products should range between minus twenty-three and minus twenty-nine for storage.
- The Italian Frozen Food Institute (IFFI) accepts minus twenty-two degree Celsius for frozen goods' storage (Arduino et al. 2015).

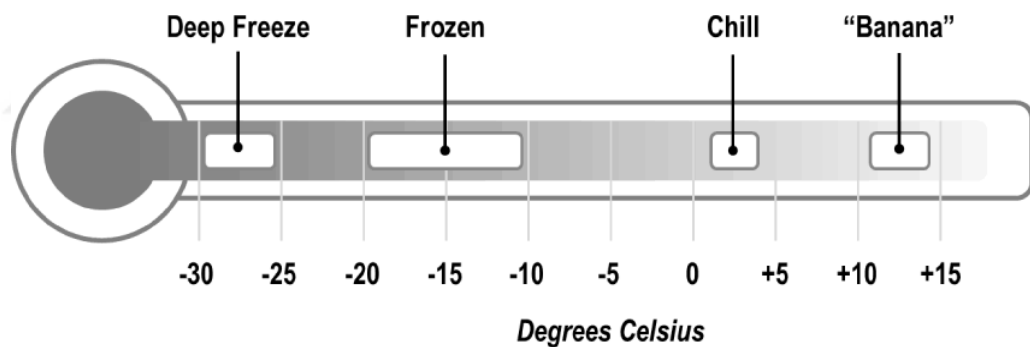


Figure 2.6: Temperature condition indicator

Shortly products can be evaluated in four groups (Turcu, 2010) as stated in Figure 2.6 above and their explanation;

- It is called Frozen up to the -25°C and ice cream can be the best example, and continues to -18°C for the other products.
- Fresh poultry and meat and also most of the dairy products, fruits and vegetables are called cold chill from 0°C to 1°C
- The temperature which is good for cheeses, fats or butters kind of products is called as medium chill. And it is 5°C.

- Bananas, exotic fruits, eggs and potatoes are kept under exotic chill conditions which is 10°C -15°C.

Stragas et al. (2014) have stated that there are some authorities and legislations about perishable goods. Authorities are; “The European Food and Safety Authority (EFSA)”, this authority provides independent scientific advice and clear communication on existing and emerging risks. “The U.S. Food and Drug Administration (FDA)” is responsible for protecting the public health by ensuring safety and security of drugs, biological products, medical devices, USA food supply, cosmetics and product that emit radiation. Regulations are; Regulation (EC) No 178/2002, this regulations formulates principles to protect human health. Regulation (EC) No 1642/2003, this regulation is amending Regulation (EC) No 178/2002 additionally prerequisites that characterize food law. Regulation (EC) No 852/2004 this regulation emphasizes the fact that food safety should be ensured starting from the production.

And also, there has been an agreement regarding transportation and handling and warehousing of temperature sensitive products in 1970. This agreement has been done to ensure operation conditions meet the technical or biological standards which is listed in this agreement. (Bogataj et al. 2005). By the way, this agreement has been done in Geneva and Turkey is not a party to this agreement (Sarisoy, 2011).

The cold chain is evaluated as technology, process and science. It's process because it has different kind of interrelated operations that need to be done for effective cold chain management of perishable goods (Rodrigue et al., 2013). It's technology because monitoring or measuring cannot be done without technology and technological devices during storage and shipment. It's science because biological or chemical processes should be understood very well since it has direct relations to food perishability.

We can easily state what should be done for effective cold chain logistics but according to Subin (2011), market has some issues and obstacle such as; lack of knowhow, lack of trained manpower, lack of backward and forward linkages, lack of trust concerning viability of cold chain projects, high capital investments, high operational cost due to high cost of power, problems of optimization in reefer transport.

In this study warehouses, which are one of the most important part of cold chain logistics, have been handled. Because it is often not possible to sell a manufactured product immediately. That's why, we need to store our product under right conditions. For perishable products this conditions are much more sensitive and you can find some examples of this conditions in Table 2.3.

As it is said before management of cold chain should be evaluated as a factor that has direct impact on community health. Fungal, bacterial and microbial shipment contamination can be reduced by using refrigerated and cooled transportation equipment. Warehouse location selection of temperature sensitive and perishable goods is a decision problem which has multi criteria. Different type of criteria have been used from past to present in accordance with purpose of the study.

Table 2.3: Storage conditions

Food	Storage condition			
	Optimum	+10 °C	+20 °C	+30 °C
Fresh fish	10 days at 0 °C	4-5 days at 10 °C	1-2 days at 20 °C	few hours at 30 °C
Milk	2 weeks at 0 °C	7 days at 10 °C	2-3 days at 20 °C	few hours at 30 °C
Vegetable	1 month at 0 °C	2 weeks at 10 °C	1 week at 20 °C	<=2 days at 30 °C
Potato	5-10 months at 4-12 °C	2 months at 10 °C	1 month at 32 °C	<=2 weeks at 42 °C
Mango	2-3 weeks at 13 °C	1 week at 23 °C	4 days at 33 °C	2 days at 43 °C
Apple	3-6 months at -1 °C	2 months at 10 °C	1 month at 20 °C	few weeks at 30 °C

We can evaluate warehouse location selection problems based on fuzzy logic because criteria are not absolute must. But they can be near the absolute must. As for temperature controlled warehouse location selection, it wasn't preferred to use fuzzy logic because this problem has much more strict and absolute must criterions such as government regulations, IT infrastructure for instant visualization, Quality warehouse management system that allows well expired in first out (FEFO) or first in first out (FIFO) tracking. That's why, a new scientific method named interval valued neutrosophic EDAS has been

used in this project to give a new scientific point of view for warehouse selection in cold chain logistics.

2.5. Third Party Logistics Concept

Logistics is a specific field of expertise, and it has plenty of parameters that you need to take into account to optimize your processes and reduce logistics costs. Effective logistics management is crucial for producers, suppliers, distributors or vendors. Companies with inefficient logistics management experience problems such as loss of sales, loss of prestige, loss of money, and loss of labour. The companies which do not want to experience such problems get external support from the companies that have deep knowledge and knowhow about warehousing and transportation. These companies are named as 3PL or 4PL supplier.

According to Aguezzoul (2008) 3PL supplier is an independent firm which manages logistics processes on behalf of customer under a contract. According to Göl et al. (2007), 3PL suppliers make their customers to achieve operational efficiency, greater flexibility, high quality customer service and focus on core business. The areas which 3PL suppliers support have been stated in Figure 2.7 below;

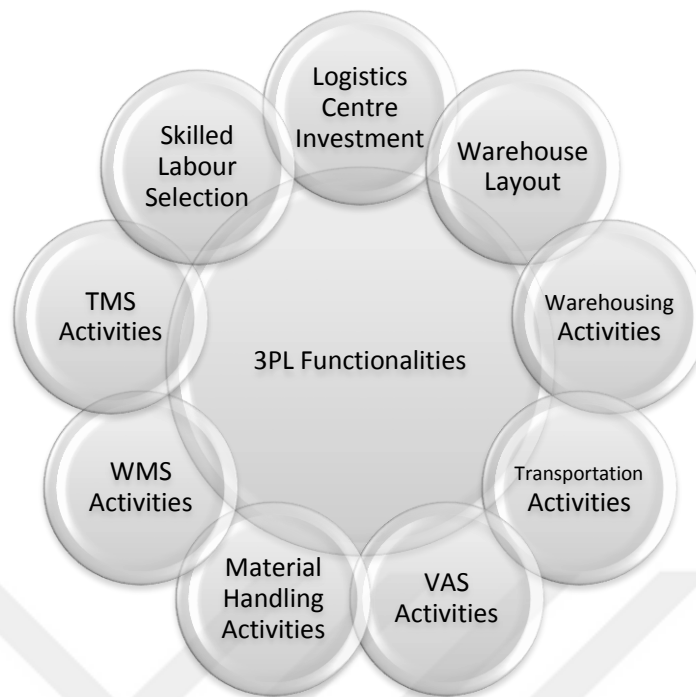


Figure 2.7: 3PL functionalities

2.6. Interval Valued Neutrosophic EDAS

Companies and organizations face with different kind of decision making problem in their daily routine. Sometimes this can be a small matter that can be evaluated easily with traditional and unscientific method, sometimes can be much more complex and risky decision. And if you are talking about decision of something, there should be different alternatives with different attributes and traditional methods are not able to solve this problem. You need to make some scientific calculations to analyse best alternative.

According to Zimmerman (2011), elements are inside or outside of the set in general set theory, a solution can be infeasible or feasible in the optimization, and as for logic of Boolean, a statement either false or true, nothing can be in between in. But in facts of the life, all the things are not certain and have a degree of it and this cannot be explained with conventional logic. So below improvements have been done to cope with this uncertainty;

1. Fuzzy Sets Theory has been found in 1965 (Zadeh et al., 1965).

2. Zadeh et al. (1975) developed Type-n Fuzzy Sets to handle uncertainty of membership function.
3. Interval Valued Fuzzy Sets has been used by Jahn, Zadeh, Sambuc, and Grattan Guinness for the first time in 1975.
4. Intuitionistic Fuzzy Set (IFSs) have been used by Atanassov (1986). This method determines the membership function with degree of membership and non-membership by considering DM's hesitations.
5. Torra (2010) has studied on "hesitant fuzzy sets" and this sets accept the sets that have only one element. And there is no difference with normal fuzzy theory. The only difference is the sets with single element.
6. Neutrosophic sets, which is another intuitionistic fuzzy sets, have been developed by Smarandache (2006) to allow decision-makers to reflect their feelings for definition of membership function.
7. Relatively new method named EDAS has used by Keshavarz et al. (2015). This method has some calculations according to distance to the average solution(Ghorabae et al. (2017)).

Interval valued neutrosophic sets are able to represent imprecise, uncertain, inconsistent and incomplete information (Deli, 2015). In the neutrosophic sets considers uncertainty of one set's members. Uncertainty consists of some values such as falsity, indeterminacy or truth and these are related to absoluteness or belongingness. Thanks to this calculations and observations neutrosophic sets;

- Reduce the system's uncertainty factor.
- Reduce indecision of incoherent information (Karaşan et al. (2018)).

Shortly, all member of a set has a degree of truth, fault and uncertainty. This degree can take any value between 0 and 1 (Rivieccio, (2008)).

Other MCDM techniques such as VIKOR, TOPSIS calculate the optimal solution based on min. distance from positive or best ideal solution at the same time with max. distance from negative solution. However, the best alternative in the EDAS method is calculated based on the distance value from AV (average solution) (Kahraman et al. (2017)). EDAS method calculations is done by comparing average solution and alternatives. The distance

from average solution is calculated for every single alternative according to all possible criterion (Karaşan et al. (2018)). It is aimed to determine the best solution by making two different distance calculations which are called as the NDA (negative distance calculation from average solution) and the PDA (positive distance calculation from average solution). To reach best alternative we need to find the alternative with lower negative distance from average and larger positive distance from average.

Neutrosophic sets are used to extent EDAS method for the first time. With the use of Neutrosophic sets, opinions and tendencies of decision makers could be taken into account (Karaşan et al. (2019)) and DM's T (truthiness), F (falsity) and I (indeterminacy) could be observed. Thus, such advantages as absoluteness, reflection caused by relativity of decision makers and also subsets' independency, which provide huge freedom to determine subsets' values, is used and utilized.

3. CRITERIA AND SUB-CRITERIA

There are lots of researches on warehouse location selection topic, and if we are working on selection problem, MCDM techniques come into play. If we would like to use MCDM techniques on our research, we need to have some criteria. Without deciding on right criteria, we can't get correct result by using MCDM techniques. Because almost all of them wait for correct criteria selection for calculation and evaluation.

In this study, 3rd Party Logistics Companies are handled in terms of their capability to manage warehouses for temperature sensitive products. As we have mentioned before 3PL companies provide a successful logistics management to their customer. And they should run different customers in one location. That's why the location of the warehouse plays a crucial role to get high customer satisfaction. If any organization would like to decide best temperature controlled warehouse location, needs to evaluate main criteria such as location, cost, warehouse facilities, macro environment and cooling facilities. And you can find their sub-criteria as below.

First main criteria is location and it is related to accessibility of warehouse from some target and source points. The better the location, the more competitiveness. Right location selection takes you one step ahead of your competitors. Sub-criteria of location are, proximity to potential markets, proximity to producers, proximity to seaports, main roads and airports, proximity to forwarding agents, climate conditions and availability of skilled workforce.

- Proximity to potential markets: It is preferred to locate your site around market places because it provides an advantage in reducing delivery times.
- Proximity to producers: If you locate your site around producers, it will be much easier to reach new possible customers.

- Proximity to seaport, main road and airport: It is preferred to reach different modes of transportation easily to plan your delivery in most efficient way.
- Proximity to forwarding agents: If you locate your warehouse near the forwarding agents, this will give you an advantage to find transportation at the right time, in the right way.
- Climate conditions: It is not preferred to have a warehouse in places where climatic conditions affect negatively transportation.
- Availability to skilled workforce: Human resources is one of the most important part of an organization. To find skilled workforce will make your operation much more efficient.

Second is cost criteria and it has direct connection with profitability of an organization. The lower the cost, the more the profit or the more customer satisfaction. Overall cost includes followings as sub-criteria; storage cost, investment cost, rental cost, labor cost, transportation cost and energy cost.

- Storage cost: It means unit storage cost in terms of m2. It differs from location to location.
- Investment cost: All investment projects have particular cost items, and investment cost is determined according to this items.
- Rental cost: This cost also differs from one location to another according to facilities of warehouse.
- Labor cost: Human resource is one of the cost item of the project that is why it is preferred to choose suitable location to reach skilled workforce with minimum cost.
- Transportation cost: If any site is far from main roads and main modes of transportation, It will be added to you cost items.
- Energy cost: It makes companies much more efficient to choose warehouse that has different type of energy solutions.

Third is related to facilities and opportunities that are provided by warehouse. If you are a 3rd party logistics supplier, you need to have facilities and opportunities in your warehouse to get more customer. This facilities or features makes customer's operations

much better and increase your preferability. These can be stated as structural suitability, parking facilities, hygiene facilities, hydraulic ramp facility, adequate truck manoeuvre field, security, stock holding capacity, separated waste field, adequate IT/Network system.

- Structural suitability: this is important because you are able to use storage area much more effective compared to poorly structured warehouse.
- Parking facilities: As the company serves as a supplier, most of the customers, customers' guests and possible customers will come to visit. And also you need a free field to park operation cars.
- Hygiene facilities: This is also another important criterion, because most of the product that will be stored will be food.
- Hydraulic ramp facility: This criterion important because it gives you flexibility during loading and unloading.
- Adequate truck manoeuvre field: It is preferred to have warehouse that is also friendly for trucks.
- Security: Having good security facility will increase customer trust.
- Stock holding capacity: Storage earnings is directly connected to this criterion. Because the more area, the more profit.
- Separated waste field: To have separated waste area is another reason of choose in our daily life.
- Adequate IT/Network System: This it almost the most important criterion because you cannot manage any operation with poor IT Structure.

Fourth criteria is macro environment, and this consists government policies and industrial regulations and laws as sub-criteria. This may be the most important criteria because if you don't align with government policies, then you cannot do that business. On the other hand, if you miss some incentives or opportunities then you cannot take the advantage.

- Government policies: This criterion is important to take into account before making any warehouse investment. Because policies vary country by country.
- Industrial regulations and laws: It is not possible to use any warehouse that doesn't match with requirements.

The last criteria is related to temperature and it is named as Cooling Facilities main criterion. If you have different areas which are suitable for dry, cold or frozen storage. This makes you much more competitive and increase your preferability. You can serve for different type of customers and different kind of product range. So to have facilities of cold storage, cold processing and cold transportation is so important to have efficient cold chain management.

- Cold storage: sub-criterion is a must to store perishable goods in right conditions.
- Cold processing: Temperature standards also should be provided during handling process. That's why we need this sub-criterion.
- Cold transportation: This sub-criterion is also must to transport perishable goods to related destination.

Table 3.1a: Criteria table

Code	Criteria	SubCode	Subcriteria	Covered by
<u>C1</u>	Location	C1.1	Proximity to potential markets	Özcan T. et al (2011), Roh S. Y. et al. (2013), Dey B. et al. (2015) , Öztayşi B. et al.(2016), Dey B. et al. (2016)
		C1.2	Proximity to producers	Özcan T. et al (2011), Asrafzadeh M. et al.(2012)
		C1.3	Proximity to mainroads, seaports and airports	Kaboli A. et al. (2007), Demirel T. et al. (2010), Dey B. et al. (2013), Roh S.Y. et al. (2013), Dey B. et al. (2015), Öztayşi B. et al.(2016),
		C1.4	Proximity to forwarding agents	Roh S.Y et al. (2013)
		C1.5	Climate conditions	Kaboli A. et al. (2007 Asrafzadeh M. et al. (2012), Dey B. et al. (2013), Öztayşi B. et al. (2016), Raut R.D. et al.(2017)
		C1.6	Availability of skilled workforce	Chu T.C. et al. (2002), Demirel. T.et al. (2010), Asrafzadeh M. et al. (2012), Öztayşi B. et al. (2016), Raut R.D. et al.(2017)

Table 3.1b: Criteria table

Code	Criteria	SubCode	Subcriteria	Covered by
<u>C2</u>	Cost	C2.1	Storage cost	Roh S.Y. et al. (2013), Öztayşi B. et al.(2016)
		C2.2	Investment cost	Chu T.C. (2002), Dey B. et al. (2013)
		C2.3	Rental cost	Asrafzadeh M. et al. (2012), Roh S. Y et al. (2013), Öztayşi B. et al.(2016)
		C2.4	Labor cost	Demirel T. et al. (2010), Asrafzadeh M. et al. (2012), Roh S.Y. et al. (2013), Öztayşi B. et al.(2016),
		C2.5	Energy cost	
		C2.6	Tax cost	Demirel T. et al. (2010)
		C2.7	Transportation cost	Asrafzadeh M. et al. (2012), Raut R. D. et al. (2017)
<u>C3</u>	Warehouse Facilities	C3.1	Structural suitability	Demirel T. et al. (2010)
		C3.2	Parking facilities	Raut R.D. et al.(2017),
		C3.3	Hygiene facilities	
		C3.4	Hydraulic ramp facility	
		C3.5	Adequate truck manoeuvre field	
		C3.6	Security	Öztayşi B. et al.(2016)
		C3.7	Stock holding capacity	Özcan T. et al (2011)
		C3.8	Separated waste field	Raut R.D. et al.(2017)
		C3.9	Adequate IT/network system	Demirel. T. et al. (2010), Asrafzadeh M. et al. (2012), Öztayşi B. et al.(2016), Singh R.P. et al. (2017), Raut R.D. et al.(2017),
<u>C4</u>	Macro Environment	C4.1	Government policies	Demirel T. et al. (2010), Roh S.Y. et al. (2013), Dey B. et al. (2015), Öztayşi B. et al.(2016), Raut R.D. et al.(2017),
		C4.2	Industrial regulations and laws	Demirel T. et al. (2010), Roh S.Y. et al. (2013), Dey B. et al. (2015), Öztayşi.B. et al.(2016), Raut R.D. et al.(2017)
<u>C5</u>	Cooling Facilities	C5.1	Cold storage	
		C5.2	Cold transport	
		C5.3	Cold processing	

4. ALTERNATIVE DETERMINATION

As for location alternatives that are stated in Table 4.1, all have been evaluated in terms of every single criteria stated in Table 3.1. This cities and countries, which is displayed Figure 4.1, are determined as Abu Dhabi (UAE), Dubai (UAE), Al Ayn (UAE), Doha (Qatar), Manama (Bahrain), Riyadh (Saudi Arabia), Medina (Saudi Arabia), Jeddah (Saudi Arabia), Mecca (Saudi Arabia), Kuwait City (Kuwait), Masqat (Oman). Arabian Gulf has been used as sample region because annual average temperature is around 37 °C in this region. Considering the very high temperature and humidity levels, cold chain logistics have become important more than ever.

Table 4.1: Alternative table

Code	Alternative	Country
A1	Abu Dhabi	UAE
A2	Dubai	UAE
A3	Al Ayn	UAE
A4	Doha	Qatar
A5	Manama	Bahrain
A6	Riyadh	Saudi Arabia
A7	Medina	Saudi Arabia
A8	Jeddah	Saudi Arabia
A9	Mecca	Saudi Arabia
A10	Kuwait City	Kuwait
A11	Masqat	Oman



Figure 4.1: Warehouse location alternatives

5. METHODOLOGY

EDAS method has been used in the computational study of this project. Following section includes some explanations and notations of EDAS.

5.1. EDAS Methodology

The steps of basic EDAS algorithm are stated as below.

Step 1: Most proper criteria (attributes) is chosen which can be used to describe the alternatives of a particular decision problem.

Step 2: Decision matrix is constructed according to Eq. (1). Performance rating of i th alternative $A_1, A_2, \dots, A_n$, ($i = 1, 2, \dots, n$) is x_{ij} the with respect to j th criterion C_j ($j = 1, 2, \dots, m$).

$$X = [x_{ij}]_{n \times m} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \quad (1)$$

$$W = [w_1, w_2, \dots, w_m]$$

For ($i = 1, 2, \dots, n$) and ($j = 1, 2, \dots, m$) where w_j is weight of criterion j .

Step 3: Determine the average solutions according to all criteria as given in Eq. (2).

$$AV_j = \frac{\sum_{i=1}^n x_{ij}}{n} \quad (2)$$

Step 4: Calculate the positive distance from average (PDA) and the negative distance from average (NDA) matrices as given in Eqs. (3 and 4).

$$PDA_{ij} = \frac{\max(0, (x_{ij} - AV_j))}{AV_j} \quad (3)$$

and

$$NDA_{ij} = \frac{\max(0, (AV_j - x_{ij}))}{AV_j} \quad (4)$$

PDA_{ij} and NDA_{ij} represent the positive and negative distances of i th alternative from average solution in terms of j th criterion, respectively.

Step 5: Obtain weighted summation of the positive and negative distances from average matrix:

$$SP_i = \sum_{j=1}^m w_j PDA_{ij} \quad (5)$$

and

$$SP_i = \sum_{j=1}^m w_j PDA_{ij} \quad (6)$$

Step 6: Calculate the normalized SP_i and SN_i values for every single alternatives, as stated in Eq.(7):

$$NSP_i = \frac{SP_i}{\max_i(SP_i)} \quad (7)$$

and

$$NSN_i = 1 - \frac{SN_i}{\max_i(SN_i)} \quad (8)$$

Step 7: Calculate the appraisal score (AS) for every single alternatives, as stated in Eq. (8):

$$AS_i = \frac{1}{2}(NSP_i + NSN_i), \quad (9)$$

where $0 \leq AS_i \leq 1$.

Step 8: Rank the alternatives according to the decreasing values of AS_i appraisal score. The alternative with the highest AS_i is the best option out of the others.

5.2. Interval-Valued Neutrosophic EDAS

In this section, we propose IVN EDAS with its details. Deneutrosophication technique for the IVN sets is developed and subtraction operation for the IVN sets is developed.

5.2.1. Preliminaries for Neutrosophic Sets

Definition 1 Let $x_j = \langle [T_j^L, T_j^U], [I_j^L, I_j^U], [F_j^L, F_j^U] \rangle$ be a collection of interval-valued neutrosophic number (IVNN) where j represents decision maker ($j = 1, 2, \dots, n$). Based on the weighted aggregation operators of IVNNs, the interval-valued neutrosophic weighted arithmetic average operator (INWAA) is as in Eq. (10) [13]:

$$INWAA(x_1, x_2, \dots, x_n) = \sum_{k=1}^n y_k x_j$$

Where

$$\langle [1 - \prod_{k=1}^n (1 - T_j^L)^{y_k}, 1 - \prod_{k=1}^n (1 - T_j^U)^{y_k}], [\prod_{k=1}^n (I_j^L)^{y_k}, \prod_{k=1}^n (I_j^U)^{y_k}], [\prod_{k=1}^n (F_j^L)^{y_k}, \prod_{k=1}^n (F_j^U)^{y_k}] \rangle \quad (10)$$

and y_k is the weight vector of decision maker.

Definition 2 The ranking operation of an IVNN which is stated above is calculated as in Eq. (11):

$$\kappa(x) = \frac{(T_x^L * (2 - I_x^L - I_x^U)) + (T_x^U * (2 - I_x^L - I_x^U)) + (1 - F_x^L) * (2 - I_x^L - I_x^U) + (1 - F_x^U) * (2 - I_x^L - I_x^U)}{8} \quad (11)$$

where $x = \langle [T_x^L, T_x^U], [I_x^L, I_x^U], [F_x^L, F_x^U] \rangle$.

Definition 3 A function is identified to find the maximum value between IVN set and zero as in Eq. (12).

$$Z(x_j) = \begin{cases} x_j, & \text{if } \kappa(x_j) > 0 \\ 0, & \text{if } \kappa(x_j) \leq 0 \end{cases} \quad (12)$$

where $x_j = \langle [T_j^L, T_j^U], [I_j^L, I_j^U], [F_j^L, F_j^U] \rangle$ and $0 = \langle [0, 0], [1, 1], [1, 1] \rangle$.

Definition 4 Let X be a universe of discourse. An IVN set N in X is independently characterized by a truth membership function $T_N(x)$, an indeterminacy membership function $I_N(x)$, and a falsity membership function $F_N(x)$ for each $x \in X$,

where

$$T_N(x) = [T_{N(x)}^L, T_{N(x)}^U] \subseteq [0, 1], I_N(x) = [I_{N(x)}^L, I_{N(x)}^U] \subseteq [0, 1],$$

$$\text{and } F_N(x) = [F_{N(x)}^L, F_{N(x)}^U] \subseteq [0, 1].$$

Then, they need to satisfy the condition of $0 \leq T_{N(x)}^L + I_{N(x)}^L + F_{N(x)}^L \leq 3$.

Thus, the IVNS can be denoted as [14]:

$$N = \{ \langle x, [T_{N(x)}^L, T_{N(x)}^U], [I_{N(x)}^L, I_{N(x)}^U], [F_{N(x)}^L, F_{N(x)}^U] \rangle | x \in X \} \quad (13)$$

We will denote Eq.(1) as $[T_N^L, T_N^U], [I_N^L, I_N^U], [F_N^L, F_N^U]$ for short.

Let $a = [T_a^L, T_a^U], [I_a^L, I_a^U], [F_a^L, F_a^U]$ and $b = [T_b^L, T_b^U], [I_b^L, I_b^U], [F_b^L, F_b^U]$ be two INNs, the relations of them are shown as below [13]:

1. $a^c = \langle [T_a^L, T_a^U], [1 - I_a^L, 1 - I_a^U], [F_a^L, F_a^U] \rangle$
2. $a \subseteq b$ if and only if $T_a^L \leq T_b^L, T_a^U \leq T_b^U; I_a^L \geq I_b^L, I_a^U \geq I_b^U; F_a^L \geq F_b^L, F_a^U \geq F_b^U$
3. $a = b$ if and only if $a \subseteq b$ and $b \subseteq a$.
4. $a \oplus b = \langle [T_a^L + T_b^L - T_a^L T_b^L, T_a^U + T_b^U - T_a^U T_b^U], [I_a^L I_b^L, I_a^U I_b^U], [F_a^L F_b^L, F_a^U F_b^U] \rangle$
5. $a \otimes b = \langle [T_a^L T_b^L, T_a^U T_b^U], [I_a^L + I_b^L - I_a^L I_b^L, I_a^U + I_b^U - I_a^U I_b^U], [F_a^L + F_b^L - F_a^L F_b^L, F_a^U + F_b^U - F_a^U F_b^U] \rangle$

Definition 5 Subtraction operation of two interval valued neutrosophic sets is given as follows:

$$x \ominus y = \langle [T_x^L - T_y^U, T_x^U - T_y^L], [Max(I_x^L, I_y^L), Max(I_x^U, I_y^U)], [F_x^L - F_y^U, F_x^U - F_y^L] \rangle \quad (14)$$

where $x = \langle [T_x^L, T_x^U], [I_x^L, I_x^U], [F_x^L, F_x^U] \rangle$ and $y = \langle [T_y^L, T_y^U], [I_y^L, I_y^U], [F_y^L, F_y^U] \rangle$.

Definition 6 Let $A = \langle [T^L, T^U], [I^L, I^U], [F^L, F^U] \rangle$ be an IVN number. The deneutrosophicated A value $\kappa(x)$ is given by Eq. (6):

$$\kappa(A) = \frac{T^L + T^U + 2 - F^L - F^U + T^L * T^U + \sqrt{(1 - F^L) * (1 - F^U)}}{6} * \left[\left(1 - \frac{I^L + I^U}{2} \right) - (\sqrt{I^L * I^U}) \right] \quad (15)$$

5.2.2. Interval Valued Neutrosophic EDAS Method

In this section, we use interval valued neutrosophic sets in EDAS method to surpass incompleteness, indeterminacy, and inconsistency information in the system. The steps of the extended method are:

Step 1: Construct the IVN decision matrix D_j with regard to j experts, where the benefit and cost variables are b_{mn} and c_{mn} , respectively. The columns are the alternatives (n) and the rows are the criteria (m). The scale used to construct IVN decision matrix is given in Table 5.1.

Through the scale, IVN decision matrix with respect to Expert j is given in Table 5.2.

Here, we use $x_{jmn} = \langle [T_y^L, T_y^U], [I_y^L, I_y^U], [F_y^L, F_y^U] \rangle$ notation to express IVN number with respect to Expert j .

Step 2: Decision matrix aggregation

To obtain average IVN decision matrix, Eq. (10) is used for aggregation.

Aggregated IVN decision matrix (A) is created as in Table 5.3. Here, $x_{mn} = \langle [T_A^L, T_A^U], [I_A^L, I_A^U], [F_A^L, F_A^U] \rangle$ notation is used to express aggregated IVN number.

Step 3: Construct the average solution matrix of criteria weights with regards to experts (j). The criteria weights are determined by Table 5.4. The weights are:

$$W = [w_j]_{1 \times m} \quad (16)$$

Table 5.1: IVN decision matrix scales

Linguistic Terms		$\langle T, I, F \rangle$
CL	Certainly Low	$\langle [0.15, 0.25], [0.15, 0.25], [0.85, 0.95] \rangle$
VL	Very Low	$\langle [0.25, 0.35], [0.35, 0.45], [0.75, 0.85] \rangle$
L	Low	$\langle [0.35, 0.45], [0.45, 0.55], [0.65, 0.75] \rangle$
BA	Below Average	$\langle [0.45, 0.55], [0.55, 0.65], [0.55, 0.65] \rangle$
A	Average	$\langle [0.55, 0.60], [0.65, 0.75], [0.45, 0.55] \rangle$
AA	Above Average	$\langle [0.55, 0.65], [0.55, 0.65], [0.45, 0.55] \rangle$
H	High	$\langle [0.65, 0.75], [0.45, 0.55], [0.35, 0.45] \rangle$
VH	Very High	$\langle [0.75, 0.85], [0.25, 0.35], [0.25, 0.35] \rangle$
CH	Certainly High	$\langle [0.85, 0.95], [0.15, 0.25], [0.15, 0.25] \rangle$

where w_j is obtained by using Eq. (1)

Step 4: Construct the matrix of average criteria weights (AV) with regard to scores that are determined in Table 5.5. The constructed criteria weight matrix is given in Table 5.5.

In here, $av_n = \langle [T_{AV}^L, T_{AV}^U], [I_{AV}^L, I_{AV}^U], [F_{AV}^L, F_{AV}^U] \rangle$ where the average weights of criteria with respect to scores are taken from the decision matrix.

Step 5: Calculate the positive and negative distances from average (PDA and NDA) according to benefit and cost criteria, respectively. As we mentioned above benefit and cost variables are shown as b_{mn} and c_{mn} .

$$PDA = [pda_{mn}]_{m*n} \quad (17)$$

$$NDA = [nda_{mn}]_{m*n} \quad (18)$$

where pda_{mn} and nda_{mn} denote the positive and negative distance performance value of the n th alternative from average solution in terms of m th criterion, respectively.

$$pda_{mn} = \begin{cases} \frac{Z(x_{mn} \ominus av_n)}{\kappa(av_n)}, & \text{if } m \in B \\ \frac{Z(av_n \ominus x_{mn})}{\kappa(av_n)}, & \text{if } m \in C \end{cases} \quad (19)$$

Table 5.2: IVN decision matrix as per DM's

Criterion	Type	AL ₁	AL ₂	...	AL _N
C ₁₁	Linguistic Cost	$\langle [T_j^L, T_j^U], [I_j^L, I_j^U], [F_j^L, F_j^U] \rangle$	$\langle [T_j^L, T_j^U], [I_j^L, I_j^U], [F_j^L, F_j^U] \rangle$	...	$\langle [T_j^L, T_j^U], [I_j^L, I_j^U], [F_j^L, F_j^U] \rangle$
C ₁₂	Numerical Cost	$\langle [T_j^L, T_j^U], [I_j^L, I_j^U], [F_j^L, F_j^U] \rangle$	$\langle [T_j^L, T_j^U], [I_j^L, I_j^U], [F_j^L, F_j^U] \rangle$	...	$\langle [T_j^L, T_j^U], [I_j^L, I_j^U], [F_j^L, F_j^U] \rangle$
⋮	⋮	⋮	⋮	⋮	⋮
C _m	Linguistic Benefit	$\langle [T_j^L, T_j^U], [I_j^L, I_j^U], [F_j^L, F_j^U] \rangle$	$\langle [T_j^L, T_j^U], [I_j^L, I_j^U], [F_j^L, F_j^U] \rangle$	...	$\langle [T_j^L, T_j^U], [I_j^L, I_j^U], [F_j^L, F_j^U] \rangle$

Table 5.3: Aggregated IVN decision matrix

Criterion	Type	AL_1	AL_2	...	AL_N
C_{11}	Linguistic Cost	$\langle [T_A^L, T_A^U], [I_A^L, I_A^U], [F_A^L, F_A^U] \rangle$	$\langle [T_A^L, T_A^U], [I_A^L, I_A^U], [F_A^L, F_A^U] \rangle$	...	$\langle [T_A^L, T_A^U], [I_A^L, I_A^U], [F_A^L, F_A^U] \rangle$
C_{12}	Numerical Cost	$\langle [T_A^L, T_A^U], [I_A^L, I_A^U], [F_A^L, F_A^U] \rangle$	$\langle [T_A^L, T_A^U], [I_A^L, I_A^U], [F_A^L, F_A^U] \rangle$	...	$\langle [T_A^L, T_A^U], [I_A^L, I_A^U], [F_A^L, F_A^U] \rangle$
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
C_m	Linguistic Benefit	$\langle [T_A^L, T_A^U], [I_A^L, I_A^U], [F_A^L, F_A^U] \rangle$	$\langle [T_A^L, T_A^U], [I_A^L, I_A^U], [F_A^L, F_A^U] \rangle$	...	$\langle [T_A^L, T_A^U], [I_A^L, I_A^U], [F_A^L, F_A^U] \rangle$

Table 5.4: Criteria weighting scales

Linguistic Terms		$\langle T, I, F \rangle$
CLI	Certainly Low Importance	$\langle [0.08, 0.24], [0.69, 0.80], [0.85, 1.00] \rangle$
VLI	Very Low Importance	$\langle [0.24, 0.35], [0.58, 0.69], [0.4, 0.85] \rangle$
LI	Low Importance	$\langle [0.35, 0.46], [0.46, 0.58], [0.63, 0.74] \rangle$
BAI	Below Average Importance	$\langle [0.46, 0.58], [0.35, 0.46], [0.52, 0.63] \rangle$
AI	Average Importance	$\langle [0.52, 0.58], [0.13, 0.24], [0.46, 0.52] \rangle$
AA	Above Average Importance	$\langle [0.52, 0.63], [0.35, 0.46], [0.46, 0.58] \rangle$
HI	High Importance	$\langle [0.63, 0.74], [0.46, 0.58], [0.35, 0.46] \rangle$
VHI	Very High Importance	$\langle [0.74, 0.85], [0.58, 0.69], [0.24, 0.35] \rangle$
CHI	Certainly High Importance	$\langle [0.85, 1.00], [0.69, 0.80], [0.08, 0.24] \rangle$

Table 5.5 Average criteria weights for scores

Linguistic Terms		$\langle T, I, F \rangle$
C ₁	Linguistic cost	$\langle [T_{AV}^L, T_{AV}^U], [I_{AV}^L, I_{AV}^U], [F_{AV}^L, F_{AV}^U] \rangle$
C ₁₂	Numerical cost	$\langle [T_{AV}^L, T_{AV}^U], [I_{AV}^L, I_{AV}^U], [F_{AV}^L, F_{AV}^U] \rangle$
.	.	.
.	.	.
.	.	.
C _m	Linguistic Benefit	$\langle [T_{AV}^L, T_{AV}^U], [I_{AV}^L, I_{AV}^U], [F_{AV}^L, F_{AV}^U] \rangle$

$$nda_{mn} = \begin{cases} \frac{Z(av_n \ominus x_{mn})}{\kappa(av_n)}, & \text{if } m \in B \\ \frac{Z(x_{mn} \ominus av_n)}{\kappa(av_n)}, & \text{if } m \in C \end{cases} \quad (20)$$

Step 6: Calculate the weighted sum of positive and negative distances for all alternatives as in Eqs. (21 and 22):

$$sp_n = \sum_{j=1}^l (w_j \otimes pda_{mn}) \quad (21)$$

$$np_n = \sum_{j=1}^l (w_j \otimes nda_{mn}) \quad (22)$$

Step 7: Normalize the sp_n and np_n values. The normalize values of sp_n and np_n for all alternatives are calculated using Eqs. (23 and 24):

$$nsp_n = \frac{sp_n}{\text{Max}(\kappa(sp_n))} \quad (23)$$

$$nsn_n = 1 - \frac{sn_n}{\text{Max}(\kappa(sn_n))} \quad (24)$$

Step 8: Calculate the appraisal score (as_n) for all alternatives as in Eq. (25):

$$as_n = \frac{1}{2} (nsp_n \oplus nsn_n) \quad (25)$$

Step 9: Rank the alternatives according to the decreasing values of appraisal score (as_n)

6. COMPUTATIONAL STUDY

As it is stated in previous sections, warehouse location selection for cold chain logistics has been experienced by using Neutrosophic EDAS which is one of the MCDM techniques. Arabian Gulf Countries are the target region of this selection problem because the temperature, consumption and importation indicators are pretty high for the region. Best city in this region has been evaluated according to most important criteria and tried to be selected.

Since this is a decision making problem, it includes decision makers. The decision makers of this study are from members of three departments of one of the globally leading logistics company. Related departments are Business Development Department, Operational Excellence Department and Contract Logistics Department.

Business Development Department consist of sales and solution design experts. Sales team members work a lot to get a lucrative customer in terms of money and prestige. They prepare an offer for the tender according to company rules and expected rate of return. They need the collaboration of different disciplines by doing this, this disciplines are operational excellence, contract logistics and law and information technologies departments.

Operational Excellence Department is another part which provide another inputs of new investment decisions. Because they have a deep knowledge about the numbers of the other projects within the organisation or the logistics sectors. So they know clues and musts to manage an operation with the most effective way.

Contract Logistics Department consist of operation managers who are the one run the operations. So they have a deep knowhow about how to manage a warehouse and its members such as customer, personnel and equipment. So they provide some operational information such as how many person is needed to run any particular operation and how many reach truck is needed. So the decision makers and their weights on a project is stated in Table 6.1.

Table 6.1: Decision makers and its weights on a project

Code	Explanation	Weights
DM1	Business Development Department	0.40
DM2	Operational Excellence Department	0.30
DM3	Contract Logistics Department	0.30

Step 1: Construct Interval-valued neutrosophic decision matrix with respect to experts. First step of the calculations are the determination of the interval-valued neutrosophic decision matrix with respect to every single expert. In this part of the study, it is asked for expertise of business development, operational excellence and contract logistics departments' members of leading logistics company. They have evaluated every single alternative according to criteria stated in Table 3.1a, Table 3.1b and Table 3.1c. This evaluation has been done in terms of scale of IVN decision matrix stated in Table 5.1.

The IVN decision matrix which is created after evaluation of departments are as below Table 6.2a, 6.2b and 6.2c.

Table 6.2a: Decision matrix as per DM1

DM1	weight = 0.4	Abu Dhabi	Dubai	Al Ayn	Doha	Manama	Riyadh	Medina	Jeddah	Mecca	Kuwait City	Masqat
Criterion	Type	AL1	AL2	AL3	AL4	AL5	AL6	AL7	AL8	AL9	AL10	AL11
C1.1	Benefit	VH	VH	BA	H	H	VH	BA	A	BA	A	VL
C1.2	Benefit	VH	VH	BA	H	AA	VH	L	AA	L	AA	L
C1.3	Benefit	VH	VH	BA	VH	AA	VH	BA	VH	L	H	L
C1.4	Benefit	VH	VH	A	VH	H	VH	A	VH	A	H	BA
C1.5	Benefit	A	A	A	A	A	BA	A	A	A	A	A
C1.6	Benefit	H	H	A	H	A	H	L	A	BA	AA	VL
C2.1	Cost	H	H	CL	VH	AA	VH	BA	H	VL	AA	CL
C2.2	Cost	VH	VH	L	VH	AA	VH	AA	H	AA	AA	L
C2.3	Cost	H	H	VL	H	A	H	AA	AA	A	AA	L
C2.4	Cost	H	H	BA	H	BA	H	AA	AA	A	AA	BA
C2.5	Cost	A	A	AA	A	AA	A	AA	AA	A	A	AA
C2.6	Cost	A	A	AA	A	AA	A	A	AA	A	A	AA
C2.7	Cost	AA	AA	A	A	AA	AA	A	AA	A	AA	A
C3.1	Benefit	VH	VH	BA	VH	A	VH	A	A	A	A	A
C3.2	Benefit	VH	VH	A	A	A	VH	VH	H	VH	AA	AA
C3.3	Benefit	H	H	AA	VH	A	H	A	A	BA	A	A
C3.4	Benefit	VH	VH	BA	VH	BA	VH	BA	AA	BA	A	VH
C3.5	Benefit	VH	VH	VH	BA	BA	VH	H	AA	H	BA	AA
C3.6	Benefit	H	H	A	VH	A	AA	H	AA	BA	AA	BA
C3.7	Benefit	H	H	AA	BA	BA	VH	H	AA	AA	BA	A
C3.8	Benefit	H	CH	CL	H	VL	VH	AA	AA	AA	AA	A
C3.9	Benefit	CH	CH	BA	CH	A	CH	VL	AA	VL	BA	BA
C4.1	Benefit	H	H	H	AA	A	AA	AA	AA	AA	AA	H
C4.2	Benefit	H	H	H	AA	A	AA	AA	AA	AA	AA	H
C5.1	Benefit	VH	CH	L	AA	AA	CH	CH	AA	H	AA	AA
C5.2	Benefit	VH	VH	BA	H	H	VH	VH	H	AA	H	AA
C5.3	Benefit	VH	VH	A	H	AA	VH	VH	H	A	AA	BA

Table 6.2b: Decision matrix as per DM2

DM2	weight = 0.3	Abu Dhabi	Dubai	Al Ayn	Doha	Manama	Riyadh	Medina	Jeddah	Mecca	Kuwait City	Masqat
Criterion	Type	AL1	AL2	AL3	AL4	AL5	AL6	AL7	AL8	AL9	AL10	AL11
C1.1	Benefit	CH	CH	BA	VH	VL	CH	BA	A	BA	A	VL
C1.2	Benefit	CH	CH	A	VH	H	CH	A	H	A	H	BA
C1.3	Benefit	CH	CH	A	CH	H	CH	A	CH	BA	VH	BA
C1.4	Benefit	VH	VH	A	VH	H	VH	A	VH	A	H	BA
C1.5	Benefit	AA	AA	AA	AA	AA	A	AA	AA	AA	AA	AA
C1.6	Benefit	VH	VH	AA	VH	AA	VH	BA	AA	A	H	L
C2.1	Cost	AA	AA	CL	H	A	H	L	AA	VL	A	CL
C2.2	Cost	H	H	VL	H	A	H	A	AA	A	A	VL
C2.3	Cost	H	H	VL	H	A	H	AA	AA	A	AA	L
C2.4	Cost	AA	AA	L	AA	L	AA	A	A	BA	A	L
C2.5	Cost	A	A	AA	A	AA	A	AA	AA	A	A	AA
C2.6	Cost	BA	VH	A	BA	A	BA	BA	A	BA	BA	A
C2.7	Cost	A	A	BA	BA	A	A	BA	A	BA	A	BA
C3.1	Benefit	CH	CH	A	CH	AA	CH	AA	AA	AA	AA	AA
C3.2	Benefit	CH	CH	AA	AA	AA	CH	CH	VH	CH	H	H
C3.3	Benefit	VH	VH	H	CH	AA	VH	AA	AA	A	H	H
C3.4	Benefit	CH	CH	A	CH	A	CH	A	H	A	AA	CH
C3.5	Benefit	CH	CH	CH	A	A	CH	VH	H	VH	A	H
C3.6	Benefit	CH	CH	AA	CH	AA	H	VH	H	A	H	A
C3.7	Benefit	VH	VH	H	A	A	CH	VH	H	H	A	AA
C3.8	Benefit	VH	CH	L	VH	L	CH	H	H	H	H	AA
C3.9	Benefit	CH	CH	A	CH	AA	CH	L	H	L	A	A
C4.1	Benefit	VH	VH	VH	H	AA	H	H	H	H	H	VH
C4.2	Benefit	VH	VH	VH	H	AA	H	H	H	H	H	VH
C5.1	Benefit	CH	CH	BA	H	H	CH	CH	H	VH	H	H
C5.2	Benefit	CH	CH	A	VH	VH	CH	CH	VH	H	VH	H
C5.3	Benefit	CH	CH	AA	VH	H	CH	CH	VH	AA	H	A

Table 6.2c: Decision matrix as per DM3

DM3	weight = 0.3	Abu Dhabi	Dubai	Al Ayn	Doha	Manama	Riyadh	Medina	Jeddah	Mecca	Kuwait City	Masqat
Criterion	Type	AL1	AL2	AL3	AL4	AL5	AL6	AL7	AL8	AL9	AL10	AL11
C1.1	Benefit	CH	CH	AA	CH	CH	CH	AA	H	AA	H	BA
C1.2	Benefit	CH	CH	AA	CH	VH	CH	A	VH	A	VH	A
C1.3	Benefit	CH	CH	AA	CH	VH	CH	AA	CH	A	CH	A
C1.4	Benefit	CH	CH	H	CH	CH	CH	H	CH	H	CH	AA
C1.5	Benefit	H	H	H	H	H	AA	H	H	H	H	H
C1.6	Benefit	CH	CH	H	CH	H	CH	A	H	AA	VH	BA
C2.1	Cost	CH	CH	L	CH	VH	CH	AA	CH	BA	VH	L
C2.2	Cost	CH	CH	A	CH	VH	CH	VH	CH	VH	VH	A
C2.3	Cost	CH	CH	BA	CH	H	CH	VH	VH	H	VH	A
C2.4	Cost	CH	CH	AA	CH	AA	CH	VH	VH	H	VH	AA
C2.5	Cost	H	H	VH	H	VH	H	VH	VH	H	H	VH
C2.6	Cost	H	H	VH	H	VH	H	H	VH	H	H	VH
C2.7	Cost	VH	VH	H	H	VH	VH	H	VH	H	VH	H
C3.1	Benefit	CH	CH	AA	CH	H	CH	H	H	H	H	H
C3.2	Benefit	CH	CH	H	H	H	CH	CH	CH	CH	VH	VH
C3.3	Benefit	CH	CH	VH	CH	H	CH	H	H	AA	H	H
C3.4	Benefit	CH	CH	AA	CH	AA	CH	AA	VH	AA	H	CH
C3.5	Benefit	CH	CH	CH	AA	AA	CH	CH	VH	CH	AA	VH
C3.6	Benefit	CH	CH	H	CH	H	VH	CH	VH	AA	VH	AA
C3.7	Benefit	CH	CH	VH	AA	AA	CH	CH	VH	VH	AA	H
C3.8	Benefit	CH	CH	L	CH	BA	CH	VH	VH	VH	VH	H
C3.9	Benefit	CH	CH	AA	CH	H	CH	BA	VH	BA	AA	AA
C4.1	Benefit	CH	CH	CH	VH	H	VH	VH	VH	VH	VH	CH
C4.2	Benefit	CH	CH	CH	VH	H	VH	VH	VH	VH	VH	CH
C5.1	Benefit	CH	CH	A	VH	VH	CH	CH	VH	CH	VH	VH
C5.2	Benefit	CH	CH	AA	CH	CH	CH	CH	CH	VH	CH	VH
C5.3	Benefit	CH	CH	H	CH	VH	CH	CH	CH	H	VH	AA

Step 2: Construct aggregated interval-valued neutrosophic decision matrix.

In this step of the calculations, the interval-valued neutrosophic weighted arithmetic averages of every single criterion is calculated by using IVNN of decision makers. Eq. 10 is used to obtain IVNN and then this IVNN's are aggregated according to Table 5.3 The aggregated IVN decision matrix is as below Table 6.3a, Table 6.3b, Table 6.3c, Table 6.3d, Table 6.3e and Table 6.3f.

Table 6.3a: Aggregated IVN decision matrix

		Abu Dhabi	Dubai
Criterion	Type	AL1	AL2
C1.1	Benefit	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C1.2	Benefit	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C1.3	Benefit	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C1.4	Benefit	[(0.79;0.89),(0.21;0.32),(0.21;0.32)]	[(0.79;0.89),(0.21;0.32),(0.21;0.32)]
C1.5	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]
C1.6	Benefit	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]
C2.1	Cost	[(0.71;0.83),(0.34;0.46),(0.29;0.4)]	[(0.71;0.83),(0.34;0.46),(0.29;0.4)]
C2.2	Cost	[(0.76;0.87),(0.26;0.36),(0.24;0.34)]	[(0.76;0.87),(0.26;0.36),(0.24;0.34)]
C2.3	Cost	[(0.73;0.85),(0.32;0.43),(0.27;0.38)]	[(0.73;0.85),(0.32;0.43),(0.27;0.38)]
C2.4	Cost	[(0.71;0.83),(0.34;0.46),(0.29;0.4)]	[(0.71;0.83),(0.34;0.46),(0.29;0.4)]
C2.5	Cost	[(0.58;0.65),(0.58;0.68),(0.42;0.52)]	[(0.58;0.65),(0.58;0.68),(0.42;0.52)]
C2.6	Cost	[(0.56;0.64),(0.55;0.65),(0.44;0.54)]	[(0.65;0.74),(0.44;0.54),(0.35;0.45)]
C2.7	Cost	[(0.62;0.72),(0.46;0.56),(0.38;0.48)]	[(0.62;0.72),(0.46;0.56),(0.38;0.48)]
C3.1	Benefit	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C3.2	Benefit	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C3.3	Benefit	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]
C3.4	Benefit	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C3.5	Benefit	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C3.6	Benefit	[(0.79;0.9),(0.23;0.34),(0.21;0.32)]	[(0.79;0.9),(0.23;0.34),(0.21;0.32)]
C3.7	Benefit	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]
C3.8	Benefit	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]	[(0.85;0.95),(0.15;0.25),(0.15;0.25)]
C3.9	Benefit	[(0.85;0.95),(0.15;0.25),(0.15;0.25)]	[(0.85;0.95),(0.15;0.25),(0.15;0.25)]
C4.1	Benefit	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]
C4.2	Benefit	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]
C5.1	Benefit	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]	[(0.85;0.95),(0.15;0.25),(0.15;0.25)]
C5.2	Benefit	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C5.3	Benefit	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]

Table 6.3b: Aggregated IVN decision matrix

		Al Ayn	Doha
Criterion	Type	AL3	AL4
C1.1	Benefit	[(0.48;0.58),(0.55;0.65),(0.52;0.62)]	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]
C1.2	Benefit	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]
C1.3	Benefit	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C1.4	Benefit	[(0.58;0.65),(0.58;0.68),(0.42;0.52)]	[(0.79;0.89),(0.21;0.32),(0.21;0.32)]
C1.5	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]
C1.6	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]
C2.1	Cost	[(0.22;0.32),(0.21;0.32),(0.78;0.88)]	[(0.76;0.87),(0.26;0.36),(0.24;0.34)]
C2.2	Cost	[(0.39;0.47),(0.47;0.57),(0.61;0.71)]	[(0.76;0.87),(0.26;0.36),(0.24;0.34)]
C2.3	Cost	[(0.32;0.42),(0.4;0.5),(0.68;0.78)]	[(0.73;0.85),(0.32;0.43),(0.27;0.38)]
C2.4	Cost	[(0.46;0.56),(0.52;0.62),(0.54;0.65)]	[(0.71;0.83),(0.34;0.46),(0.29;0.4)]
C2.5	Cost	[(0.62;0.73),(0.43;0.54),(0.38;0.48)]	[(0.58;0.65),(0.58;0.68),(0.42;0.52)]
C2.6	Cost	[(0.62;0.72),(0.46;0.56),(0.38;0.48)]	[(0.56;0.64),(0.55;0.65),(0.44;0.54)]
C2.7	Cost	[(0.56;0.64),(0.55;0.65),(0.44;0.54)]	[(0.56;0.64),(0.55;0.65),(0.44;0.54)]
C3.1	Benefit	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C3.2	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]
C3.3	Benefit	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C3.4	Benefit	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C3.5	Benefit	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]
C3.6	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C3.7	Benefit	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]
C3.8	Benefit	[(0.28;0.38),(0.29;0.4),(0.72;0.82)]	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]
C3.9	Benefit	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]	[(0.85;0.95),(0.15;0.25),(0.15;0.25)]
C4.1	Benefit	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C4.2	Benefit	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C5.1	Benefit	[(0.45;0.53),(0.53;0.63),(0.55;0.65)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C5.2	Benefit	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]
C5.3	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]

Table 6.3c: Aggregated IVN decision matrix

		Manama	Riyadh
Criterion	Type	AL5	AL6
C1.1	Benefit	[(0.66;0.79),(0.3;0.41),(0.34;0.46)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C1.2	Benefit	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C1.3	Benefit	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C1.4	Benefit	[(0.73;0.85),(0.32;0.43),(0.27;0.38)]	[(0.79;0.89),(0.21;0.32),(0.21;0.32)]
C1.5	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]
C1.6	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]
C2.1	Cost	[(0.62;0.72),(0.46;0.56),(0.38;0.48)]	[(0.76;0.87),(0.26;0.36),(0.24;0.34)]
C2.2	Cost	[(0.62;0.72),(0.46;0.56),(0.38;0.48)]	[(0.76;0.87),(0.26;0.36),(0.24;0.34)]
C2.3	Cost	[(0.58;0.65),(0.58;0.68),(0.42;0.52)]	[(0.73;0.85),(0.32;0.43),(0.27;0.38)]
C2.4	Cost	[(0.46;0.56),(0.52;0.62),(0.54;0.65)]	[(0.71;0.83),(0.34;0.46),(0.29;0.4)]
C2.5	Cost	[(0.62;0.73),(0.43;0.54),(0.38;0.48)]	[(0.58;0.65),(0.58;0.68),(0.42;0.52)]
C2.6	Cost	[(0.62;0.72),(0.46;0.56),(0.38;0.48)]	[(0.56;0.64),(0.55;0.65),(0.44;0.54)]
C2.7	Cost	[(0.62;0.72),(0.46;0.56),(0.38;0.48)]	[(0.62;0.72),(0.46;0.56),(0.38;0.48)]
C3.1	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C3.2	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C3.3	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]
C3.4	Benefit	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C3.5	Benefit	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C3.6	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C3.7	Benefit	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C3.8	Benefit	[(0.35;0.45),(0.43;0.53),(0.65;0.76)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C3.9	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]	[(0.85;0.95),(0.15;0.25),(0.15;0.25)]
C4.1	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C4.2	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C5.1	Benefit	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]	[(0.85;0.95),(0.15;0.25),(0.15;0.25)]
C5.2	Benefit	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C5.3	Benefit	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]

Table 6.3d: Aggregated IVN decision matrix

		Medina	Jeddah
Criterion	Type	AL7	AL8
C1.1	Benefit	[(0.48;0.58),(0.55;0.65),(0.52;0.62)]	[(0.58;0.65),(0.58;0.68),(0.42;0.52)]
C1.2	Benefit	[(0.48;0.55),(0.56;0.66),(0.52;0.62)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C1.3	Benefit	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C1.4	Benefit	[(0.58;0.65),(0.58;0.68),(0.42;0.52)]	[(0.79;0.89),(0.21;0.32),(0.21;0.32)]
C1.5	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]
C1.6	Benefit	[(0.45;0.53),(0.53;0.63),(0.55;0.65)]	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]
C2.1	Cost	[(0.46;0.56),(0.52;0.62),(0.54;0.65)]	[(0.71;0.83),(0.34;0.46),(0.29;0.4)]
C2.2	Cost	[(0.62;0.72),(0.46;0.56),(0.38;0.48)]	[(0.71;0.83),(0.34;0.46),(0.29;0.4)]
C2.3	Cost	[(0.62;0.73),(0.43;0.54),(0.38;0.48)]	[(0.62;0.73),(0.43;0.54),(0.38;0.48)]
C2.4	Cost	[(0.62;0.72),(0.46;0.56),(0.38;0.48)]	[(0.62;0.72),(0.46;0.56),(0.38;0.48)]
C2.5	Cost	[(0.62;0.73),(0.43;0.54),(0.38;0.48)]	[(0.62;0.73),(0.43;0.54),(0.38;0.48)]
C2.6	Cost	[(0.56;0.64),(0.55;0.65),(0.44;0.54)]	[(0.62;0.72),(0.46;0.56),(0.38;0.48)]
C2.7	Cost	[(0.56;0.64),(0.55;0.65),(0.44;0.54)]	[(0.62;0.72),(0.46;0.56),(0.38;0.48)]
C3.1	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]
C3.2	Benefit	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]
C3.3	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]
C3.4	Benefit	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C3.5	Benefit	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C3.6	Benefit	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C3.7	Benefit	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C3.8	Benefit	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C3.9	Benefit	[(0.35;0.45),(0.43;0.53),(0.65;0.76)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C4.1	Benefit	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C4.2	Benefit	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C5.1	Benefit	[(0.85;0.95),(0.15;0.25),(0.15;0.25)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C5.2	Benefit	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]
C5.3	Benefit	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]

Table 6.3e: Aggregated IVN decision matrix

		Mecca	Kuwait City
Criterion	Type	AL9	AL10
C1.1	Benefit	[(0.48;0.58),(0.55;0.65),(0.52;0.62)]	[(0.58;0.65),(0.58;0.68),(0.42;0.52)]
C1.2	Benefit	[(0.48;0.55),(0.56;0.66),(0.52;0.62)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C1.3	Benefit	[(0.45;0.53),(0.53;0.63),(0.55;0.65)]	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]
C1.4	Benefit	[(0.58;0.65),(0.58;0.68),(0.42;0.52)]	[(0.73;0.85),(0.32;0.43),(0.27;0.38)]
C1.5	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]
C1.6	Benefit	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C2.1	Cost	[(0.32;0.42),(0.4;0.5),(0.68;0.78)]	[(0.62;0.72),(0.46;0.56),(0.38;0.48)]
C2.2	Cost	[(0.62;0.72),(0.46;0.56),(0.38;0.48)]	[(0.62;0.72),(0.46;0.56),(0.38;0.48)]
C2.3	Cost	[(0.58;0.65),(0.58;0.68),(0.42;0.52)]	[(0.62;0.72),(0.43;0.54),(0.38;0.48)]
C2.4	Cost	[(0.56;0.64),(0.55;0.65),(0.44;0.54)]	[(0.62;0.72),(0.46;0.56),(0.38;0.48)]
C2.5	Cost	[(0.58;0.65),(0.58;0.68),(0.42;0.52)]	[(0.58;0.65),(0.58;0.68),(0.42;0.52)]
C2.6	Cost	[(0.56;0.64),(0.55;0.65),(0.44;0.54)]	[(0.56;0.64),(0.55;0.65),(0.44;0.54)]
C2.7	Cost	[(0.56;0.64),(0.55;0.65),(0.44;0.54)]	[(0.62;0.72),(0.46;0.56),(0.38;0.48)]
C3.1	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]
C3.2	Benefit	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C3.3	Benefit	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]	[(0.61;0.7),(0.52;0.62),(0.39;0.49)]
C3.4	Benefit	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]
C3.5	Benefit	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]
C3.6	Benefit	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C3.7	Benefit	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]
C3.8	Benefit	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C3.9	Benefit	[(0.35;0.45),(0.43;0.53),(0.65;0.76)]	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]
C4.1	Benefit	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C4.2	Benefit	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C5.1	Benefit	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C5.2	Benefit	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]
C5.3	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]

Table 6.3f: Aggregated IVN decision matrix

		Masqat
Criterion	Type	AL11
C1.1	Benefit	[(0.32;0.42),(0.4;0.5),(0.68;0.78)]
C1.2	Benefit	[(0.45;0.53),(0.53;0.63),(0.55;0.65)]
C1.3	Benefit	[(0.45;0.53),(0.53;0.63),(0.55;0.65)]
C1.4	Benefit	[(0.48;0.58),(0.55;0.65),(0.52;0.62)]
C1.5	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]
C1.6	Benefit	[(0.35;0.45),(0.43;0.53),(0.65;0.76)]
C2.1	Cost	[(0.22;0.32),(0.21;0.32),(0.78;0.88)]
C2.2	Cost	[(0.39;0.47),(0.47;0.57),(0.61;0.71)]
C2.3	Cost	[(0.42;0.5),(0.5;0.6),(0.58;0.68)]
C2.4	Cost	[(0.46;0.56),(0.52;0.62),(0.54;0.65)]
C2.5	Cost	[(0.62;0.73),(0.43;0.54),(0.38;0.48)]
C2.6	Cost	[(0.62;0.72),(0.46;0.56),(0.38;0.48)]
C2.7	Cost	[(0.56;0.64),(0.55;0.65),(0.44;0.54)]
C3.1	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]
C3.2	Benefit	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C3.3	Benefit	[(0.61;0.7),(0.52;0.62),(0.39;0.49)]
C3.4	Benefit	[(0.82;0.92),(0.18;0.29),(0.18;0.29)]
C3.5	Benefit	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C3.6	Benefit	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]
C3.7	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]
C3.8	Benefit	[(0.58;0.67),(0.55;0.65),(0.42;0.52)]
C3.9	Benefit	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]
C4.1	Benefit	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]
C4.2	Benefit	[(0.75;0.87),(0.27;0.38),(0.25;0.35)]
C5.1	Benefit	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C5.2	Benefit	[(0.65;0.75),(0.41;0.51),(0.35;0.45)]
C5.3	Benefit	[(0.51;0.6),(0.58;0.68),(0.49;0.59)]

Step 3: Construct the average solution matrix of criteria weights with regards to experts. First of all, the decision makers determine the weights of the every single criterion according to the scale stated in Table 5.4. The criterion evaluation of decision makers are stated in Table 6.4 below.

Table 6.4: Criteria scores determined by DMs

Criterion	Code	DM1	DM2	DM3
Proximity to potential markets	C1.1	HI	HI	VHI
Proximity to producers	C1.2	HI	HI	HI
Proximity to mainroads, seaports and airports	C1.3	AAI	HI	VHI
Proximity to forwarding agents	C1.4	HI	HI	HI
Climate conditions	C1.5	LI	LI	LI
Availability of skilled workforce	C1.6	HI	AAI	AAI
Storage cost	C2.1	HI	VHI	VHI
Investment cost	C2.2	VHI	VHI	HI
Rental cost	C2.3	HI	VHI	VHI
Labor cost	C2.4	AI	HI	VHI
Energy cost	C2.5	AI	AI	AI
Tax cost	C2.6	AI	AI	AI
Transportation cost	C2.7	HI	HI	HI
Structural suitability	C3.1	VHI	HI	VHI
Parking facilities	C3.2	HI	AI	HI
Hygiene facilities	C3.3	AI	AI	HI
Hydraulic ramp facility	C3.4	BAI	BAI	VHI
Adequate truck manoeuvre field	C3.5	VHI	AI	AAI
Security	C3.6	AI	AI	AI
Stock holding capacity	C3.7	HI	HI	HI
Separated waste field	C3.8	BAI	BAI	BAI
Adequate IT/network system	C3.9	VHI	AI	HI
Government policies	C4.1	HI	VHI	LI
Industrial regulations and laws	C4.2	HI	VHI	LI
Cold storage	C5.1	CHI	CHI	CHI
Cold transport	C5.2	AAI	AAI	AAI
Cold processing	C5.3	VHI	VHI	VHI

Step 4: Construct the matrix of average criteria weights

After decision makers scored the every single criterion, average criteria weights matrix is created.

Table 6.5: Average criteria weights matrix

Criterion	Code	Average Weights
Proximity to potential markets	C1.1	[(0.67;0.78),(0.49;0.61),(0.31;0.42)]
Proximity to producers	C1.2	[(0.63;0.74),(0.46;0.58),(0.35;0.46)]
Proximity to mainroads, seaports and airports	C1.3	[(0.63;0.75),(0.44;0.56),(0.35;0.46)]
Proximity to forwarding agents	C1.4	[(0.63;0.74),(0.46;0.58),(0.35;0.46)]
Climate conditions	C1.5	[(0.35;0.46),(0.46;0.58),(0.63;0.74)]
Availability of skilled workforce	C1.6	[(0.57;0.68),(0.39;0.5),(0.41;0.53)]
Storage cost	C2.1	[(0.7;0.81),(0.53;0.64),(0.28;0.39)]
Investment cost	C2.2	[(0.71;0.82),(0.54;0.65),(0.27;0.38)]
Rental cost	C2.3	[(0.7;0.81),(0.53;0.64),(0.28;0.39)]
Labor cost	C2.4	[(0.63;0.73),(0.3;0.43),(0.35;0.45)]
Energy cost	C2.5	[(0.52;0.58),(0.13;0.24),(0.46;0.52)]
Tax cost	C2.6	[(0.52;0.58),(0.13;0.24),(0.46;0.52)]
Transportation cost	C2.7	[(0.63;0.74),(0.46;0.58),(0.35;0.46)]
Structural suitability	C3.1	[(0.71;0.82),(0.54;0.65),(0.27;0.38)]
Parking facilities	C3.2	[(0.6;0.7),(0.31;0.45),(0.38;0.48)]
Hygiene facilities	C3.3	[(0.56;0.64),(0.19;0.31),(0.42;0.5)]
Hydraulic ramp facility	C3.4	[(0.57;0.69),(0.41;0.52),(0.41;0.53)]
Adequate truck manoeuvre field	C3.5	[(0.62;0.73),(0.32;0.45),(0.35;0.46)]
Security	C3.6	[(0.52;0.58),(0.13;0.24),(0.46;0.52)]
Stock holding capacity	C3.7	[(0.63;0.74),(0.46;0.58),(0.35;0.46)]
Separated waste field	C3.8	[(0.46;0.58),(0.35;0.46),(0.52;0.63)]
Adequate IT/network system	C3.9	[(0.65;0.76),(0.35;0.48),(0.33;0.43)]
Government policies	C4.1	[(0.61;0.73),(0.49;0.61),(0.37;0.49)]
Industrial regulations and laws	C4.2	[(0.61;0.73),(0.49;0.61),(0.37;0.49)]
Cold storage	C5.1	[(0.85;1),(0.69;0.8),(0.08;0.24)]
Cold transport	C5.2	[(0.52;0.63),(0.35;0.46),(0.46;0.58)]
Cold processing	C5.3	[(0.74;0.85),(0.58;0.69),(0.24;0.35)]

Step 5: Calculate PDA and NDA

In this step, PDA and NDA values of every single criterion are calculated for every single alternative. Criterion type is an important input in this calculation. It can be either cost or benefit. Calculations are done according to equations 19 and 20. And the PDA and NDA value of Abu Dhabi is stated in Table 6.6. The values of other alternatives are included in Appendix A.

Table 6.6: PDA and NDA values for Abu Dhabi

	Abu Dhabi	Abu Dhabi
Criterion	PDA	NDA
C1.1	[(0.05;0.36),(0.7;0.87),(-0.34;-0.04)]	[(-0.36;-0.05),(0.7;0.87),(0.04;0.34)]
C1.2	[(0.11;0.41),(0.65;0.82),(-0.39;-0.09)]	[(-0.41;-0.11),(0.65;0.82),(0.09;0.39)]
C1.3	[(0.09;0.39),(0.6;0.75),(-0.38;-0.08)]	[(-0.39;-0.09),(0.6;0.75),(0.08;0.38)]
C1.4	[(0.06;0.37),(0.65;0.82),(-0.35;-0.05)]	[(-0.37;-0.06),(0.65;0.82),(0.05;0.35)]
C1.5	[(0.31;0.79),(1.38;1.64),(-0.81;-0.28)]	[(-0.79;-0.31),(1.38;1.64),(0.28;0.81)]
C1.6	[(0.1;0.41),(0.53;0.68),(-0.38;-0.08)]	[(-0.41;-0.1),(0.53;0.68),(0.08;0.38)]
C2.1	[(-0.19;0.16),(0.78;0.94),(-0.18;0.14)]	[(0.01;0.19),(0.78;0.94),(-0.14;0.18)]
C2.2	[(-0.24;0.09),(0.81;0.98),(-0.11;0.21)]	[(0.08;0.24),(0.81;0.98),(-0.21;0.11)]
C2.3	[(-0.21;0.12),(0.78;0.94),(-0.14;0.17)]	[(0.04;0.21),(0.78;0.94),(-0.17;0.14)]
C2.4	[(-0.21;0.03),(0.36;0.48),(-0.05;0.16)]	[(0.08;0.21),(0.36;0.48),(-0.16;0.05)]
C2.5	[(-0.13;0),(0.58;0.68),(-0.06;0.1)]	[(0.06;0.13),(0.58;0.68),(-0.1;0.06)]
C2.6	[(-0.12;0.02),(0.55;0.65),(-0.08;0.08)]	[(0.04;0.12),(0.55;0.65),(-0.08;0.08)]
C2.7	[(-0.12;0.16),(0.65;0.82),(-0.18;0.12)]	[(-0.01;0.12),(0.65;0.82),(-0.12;0.18)]
C3.1	[(-0.01;0.31),(0.81;0.98),(-0.29;0.03)]	[(-0.31;0.01),(0.81;0.98),(-0.03;0.29)]
C3.2	[(0.13;0.37),(0.36;0.51),(-0.33;-0.11)]	[(-0.37;-0.13),(0.36;0.51),(0.11;0.33)]
C3.3	[(0.12;0.32),(0.28;0.39),(-0.26;-0.08)]	[(-0.32;-0.12),(0.28;0.39),(0.08;0.26)]
C3.4	[(0.17;0.49),(0.57;0.72),(-0.48;-0.18)]	[(-0.49;-0.17),(0.57;0.72),(0.18;0.48)]
C3.5	[(0.09;0.33),(0.35;0.49),(-0.3;-0.08)]	[(-0.33;-0.09),(0.35;0.49),(0.08;0.3)]
C3.6	[(0.21;0.38),(0.23;0.34),(-0.31;-0.14)]	[(-0.38;-0.21),(0.23;0.34),(0.14;0.31)]
C3.7	[(0.02;0.33),(0.65;0.82),(-0.3;0)]	[(-0.33;-0.02),(0.65;0.82),(0;0.3)]
C3.8	[(0.27;0.63),(0.54;0.71),(-0.59;-0.26)]	[(-0.63;-0.27),(0.54;0.71),(0.26;0.59)]
C3.9	[(0.1;0.33),(0.38;0.53),(-0.31;-0.08)]	[(-0.33;-0.1),(0.38;0.53),(0.08;0.31)]
C4.1	[(0.05;0.41),(0.77;0.95),(-0.38;-0.04)]	[(-0.41;-0.05),(0.77;0.95),(0.04;0.38)]
C4.2	[(0.05;0.41),(0.77;0.95),(-0.38;-0.04)]	[(-0.41;-0.05),(0.77;0.95),(0.04;0.38)]
C5.1	[(-0.35;0.14),(1.32;1.54),(-0.11;0.4)]	[(-0.14;0.35),(1.32;1.54),(-0.4;0.11)]
C5.2	[(0.26;0.55),(0.48;0.63),(-0.54;-0.24)]	[(-0.55;-0.26),(0.48;0.63),(0.24;0.54)]
C5.3	[(-0.05;0.29),(0.92;1.09),(-0.26;0.07)]	[(-0.29;0.05),(0.92;1.09),(-0.07;0.26)]

Step 6: Weighted sum of negative and positive distance calculation

In this step, Weighted sum of negative and positive distance calculation has been done in this step. Eq. 21 and 22 are used for this calculations. Criterion weights are stated in Table 6.5. We need to multiply the values in Table 6.5 with PDA and NDA matrix which is calculated in step 5 so to reach weighted sums which is stated in Table 6.17 as an example for Abu Dhabi. The weighted PDA and NDA values of other alternatives are stated in Appendix B. After this calculation sp_n and np_n values are found and stated in Table 6.28.

Table 6.17: Weighted sum of positive and negative distances for Abu Dhabi

	Abu Dhabi	Abu Dhabi
Criterion	sp_n	np_n
C1.1	[(0.03;0.28),(0.85;0.95),(0.08;0.4)]	[(-0.24;-0.04),(0.85;0.95),(0.34;0.62)]
C1.2	[(0.1;0.5),(0.69;0.88),(0.01;0.17)]	[(-0.56;-0.12),(0.69;0.88),(0.14;0.42)]
C1.3	[(0.15;0.65),(0.53;0.78),(0;0.07)]	[(-0.95;-0.2),(0.53;0.78),(0.06;0.28)]
C1.4	[(0.19;0.74),(0.43;0.72),(0;0.03)]	[(-1.4;-0.26),(0.43;0.72),(0.02;0.18)]
C1.5	[(0.27;0.84),(0.52;0.91),(0;0.02)]	[(-2.07;-0.44),(0.52;0.91),(0.02;0.17)]
C1.6	[(0.32;0.88),(0.37;0.77),(0;0.01)]	[(-2.78;-0.54),(0.37;0.77),(0.01;0.12)]
C2.1	[(0.23;0.9),(0.33;0.75),(0;0)]	[(-2.75;-0.3),(0.33;0.75),(0;0.06)]
C2.2	[(0.09;0.9),(0.3;0.75),(0;0)]	[(-2.55;-0.04),(0.3;0.75),(0;0.03)]
C2.3	[(-0.04;0.91),(0.27;0.73),(0;0)]	[(-2.45;0.14),(0.27;0.73),(0;0.01)]
C2.4	[(-0.18;0.92),(0.15;0.52),(0;0)]	[(-2.27;0.27),(0.15;0.52),(0;0.01)]
C2.5	[(-0.26;0.92),(0.09;0.39),(0;0)]	[(-2.16;0.33),(0.09;0.39),(0;0)]
C2.6	[(-0.34;0.92),(0.06;0.29),(0;0)]	[(-2.1;0.38),(0.06;0.29),(0;0)]
C2.7	[(-0.45;0.93),(0.05;0.27),(0;0)]	[(-2.12;0.43),(0.05;0.27),(0;0)]
C3.1	[(-0.46;0.95),(0.04;0.26),(0;0)]	[(-2.82;0.44),(0.04;0.26),(0;0)]
C3.2	[(-0.34;0.96),(0.02;0.19),(0;0)]	[(-3.67;0.38),(0.02;0.19),(0;0)]
C3.3	[(-0.25;0.97),(0.01;0.11),(0;0)]	[(-4.49;0.34),(0.01;0.11),(0;0)]
C3.4	[(-0.13;0.98),(0.01;0.1),(0;0)]	[(-6.03;0.26),(0.01;0.1),(0;0)]
C3.5	[(-0.06;0.98),(0;0.07),(0;0)]	[(-7.46;0.21),(0;0.07),(0;0)]
C3.6	[(0.05;0.99),(0;0.03),(0;0)]	[(-9.16;0.11),(0;0.03),(0;0)]
C3.7	[(0.06;0.99),(0;0.03),(0;0)]	[(-11.29;0.1),(0;0.03),(0;0)]
C3.8	[(0.18;0.99),(0;0.03),(0;0)]	[(-14.84;-0.04),(0;0.03),(0;0)]
C3.9	[(0.23;1),(0;0.02),(0;0)]	[(-18.23;-0.12),(0;0.02),(0;0)]
C4.1	[(0.26;1),(0;0.02),(0;0)]	[(-23;-0.16),(0;0.02),(0;0)]
C4.2	[(0.28;1),(0;0.02),(0;0)]	[(-28.94;-0.2),(0;0.02),(0;0)]
C5.1	[(0.06;1),(0;0.02),(0;0)]	[(-32.48;0.23),(0;0.02),(0;0)]
C5.2	[(0.18;1),(0;0.02),(0;0)]	[(-42.12;0.1),(0;0.02),(0;0)]
C5.3	[(0.15;1),(0;0.02),(0;0)]	[(-51.3;0.14),(0;0.02),(0;0)]

Table 6.28: sp_n and np_n values of all alternatives

		sp_n	np_n
Abu Dhabi	ALT 1:	$[(0.15;1),(0;0.02),(0;0)]$	$[(-51.3;0.14),(0;0.02),(0;0)]$
Dubai	ALT 2:	$[(0.21;1),(0;0.02),(0;0)]$	$[(-53.05;0.05),(0;0.02),(0;0)]$
Al Ayn	ALT 3:	$[(-3.6;0.99),(0;0.07),(0;0)]$	$[(-2.53;1.01),(0;0.07),(0;0)]$
Doha	ALT 4:	$[(-1.53;0.99),(0;0.02),(0;0)]$	$[(-15.12;0.87),(0;0.02),(0;0)]$
Manama	ALT 5:	$[(-9.1;0.94),(0;0.08),(0;0)]$	$[(-3;0.98),(0;0.08),(0;0)]$
Riyadh	ALT 6:	$[(-0.07;1),(0;0.02),(0;0)]$	$[(-39.9;0.33),(0;0.02),(0;0)]$
Medina	ALT 7:	$[(-3.8;0.98),(0;0.04),(0;0)]$	$[(-6.89;0.92),(0;0.04),(0;0)]$
Jeddah	ALT 8:	$[(-4.35;0.98),(0;0.03),(0;0)]$	$[(-7.62;0.94),(0;0.03),(0;0)]$
Mecca	ALT 9:	$[(-6.08;0.97),(0;0.08),(0;0)]$	$[(-3.54;0.97),(0;0.08),(0;0)]$
Kuwait City	ALT 10:	$[(-5.89;0.97),(0;0.06),(0;0)]$	$[(-4.95;0.96),(0;0.06),(0;0)]$
Masqat	ALT 11:	$[(-3.69;0.99),(0;0.06),(0;0)]$	$[(-3.66;0.98),(0;0.06),(0;0)]$

Step 7: Normalization of the np_n and sp_n values.

In this step, normalized values of np_n and sp_n are calculated for all alternatives by using equations 23 and 24. The values are stated in Table 6.29.

Table 6.29: Normalized nsp_n and nsn_n values

Alternative	Code	nsp_n	nsn_n
Abu Dhabi	AL1	$[(0.19;1.25),(0;0.02),(0;0)]$	$[(450.71;-0.25),(1;0.84),(1;1)]$
Dubai	AL2	$[(0.27;1.25),(0;0.02),(0;0)]$	$[(466.05;0.56),(1;0.86),(1;1)]$
Al Ayn	AL3	$[(-4.52;1.24),(0;0.09),(0;0)]$	$[(23.2;-7.83),(0.98;0.35),(1;1)]$
Doha	AL4	$[(-1.92;1.25),(0;0.03),(0;0)]$	$[(133.58;-6.58),(1;0.79),(1;1)]$
Manama	AL5	$[(-11.43;1.19),(0;0.1),(0;0)]$	$[(27.27;-7.57),(0.97;0.33),(1;1)]$
Riyadh	AL6	$[(-0.08;1.25),(0;0.03),(0;0)]$	$[(350.8;-1.93),(1;0.8),(1;1)]$
Medina	AL7	$[(-4.77;1.24),(0;0.05),(0;0)]$	$[(61.36;-7.1),(0.99;0.64),(1;1)]$
Jeddah	AL8	$[(-5.46;1.23),(0;0.04),(0;0)]$	$[(67.76;-7.25),(0.99;0.7),(1;1)]$
Mecca	AL9	$[(-7.63;1.22),(0;0.1),(0;0)]$	$[(31.99;-7.47),(0.97;0.29),(1;1)]$
Kuwait City	AL10	$[(-7.4;1.22),(0;0.08),(0;0)]$	$[(44.43;-7.42),(0.98;0.47),(1;1)]$
Masqat	AL11	$[(-4.64;1.24),(0;0.08),(0;0)]$	$[(33.06;-7.57),(0.98;0.44),(1;1)]$

Step 8: Appraisal score calculation

In this step, appraisal scores (as_n values) of all alternatives have been calculated by using equation 25. At the end, appraisal scores (as_n) are converted to ranking scores (RS) via defuzzification technique and the results are stated in Table 6.30.

Table 6.30: Appraisal scores of each alternative

Alternative	Code	as_n	RS
Abu Dhabi	AL1	[(225.45;0.5),(0.5;0.43),(0.5;0.5)]	30.29
Dubai	AL2	[(233.16;0.91),(0.5;0.44),(0.5;0.5)]	31.14
Al Ayn	AL3	[(9.34;-3.29),(0.49;0.22),(0.5;0.5)]	1.13
Doha	AL4	[(65.83;-2.67),(0.5;0.41),(0.5;0.5)]	8.74
Manama	AL5	[(7.92;-3.19),(0.49;0.21),(0.5;0.5)]	0.93
Riyadh	AL6	[(175.36;-0.34),(0.5;0.41),(0.5;0.5)]	23.91
Medina	AL7	[(28.29;-2.93),(0.5;0.34),(0.5;0.5)]	3.82
Jeddah	AL8	[(31.15;-3.01),(0.5;0.37),(0.5;0.5)]	4.11
Mecca	AL9	[(12.18;-3.13),(0.49;0.19),(0.5;0.5)]	1.65
Kuwait City	AL10	[(18.52;-3.1),(0.49;0.27),(0.5;0.5)]	2.53
Masqat	AL11	[(14.21;-3.16),(0.49;0.26),(0.5;0.5)]	1.88

Step 9: Ranking Alternatives

In the last steps of the technique, alternatives are ranked according to decreasing score value. The biggest score means that the best alternative. As per the Table 6.31 below, Dubai is the most appropriate city for a cold chain warehouse investment.

Table 6.31: Rank of alternatives

Rank	Alternatives		RS
1	Dubai	AL2	31.14
2	Abu Dhabi	AL1	30.29
3	Riyadh	AL6	23.91
4	Doha	AL4	8.74
5	Jeddah	AL8	4.11
6	Medina	AL7	3.82
7	Kuwait City	AL10	2.53
8	Masqat	AL11	1.88
9	Mecca	AL9	1.65
10	Al Ayn	AL3	1.13
11	Manama	AL5	0.93

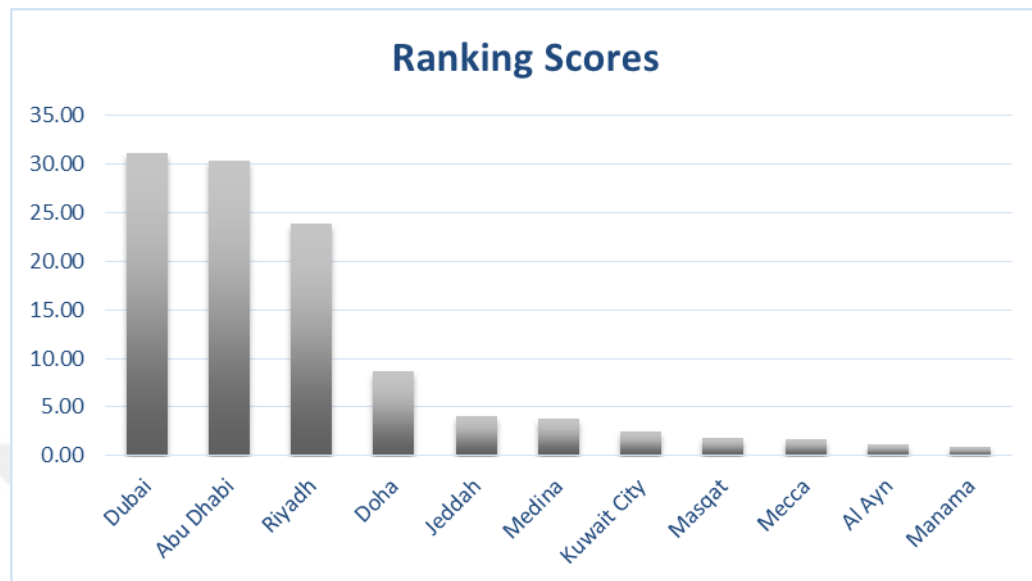


Figure 6.1: Ranking scores

As it we can see in the Figure 6.1 above, Dubai has been the most appropriate city out of 11 Arabian Guld cities. The most important factor affecting this result is that the facilities in this city are more attractive to decision makers. Abu Dhabi has same characteristic as Dubai but Riyadh has been top ranked because of its central location.

7. CONCLUSION

Logistics is one of the most essential stones of the supply chain. Because in order to supply, a product or service must be able to be taken from one place to another. It also needs to be stored and handled where it is taken. Concepts such as global supply chain and logistics management are gaining importance day by day. Because companies are in a serious competition to increase their service quality. In doing so, they focus on keeping their costs constant or reducing their costs. This forces companies to look for new ways and become more innovative. Otherwise, the companies that continue their business in traditional ways count on the spot, and many of them are sinking because the service level is low.

Information became more accessible than before, after the internet gained serious importance and became a part of people's lives. With the storage and analysis of information, companies and institutions were able to analyze their processes, measure their quality, and identify processes that were disrupted.

In the light of this information, analyzes were carried out on how to ensure an efficient cold chain just like in other sectors. Because temperature sensitive products had to be transported from regions where production is high, to regions where production is less, before their shelf life is completed. Because, with the global warming awareness, the issue of waste came back to the agenda.

After years of waste and consumption craze in the today's world, savings and sustainability are at the forefront anymore. Countries, organizations, companies, and even families are focused on what is sustainable and stays fresh up to the end. And this rate is expected to increase gradually.

In this study, cold chain logistics was examined. What this concept consists of, and its sine qua non, was investigated. In addition, the differences from other logistics methods were mentioned. However, the main purpose of the study is to examine the storage and warehousing part of the cold chain. Studies and analysis show that if the chain is properly protected, the products do not fill their shelf life, reaching the end consumer in a healthy and fresh way. In order to protect the cold chain, receiving, material handling, storage and shipment operations should be done under the right conditions. To achieve this, temperature-controlled storage, handling and shipping areas are needed. In addition, the transportation process should be done at the right temperature with frigo vehicles.

Providing all these conditions may be too costly for a company that manufactures or markets. At this point, third party companies that specialize in a certain area come into play. These companies are named as 3PL and 4PL in the logistics sector and they carry out the logistics activities of your company according to a specific contract. If a company failed to manage their logistics processes well, It decide to outsource this process to any third party logistics supplier which are specialized in this field. That's why, the warehouse location selection of logistics service providers is a crucial decision problem. Because this kind of investment decisions are really costly and hard to repair. Also this decisions are one of the most important strategic decisions for companies.

In this study, the selection of cold chain warehouse location for third party logistics suppliers was discussed. First of all, the concepts which is familiar with cold chain and 3PL were reviewed. In the literature review part, the subjects such as supply chain, warehouse location selection, cold chain logistics, 3PL and supply chain management was investigated.

In an environment where the concept of choice exists, there has to be a decision making process. It has been determined that there are many decision making methods after the result of scientific studies carried out for years. In this study, Interval Valued Neutrosophic EDAS multi-criteria decision making technique was used. If we want to decide something, we should have alternatives, and alternatives of this study consist of cities that are ports and commercial centers in Arabian Gulf countries. The reason for choosing this region is that its climate is hot all the year round so the region needs efficient

cold chain management. Also this region has high consumption and most of the goods are imported from another countries since it is hard to produce because of climate conditions.

In the experimental analysis part, alternative cities are evaluated according to Interval Valued Neutrosophic EDAS rules and it's seen that this method is usable in solving that kinds of selection problems. Business Development, Operational Excellence and Contract Logistics departments of the one of leading logistics company in Turkey is asked for criteria evaluation. According to evaluations of these decision makers, Interval Valued Neutrosophic EDAS calculations have been done. We used IVN EDAS method in this study because wanted to take into account the aspect of falsity, indeterminacy and trueness of decision makers.

As a result of this calculations Dubai, Abu Dhabi and Riyadh has been the top three ranked cities. The cities which we consider strong at the early stages of the study come first. Because it's obvious that criteria selection is the most important key for this project. And these three cities are better than the other cities in terms of overall criteria. Doha was another important alternative but the score came lower due to political disputes in the region. Because the decision makers expected to provide service to maximum country in the gulf region.

Considering all this; Dubai, Abu Dhabi and Riyadh are the cities with the highest trade in the region. They are close to potential customers and potential markets. When we want to compare this three cities with the other ones, their geographical positions, political situations, or warehouse facilities are better. So, an investment is appropriate in this cities.

As for future studies related to this study, followings can be done and results can be applied to any company.

- Different department can be used and their effects can be analysed.
- Different weights can be used for departments and effects can be analysed.
- Sensitivity analysis can be done.
- Different MCDM method can be used.
- Same study can be done for different region, for example South Africa.

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APPENDICES

Appendix A.

Table A.1: PDA and NDA values for Dubai

	Dubai	Dubai
Criterion	PDA	NDA
C1.1	[(0.05;0.36),(0.7;0.87),(-0.34;-0.04)]	[(-0.36;-0.05),(0.7;0.87),(0.04;0.34)]
C1.2	[(0.11;0.41),(0.65;0.82),(-0.39;-0.09)]	[(-0.41;-0.11),(0.65;0.82),(0.09;0.39)]
C1.3	[(0.09;0.39),(0.6;0.75),(-0.38;-0.08)]	[(-0.39;-0.09),(0.6;0.75),(0.08;0.38)]
C1.4	[(0.06;0.37),(0.65;0.82),(-0.35;-0.05)]	[(-0.37;-0.06),(0.65;0.82),(0.05;0.35)]
C1.5	[(0.31;0.79),(1.38;1.64),(-0.81;-0.28)]	[(-0.79;-0.31),(1.38;1.64),(0.28;0.81)]
C1.6	[(0.1;0.41),(0.53;0.68),(-0.38;-0.08)]	[(-0.41;-0.1),(0.53;0.68),(0.08;0.38)]
C2.1	[(-0.19;0.16),(0.78;0.94),(-0.18;0.14)]	[(0.01;0.19),(0.78;0.94),(-0.14;0.18)]
C2.2	[(-0.24;0.09),(0.81;0.98),(-0.11;0.21)]	[(0.08;0.24),(0.81;0.98),(-0.21;0.11)]
C2.3	[(-0.21;0.12),(0.78;0.94),(-0.14;0.17)]	[(0.04;0.21),(0.78;0.94),(-0.17;0.14)]
C2.4	[(-0.21;0.03),(0.36;0.48),(-0.05;0.16)]	[(0.08;0.21),(0.36;0.48),(-0.16;0.05)]
C2.5	[(-0.13;0),(0.58;0.68),(-0.06;0.1)]	[(0.06;0.13),(0.58;0.68),(-0.1;0.06)]
C2.6	[(-0.22;-0.07),(0.44;0.54),(0.01;0.17)]	[(0.13;0.22),(0.44;0.54),(-0.17;-0.01)]
C2.7	[(-0.12;0.16),(0.65;0.82),(-0.18;0.12)]	[(-0.01;0.12),(0.65;0.82),(-0.12;0.18)]
C3.1	[(-0.01;0.31),(0.81;0.98),(-0.29;0.03)]	[(-0.31;0.01),(0.81;0.98),(-0.03;0.29)]
C3.2	[(0.13;0.37),(0.36;0.51),(-0.33;-0.11)]	[(-0.37;-0.13),(0.36;0.51),(0.11;0.33)]
C3.3	[(0.12;0.32),(0.28;0.39),(-0.26;-0.08)]	[(-0.32;-0.12),(0.28;0.39),(0.08;0.26)]
C3.4	[(0.17;0.49),(0.57;0.72),(-0.48;-0.18)]	[(-0.49;-0.17),(0.57;0.72),(0.18;0.48)]
C3.5	[(0.09;0.33),(0.35;0.49),(-0.3;-0.08)]	[(-0.33;-0.09),(0.35;0.49),(0.08;0.3)]
C3.6	[(0.21;0.38),(0.23;0.34),(-0.31;-0.14)]	[(-0.38;-0.21),(0.23;0.34),(0.14;0.31)]
C3.7	[(0.02;0.33),(0.65;0.82),(-0.3;0)]	[(-0.33;-0.02),(0.65;0.82),(0;0.3)]
C3.8	[(0.41;0.75),(0.54;0.71),(-0.74;-0.41)]	[(-0.75;-0.41),(0.54;0.71),(0.41;0.74)]
C3.9	[(0.1;0.33),(0.38;0.53),(-0.31;-0.08)]	[(-0.33;-0.1),(0.38;0.53),(0.08;0.31)]
C4.1	[(0.05;0.41),(0.77;0.95),(-0.38;-0.04)]	[(-0.41;-0.05),(0.77;0.95),(0.04;0.38)]
C4.2	[(0.05;0.41),(0.77;0.95),(-0.38;-0.04)]	[(-0.41;-0.05),(0.77;0.95),(0.04;0.38)]
C5.1	[(-0.29;0.19),(1.32;1.54),(-0.17;0.33)]	[(-0.19;0.29),(1.32;1.54),(-0.33;0.17)]
C5.2	[(0.26;0.55),(0.48;0.63),(-0.54;-0.24)]	[(-0.55;-0.26),(0.48;0.63),(0.24;0.54)]
C5.3	[(-0.05;0.29),(0.92;1.09),(-0.26;0.07)]	[(-0.29;0.05),(0.92;1.09),(-0.07;0.26)]

Table A.2: PDA and NDA values for Al Ayn

	Al Ayn	Al Ayn
Criterion	PDA	NDA
C1.1	$[(-0.42;-0.12),(0.78;0.93),(0.13;0.44)]$	$[(0.12;0.42),(0.78;0.93),(-0.44;-0.13)]$
C1.2	$[(-0.32;-0.05),(0.81;0.95),(0.04;0.33)]$	$[(0.05;0.32),(0.81;0.95),(-0.33;-0.04)]$
C1.3	$[(-0.31;-0.05),(0.78;0.91),(0.03;0.32)]$	$[(0.05;0.31),(0.78;0.91),(-0.32;-0.03)]$
C1.4	$[(-0.22;0.03),(0.82;0.96),(-0.06;0.24)]$	$[(-0.03;0.22),(0.82;0.96),(-0.24;0.06)]$
C1.5	$[(0.31;0.79),(1.38;1.64),(-0.81;-0.28)]$	$[(-0.79;-0.31),(1.38;1.64),(0.28;0.81)]$
C1.6	$[(-0.13;0.13),(0.75;0.89),(-0.15;0.14)]$	$[(-0.13;0.13),(0.75;0.89),(-0.14;0.15)]$
C2.1	$[(0.56;0.88),(0.78;0.94),(-0.89;-0.58)]$	$[(-0.71;-0.56),(0.78;0.94),(0.58;0.89)]$
C2.2	$[(0.35;0.64),(0.81;0.98),(-0.66;-0.34)]$	$[(-0.47;-0.35),(0.81;0.98),(0.34;0.66)]$
C2.3	$[(0.41;0.73),(0.78;0.94),(-0.74;-0.43)]$	$[(-0.56;-0.41),(0.78;0.94),(0.43;0.74)]$
C2.4	$[(0.08;0.29),(0.55;0.65),(-0.31;-0.1)]$	$[(-0.18;-0.08),(0.55;0.65),(0.1;0.31)]$
C2.5	$[(-0.21;-0.04),(0.43;0.54),(-0.02;0.14)]$	$[(0.1;0.21),(0.43;0.54),(-0.14;0.02)]$
C2.6	$[(-0.2;-0.04),(0.46;0.56),(-0.02;0.14)]$	$[(0.1;0.2),(0.46;0.56),(-0.14;0.02)]$
C2.7	$[(-0.01;0.26),(0.78;0.92),(-0.27;0.02)]$	$[(-0.1;0.01),(0.78;0.92),(-0.02;0.27)]$
C3.1	$[(-0.46;-0.17),(0.86;1.01),(0.16;0.48)]$	$[(0.17;0.46),(0.86;1.01),(-0.48;-0.16)]$
C3.2	$[(-0.13;0.08),(0.63;0.75),(-0.07;0.16)]$	$[(-0.08;0.13),(0.63;0.75),(-0.16;0.07)]$
C3.3	$[(0.01;0.2),(0.42;0.52),(-0.15;0.03)]$	$[(-0.2;-0.01),(0.42;0.52),(-0.03;0.15)]$
C3.4	$[(-0.25;0.04),(0.8;0.94),(-0.06;0.24)]$	$[(-0.04;0.25),(0.8;0.94),(-0.24;0.06)]$
C3.5	$[(0.09;0.33),(0.35;0.49),(-0.3;-0.08)]$	$[(-0.33;-0.09),(0.35;0.49),(0.08;0.3)]$
C3.6	$[(0;0.15),(0.55;0.65),(-0.1;0.06)]$	$[(-0.15;0),(0.55;0.65),(-0.06;0.1)]$
C3.7	$[(-0.13;0.18),(0.65;0.82),(-0.15;0.14)]$	$[(-0.18;0.13),(0.65;0.82),(-0.14;0.15)]$
C3.8	$[(-0.47;-0.13),(0.54;0.71),(0.14;0.47)]$	$[(0.13;0.47),(0.54;0.71),(-0.47;-0.14)]$
C3.9	$[(-0.27;-0.06),(0.64;0.75),(0.07;0.29)]$	$[(0.06;0.27),(0.64;0.75),(-0.29;-0.07)]$
C4.1	$[(0.05;0.41),(0.77;0.95),(-0.38;-0.04)]$	$[(-0.41;-0.05),(0.77;0.95),(0.04;0.38)]$
C4.2	$[(0.05;0.41),(0.77;0.95),(-0.38;-0.04)]$	$[(-0.41;-0.05),(0.77;0.95),(0.04;0.38)]$
C5.1	$[(-1.06;-0.62),(1.32;1.54),(0.6;1.1)]$	$[(0.62;1.06),(1.32;1.54),(-1.1;-0.6)]$
C5.2	$[(-0.16;0.11),(0.8;0.93),(-0.13;0.18)]$	$[(-0.11;0.16),(0.8;0.93),(-0.18;0.13)]$
C5.3	$[(-0.42;-0.12),(0.92;1.09),(0.11;0.44)]$	$[(0.12;0.42),(0.92;1.09),(-0.44;-0.11)]$

Table A.3: PDA and NDA values for Doha

	Doha	Doha
Criterion	PDA	NDA
C1.1	$[(-0.04;0.29),(0.7;0.87),(-0.25;0.05)]$	$[(-0.29;0.04),(0.7;0.87),(-0.05;0.25)]$
C1.2	$[(0.02;0.33),(0.65;0.82),(-0.3;0)]$	$[(-0.33;-0.02),(0.65;0.82),(0;0.3)]$
C1.3	$[(0.09;0.39),(0.6;0.75),(-0.38;-0.08)]$	$[(-0.39;-0.09),(0.6;0.75),(0.08;0.38)]$
C1.4	$[(0.06;0.37),(0.65;0.82),(-0.35;-0.05)]$	$[(-0.37;-0.06),(0.65;0.82),(0.05;0.35)]$
C1.5	$[(0.31;0.79),(1.38;1.64),(-0.81;-0.28)]$	$[(-0.79;-0.31),(1.38;1.64),(0.28;0.81)]$
C1.6	$[(0.1;0.41),(0.53;0.68),(-0.38;-0.08)]$	$[(-0.41;-0.1),(0.53;0.68),(0.08;0.38)]$
C2.1	$[(-0.25;0.07),(0.78;0.94),(-0.09;0.22)]$	$[(0.09;0.25),(0.78;0.94),(-0.22;0.09)]$
C2.2	$[(-0.24;0.09),(0.81;0.98),(-0.11;0.21)]$	$[(0.08;0.24),(0.81;0.98),(-0.21;0.11)]$
C2.3	$[(-0.21;0.12),(0.78;0.94),(-0.14;0.17)]$	$[(0.04;0.21),(0.78;0.94),(-0.17;0.14)]$
C2.4	$[(-0.21;0.03),(0.36;0.48),(-0.05;0.16)]$	$[(0.08;0.21),(0.36;0.48),(-0.16;0.05)]$
C2.5	$[(-0.13;0),(0.58;0.68),(-0.06;0.1)]$	$[(0.06;0.13),(0.58;0.68),(-0.1;0.06)]$
C2.6	$[(-0.12;0.02),(0.55;0.65),(-0.08;0.08)]$	$[(0.04;0.12),(0.55;0.65),(-0.08;0.08)]$
C2.7	$[(-0.01;0.26),(0.78;0.92),(-0.27;0.02)]$	$[(-0.1;0.01),(0.78;0.92),(-0.02;0.27)]$
C3.1	$[(-0.01;0.31),(0.81;0.98),(-0.29;0.03)]$	$[(-0.31;0.01),(0.81;0.98),(-0.03;0.29)]$
C3.2	$[(-0.13;0.08),(0.63;0.75),(-0.07;0.16)]$	$[(-0.08;0.13),(0.63;0.75),(-0.16;0.07)]$
C3.3	$[(0.18;0.37),(0.19;0.32),(-0.32;-0.14)]$	$[(-0.37;-0.18),(0.19;0.32),(0.14;0.32)]$
C3.4	$[(0.17;0.49),(0.57;0.72),(-0.48;-0.18)]$	$[(-0.49;-0.17),(0.57;0.72),(0.18;0.48)]$
C3.5	$[(-0.24;-0.03),(0.64;0.75),(0.03;0.26)]$	$[(0.03;0.24),(0.64;0.75),(-0.26;-0.03)]$
C3.6	$[(0.24;0.4),(0.18;0.29),(-0.34;-0.17)]$	$[(-0.4;-0.24),(0.18;0.29),(0.17;0.34)]$
C3.7	$[(-0.32;-0.05),(0.81;0.95),(0.04;0.33)]$	$[(0.05;0.32),(0.81;0.95),(-0.33;-0.04)]$
C3.8	$[(0.27;0.63),(0.54;0.71),(-0.59;-0.26)]$	$[(-0.63;-0.27),(0.54;0.71),(0.26;0.59)]$
C3.9	$[(0.1;0.33),(0.38;0.53),(-0.31;-0.08)]$	$[(-0.33;-0.1),(0.38;0.53),(0.08;0.31)]$
C4.1	$[(-0.12;0.23),(0.77;0.95),(-0.22;0.12)]$	$[(-0.23;0.12),(0.77;0.95),(-0.12;0.22)]$
C4.2	$[(-0.12;0.23),(0.77;0.95),(-0.22;0.12)]$	$[(-0.23;0.12),(0.77;0.95),(-0.12;0.22)]$
C5.1	$[(-0.67;-0.18),(1.32;1.54),(0.21;0.71)]$	$[(0.18;0.67),(1.32;1.54),(-0.71;-0.21)]$
C5.2	$[(0.17;0.48),(0.48;0.63),(-0.46;-0.15)]$	$[(-0.48;-0.17),(0.48;0.63),(0.15;0.46)]$
C5.3	$[(-0.15;0.2),(0.92;1.09),(-0.17;0.17)]$	$[(-0.2;0.15),(0.92;1.09),(-0.17;0.17)]$

Table A.4: PDA and NDA values for Manama

	Manama	Manama
Criterion	PDA	NDA
C1.1	$[(-0.17;0.18),(0.7;0.87),(-0.12;0.2)]$	$[(-0.18;0.17),(0.7;0.87),(-0.2;0.12)]$
C1.2	$[(-0.13;0.18),(0.65;0.82),(-0.15;0.14)]$	$[(-0.18;0.13),(0.65;0.82),(-0.14;0.15)]$
C1.3	$[(-0.13;0.17),(0.6;0.75),(-0.16;0.14)]$	$[(-0.17;0.13),(0.6;0.75),(-0.14;0.16)]$
C1.4	$[(-0.02;0.3),(0.65;0.82),(-0.27;0.04)]$	$[(-0.3;0.02),(0.65;0.82),(-0.04;0.27)]$
C1.5	$[(0.31;0.79),(1.38;1.64),(-0.81;-0.28)]$	$[(-0.79;-0.31),(1.38;1.64),(0.28;0.81)]$
C1.6	$[(-0.13;0.13),(0.75;0.89),(-0.15;0.14)]$	$[(-0.13;0.13),(0.75;0.89),(-0.14;0.15)]$
C2.1	$[(-0.02;0.28),(0.78;0.94),(-0.3;0.02)]$	$[(-0.11;0.02),(0.78;0.94),(-0.02;0.3)]$
C2.2	$[(-0.01;0.3),(0.81;0.98),(-0.32;0)]$	$[(-0.13;0.01),(0.81;0.98),(0;0.32)]$
C2.3	$[(0.07;0.34),(0.85;1),(-0.35;-0.04)]$	$[(-0.17;-0.07),(0.85;1),(0.04;0.35)]$
C2.4	$[(0.08;0.29),(0.55;0.65),(-0.31;-0.1)]$	$[(-0.18;-0.08),(0.55;0.65),(0.1;0.31)]$
C2.5	$[(-0.21;-0.04),(0.43;0.54),(-0.02;0.14)]$	$[(0.1;0.21),(0.43;0.54),(-0.14;0.02)]$
C2.6	$[(-0.2;-0.04),(0.46;0.56),(-0.02;0.14)]$	$[(0.1;0.2),(0.46;0.56),(-0.14;0.02)]$
C2.7	$[(-0.12;0.16),(0.65;0.82),(-0.18;0.12)]$	$[(-0.01;0.12),(0.65;0.82),(-0.12;0.18)]$
C3.1	$[(-0.36;-0.07),(0.82;0.98),(0.06;0.37)]$	$[(0.07;0.36),(0.82;0.98),(-0.37;-0.06)]$
C3.2	$[(-0.13;0.08),(0.63;0.75),(-0.07;0.16)]$	$[(-0.08;0.13),(0.63;0.75),(-0.16;0.07)]$
C3.3	$[(-0.05;0.11),(0.56;0.67),(-0.09;0.1)]$	$[(-0.11;0.05),(0.56;0.67),(-0.1;0.09)]$
C3.4	$[(-0.25;0.04),(0.8;0.94),(-0.06;0.24)]$	$[(-0.04;0.25),(0.8;0.94),(-0.24;0.06)]$
C3.5	$[(-0.24;-0.03),(0.64;0.75),(0.03;0.26)]$	$[(0.03;0.24),(0.64;0.75),(-0.26;-0.03)]$
C3.6	$[(0;0.15),(0.55;0.65),(-0.1;0.06)]$	$[(-0.15;0),(0.55;0.65),(-0.06;0.1)]$
C3.7	$[(-0.32;-0.05),(0.81;0.95),(0.04;0.33)]$	$[(0.05;0.32),(0.81;0.95),(-0.33;-0.04)]$
C3.8	$[(-0.36;-0.02),(0.66;0.82),(0.04;0.36)]$	$[(0.02;0.36),(0.66;0.82),(-0.36;-0.04)]$
C3.9	$[(-0.19;0.02),(0.61;0.72),(-0.01;0.21)]$	$[(-0.02;0.19),(0.61;0.72),(-0.21;0.01)]$
C4.1	$[(-0.22;0.09),(0.86;1.02),(-0.11;0.23)]$	$[(-0.09;0.22),(0.86;1.02),(-0.23;0.11)]$
C4.2	$[(-0.22;0.09),(0.86;1.02),(-0.11;0.23)]$	$[(-0.09;0.22),(0.86;1.02),(-0.23;0.11)]$
C5.1	$[(-0.67;-0.18),(1.32;1.54),(0.21;0.71)]$	$[(0.18;0.67),(1.32;1.54),(-0.71;-0.21)]$
C5.2	$[(0.17;0.48),(0.48;0.63),(-0.46;-0.15)]$	$[(-0.48;-0.17),(0.48;0.63),(0.15;0.46)]$
C5.3	$[(-0.32;0.02),(0.92;1.09),(0;0.33)]$	$[(-0.02;0.32),(0.92;1.09),(-0.33;0)]$

Table A.5: PDA and NDA values for Riyadh

	Riyadh	Riyadh
Criterion	PDA	NDA
C1.1	[(0.05;0.36),(0.7;0.87),(-0.34;-0.04)]	[(-0.36;-0.05),(0.7;0.87),(0.04;0.34)]
C1.2	[(0.11;0.41),(0.65;0.82),(-0.39;-0.09)]	[(-0.41;-0.11),(0.65;0.82),(0.09;0.39)]
C1.3	[(0.09;0.39),(0.6;0.75),(-0.38;-0.08)]	[(-0.39;-0.09),(0.6;0.75),(0.08;0.38)]
C1.4	[(0.06;0.37),(0.65;0.82),(-0.35;-0.05)]	[(-0.37;-0.06),(0.65;0.82),(0.05;0.35)]
C1.5	[(0.13;0.62),(1.45;1.7),(-0.63;-0.1)]	[(-0.62;-0.13),(1.45;1.7),(0.1;0.63)]
C1.6	[(0.1;0.41),(0.53;0.68),(-0.38;-0.08)]	[(-0.41;-0.1),(0.53;0.68),(0.08;0.38)]
C2.1	[(-0.25;0.07),(0.78;0.94),(-0.09;0.22)]	[(0.09;0.25),(0.78;0.94),(-0.22;0.09)]
C2.2	[(-0.24;0.09),(0.81;0.98),(-0.11;0.21)]	[(0.08;0.24),(0.81;0.98),(-0.21;0.11)]
C2.3	[(-0.21;0.12),(0.78;0.94),(-0.14;0.17)]	[(0.04;0.21),(0.78;0.94),(-0.17;0.14)]
C2.4	[(-0.21;0.03),(0.36;0.48),(-0.05;0.16)]	[(0.08;0.21),(0.36;0.48),(-0.16;0.05)]
C2.5	[(-0.13;0),(0.58;0.68),(-0.06;0.1)]	[(0.06;0.13),(0.58;0.68),(-0.1;0.06)]
C2.6	[(-0.12;0.02),(0.55;0.65),(-0.08;0.08)]	[(0.04;0.12),(0.55;0.65),(-0.08;0.08)]
C2.7	[(-0.12;0.16),(0.65;0.82),(-0.18;0.12)]	[(-0.01;0.12),(0.65;0.82),(-0.12;0.18)]
C3.1	[(-0.01;0.31),(0.81;0.98),(-0.29;0.03)]	[(-0.31;0.01),(0.81;0.98),(-0.03;0.29)]
C3.2	[(0.13;0.37),(0.36;0.51),(-0.33;-0.11)]	[(-0.37;-0.13),(0.36;0.51),(0.11;0.33)]
C3.3	[(0.12;0.32),(0.28;0.39),(-0.26;-0.08)]	[(-0.32;-0.12),(0.28;0.39),(0.08;0.26)]
C3.4	[(0.17;0.49),(0.57;0.72),(-0.48;-0.18)]	[(-0.49;-0.17),(0.57;0.72),(0.18;0.48)]
C3.5	[(0.09;0.33),(0.35;0.49),(-0.3;-0.08)]	[(-0.33;-0.09),(0.35;0.49),(0.08;0.3)]
C3.6	[(0.07;0.23),(0.41;0.51),(-0.17;-0.01)]	[(-0.23;-0.07),(0.41;0.51),(0.01;0.17)]
C3.7	[(0.11;0.41),(0.65;0.82),(-0.39;-0.09)]	[(-0.41;-0.11),(0.65;0.82),(0.09;0.39)]
C3.8	[(0.36;0.71),(0.54;0.71),(-0.69;-0.36)]	[(-0.71;-0.36),(0.54;0.71),(0.36;0.69)]
C3.9	[(0.1;0.33),(0.38;0.53),(-0.31;-0.08)]	[(-0.33;-0.1),(0.38;0.53),(0.08;0.31)]
C4.1	[(-0.12;0.23),(0.77;0.95),(-0.22;0.12)]	[(-0.23;0.12),(0.77;0.95),(-0.12;0.22)]
C4.2	[(-0.12;0.23),(0.77;0.95),(-0.22;0.12)]	[(-0.23;0.12),(0.77;0.95),(-0.12;0.22)]
C5.1	[(-0.29;0.19),(1.32;1.54),(-0.17;0.33)]	[(-0.19;0.29),(1.32;1.54),(-0.33;0.17)]
C5.2	[(0.26;0.55),(0.48;0.63),(-0.54;-0.24)]	[(-0.55;-0.26),(0.48;0.63),(0.24;0.54)]
C5.3	[(-0.05;0.29),(0.92;1.09),(-0.26;0.07)]	[(-0.29;0.05),(0.92;1.09),(-0.07;0.26)]

Table A.6: PDA and NDA values for Medina

	Medina	Medina
Criterion	PDA	NDA
C1.1	$[(-0.42;-0.12),(0.78;0.93),(0.13;0.44)]$	$[(0.12;0.42),(0.78;0.93),(-0.44;-0.13)]$
C1.2	$[(-0.37;-0.12),(0.79;0.93),(0.09;0.38)]$	$[(0.12;0.37),(0.79;0.93),(-0.38;-0.09)]$
C1.3	$[(-0.31;-0.05),(0.78;0.91),(0.03;0.32)]$	$[(0.05;0.31),(0.78;0.91),(-0.32;-0.03)]$
C1.4	$[(-0.22;0.03),(0.82;0.96),(-0.06;0.24)]$	$[(-0.03;0.22),(0.82;0.96),(-0.24;0.06)]$
C1.5	$[(0.31;0.79),(1.38;1.64),(-0.81;-0.28)]$	$[(-0.79;-0.31),(1.38;1.64),(0.28;0.81)]$
C1.6	$[(-0.32;-0.05),(0.72;0.86),(0.03;0.33)]$	$[(0.05;0.32),(0.72;0.86),(-0.33;-0.03)]$
C2.1	$[(0.21;0.52),(0.78;0.94),(-0.54;-0.23)]$	$[(-0.36;-0.21),(0.78;0.94),(0.23;0.54)]$
C2.2	$[(-0.01;0.3),(0.81;0.98),(-0.32;0)]$	$[(-0.13;0.01),(0.81;0.98),(0;0.32)]$
C2.3	$[(-0.04;0.28),(0.78;0.94),(-0.3;0.02)]$	$[(-0.11;0.04),(0.78;0.94),(-0.02;0.3)]$
C2.4	$[(-0.09;0.12),(0.48;0.6),(-0.14;0.07)]$	$[(-0.01;0.09),(0.48;0.6),(-0.07;0.14)]$
C2.5	$[(-0.21;-0.04),(0.43;0.54),(-0.02;0.14)]$	$[(0.1;0.21),(0.43;0.54),(-0.14;0.02)]$
C2.6	$[(-0.12;0.02),(0.55;0.65),(-0.08;0.08)]$	$[(0.04;0.12),(0.55;0.65),(-0.08;0.08)]$
C2.7	$[(-0.01;0.26),(0.78;0.92),(-0.27;0.02)]$	$[(-0.1;0.01),(0.78;0.92),(-0.02;0.27)]$
C3.1	$[(-0.36;-0.07),(0.82;0.98),(0.06;0.37)]$	$[(0.07;0.36),(0.82;0.98),(-0.37;-0.06)]$
C3.2	$[(0.13;0.37),(0.36;0.51),(-0.33;-0.11)]$	$[(-0.37;-0.13),(0.36;0.51),(0.11;0.33)]$
C3.3	$[(-0.05;0.11),(0.56;0.67),(-0.09;0.1)]$	$[(-0.11;0.05),(0.56;0.67),(-0.1;0.09)]$
C3.4	$[(-0.25;0.04),(0.8;0.94),(-0.06;0.24)]$	$[(-0.04;0.25),(0.8;0.94),(-0.24;0.06)]$
C3.5	$[(0.02;0.27),(0.35;0.49),(-0.23;-0.01)]$	$[(-0.27;-0.02),(0.35;0.49),(0.01;0.23)]$
C3.6	$[(0.17;0.35),(0.27;0.38),(-0.27;-0.11)]$	$[(-0.35;-0.17),(0.27;0.38),(0.11;0.27)]$
C3.7	$[(0.02;0.33),(0.65;0.82),(-0.3;0)]$	$[(-0.33;-0.02),(0.65;0.82),(0;0.3)]$
C3.8	$[(0.11;0.45),(0.63;0.79),(-0.43;-0.1)]$	$[(-0.45;-0.11),(0.63;0.79),(0.1;0.43)]$
C3.9	$[(-0.46;-0.23),(0.48;0.59),(0.25;0.47)]$	$[(0.23;0.46),(0.48;0.59),(-0.47;-0.25)]$
C4.1	$[(-0.12;0.23),(0.77;0.95),(-0.22;0.12)]$	$[(-0.23;0.12),(0.77;0.95),(-0.12;0.22)]$
C4.2	$[(-0.12;0.23),(0.77;0.95),(-0.22;0.12)]$	$[(-0.23;0.12),(0.77;0.95),(-0.12;0.22)]$
C5.1	$[(-0.29;0.19),(1.32;1.54),(-0.17;0.33)]$	$[(-0.19;0.29),(1.32;1.54),(-0.33;0.17)]$
C5.2	$[(0.26;0.55),(0.48;0.63),(-0.54;-0.24)]$	$[(-0.55;-0.26),(0.48;0.63),(0.24;0.54)]$
C5.3	$[(-0.05;0.29),(0.92;1.09),(-0.26;0.07)]$	$[(-0.29;0.05),(0.92;1.09),(-0.07;0.26)]$

Table A.7: PDA and NDA values for Jeddah

	Jeddah	Jeddah
Criterion	PDA	NDA
C1.1	$[(-0.28;-0.02),(0.83;0.97),(-0.01;0.29)]$	$[(0.02;0.28),(0.83;0.97),(-0.29;0.01)]$
C1.2	$[(-0.13;0.18),(0.65;0.82),(-0.15;0.14)]$	$[(-0.18;0.13),(0.65;0.82),(-0.14;0.15)]$
C1.3	$[(0.09;0.39),(0.6;0.75),(-0.38;-0.08)]$	$[(-0.39;-0.09),(0.6;0.75),(0.08;0.38)]$
C1.4	$[(0.06;0.37),(0.65;0.82),(-0.35;-0.05)]$	$[(-0.37;-0.06),(0.65;0.82),(0.05;0.35)]$
C1.5	$[(0.31;0.79),(1.38;1.64),(-0.81;-0.28)]$	$[(-0.79;-0.31),(1.38;1.64),(0.28;0.81)]$
C1.6	$[(-0.13;0.13),(0.75;0.89),(-0.15;0.14)]$	$[(-0.13;0.13),(0.75;0.89),(-0.14;0.15)]$
C2.1	$[(-0.19;0.16),(0.78;0.94),(-0.18;0.14)]$	$[(0.01;0.19),(0.78;0.94),(-0.14;0.18)]$
C2.2	$[(-0.18;0.17),(0.81;0.98),(-0.2;0.13)]$	$[(-0.01;0.18),(0.81;0.98),(-0.13;0.2)]$
C2.3	$[(-0.04;0.28),(0.78;0.94),(-0.3;0.02)]$	$[(-0.11;0.04),(0.78;0.94),(-0.02;0.3)]$
C2.4	$[(-0.09;0.12),(0.48;0.6),(-0.14;0.07)]$	$[(-0.01;0.09),(0.48;0.6),(-0.07;0.14)]$
C2.5	$[(-0.21;-0.04),(0.43;0.54),(-0.02;0.14)]$	$[(0.1;0.21),(0.43;0.54),(-0.14;0.02)]$
C2.6	$[(-0.2;-0.04),(0.46;0.56),(-0.02;0.14)]$	$[(0.1;0.2),(0.46;0.56),(-0.14;0.02)]$
C2.7	$[(-0.12;0.16),(0.65;0.82),(-0.18;0.12)]$	$[(-0.01;0.12),(0.65;0.82),(-0.12;0.18)]$
C3.1	$[(-0.36;-0.07),(0.82;0.98),(0.06;0.37)]$	$[(0.07;0.36),(0.82;0.98),(-0.37;-0.06)]$
C3.2	$[(0.06;0.31),(0.36;0.51),(-0.26;-0.03)]$	$[(-0.31;-0.06),(0.36;0.51),(0.03;0.26)]$
C3.3	$[(-0.05;0.11),(0.56;0.67),(-0.09;0.1)]$	$[(-0.11;0.05),(0.56;0.67),(-0.1;0.09)]$
C3.4	$[(-0.06;0.26),(0.57;0.72),(-0.25;0.06)]$	$[(-0.26;0.06),(0.57;0.72),(-0.06;0.25)]$
C3.5	$[(-0.09;0.14),(0.45;0.56),(-0.12;0.11)]$	$[(-0.14;0.09),(0.45;0.56),(-0.11;0.12)]$
C3.6	$[(0.07;0.23),(0.41;0.51),(-0.17;-0.01)]$	$[(-0.23;-0.07),(0.41;0.51),(0.01;0.17)]$
C3.7	$[(-0.13;0.18),(0.65;0.82),(-0.15;0.14)]$	$[(-0.18;0.13),(0.65;0.82),(-0.14;0.15)]$
C3.8	$[(0.11;0.45),(0.63;0.79),(-0.43;-0.1)]$	$[(-0.45;-0.11),(0.63;0.79),(0.1;0.43)]$
C3.9	$[(-0.12;0.11),(0.45;0.57),(-0.09;0.14)]$	$[(-0.11;0.12),(0.45;0.57),(-0.14;0.09)]$
C4.1	$[(-0.12;0.23),(0.77;0.95),(-0.22;0.12)]$	$[(-0.23;0.12),(0.77;0.95),(-0.12;0.22)]$
C4.2	$[(-0.12;0.23),(0.77;0.95),(-0.22;0.12)]$	$[(-0.23;0.12),(0.77;0.95),(-0.12;0.22)]$
C5.1	$[(-0.67;-0.18),(1.32;1.54),(0.21;0.71)]$	$[(0.18;0.67),(1.32;1.54),(-0.71;-0.21)]$
C5.2	$[(0.17;0.48),(0.48;0.63),(-0.46;-0.15)]$	$[(-0.48;-0.17),(0.48;0.63),(0.15;0.46)]$
C5.3	$[(-0.15;0.2),(0.92;1.09),(-0.17;0.17)]$	$[(-0.2;0.15),(0.92;1.09),(-0.17;0.17)]$

Table A.8: PDA and NDA values for Mecca

	Mecca	Mecca
Criterion	PDA	NDA
C1.1	$[(-0.42;-0.12),(0.78;0.93),(0.13;0.44)]$	$[(0.12;0.42),(0.78;0.93),(-0.44;-0.13)]$
C1.2	$[(-0.37;-0.12),(0.79;0.93),(0.09;0.38)]$	$[(0.12;0.37),(0.79;0.93),(-0.38;-0.09)]$
C1.3	$[(-0.4;-0.14),(0.72;0.85),(0.12;0.41)]$	$[(0.14;0.4),(0.72;0.85),(-0.41;-0.12)]$
C1.4	$[(-0.22;0.03),(0.82;0.96),(-0.06;0.24)]$	$[(-0.03;0.22),(0.82;0.96),(-0.24;0.06)]$
C1.5	$[(0.31;0.79),(1.38;1.64),(-0.81;-0.28)]$	$[(-0.79;-0.31),(1.38;1.64),(0.28;0.81)]$
C1.6	$[(-0.23;0.04),(0.78;0.92),(-0.06;0.24)]$	$[(-0.04;0.23),(0.78;0.92),(-0.24;0.06)]$
C2.1	$[(0.41;0.73),(0.78;0.94),(-0.74;-0.43)]$	$[(-0.56;-0.41),(0.78;0.94),(0.43;0.74)]$
C2.2	$[(-0.01;0.3),(0.81;0.98),(-0.32;0)]$	$[(-0.13;0.01),(0.81;0.98),(0;0.32)]$
C2.3	$[(0.07;0.34),(0.85;1),(-0.35;-0.04)]$	$[(-0.17;-0.07),(0.85;1),(0.04;0.35)]$
C2.4	$[(-0.01;0.19),(0.58;0.69),(-0.21;0)]$	$[(-0.08;0.01),(0.58;0.69),(0;0.21)]$
C2.5	$[(-0.13;0),(0.58;0.68),(-0.06;0.1)]$	$[(0.06;0.13),(0.58;0.68),(-0.1;0.06)]$
C2.6	$[(-0.12;0.02),(0.55;0.65),(-0.08;0.08)]$	$[(0.04;0.12),(0.55;0.65),(-0.08;0.08)]$
C2.7	$[(-0.01;0.26),(0.78;0.92),(-0.27;0.02)]$	$[(-0.1;0.01),(0.78;0.92),(-0.02;0.27)]$
C3.1	$[(-0.36;-0.07),(0.82;0.98),(0.06;0.37)]$	$[(0.07;0.36),(0.82;0.98),(-0.37;-0.06)]$
C3.2	$[(0.13;0.37),(0.36;0.51),(-0.33;-0.11)]$	$[(-0.37;-0.13),(0.36;0.51),(0.11;0.33)]$
C3.3	$[(-0.13;0.04),(0.59;0.69),(-0.01;0.17)]$	$[(-0.04;0.13),(0.59;0.69),(-0.17;0.01)]$
C3.4	$[(-0.25;0.04),(0.8;0.94),(-0.06;0.24)]$	$[(-0.04;0.25),(0.8;0.94),(-0.24;0.06)]$
C3.5	$[(0.02;0.27),(0.35;0.49),(-0.23;-0.01)]$	$[(-0.27;-0.02),(0.35;0.49),(0.01;0.23)]$
C3.6	$[(-0.07;0.08),(0.58;0.68),(-0.03;0.13)]$	$[(-0.08;0.07),(0.58;0.68),(-0.13;0.03)]$
C3.7	$[(-0.13;0.18),(0.65;0.82),(-0.15;0.14)]$	$[(-0.18;0.13),(0.65;0.82),(-0.14;0.15)]$
C3.8	$[(0.11;0.45),(0.63;0.79),(-0.43;-0.1)]$	$[(-0.45;-0.11),(0.63;0.79),(0.1;0.43)]$
C3.9	$[(-0.46;-0.23),(0.48;0.59),(0.25;0.47)]$	$[(0.23;0.46),(0.48;0.59),(-0.47;-0.25)]$
C4.1	$[(-0.12;0.23),(0.77;0.95),(-0.22;0.12)]$	$[(-0.23;0.12),(0.77;0.95),(-0.12;0.22)]$
C4.2	$[(-0.12;0.23),(0.77;0.95),(-0.22;0.12)]$	$[(-0.23;0.12),(0.77;0.95),(-0.12;0.22)]$
C5.1	$[(-0.47;0.03),(1.32;1.54),(0.01;0.52)]$	$[(-0.03;0.47),(1.32;1.54),(-0.52;-0.01)]$
C5.2	$[(0.03;0.32),(0.56;0.71),(-0.32;-0.01)]$	$[(-0.32;-0.03),(0.56;0.71),(0.01;0.32)]$
C5.3	$[(-0.42;-0.12),(0.92;1.09),(0.11;0.44)]$	$[(0.12;0.42),(0.92;1.09),(-0.44;-0.11)]$

Table A.9: PDA and NDA values for Kuwait City

	Kuwait City	Kuwait City
Criterion	PDA	NDA
C1.1	$[(-0.28;-0.02),(0.83;0.97),(-0.01;0.29)]$	$[(0.02;0.28),(0.83;0.97),(-0.29;0.01)]$
C1.2	$[(-0.13;0.18),(0.65;0.82),(-0.15;0.14)]$	$[(-0.18;0.13),(0.65;0.82),(-0.14;0.15)]$
C1.3	$[(0.01;0.32),(0.6;0.75),(-0.3;0)]$	$[(-0.32;-0.01),(0.6;0.75),(0;0.3)]$
C1.4	$[(-0.02;0.3),(0.65;0.82),(-0.27;0.04)]$	$[(-0.3;0.02),(0.65;0.82),(-0.04;0.27)]$
C1.5	$[(0.31;0.79),(1.38;1.64),(-0.81;-0.28)]$	$[(-0.79;-0.31),(1.38;1.64),(0.28;0.81)]$
C1.6	$[(-0.04;0.25),(0.55;0.7),(-0.24;0.05)]$	$[(-0.25;0.04),(0.55;0.7),(-0.05;0.24)]$
C2.1	$[(-0.02;0.28),(0.78;0.94),(-0.3;0.02)]$	$[(-0.11;0.02),(0.78;0.94),(-0.02;0.3)]$
C2.2	$[(-0.01;0.3),(0.81;0.98),(-0.32;0)]$	$[(-0.13;0.01),(0.81;0.98),(0;0.32)]$
C2.3	$[(-0.04;0.28),(0.78;0.94),(-0.3;0.02)]$	$[(-0.11;0.04),(0.78;0.94),(-0.02;0.3)]$
C2.4	$[(-0.09;0.12),(0.48;0.6),(-0.14;0.07)]$	$[(-0.01;0.09),(0.48;0.6),(-0.07;0.14)]$
C2.5	$[(-0.13;0),(0.58;0.68),(-0.06;0.1)]$	$[(0.06;0.13),(0.58;0.68),(-0.1;0.06)]$
C2.6	$[(-0.12;0.02),(0.55;0.65),(-0.08;0.08)]$	$[(0.04;0.12),(0.55;0.65),(-0.08;0.08)]$
C2.7	$[(-0.12;0.16),(0.65;0.82),(-0.18;0.12)]$	$[(-0.01;0.12),(0.65;0.82),(-0.12;0.18)]$
C3.1	$[(-0.36;-0.07),(0.82;0.98),(0.06;0.37)]$	$[(0.07;0.36),(0.82;0.98),(-0.37;-0.06)]$
C3.2	$[(-0.06;0.18),(0.47;0.59),(-0.15;0.08)]$	$[(-0.18;0.06),(0.47;0.59),(-0.08;0.15)]$
C3.3	$[(-0.02;0.14),(0.53;0.63),(-0.12;0.06)]$	$[(-0.14;0.02),(0.53;0.63),(-0.06;0.12)]$
C3.4	$[(-0.15;0.14),(0.77;0.91),(-0.15;0.15)]$	$[(-0.14;0.15),(0.77;0.91),(-0.15;0.15)]$
C3.5	$[(-0.24;-0.03),(0.64;0.75),(0.03;0.26)]$	$[(0.03;0.24),(0.64;0.75),(-0.26;-0.03)]$
C3.6	$[(0.07;0.23),(0.41;0.51),(-0.17;-0.01)]$	$[(-0.23;-0.07),(0.41;0.51),(0.01;0.17)]$
C3.7	$[(-0.32;-0.05),(0.81;0.95),(0.04;0.33)]$	$[(0.05;0.32),(0.81;0.95),(-0.33;-0.04)]$
C3.8	$[(0.11;0.45),(0.63;0.79),(-0.43;-0.1)]$	$[(-0.45;-0.11),(0.63;0.79),(0.1;0.43)]$
C3.9	$[(-0.27;-0.06),(0.64;0.75),(0.07;0.29)]$	$[(0.06;0.27),(0.64;0.75),(-0.29;-0.07)]$
C4.1	$[(-0.12;0.23),(0.77;0.95),(-0.22;0.12)]$	$[(-0.23;0.12),(0.77;0.95),(-0.12;0.22)]$
C4.2	$[(-0.12;0.23),(0.77;0.95),(-0.22;0.12)]$	$[(-0.23;0.12),(0.77;0.95),(-0.12;0.22)]$
C5.1	$[(-0.67;-0.18),(1.32;1.54),(0.21;0.71)]$	$[(0.18;0.67),(1.32;1.54),(-0.71;-0.21)]$
C5.2	$[(0.17;0.48),(0.48;0.63),(-0.46;-0.15)]$	$[(-0.48;-0.17),(0.48;0.63),(0.15;0.46)]$
C5.3	$[(-0.32;0.02),(0.92;1.09),(0;0.33)]$	$[(-0.02;0.32),(0.92;1.09),(-0.33;0)]$

Table A.10: PDA and NDA values for Masqat

	Masqat	Masqat
Criterion	PDA	NDA
C1.1	$[(-0.66;-0.35),(0.7;0.87),(0.37;0.67)]$	$[(0.35;0.66),(0.7;0.87),(-0.67;-0.37)]$
C1.2	$[(-0.41;-0.14),(0.75;0.89),(0.13;0.43)]$	$[(0.14;0.41),(0.75;0.89),(-0.43;-0.13)]$
C1.3	$[(-0.4;-0.14),(0.72;0.85),(0.12;0.41)]$	$[(0.14;0.4),(0.72;0.85),(-0.41;-0.12)]$
C1.4	$[(-0.36;-0.07),(0.77;0.91),(0.08;0.38)]$	$[(0.07;0.36),(0.77;0.91),(-0.38;-0.08)]$
C1.5	$[(0.31;0.79),(1.38;1.64),(-0.81;-0.28)]$	$[(-0.79;-0.31),(1.38;1.64),(0.28;0.81)]$
C1.6	$[(-0.45;-0.16),(0.59;0.72),(0.17;0.47)]$	$[(0.16;0.45),(0.59;0.72),(-0.47;-0.17)]$
C2.1	$[(0.56;0.88),(0.78;0.94),(-0.89;-0.58)]$	$[(-0.71;-0.56),(0.78;0.94),(0.58;0.89)]$
C2.2	$[(0.35;0.64),(0.81;0.98),(-0.66;-0.34)]$	$[(-0.47;-0.35),(0.81;0.98),(0.34;0.66)]$
C2.3	$[(0.29;0.58),(0.78;0.94),(-0.59;-0.28)]$	$[(-0.41;-0.29),(0.78;0.94),(0.28;0.59)]$
C2.4	$[(0.08;0.29),(0.55;0.65),(-0.31;-0.1)]$	$[(-0.18;-0.08),(0.55;0.65),(0.1;0.31)]$
C2.5	$[(-0.21;-0.04),(0.43;0.54),(-0.02;0.14)]$	$[(0.1;0.21),(0.43;0.54),(-0.14;0.02)]$
C2.6	$[(-0.2;-0.04),(0.46;0.56),(-0.02;0.14)]$	$[(0.1;0.2),(0.46;0.56),(-0.14;0.02)]$
C2.7	$[(-0.01;0.26),(0.78;0.92),(-0.27;0.02)]$	$[(-0.1;0.01),(0.78;0.92),(-0.02;0.27)]$
C3.1	$[(-0.36;-0.07),(0.82;0.98),(0.06;0.37)]$	$[(0.07;0.36),(0.82;0.98),(-0.37;-0.06)]$
C3.2	$[(-0.06;0.18),(0.47;0.59),(-0.15;0.08)]$	$[(-0.18;0.06),(0.47;0.59),(-0.08;0.15)]$
C3.3	$[(-0.02;0.14),(0.53;0.63),(-0.12;0.06)]$	$[(-0.14;0.02),(0.53;0.63),(-0.06;0.12)]$
C3.4	$[(0.17;0.49),(0.57;0.72),(-0.48;-0.18)]$	$[(-0.49;-0.17),(0.57;0.72),(0.18;0.48)]$
C3.5	$[(-0.09;0.14),(0.45;0.56),(-0.12;0.11)]$	$[(-0.14;0.09),(0.45;0.56),(-0.11;0.12)]$
C3.6	$[(-0.07;0.08),(0.58;0.68),(-0.03;0.13)]$	$[(-0.08;0.07),(0.58;0.68),(-0.13;0.03)]$
C3.7	$[(-0.22;0.05),(0.78;0.92),(-0.06;0.24)]$	$[(-0.05;0.22),(0.78;0.92),(-0.24;0.06)]$
C3.8	$[(0;0.32),(0.85;1.01),(-0.33;0)]$	$[(-0.32;0),(0.85;1.01),(0;0.33)]$
C3.9	$[(-0.27;-0.06),(0.64;0.75),(0.07;0.29)]$	$[(0.06;0.27),(0.64;0.75),(-0.29;-0.07)]$
C4.1	$[(0.05;0.41),(0.77;0.95),(-0.38;-0.04)]$	$[(-0.41;-0.05),(0.77;0.95),(0.04;0.38)]$
C4.2	$[(0.05;0.41),(0.77;0.95),(-0.38;-0.04)]$	$[(-0.41;-0.05),(0.77;0.95),(0.04;0.38)]$
C5.1	$[(-0.67;-0.18),(1.32;1.54),(0.21;0.71)]$	$[(0.18;0.67),(1.32;1.54),(-0.71;-0.21)]$
C5.2	$[(0.03;0.32),(0.56;0.71),(-0.32;-0.01)]$	$[(-0.32;-0.03),(0.56;0.71),(0.01;0.32)]$
C5.3	$[(-0.53;-0.23),(0.92;1.09),(0.22;0.55)]$	$[(0.23;0.53),(0.92;1.09),(-0.55;-0.22)]$

Appendix B.

Table B.1: Weighted sum of positive and negative distances for Dubai

	Dubai	Dubai
Criterion	sp_n	np_n
C1.1	[(0.03;0.28),(0.85;0.95),(0.08;0.4)]	[(-0.24;-0.04),(0.85;0.95),(0.34;0.62)]
C1.2	[(0.1;0.5),(0.69;0.88),(0.01;0.17)]	[(-0.56;-0.12),(0.69;0.88),(0.14;0.42)]
C1.3	[(0.15;0.65),(0.53;0.78),(0;0.07)]	[(-0.95;-0.2),(0.53;0.78),(0.06;0.28)]
C1.4	[(0.19;0.74),(0.43;0.72),(0;0.03)]	[(-1.4;-0.26),(0.43;0.72),(0.02;0.18)]
C1.5	[(0.27;0.84),(0.52;0.91),(0;0.02)]	[(-2.07;-0.44),(0.52;0.91),(0.02;0.17)]
C1.6	[(0.32;0.88),(0.37;0.77),(0;0.01)]	[(-2.78;-0.54),(0.37;0.77),(0.01;0.12)]
C2.1	[(0.23;0.9),(0.33;0.75),(0;0)]	[(-2.75;-0.3),(0.33;0.75),(0;0.06)]
C2.2	[(0.09;0.9),(0.3;0.75),(0;0)]	[(-2.55;-0.04),(0.3;0.75),(0;0.03)]
C2.3	[(-0.04;0.91),(0.27;0.73),(0;0)]	[(-2.45;0.14),(0.27;0.73),(0;0.01)]
C2.4	[(-0.18;0.92),(0.15;0.52),(0;0)]	[(-2.27;0.27),(0.15;0.52),(0;0.01)]
C2.5	[(-0.26;0.92),(0.09;0.39),(0;0)]	[(-2.16;0.33),(0.09;0.39),(0;0)]
C2.6	[(-0.41;0.91),(0.05;0.26),(0;0)]	[(-1.95;0.41),(0.05;0.26),(0;0)]
C2.7	[(-0.52;0.92),(0.04;0.24),(0;0)]	[(-1.97;0.47),(0.04;0.24),(0;0)]
C3.1	[(-0.53;0.94),(0.04;0.23),(0;0)]	[(-2.63;0.47),(0.04;0.23),(0;0)]
C3.2	[(-0.41;0.96),(0.02;0.17),(0;0)]	[(-3.43;0.42),(0.02;0.17),(0;0)]
C3.3	[(-0.31;0.97),(0.01;0.1),(0;0)]	[(-4.22;0.38),(0.01;0.1),(0;0)]
C3.4	[(-0.18;0.98),(0.01;0.09),(0;0)]	[(-5.68;0.31),(0.01;0.09),(0;0)]
C3.5	[(-0.12;0.98),(0;0.06),(0;0)]	[(-7.04;0.26),(0;0.06),(0;0)]
C3.6	[(0.01;0.99),(0;0.03),(0;0)]	[(-8.65;0.17),(0;0.03),(0;0)]
C3.7	[(0.02;0.99),(0;0.03),(0;0)]	[(-10.69;0.16),(0;0.03),(0;0)]
C3.8	[(0.21;0.99),(0;0.02),(0;0)]	[(-14.73;-0.05),(0;0.02),(0;0)]
C3.9	[(0.26;1),(0;0.02),(0;0)]	[(-18.11;-0.13),(0;0.02),(0;0)]
C4.1	[(0.28;1),(0;0.02),(0;0)]	[(-22.84;-0.16),(0;0.02),(0;0)]
C4.2	[(0.3;1),(0;0.02),(0;0)]	[(-28.74;-0.2),(0;0.02),(0;0)]
C5.1	[(0.13;1),(0;0.02),(0;0)]	[(-33.6;0.14),(0;0.02),(0;0)]
C5.2	[(0.24;1),(0;0.02),(0;0)]	[(-43.56;0.01),(0;0.02),(0;0)]
C5.3	[(0.21;1),(0;0.02),(0;0)]	[(-53.05;0.05),(0;0.02),(0;0)]

Table B.2: Weighted sum of positive and negative distances for Al Ayn

	Al Ayn	Al Ayn
Criterion	sp_n	np_n
C1.1	$[(-0.28;-0.09),(0.89;0.97),(0.4;0.67)]$	$[(0.08;0.33),(0.89;0.97),(0.01;0.35)]$
C1.2	$[(-0.54;-0.13),(0.8;0.95),(0.15;0.43)]$	$[(0.11;0.49),(0.8;0.95),(0;0.15)]$
C1.3	$[(-0.85;-0.17),(0.7;0.92),(0.06;0.28)]$	$[(0.13;0.61),(0.7;0.92),(0;0.07)]$
C1.4	$[(-1.1;-0.14),(0.63;0.9),(0.02;0.16)]$	$[(0.11;0.67),(0.63;0.9),(0;0.03)]$
C1.5	$[(-0.88;0.27),(0.76;1.14),(0.01;0.11)]$	$[(-0.13;0.63),(0.76;1.14),(0;0.03)]$
C1.6	$[(-1.02;0.34),(0.65;1.08),(0;0.06)]$	$[(-0.22;0.66),(0.65;1.08),(0;0.02)]$
C2.1	$[(-0.22;0.81),(0.58;1.06),(0;0)]$	$[(-0.82;0.5),(0.58;1.06),(0;0.02)]$
C2.2	$[(0.09;0.91),(0.53;1.05),(0;0)]$	$[(-1.44;0.36),(0.53;1.05),(0;0.01)]$
C2.3	$[(0.35;0.96),(0.47;1.03),(0;0)]$	$[(-2.4;0.14),(0.47;1.03),(0;0.01)]$
C2.4	$[(0.38;0.97),(0.32;0.82),(0;0)]$	$[(-2.8;0.09),(0.32;0.82),(0;0.01)]$
C2.5	$[(0.32;0.97),(0.16;0.54),(0;0)]$	$[(-2.59;0.2),(0.16;0.54),(0;0)]$
C2.6	$[(0.25;0.97),(0.09;0.36),(0;0)]$	$[(-2.4;0.3),(0.09;0.36),(0;0)]$
C2.7	$[(0.24;0.98),(0.08;0.35),(0;0)]$	$[(-2.62;0.3),(0.08;0.35),(0;0)]$
C3.1	$[(-0.01;0.97),(0.07;0.35),(0;0)]$	$[(-2.19;0.57),(0.07;0.35),(0;0)]$
C3.2	$[(-0.09;0.97),(0.05;0.3),(0;0)]$	$[(-2.33;0.61),(0.05;0.3),(0;0)]$
C3.3	$[(-0.08;0.98),(0.03;0.2),(0;0)]$	$[(-2.7;0.61),(0.03;0.2),(0;0)]$
C3.4	$[(-0.24;0.98),(0.02;0.2),(0;0)]$	$[(-2.79;0.67),(0.02;0.2),(0;0)]$
C3.5	$[(-0.17;0.98),(0.01;0.14),(0;0)]$	$[(-3.57;0.65),(0.01;0.14),(0;0)]$
C3.6	$[(-0.16;0.98),(0.01;0.1),(0;0)]$	$[(-3.92;0.65),(0.01;0.1),(0;0)]$
C3.7	$[(-0.26;0.99),(0.01;0.1),(0;0)]$	$[(-4.46;0.68),(0.01;0.1),(0;0)]$
C3.8	$[(-0.53;0.99),(0;0.08),(0;0)]$	$[(-4.14;0.77),(0;0.08),(0;0)]$
C3.9	$[(-0.8;0.98),(0;0.07),(0;0)]$	$[(-3.94;0.82),(0;0.07),(0;0)]$
C4.1	$[(-0.75;0.99),(0;0.07),(0;0)]$	$[(-5.16;0.81),(0;0.07),(0;0)]$
C4.2	$[(-0.7;0.99),(0;0.07),(0;0)]$	$[(-6.68;0.8),(0;0.07),(0;0)]$
C5.1	$[(-2.24;0.99),(0;0.07),(0;0)]$	$[(-2.66;1.01),(0;0.07),(0;0)]$
C5.2	$[(-2.51;0.99),(0;0.07),(0;0)]$	$[(-2.87;1.01),(0;0.07),(0;0)]$
C5.3	$[(-3.6;0.99),(0;0.07),(0;0)]$	$[(-2.53;1.01),(0;0.07),(0;0)]$

Table B.3: Weighted sum of positive and negative distances for Doha

	Doha	Doha
Criterion	sp_n	np_n
C1.1	[(-0.02;0.22),(0.85;0.95),(0.14;0.45)]	[(-0.19;0.03),(0.85;0.95),(0.28;0.57)]
C1.2	[(-0.01;0.41),(0.69;0.88),(0.02;0.21)]	[(-0.44;0.01),(0.69;0.88),(0.1;0.36)]
C1.3	[(0.05;0.59),(0.53;0.78),(0;0.09)]	[(-0.8;-0.06),(0.53;0.78),(0.04;0.24)]
C1.4	[(0.09;0.7),(0.43;0.72),(0;0.04)]	[(-1.22;-0.11),(0.43;0.72),(0.01;0.15)]
C1.5	[(0.19;0.81),(0.52;0.91),(0;0.03)]	[(-1.83;-0.26),(0.52;0.91),(0.01;0.15)]
C1.6	[(0.23;0.86),(0.37;0.77),(0;0.01)]	[(-2.48;-0.35),(0.37;0.77),(0.01;0.1)]
C2.1	[(0.1;0.87),(0.33;0.75),(0;0.01)]	[(-2.26;-0.07),(0.33;0.75),(0;0.05)]
C2.2	[(-0.06;0.88),(0.3;0.75),(0;0)]	[(-2.08;0.14),(0.3;0.75),(0;0.02)]
C2.3	[(-0.22;0.89),(0.27;0.73),(0;0)]	[(-1.99;0.29),(0.27;0.73),(0;0.01)]
C2.4	[(-0.38;0.89),(0.15;0.52),(0;0)]	[(-1.84;0.4),(0.15;0.52),(0;0)]
C2.5	[(-0.47;0.89),(0.09;0.39),(0;0)]	[(-1.75;0.45),(0.09;0.39),(0;0)]
C2.6	[(-0.57;0.9),(0.06;0.29),(0;0)]	[(-1.69;0.49),(0.06;0.29),(0;0)]
C2.7	[(-0.58;0.92),(0.05;0.28),(0;0)]	[(-1.87;0.49),(0.05;0.28),(0;0)]
C3.1	[(-0.59;0.94),(0.05;0.28),(0;0)]	[(-2.51;0.5),(0.05;0.28),(0;0)]
C3.2	[(-0.72;0.94),(0.03;0.24),(0;0)]	[(-2.67;0.54),(0.03;0.24),(0;0)]
C3.3	[(-0.54;0.95),(0.01;0.13),(0;0)]	[(-3.43;0.49),(0.01;0.13),(0;0)]
C3.4	[(-0.39;0.97),(0.01;0.11),(0;0)]	[(-4.67;0.43),(0.01;0.11),(0;0)]
C3.5	[(-0.6;0.97),(0.01;0.09),(0;0)]	[(-4.57;0.53),(0.01;0.09),(0;0)]
C3.6	[(-0.41;0.98),(0;0.04),(0;0)]	[(-5.73;0.46),(0;0.04),(0;0)]
C3.7	[(-0.69;0.98),(0;0.04),(0;0)]	[(-5.54;0.59),(0;0.04),(0;0)]
C3.8	[(-0.48;0.98),(0;0.04),(0;0)]	[(-7.42;0.53),(0;0.04),(0;0)]
C3.9	[(-0.38;0.99),(0;0.03),(0;0)]	[(-9.23;0.49),(0;0.03),(0;0)]
C4.1	[(-0.48;0.99),(0;0.03),(0;0)]	[(-10.67;0.54),(0;0.03),(0;0)]
C4.2	[(-0.59;0.99),(0;0.03),(0;0)]	[(-12.31;0.58),(0;0.03),(0;0)]
C5.1	[(-1.5;0.99),(0;0.03),(0;0)]	[(-10.24;0.86),(0;0.03),(0;0)]
C5.2	[(-1.27;0.99),(0;0.02),(0;0)]	[(-13.03;0.85),(0;0.02),(0;0)]
C5.3	[(-1.53;0.99),(0;0.02),(0;0)]	[(-15.12;0.87),(0;0.02),(0;0)]

Table B.4: Weighted sum of positive and negative distances for Manama

	Manama	Manama
Criterion	sp_n	np_n
C1.1	[(-0.11;0.14),(0.85;0.95),(0.23;0.54)]	[(-0.12;0.13),(0.85;0.95),(0.17;0.49)]
C1.2	[(-0.2;0.25),(0.69;0.88),(0.06;0.29)]	[(-0.24;0.21),(0.69;0.88),(0.04;0.27)]
C1.3	[(-0.3;0.35),(0.53;0.78),(0.01;0.16)]	[(-0.38;0.29),(0.53;0.78),(0.01;0.15)]
C1.4	[(-0.31;0.49),(0.43;0.72),(0;0.08)]	[(-0.64;0.3),(0.43;0.72),(0;0.09)]
C1.5	[(-0.17;0.68),(0.52;0.91),(0;0.05)]	[(-1.09;0.2),(0.52;0.91),(0;0.08)]
C1.6	[(-0.26;0.71),(0.44;0.86),(0;0.03)]	[(-1.25;0.27),(0.44;0.86),(0;0.05)]
C2.1	[(-0.28;0.77),(0.39;0.84),(0;0.01)]	[(-1.43;0.29),(0.39;0.84),(0;0.03)]
C2.2	[(-0.29;0.83),(0.36;0.84),(0;0)]	[(-1.66;0.29),(0.36;0.84),(0;0.02)]
C2.3	[(-0.23;0.88),(0.33;0.84),(0;0)]	[(-1.98;0.25),(0.33;0.84),(0;0.01)]
C2.4	[(-0.17;0.9),(0.23;0.67),(0;0)]	[(-2.33;0.21),(0.23;0.67),(0;0.01)]
C2.5	[(-0.29;0.9),(0.12;0.44),(0;0)]	[(-2.15;0.3),(0.12;0.44),(0;0)]
C2.6	[(-0.43;0.9),(0.06;0.29),(0;0)]	[(-1.98;0.38),(0.06;0.29),(0;0)]
C2.7	[(-0.54;0.91),(0.05;0.27),(0;0)]	[(-2;0.44),(0.05;0.27),(0;0)]
C3.1	[(-0.93;0.91),(0.05;0.27),(0;0)]	[(-1.86;0.6),(0.05;0.27),(0;0)]
C3.2	[(-1.08;0.91),(0.03;0.23),(0;0)]	[(-1.99;0.64),(0.03;0.23),(0;0)]
C3.3	[(-1.15;0.92),(0.02;0.18),(0;0)]	[(-2.18;0.65),(0.02;0.18),(0;0)]
C3.4	[(-1.45;0.92),(0.02;0.17),(0;0)]	[(-2.25;0.71),(0.02;0.17),(0;0)]
C3.5	[(-1.82;0.92),(0.01;0.15),(0;0)]	[(-2.19;0.76),(0.01;0.15),(0;0)]
C3.6	[(-1.81;0.92),(0.01;0.11),(0;0)]	[(-2.43;0.76),(0.01;0.11),(0;0)]
C3.7	[(-2.38;0.92),(0.01;0.11),(0;0)]	[(-2.33;0.82),(0.01;0.11),(0;0)]
C3.8	[(-2.94;0.92),(0.01;0.1),(0;0)]	[(-2.3;0.86),(0.01;0.1),(0;0)]
C3.9	[(-3.44;0.92),(0;0.08),(0;0)]	[(-2.34;0.88),(0;0.08),(0;0)]
C4.1	[(-4.04;0.93),(0;0.08),(0;0)]	[(-2.53;0.9),(0;0.08),(0;0)]
C4.2	[(-4.72;0.93),(0;0.08),(0;0)]	[(-2.73;0.91),(0;0.08),(0;0)]
C5.1	[(-7.99;0.92),(0;0.09),(0;0)]	[(-2.15;0.97),(0;0.09),(0;0)]
C5.2	[(-7.19;0.94),(0;0.07),(0;0)]	[(-2.93;0.97),(0;0.07),(0;0)]
C5.3	[(-9.1;0.94),(0;0.08),(0;0)]	[(-3;0.98),(0;0.08),(0;0)]

Table B.5: Weighted sum of positive and negative distances for Riyadh

	Riyadh	Riyadh
Criterion	sp_n	np_n
C1.1	[(0.03;0.28),(0.85;0.95),(0.08;0.4)]	[(-0.24;-0.04),(0.85;0.95),(0.34;0.62)]
C1.2	[(0.1;0.5),(0.69;0.88),(0.01;0.17)]	[(-0.56;-0.12),(0.69;0.88),(0.14;0.42)]
C1.3	[(0.15;0.65),(0.53;0.78),(0;0.07)]	[(-0.95;-0.2),(0.53;0.78),(0.06;0.28)]
C1.4	[(0.19;0.74),(0.43;0.72),(0;0.03)]	[(-1.4;-0.26),(0.43;0.72),(0.02;0.18)]
C1.5	[(0.22;0.82),(0.53;0.93),(0;0.02)]	[(-1.93;-0.33),(0.53;0.93),(0.01;0.16)]
C1.6	[(0.27;0.87),(0.38;0.78),(0;0.01)]	[(-2.6;-0.43),(0.38;0.78),(0.01;0.12)]
C2.1	[(0.14;0.88),(0.34;0.77),(0;0.01)]	[(-2.37;-0.13),(0.34;0.77),(0;0.05)]
C2.2	[(-0.01;0.88),(0.31;0.76),(0;0)]	[(-2.19;0.09),(0.31;0.76),(0;0.02)]
C2.3	[(-0.16;0.9),(0.28;0.75),(0;0)]	[(-2.09;0.25),(0.28;0.75),(0;0.01)]
C2.4	[(-0.31;0.9),(0.15;0.53),(0;0)]	[(-1.94;0.37),(0.15;0.53),(0;0.01)]
C2.5	[(-0.4;0.9),(0.1;0.4),(0;0)]	[(-1.84;0.42),(0.1;0.4),(0;0)]
C2.6	[(-0.49;0.9),(0.06;0.29),(0;0)]	[(-1.79;0.46),(0.06;0.29),(0;0)]
C2.7	[(-0.61;0.91),(0.05;0.27),(0;0)]	[(-1.8;0.51),(0.05;0.27),(0;0)]
C3.1	[(-0.62;0.93),(0.04;0.27),(0;0)]	[(-2.43;0.51),(0.04;0.27),(0;0)]
C3.2	[(-0.49;0.95),(0.02;0.2),(0;0)]	[(-3.19;0.46),(0.02;0.2),(0;0)]
C3.3	[(-0.39;0.96),(0.01;0.11),(0;0)]	[(-3.93;0.42),(0.01;0.11),(0;0)]
C3.4	[(-0.25;0.97),(0.01;0.1),(0;0)]	[(-5.31;0.35),(0.01;0.1),(0;0)]
C3.5	[(-0.18;0.98),(0;0.07),(0;0)]	[(-6.6;0.31),(0;0.07),(0;0)]
C3.6	[(-0.14;0.98),(0;0.04),(0;0)]	[(-7.53;0.28),(0;0.04),(0;0)]
C3.7	[(-0.06;0.99),(0;0.04),(0;0)]	[(-9.74;0.23),(0;0.04),(0;0)]
C3.8	[(0.11;0.99),(0;0.03),(0;0)]	[(-13.24;0.06),(0;0.03),(0;0)]
C3.9	[(0.17;0.99),(0;0.03),(0;0)]	[(-16.3;-0.01),(0;0.03),(0;0)]
C4.1	[(0.11;1),(0;0.03),(0;0)]	[(-18.73;0.08),(0;0.03),(0;0)]
C4.2	[(0.05;1),(0;0.02),(0;0)]	[(-21.51;0.16),(0;0.02),(0;0)]
C5.1	[(-0.18;1),(0;0.03),(0;0)]	[(-25.18;0.4),(0;0.03),(0;0)]
C5.2	[(-0.02;1),(0;0.02),(0;0)]	[(-32.72;0.3),(0;0.02),(0;0)]
C5.3	[(-0.07;1),(0;0.02),(0;0)]	[(-39.9;0.33),(0;0.02),(0;0)]

Table B.6: Weighted sum of positive and negative distances for Medina

	Medina	Medina
Criterion	sp_n	np_n
C1.1	$[(-0.28;-0.09),(0.89;0.97),(0.4;0.67)]$	$[(0.08;0.33),(0.89;0.97),(0.01;0.35)]$
C1.2	$[(-0.58;-0.19),(0.79;0.94),(0.16;0.45)]$	$[(0.15;0.51),(0.79;0.94),(0;0.14)]$
C1.3	$[(-0.89;-0.23),(0.69;0.91),(0.06;0.29)]$	$[(0.17;0.63),(0.69;0.91),(0;0.06)]$
C1.4	$[(-1.16;-0.2),(0.62;0.89),(0.02;0.17)]$	$[(0.16;0.69),(0.62;0.89),(0;0.03)]$
C1.5	$[(-0.93;0.24),(0.75;1.13),(0.01;0.11)]$	$[(-0.08;0.64),(0.75;1.13),(0;0.03)]$
C1.6	$[(-1.27;0.21),(0.63;1.05),(0;0.08)]$	$[(-0.05;0.72),(0.63;1.05),(0;0.02)]$
C2.1	$[(-0.93;0.55),(0.56;1.03),(0;0.02)]$	$[(-0.31;0.67),(0.56;1.03),(0;0.01)]$
C2.2	$[(-0.95;0.66),(0.51;1.02),(0;0.01)]$	$[(-0.43;0.67),(0.51;1.02),(0;0.01)]$
C2.3	$[(-1;0.74),(0.46;1),(0;0)]$	$[(-0.55;0.69),(0.46;1),(0;0)]$
C2.4	$[(-1.12;0.76),(0.29;0.77),(0;0)]$	$[(-0.55;0.71),(0.29;0.77),(0;0)]$
C2.5	$[(-1.35;0.75),(0.15;0.5),(0;0)]$	$[(-0.47;0.74),(0.15;0.5),(0;0)]$
C2.6	$[(-1.5;0.76),(0.09;0.37),(0;0)]$	$[(-0.44;0.76),(0.09;0.37),(0;0)]$
C2.7	$[(-1.52;0.8),(0.08;0.36),(0;0)]$	$[(-0.54;0.76),(0.08;0.36),(0;0)]$
C3.1	$[(-2.16;0.79),(0.07;0.35),(0;0)]$	$[(-0.46;0.83),(0.07;0.35),(0;0)]$
C3.2	$[(-1.91;0.85),(0.04;0.26),(0;0)]$	$[(-0.79;0.82),(0.04;0.26),(0;0)]$
C3.3	$[(-2;0.86),(0.03;0.2),(0;0)]$	$[(-0.9;0.82),(0.03;0.2),(0;0)]$
C3.4	$[(-2.42;0.86),(0.02;0.19),(0;0)]$	$[(-0.94;0.85),(0.02;0.19),(0;0)]$
C3.5	$[(-2.37;0.89),(0.01;0.14),(0;0)]$	$[(-1.27;0.85),(0.01;0.14),(0;0)]$
C3.6	$[(-2.06;0.91),(0;0.07),(0;0)]$	$[(-1.68;0.84),(0;0.07),(0;0)]$
C3.7	$[(-2.02;0.93),(0;0.07),(0;0)]$	$[(-2.24;0.83),(0;0.07),(0;0)]$
C3.8	$[(-1.87;0.95),(0;0.06),(0;0)]$	$[(-2.92;0.82),(0;0.06),(0;0)]$
C3.9	$[(-2.73;0.94),(0;0.05),(0;0)]$	$[(-2.33;0.88),(0;0.05),(0;0)]$
C4.1	$[(-2.99;0.95),(0;0.05),(0;0)]$	$[(-2.8;0.89),(0;0.05),(0;0)]$
C4.2	$[(-3.28;0.96),(0;0.05),(0;0)]$	$[(-3.34;0.9),(0;0.05),(0;0)]$
C5.1	$[(-4.32;0.97),(0;0.05),(0;0)]$	$[(-4.05;0.93),(0;0.05),(0;0)]$
C5.2	$[(-3.62;0.98),(0;0.04),(0;0)]$	$[(-5.5;0.92),(0;0.04),(0;0)]$
C5.3	$[(-3.8;0.98),(0;0.04),(0;0)]$	$[(-6.89;0.92),(0;0.04),(0;0)]$

Table B.7: Weighted sum of positive and negative distances for Jeddah

	Jeddah	Jeddah
Criterion	sp_n	np_n
C1.1	$[(-0.28;-0.09),(0.89;0.97),(0.4;0.67)]$	$[(0.08;0.33),(0.89;0.97),(0.01;0.35)]$
C1.2	$[(-0.19;-0.02),(0.91;0.99),(0.31;0.59)]$	$[(0.01;0.22),(0.91;0.99),(0.11;0.43)]$
C1.3	$[(-0.28;0.12),(0.74;0.91),(0.08;0.32)]$	$[(-0.1;0.29),(0.74;0.91),(0.03;0.23)]$
C1.4	$[(-0.21;0.37),(0.57;0.81),(0.01;0.13)]$	$[(-0.37;0.24),(0.57;0.81),(0.01;0.16)]$
C1.5	$[(-0.16;0.55),(0.46;0.75),(0;0.06)]$	$[(-0.68;0.21),(0.46;0.75),(0;0.1)]$
C1.6	$[(-0.03;0.71),(0.56;0.95),(0;0.04)]$	$[(-1.15;0.09),(0.56;0.95),(0;0.1)]$
C2.1	$[(-0.11;0.74),(0.47;0.9),(0;0.02)]$	$[(-1.31;0.17),(0.47;0.9),(0;0.06)]$
C2.2	$[(-0.26;0.77),(0.42;0.88),(0;0.01)]$	$[(-1.3;0.3),(0.42;0.88),(0;0.03)]$
C2.3	$[(-0.41;0.8),(0.39;0.87),(0;0.01)]$	$[(-1.31;0.4),(0.39;0.87),(0;0.01)]$
C2.4	$[(-0.45;0.85),(0.35;0.85),(0;0)]$	$[(-1.49;0.42),(0.35;0.85),(0;0.01)]$
C2.5	$[(-0.54;0.86),(0.22;0.66),(0;0)]$	$[(-1.5;0.46),(0.22;0.66),(0;0)]$
C2.6	$[(-0.7;0.86),(0.11;0.43),(0;0)]$	$[(-1.37;0.53),(0.11;0.43),(0;0)]$
C2.7	$[(-0.88;0.85),(0.06;0.29),(0;0)]$	$[(-1.24;0.58),(0.06;0.29),(0;0)]$
C3.1	$[(-1.03;0.87),(0.05;0.26),(0;0)]$	$[(-1.26;0.62),(0.05;0.26),(0;0)]$
C3.2	$[(-1.54;0.86),(0.04;0.26),(0;0)]$	$[(-1.15;0.73),(0.04;0.26),(0;0)]$
C3.3	$[(-1.45;0.89),(0.02;0.19),(0;0)]$	$[(-1.54;0.72),(0.02;0.19),(0;0)]$
C3.4	$[(-1.52;0.9),(0.02;0.15),(0;0)]$	$[(-1.7;0.73),(0.02;0.15),(0;0)]$
C3.5	$[(-1.6;0.92),(0.01;0.13),(0;0)]$	$[(-2.1;0.74),(0.01;0.13),(0;0)]$
C3.6	$[(-1.75;0.93),(0.01;0.1),(0;0)]$	$[(-2.38;0.76),(0.01;0.1),(0;0)]$
C3.7	$[(-1.65;0.94),(0;0.06),(0;0)]$	$[(-2.79;0.75),(0;0.06),(0;0)]$
C3.8	$[(-1.86;0.95),(0;0.06),(0;0)]$	$[(-3.21;0.77),(0;0.06),(0;0)]$
C3.9	$[(-1.72;0.96),(0;0.05),(0;0)]$	$[(-4.09;0.76),(0;0.05),(0;0)]$
C4.1	$[(-1.93;0.96),(0;0.04),(0;0)]$	$[(-4.46;0.78),(0;0.04),(0;0)]$
C4.2	$[(-2.14;0.97),(0;0.04),(0;0)]$	$[(-5.23;0.8),(0;0.04),(0;0)]$
C5.1	$[(-2.36;0.97),(0;0.04),(0;0)]$	$[(-6.11;0.81),(0;0.04),(0;0)]$
C5.2	$[(-4.28;0.97),(0;0.04),(0;0)]$	$[(-5;0.94),(0;0.04),(0;0)]$
C5.3	$[(-3.81;0.98),(0;0.03),(0;0)]$	$[(-6.5;0.93),(0;0.03),(0;0)]$

Table B.8: Weighted sum of positive and negative distances for Mecca

	Mecca	Mecca
Criterion	sp_n	np_n
C1.1	$[(-0.28;-0.09),(0.89;0.97),(0.4;0.67)]$	$[(0.08;0.33),(0.89;0.97),(0.01;0.35)]$
C1.2	$[(-0.58;-0.19),(0.79;0.94),(0.16;0.45)]$	$[(0.15;0.51),(0.79;0.94),(0;0.14)]$
C1.3	$[(-0.98;-0.31),(0.66;0.88),(0.07;0.31)]$	$[(0.22;0.66),(0.66;0.88),(0;0.06)]$
C1.4	$[(-1.26;-0.28),(0.6;0.87),(0.02;0.18)]$	$[(0.21;0.71),(0.6;0.87),(0;0.03)]$
C1.5	$[(-1.02;0.19),(0.72;1.1),(0.01;0.12)]$	$[(-0.01;0.67),(0.72;1.1),(0;0.03)]$
C1.6	$[(-1.27;0.21),(0.63;1.06),(0;0.08)]$	$[(-0.04;0.72),(0.63;1.06),(0;0.01)]$
C2.1	$[(-0.61;0.68),(0.56;1.04),(0;0.01)]$	$[(-0.45;0.63),(0.56;1.04),(0;0.01)]$
C2.2	$[(-0.62;0.76),(0.51;1.03),(0;0)]$	$[(-0.58;0.63),(0.51;1.03),(0;0.01)]$
C2.3	$[(-0.54;0.82),(0.48;1.03),(0;0)]$	$[(-0.77;0.61),(0.48;1.03),(0;0)]$
C2.4	$[(-0.55;0.85),(0.34;0.85),(0;0)]$	$[(-0.86;0.62),(0.34;0.85),(0;0)]$
C2.5	$[(-0.66;0.85),(0.22;0.64),(0;0)]$	$[(-0.8;0.65),(0.22;0.64),(0;0)]$
C2.6	$[(-0.76;0.85),(0.13;0.47),(0;0)]$	$[(-0.76;0.67),(0.13;0.47),(0;0)]$
C2.7	$[(-0.78;0.88),(0.12;0.46),(0;0)]$	$[(-0.88;0.67),(0.12;0.46),(0;0)]$
C3.1	$[(-1.23;0.87),(0.11;0.45),(0;0)]$	$[(-0.79;0.77),(0.11;0.45),(0;0)]$
C3.2	$[(-1.06;0.9),(0.06;0.33),(0;0)]$	$[(-1.18;0.75),(0.06;0.33),(0;0)]$
C3.3	$[(-1.2;0.91),(0.04;0.26),(0;0)]$	$[(-1.24;0.77),(0.04;0.26),(0;0)]$
C3.4	$[(-1.51;0.91),(0.04;0.25),(0;0)]$	$[(-1.29;0.81),(0.04;0.25),(0;0)]$
C3.5	$[(-1.47;0.93),(0.02;0.18),(0;0)]$	$[(-1.67;0.81),(0.02;0.18),(0;0)]$
C3.6	$[(-1.56;0.93),(0.01;0.14),(0;0)]$	$[(-1.78;0.81),(0.01;0.14),(0;0)]$
C3.7	$[(-1.76;0.94),(0.01;0.13),(0;0)]$	$[(-2.09;0.83),(0.01;0.13),(0;0)]$
C3.8	$[(-1.62;0.96),(0.01;0.11),(0;0)]$	$[(-2.73;0.82),(0.01;0.11),(0;0)]$
C3.9	$[(-2.41;0.95),(0.01;0.09),(0;0)]$	$[(-2.17;0.88),(0.01;0.09),(0;0)]$
C4.1	$[(-2.65;0.96),(0;0.09),(0;0)]$	$[(-2.62;0.89),(0;0.09),(0;0)]$
C4.2	$[(-2.91;0.96),(0;0.08),(0;0)]$	$[(-3.13;0.9),(0;0.08),(0;0)]$
C5.1	$[(-4.48;0.97),(0;0.09),(0;0)]$	$[(-3.25;0.95),(0;0.09),(0;0)]$
C5.2	$[(-4.4;0.97),(0;0.08),(0;0)]$	$[(-3.96;0.95),(0;0.08),(0;0)]$
C5.3	$[(-6.08;0.97),(0;0.08),(0;0)]$	$[(-3.54;0.97),(0;0.08),(0;0)]$

Table B.9: Weighted sum of positive and negative distances for Kuwait City

	Kuwait City	Kuwait City
Criterion	sp_n	np_n
C1.1	$[(-0.19;-0.02),(0.91;0.99),(0.31;0.59)]$	$[(0.01;0.22),(0.91;0.99),(0.11;0.43)]$
C1.2	$[(-0.28;0.12),(0.74;0.91),(0.08;0.32)]$	$[(-0.1;0.29),(0.74;0.91),(0.03;0.23)]$
C1.3	$[(-0.27;0.33),(0.57;0.81),(0.01;0.15)]$	$[(-0.32;0.29),(0.57;0.81),(0.01;0.15)]$
C1.4	$[(-0.29;0.48),(0.46;0.75),(0;0.07)]$	$[(-0.57;0.29),(0.46;0.75),(0;0.09)]$
C1.5	$[(-0.15;0.67),(0.56;0.95),(0;0.05)]$	$[(-1;0.19),(0.56;0.95),(0;0.08)]$
C1.6	$[(-0.17;0.72),(0.41;0.81),(0;0.03)]$	$[(-1.29;0.22),(0.41;0.81),(0;0.05)]$
C2.1	$[(-0.19;0.79),(0.36;0.79),(0;0.01)]$	$[(-1.47;0.23),(0.36;0.79),(0;0.03)]$
C2.2	$[(-0.2;0.84),(0.33;0.78),(0;0)]$	$[(-1.7;0.24),(0.33;0.78),(0;0.02)]$
C2.3	$[(-0.24;0.88),(0.3;0.77),(0;0)]$	$[(-1.92;0.26),(0.3;0.77),(0;0.01)]$
C2.4	$[(-0.31;0.89),(0.19;0.59),(0;0)]$	$[(-1.93;0.31),(0.19;0.59),(0;0.01)]$
C2.5	$[(-0.4;0.89),(0.12;0.45),(0;0)]$	$[(-1.84;0.37),(0.12;0.45),(0;0)]$
C2.6	$[(-0.48;0.89),(0.07;0.33),(0;0)]$	$[(-1.78;0.41),(0.07;0.33),(0;0)]$
C2.7	$[(-0.6;0.9),(0.06;0.31),(0;0)]$	$[(-1.8;0.46),(0.06;0.31),(0;0)]$
C3.1	$[(-1.01;0.9),(0.05;0.3),(0;0)]$	$[(-1.67;0.62),(0.05;0.3),(0;0)]$
C3.2	$[(-1.07;0.91),(0.03;0.23),(0;0)]$	$[(-1.95;0.64),(0.03;0.23),(0;0)]$
C3.3	$[(-1.1;0.92),(0.02;0.17),(0;0)]$	$[(-2.19;0.64),(0.02;0.17),(0;0)]$
C3.4	$[(-1.28;0.93),(0.02;0.17),(0;0)]$	$[(-2.44;0.68),(0.02;0.17),(0;0)]$
C3.5	$[(-1.63;0.92),(0.01;0.14),(0;0)]$	$[(-2.38;0.74),(0.01;0.14),(0;0)]$
C3.6	$[(-1.53;0.93),(0.01;0.09),(0;0)]$	$[(-2.79;0.73),(0.01;0.09),(0;0)]$
C3.7	$[(-2.04;0.93),(0.01;0.09),(0;0)]$	$[(-2.68;0.79),(0.01;0.09),(0;0)]$
C3.8	$[(-1.89;0.95),(0;0.08),(0;0)]$	$[(-3.44;0.78),(0;0.08),(0;0)]$
C3.9	$[(-2.4;0.95),(0;0.07),(0;0)]$	$[(-3.27;0.82),(0;0.07),(0;0)]$
C4.1	$[(-2.65;0.96),(0;0.07),(0;0)]$	$[(-3.87;0.84),(0;0.07),(0;0)]$
C4.2	$[(-2.91;0.96),(0;0.07),(0;0)]$	$[(-4.55;0.85),(0;0.07),(0;0)]$
C5.1	$[(-5.14;0.96),(0;0.07),(0;0)]$	$[(-3.69;0.95),(0;0.07),(0;0)]$
C5.2	$[(-4.59;0.97),(0;0.06),(0;0)]$	$[(-4.85;0.95),(0;0.06),(0;0)]$
C5.3	$[(-5.89;0.97),(0;0.06),(0;0)]$	$[(-4.95;0.96),(0;0.06),(0;0)]$

Table B.10: Weighted sum of positive and negative distances for Masqat

	Masqat	Masqat
Criterion	sp_n	np_n
C1.1	$[(-0.44;-0.28),(0.85;0.95),(0.57;0.81)]$	$[(0.24;0.51),(0.85;0.95),(-0.15;0.21)]$
C1.2	$[(-0.81;-0.41),(0.73;0.91),(0.25;0.56)]$	$[(0.3;0.66),(0.73;0.91),(-0.01;0.08)]$
C1.3	$[(-1.28;-0.55),(0.62;0.85),(0.11;0.38)]$	$[(0.36;0.76),(0.62;0.85),(0;0.03)]$
C1.4	$[(-1.8;-0.63),(0.54;0.82),(0.04;0.25)]$	$[(0.39;0.83),(0.54;0.82),(0;0.01)]$
C1.5	$[(-1.5;-0.04),(0.66;1.04),(0.01;0.17)]$	$[(0.22;0.8),(0.66;1.04),(0;0.01)]$
C1.6	$[(-2.14;-0.15),(0.49;0.89),(0.01;0.13)]$	$[(0.3;0.86),(0.49;0.89),(0;0.01)]$
C2.1	$[(-0.9;0.67),(0.44;0.88),(0;0)]$	$[(-0.06;0.8),(0.44;0.88),(0;0.01)]$
C2.2	$[(-0.42;0.84),(0.4;0.87),(0;0)]$	$[(-0.41;0.74),(0.4;0.87),(0;0)]$
C2.3	$[(-0.13;0.92),(0.36;0.85),(0;0)]$	$[(-0.82;0.68),(0.36;0.85),(0;0)]$
C2.4	$[(-0.07;0.94),(0.24;0.68),(0;0)]$	$[(-1.04;0.66),(0.24;0.68),(0;0)]$
C2.5	$[(-0.19;0.93),(0.12;0.44),(0;0)]$	$[(-0.93;0.7),(0.12;0.44),(0;0)]$
C2.6	$[(-0.31;0.93),(0.07;0.3),(0;0)]$	$[(-0.82;0.74),(0.07;0.3),(0;0)]$
C2.7	$[(-0.32;0.94),(0.06;0.29),(0;0)]$	$[(-0.94;0.74),(0.06;0.29),(0;0)]$
C3.1	$[(-0.66;0.94),(0.05;0.28),(0;0)]$	$[(-0.85;0.82),(0.05;0.28),(0;0)]$
C3.2	$[(-0.72;0.95),(0.03;0.22),(0;0)]$	$[(-1.05;0.82),(0.03;0.22),(0;0)]$
C3.3	$[(-0.74;0.95),(0.02;0.16),(0;0)]$	$[(-1.21;0.83),(0.02;0.16),(0;0)]$
C3.4	$[(-0.57;0.97),(0.02;0.14),(0;0)]$	$[(-1.83;0.81),(0.02;0.14),(0;0)]$
C3.5	$[(-0.66;0.97),(0.01;0.11),(0;0)]$	$[(-2.08;0.82),(0.01;0.11),(0;0)]$
C3.6	$[(-0.72;0.97),(0.01;0.08),(0;0)]$	$[(-2.21;0.83),(0.01;0.08),(0;0)]$
C3.7	$[(-0.96;0.97),(0.01;0.08),(0;0)]$	$[(-2.31;0.85),(0.01;0.08),(0;0)]$
C3.8	$[(-0.95;0.98),(0;0.08),(0;0)]$	$[(-2.79;0.85),(0;0.08),(0;0)]$
C3.9	$[(-1.3;0.98),(0;0.07),(0;0)]$	$[(-2.64;0.88),(0;0.07),(0;0)]$
C4.1	$[(-1.24;0.98),(0;0.07),(0;0)]$	$[(-3.54;0.88),(0;0.07),(0;0)]$
C4.2	$[(-1.17;0.99),(0;0.07),(0;0)]$	$[(-4.67;0.88),(0;0.07),(0;0)]$
C5.1	$[(-2.41;0.99),(0;0.07),(0;0)]$	$[(-3.79;0.96),(0;0.07),(0;0)]$
C5.2	$[(-2.37;0.99),(0;0.06),(0;0)]$	$[(-4.59;0.96),(0;0.06),(0;0)]$
C5.3	$[(-3.69;0.99),(0;0.06),(0;0)]$	$[(-3.66;0.98),(0;0.06),(0;0)]$

BIOGRAPHICAL SKETCH

Berkay Özcan was born in Sinop on May 14, 1992. He graduated from Atatürk Anatolian High School in 2010. He started to study Industrial Engineering at Istanbul Arel University in the same year. In the last semester of university, he started to work for Sony Eurasia as Managament Trainee for 6 months. In 2015, he obtained a B.S degree in Industrial Engineering as top scoring student. After graduation, he has worked for Netlog Logistics for 2 years as IT Project Specialist. Now he has been working for CEVA Logistics for 3 years as IT Project Executive. In 2017, he entitled to study Logistics and Financial Management master programme at Galatasaray University. Now, he is a candidate of M.Sc. degree. And he performed a thesis study on “ Warehouse Location Selection for 3PL Cold Chain Suppliers” in parallel with his experience.