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SELECTING THE FIELD HOSPITAL LOCATION FOR DISASTERS: A CASE STUDY IN ISTANBUL

M.Sc. THESIS

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AFET DURUMLARI İÇİN SEYYAR HASTANE YERİ SEÇİMİ: İSTANBUL'DAN BİR VAKA ÇALIŞMASI

YÜKSEK LİSANS TEZİ

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To my mother and father,

FOREWORD

A study like this is never the work of anyone alone. The contributions of many different people, in their different ways, have made this possible. I would like to extend my appreciation especially to the following:

Thanks God for the wisdom and perseverance that he has been bestowed upon me during this thesis, and indeed, throughout my life.

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ABBREVIATIONS

AHP : Analytic hierarchy process
ANP : Analytic Network Process
CPR : Cardiopulmonary resuscitation
CHW : Community Health Worker
DM : Decision Making
GIS : Geographical Information System
GPS : Global Positioning System
HFA : Hyogo Framework for Action
ICS : Incident Command System
IFRC : International Federation of Red Cross
FIG : International Federation of Surveyors
LIDAR : LIght Detecting And Ranging
MIS : Management Information Systems
MCI : Mass Casualty Incident
MCDM : Multi Criteria Decision Making
MCDA : Multi-Criteria Decision Analysis
MODM : Multi-Objective Decision Making
NGO : Non-government organization
IPCC : Panel on Climate Change
PHC : Primary Health Care
TOPSIS : Technique for Order of Preference by Similarity to Ideal Solution
TAR : Third Assessment Report
TB : Tubercle Bacillus
TUIK : Turkiye Istatistik Kurumu
WPM : Weighted product model
WSM : Weighted Sum Model

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SELECTING THE FIELD HOSPITAL LOCATION FOR DISASTERS: A CASE STUDY IN ISTANBUL

SUMMARY

Increasing population growth and lack of enough medicine care is the most important problem for the disaster managers and metropolitans within disasters such as volcanic eruption, typhoon, tropical cyclone, tornado an earthquake, a landslide or war. Disaster is defined as a serious disruption that are caused by terrible events such as earthquake and make loss of human life, material and economic.

Disaster management improves the ability of community or society to decrease these resources loosing. Disaster manager has an important role to facing with disasters and preparedness of facilities for responding. Reliable, accurate and up-to-date informations help to the disaster managers for successful responds before, within and after disasters. Facilitating, sharing and coordinating these informations between different parts are another disaster manager’s duties.

Importance of disaster preparedness, the effects of disasters in previous years, and importance of medical services in case of emergency persuaded us to select a proper place for emergency field hospital. In the emergency cases we can use Multi-Criteria Decision Making (MCDM) and Geographical Information System (GIS) together for having better selection.

GIS is a visual system which can provides maps from spatial entry data. A map reader can add layers to the attribute contents of maps and produce custom maps based on require information for specific project. GIS results have important role in different phases of disasters that are consisted of mitigating, detecting, responding, and recovering.

AHP is one of them most useful and applicable method of MCDM which is used for solving complex problems with some techniques which are based on mathematics and psychology. AHP decomposes problem to the simplest sub problems which are hierarchy and decision maker can analyzed them independently. In this method, decision makes can evaluate criteria and alternatives with comparing them together (one by another two).

So, we use Multi-Criteria Decision Making process that combines Geographical Information System (GIS) analysis with the Analytical Hierarchy Process (AHP), and use this process to determine the optimum site for field hospital in the Istanbul urban area. Istanbul is one of the most important and biggest city in Turkey which is located in side of Bosporus Channel and Marmara Sea in Europe and Asia. In this area, risk of happening earthquake is high and municipality should prepare facilities to facing with probable disasters.

We use criteria are defined as Distance from Arterial Routes, Distance to existing hospitals, Population Density, Time of Operate, and Capacity of Beds. Also, five alternative parks which are located in Besiktas are compared for selecting the best

place for field hospital. This study introduces a specific method for best site selection for field hospital in disaster situation by helping GIS and AHP method in Istanbul.

As result the best place for building field hospital is Yildiz Park. Then, Prof. Dr. Aykut Park, Besiktas Sanatcilar Park, Ulus Park, and Cemil Topuzlu Park are sequentially next priorities for bilding field hospital in Besiktas (Figure 6.12). Their weights are defined sequentially 0.368, 0.249, 0.167, 0.157, and 0.060.

Each criteria has specific participation in the model which is determined the role of criteria and its importance. The most important criteria is Population Density with 40.9% participation. Also, the least important criteria is Distance from Arterial Routes with 5.4% participation in the model. Other criteria will be held between these two criteria. The participation of them are defined as Distance from Existing Hospital is 23.4%, Time to Operate is 18.7%, and Capacity of Bed is 11.5% sequentially from highest to lowest.

AFET DURUMLARI İÇİN SEYYAR HASTANE YERİ SEÇİMİ: İSTANBUL'DAN BİR VAKA ÇALIŞMASIBUI

ÖZET

Noise, Artan popülasyon büyüklüğü ve yeteri kadar sağlık yardımının olmayışı, volkanik patlamalar, tayfun, tropikal hortum, kasırga, deprem, toprak kayması ve savaş gibi felaketlerde afet yöneticisi ve büyükşehirliler için en önemli problemdir. Afet genel olarak deprem vb. korkunç olaylardan kaynaklanan ve can ve mal kaybına yol açacak ciddi felaketler olarak tanımlanmaktadır. Afet yönetimi, kaynakların kaybını azaltmak için toplumun veya halkın gücünü geliştirmektedir. Bu anlamda afet yöneticisi, afetlerle yüz yüze kalmakta ve afetlerde tepki vermek için tesislerin hazırlanmasında önemli role sahiptir. Güvenilir, kesin ve güncel bilgiler afet öncesinde, sırasında ve sonrasında başarılı tepkiler vermede afet yöneticilerine yardım etmektedir. Farklı bölümlerde bilgileri paylaşma, koordine etme ve kolaylaştırma da afet yöneticilerinin diğer görevleri olarak sıralanabilir.

Yüzyıllardır depremler Türkiye'de can ve mal kayıplarına sebep olan felaketlerin basında gelmektedir. Türkiye'nin ekonomik, kültürel ve sanayi merkezi olan İstanbul'da da deprem tehlikesi oldukça yüksektir. İstanbul'un kentsel yapılasmasına bakıldığında bağlı ilçelerinin birbirinden çok farklı özellikler gösterdiği görülmektedir. Bu nedenle ilçelerin detaylı deprem tehlike analizlerine dayanan kapsamlı zarar azaltma planlarının hazırlanması gerekmektedir. Gecmis depremlerden elde edilen verilerin duzenli ve yeterli olmaması nedeniyle binaların ve diğer yapıların hasar gorebilirlikleri hakkında cok doğru ve yeterli bilgi bulunmamaktadır. Bu nedenle yapıların hasar gorebilirlik modelleri tekil binalardan cok bina toplulukları hakkında bilgiler vermektedir. Bu calısmada yararlanılan hasar gorebilirlik analizi yardımıyla elde edilen değerler nufus-bina iliskileri kullanılarak analiz edilmis ve su sonuclar elde edilmistir.

Türkiye yüzyıllardır depremler nedeniyle can ve mal kayıplarına uğrayan ülkeler arasında üst sıralarda yer almaktadır. Bunun en önemli nedeni Türkiye'nin aktif deprem kusağında bulunmasıdır. Kuzey Anadolu Fay Zonu'nun Marmara denizindeki uzantısından dolayı, ekonomik, kültürel ve sanayi merkezi olan İstanbul'da deprem tehlikesi oldukça yüksektir. Tarihsel depremlere ve Kuzey Anadolu Fay Zonu'nun yapısına bakıldığında İstanbul'da 1999 yılından sonra 30 yıl içerisinde büyüklüğü 7 ve üzerinde bir depremin gerçeklesmesi olasılığı yüzde 70 olarak hesaplanmaktadır. Ayrıca, istanbul gibi büyük bir metropol alanın çok hızlı ve plansız kentlesmesi, sartnamelere uymayan insaat uygulamaları, yetersiz altyapı ve çevresel bozulmalar nedeniyle deprem riski oldukça artmaktadır. Bu nedenle İstanbul'un deprem öncesinde acil müdahale planlamasının yapılması, ilk yardım ve acil barınma ihtiyaçlarının belirlenebilmesi gerekmektedir.

Bu çalısmanın amacı, Coğrafi Bilgi Sistemleri kullanılarak Besiktas ilçesinin deprem riskine karsı hazır olup olmadığının ve cevap verebilme potansiyelinin arastırılması ile kapsamlı zarar azaltma planlarına altlık olusturacak analizlerin yapılmasıdır. Böylece deprem sonrası ilçede yasayanlara toplanma ve çadır alanları gösterilmesi,

yaralılar için en yakın ilk yardım ve acil müdahale merkezlerinin belirlenmesine çalısılmıstır.

Afete hazır olmanın önemi, afetlerin önceki yıllardaki etkisi ve acil durumlarda tıbbi servislerin önemi bize acil sahra hastanelerinin uygun yer seçimini konusuna yönlendirmektedir. Acil durumlarda çok kriterli karar verme (ÇKKV) ve coğrafi bilgi sistemlerini (CBS) beraber kullanma daha iyi bir seçim yapmamıza yardımcı olabilir.

Coğrafi bilgi sistemleri (CBS), konumsal giriş verilerinden haritalar elde eden bir görsel sistemdir. Bir harita okuyucu ile haritalara varlık kapsamında katmanlar eklemektedir ve bunlardan belli bir proje için gereken bilgilere dayalı ticari haritalar elde etmektedir. Coğrafi bilgi sistemleri sonuçları azaltma, tespit etme, iyileştirme ve kurtarma gibi aşamalardan oluşan afetlerin farklı aşamaları için önemli bir role sahiptir.

AHP (Analitik Hiyerarşi Prosesi), matematik ve psikolojiye dayanan bazı teknikler ile kompleks problemlerin çözülmesinde kullanılan ve uygulanan çok kriterli karar verme araçlarından en önemlilerinden biridir. AHP ile problem, hiyerarşik olarak daha basit alt problemlere ayrıştırılır ve karar verici bu problemleri ayrı ayrı analiz eder. Bu metotta, karar verici alternatif ve kriterleri beraber (birini diğer ikisiyle) karşılaştırır. Çevre ve deprem duyarlı bir planlama yaklaşımı, planlama öncesinde jeoçevresel değerlendirmeye dayalı bir uygunluk değerlendirmesini gerektirir. Uygunluk değerlendirme analizlerinde ise, farklı disiplinlere ait mekansal veri ve bilgiler birlikte sentezlenmelidir. Bu analizlerde jeoçevresel kriterlerin önceliği ve ağırlığı arazi kullanımının türüne göre değişir. Coğrafi bilgi sistemleri (CBS), çoklu kriter analiz yöntemleriyle entegre edilerek, en doğru arazi kullanımının seçiminde mekansal ve mekansal olmayan verilerin birlikte analiz ve sentezini yaparak, jeoçevresel kriterlerin öncelik ve ağırlıklarının belirlenmesini sağlar.

Nihayetinde, Coğrafi bilgi sistemleri (CBS) ve Analitik Hiyerarşi Prosesi (AHP) yöntemlerini birleştirecek çok kriterli karar verme prosesi uygulanmıştır ve bu metot İstanbul kenti sahra hastanesi optimum yerinin belirlenmesinde kullanılmıştır. İstanbul, Boğaz ve Avrupa-Asya'da bulunan Marmara Denizi'nde konumlanan Türkiye'nin en önemli ve büyük kentlerinden biridir. Bu çalışma için, Avrupa bölgesinin Boğaz kıyısında bulunan Beşiktaş semti örnek olay olarak seçilmiştir. Beşiktaş'ın nüfusu TUİK 2013 verilerine göre 1,865,750 'tir ve İstanbul'un en küçük ve önemli semtlerinden biri yapan 21 km2 (8 mil kare) alanı kapsamaktadır. Bu alanda deprem olma riski oldukça yüksek olup belediyenin olası afetlere karşı gereken tesisleri hazırlaması gerekmektedir. Besiktas İstanbul'un Avrupa yakasında yer alan, bünyesinde 7 üniversite kampüsü, 1900 den fazla tarihi eser ve birçok bankanın genel merkezlerini bulunduran, ekonomik, kültürel ve tarihi bakımdan büyük önem tasıyan bir ilçesidir. Bunun yanında ana ulasım güzergâhları Beşiktaş ilçesinde bulunmakta ve günlük nüfusu 2 milyonlara ulasmaktadır. Bu nedenle böyle bir bölgenin risk analizinin yapılması zorunludur.

Bu çalışmada kriter olarak ana arterlere uzaklık, mevcut hastanelere uzaklık, popülasyon yoğunluğu, operasyon süreleri ve yatak kapasitesi olarak tanımlanmıştır. Ayrıca, Beşiktaş'ta bulunan 5 alternatif park da sahra hastanesi alanı seçimi bakımından karşılaştırılmıştır. Bu çalışma İstanbul'da afet durumunda sahra hastanesi en iyi yer seçimi için AHP ve CBS yöntemlerini kapsayan özel bir metot içermektedir.

Bu çalışma optimal sahra hastanesi yeri belirlenmesi için AHP ve CBS yöntemlerini birleştirmektedir. Bu çalışmada, önce alternatifler tanımlanmış, sahra hastanesi en iyi yer seçimi için değerlendirme kriterleri belirlenmiş, en iyi yer seçimi tahmininde AHP ve CBS' nin rolü tanımlanmış ve İstanbul- Beşiktaş bölgesi için en iyi sahra hastanesi seçimi örnek olay sonuçları verilmiştir. Kriterlerin önemi, örnek olayımızdaki faktörleri değerlendiren afet yönetimi konusunda uzman 3 akademisyen tarafından belirlenmiştir.

Sahra hastanesi için en iyi yer seçimini kolaylaştırma, AHP ve güçlü görselleriyle öne çıkan CBS 'nin birleşimiyle desteklenen karar verme metodolojisi kullanılarak sağlanmıştır. Bu kombinasyon afet durumunda karar vermede afet yönetimi gücünü geliştirmek için sahra hastanesi yeri seçimi alternatiflerinin değerlendirilmesinde güçlü bir yöntem sağlamaktadır. Acil durum yönetiminde AHP ve CBS etkileşimi üzerine çalışılmış ve bu üç durumu aynı zamanda ele alan bir model elde edilmiştir. Acil durumlarda karar vermede ve hızlı tepki vermede kriterlerin kesin olarak tanımlanması, analizi ve değerlendirilmesi hayati önem taşımaktadır.

Bu çalışma, konumsal verinin karar vericilerin ve afet yöneticilerinin toplumu afetlere karşı hazırlayan bazı eylemler için karar almada nasıl yardımcı olduğunu göstermektedir. Ayrıca bu, İstanbul'un Beşiktaş semti sahra hastanesi için en iyi yer seçimini belirleyecektir.

Bu çalışma analizi daha iyi yapacak ArcGIS yazılımını kullanarak görsel açıdan güçlü haritalar elde etmektedir. Ayrıca, Expert Choice yazılımını kullanarak gelişmeci bir karar verme modeli sunmaktadır. Bu model afet ve acil durum anında can kaybını önleme adına karar verme prosesini geliştirmektedir.

Bu çalışmada CBS ile ilişkili ArcGIS 10.2 yazılımı kullanılmıştır. Bu yazılım kullanılarak ilgili popülasyon verisini Türkiye İstatistik Kurumu tarafından hazırlanan verilerden alınarak analiz yapılmıştır. Ayrıca, İstanbul haritasının hücresel verilerine, yol ağ haritalarına ve hastanelere Ulaşım Planlama Müdürlüğünden alınan verilere ihtiyaç duyulmuştur. Buna ek olarak park koordinat eksen verileri Beşiktaş Belediyesi tarafından alınmıştır.

ArcGIS'te veriler tanıtılıp dönüştürüldükten sonra, kriter öncelik ve ağırlıklarını tanımlamak için Expert Choice 11 kullanılarak bir AHP modeli oluşturulmuştur.

Sahra hastanesi kurmak için en uygun yer Yıldız Parkı olarak belirlenmiştir. Öncelik sırasıyla Prof. Dr. Aykut Parkı, Beşiktaş Sanatçılar Parkı, Ulus Parkı ve Cemil Topuzlu Parkı da Beşiktaş'ta sahra hastanesi kurmak için en iyi bölgeler olarak seçilmiştir. (Şekil 6.12). Bu parkların ağırlıkları sırasıyla 0.368, 0.249, 0.167, 0.157 ve 0.060'tır.

Tüm öncelikler belirlendikten sonra, duyarlılık analizi kullanılmıştır. Duyarlılık analiziyle amaç altında bulunan kriterlere göre alternatiflerin duyarlılığı gösterilmiştir. Duyarlılık analizinin 5 çeşidi mevcuttur: Dinamik, Performans, Gradyan, Başa baş ve İki Boyutlu (2D).

Oluşturulan modele her bir kriterin önemi ve rolüyle belirlenmiş belirli bir katkısı bulunmaktadır. Dinamik duyarlılık analizinden en önemli kriter olarak 40.9% katkıyla popülasyon yoğunluğu bulunmuştur. Ayrıca, ana arterlere uzaklık da 5.4% katkıyla en az öneme sahip kriter olarak belirlenmiştir. Diğer kriterler bu iki kriter arasındadır. Diğer kriterlerin katkıları 23.4% katkıyla hastaneye uzaklık, 18.7% katkıyla operasyon süresi ve 11.5% katkıyla yatak kapasitesi olarak hesaplanmıştır.

Duyarlılık analizi performansından kriter katkı oranında yapılan küçük bir değişim sonucu etkilememektedir. Bu da modelin güvenilir olduğunu göstermektedir.

Bu çalışma sahra hastanesi planlaması için ana faktörleri analiz etmiş ve CBS-GIS tabanlı özel bir planlama modeli önermiştir. İstanbul Belediyesi'nden alınan verilerle CBS kullanılarak hazırlanan AHP modeli önerilmiştir. CBS' nin ArcGIS yazılımının araçlarından biri olan Buffer Metodu ile görsel haritaların oluşturulmasında bu modele yadsınamaz bir katkısı bulunmaktadır.

1. INTRODUCTION

"Mimarlık In previous decades, the number of hazards and disasters increased significantly. Disasters have violent threat on the people's lives and health, and cuase losses about human life and property. Local and national governments are concerned to the improving ability to oppose to disasters (Gilpin & Murphy, 2008). Disasters may happen anytime and anywhere without any previous warning with different forms. Some of them are natural and some others are man-made. Because of their violent effect on infrastructures of cities and communications, and organizations, they cause huge challenges for people and organization in various levels and fields.

Disaster management defines as a cycle of related activities that are included mitigation, preparedness, response and recovery (TFDM, 2014). The complete cycle of disaster management can modify causes of disasters or decrease and mitigate disaster's effects on people, property, and infrastructure by shaping the public policies and plans (DMC, 2014). In addition disaster manager is a person who knows threats and uses opportunities very well and he should seek the ways to reduce the size of the disaster (TFDM, 2014).

The effects of disaster on health depend on the type of disaster and time of onset. Some disasters happen suddenly such as earthquake and they are called fast onset. Their threats are greater than slow onset disasters (IFRC, 2014). We can response to decreasing the effects of disasters on health, in disaster preparedness phase by doing some preventive activities such as determining field hospital location in different parts of urban area.

Hospitals are one of the most important organizations which face with big challenges within and after disasters. According to the U.S. Geological Survey (2012), the estimated number of people who died because of earthquakes worldwide from 2000-2012 is 812,600. At the disaster times, hospitals need to provide more healthcare services for the large number of people who are injured from destroyed buildings, bridges and houses and these people may arrive to the hospitals at the same time.

Within disaster time, we should consider this point that hospitals also may be affected by the disasters. For example, their staffs may be injured and loss their ability for giving healthcare services to the injured people. So, the number of hospitals which can give health care services to the injured people decrease. This situation will put hospitals in a hard challenge that need preparing for these kind of situations and importance of field hospital will be considered.

1.1 Purpose of Study

The study area is located in Istanbul that is the most important city in Turkey and the risk of happening earthquake is high in there. We selected Besiktas (Beşiktaş) district as a case study that is on the European side of Istanbul, by the coast of the Bosphorus. The population of Besiktas is 1865,750 according to the TUIK 2013 and it cover an area of 21 km2 (8 sq mi) which makes one of the smallest and important districts of Istanbul.

When a disaster is happened, the result of interaction between vulnerabilities and disaster hazards causes injuries and loss of human lives. In this situation, some hospitals and medical facilities will destroy thereby establishing emergency health services is critical. (IFRC, 2014).

Importance of disaster preparedness, the effects of disasters in previous years, and importance of medical services in case of emergency persuaded us to select a proper place for emergency field hospital with using GIS and AHP methods.

The terrorist attack on the World Trade Center and the Pentagon on Sep. 11, 2001 in US were the disaster management experiences and proved that spatial data such as Geographical Information System (GIS), Global Positioning System (GPS), and Light Detecting & Ranging (LIDAR) can be useful and effective in disaster management. Without this information, disaster managers cannot have prompt and reliable decision (Mansourian et al., 2006).

This study will show that how spatial data can help decision makers and disaster managers for making decision to do some activities which prepare the society against disasters. Also, it will determine the best locations for field hospitals in Besiktas district of Istanbul.

1.2 Application

All of people make decision in daily life with their information unconsciously. Namely word, everybody are decision maker in the daily life by evaluating events based on their information that are obtained from occurrences. Sometimes we have too much information but it will not be guarantee for making true decision, information must not be little or much, it must be enough and suitable for making decision (Saaty, 2008). The characteristic of the decision making should be simple, be adapted to group and individuals, be understandable for us naturally, encourage the reconciliation and the unanimity, and should not request for skilful person by deep detail information (Saaty 1982). MCDM problems have multiple attributes that are referred to the goals or decision criteria of MCDM problems and show different dimensions of alternatives which can be considered (Triantaphyllou, 2000).

The main goal of Multi-criteria Decision Making (MCDM) is to help person who is decision maker (DM) for having the best choice among the number of alternative and multi criterion priorities. Erden and Cooskun (2011) said “The multi-criterion choice can be attributed to many spatial decision-making problems involving search and location/allocation of natural resources. These problems, often analysed in GIS, include location/site selection for: service facilities, retail outlets, critical areas, hazardous waste disposal sites and emergency service locations”. Site selection with the MCDM method has four steps are defined as (i) definition of criteria, (ii) expression of relevance of criteria in the respect of decision making process, (iii) improving the sites that are selected as alternatives in MCDM problem, and (iv) defining the pairwise matrices and evaluating alternatives and making decision for site selection problem (Ertugrul and Karakasoglu, 2008).

In this study, five criteria have been considered to find best place for the field hospital in Besiktas of Istanbul as the influence factors. The first and more important criteria is Distance from arterial routs, the second criteria is Distance from existing hospital, the third one is Population density, the fourth criteria is Time to operate and the last one is Capacity of bed. For the first three criteria we prepared the visualized maps by using ArcGIS software from GIS data. Some of the data that we collect them from municipality were raster data and some of were not. In the ArcGIS software we should just use raster data and for some data which were not raster data we use forced to change them to the raster data by using some tools in the ArcGIS software. Decision makers can make reliable decision by using these maps.

Also, we selected five parks In Besiktas as our alternatives for giving priority to them for installing field hospital in there. These park are Yildiz Park, Besiktas Sanatcilar Park, Cemil Topuzlu Park, Prof. Dr. Aykut Barka Park, and Ulus Park. The figure 6.3 shows the location of these parks in Besiktas.

After preparing visualized map, we used Analytic Hierarchy Process (AHP) method which is the subtitle of MCDM for determining the priority of alternatives. AHP is preferred for the site selection problems which is developed by Saaty (1980). The AHP procedure generally involves six steps that are defined as (Lee et al., 2008; Vahidnia et al., 2009) (i) Define the unstructured problem, (ii) Decompose the problem into a hierarchical structure, (iii) Employ pairwise comparisons. Decision elements at each hierarchy level are compared pairwisely, and relative ratings are assigned. Saati (1980) recommended the use of nine-point scale to express preferences between elements as equally, moderately, strongly, very strongly, or extremely preferred (with pairwise weights of 1,3,5,7, and 9) and value of 2,4,6, and 8 are intermediate values, (iv) Calculate the maximum eigenvalues and eigenvectors, (v) Check the consistency of the matrices, and (vi) Obtain an overall rating of decision alternatives by aggregating the relative priorities of the decision elements. An overall priority ranking of the decision alternatives can be obtained by combining the criterion priorities and priorities of each decision alternatives relative to each criterion (chen et al., 2006).

Group decision makers which consist of three experts in disaster management area, evaluated alternatives by using visualized maps and their knowledge, then we made the pairwise matrices and determined the priority of these alternatives by using Expert Choice software.

2. DISASTER AND DISASTER MANAGEMENT

2.1 Basic Definitions

Hazard is a physical event with potential damage that causes loss of life or injury, property damage, social economic disruption or environmental degradation. Hazards may not visible at the time, and it shows its effects in future with deferent origins such as natural events or by human activities or both, such as environmental degradation or technological hazards. Hazard may accrue by single origin and effects, sequential or combined. Any hazard will define by location, intensity, frequency and probability (UN/ISDR 2014).

Disaster defines as a terrible event that is disrupted the functioning of community or society seriously. It causes human, material, and economic or environmental losses that improves the ability of community or society to cope using its own resources. Disaster is a phenomenon that can cause damage to life and property and destroy the economic, social and cultural life of people.

Hazards have different origins and cause disasters. By considering to their origins, disasters will be classified in three groups (Mansourian et al., 2006):

- Natural disasters: Earthquakes, typhoon, tropical cyclone, volcanic eruption, flood, drought and wild fires cause natural disasters.
- Technological disasters: industrial accidents, transport accidents and bomb explosions cause technological disasters.
- Man-made disasters: War and terrorist activities can be considered man-made disasters which may occur in the form of natural or technological accidents.

The extent of the disaster depends on both the intensity of the hazard event and the degree of vulnerability of the society. For example a powerful earthquake in an unpopulated area is not a disaster, while a weak earthquake which hits an urban area with buildings not constructed to withstand earthquakes, can cause great misery (GITEWS 2014).

The most important influential factors that cause increasing disasters are listed (GITEWS 2014):

- **Population growth and gross socioeconomic inequities** between rich and poor countries, which lead to an over-exploitation of natural resources. United Nations Department of Economic and Social Affairs reported that the total population will increase from 6.4 billion in 2005 to 8.2 billion in 2030. Most of this growth will be concentrated in urban area and in the less developed country. This growth will cause that more than half of the world's population will live in the cities and urban areas.
- **Global climate change**, which in long term results in earth warming and an increasing ocean level. Increasing global warming is fast and dramatic for environment. According to the Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change (IPCC), the global average surface temperature has increased by about 0.6°C over the 20th century. The report estimates that the average surface temperature will increase by 1.4 to 5.8°C over the period 1990 to 2100 and the sea level will increase by 0.1 to 0.9 metres over the same period.

The military has main role in the disaster and it is the first responders when hazards are happened. Hierarchical command structure of military leads to its rapid and coordinated response. Military affords to access to the main and vital resources such as distribution, security services, search and rescue, logistics assistance, transportation to have high performance in the disaster. (IFRC 2014).

Disasters have interruptive effects on the society by creating victims and destroying infrastructures. Society should allocate budgets and funds to reconstruct of these effects. Developing countries suffer when disasters occur because they should to divert the budgets that allocated for developing purposes to the reconstructing effects of disasters. So, disasters have negative effects on the developing countries economy.

2.2 Disaster Management

Disaster management defines as a cycle of related activities that are included mitigation, preparedness, response and recovery (TFDM, 2014).

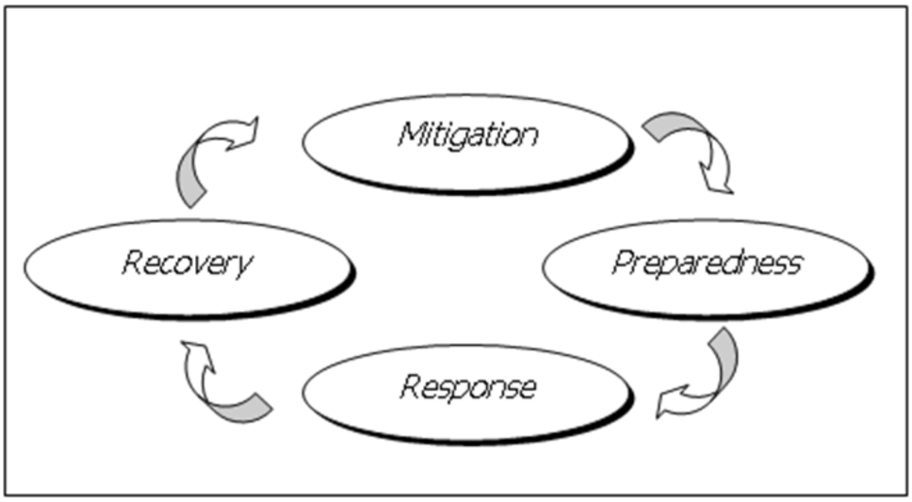

Figure 2.1 : The four phases of emergency management

Mitigation efforts refer to those activities that reduce the vulnerability of society to the impacts of disasters. This phase known as the prevention phase is characterized by the measures taken to reduce the harmful effects of a disaster in order to limit its impact on human health, community function, and economic infrastructure (TFDM, 2014 and Herrmann, 2007).

Preparedness efforts refer to those activities that prepare the government and disaster responders and society for encountering to a disaster, if it occurs. These kinds of activities are arranging practices, training and drill program or increasing anti-crisis plans (TFDM, 2014).

The necessary activities for readiness phais are expressed as (i)Preparing the maps of vulnerability or high risk area in urban and rural an industrial zones, (ii)Preparing the vulnerability and immunization plans, (iii)Determining the committees and duties are require for first aid phase and reconstruction phase, (iv)Determining suitable places for temporary settling, and (v)Determining groups and companies (governmental organizations or private companies) for reconstruction phase.

During this phase, steps are taken to prepare a community or house of worship for disaster, especially high-risk locations (e.g. hospitals in areas that typically flood) and populations. There is supporting research that suggests individuals, communities, and hospitals are more resilient following disaster when they have anticipated and prepared for disaster outcomes. For example, having a personal or family disaster plan can be a step towards mitigating the effects of disaster when it strikes a particular family. Ensuring that all personnel understand their roles in disaster response and are educated on the appropriate evacuation plan for a particular individual, family, agency, department, or organization, and other response activities can achieve similar positive outcomes (TFDM, 2014 and Herrmann, 2007).

Response refers to the necessary activities such as relief, rescue, search, firefighting, medical service, permit control, sheltering, evacuation, law enforcement to response the immediate and short-term effects of a disaster that is focused on primarily actions to save lives, to protect property and to meet basic human needs (TFDM, 2014).

The Recovery Phase focuses on the stabilization and return of the community and health care system to its pre-impact status or what some describe as "getting back to normal." Activities of the Recovery Phase can range from rebuilding damaged buildings and repairing a community's infrastructure to relocating populations and instituting intermediate and long-term mental health interventions. The Recovery Phase can begin days, or in some cases, months after disaster strikes. In the aftermath of catastrophic disasters such as Hurricane Katrina, the concept of returning a community or healthcare system to its pre-impact status might seem unlikely or impossible (Herrmann, 2007).

The complete cycle of disaster management can modify causes of disasters or decrease and mitigate disaster's effects on people, property, and infrastructure by shaping the public policies and plans. The goals of disaster management are elimination of crisis and emergency, returning the society to the normal situation rapidly, decreasing damage of society especially about financial damage and live damage, decreasing the crisis's effects and deal with it with minimal costs, prepare society to deal with crisis, restructuring critical area physically, emotionally and cultural, and arranging practices, training and drill program for people and managers at the different places to reach readiness against crisis (DMC, 2014)

Disaster manager is a person who knows threats and uses opportunities very well. Disaster managers should seek the ways to reduce size of the disaster. In the other word, he should compare the effects of each factor with other parameters and after analyzing, try to eliminate its vulnerabilities. He should know the concept of strategic management and organize the agitation of his mental in the shortest time while disaster is happened.

Roles and responsibilities of disaster manager are defined as full preparedness for any event, preparing updated database for better and efficient utilization, using hazard alarm system although it is very expensive, separating the duties of different rescue teams and implement the annual maneuver, acquainting public opinion, immunization of networks and vital lifeline such as water, electricity, fuel, roads, dams, and airport control tower, identifying different types of crisis and assessing risk and prioritizing them, determining strategies for dealing with the media, organizing the group of disaster management and preparing the disaster management plans, predicting and preventing crises, determining methods for intervention in the crisis, planning and organizing and trying to optimum utilization of resources (TFDM, 2014).

2.3 Effective Steps in Disaster Management

Decision-maker need to be updated about latest emergency situation because disaster response is dynamic and time-sensitive with little permission on delay in decision making and response operation process. Therefore, any problem or delay in data collection, access, usage and dissemination has negative impacts on the quality of decision-making and hence the quality of disaster response (Mansourian et al., 2006). So, disaster managers need to be so quickly and effective in the disasters and for achieving this goal they learn some techniques which are defined as below:

1. **Facing with crisis:** It means that doing any actions that are necessary to reduce the damages and losses caused by the crisis. For example, they should determine the members of disaster management group and define the duties of each members.
2. **Rethinking:** After considering the crisis through encountering, managers need a gap for refreshing and compensating mental and psychological fatigue, but it should not be too long. This gap is opportunity for managers to find answers of questions that are listed as below:

I. What did happen and how did it?

II. What was the cause of this event?

III. Why did this event occur like that?

3. **Renovation Planning:** managers should to prepare renovation plans and improve them continuously. Governments should hold training courses for disaster managers and the end of each course, give certificate to them. These courses should be continuously and started from elementary up to advanced levels.
4. **Intervention and Act:** Feeling and understanding of the disaster symptoms in the especial situation that the primary signs of danger are clear and not negligible, managers may be forced interference. Review of these symptoms, consult with experts and risk assessment of all relevant factors to being ensure that symptoms do not cause the crisis, it is important for managers.
5. **The Last Action in the Face of Crisis:** for example, people who live near the river that overflows sometimes, use sandbags as a method for controlling flood. When flood will happen, and and no way to control flood, then, maybe using sandbags is the just a way for preserving houses, so, these people use sandbags. In the other word, they do everything that they be able to do. Also, when Intervention activities cannot control a primitive disaster, so managers have to use all of organization's facilities as a last action in the face of crisis (TFDM, 2014).

To improving the performance of disaster management before, within and after disaster we have some guidlines that will be offered. The guidelines for crisis prevention are permanent and balanced growth, researching and training, coordinating the activities of relevant organizations in order to prevent crisis, legislating rules and regulations and instructors in order to prevent crisis, having statistic system, strengthening safety culture and prevent crisis culture, and scheduling and resource allocation (TFDM, 2014).

Guildlines for preparedness of crisis are introduced as general and expertize informing for preparedness crisis, existing infrastructure of communication and telecommunication, designing and establishing support systems in order to preparedness of crisis, managing information systems, strengthening preparedness culture within facing with crisis, legislating rules and regulations and instructors in order to preparedness of crisis, researching and training, documentation system for recording the experiences of previous crises, monitoring and evaluating system to improve the process of preparedness of crisis, scheduling and allocating budget for plans of preparedness of crisis, writing a simple and flexible written plan, and having stronger emergency management networks(TFDM, 2014).

Guidelines for encounter and cope with crisis are expressed as informing and debriefing systems, structuring and coordinating operations within crisis, looking for, rescue, evacuating and transferring, medical emergency, general and expertize supporting for rescue operations, and monitoring and evaluating rescue operations (TFDM, 2014).

Also, guidelines for after crisis are demonstrated as structuring and coordinating activities of relevant organizations after the crisis, managing information systems, evaluate primary estimate of needs relative to normalize the lives of disaster victims, settling disaster victims, distributing general necessities ready to use by disaster victims, providing and delivering pure water for drinking and sanitary purposes, providing issues that are related to health and sanitary of disaster victims, providing general sanitary for public sphere, establishing facilities and vital infrastructure for life, supplying required fuel and energy, providing general security for camps and residences, general and expertize supporting after the crisis, evaluating operations of normalize and reconstruction and renovation after the crisis (TFDM, 2014).

2.4 Risk of Disaster:

The risk of disaster is expressed by a compound function of natural hazard and the number of people, characterized by their varying degrees of vulnerability to the specific hazard, who occupy the space and time of exposure to the hazard event (Wisner et al., 2004).

The Disaster Risk utilizes a simple formula as shown bellow (FGI, 2006):

$$\textbf{Risk} = \textbf{Hazards} \times \textbf{Vulnerability}$$

Risk is defined as a probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human induced hazards and vulnerable conditions (FGI, 2006).

Hazard is defined as a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation (FGI, 2006).

Vululnerability is eepressed as a conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards (FGI, 2006).

In the figure 2.2, the circumstance of disaster risk is shown. Natural and human causes make natural and technological hazards which the multiplication of them to the vulnerability will result the disaster risk. Disaster risk has effect on different compounds such as human being, fauna or flora, soil or water or climate, culture or goods. They have interaction effects between themselves and total effects which their resultant make feedback that can change the causes of human and natural hazards.

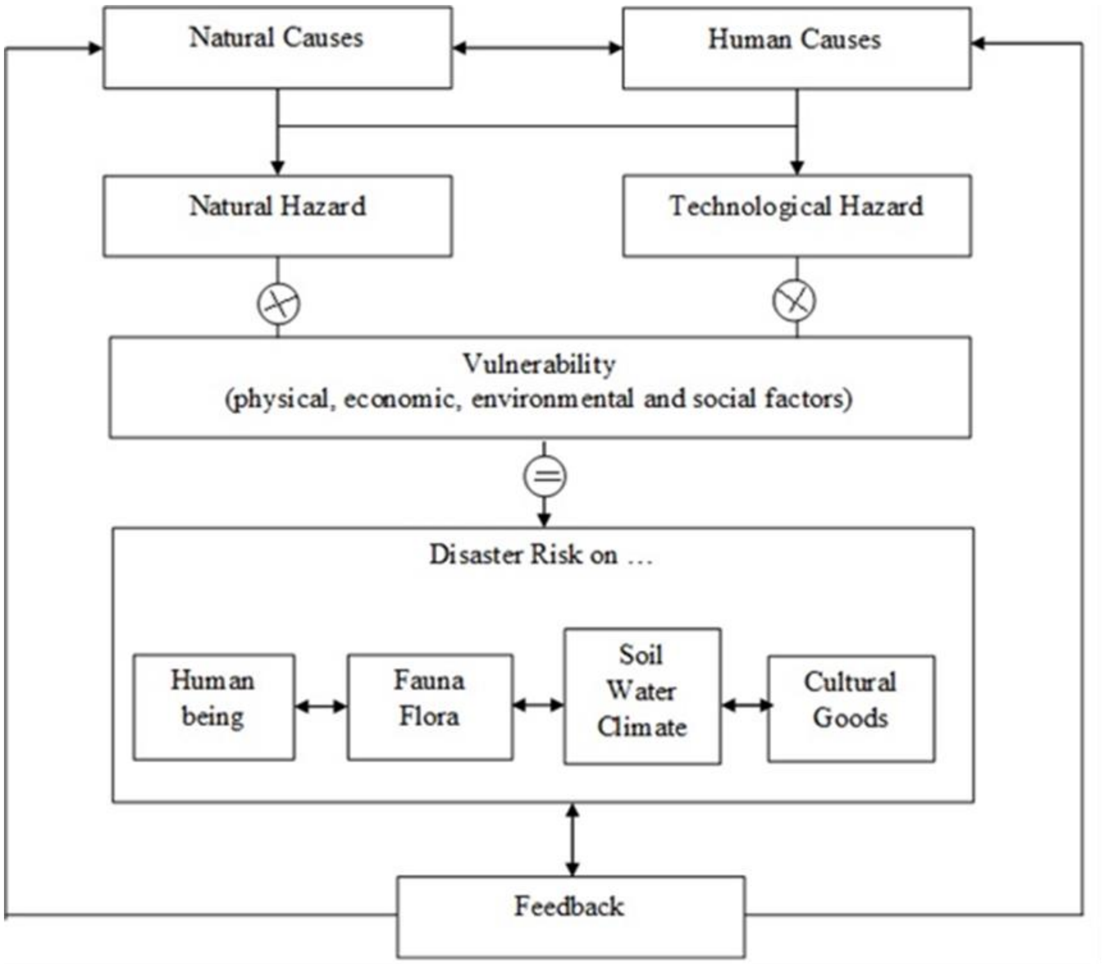

Figure 2.2: Disaster risk as the product of hazard and vulnerability (FGI, 2006).

2.5 Disaster Risk Management:

The systematic management of administrative decisions, organization, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters. This comprises all forms of activities, including structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects of hazards (UN/ISDR 2014).

The disaster risk management consists of some factors that are as bellow:

- **Risk Identification and Assessment:** determining and analyzing the potential, origin, characteristics and behaviour of the hazard.
- **Knowledge of Management:** information programs and systems, public awareness policy, education and training, research in disaster reduction.
- **Political Commitment and Institutional Development:** good governance to elevate disaster risk reduction as a policy priority, integration in development planning and sectoral policies, implementing organizational structures, legal and regulatory framework.
- **Application of Risk Reduction Measures:** planning and implementation of structural interventions or non-structural measures like disaster legislation.
- **Early Warning:** provision of timely and effective information, through identified institutions, that allow individuals exposed to a hazard, to take action to avoid or reduce their risk and prepare for effective response.
- **Disaster Preparedness and Emergency Management:** activities and measures taken in advance to ensure effective response to the impact of a hazard, including measures related to timely and effective warnings as well as evacuation and emergency planning.
- **Recovery/Reconstruction:** decisions and actions taken in the post-disaster phase with a view to restoring the living conditions of the affected population.

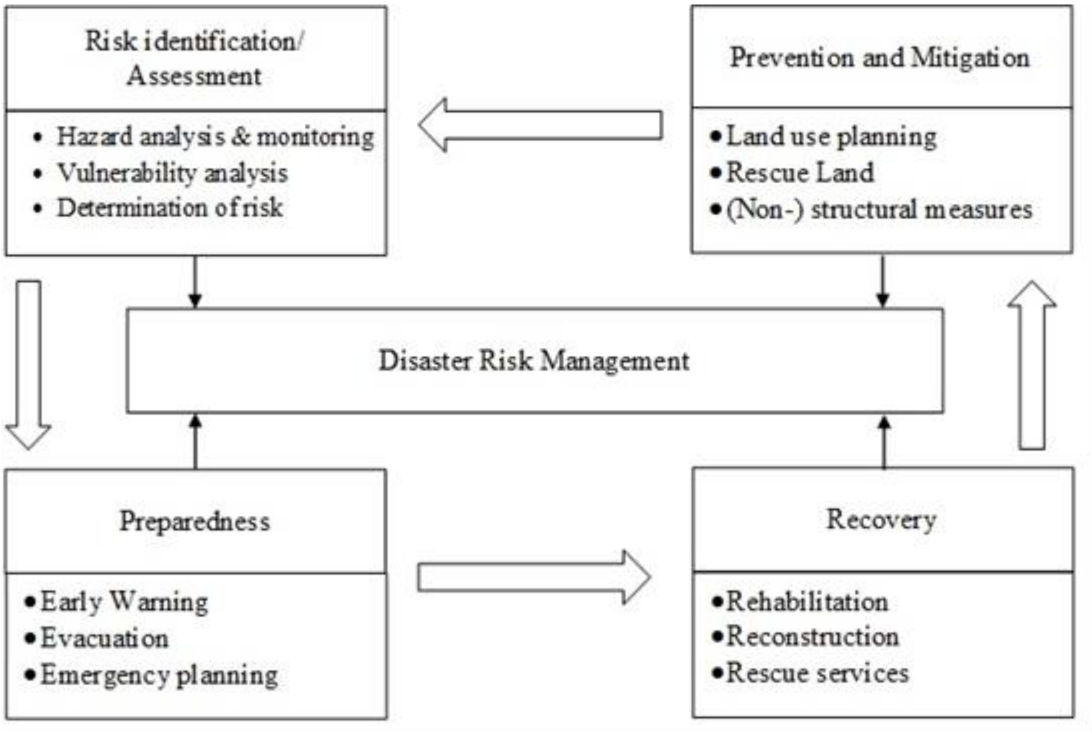

Figure 2.3: Cycle of disaster risk management activities(FGI, 2006).

Based on the above specified components, disaster risk management includes measures before (risk analysis, prevention, preparedness), during (emergency aid) and after a disaster (reconstruction). Sometimes disaster risk management includes only a part of disaster management, focusing on the before of the extreme natural event (FGI 2006).

2.6 Disaster Risk Reduction

The conceptual framework of elements considered with the possibilities to minimize vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards, within the broad context of sustainable development (UN/ISDR 2014). Disaster risk reduction is the series of applicable actions for local performers with national and international organization's support especially in humanitarian actions. Disaster risk reduction (prevention, preparedness and mitigation) and humanitarian and development actions (emergency response, relief and reconstruction) are related to the disaster risk management. (Schipper and Pelling, 2006). The bellow chart shows that measures are interrelated and their resultant can decrease the disaster risk (Rottach, 2014):

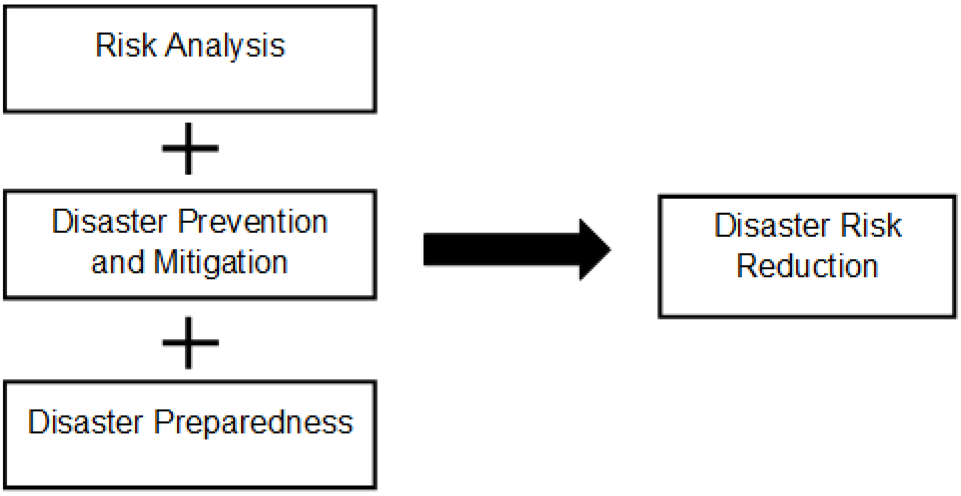

Figure 2.4: Measure of reduction risk disaster (Rottach, 2014).

The Hyogo Framework divided risk reduction into two section, sectorial planning and emergency preparedness or early warning systems. Sectorial planning is defined as traditional development activities unless focused on protecting key infrastructure and economic activities necessary for basic human needs in the event of a disaster. Emergency preparedness is relied on multiple levels of feedback loops to ensure sufficient penetration of disaster education and warnings. The feedback mechanisms needed for DRR is built upon the existence of social capital and community organization. The penetration of disaster education and warning systems is reliant upon community organizations. Similarly the effectiveness of such systems can only be known when feedback occurs. Disaster risk reduction is a part of disaster management that include pre-disaster and post-disaster activities. Disaster risk reduction includes strategies and actions which refer to the wide range of development and cooperation. Therefore, humanitarian should have close interaction with development activities and it can be implemented as a part of relief and rehabilitation programs after a disaster or as a part of developing projects are taken place in the high risk area with the elements of disaster risk reduction or as detached from actual disaster but in the area with high risk in taking place a disaster because this area is prone-area as a result of past events or because scientific research which indicate the area is a disaster hot spot zone. (UNISDR/HFA, 2014).

3. EMERGENCY HEALTH SERVICE

3.1 Basic Definition

When a disaster is happened, the result of interaction between vulnerabilities and disaster hazards causes injuries and loss of human lives. In this situation, some hospitals and medical facilities will destroy thereby establishing emergency health services is critical. The type of health services provided depends on whether the emergency situation is a natural disaster, a complex emergency or protracted refugee health; but it must guarantee basic physical and mental care as well as prevention. In all emergency situations, considering short-term and long-term needs of victims is necessary (IFRC, 2014).

Guidance in providing emergency health care for different kinds of emergencies are defined as (i) mass event with major long-term implications such as an earthquake or tsunami that results in major damage to the health system, (ii) mass event of immediate but limited implications such as a train crash, (iii) intermediate events such as displacement from flooding, and (iv) mass displacement such as refugees fleeing from a neighboring country.

The emergency health program must match the government’s health policies such as essential drugs, treatment protocols and referral systems. The priorities for health services in the emergency phase should focus on treating common health conditions such as trauma injuries, acute infections and acute exacerbation of chronic diseases. In the post-emergency phase, health services can be expanded to include treatment of chronic diseases, comprehensive reproductive health and mental health care (IFRC, 2014).

3.2 Effects of Disasters on Health

The effects of disaster on health depend on the type of disaster and time of onset. Some disasters happen suddenly such as earthquake and they are called fast onset. Their threats are greater than slow onset disasters. The actual and potential health problems resulting from the disaster are multifaceted and do not all occur at the same time. The resulting health problems might be related to food and nutrition, water and sanitation, mental health, climatic exposure and shelter, communicable diseases, health infrastructure and population displacement (IFRC, 2014).

Some of damage to health infrastructure are as disasters can cause serious damage to health facilities, water supplies and sewage systems; limited road access makes it at least difficult for disaster victims to reach health care centers; disrupted communication systems lead to a poor understanding of the various receiving facilities from actual capacity (IFRC, 2014).

For decreasing the effects of disasters on health, we can response according to three levels of preventive health measures that are listed as below (IFRC, 2014):

1. **Primary prevention:** Its goal is providing preventive health care. It aims to prevent the transmission of disease to generally healthy populations by using the following actions:
    - Promoting healthy practices.
    - Implementing public health measures that reduce a population's exposure to risk factors such as ensuring a safe drinking water supply to prevent diarrhoea, an adequate food supply to minimise malnutrition and distributing mosquito nets to prevent malaria.
    - Conducting medical interventions such as chemo-prophylactics against malaria and measles immunisation.
2. **Secondary prevention:** Treat illness people as early as possible to prevent the infection from proceeding to a serious disease or death. It will do by using the following:
    - Alleviating symptoms of diseases such as giving Oral Rehydration Solution early to a child with diarrhoea to prevent dehydration and possible death.
    - Curing patients with diseases through early detection and treatment of TB, dysentery, etc.

3. **Tertiary prevention:** reduces permanent damage from disease such as a patient being offered rehabilitative services to lower the effects of paralysis due to polio or land mine injuries.

3.3 Disaster Preparedness for Health Care

The health objectives of disaster preparedness are defined as (i) Prevent morbidity and mortality, (ii) Provide care for casualties, (iii) manage adverse climatic and environmental conditions, (iv) ensure restoration of normal health, (v) re-establish health services, (vi) protect staff, (vii) protect public health and medical assets.

The most important part of disaster preparedness on health services is training and educating to people and communities that are responder about disasters. These communities will learn important skills and knowledge that are needed for making them effectively. They learn how they can participate in emergency management and which appropriate and critical actions needed in an emergency (IFRC, 2014).

3.4 Establishing Emergency Health Care

The objective of establishing emergency health system is extending the local health care system. Giving services to patient must be effective and coordinated for reaching some goals are defined as comprehensive care which is consisted seeking and finding patients that may not report some illnesses such as depression, persistent headache. Also, continuity of care which is consisted seeking and finding treatment and immunization of some illnesses such as TB. In addition integrated care that is consisted seeking and finding new method to combine curative and preventive ways for treating patients(IFRC, 2014).

The goals of establishing emergency health care for large displaced populations can be defined as reducing excess mortality and morbidity, and targeting the health problems that are causing the excess mortality. Reducing excess mortality and morbidity can be reached by providing the appropriate medical care to those with acute injuries resulting from trauma or acute exacerbation of chronic medical diseases in a disaster's aftermath, and clinical illnesses from communicable diseases. Also, some prevention methods will use to decrease mortality and these method are introduced as implementing preventive health measures that combine primary, secondary and tertiary prevention; targeting vulnerable groups for preventive health services such as children under five, pregnant women, the elderly and unaccompanied minors; and monitoring population and health services data to detect emerging health problems (IFRC, 2014).

For large displaced population, two strategies are basic strategy for preparing emergency health care (IFRC, 2014):

Facility-Based Health Care: Facility-based health care can be established by:

- **Augmenting the local health care system:** Some local health systems will have the capacity to absorb the additional demand from displaced populations, especially in situations where: local services cover the total displaced population, there is little political tension between the local population and the newcomers, there is no excess demand for health services from disease outbreak or mass casualty incidents.

- **Setting up a separate health care system:** Sometimes local services are inaccessible, overloaded or short-staffed. If setting up new facilities is the only option, seek approval from the national health authorities at the beginning. Where possible, policies of the host country health system should be adopted for the points which are followe: clinical diagnosis and therapeutic protocols, essential drugs and drug supply, patient flow and referral system, health information system, training curriculum for health workers including health workers from the displaced population, minimum staffing levels per facility including expatriates, coordinating health care and relations with the national health care system. Creating good coordination between national health authorities and separate health care system is hard for host governments because of existing differences between the levels of health care services for local and national authorities and it is happened especially the local health care is substandard, the host government must prepare health service for displaced population that are free with best quality and they should ensure that not competition exist between local and private health services, cultural and language barriers force government for employ workers who are modern and young for having better understand about foreign documents and etc.

- **setting up mobile or satellite clinics:** Mobile and satellite clinics are appropriate for preventive care activities such as immunizations and antenatal care but they are not appropriate for treating serious medical conditions that require frequent medical cares.

Community-Based Health Care: Some people will not use local health facilities although they have seriously illnesses, until the facilities located nearby and free. Some limitations for finding health care facilities are lack of awareness of available services; access due to various problems such as being too far, inconvenient hours of operation, health workers' poor attitudes, no money for drugs, ethnic-based or politically-based discrimination and inadequate security; and health care resources such as drugs, materials, staff and services.

There are two ways of establishing community-based health care (IFRC, 2014):

1) **Setting up a Community Health Worker (CHW) programs.** Members of Community Health Workers (CHWs) are trained for being the first responders in the acute phase of disasters before arriving external helps. They are intermediaries between victims and heath care systems because of their valuable knowledge about local geography, people and health systems. The adequate level of training for CHWs depends on available resources that include CHW trainers and supervisor and also the CHW's expected role in providing Primary Health Care (PHC). The reasons for setting up a network of CHWs are to extend emergency health care for public health initiatives and preventive health activities such as disease control and surveillance. CHWs train people to improve their own health and prevention measures, thereby decrease the cost of health care facilities. During the acute emergency phase, initial training should focus on simple priority tasks that address immediate health needs such as identifying cases of disease as early as possible, referring the seriously ill as early as possible, identifying vulnerable groups, information, education and communication about disease prevention and control such as water and sanitation and re-hydration and good nutrition and immunization, and data collection on all the above activities.

The following points should be considered when setting up a CHW programme:

- All of CHWs member must be ethnic and at least half of them must be female.
- Some CHWs are analphabet, so they need training and updating health protocols with different ways that must be understandable for them. Some of these way are as showing picture, verbal communication etc.
- Define CHW's roles clearly.

2) **Integrating alternate health providers:** Some disaster victims use the services of alternate health providers and government must integrate these alternate health providers into the emergency health system. Some health providers that are invited in the emergency health system are such as modern health practitioners, Non-Government Organization (NGO) hospitals, elders, religious leaders, teachers, and social service organizations community.

3.5 Setting Standards for Emergency Health Care

Health workers will integrate from local health services and external teams who have different training background for delivery health services to the displaced population. For integrating this teams and groups, governments must standardize their emergency health training. Some advantages of this standardization are defined ase asier integration of new staff members, regulating patient referrals to higher levels of care, improving management of drugs and equipment, preventing competition between facilities that provide the same care (IFRC, 2014).

Also, to prevent unnecessary treatment, investigations and the wastage of limited resources, drugs and staff, standard for emergency health care management procedures must be established. These include standard (IFRC, 2014):

- Diagnostic protocols and case definitions.
- Procedures for diagnostic common illnesses.
- Investigation procedure.
- Treatment protocols. Most countries have established national treatment protocols for common ailments based on the essential drugs supply.

- Admission criteria. Standardizing admission procedures prevents the admission of non-serious cases that could overload inpatient facilities.
- Referral criteria. Standardizing the criteria for patient referral helps define the limits of each level of care and the health conditions that require higher level of attention and skills.

3.6 Mass Casualty Incident

A Mass Casualty Incident (MCI) is any incident with large number of victims that disrupt the normal capabilities of the local health service and its resources such as personnel and equipment. In a Mass Casualty Incident (MCI), large number of people who are victims need local health care services. MCIs include all events from a bus accident to natural disasters that have the large number of victims who need health care service. These people need immediately medical care after disasters and for achieving this goal, disaster health management requires to define guidelines of an Incident Command System (ICS), triage and patient flows according to the hospital's plan. MCI procedures should be adapted to the local situation in terms of staff skills, transport, communication, supplies and equipment. Standardization of routine emergency activities will make the teams more efficient and will improve the overall survival of MCI victims (IFRC, 2014).

3.6.1 Management of Mass Casualty Incident (MCI)

Management of MCI will start by preparing the mobilization of resources and following the standard procedures in the field and at the hospital. Countries with limited resources should focus on the following preparations for managing a MCI (IFRC, 2014):

- Improving routine emergency services for sudden-impact, small-scale incidents such as car accidents or accidents in the home. To avoid confusion, the same procedures that are necessary to save lives during an MCI should be performed during routine emergency services.
- Coordinating activities that involve more than one emergency unit such as police, fire fighters, ambulances and hospitals, etc. Each emergency unit (police, fire, health) should be prepared to respond to a MCI.

- Ensuring a quick transition from routine emergency services to mass casualty management.
- Establishing standard procedures for managing incidents of all scales such as search and rescue, first aid, triage, transfer to hospitals and hospital care.

Basic MCI management is a series of steps that together meet the immediate health needs of disaster victims. It begins with a search and rescue at the disaster site and ends with either a referral to a health facility or release for home care. Figure 3.1 illustrates the general organisation of an MCI management field (IFCR 2014).

MCI process is shown in the figure 3.1, each team has especial responsibilities to rescue all victims of disaster and transfer them to the hospitals. These responsibilities are giving by the Rapid Assessment Team. The responsibilities of each team are following:

- Command Post Team: The incident commander based at the command post has overall authority coordinating the multi-sector operation. The Command Post Team’s responsibility is to set up the field posts and assess and report continuously on the general situation. The Command Post’s location should be strategically placed close to the disaster center but far enough from the center so that risk of continuing danger is minimized such as down wind of a forest fire or chemical spill or high ground in a flood.
- Search and Rescue Team: The search and rescue team’s priority is to locate and evacuate victims from the impact zone and transfer them to the medical post after assessing their status. The search and rescue team may provide to victims in the impact zone essential first aid measures such as control bleeding, maintaining clear airways, but this is not the time for cardiopulmonary resuscitation.
- Triage Team: The triage team, under the leadership of the Triage Officer, tags, treats and releases patients from the medical post according to their health conditions.
- Medical Post: A medical post should be established as close as possible to the impact zone while again maintaining a safe distance. The medical post should be located in a building or shelter as soon as possible.

- Evacuation Team: The evacuation team is responsible for the safe transfer of stabilized victims to a health care facility using the most appropriate transport and escorts available. Victims with minor injuries may be transferred by non-medical transport after all acute victims have been evacuated. Upon arrival at the hospital, every injured person must be re-triaged, reassessed, stabilized and given definitive care.

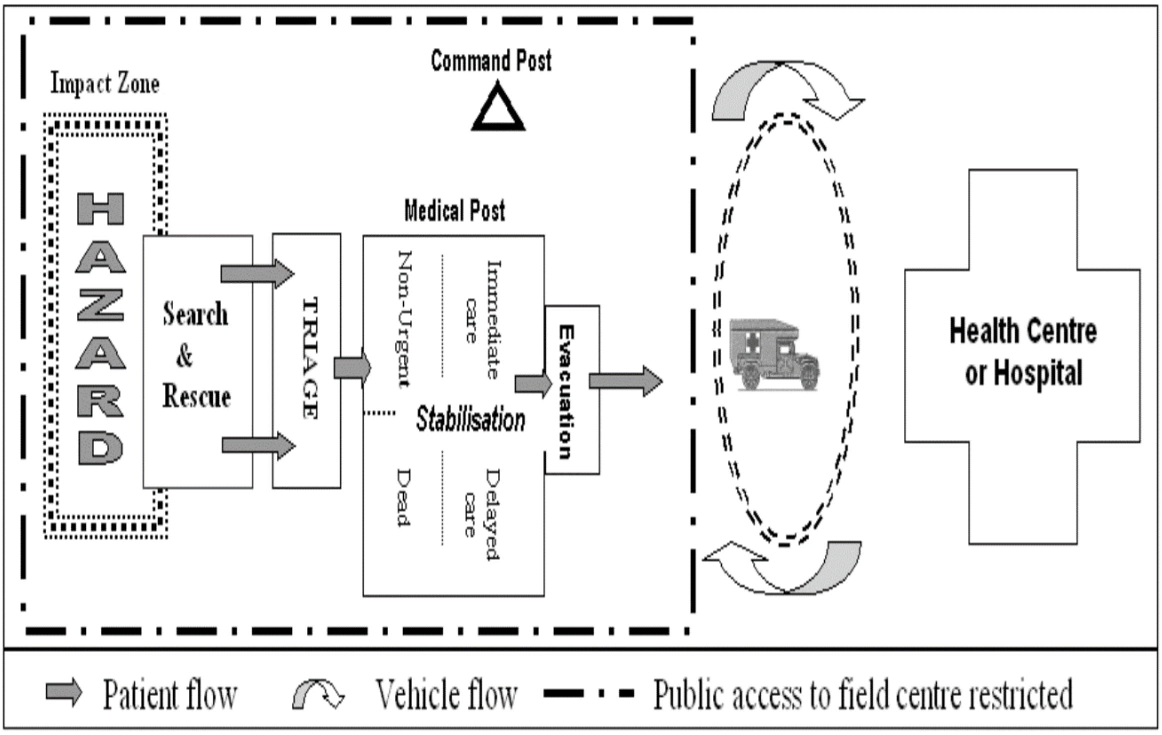

Figure 3.1 :General organisation of a Mass Casualty Management field (IFRC, 2014).

3.6.2 The incident command system

Incident command system is a hierarchical structure that commands, controls and coordinates an effective emergency response among all the agencies and organizations in a disaster. It is designed to organize people and resources and to allocate necessary services to the population in need. Incident command system was developed in the United States in 1970 after previous problems with MCI responses. Previous problems included inadequate planning, poor communications, lack of an on-the-scene needs assessment and inappropriate triage of patients. Incident command system is composed of five major components:

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- Incident command.
- Operations.
- Planning.
- Logistics.
- Finance.

In a small incident, the incident commander can manage with the above five components. In large scale incidents, a chief for each sector will be necessary to report to the incident commander.

Commander, who establishes information that are consisted the time and extent of the damage, the potential continuing danger from the disaster, the estimated number of casualties and exposed victims, the resources needed for response.

The structure of Incident command system organizational is explained in the figure 3.2 is follow.

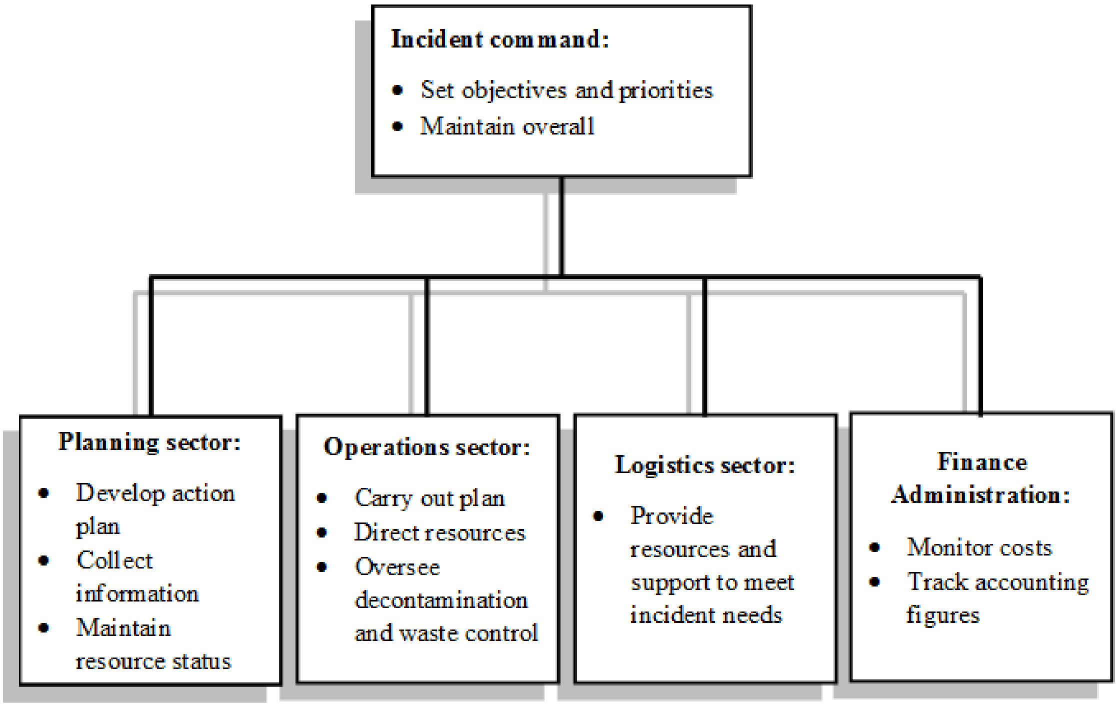

Figure 3.2 : Incident command system organizational structure (IFRC, 2014).

3.7 Triage

The main roll of triage in disasters is sorting and defining priority for victims because of shortage of facilities for all victims. Triage defines priority for victims based medical attention according to the degree of injury or illness and expectations for survival, thereby health facilities such as personnel, supplies and transportation vehicles will be free to attend to more critical tasks. When health facilities cannot meet the needs of all victims immediately, it is appropriate to give the limited resources to those most likely to survive. Each patient's need for medical care is judged as being urgent or not urgent, based on the patient's condition rather than relative to other patients.

The commonly used triage system is the classification of the patient's medical condition into four levels:

- Immediate medical care.
- Delayed care.
- Non-urgent or minor.
- Dead or near dead.

Triage has some general rules which are defined as in borderline cases, select the more urgent category; when children are involved, give them priority over adults in the same triage class; give a higher priority than the medical condition warrants to victims with hysteria or hysterical relatives; stabilise all patients before giving further care to any individual; and definitive care such as cleaning and stitching wounds, antibiotic treatments, applying plaster for fractures etc. can be started once no more casualties arrive and all the injured are in a stable condition.

3.8 Field Hospital

3.8.1 History

The idea of establishing international aid organization was born during the Battle of Solferino in 1859. This battle was the mutation for the aid activities and aid organization. Swiss Henri Dunant organized volunteers to help the victims of the Battle of Solferino in Northern Italy in 1859, and wrote a book about his experiences, A Memory of Solferino (1862). He proposed that a voluntary organization be started in every country to help provide medical care in time of war and that the care of the wounded would be ensured through international treaties. At the first half of next year, a committee was establish in Geneva which in 1876 became the International Committee of the Red Cross. Dunant recommended the tasks of aid organization and their establishment. After that, national organization established in different parts of Europe and then in other countries.

The first field hospital equipped by the Finnish Red Cross during the war in Turkey in 1977. The organization of first aid courses began in 1885 with the training of railway workers and policemen. The organization of blood donations was transferred to the Red Cross in 1948 (FRC, 2014).

Figure 3.3: Field hospital in the past (FRC, 2014).

3.8.2 Definition of field hospital

Field hospital is defined as a large mobile medical unit, or mini hospital which temporarily takes care of victims in the casualty site before they can transfer to the permanent hospital facilities. A field hospital is consisted of mobile medical kit and often, a wide tent as a shelter. So, it can be install near the center of disaster for giving health care services to the victims. In urban areas, field hospital will set up in an easily accessible and highly visible buildings such as school, restaurant, stadium, park, etc. Field hospital is smaller than a permanent hospital but bigger than temporary first aid station (WIKI, 2014).

Mobile, self-contained, and self-sufficient health care facilities that are capable with rapid deployment and expansion or contraction to meet immediate emergency requirements for a specified period of time need to set up field hospital. It can be set up as a tent and can be classified in four groups that are classified as hospitals are into the metal containers with the ability to transport by plane, helicopter, boat, trailer, train; hospitals are into the containers and drag by trailer; hospitals are into containers that are shipped on trucks; and hospitals are into the standard or inflatable tent (Schreeb et al., 2013). Fuigers 3.4, 3.5, and 3.6 are shown the perespective and CPR room and ward of feild hospital.

Figure 3.4: The perspective of field hospital with 50 beds (EIR, 2014).

Figure 3.5: The ward of field hospital (EIR, 2014).

Figure 3.6: The CPR room in a field hospital (EIR, 2014).

3.8.3 General field hospital

General field hospital will deploy in an area that is damaged with a nature disaster. It acts as a referral hospital for mobile and fixed basic health care centers and gives health care services to the victims. General field hospital consists of surgery unit, laboratory unit and often, maternity ward with gynaecology services and ante-postnatal guidance. Staffs in it will assess and treat trauma patients, pediatric patients, and infection diseases. Setting up the general field hospital needs the minimum area about 4000 to 6000 square meters of suitable land. The ingradients of general field hospital are about 70000 kilos and for transferring them to the damaged area needs five semi-trailer trucks or two regular freight planes. The general field hospital has the capacity to serve a population of 200,000 to 300,000. It has the ability to treat 150 to 250 patients per day. Standard ward capacity of the hospital is 160 beds. (FRC, 2014).

Deployment layout for general field hospital is shown in the figure 3.7. It is consisted of 29 sectors that are appropriated as 1. Gate 2. Water point 3. Latrine 4. Ward unit 5. Laundry 6. Showers 7. Kitchen 8. Morgue 9. X-ray 10. Medical warehouse 11. Laboratory 12. Intensive care unit 13. Operation theatre 14. Sterilization 15. Dispensary 16. Administration, incl. communication and data traffic 17. Workshop, general stockroom and technical depot 18. Communication antenna 19. Dressing unit 20. Outpatient unit 21. Water storage 22. Water purification 23. Generators 24. Waiting area and patient registry 25. 4x4 pickup 26. 4x4 all terrain vehicle 27. Personnel accommodation area 28. Sauna 29. Dining area, relaxation area.

Figure 3.7 : General field hospital's layout (FRC, 2014).

The staffs of general field hospital is consisted of one team leader, one medical coordinator, one surgeon, one anaesthesiologist, one gynaecologist, one paediatrician, one general practitioner, sixteen nurses (specialities: OT, anaesthesia, paediatrics, midwife, ward nurses), one pharmacist, one laboratory technician, one X-ray technician, one administration delegate, one Information delegate, five technical delegates (specialities: water and sanitation, IT, electricity plus generalists).

The laboratory unit should be existed in the basic layout of general field hospital and surgical field hospital. This unit must be able to perform twenty to thirty different laboratory examinations based on samples of blood, urine, faeces, and other excrete and puncture samples. The laboratory's staffs are consisted of one laboratory technician delegate and two local laboratory technicians. The different parts of laboratory unit is shown in the figure 3.8 and its sectors are listed as 1. Patient area. "Staff only" on the other side of the curtain 2. Heating poultice 3. Cell counter and blood glucose meter 4. Microscope 5. Laboratory fridge 6. Laboratory accessories 7. Sampling tubes 8. Water container 9. Centrifuge 10. Examination of urine, faeces and other excrete samples is performed in this part of the laboratory 11. Examination of blood samples is performed in this part of the laboratory 12. Blood sampling (FRC, 2014).

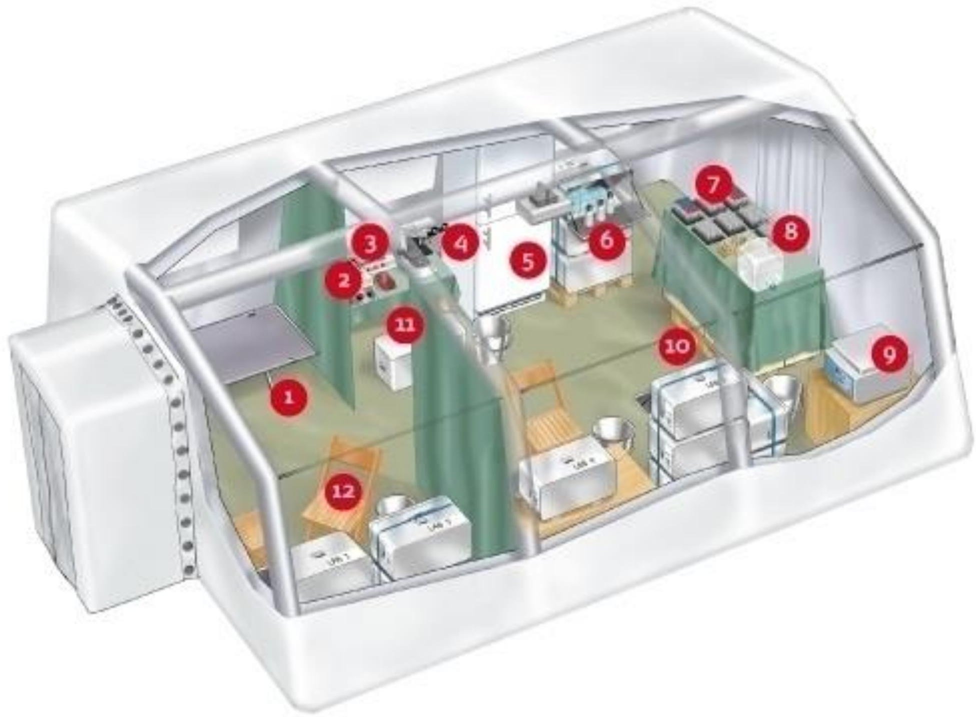

Figure 3.8: Different parts of laboratory unit (FRC, 2014).

3.8.4 Surgical field hospital

The surgical field hospital has the capacity to serve a population of 200,000 to 300,000. It has the ability to treat 50 to 100 patients per day. Surgeons can perform anything up to 20 operations per day. Standard ward capacity of the hospital is 80 beds. Setting up a surgical field hospital requires a minimum of 3.000 to 5.000 square meters of suitable land. Deployment layout for surgical field hospital is same as general field hospital that shown in the figure 3.7. The operation theatre is the basic part of both the general field hospital and the surgical field hospital. In this unit, all of operation from head to toe can be done such as trauma surgery, treatment of large wounds, fracture repairs, and performing amputations. The figure 3.9 depicts the deployment of operation theatre tent and its sectors are listed as 1. Patient preparation 2. Oxygen concentrator 3. Fluids, IV-equipment, tubes, syringes, needles etc. 4. Anaesthesia machine 5. Electric suction machine 6. Hand washing 7. Operating table 8. Surgical clothes 9. Instrument table 10. Mayo table 11. Instruments 12. Diathermy device with which i.e. leaking blood vessels are sealed 13. Operation theatre light with battery 14. Ceiling light fixture (FRC, 2014).

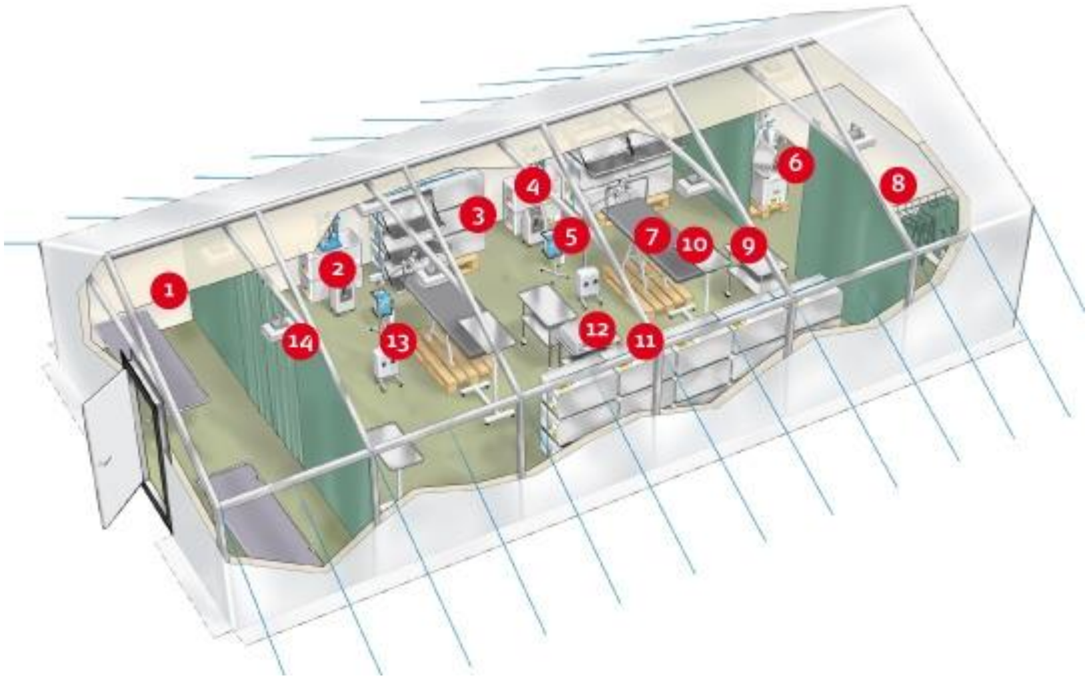

Figure 3.9: Different parts of operation theatre tent (FRC, 2014).

4. LITERATURE REVIEW

4.1 GIS or AHP Applications for Site Selection

Abstract Mathematical Models and GIS combined with AHP are two ways to prepare the plan of field hospital. The first step in the Abstract Mathematical Models method is that identify problem by choosing elements that need to be researched into according to the requirement of fire sites selection. Then we should build model by using of mathematical equations or geometric symbolic. At the end, we should solve problem under previous steps (lai et al., 2011).

We can solve the site selection problems which have just one factor. But, some factors such as density data is difficult to define by mathematics equation. Furthermore, it needs specific mathematics skills because of complicated models. Also, converting this model from mathematical models to the computer models is very difficult. Some abstract models are easy to dissociate from reality, and it is not easy to consider all the complicated essential factors and their common impacts. The versatility of this traditional method is not so good. Therefore, it is hard to provide interactive analysis-tools to policy-making people (lai et al., 2011).

We should consider about that the site selection models are understandable models. Also, there is different types of GIS software and it protect us to realizing all of foundational analysis. In addition, expansion functions of GIS can also be used to develop excellent man-machine interactive interface. So, using GIS with AHP is considered by scientists these days and they use this method for site selection problem (lai et al., 2011).

Land-use suitability analysis aims at identifying the most appropriate spatial pattern for future land uses according to specify requirements, preferences, or predictors of some activity (Hopkins, 1977; Collins et al., 2001). The GIS-based land-use suitability analysis has been applied in a wide variety of situations including ecological approaches for defining land suitability/habitant for animal and plant species (Pereira and Duckstein, 1993; Store and Kangas, 2001), geological favourability (Bonham-Carter, 1994), suitability of land for agricultural activities (Cambell et al., 1992; Kalogirou, 2002), landscape evaluation and planning (Miller et al., 1998), selecting the best site for the public and private sector facilities (Eastman et al., 1993; Church, 2002), regional planning (Janssen and Rietveld, 1990) and environmental impact assessment (Moreno and Seigel, 1988). But, considerable attention has been paid to integration of the multi- criteria decision making approach with GIS for solving spatial planning problems (e.g. Sharifi and Retsios, 2004). Malczewski (2006) has provided a comprehensive review on integration of GIS and multi-criteria decision analysis and has shown that during last two decades there has been significant interest in developing GIS-based multi-criteria decision analysis in many different field of researches including ecological sciences, urban-regional planning, waste management, hydrology and water resource, agriculture, forestry, natural hazards, recreation/ tourism, housing/real estate, geological sciences, manufacturing and cartography.

Siddiqui et al. (1996) were the first to use a combined geographical information system (GIS) and analytical hierarchy process (AHP) procedure to aid in site selection. Similarly Charnpratheep et al. (1997) uti-lized fuzzy set theory with GIS for the screening of landfill sites in Thailand.

In recent years, there have been a number of papers published about site selection using spatial information technologies and AHP (Guigin et al., 2009; Sener et al., 2006; Kontos et al., 2005; Jun, 2000; Reveshti and Heidari, 2007; Eldrandaly et al., 2003). Kontos et al. (2005) described a methodology which comprises several methods from different scientific fields such as multiple criteria analysis, GIS, spatial analysis and spatial statistics to evaluate the suitability of the study region in order to optimally site a landfill. Sener et al. (2006) have also dealt with landfill site selection problems considering several map layers from topography to land use. They have used GIS and multi criteria decision-making methods such as AHP and weighted linear combination in their study. Raveshti and Heidari (2007) have proposed fire extinguisher stations for the city of Zanjan in Iran by using AHP and network analysis method in ArcGIS. Jun (2000) have developed a framework for integrating the strengths of GIS, expert systems and the AHP to incorporate the decision maker's preferences on a range of factors used in finding optimally suitable sites. Eldrandaly et al. (2003) have suggested a decision support system to select the location of the industrial sites in which expert systems, GIS and the AHP were successfully integrated by using the component object model technology.

4.2 GIS applications in Decision Making

Vahidnia et al. (2009) said that "During the last few years, GIS has been used as a system for management, manipulation, representation and analysis of geospatial data to facilitate and cut down costs in the site selection process." The general goal of site selection problems is to find the best location which is optimum about satisfying the problem's criteria (Healey and Ilbery, 1990). The site selection process has two stages that are defined as screening for defining alternative from large geographical area and evaluating of alternatives for selecting optimum site (Chang et al., 2008).

Broadly defined, land-use suitability analysis aims at identifying the most appropriate spatial pattern for future land uses according to specify requirements, preferences, or predictors of some activity (Hopkins, 1977; Collins et al., 2001). The GIS-based land-use suitability analysis has been applied in a wide variety of situations including ecological approaches for defining land suitability/habitant for animal and plant species (Pereira and Duckstein, 1993; Store and Kangas, 2001), geological favourability (Bonham-Carter, 1994), suitability of land for agricultural activities (Cambell et al., 1992; Kalogirou, 2002), landscape evaluation and planning (Miller et al., 1998), selecting the best site for the public and private sector facilities (Eastman et al., 1993; Church, 2002), regional planning (Janssen and Rietveld, 1990) and environmental impact assessment (Moreno and Seigel, 1988) which is to be applied in this research. Considerable attention has been paid to integration of the multi- criteria decision making approach with GIS for solving spatial planning problems (e.g. Sharifi and Retsios, 2004). A land suitability assessment is a planning tool for the design of a land-use pattern that prevents environmental conflicts through the segregation of competing land-uses (Eastman et al., 1993). It is a decision problem under multiple criteria and multiple objectives that, when adapted into a geographical information system (GIS), produces a land-use pattern that minimizes conflicts and maximizes consensus among the stakeholders (Eastman et al., 1993 and Malczewski et al., 1997). In fact, land-use decisions depend upon the socioeconomic activities and the character of the involved social organizations (Malczewski and Ogryczak 1995). However, environmental conflicts appear whenever different sectors with incompatible activities compete for available land (Bojorquez-Tapia et al., 1994). Environmental conflicts over the allocation of land have resulted in laws and policies that require public participation in decision making. Since ideas, values, and attitudes over natural resources vary between social organizations and people (Smith et al., 1995), the goal is to provide the zone with an opportunity to collaborate and to reach consensual land-use decision making (Bojorquez-Tapia et al., 1994, Brown 1986). Conflict resolution then implies making judgments about the stakeholders' goals and interests (Edwards and Newman 1986). It also include the comparison of trade-offs among different decisions resulting from particular sectorial interest and land use scenarios (Van Huylenbroeck and Coppens 1995). Hence, a critical issue in consensual decision making is the credibility of the conflict resolution process particularly with respect to the unique demands of the stakeholders involved in participatory planning (Selin and Chavez 1995). A land suitability assessment is a planning tool for the design of a land-use pattern that prevents environmental conflicts through the segregation of competing land-uses (Eastman et al., 1993). Hence, GIS-based assessments have to include the three land-use decision elements at the regional scale (Smith et al., 1995): (1) the distribution of land cover, population, and human activities over the landscape, or infrastructure; (2) the social organizations present in a region, or structure, and (3) the ideas, values, and attitudes that people have about the particular uses of the land, or superstructure.

Malczewski (2006) has provided a comprehensive review on integration of GIS and multi-criteria decision analysis and has shown that during last two decades there has been significant interest in developing GIS-based multi-criteria decision analysis in many different field of researches including ecological sciences, urban-regional planning, waste management, hydrology and water resource, agriculture, forestry, natural hazards, recreation/ tourism, housing/real estate, geological sciences, manufacturing and cartography.

4.3 AHP Applications in Site Selection

Nowadays people bump into many policy-making problems in their daily life. For example, if you want to buy a shirt, you must make the choices like whether to buy shirts made of cotton, silk or polyester fiber. If you invite friends to have a dinner, you must make choices like holding the dinner at home or going to a restaurant.

When people handle with these policy-making problems, they have to consider different kinds of factors, but they have commons in features such as relating to economy, society, humanity and etc. When making comparison, judgment, evaluate and decision, we find that it is always difficult to quantify the importance, influence or priority of those factors (lai et al., 2011).

Multi-criteria decision making implies a process of assigning values to alternatives that are evaluated along multi-criteria. Multi-criteria decision making can be divided into two broad classes of multi-attribute decision making and multi-objective decision making. If the problem is to evaluate a finite feasible set of alternatives and to select the best one based on the scores of a set of attributes, it is a multi-attribute decision making problem. The multi-objective decision making deals with the selection of the best alternative based on a series of conflicting objectives (Massam, 1988). Both multi-attribute decision making and multi-objective decision making problems can be single-decision-maker problems or group decision problems. There are many classifications in place for the extensive formal methods and procedures for handling multi-criteria decision making (Hwang and Masud, 1981; Massam, 1988).

The Analytical Hierarchy Process (AHP) described by Saaty (1980) is one of the more useful methodologies, and plays an important role in selecting optimized alternatives (Dey and Ramcharan, 2008). AHP is a partial form of the Analytic Network Process (ANP), which models the decision process as a sequence of uni-directional, hierarchical relationships rather than a complex network of objectives (Tuzkaya et al., 2008).

The multi criterion choice can be attributed to many spatial decision-making problems involving search and location/allocation of natural resources. These problems, often analyzed in GIS, include location/site selection for: service facilities, retail outlets, critical areas, hazardous waste disposal sites and emergency service locations (Jankowski, 1995).

Crouch and Ritchie (1998) proposed a 5-step conceptual model of the site selection process and identified several categories of site selection factors, together with various history conditions and competing sites influences. The five steps are convention preplanning, site selection analysis and recommendations, site selection decision, convention held, and post-convention evaluation. The factors affecting the site selection decision can be broadly divided into site-specific and association factors (Weber and Chon 2002).

Some tools ad systems are useful for site selection problems such as Expert Systems (ES) for well-defined and structured problems and Decision Support System (DSS) for ill-structured problems or their combination (Vahidnia et al., 2009). But for ill-structured or semi-structured problem, combining GIS and MCDM techniques can simplify the process of site selection (Zucca et al., 2008; Chang et al., 2008; Witlox, 2005; Vahidnia et al., 2009).

The AHP method has been used for a wide variety of decision makings in fields such as government, business, industry, healthcare, and education (Boroushaki & Malczewski, 2008; Forman & Gass, 2001; Jyrki et al., 2008; Linkov, Satterstrom, Steevens, Ferguson, & Pleus, 2007; Raharjo, Xie, & Brombacher 2009; Saaty, 2008), and also for site-selection problems. For example, Ballis (2003) used the AHP method for an airport-site selection on the Island of Samothraki, Greece, and Korpela, Lehmusvaara, and Nisonen (2007) selected a warehouse operator network using a combination of the AHP and DEA methods. Also, Onut and Soner (2008) used the method for trans-shipment site selection and Rosenberg and Esnard (2008) used a hybrid version for a transit site selection. Furthermore, Hsu, Tsai, and Wu (2009) used the method to analyze tourist choice of destination, Dagdeviren, Yavuz, and Kilinc (2009) to analyze the problem of weapon selection, and Garcia-Cascales and Lamata (2009) to choose a cleaning system for engine maintenance.

5. METHODOLOGY

The analysis of the way people make decisions (prescriptive theories) or the way people should to make decisions (normative theories) is perhaps as old as the recorded history of mankind. Of course, not all these analyses were characterized by the difficult scientific approaches we see in the literature today. Therefore, it is not surprising that the literature in decision making is very much and continuously increasing. At the same time, however, the development of the perfect decision making method for rational real life decision making still remains a smart goal. This contradiction between the extensiveness of the study on this subject and the smartness of the final goal of the real life applicability of the findings, constitutes in a way the ultimate decision making paradox (Triantaphyllou, 2000).

For a very long time people believed and argued strongly that it is impossible to express the intensity of people's feelings with numbers. The abstract of such a belief was expressed by A.F. MacKay who writes in his book MacKay, A.F. Arrow's Theorem: The Paradox of Social Choice - A Case Study in the Philosophy of Economics. It was also expressed by Davis, P.J. and R. Hersh, "Descartes Dream", Harcourt Brace and Jovanovich, New York, 1986, "If you are more of a human being, you will be aware there are such things as emotions, beliefs, attitudes, dreams, intentions, jealousy, envy, yearning, regret, longing, anger, compassion and many others. These things- the inner world of human life- can never be calculable." LeShan, L. and Margenau H. (1982) said that we cannot as we have indicated before, quantify the observables in the domain of consciousness. There are no rules of correspondence possible that would enable us to quantify our feelings. We can make statements of the relative intensity of feelings, but we cannot go beyond this. We can say, "I feel angrier at him today than I did yesterday "We cannot, however, make meaningful statements such as, I feel three and one half times angrier than I did yesterday."

George Allen and Unwin (1910): "But even the opponents of psychophysics do not see any harm in speaking of one sensation as being more intense than another, of one effort as being greater than another, and in thus setting up differences of quantity between purely internal states." Common sense, moreover, has not the slightest hesitation in giving its verdict on this point ; people say they are more or less warm, or more or less sad, and this distinction of more and less, even when it is carried over to the region of subjective facts and unextended objects, surprises nobody.

All of people make decisions in daily life with their information unconsciously. In another word everybody is a decision maker in the daily life by evaluating events based on their information that is obtained from events. Sometimes we have too much information but it will not be guarantee for making true decision, information must not be little or much, it must be enough and suitable for making decisions (Saaty, 2008).

For making decision we should know the problem and needs, purpose, criteria, and sub-criteria of decision and groups affected and alternative actions. Then, we will define the priority of alternatives for selecting the best alternatives or allocating resources(Saaty, 2008).

The characteristics of the decision making are listed as bellow (Saaty 1982):

- Its construction should be simple.
- It should adapt to groups and individuals.
- It should be understandable for us naturally.
- It should encourage the reconciliation and the unanimity.
- It should not request for skilful person by deep detail information.
- The detail of the decision making processes should be reviewed easily.

Decision makers should select best method of DM by comparing their value and efficiency for making decision within too many decision methods. Each of the methods uses numeric techniques to help decision makers choose among a discrete set of alternative decisions. This is achieved on the basis of the impact of the alternatives on certain criteria and thereby on the overall utility of the decision maker(s) (Triantaphyllou, 2000).

5.1 Multi Criteria Decision Making

Multi-Criteria Decision Making (MCDM) has been one of the fastest growing problem areas during at least the last two decades. In business, decision making has changed over the last decades. From a single person (the Boss!) and a single criterion (profit), decision environments have developed increasingly to become multi-person and multi-criteria situations. In theory many methods have been proposed and developed since the sixties to solve this problem in numerous ways. Two main theoretical streams can be distinguished. First, multi-objective decision making models which assume continuous solution spaces (and therefore are based on continuous mathematics), try to determine optimal compromise solutions and generally assume, that the problem to be solved can be modeled as a mathematical programming model. This is primarily the area of theoreticians since continuous mathematics is very elegant and powerful and readily allows for many modifications of a basic model or method. Unfortunately mathematical programming does not solve the majority of MCDM-problems in practice, and so these nice and powerful methods are only of limited value for the practitioner. The second stream focuses on problems with separate decision spaces, i.e. with countable few decision alternatives and basically uses approaches from discrete mathematics, which are mathematically not as elegant as the former. This stream is often called "Multi-Attribute Decision Making". These models do not try to compute an optimal solution, but they try to determine via various ranking procedures either a ranking of the relevant actions (decision alternatives) that is "optimal" with respect to several criteria, or they try to find the "optimal" actions amongst the existing solutions (decision alternatives). Even though this type of problem is much more relevant and frequent in practice, there are many fewer methods available and their quality is much harder to determine than in the continuous case. Therefore, the question "Which is the best method for a given problem?" has become one of the most important but also most difficult to answer for each problem. In this case study we prepare to use AHP that is the subtitle of MCDM (Triantaphyllou, 2000).

Decision making process has different branches and one of the most important of them is Multi-Criteria Decision Making (MCDM) (Zimmermann, 1996). It is divided in to two parts, Multi-Objective Decision Making (MODM) and Multi-Attribute Decision Making (MADM).

The main difference between these two methods is related to the number of alternatives under evaluation. MADM methods use for discrete alternatives while MODM method is designed for multi-objective problems that have infinite number of continuous alternatives which are defined by a set of limitation on the vector of decision variables (Korhonen et al., 1992; Hayashi, 2000; Belton and Stewart, 2002). The other differences between these methods are summarized in the table 5.1.

Table 5.1: Comparison of MODM and MADM approaches (Malczewski, 1999; Mendoza and Martins, 2006)

Criteria for comparison	**MODM**	**MADM**
Criteria defined by	Objectives	Attributes
Objectives defined	Explicitly	Implicitly
Attributes defined	Implicitly	Explicitly
Constraints defined	Explicitly	Implicitly
Alternatives defined	Implicitly	Explicitly
Number of alternatives	Infinite (large)	Finite (small)
Decision maker's control	Significant	Limited
Decision modelling paradigm	Process-oriented	Outcome-oriented
Relevant to	Design/search	Evaluation/choice

MODM studies decision problems in which the decision space is continuous. A typical example is mathematical programming problems with multiple objective functions. The first reference to this problem, also known as the "vector-maximum" problem, is attributed to Kuhn and Tucker (1951). On the other hand, MCDM/MADM concentrates on problems with discrete decision spaces. In these problems the set of decision alternatives has been predetermined. Although MCDM methods may be widely diverse, many of them have certain aspects in common

(Chen and Hwang, 1991). These are the notions of alternatives and attributes also often called goals or decision criteria.

The components of MCDM are defined briefly as follow (Triantaphyllou, 2000):

Alternatives: Usually alternatives represent the different choices of action available to the decision maker. They are supposed to be screened, prioritized, and eventually ranked.

Multiple Attributes: MCDM problems have multiple attributes that are referred to the goals or decision criteria of MCDM problems and show different dimensions of alternatives which can be considered. In cases in which the number of criteria is large (e. g., more than a dozen), criteria may be arranged in a hierarchical manner. That is, some criteria may be major ones. Each major criterion may be associated with several sub-criteria. Similarly, each sub-criterion may be associated with several sub-sub-criteria and so on. Although some MCDM methods may explicitly consider a hierarchical structure in the criteria of a decision problem, most of them assume a single level of criteria (e.g., no hierarchies).

Conflict among Criteria: Since different criteria represent different dimensions of the alternatives, they may conflict with each other. For instance, cost may conflict with profit etc.

Incommensurable Units: Different criteria may be associated with different units of measure. For instance, in the case of buying a used car, the criteria "cost" and "mileage" may be measured in terms of dollars and thousands of miles, respectively. It is this nature of having to consider different units which makes MCDM problems intrinsically hard to solve.

Decision Weights: Most of the MCDM methods require that the criteria be assigned weights of importance. Usually, these weights are normalized to add up to one.

Decision Matrix: An MCDM problem can be easily expressed in a matrix format. A decision matrix A is an (m X n) matrix which its element defined as: m alternatives denoted as: A1, A2,A3,… Am; n decision criteria denoted as: Cl , C2, C3, ... , Cn; Performance value of each alternative in terms of each criteria denoted as: aij (i=1,2,3,…,m and j=1,2,3,…,n). Matrices A is defined with the aij values along with the criteria weights Wj. This information is best summarized in the figure 5.1(Zimmermann, 1996).

	Criteria				
	C_1	C_2	C_3	...	C_n
Alts.	(w_1	w_2	w_3	...	w_n)
A_1	a_{11}	a_{12}	a_{13}	...	a_{1n}
A_2	a_{21}	a_{22}	a_{23}	...	a_{2n}
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
A_m	a_{m1}	a_{m2}	a_{m3}	...	a_{mn}

Figure 5.1: A typical decision matrix (Triantaphyllou, 2000).

All of decision making's methods have similar steps in numerical analysis of alternatives denfined as (i) Determine the relevant criteria and alternatives. (ii) Attach numerical measures to the relative importance of the criteria and to the impacts of the alternatives on these criteria. (iii) Process the numerical values to determine a ranking of each alternative.

Multi-criteria decision making methods are classified as bellow based on multi-dimensional:

- WSM (Weighted Sum Model)
- WPM (Weighted product model)
- ELECTRE (ELimination and Choice Expressing Reality)
- TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution)
- AHP (Analytic hierarchy process)
- ANP (Analytic Network Process)

5.1.1 The WSM method

The weighted sum model (WSM) is probably the most commonly used approach, especially in single dimensional problems. If there are m alternatives and n criteria then, the best alternative is the one that satisfies (in the maximization case) the following expression (Fishburn, 1967):

$$A^*_{WSM-Score} = MAX \sum_{j=1}^{n} aij \, . \, wj \quad , \quad for \;\; i = 1,2,3,\ldots,m \qquad \textbf{(5.1)}$$

A* WSM-score : the WSM score of the best alternative

n: the number of decision criteria

aij: the actual value of the i-th alternative in terms of the j-th criterion

wj: the weight of importance of the j-th criterion

Example 5.1: Suppose that an MCDM problem involves four criteria, which are expressed in exactly the same unit, and three alternatives. The relative weights of the four criteria were determined to be: w_J = 0.20, w2 = 0.15, W_3 = 0.40, and W_4 = 0.25. Also, the performance values of the three alternatives in terms of the four decision criteria are assumed to be as follows:

$$A = \begin{bmatrix} 25 & 20 & 15 & 30 \\ 10 & 30 & 20 & 30 \\ 30 & 10 & 30 & 10 \end{bmatrix}$$

Therefore, the data for this MCDM problem are summarized in the following decision matrix:

Crit. *Alt.*	*C1* 0.20	*C2* 0.15	*C3* 0.40	*C4* 0.25
A1	25	20	15	30
A2	10	30	20	30
A3	30	10	30	10

When formula (5.1) is applied on the previous data the scores of the three alternatives are:

$A_{1,\, WSM-Score}$ = 250 × 0.20 + 20 × 0.15 + 15 × 0.40 + 40 × 0.25 = 21.50

Similarly, we get:

$A_{2,\, WSM-Score}$ = 22.00

$A_{3,\, WSM-Score}$ = 20.00

Therefore, the best alternative (in the maximization case) is alternative A_2 (because it has the highest WSM score; 22.00). Moreover, the following ranking is derived: $A_2 > A_J > A_3$.

5.1.2 The WPM method

The weighted product model (WPM) is very similar to the WSM. The main difference is that instead of addition in the model there is multiplication. If there are m alternatives and n criteria and all the criteria are benefit, then criteria wj denotes the relative weight of importance of the criterion Cj and aij is the performance value of alternative Ai when it is evaluated in terms of criterion Cj .Each alternative is compared with the others by multiplying a number of ratios, one for each criterion. Each ratio is raised to the power equivalent to the relative weight of the corresponding criterion. In general, in order to compare two alternatives AK and AL, the following product (Bridgman, 1922 and Miller and Starr, 1969) has to be calculated:

$$R(A_K/A_L) = \prod_{j=1}^{n} \left(a_{Kj}/a_{Lj}\right)^{wj} \qquad for\ K, L = 1,2,3, \ldots, m \qquad \textbf{(5.2)}$$

n: the number of criteria

a_{ij}: the actual value of the i-th alternative in terms of the j-th criterion

w_j: the weight of importance of the j-th criterion

If the term $R(A_K / A_J)$ is greater than or equal to one, then it indicates that alternative AK is more desirable than alternative A_L (in the maximization case). The best alternative is the one that is better than or at least equal to all other alternatives.

The WPM is sometimes called dimensionless analysis because its structure eliminates any units of measure. Thus, the WPM can be used in single- and multi-dimensional MCDM. An advantage of the method is that instead of the actual values it can use relative ones. This is true because:

$$\frac{a_{Kj}}{a_{Lj}} = \frac{a_{Kj}/\sum_{i=1}^{n} a_{Ki}}{a_{Lj}/\sum_{i=1}^{n} a_{Li}} = \frac{a'_{Kj}}{a'_{Lj}} \qquad \textbf{(5.3)}$$

An alternative approach with the WPM method is for the decision maker to use only products without ratios. That is, to use the following variant of formula:

$$R(A_K) = \prod_{j=1}^{n} (a_{Kj})^{wj} \qquad \textbf{(5.4)}$$

Example 5.2: Consider the problem presented in the previous Example 5.1. However, now the restriction to express all criteria in terms of the same unit is not needed. When the WPM is applied, then the following values are derived:

$$R(A_1/A_2) = (25/100)^{0.20} \times (20/30)^{0.15} \times (15/20)^{0.40} \times (30/30)^{0.20} = 1.007 > 1.$$

Similarly, we also get:

$$R(A_1/A_3) = 1.67 > 1$$

$$R(A_2/A_3) = 1.59 > 1$$

Therefore, the best alternative is A1 since it is superior to all the other alternatives. Moreover, the ranking of these alternatives is as follows: Al > A2 > A3 .

5.1.3 The ELECTRE method

The ELECTRE (for Elimination and Choice Translating Reality; English translation from the French original) method was first introduced in (Benayoun et al., 1966). The basic concept of the ELECTRE method is to deal with "outranking relations" by using pairwise comparisons among alternatives under each one of the criteria separately. The outranking relationship of the two alternatives Ai and Aj , denoted as Ai→Aj describes that even when the i-th alternative does not dominate the J-th alternative quantitatively, then the decision maker may still take the risk of regarding Ai as almost surely better than Aj (Roy, 1973). Alternatives are said to be dominated, if there is another alternative which excels them in one or more criteria and equals in the remaining criteria.

The ELECTRE method begins with pairwise comparisons of alternatives under each criterion. Using physical or monetary values, denoted as gi(Aj) and gi(Ak) of the alternatives Aj and Ak respectively, and by introducing threshold levels for the difference gi(Aj) - gi(Ak), the decision maker may declare that he/she is indifferent between the alternatives under consideration, that he/she has a weak or a strict preference for one of the two, or that he/she is unable to express any of these preference relations. Therefore, a set of binary relations of alternatives, the so-called outranking relations, may be complete or incomplete. Next, the decision maker is requested to assign weights or importance factors to the criteria in order to express their relative importance.

Through the consecutive assessments of the outranking relations of the alternatives, the ELECTRE method elicits the so-called concordance index, defined as the amount of evidence to support the conclusion that alternative Aj outranks, or dominates, alternative Ak , as well as the discordance index, the counter-part of the concordance index.

Finally, the ELECTRE method yields a system of binary outranking relations between the alternatives. Because this system is not necessarily complete, the ELECTRE method is sometimes unable to identify the most preferred alternative. It only produces a core of leading alternatives. This method has a clearer view of alternatives by eliminating less favorable ones. This method is especially convenient when there are decision problems that involve a few criteria with a large number of alternatives (Lootsma, 1990).

There are many variants of the ELECTRE method. The organization of the original version of the ELECTRE method is illustrated in the 7 steps are defined as (Benayoun et al., 1966): Step 1: Normalizing the Decision Matrix; Step 2: Weighting the Nonnalized Decision Matrix; SteR 3: Determine the Concordance and Discordance Sets; Step 4: Construct the Concordance and Discordance Matrices; Step 5: Determine the Concordance and Discordance Dominance Matrices; Step 6: Determine the Aggregate Dominance Matrix; Step 7: Eliminate the Less Favorable Alternatives.

5.1.4 The TOPSIS method

TOPSIS (for the Technique for Order Preference by Similarity to Ideal Solution) was developed by Yo on and Hwang (1980) as an alternative to the ELECTRE method and can be considered as one of its most widely accepted variants. The basic concept of this method is that the selected alternative should have the shortest distance from the ideal solution and the farthest distance from the negative-ideal solution in some geometrical sense.

The TOPSIS method assumes that each criterion has a tendency of monotonically increasing or decreasing utility. Therefore, it is easy to define the ideal and negative-ideal solutions. The Euclidean distance approach was proposed to evaluate the relative closeness of the alternatives to the ideal solution. Thus, the preference order of the alternatives can be derived by a series of comparisons of these relative distances.

The steps of the TOPSIS method are defined as Step 1: Construct the Normalized Decision Matrix; Step 2: Construct the Weighted Normalized Decision Matrix; Step 3: Determine the Ideal and the Negative-Ideal Solutions; Step 4: Calculate the Separation Measure; Step 5: Calculate the Relative Closeness to the Ideal Solution; Step 6: Rank the Preference Order.

5.1.5 The AHP method

The Analytic Hierarchy Process (AHP) is due to Saaty (1980) and quite often is referred to, as the Saaty method. It is popular and widely used, in decision making and in a wide range of applications. Saaty, in his book, describes case applications ranging from the choice of a school for his son, through to the planning of transportation systems for the Sudan.

The AHP method express how to establish the priority of a set of alternatives and the relative importance of criteria in a multiple criteria decision making problem, and has been extensively discussed in a variety of aspects. The consideration area of AHP is not only the qualitative but also quantitative approaches. AHP researches and combines these approaches into a single experimental inquisition. Qualitative method is used to decompose an unstructured problem into a systematic decision hierarchy; on the other hand quantitative approach utilizes a pair-wise comparison to perform a consistency test to validate the consistency of answers.

AHP was suggested by these researchers mainly because of its fundamental qualifications to handle not only qualitative but also quantitative criteria those are used in ste selection decisions. Besides, AHP can make easy the decision making process. By the help of hierarchical structure the problems are pictured analytically in means of criteria and sub criteria by the team who evaluate the problem (Gnanasekaran et al., 2006).

The AHP approach is based on six principles of methodical processes: 1) Define the unstructured problem, 2) Decompose the problem into a hierarchical structure, and 3) Employ pairwise comparisons, 4) Calculate the maximum eigenvalues and eigenvectors, 5) Check the consistency of the matrices, and 6) Obtain an overall rating of decision alternatives by aggregating the relative priorities of the decision elements. (Lee et al., 2008; Vahidnia et al., 2009):

1- Define the unstructured problem: The problem should be define clearly and the alternatives and criteria should be included.

2- Decompose the problem into a hierarchical structure: The second step in AHP is to work on the decision problem in order to decompose it and then try to build a hierarchical structure from the criteria or sub criteria. Saaty and Vargas (2006) studied this problem and reviewed that the most creative and influential part of decision making is the structuring of the decision as a hierarchy and they stated that the basic principle to create a structure is to know the answer of ―Can I compare the elements on a lower level in terms of some or all of the elements on the next higher level? And to proceed on structuring the hierarchy, there should be some steps are define as (i) Decision maker should recognize the main goal and clearly state. Question of this step is: "What are you going to accomplish?" and "What is the main problem?" (ii) Decision maker should identify the sub-goals of the main goal. Time prospects that affect the decision may be identified. (iii) Decision maker should identify criteria that must conform to the sub-goals of the main goal. (iv) Decision maker may reveal sub-criteria under each criterion. Criteria and sub criteria may be defined as values of parameters or as verbal intensities such as medium, high, low. (v) Decision maker may state which actors involved to this process. (vi) Decision maker may state identify the actors' (macro environmental forces) goals. (vii) Decision maker may state identify the actors' policies. (viii) Decision maker may state identify the alternatives or results (Saaty and Vargas, 2006).

Saaty and Vargas (2006) gave an example to a basic hierarchical structure which is illustrated in Figure 5.2. The above steps are the guidelines within a structured hierarchical model.

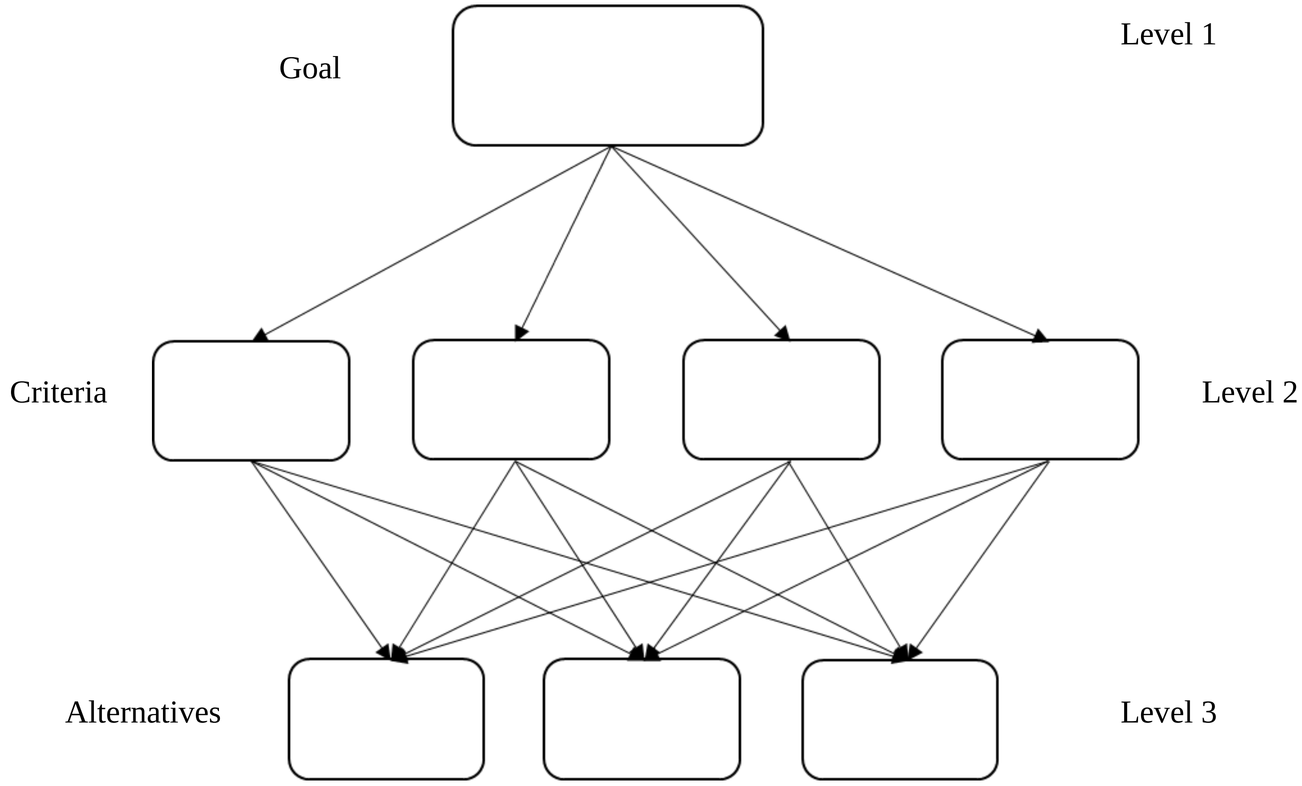

Figure 5.2: Three level hierarchy framework design.

Decision maker should be careful during the structuring the hierarchy. He should present the problem in a best way; consider All side factors that affect the problem; consider all the information sources that may help; define All the participators who will be in the problem process (Saaty, 1990).

3- Employ pairwise comparisons:

The second step in using AHP is to set the priorities and weights for each element. The elements of each level of the hierarchy are rated using the pair-wise comparison approach. The actor‘s comparative decisions between the paired goals build the basic pair wise comparison according to the relative importance of one goal over another. Within goals, there should be n (n-1)/2 possible paired comparisons (Basarir, 2002). Paired comparisons are asked to the respondents in order to define which goal or criteria in the pair are more important to him/her. Saaty‘s scale of measurement for the paired comparisons uses the verbal comparisons to determine the weight of criteria by translating the verbal comparisons into the numerical value of the scale. The scale of measurement, which is used to extract the comparisons recommended by Saaty (1990) are presented in Table 5.2.

Table 5.2 : Saaty's scale of measurement for pair-wise comparisons

Intensity of importance	Definition	Explanation
1	Equal importance	Two factors contribute equally to the objective.
3	Somewhat more important	Experience and judgment slightly favor one over the other.
5	Much more important	Experience and judgment strongly favor one over the other.
7	Very much more important	Experience and judgment very strongly favor one over the other. Its importance is demonstrated in practice.
9	Absolutely more important	The evidence favoring one over the other is of the highest possible validity.
2, 4, 6, 8	Intermediate values	When compromise is needed.

After all criteria have been compared with the priority scale pair by pair, a paired comparison matrix is formed which is shown as 5.5 by Saaty (1990). The matrix is given as:

$$A = (aij) = \begin{bmatrix} a11 & a12 & . & . & a1n \\ a21 & a22 & . & . & a2n \\ . & . & . & . & . \\ . & . & . & . & . \\ an1 & an2 & . & . & ann \end{bmatrix} (i = j = 1, 2, \dots, n) \qquad \textbf{(5.5)}$$

The entries are defined as below

$$a_{ij} = \propto then\ a_{ji} = \frac{1}{\propto} \quad \propto \neq 0 \qquad \textbf{(5.6)}$$

If element j evaluated important as elemet i then a_{ij}=a_{ji}=1.

A vector of weights $w = (w_1, w_2, \ldots w_n)$ is then computed. If the decisions were completely reliable (aik akj=aij) then the entire matrix would contain no error, and could be expressed as $a_{ij}=w_i/w_j$. In this case, the final weights can be expressed as (5.7) :

$$Wi=a_{ij} \div \sum_{k=1}^{n} a_{kj} \quad \text{for all } i=1,2,3, \ldots, N \qquad \textbf{(5.7)}$$

Within solving a classic AHP problem, if there is no opportunity to solve with the computer, four methods was developed in order to find the relative importance vector we should fallow 4 steps which are defined as (Yagci, 2002): (i)All elements in the same row are summed and each sum is divided to the total sum of rows, so that normalization is done. A new vector is created and in this new vector, the first element shows the characteristic of the first element, second new element shows the second element‘s characteristic and the nth new element shows the nth element characteristics. This method gives the roughest prediction among the four methods. (ii)All elements in the column are summed and the opposite of the sums are taken. Each of the opposite sums is divided to the sum of the opposites, so that normalization is done. (iii) Each element of the column is divided to the sum of the column, so that the elements are normalized. Each element of the new row is summed and this sum is divided the number of the elements in one row. So that a mean is got from the normalized row.(iv) N pieces element in the row are multiplied to each other and the nth degree root of this product is calculated. So that normalization is done.

4- Calculate the maximum eigenvalues and eigenvectors:

We can use the eigenvalue method (or some other method) to estimate the relative weights of the decision elements. In order to estimate the relative weight of the decision elements in a matrix, we can use the (5.8) formula:

$$A.W=\lambda max .W \qquad \textbf{(5.8)}$$

5- Check the consistency of the matrices:

Consistency is not guaranteed in any measurement type. Even in the measurements that are done by the help of measurement tools, experimental failure or measurement tool failure can be encountered, so that this situation causes inconsistent results. For example the failure may be occurred as weighting problem; although A is heavier than B and B is heavier than C; C can be measured as heavier than A. This result may be occurred because of the closes weights of A; B and C and the measurement tool is not sensitive to be able to measure the difference. In consistency problem create big consequences for some problems. For example, inconsistency of a drug which is obtained by the mix of two chemical objects, usage of the wrong proportion may lead to catastrophic consequences (Saaty, 1990).

Second problem that decision maker may experience is the difficulty of fitting measures to the system that largely constant and permanent. It is impossible to measure the features that changing often. The third and last problem during the decision making process by the help of AHP, is creating the appropriate circumstances to create the structure of the problem and determining the priorities. After determining the hierarchy, decision maker should make face to face survey with the related people. These related people should be the people who do have to be experts of the problem but they should even know something over the problem. However, it is so difficult to determine the priorities by the paired comparison and to solve the problem because people always give inconsistent responses (Ayyıldız, 2003).

Errors in judgment are common; therefore, the consistency ratio (CR) is used to measure the consistency in pair-wise comparisons (Saaty, 1994). Saaty proved that for common matrix, the largest eigen value is equal to the size of comparison matrix, or $\lambda max=n$. Then he gave a measure of consistency, called Consistency Index as deviation or degree of consistency using the following formula (5.9):

$$CI=\frac{\lambda_{max}}{n-1} - \frac{n}{n-1} \qquad \textbf{(5.9)}$$

We use this index by comparing it with the appropriate one. The appropriate Consistency index is called Random Consistency Index (RI).

He randomly generated reciprocal matrix using scale , , …, , …, 8, 9 and get the random consistency index to see if it is about 10% or less. The average random consistency index of sample size 500 matrices is shown in the table 5.3:

Table 5.3 : Random consistency index (RI)

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Then, he proposed what is called Consistency Ratio, which is a comparison between Consistency Index and Random Consistency Index, in formula (5.10):

$$CR = CI/RI \qquad \textbf{(5.10)}$$

In general, the smaller the value of CR, the smaller is the variation from consistency. Saaty (1995) also recommends acceptable CR values for different matrix sizes; these CR values are

- For a 3 by 3 matrix, the CR value should be equal to or less than 5%;
- For a 4 by 4 matrix, the CR value should be equal to or less than 9%;
- For a larger matrix, the CR value should be equal to or less than 10%

Sometimes the CR value may be more than 10 percent, in this situation the judgments are to some extent accidental and should be revised. There are three methods in order to make these revisions. The first method is defined as asking participants to develop the quality of their decisions in making pair-wise comparisons by providing another set of answers. The second methos is an arithmetic method (compute the geometric mean of the element in each row) as suggested by Saaty (1980). However, using these methods may modify the first judgment used by the respondents. For that reason, if the results of the original consistency test are too far away from the tolerable consistency, this method should not be used. The third methos will be used if the above two methods fail, then the last alternative is to stimulate the decision hierarchy. The objective here is to develop a new hierarchy structure which results in more consistency in the pair-wise comparisons of elements in the decision hierarchy.

AHP allows evaluating more than one person‘s judgments. It is a fact that, all the participants in a group judge all the criteria so that these judgments should be combined in an agreement. In this type of situation, some methods are suggested. The first method acquires an agreement over the problem by the way of discussion. The second method gets help from a facilitator who will combine the judgments of the participants in an agreement. And the third method uses geometric mean to sum the each paired comparison.

6- Obtain an overall rating of decision alternatives by aggregating the relative priorities of the decision elements. An overall priority ranking of the decision alternatives can be obtained by combining the criterion priorities and priorities of each decision alternatives relative to each criterion (chen et al., 2006). The furmola 5.11 can help us for calculating the priority of alternatives:

$$A^* = max \sum_{j=1}^{n} a_{ij}.w_j \qquad for\ i = 1,2,3,\ldots,m \qquad \textbf{(5.11)}$$

Software:

Super Decisions and Expert Choice are softwares that can be used for decision-making with dependence and feedback. These softwares solve the Analytic Hierarchy Process (AHP) that uses the same fundamental prioritization process based on deriving priorities through judgments on pairs of elements or from direct measurements. This program let decision maker see the decision problem in a simple and clear form, make the paired judgments, measure the priorities. It let decision maker to make single or group analysis. In this research, Expert Choice is selected as decision software.

5.1.6 The ANP method

AHP and ANP are essentially ways to measure especially intangible factors by using pairwise comparisons with judgments that represent the dominance of one element over another with respect to a property that they share (Chung et al., 2005). The Analytic Network Process is a generalization of the Analytic Hierarchy Process.

Many decisions problems cannot be structured hierarchically because they involve the interaction and dependence of higher level elements in a hierarchy on lower level elements. While the AHP represents a framework with a uni-directional hierarchical AHP relationship, the ANP allows for complex interrelationships among decision levels and attributes (Saaty and Ozdemir, 2005).

ANP approach comprises four steps (Satty, 1996; Chung et al., 2005; Yuksel and Dagdeviren, 2007):

Step 1: Model construction and problem structuring: The problem should be stated clearly and decomposed into a rational system like a network.

Step 2: Pairwise comparisons and priority vectors: In ANP, like AHP, pairs of decision elements at each cluster are compared with respect to their importance towards their control criteria. In addition, interdependencies among criteria of a cluster must also be examined pairwise; the influence of each element on other elements can be represented by an eigenvector. The relative importance values are determined with Saaty's scale.

Step 3: Supermatrix formation: The supermatrix concept is similar to the Markov chain process. To obtain global priorities in a system with interdependent influences, the local priority vectors are entered in the appropriate columns of a matrix. As a result, a supermatrix is actually a partitioned matrix, where each matrix segment represents a relationship between two clusters in a system.

Step 4: Synthesis of the criteria and alternatives' priorities and selection of the best alternatives: The priority weights of the criteria and alternatives can be found in the normalized supermatrix.

The structural difference between a hierarchy and a network processes are pictured infigure 5.3.

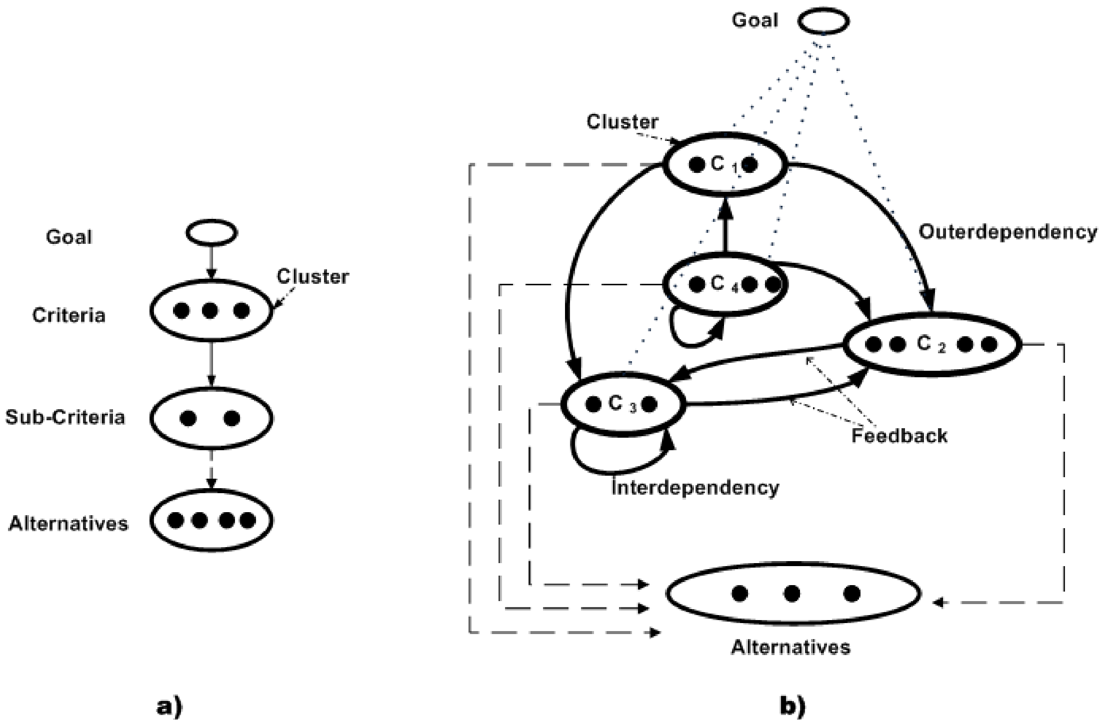

Figure 5.3: Structural difference between Hierarchy (a) and Network Processes (b).

While AHP has been very popular, ANP is less prominent in the literature (Othman et al., 2011). There are some studies studies that use ANP. Chung et al. (2005) applied ANP to constitute product mix planning in semiconductor fabricator. Dagdeviren and Yuksel (2007) developed an ANP-based personnel selection system and weighted personnel selection factors. Greda (2009) used the ANP to select the most efficient option of quality management system in food industry. Yang et al. (2009) developed a manufacturing evaluation system model with ANP approach for wafer fabricating industry. Valmohammadi (2010) used the ANP to identify specific resources and capabilities of an Iranian dairy products firm and to develop an evaluation framework of business strategy. Ayag (2011) proposed ANP-based approach to evaluate a set of simulation software alternatives.

5.2 Geographical Information Systems

Making decisions based on geography is basic to human thinking. Where shall we go, what will it be like, and what shall we do when we get there are applied to the simple event of going to the store or to the major event of launching a bathysphere into the ocean's depths. By understanding geography and people's relationship to location, we can make informed decisions about the way we live on our planet. A geographic information system (GIS) is a technological tool for comprehending geography and making intelligent decisions. GIS organizes geographic data so that a person reading a map can select data necessary for a specific project or task. A thematic map has a table of contents that allows the reader to add layers of information to a base map of real-world locations. For example, a social analyst might use the base map of Eugene, Oregon, and select datasets from the U.S. Census Bureau to add data layers to a map that shows residents' education levels, ages, and employment status. With an ability to combine a variety of datasets in an infinite number of ways, GIS is a useful tool for nearly every field of knowledge from archaeology to zoology.

Geographical Information Systems (GIS) can be described as general-purpose computer-based technologies for handling geographical data in digital form in order to capture, store, manipulate, analysis and display diverse sets of spatial or geo-referenced data. In essence, GIS are spatial databases of digital maps which store information on various phenomena and their locations (Burrough and McDonnell, 1998).

GIS integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts. A GIS helps you answer questions and solve problems by looking at your data in a way that is quickly understood and easily shared. GIS technology can be integrated into any enterprise information system framework. Geography is the science of our world. Coupled with GIS, geography is helping us to better understand the earth and apply geographic knowledge to a host of human activities. The outcome is the emergence of The Geographic Approach—a new way of thinking and problem solving that integrates geographic information into how we understand and manage our planet. This approach allows us to create geographic knowledge by measuring the earth, organizing this data, and analyzing and modeling various processes and their relationships. The Geographic Approach also allows us to apply this knowledge to the way we design, plan, and change our world (Esri, 2014).

GIS benefits organizations of all sizes and in almost every industry. There is a growing awareness of the economic and strategic value of GIS. The benefits of GIS generally fall into five basic categories are defined as (Esri, 2014):

1-Cost Savings and Increased Efficiency: GIS is widely used to optimize maintenance schedules and daily fleet movements. Typical implementations can result in a savings of 10 to 30 percent in operational expenses through reduction in fuel use and staff time, improved customer service, and more efficient scheduling.

2-Better Decision Making: GIS is the go-to technology for making better decisions about location. Common examples include real estate site selection, route/corridor selection, evacuation planning, conservation, natural resource extraction, etc. Making correct decisions about location is critical to the success of an organization.

3-Improved Communication: GIS-based maps and visualizations greatly assist in understanding situations and in storytelling. They are a type of language that improves communication between different teams, departments, disciplines, professional fields, organizations, and the public.

4-Better Recordkeeping: Many organizations have a primary responsibility of maintaining authoritative records about the status and change of geography. GIS provides a strong framework for managing these types of records with full transaction support and reporting tools.

5-Managing Geographically: GIS is becoming essential to understanding what is happening—and what will happen—in geographic space. Once we understand, we can prescribe action. This new approach to management—managing geographically—is transforming the way that organizations operate.

6. APPLICATION

6.1 Decision Model

The main objective of this study is introducing the specific model in order to site selection for field hospital. This model support decision makers in multi-criteria decision making problems which apply AHP method with multiple decision makers. The methodology is used in this study includes these steps that are fallowed and depicts in the figure 6.1.

1. Define problem, definition of the problem/objective (site selection for field hospital).
2. Define criteria, identification of the potential criteria for finding the optimal sites of field hospital.
3. Data collection, collect and prepare data which are used in the GIS as inputs.
4. Basic maps, create raster datasets that produce basic maps of GIS.
5. GIS analysis, classification of raster datasets that use as basic information about problem for decision makers.
6. Define preference matrices, three experts who are related to the disaster management decision making groups evaluated preference value to the relevant criteria and make preference matrices.
7. Using AHP method, analysis the results obtained from AHP model.
8. Determine optimal location, define specific model and prioritize the criteria for selecting best place for field hospital.

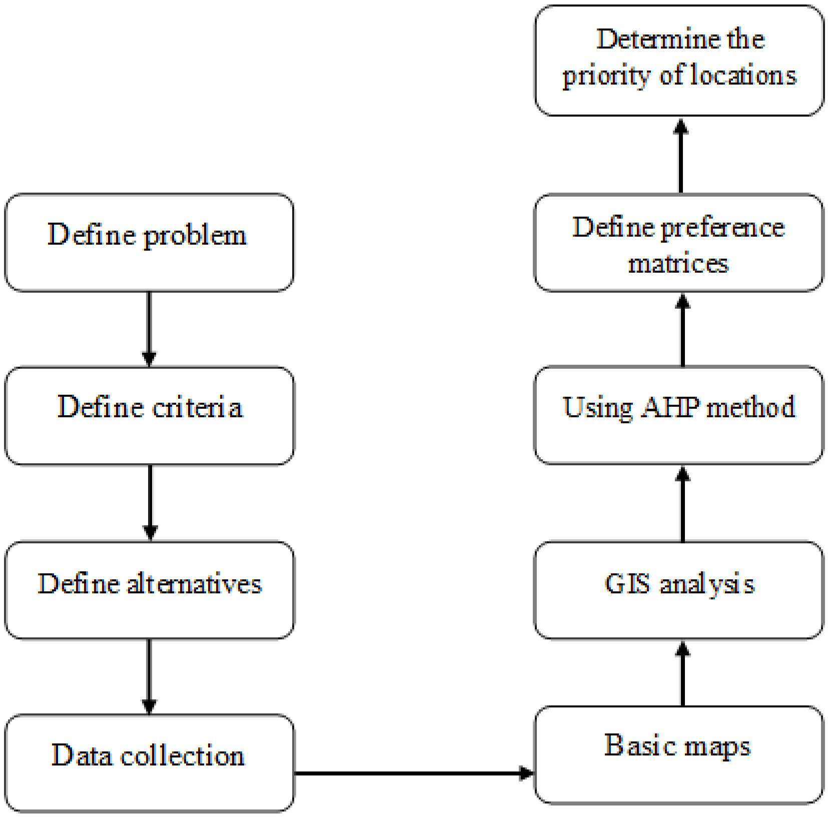

Figure 6.1: The flow chart of the methodology in this study.

6.2 Study Area

The study area is located in Istanbul that is the most important city in Turkey. We selected Besiktas (Beşiktaş) district as a case study that is on the European side of Istanbul, by the coast of the Bosphorus. Besiktas is divided to some key locations running up the Bosphorus on the European side (from Dolmabahçe Palace up to Bebek) and the land on the hills behind these settlements. The important sectors of besiktas are Arnavutkoy, Bebek, Etiler, Levent (all parts), Ortakoy, Ulus, and Yildiz. The population of besiktas is 186,570 according to the TUIK 2013 and it covers an area of 21 km2 (8 sq mi) which makes one of the smallest and important districts of Istanbul.The figure 6.2 shows the location of Besiktas district in Istanbul.

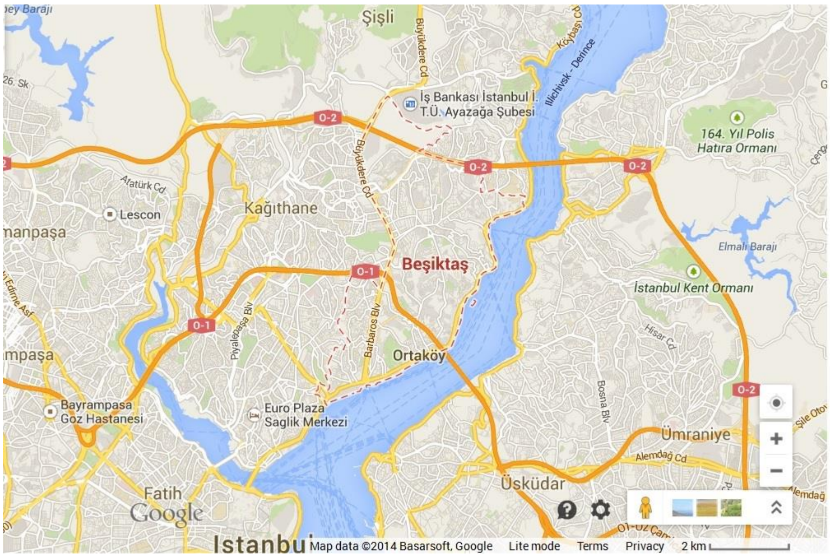

Figure 6.2: The map of Besiktas (Google, 2014).

6.3 Definition of Alternatives

We have selected five alternative (parks) that are located in the different sectors of Besiktas. Our alternative define as (i) Yildiz Park in Yildiz sector, (ii) Besiktas Sanatcilar Park in the Akat sector, (iii) Cemil Topuzlu Park in the Kurucesme sector, (iv) Prof. Dr. Aykut Barka Park in the Kultur sector, and (v) Ulus park in the Kurucesme sector. The figure 6.3 shows the location of these parks in the map.

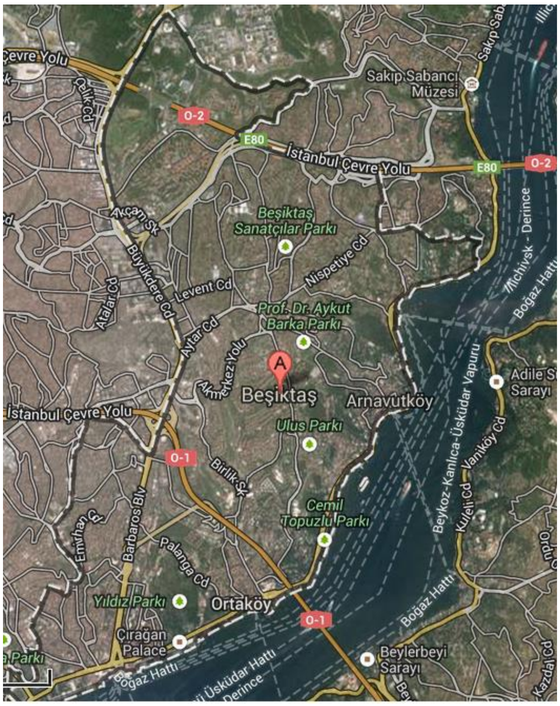

Figure 6.3: The location of parks in the map (Google, 2014).

6.4 Definition of Criteria

For defining criteria, we study other articles which are about hospital and disaster management by using GIS and AHP method. The table 6.1 shows these articles and their criteria.

Table 6.1: The criteria of other studies.

Criteria	Article
Distance from Arterial Routes **Travel Time area to access existing hospitals** **Environmental pollution** **Population Density** **Land Cost**	Vahidnia, M.H., Alesheikh, A.A., Alimohammadi, A., (2009).
Road distance **Population density** **Loss of buildings** **Distance from Existing Fire Stations**	Lai, W., Han-lun, L., Qi, L., Jing-yi, C., Yi-jiao, C., (2011).
High Population Density **Proximity to Main Roads** **Distance from Existing Fire Stations** **Distance from Hazardous Material Facilities** **Wooden Building Density**	Erden.T and Coskun, M.Z., (2010).

Five criteria have been considered to find best place for the field hospital in Besiktas of Istanbul as the influence factors.

Field hospitals should be close to a main transport route, so the first criteria is Distance from Arterial Routes. Sites located on near a main route scored the highest in this criterion (Vahidnia et al., 2009).

The next effective factor in this study is the Distance to Existing Hospitals. In the emergency situations, field hospital after doing triage and treatment phases, it will transfer patient to the normal hospitals. Those field hospitals which close to the existing hospitals have higher score in evaluating of this factor (Lai et al., 2011 and Erden and coskun, 2009).

Another important factor is the Population Density. Istanbul is a metropolitan city and it has quite high population densities, so, it is considered as a criteria in this study (Vahidnia et al., 2009 and Lai et al., 2011 and Erden and coskun, 2009).

Also, Time to Operate is other criteria in our case study that is related to the expertise of technicans who install and setup the field hospital and its facilities . The field hospital with lower time for operate and set up the facilities have higher priory because rescue activities are mainly sensitive about time in the emergency situations.

Furthermore, Capacity of Beds in the field hospital is considered as a factor because feild hospital with more beds increase the utility of facilities that used in the emergency cases.

The figure 6.4 depicts the hierarchical structure of decision-making and relationship between criteria and alternatives.

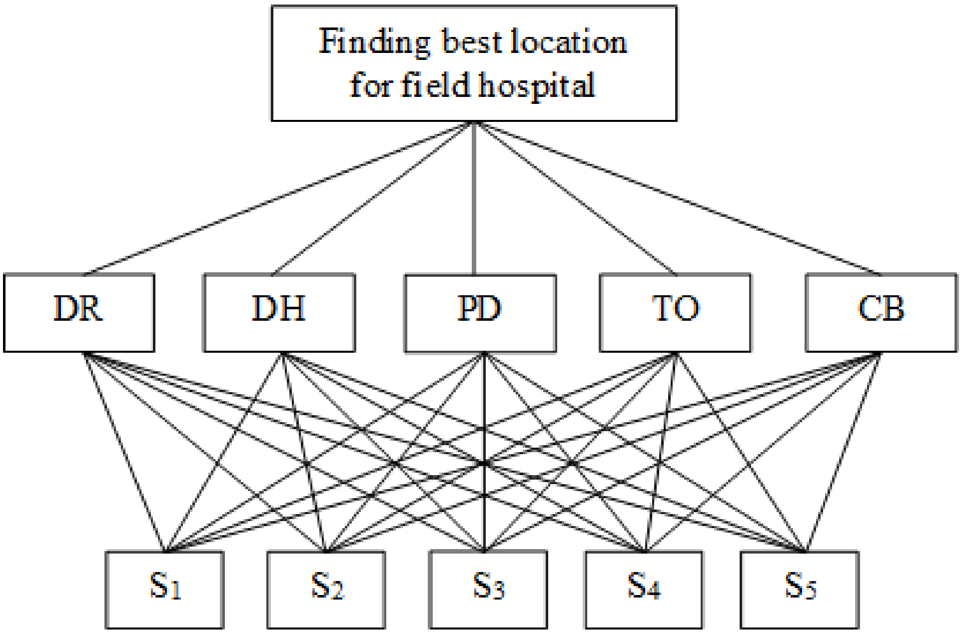

Figure 6.4: The hierarchical structure of decision-making.

DR: Distance from Arterial Routes

DH: Distance to Existing Hospitals

PD: Population Density

TO: Time to Operate

CB: Capacity of Beds

Si: Sites (Parks)

6.5 Data Collection

After definition of criteria and alternatives, we needed to collect data for preparing visualized maps. In Istanbul, giving data to the projects which are related to the urban area of Istanbul is the duty of municipality. We selected Besiktas district for study area, therefore Besiktas Municipality (Beşiktaş Belediyesi) was the right place for obtaining data of our project. At the first, we needed to take the data of parks which are our alternatives. Besiktas municipality gave us the coordinate axis of parks in the Excel file format. Also, they gave us Istanbul map as a raster data.

The next data that we needed for using in our project was the Network Routs of Besiktas. Besiktas municipality does not have the data about network routs, so they advised us to obtaining these data from Transportation Planning of Istanbul Municipality (Ulaşım Planlama Müdürlüğü). This organization gave us the network routs of Besiktas as a raster data.

The third data that is needed for our study was the Existing Hospitals in Besiktas. Also, we obtained this data from Transportation Planning of Istanbul Municipality as a raster data.

In addition, we needed Besiktas population to prepare the map which are depicted population density in Besiktas. We took this data from the website of TUIK organization (Turkiye Istatistik Kurumu) as an Excel file data.

6.6 Geographical Information System (GIS) Analysis

In this study we use Geographical Information System (GIS) and the ArcGIS software 10.2 that is related to the GIS. We used our data which were obtained from govermental organizations for preparing visualized map by using ArcGIS software.

As mantioned before, we obtained the park's data as Excel file, and we should change their format for using in ArcGIS software. We import them to the ArcGIS, then make the layer wich is incluode the parks polygons. Figure 6.5 shows this layer in the ArcGIS environment. After that we make another layer which is contained the center of each park. This layer is presented in the figure 6.6.

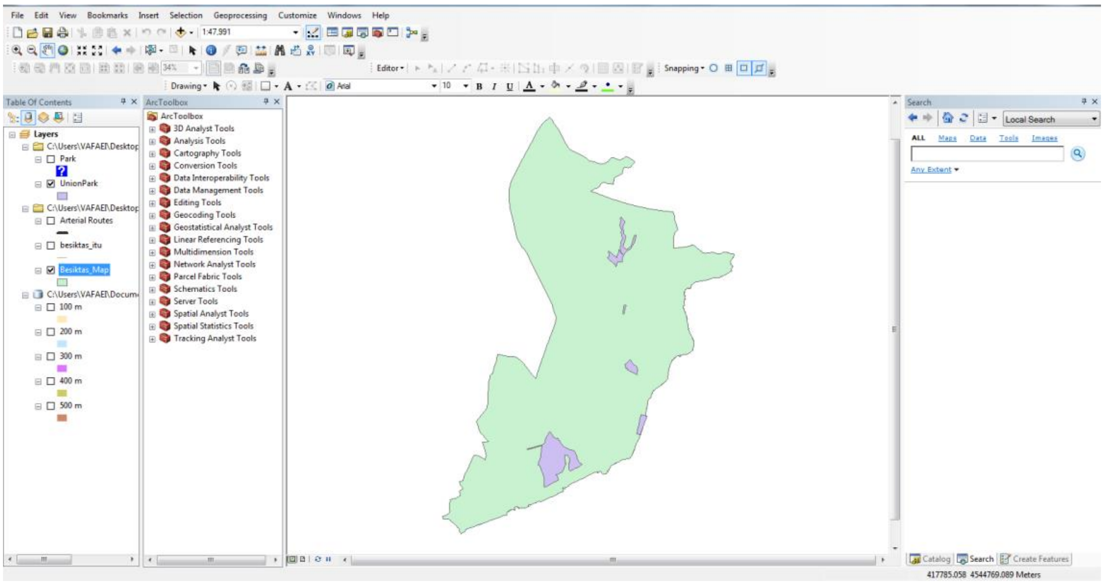

Figure 6.5: The layer of parks polygons.

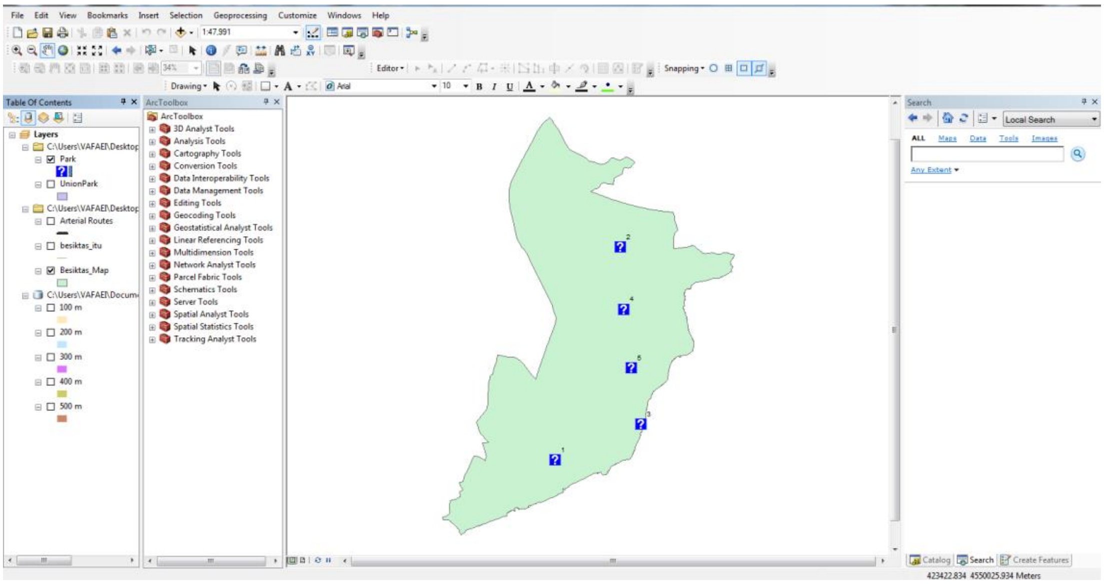

Figure 6.6: The layer of parks Center.

Also, the layer of parks centers are used for distance from existing hospital and distance from arterial routes criterions. We make buffer analysis for both distance from hospital and distance from arterial routes in the different ranges. In the analysis of distance from existing hospitals, we make buffer around each hospital with range of 2000, 1500, 1000, and 700 meters. We can find from map layer the distance of each park from existing hospitals. The figure 6.7 shows the buffers which is used around each hospital. From this figure, Yildiz Park is 1000m, Besiktas Sanatcilar Park is 1500m, Cemil Topuzlu Park is more that 2000m, Aykut Park is 1500m, and Ulus Park is 2000m far from existing hospitals.

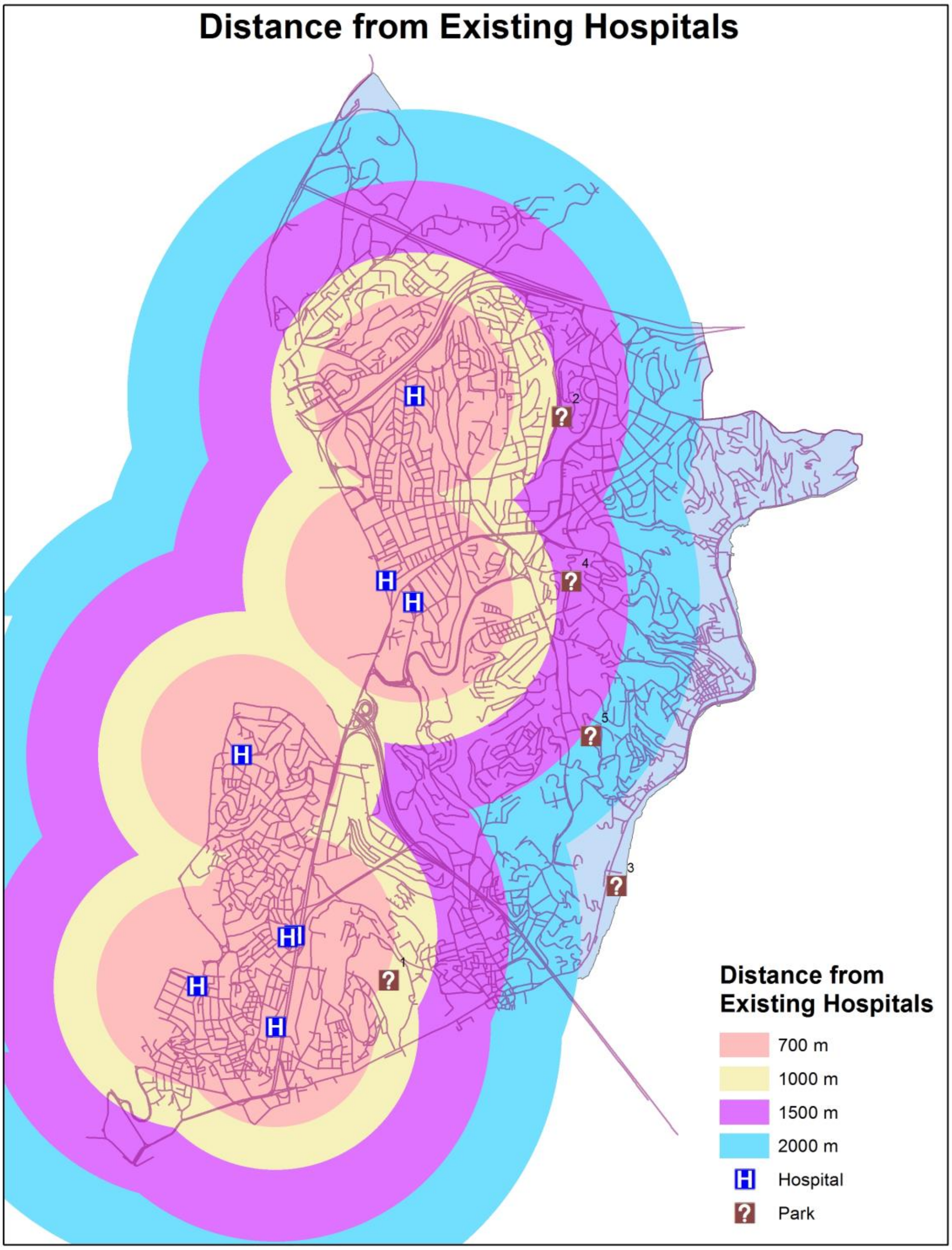

Figure 6.7: Distance from existing hospitals.

Similarly, we used buffer around arterial routs and made map layer of distance from arterial routes in the ranges 500, 400, 300, 200, and 100 meters. The figure 6.8 shows the map layer of distance from arterial routes. From this figure, Yildiz Park is 300m, Besiktas Sanatcilar Park is 500m, Cemil Topuzlu Park is more that 500m, Aykut Park is 300m, and Ulus Park is 200m far from arterial routes.

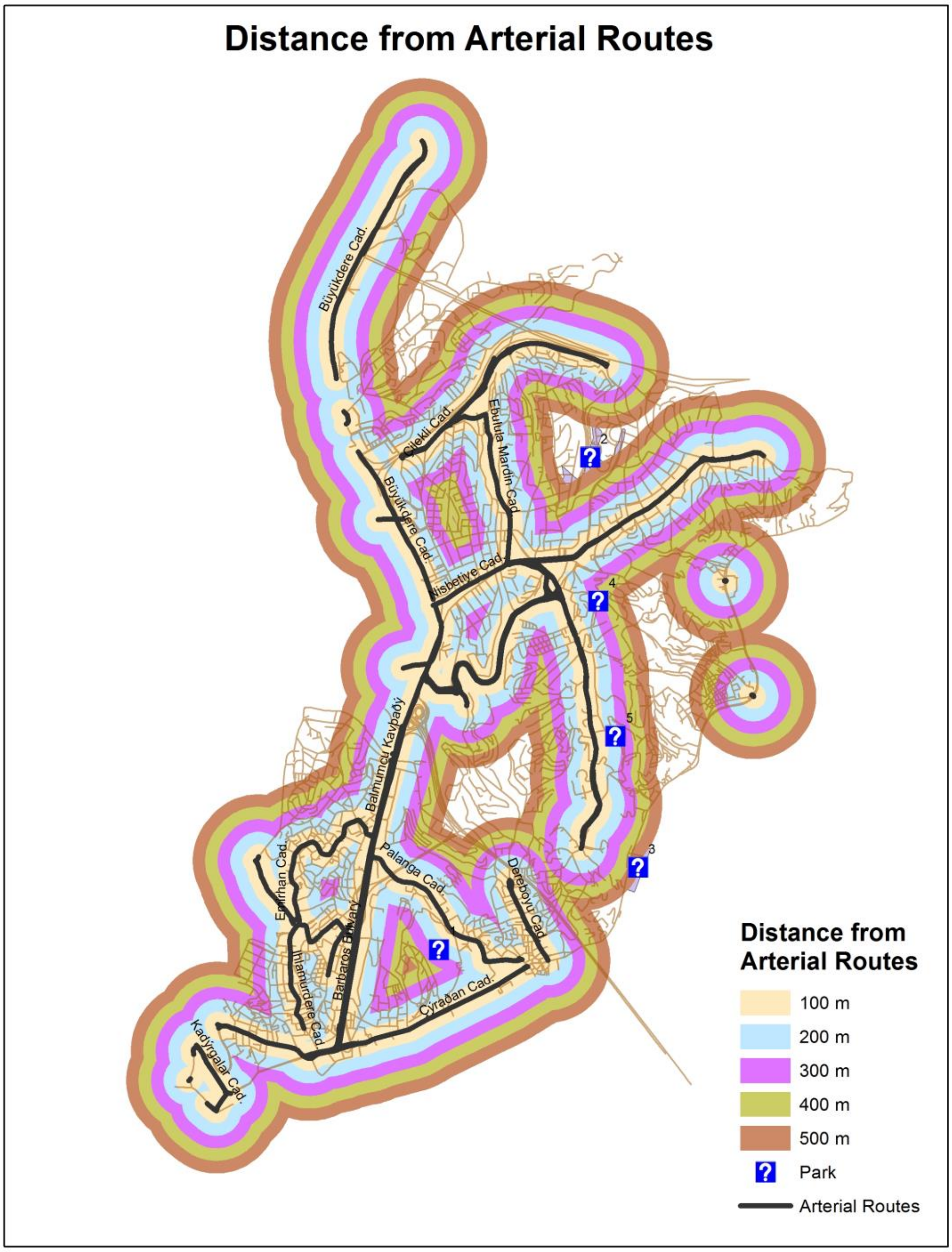

Figure 6.8: Distance from arterial routes.

Population density is used in this study, which are obtained from dividing the census data of each sector of Besiktas by area of it. raster-based data structure is preferred for presented this criterion map layer. Figure 6.9 depicts the population density in Besiktas.

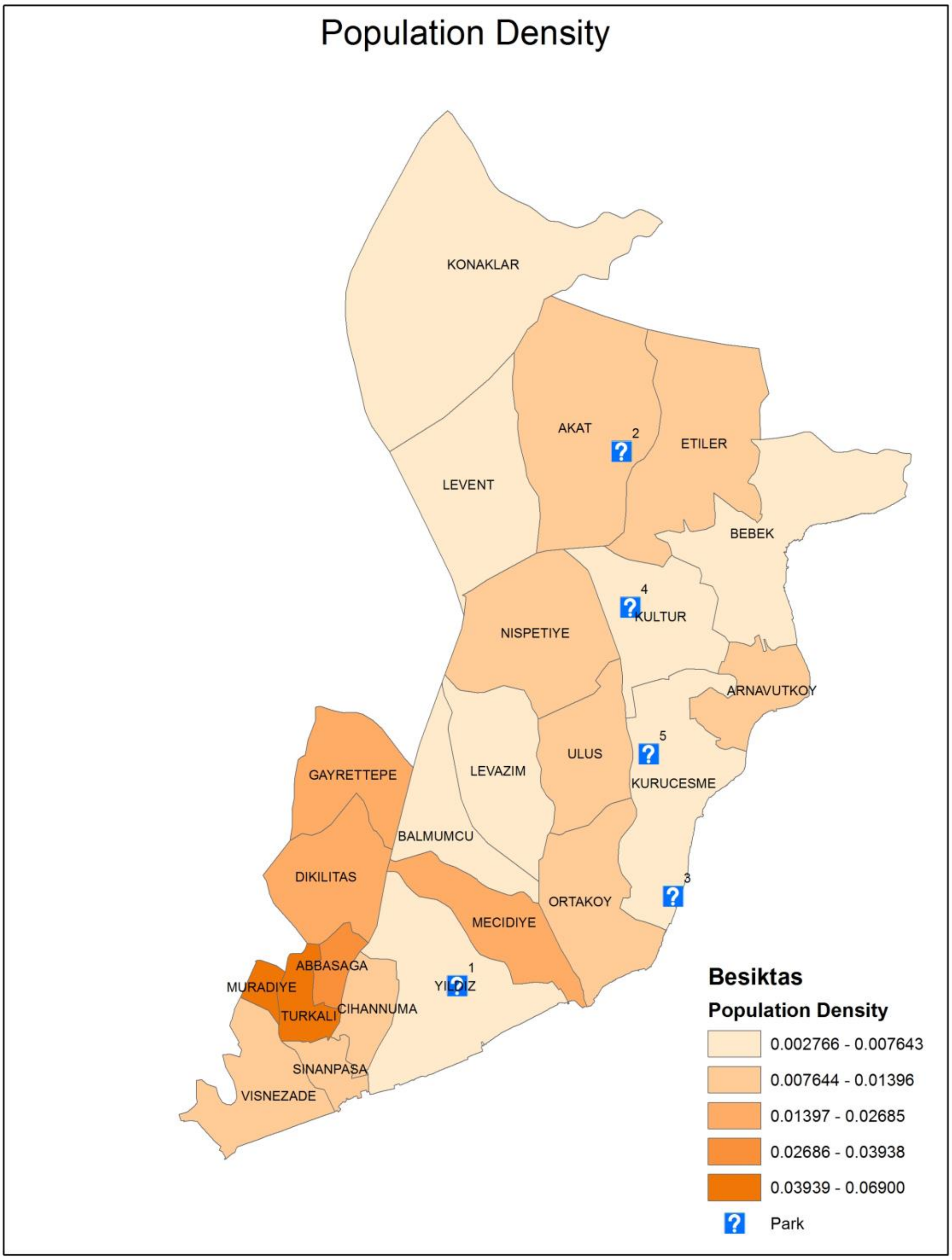

Figure 6.9: Population density of Besiktas.

6.7 Analytic Hierarchy Process (AHP)

After obtaining and converting data in ArcGIS, the AHP model is considered with using Expert Choice 11 software for determining the criteria priorities and weights. We prepared a questionnaire for determining the preference matrices by experts and thereby determining the pairwise matrices by Expert Choice software. The Appendix A presents questionnaires that are asked from three experts who are related to the disaster management department.

AHP helps to define the priority of the multiple decision maker's problem with. This procedure consists of a questionnaire for comparison of each element and geometric mean to arrive at a final solution (Saaty, 1989). We computed geometric means of all pair comparison judgments for each question in order to make input data for expert choice software. The Geometric Mean of data is given by the formula 6.1:

$$\left(\prod_{i=1}^{n} a_i\right)^{1/n} = \sqrt[n]{a_1 a_2 \cdots a_n}. \qquad \textbf{(6.1)}$$

Pairwise Comparisons

One of the major strengths of the AHP and Expert Choice is the use of pairwise comparisons to derive accurate ratio scale priorities. A pairwise comparison is the process of comparing the relative importance, preference, or likelihood of two elements (objectives) with respect to another element (the goal). Pairwise comparisons are carried out to establish priorities. There are three pairwise comparison assessment modes.

1) **Verbal Judgment:** Verbal judgments are used to compare factors using the words Equal, Moderate, Strong, Very Strong, Extreme. Equal means the two items being compared are of equal importance to you. Extreme means an order of magnitude – about 9 or 10 to 1. Judgments between these words, such as Moderate to Strong are also possible. The figure 6.10 presents the pairwise comparison of "Distance to Existing Hospitals" that is compared with verbal judgment.

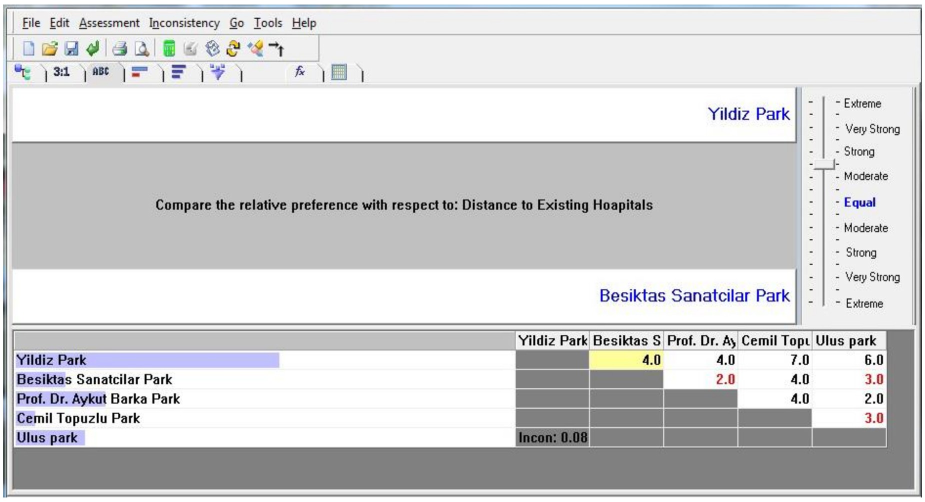

Figure 6.10: The verbal comparison for distance to existing hospitals.

2) **Graphical Judgment:** Graphical judgments are made by adjusting the relative length of two bars until the relative lengths of the bars represent how many times more important one element is than the other. The figure 6.11 presents the pairwise comparison of "Population Density" that is compared with graphical judgment.

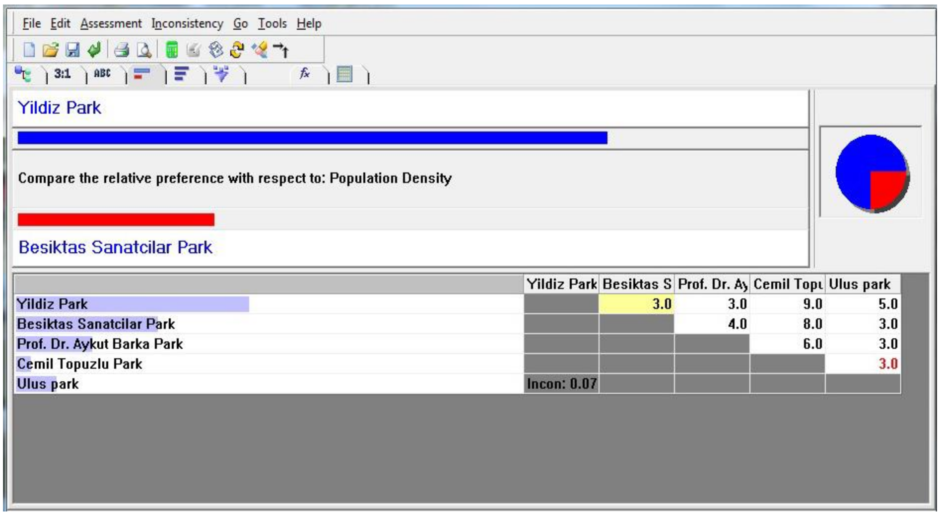

Figure 6.11: The graphical comparison for population density.

3) **Numerical Judgment:** Numerical judgments are made using a nine-point scale, represent how many times one element is more important than another. The figure 6.12 presents the pairwise comparison of "Distance from Arterial Routes" that is compared with numerical judgment.

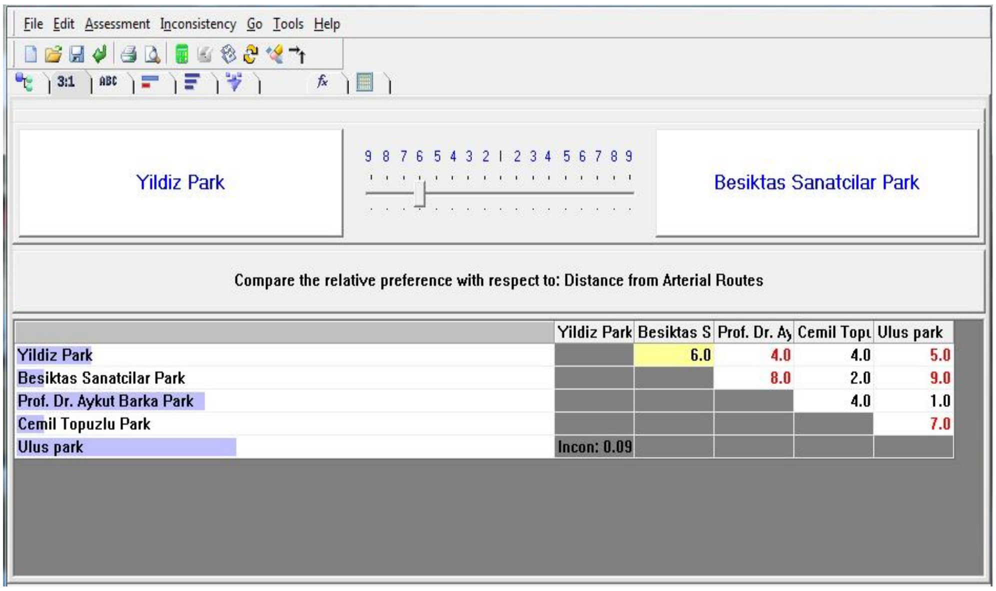

Figure 6.12: The numerical comparison for distance from arterial routes.

At each level of hierarchy, we consider about consistency ratio (CR) of the estimated vector. If CR<0.10, then pairwise comparisons are acceptable; if, CR≥0.10, the values of ratio are indicative of inconsistent judgments. In such cases, one should reconsider and revise the original pairwise comparison matrix. In order to avoid the changing in the judgments of the respondents, only small changes are applied in this study.

6.8 Results and Sensitivity Analyses

We entered all of judgment matrices that are obtained from three experts and software determined all of Local and Global weights and the priority of alternatives and criteria. The figures 6.11.1- 6.11.6 represent the priority of alternatives with respect to the each criteria.

In the figure 6.13 we can see the pairwise matrices of alternative with respect to the Distance from Arterial Routes. In this matrix the consistency is equal to 0.09 and we can be sure about reliable decision for the Distance from Arterial Routes. The priority weight of each alternative are defined as Yildiz Park (0.144), Prof. Dr. Aykut Parak (0.351), Besiktas Sanatcilar Park (0.047), Ulus Park (0.412) and Cemil Topuzlu Park (0.047). The best alternative with the respect of Distance from Arterial Routes is Ulus Park. It means that Ulus Park is closer to the arterial routes than other Parks. After that, Prof. Dr. Aykut Parak, Yildiz Park are the next priorities sequentially. And the Besiktas Sanatcilar Park and Cemil Topuzlu Park have the equal priority for being fourth alternative to site selection for field hospital.

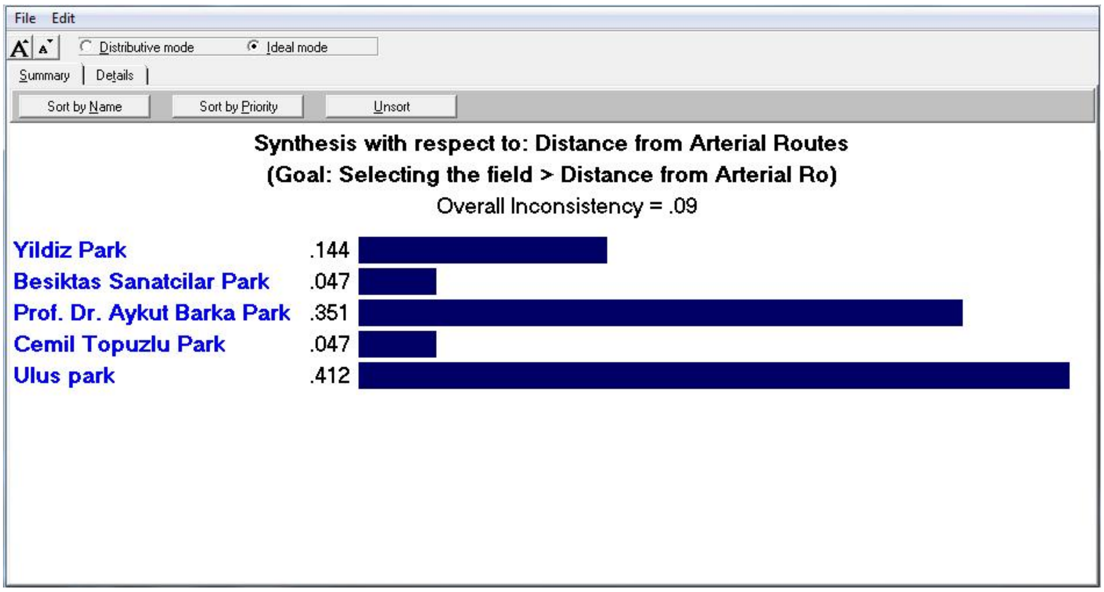

Figure 6.13: The pairwise comparison of alternatives with respect to the distance from arterial routes.

Also, in the figure 6.14 we can see the pairwise matrices of alternative with respect to the Distance to Existing Hospital. In this matrix the consistency is equal to 0.08 and we can be sure about reliable decision for the Distance to Existing Hospital. The priority weight of each alternative are defined as Yildiz Park (0.528), Prof. Dr. Aykut Parak (0.183), Besiktas Sanatcilar Park (0.103), Ulus Park (0.142) and Cemil Topuzlu Park (0.044). The best alternative with the respect of Distance to Existing Hospital is Yildiz Park. It means that Yildiz Park is closer to the existing hospital than other Parks. After that, Prof. Dr. Aykut Parak, Ulus Park, Besiktas Sanatcilar Park, and Cemil Topuzlu Park are the next priorities sequentially.

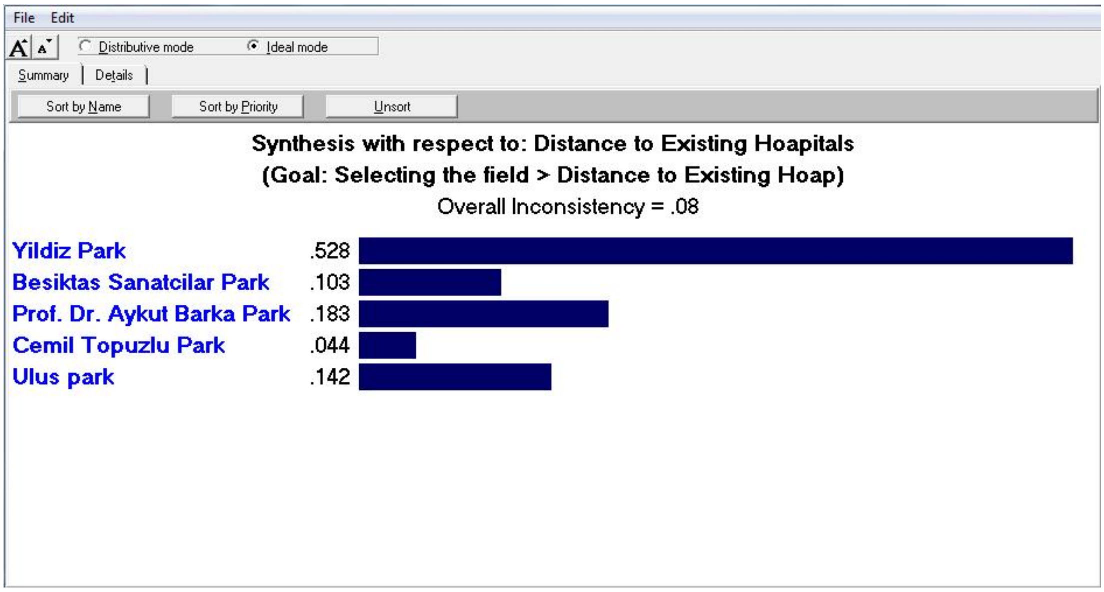

Figure 6.14: The pairwise comparison of alternatives with respect to the distance to existing hospitals.

Figure 6.15 depics the weight of alternatives in the respect of Population Density. The wight of Yildiz Park is 0.457 and it is the best location for field hospital in the respect of Population Density. Other parks with their weight are determined as Besiktas Sanatcilar Park (0.285), Prof. Dr. Aykut Barka Park (0.149), Ulus Park (0.077), and Cemil Topuzlu Park (0.032) sequentially. The consistancy is 0.07 in this matrice.

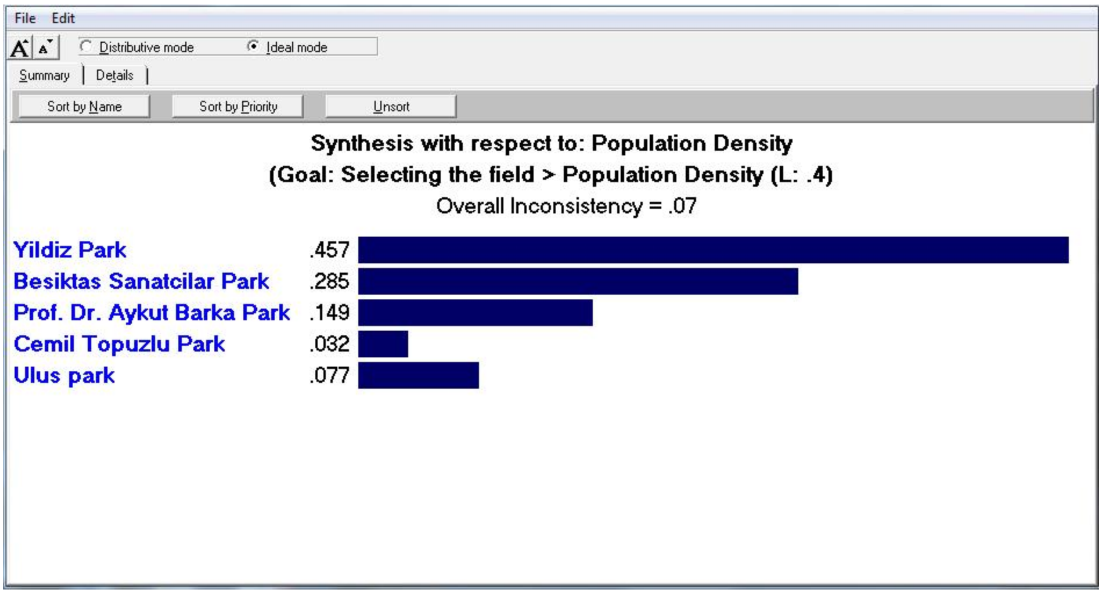

Figure 6.15: The pairwise comparison of alternatives with respect to the population density.

Figure 6.16 represented the weight of alternatives and their priority in respect to the Time to Operate. İn this part, Prof. Dr. Aykut Barka Park in the first priority and it needs shorter time to operate for installing field hospital. After this park, Ulus Park, Yildiz Park, Besiktas Sanaticilar Park, and Cemil Topozlu Park have the next priorities. Their weight are determined as 0.330, 0.240, 0.235, 0.109, and 0.088 with respect to their priority in this part. Also the consistency is 0.09.

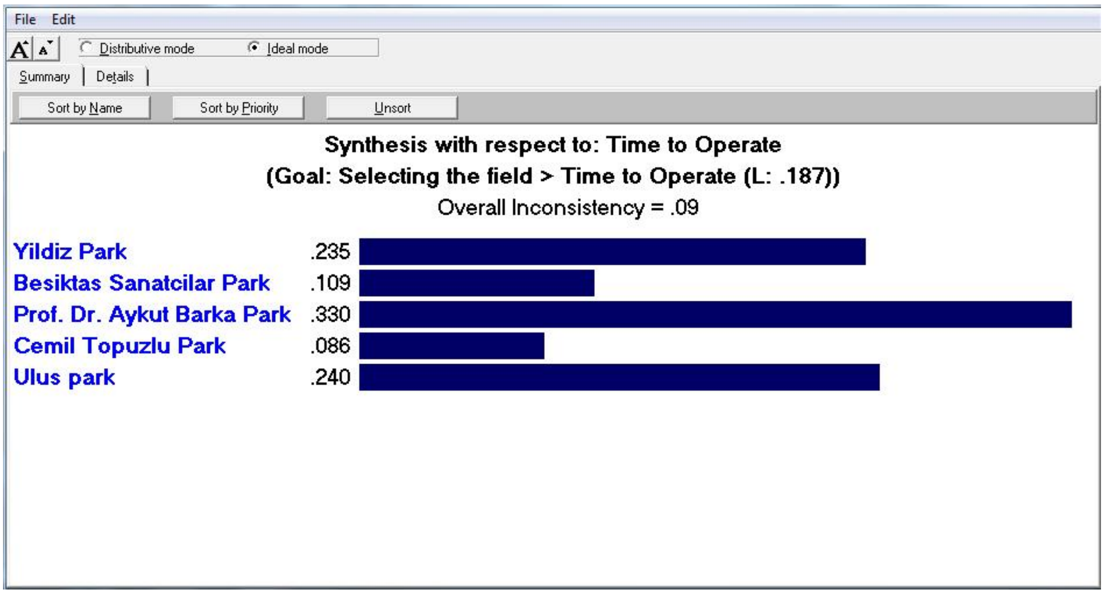

Figure 6.16: The pairwise comparison of alternatives with respect to the time to operate.

Capacity of Bed is another criteria which is shown in the figure 6.17. In this figure, the priorities of alternative are defined with respect to the Capacity of Bed with 0.08 consistency. The Prof. Dr. Aykut Barka Park has the first priority same as Time to Operate part. This park has characteristics which are compatible with the Time to operate and Capacity of Bed criteria. Yildiz Park, Ulus Park, Cemil Topuzlu Park, and Besiktas Sanaticilar Park are the next priorities sequentially. In addition, their weight are determined as 0.506, 0.165, 0.150, 0.142, and 0.037 with respect to their priorities.

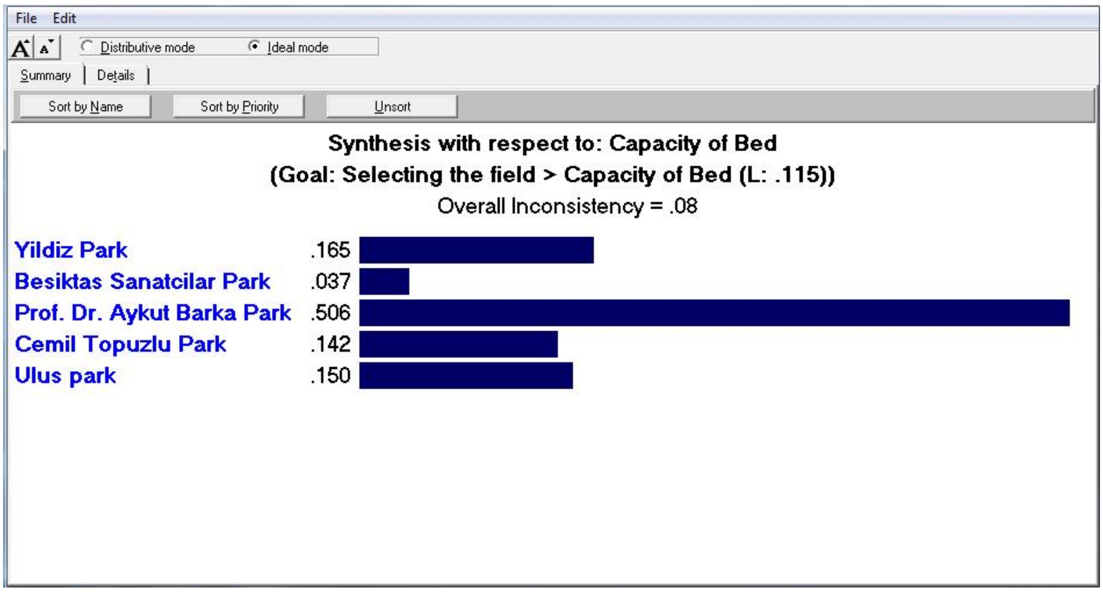

Figure 6.17: The pairwise comparison of alternatives with respect to the capacity of bed.

In the figure 6.18 we can see the local weight of each criteria with respect to the goal. The local weight of criteria are defined as Distance from Arterial Routes is 0.054, Distance to Existing Hospital is 0.234, Population Density is 0.409, Time to operate is 0.187, and Capacity of Bed is 0.115.

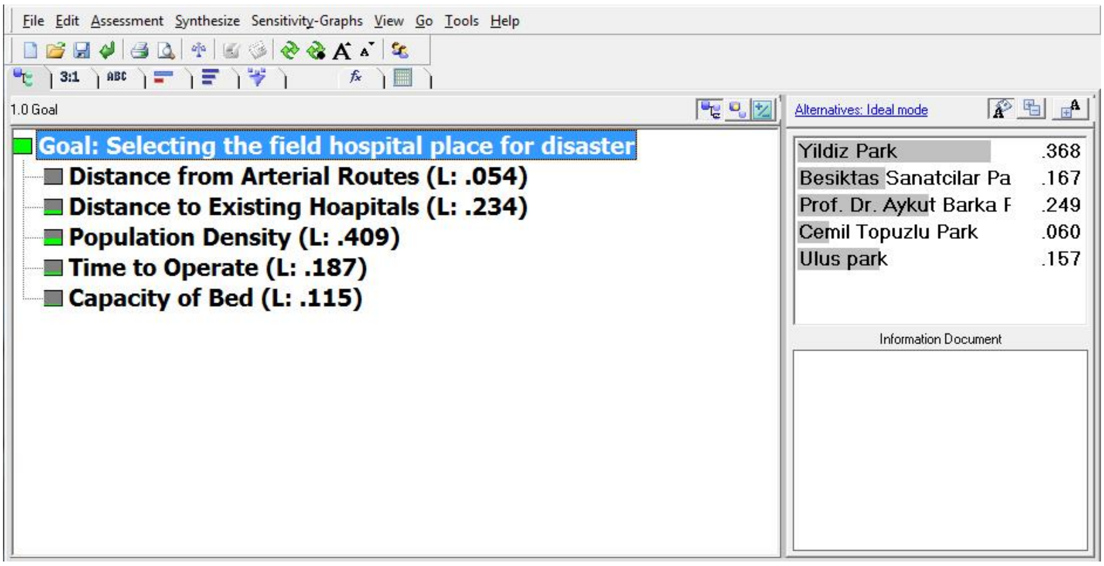

Figure 6.18: The local weight of criteria.

Priorities for the alternatives have been automatically calculated by software with respect to comparison matrices of criteria which have been defined before this. The figure 6.19 shows the pairwise comparison of alternatives.

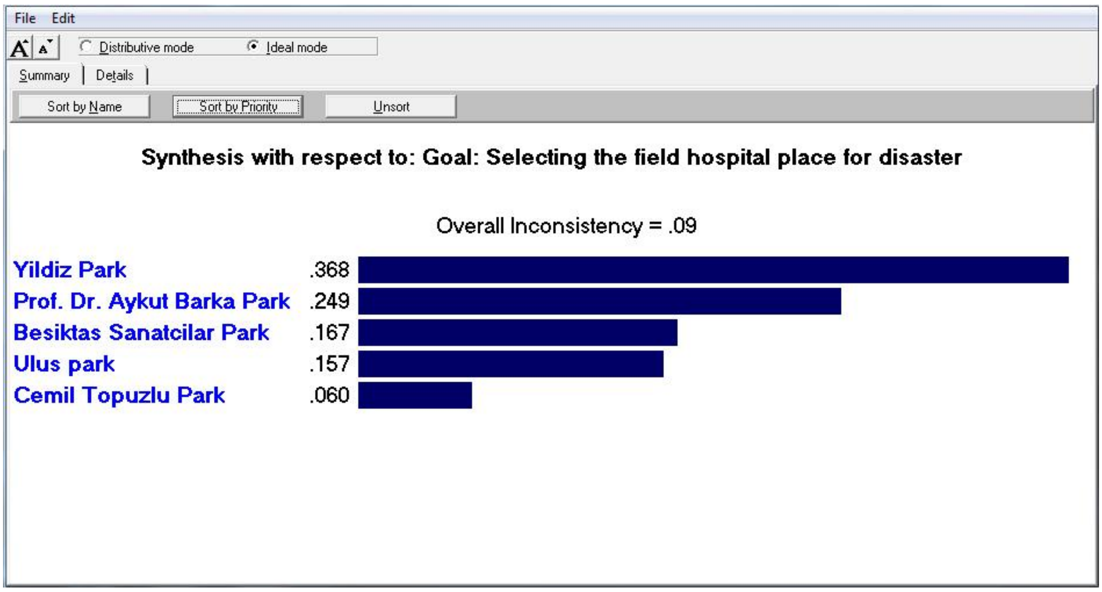

Figure 6.19: The pairwise comparison of alternatives.

As appeared in the figure 6.19 the best place for building field hospital is Yildiz Park. the next one is Prof. Dr. Aykut Parak, then Besiktas Sanatcilar Park, next one is Ulus Park, and the last one is Cemil Topuzlu Park that are located in Besiktas. The weight of these alternatives are defined as Yildiz Park (0.368), Prof. Dr. Aykut Parak (0.249), Besiktas Sanatcilar Park (0.167), Ulus Park (0.157) and Cemil Topuzlu Park (0.060). Also, the overall consistency is 0.09 that is shown our decision making is reliable.

Sensitivity Analyses

After all the judgments have been made and priorities have been calculated, a synthesis is automatically performed by software. Sensitivity analyses from the goal node will show the sensitivity of the alternatives with respect to all the objectives below the goal. There are five types of sensitivity analysis. Dynamic, Performance, Gradient, Head to Head, and Two-Dimensional (2D Plot).

1) Dynamic Sensitivity

Dynamic sensitivity analysis is used to dynamically change the priorities of the objectives to determine how these changes affect the priorities of the alternative choices. By dragging the objective's priorities back and forth in the left column, the priorities of the alternatives will change in the right column. If a decision-maker thinks an objective might be more or less important than originally indicated, the decision-maker can drag that objective's bar to the right or left to increase or decrease the objective's priority and see the impact on alternatives. Figure 6.20 shows a Dynamic Sensitivity graph with Component.

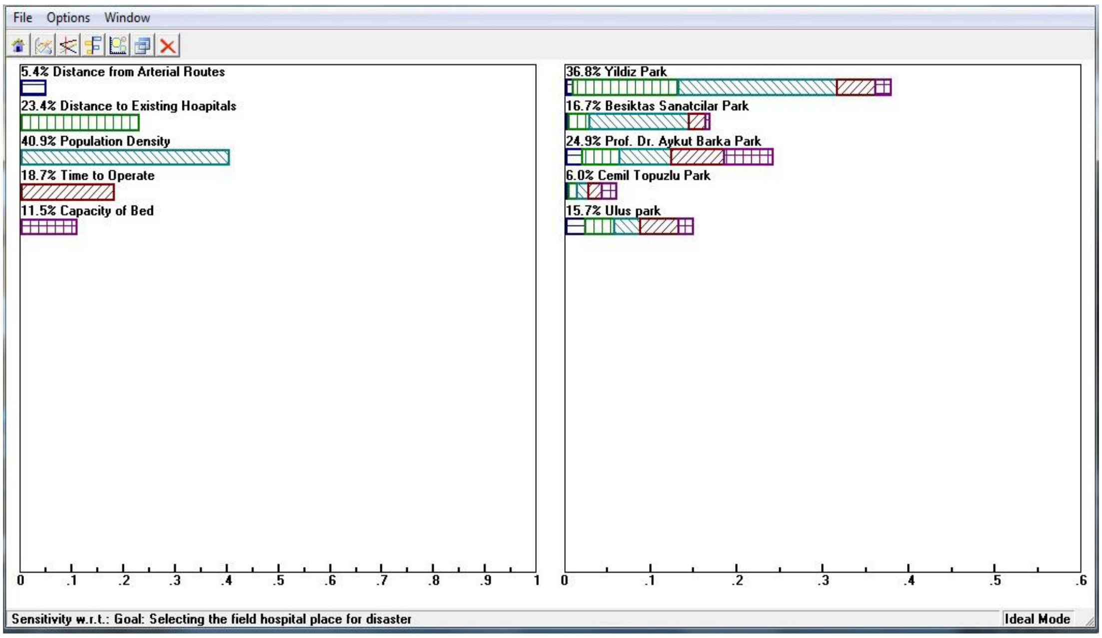

Figure 6.20: The Dynamic sensitivity with component option.

As shown in the figure 6.20, the total participation in for alternatives with respect to the goal are determined as Yildiz Park has 36.8%, Besiktas Sanatcilar Park has 16.7%, Prof. Dr. Aykut Parak has 24.9%, Cemil Topuclu Park has 6%, and Ulus Park has 15.7%. In addition, each criteria has the participation with respect to the goal. Distance from Arterial Routes has 5.4%, Distance to Existing Hospital has 23.4%, Population Density has 40.9%, Time to operate has 18.7%, and Capacity of Bed has 11.5%. It is clearly obvious that the Population Density in the most important factor in our study, after that Distance from Existing Hospitals, next one is Time to operate, the fourth one is Capacity of Bed, and the last criteria is Distance from Arterial Routes.

2) Performance Sensitivity

The Performance sensitivity analysis shows how the alternatives were prioritized relative to other alternatives with respect to each objective as well as overall. This graph is also dynamic and shows the relationship between the alternatives and their objectives. Figure 6.21 display a Performance Sensitivity graph.

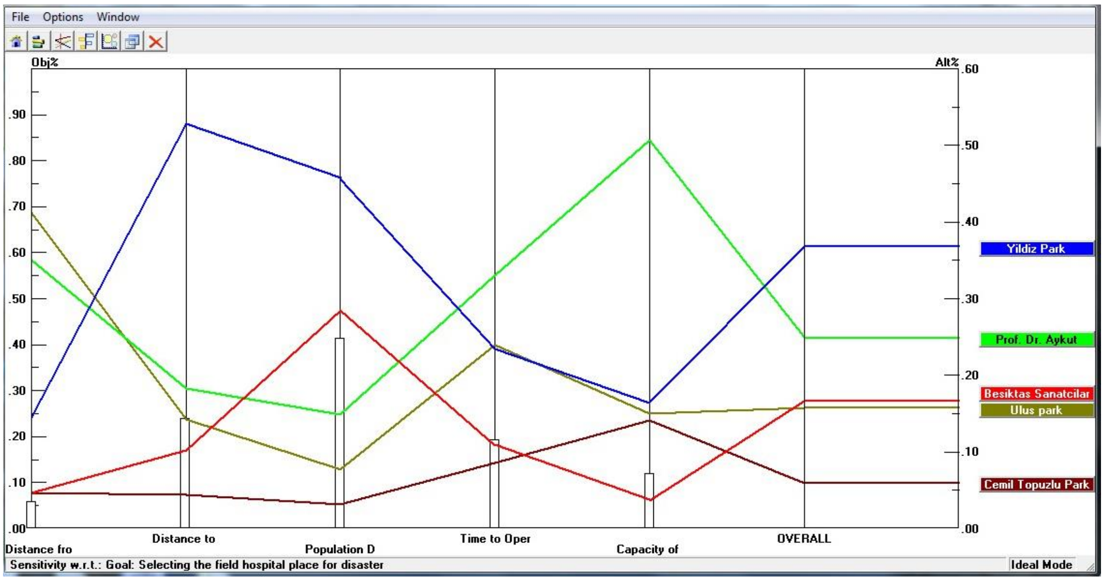

Figure 6.21: The performance sensitivity.

As figure 6.21 is depicts, in the Distance from Arterial Routes, the Ulus Park has high performance and Cemil Topuzlu Park has the lowest performance. Also, Yildiz Park has high performance in Distance to Existing Hospitals and Cemil Topuzlu Park has the lowest Performance in this factor. For the Population Density, the highest performance is related to the Yildiz Park, and the lowest performance is related to the Cemil Topuzlu Park. In addition, Prof. Dr. Aykut Park has the best performance in Time to Operate and Cemil Topuzlu Park has the worth performance in this factor. Also, for the Capacity of Bed, Yildiz is best and Besiktas Sanatcilar Park is the worth alternative.

3) Gradient Sensitivity

The Gradient sensitivity analysis shows the alternatives' priorities with respect to one objective at a time. We have the ability to select which objective appears on the x-axis in the graph and make gradient sensitivity for each criteria. The red Line shows the local weight of each criteria.

Figure 6.22 depicts a Gradient graph for Alternatives with respect to the Distance from Arterial Routes. These figures show that the Yildiz Park is the first priority and Prof. Dr. Aykut Part, Besiktas Sanatcilar Park, Ulus Park, and Cemil Topuzlu Park are the next priorities sequentially.

In this figure, also, we can study the behavior of each alternative in the head-to-head point of this alternatives with other alternatives. Each head-to-head point shows that the priority and behavior of these two alternatives are the same.

Also, ohter figures that are related to the other criteria are mentioned in the appendix.

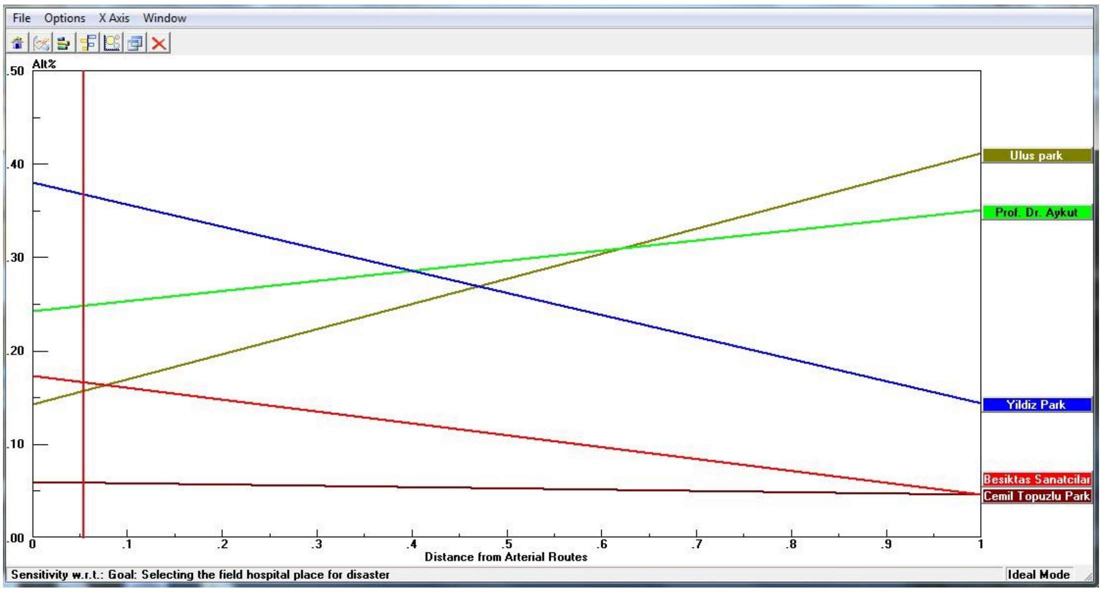

Figure 6.22: The gradient sensitivity for distance from arterial routes.

4) Head-to-Head Sensitivity

Head-to-Head sensitivity analysis shows how two alternatives compared to one another against the objectives in a decision. One alternative is listed on the left side of the graph and the other is listed on the right. The alternative on the left is fixed while the alternative on the right can be varied, by selecting a different tab on the graph. Down the middle of the graph are listed the objectives in the decision. If the left-hand alternative is preferred to the right-hand alternative with respect to an objective, a horizontal bar is displayed towards the left. If the right-hand alternative is better, the horizontal bar will be on the right. If the two choices are equal, no bar is displayed. The overall result is displayed at the bottom of the graph and shows the overall percentage by which one alternative is better than the other. Figure 6.23 represents the situation between Yildiz Park and Prof. Dr. Aykut Park. The other Head-to-Head sensitivity analysis that are related to the other alternatives are mentioned in the appendix.

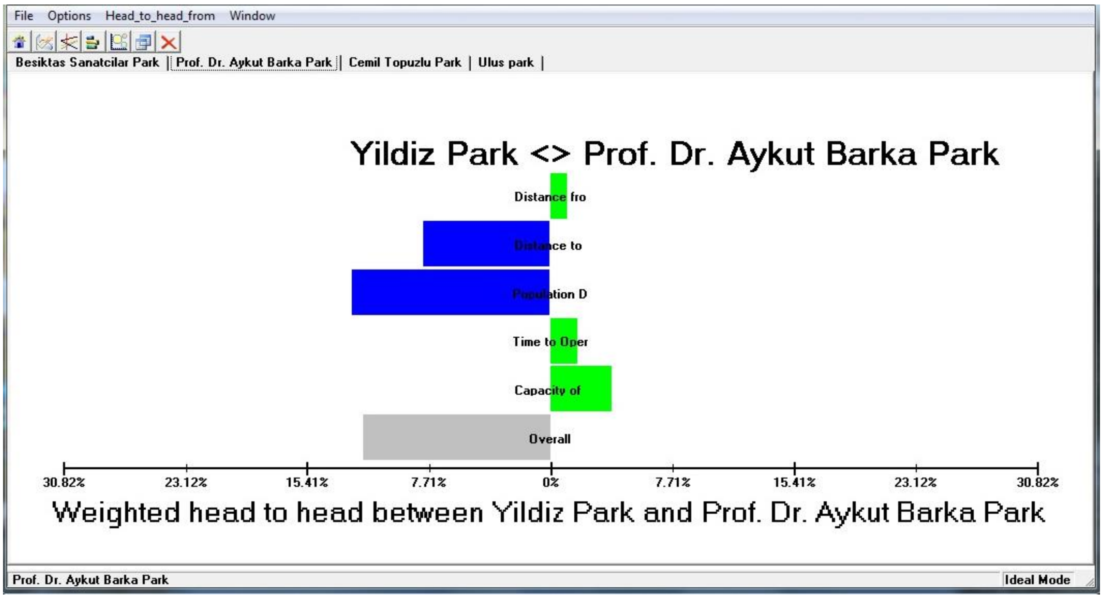

Figure 6.23: The Head-to-Head sensitivity for Yildiz Park.

5) Two-Dimensional (2D Plot) Sensitivity

Two-Dimensional (2D Plot) sensitivity graph is shown in the figure 6.24. This graph shows the alternatives' priorities with respect to two objectives at a time. By changing "X Axis" and "Y Axis" we can change the objectives are displayed in the graph. The area of the 2D plot is divided into quadrants. The most favorable alternatives with respect to the objectives on the two axes will be shown in the upper right quadrant (the closer to the upper right corner, the better the alternative). The least favorable alternatives will be shown in the lower left quadrant (the closer to the lower left corner, the less favorable the alternative). Alternatives located in the upper left and lower right quadrants indicate key tradeoffs where there is conflict between the two selected objectives.

Figure 6.24 depicts 2D graph for priority of alternatives with respect to the Population Density and Capacity of Bed. As this figur shows, Yildiz Park has better priority than others because it is located in the upper left quarter. Also, Prof. Dr. Aykut Park is the next priority which is located in the lower right quarter. The other alternative that are located in the lower left quarter have the priorities as defined as Besiktas Sanatcilar Park, Ulus Park, and Cemil Topuzlu Park sequentially.

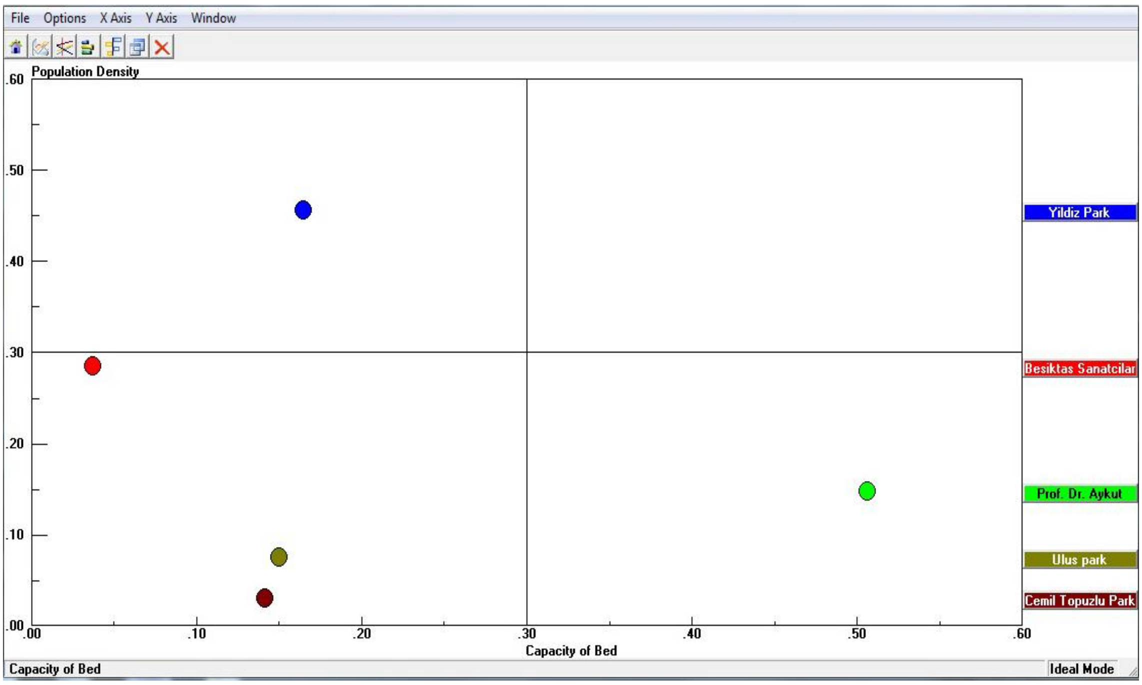

Figure 6.24: The Two-Dimensional sensitivity.

7. CONCLUSION AND RESULT

This study combined AHP and GIS to define the model to determine optimal field hospital location. In this study, the alternatives are defined, the criteria for selecting best location for field hospital are determined, the roles of AHP and GIS in estimating the optimal site are explained, and the results of case study for selecting best place of field hospital in Besiktas, Istanbul, Turkey are presented.We define the priorities of criteria by the helps of three disaster management academician who evaluated our factors in this case study.

Facilitating of finding best place for field hospital is resulted by combining the decision support methodology of AHP with powerful visualization of GIS. This combination provides strong abilities to analyzing the alternatives of field hospital site selection by improving the disaster management capabilities for making decision in the disaster. We study on AHP and GIS interaction in the emergency management and achieve specific model by considering of these three subjects at time. For making decision in emergency situation, accurate definition of criteria and evaluating and analysis are very vital for emergency response. This study provides strong visualization maps by using ArcGIS software for having better analyze. Also, it prepares a progressive decision making model by using Expert choice software. This model improves decision making process in disaster and the emergency response to decrease the loss of human life and property (Erden and coskun, 2009).

As result the best place for building field hospital is Yildiz Park. Then, Prof. Dr. Aykut Park, Besiktas Sanatcilar Park, Ulus Park, and Cemil Topuzlu Park are sequentially next priorities for bilding field hospital in Besiktas (Figure 6.12). Their weights are defined sequentially 0.368, 0.249, 0.167, 0.157, and 0.060.

Each criteria has specific participation in the model which is determined the role of criteria and its importance. The most important criteria is Population Density with 40.9% participation. Also, the least important criteria is Distance from Arterial Routes with 5.4% participation in the model. Other criteria will be held between these two criteria. The participation of them are defined as Distance from Existing

Hospital is 23.4%, Time to Operate is 18.7%, and Capacity of Bed is 11.5% sequentially from highest to lowest.

This study analyzed the major factors for field hospital planning and suggested the especial planning based on GIS and AHP for field hospital planning. Taking data from Istanbul municipality and designing AHP models for site selection by using GIS are done in this study. The main role of GIS is undeniable for preparing visualized maps with buffer method which is one method of ArcGIS software. We know that all of factors that are include in our study are not enough and we will improve our factors and detail in the next study. In the future study we will focus on Fuzzy Analytical Hierarchy Process (FAHP) for making decision in the emergency situation with GIS interaction.

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APPENDICES

APPENDIX A: Experts Survey

APPENDIX B: Gradiat Sensitivity Analysis

APPENDIX C: Head-to-Head Sensitivity Analysis

APPENDIX D: Two-Dimensional (2D Plot) Sensitivity Analysis

APPENDIX A

It is so appreciated if you compare the relative importance of criteria and alternatives that are given in the pairwise matrices respect to the maps and factors. Please put “X” in the suitable box with considering the 1-9 number scale.

Example 1: In the pairwire matrix, If you think that the importance of Besiktas Sanatcilar Park is very strongly more than Prof. Dr. Aykut Barka Park with respect to the population density, please put "X" to the box of number 7 close to the Besiktas Sanatcilar Park.

	Extreme		Very Strong		Strong		Moderate		Equal	Moderate		Strong		Very Strong		Extreme		
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Besiktas Sanatcilar Park			X															Prof. Dr. Aykut Barka Park

Example 2: In the pairwire matrix, If you think that the importance of Besiktas Sanatcilar Park is equal to Prof. Dr. Aykut Barka Park with respect to the population density, please put "X" to the box of number 1.

	Extreme		Very Strong		Strong		Moderate		Equal	Moderate		Strong		Very Strong		Extreme		
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Besiktas Sanatcilar Park									X									Prof. Dr. Aykut Barka Park

Example 3: In the pairwire matrix, If you think that the importance of Prof. Dr. Aykut Barka Park is very strongly more than Besiktas Sanatcilar Park with respect to the population density, please put "X" to the box of number 7 close to the Prof. Dr. Aykut Barka Park.

	Extreme		Very Strong		Strong		Moderate		Equal	Moderate		Strong		Very Strong		Extreme		
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Besiktas Sanatcilar Park															X			Prof. Dr. Aykut Barka Park

Question 1: Please compare the importance of Alternatives that are given in the pairwise matrices with respect to the Distance from Arterial Routes.

	Extreme		Very Strong		Strong		Moderate		Equal	Moderate		Strong		Very Strong		Extreme		
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Besiktas Sanatcilar Park																		Prof. Dr. Aykut Barka Park
Besiktas Sanatcilar Park																		Ulus Park
Besiktas Sanatcilar Park																		Cemil Topuzlu Park
Besiktas Sanatcilar Park																		Yıldız Park
Prof. Dr. Aykut Barka Park																		Ulus Park
Prof. Dr. Aykut Barka Park																		Cemil Topuzlu Park
Prof. Dr. Aykut Barka Park																		Yıldız Park
Ulus Park																		Cemil Topuzlu Park
Ulus Park																		Yıldız Park
Cemil Topuzlu Park																		Yıldız Park

Question 2: Please compare the importance of Alternatives that are given in the pairwise matrices with respect to the Distance to Existing Hospital.

	Extreme		Very Strong		Strong		Moderate		Equal	Moderate		Strong		Very Strong		Extreme		
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Besiktas Sanatcilar Park																		Prof. Dr. Aykut Barka Park
Besiktas Sanatcilar Park																		Ulus Park
Besiktas Sanatcilar Park																		Cemil Topuzlu Park
Besiktas Sanatcilar Park																		Yıldız Park
Prof. Dr. Aykut Barka Park																		Ulus Park
Prof. Dr. Aykut Barka Park																		Cemil Topuzlu Park
Prof. Dr. Aykut Barka Park																		Yıldız Park
Ulus Park																		Cemil Topuzlu Park
Ulus Park																		Yıldız Park
Cemil Topuzlu Park																		Yıldız Park

Question 3: Please compare the importance of Alternatives that are given in the pairwise matrices with respect to the Population Density.

	Extreme		Very Strong		Strong		Moderate		Equal	Moderate		Strong		Very Strong		Extreme		
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Besiktas Sanatcilar Park																		Prof. Dr. Aykut Barka Park
Besiktas Sanatcilar Park																		Ulus Park
Besiktas Sanatcilar Park																		Cemil Topuzlu Park
Besiktas Sanatcilar Park																		Yıldız Park
Prof. Dr. Aykut Barka Park																		Ulus Park
Prof. Dr. Aykut Barka Park																		Cemil Topuzlu Park
Prof. Dr. Aykut Barka Park																		Yıldız Park
Ulus Park																		Cemil Topuzlu Park
Ulus Park																		Yıldız Park
Cemil Topuzlu Park																		Yıldız Park

Question 4: Please compare the importance of Alternatives that are given in the pairwise matrices with respect to the Time to Operate.

	Extreme		Very Strong		Strong		Moderate		Equal	Moderate		Strong		Very Strong		Extreme		
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Besiktas Sanatcilar Park																		Prof. Dr. Aykut Barka Park
Besiktas Sanatcilar Park																		Ulus Park
Besiktas Sanatcilar Park																		Cemil Topuzlu Park
Besiktas Sanatcilar Park																		Yıldız Park
Prof. Dr. Aykut Barka Park																		Ulus Park
Prof. Dr. Aykut Barka Park																		Cemil Topuzlu Park
Prof. Dr. Aykut Barka Park																		Yıldız Park
Ulus Park																		Cemil Topuzlu Park
Ulus Park																		Yıldız Park
Cemil Topuzlu Park																		Yıldız Park

Question 5: Please compare the importance of Alternatives that are given in the pairwise matrices with respect to the Capacity of Bed.

	Extreme		Very Strong		Strong		Moderate		Equal	Moderate		Strong		Very Strong		Extreme		
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Besiktas Sanatcilar Park																		Prof. Dr. Aykut Barka Park
Besiktas Sanatcilar Park																		Ulus Park
Besiktas Sanatcilar Park																		Cemil Topuzlu Park
Besiktas Sanatcilar Park																		Yıldız Park
Prof. Dr. Aykut Barka Park																		Ulus Park
Prof. Dr. Aykut Barka Park																		Cemil Topuzlu Park
Prof. Dr. Aykut Barka Park																		Yıldız Park
Ulus Park																		Cemil Topuzlu Park
Ulus Park																		Yıldız Park
Cemil Topuzlu Park																		Yıldız Park

Question 6: Please compare the importance of criteria that are given in the pairwise matrices with respect to the goal: Finding the best place for building feild hospital in the disaster in Besiktas district of Istanbul.

	Extreme		Very Strong		Strong		Moderate		Equal	Moderate		Strong		Very Strong		Extreme		
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Distance from Arterial Routes																		Distance to existing hospitals
Distance from Arterial Routes																		Population density
Distance from Arterial Routes																		Time to operate
Distance from Arterial Routes																		Capacity of Beds
Distance to existing hospitals																		Population density
Distance to existing hospitals																		Time to operate
Distance to existing hospitals																		Capacity of Beds
Population density																		Time to operate
Population density																		Capacity of Beds
Time to operate																		Capacity of Beds

APPENDIX B

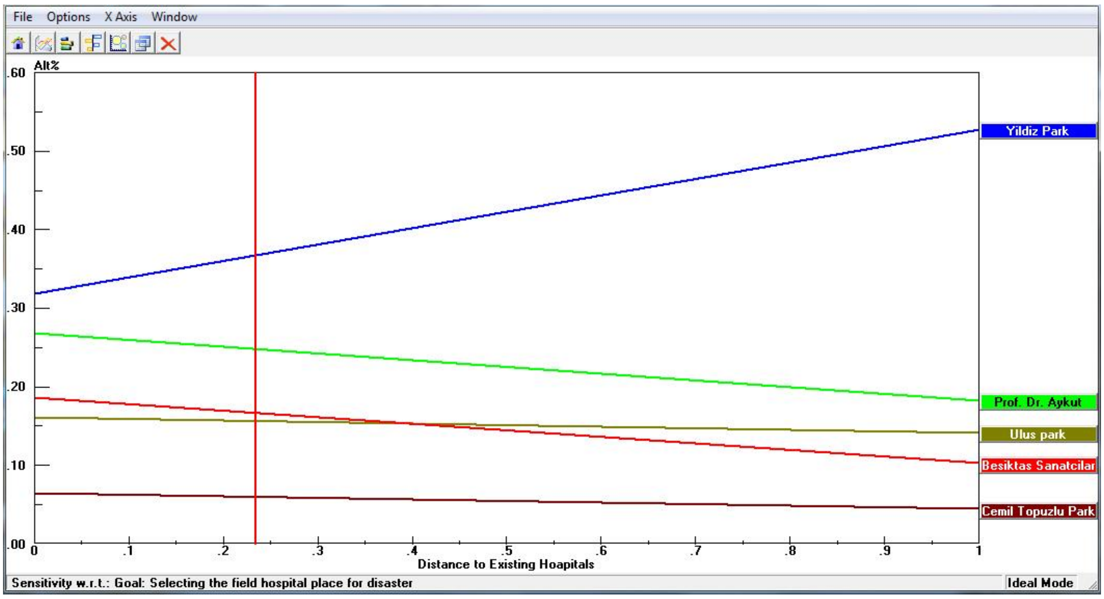

Figure 1: The Gradient Sensitivity for Distance to Existing Hospital.

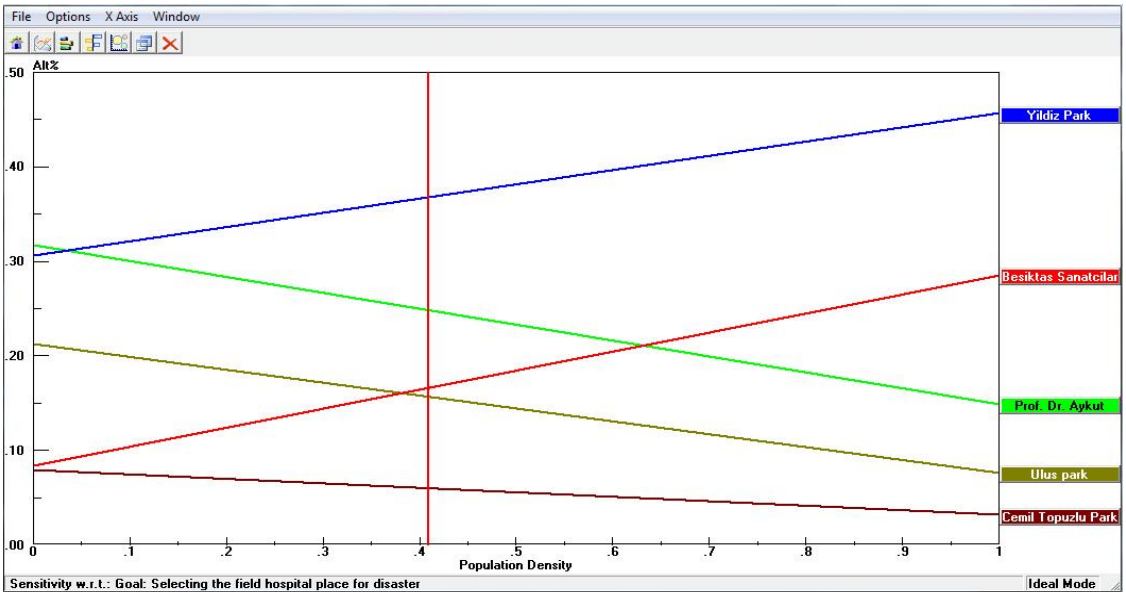

Figure 2: The Gradient Sensitivity for Population Demsity.

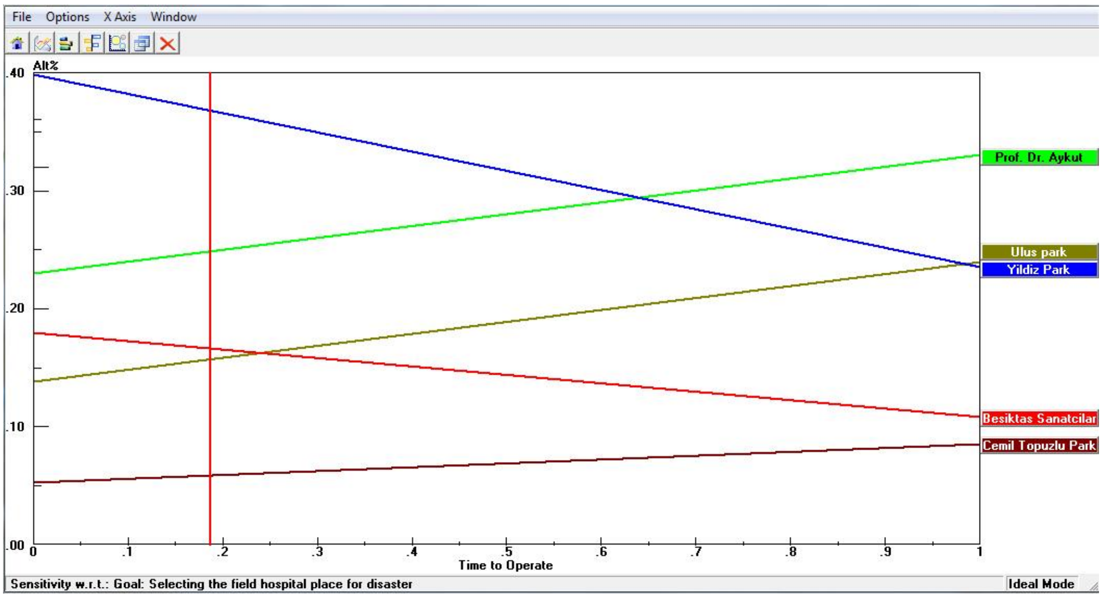

Figure 3: The Gradient Sensitivity for Time to Operate.

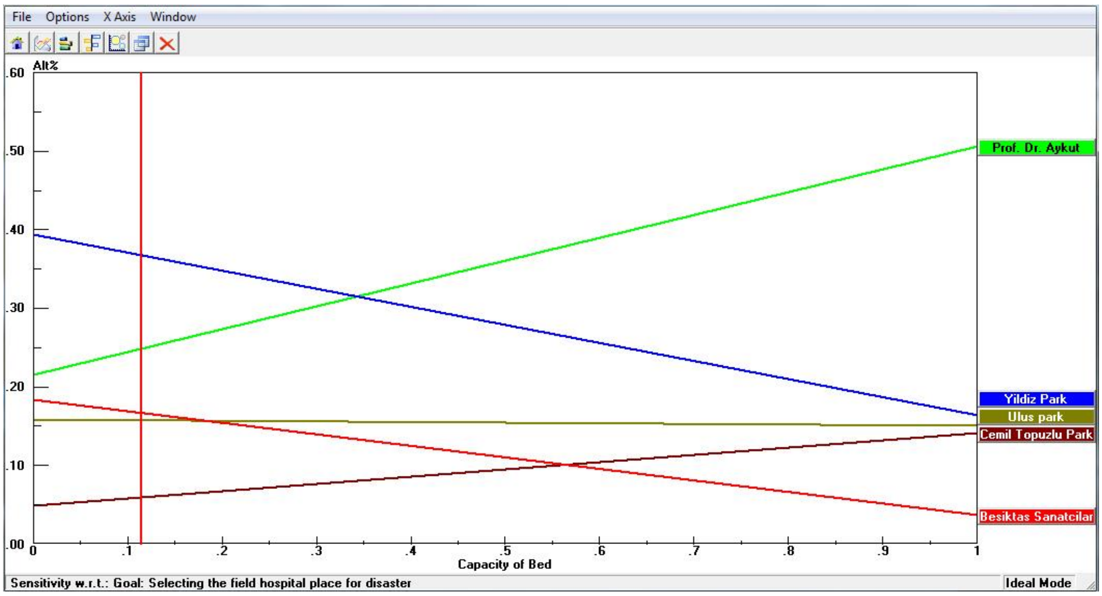

Figure 4: The Gradient Sensitivity for Capacity of Bed.

APPENDIX C

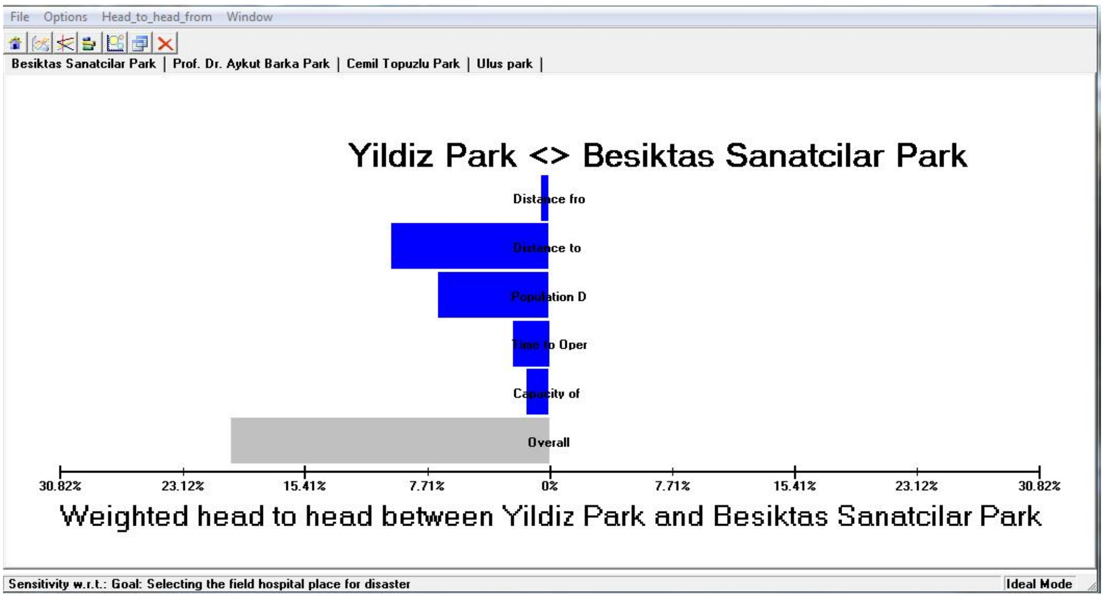

Figure 5: The Head-to-Head Sensitivity between Yildiz Park and Besiktas Sanatcilar Park.

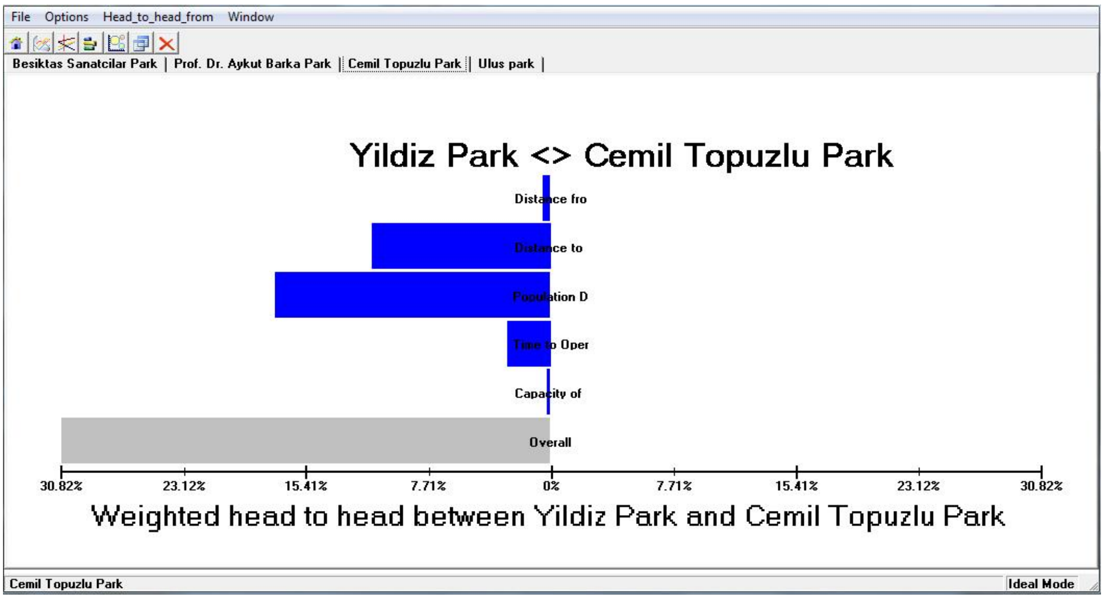

Figure 6: The Head-to-Head Sensitivity between Yildiz Park and Cemil Topuzlu Park.

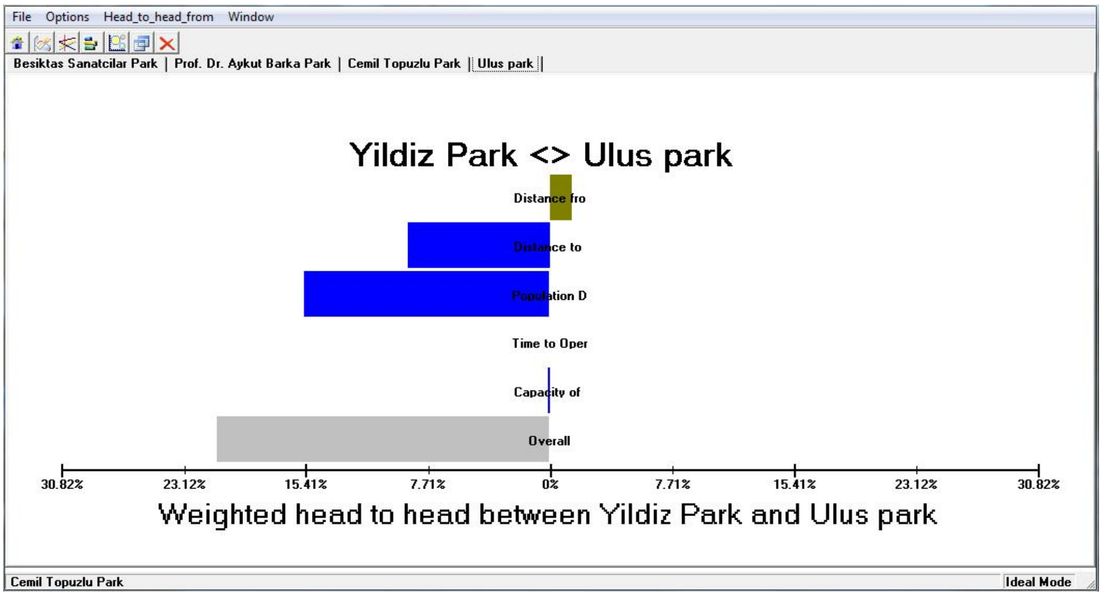

Figure 7: The Head-to-Head Sensitivity between Yildiz Park and Ulus Park.

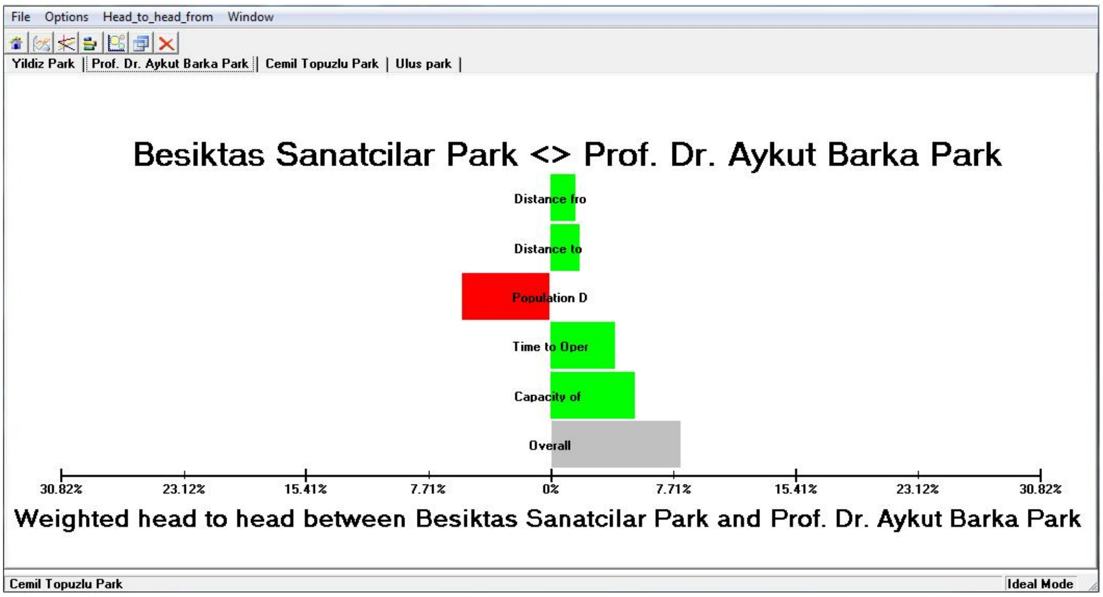

Figure 8: The Head-to-Head Sensitivity between Besiktas Sanatcilar Park and Aykut Barka Park.

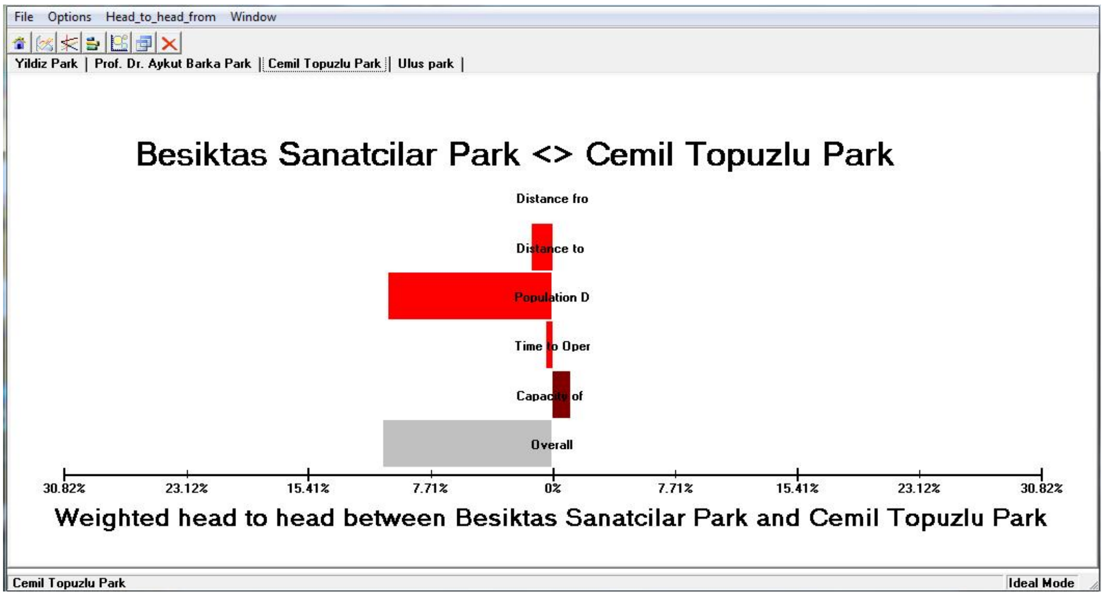

Figure 9: The Head-to-Head Sensitivity between Besiktas Sanatcilar Park and Cemil Topuzlu Park.

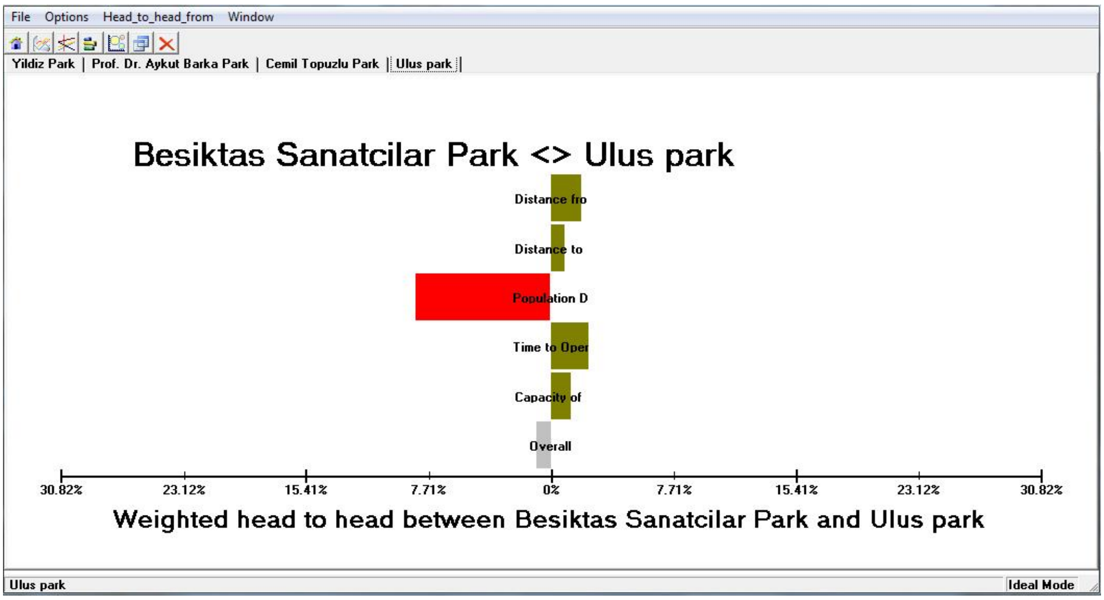

Figure 10: The Head-to-Head Sensitivity between Besiktas Sanatcilar Park and Ulus Park.

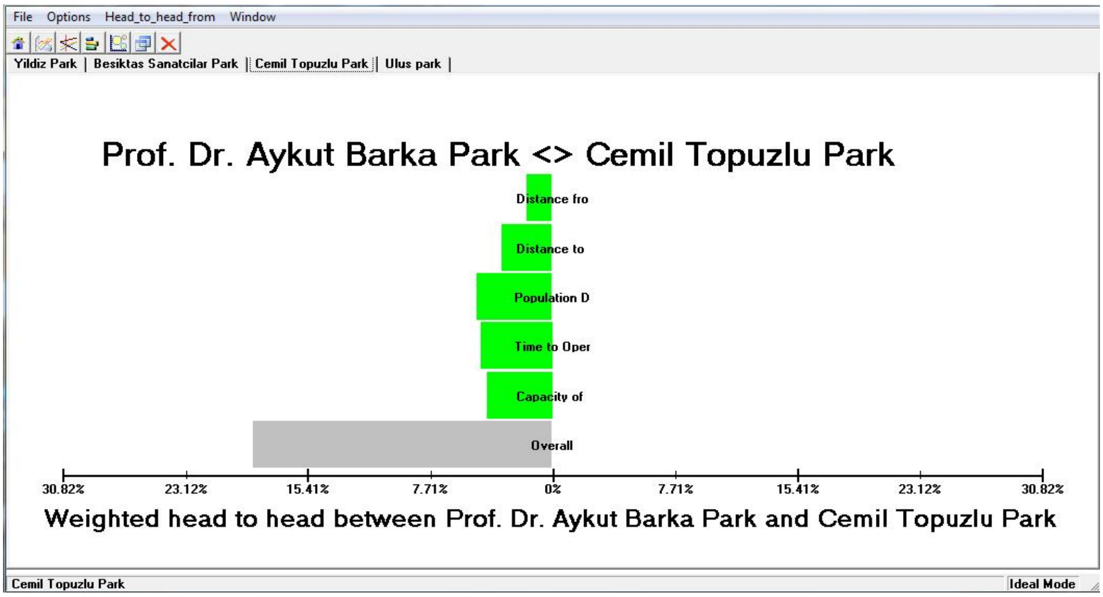

Figure 11: The Head-to-Head Sensitivity between Aykut Barka Park and Cemil Topuzlu Park.

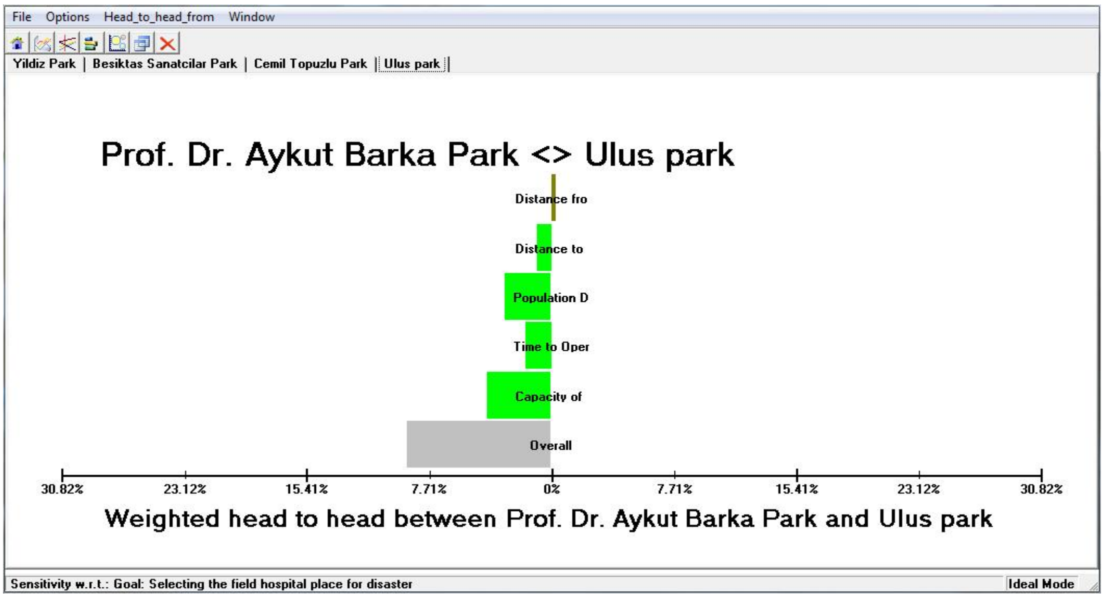

Figure 11: The Head-to-Head Sensitivity between Aykut Barka Park and Ulus Park.

APPENDIX D

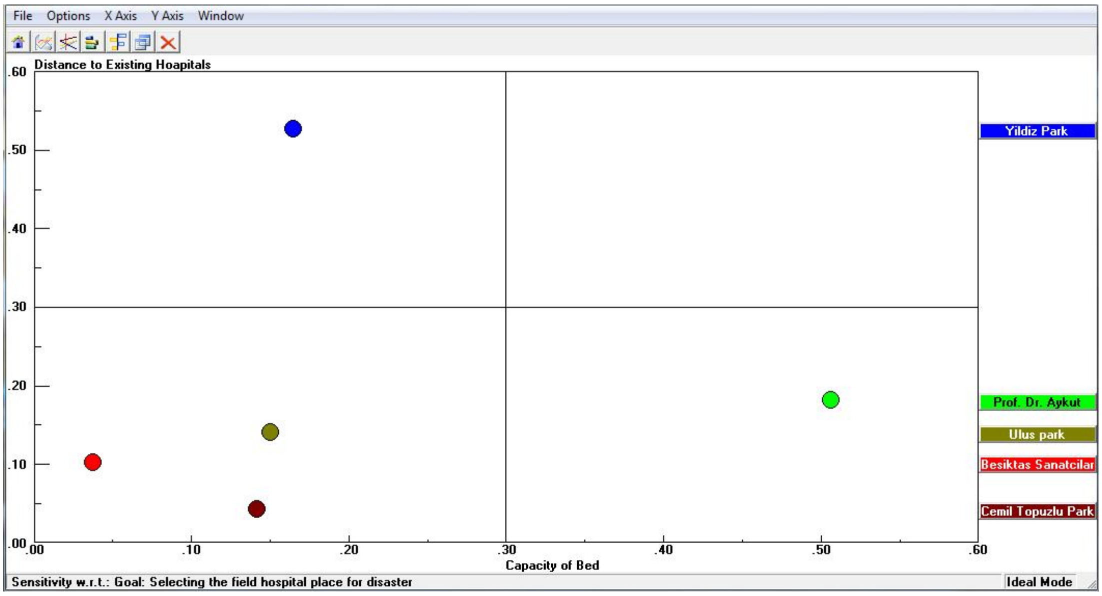

Figure 12: The Two-Dimensional sensitivity between DH and CB.

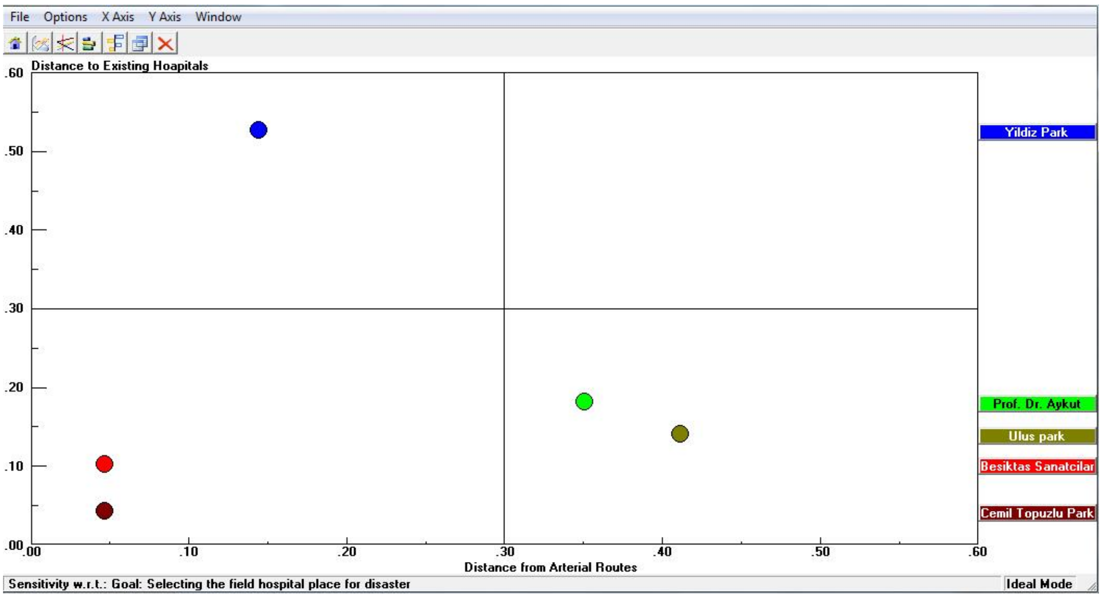

Figure 13: The Two-Dimensional sensitivity between DH and DA.

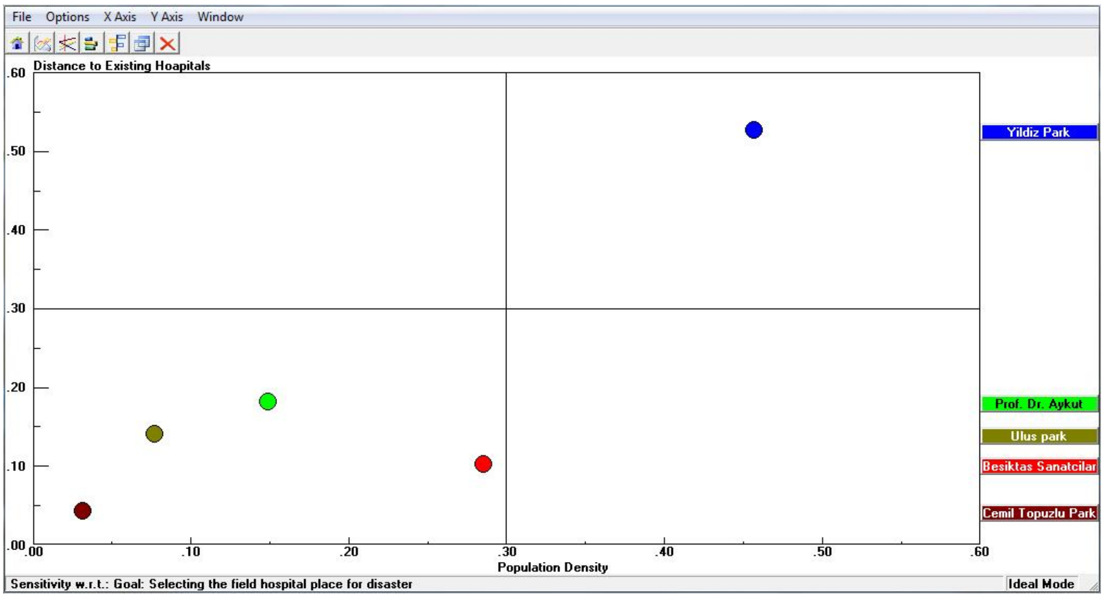

Figure 14: The Two-Dimensional sensitivity between DH and PD.

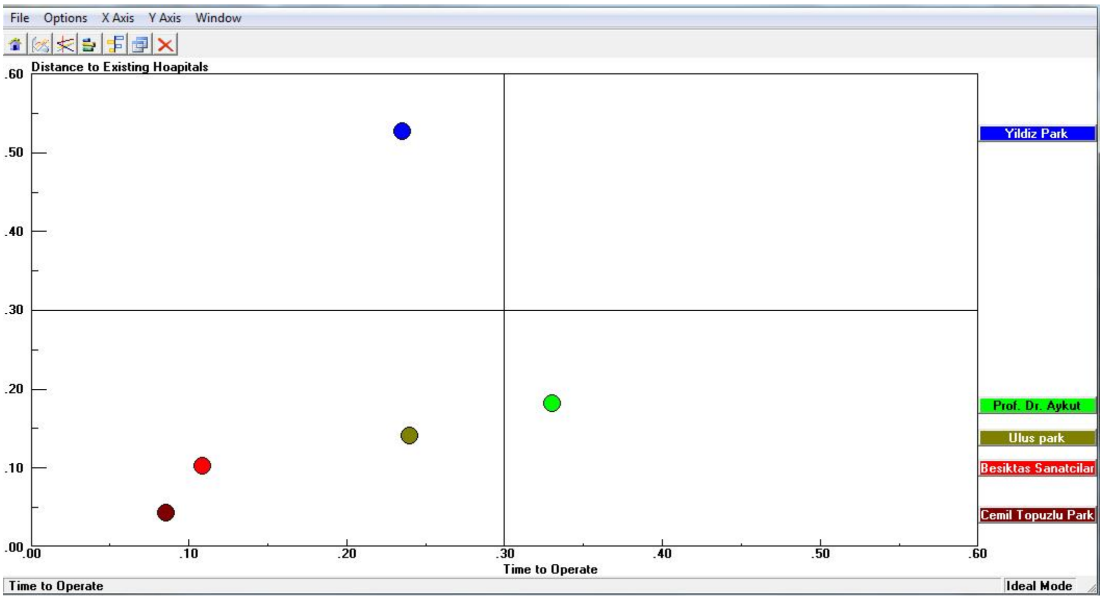

Figure 15: The Two-Dimensional sensitivity between DH and TO.

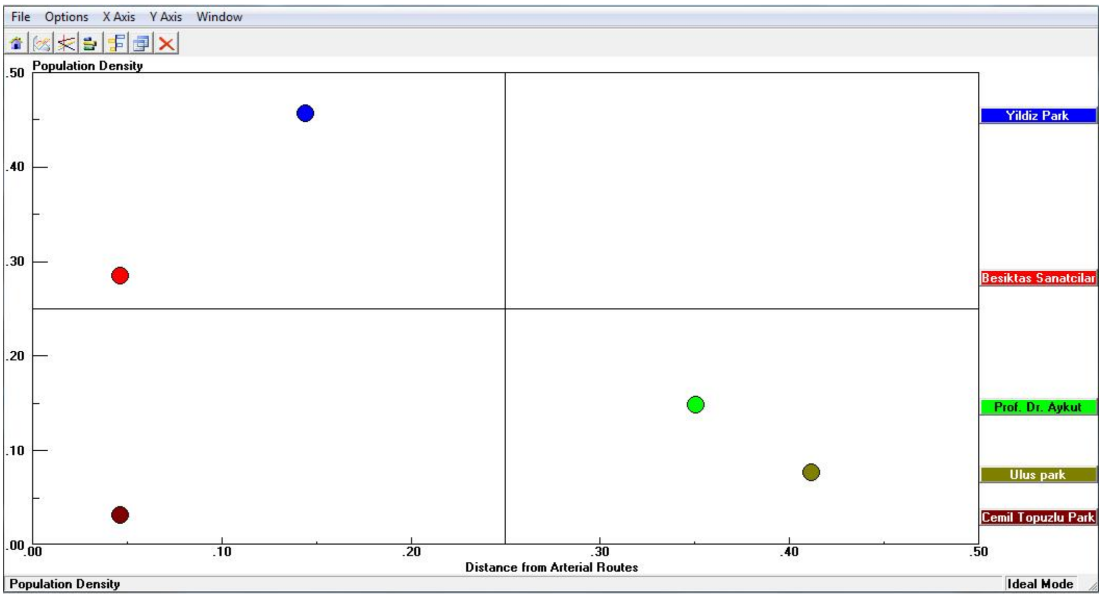

Figure 16: The Two-Dimensional sensitivity between PD and DA.

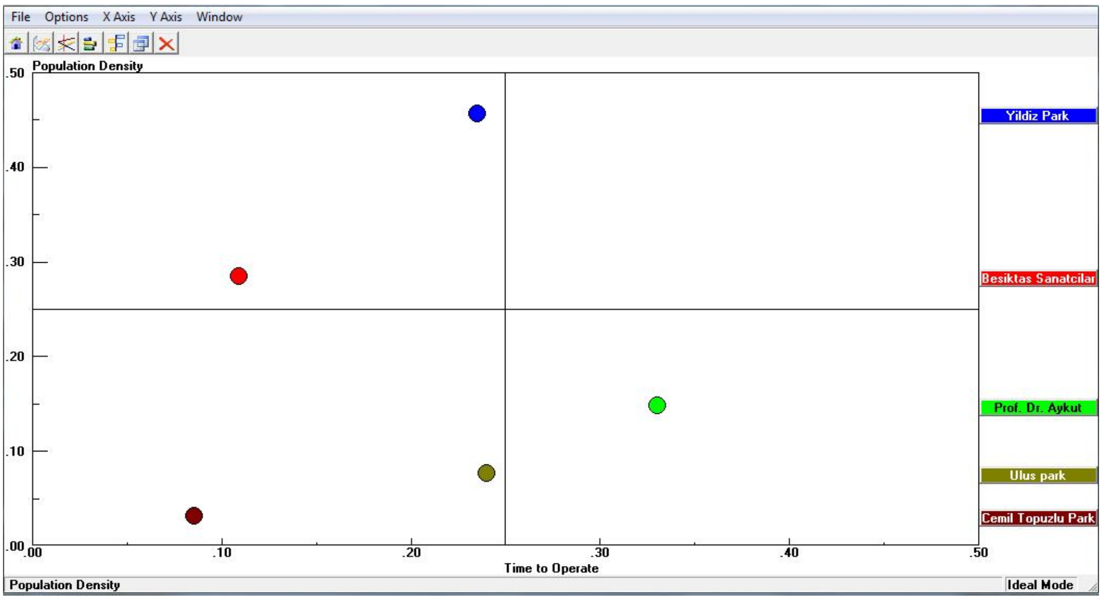

Figure 17: The Two-Dimensional sensitivity between PD and TO.

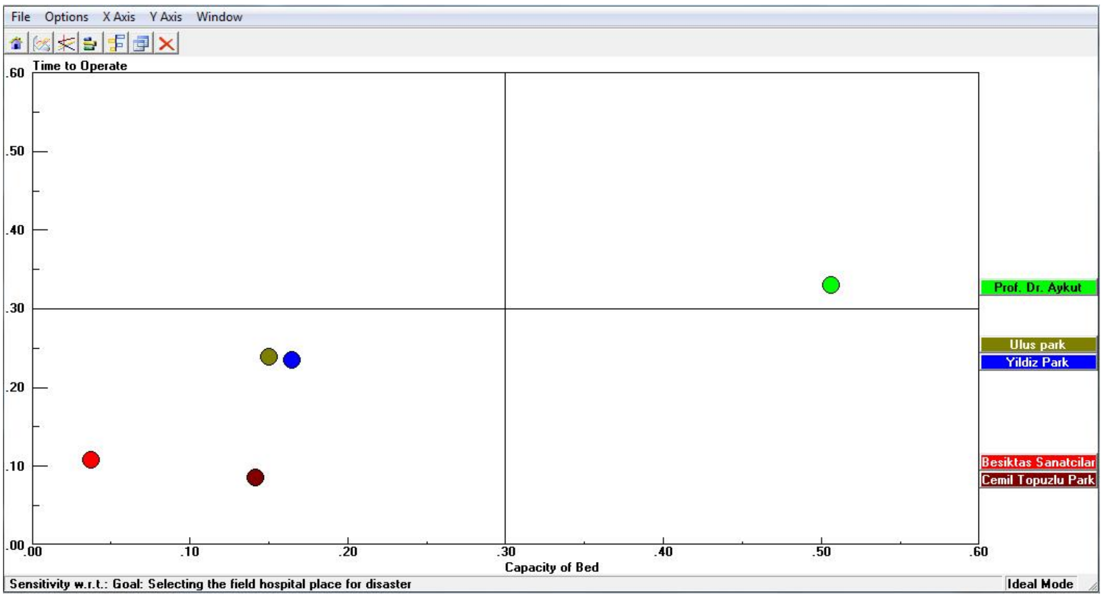

Figure 18: The Two-Dimensional sensitivity between TO and CB.

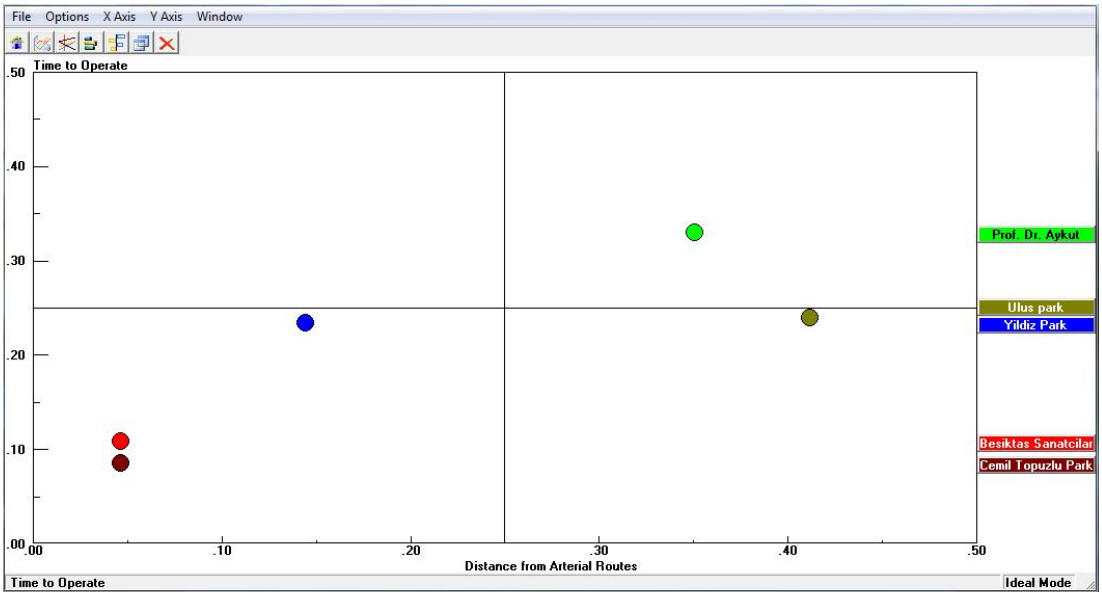

Figure 19: The Two-Dimensional sensitivity between TO and DA.

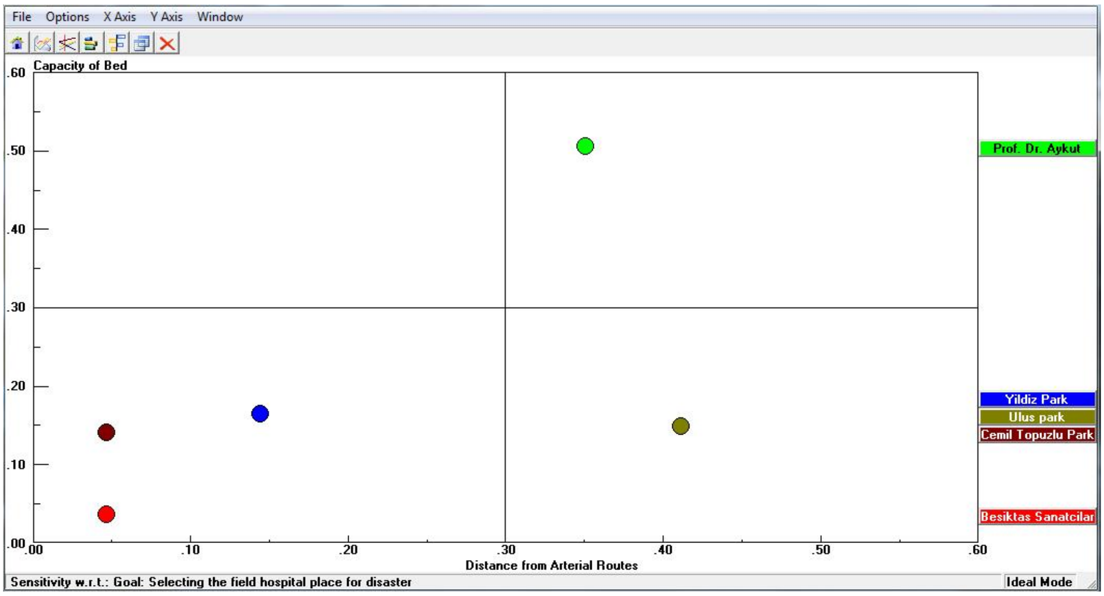

Figure 20: The Two-Dimensional sensitivity between CB and DA.

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PUBLICATIONS/PRESENTATIONS ON THE THESIS

- International Conference of the INFORMS GDN Section and the EURO Working Group on DSS, Special Focus: Group Decision Making and Web 3.0, (GDN), France, 13 June 2014.