Comparing University Campuses by Using Fuzzy Analytic Hierarchy Process

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ABSTRACT

COMPARING UNIVERSITY CAMPUSES BY USING FUZZY ANALYTIC HIERARCHY PROCESS

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Universities are one of the leading institutions providing the social progress and development. In the last decade, the rate of the new university number has increased in a great extent. However, this increment does not have the original campus planning and unique architectural notion at the same rate. The most significant criteria related to campus planning should be realized to reach an ideal university campus. In this study, the relative importance of campus planning criteria is tried to be understood through questionnaires to scholars who are known to be experts on urban planning. Because university planning has more than one criterion, weights of planning criteria are determined using "Analytical Hierarchy Process" (AHP) in a fuzzy environment. In this respect, six well-established university campuses located in Ankara are compared and analyzed. According to the results of the questionnaire; "Campus Location" is found as one of the most significant criteria of the university campus planning process among 12 criteria. This criterion is followed by "Accessibility", "Settlement of Social, Cultural, Common Education Place", "Flexibility of Campus", "Student Potential Who Use Social, Cultural, and Common Education Place", respectively. These results show to decision-makers the first five criteria which should take into consideration when planning the university campus.

Key Words: University campus planning, fuzzy AHP, ideal campus

ÖZ

ÜNİVERSİTE KAMPÜSLERİNİN BULANIK ANALİTİK HİYERARŞİ YÖNTEMİYLE KIYASLANMASI

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Üniversiteler yüksek öğretimin verildiği, toplumsal kalkınmayı sağlayan önde gelen kurumlardan biridir. Son on yılda, yeni üniversite sayısının oranı büyük ölçüde artmıştır. Ancak bu artış orijinal kampüs planlaması ve özgün mimari kavramla aynı orana sahip değildir. İdeal üniversite kampüsüne ulaşmada hangi ölçütün daha fazla öneme sahip olduğunun üniversite planlaması sırasında bilinmesi gerekmektedir. Bu çalışmada üniversite planlama ölçütlerinin göreceli önemi şehir planlaması konusunda uzman kişilere anket çalışması yapılarak anlaşılmaya çalışılmıştır. Üniversite planlaması birden çok ölçüte sahip olduğundan en çok yararlanılan çok ölçütlü karar verme yöntemlerinden biri olan “Analitik Hiyerarşi Süreci” (AHS) yöntemi bulanık ortamda kullanılmıştır. Bu bağlamda, Ankara’da bulunan altı tane köklü üniversite kampüsü kıyaslanmış ve analiz edilmiştir. Anket sonuçlarına göre, 12 ölçüt arasından üniversite kampüs planlama sürecinin en önemli ölçütlerden biri "Kampüs Konumu" olarak bulunmuştur. Bu ölçütü sırasıyla “Erişilebilirlik”, ” Sosyal, Kültürel, Ortak Eğitim Yeri Yerleşimi”, “Kampüsün Esnekliği”,” Sosyal, Kültürel ve Ortak Eğitim Yerlerini Kullanan Öğrenci Potansiyeli” izlemektedir. Bu sonuçlar karar vericilere üniversite kampüsü planlarken dikkate almaları gereken ilk beş ölçütü gösterir.

Anahtar Kelimeler: Üniversite kampüs planlaması, bulanık AHS, ideal kampüs

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LIST OF SYMBOLS/ABREVIATIONS

AHP	Analytical Hierarchy Process
C.I.A.M.	Congres Internationaux d'Architecture Moderne
DM	Decision Makers
ELECTRE	ELimination Et Choix Traduisant la REalité
MADM	Multi-Attribute Decision Making
MCDA	Multiple-Criteria Decision Analysis
MCDM	Multiple-Criteria Decision-Making
METU	Middle East Technical University
MODM	Multi-Objective Decision Making
PROMETHEE	Preference Ranking Organization Method for Enrichment Evaluations
TOPSIS	Technique for Order Preference by Similarity to the Ideal Solution
WPM	Weighted Product Model
WSM	Weighted Sum Model

CHAPTER 1

INTRODUCTION

Universities are the institutions, which give students a social identity on behalf of teaching and training purposes on different disciplinary of academic programs. Particularly, in recent year globalization effected every part of life such as, rapid improvement and development in technology, the idealism for lifelong education, the notions like the power of industry and capital made the university-community-government-industry co-operations essential which produced many new concepts like "innovation", “entrepreneurial university" and "corporate universities”. These improvements influenced the universities both formally and contextually.

University campuses are the places where the planning of the future of a society, exchange of knowledge and social activities take place. In this regard, the planning of a university is a crucial socio-cultural, economical and political fact on national level. The roles of university campuses on the development and the future of a country are increased.

Campus master plan has a big importance while construction of university campuses; however, there are many difficulties while planning stage. The great numbers of companies make their main plan, regarding its physical design and traffic junction based upon qualitative analyses, or experimental and instinctive ideas. However these cause some problems such as; traffic pollution, using place irregularly and occur negative outcomes for the improvement of University’s in long-time and also cause trouble (Yucheng, et al., 2008). Due to the fact that, prevalent campus planning and design methods conventional and not developed enough to yield an appropriate results, which are till now restricted within the urban planning architecture and areas.

However these classical campus planning methods obviously failing anymore concerning university campus planning, since the university is a lively and complex system, thus, it is required to use different and useful technique to solve this problem.

There are many construction methods in the last few centuries in campus planning evolvement history. According to Dober (1996), campus planning is a dynamic process. In his book, he proposed ways and means for development campuses. Generally, campus planning topic is constricted with architects and city planners. Zengel (1998) evaluated campus settlements with regard to accessibility criteria moreover; a case study was made for evaluation of Aegean university. Besides, Kortan (1981) worked on contemporary university campus design and wrote a book about this subject in which he mentioned that universities are gathered in two groups according to principles of C.I.A.M. (Congres Internationaux d'Architecture Moderne) and Team X which are the congress that made principles for campus design. Discussion about the university campuses designed regarding to these principles were also made. Additionally, one of the projects (METU Gaziantep University 1973) of him told in aforementioned book.

The principal aim of industrial engineers is enhancing productivity and effectivity of all system. Planning the facilities is the main subject of their branches. In order to overcome difficulties and reach the targets efficiently and economically it is essential to optimize all physical, electronic and information flow with the carefully planned construction project. Hence implementation of advanced techniques of industrial engineering makes the planning of university campus people oriented (Yucheng, et al., 2008).

This study aimed at mainly investigating criteria of university campus, the relations between university and city, usages of places in university campuses, some planning and design criteria on campus physical planning (Zengel, 1998). For this purpose, a questionnaire is prepared (Appendix A) which is aimed at making inferences about physical planning of the University campuses.

Fuzzy logic helps to overcome the indistinctness related to thinking and reasoning. Since the introduction of fuzzy logic in 1965 numerous fuzzy methods have been studied in different areas of the science, fuzzy rating method is one of them and suitable for multi criteria decision making problems. Since the main purpose is to rank the alternatives, the methodology is constructed upon the basis of the fuzzy Analytical Hierarchy Process (AHP). Campus location, cultural structure of city, financial situation of university, campus population, education system, campus traffic usage, relationship with city and industry, flexibility of campus, campus strategic growth plans, student potential who use social, cultural, common education place, settlement of social, cultural, common education place and accessibility are used as 12 criteria to evaluate alternative 6 university campuses which are located in Ankara.

Organization of the rest of the thesis is as follows: In the second chapter of this study, methodology is presented with background about the techniques and methods that are utilized throughout the development of the methodology. In chapter three, the problem definition of this study is given. Afterwards in chapter four, experimental study and results are given in detail. Finally, conclusions and recommendations are discussed.

CHAPTER 2
METHODOLOGY

2.1 Introduction

The term "decision" can be defined as the conclusions or resolutions reached after cerebration. In this respect; decision making is choosing the most appropriate solution among the alternatives based on pre-determined specific criteria. As being the one of the most known ordinary activities of human beings; decision making has been an indicator of general sense ability of decision maker. People generally encounter with the idea of decision-making which is a logical process covering the selection of the best possible alternative among several others. The main purpose of decision making has been meeting the individual and social needs of the decision makers.

2.2 Decision Theory

Decision theory, which is related with multidisciplinary area of study that affect the scientist, administrator, statist, experts in the field of mathematic, politics or economy or anybody who has to make the complex decisions. Generally, decision making techniques are standard or illustrative, i.e., it is interested with determining the best decision by taking the assumption of an perfect decision maker who is completely well informed, have an ability to calculate perfect exactness, and wholly judicious.

A problem must be with these conditions for being a decision making problem:

- a problem should have more than one behavior way,
- results of each behavior should be different from each other,
- There must be some requested objectives to perform (Tekeş, 2002).

If there is single behavior we cannot talk about making a decision. Decision-makers could reveal the structure of the problem in the form of a model in case of all these conditions existed (Tütek & Gümüşoğlu, 2000).

Decision theorem can deal with situations of certainty, risk, or uncertainty. While there is just one situation is required to consider it is decision making under certainty condition. In the case of knowing the results of each alternatives and act according to this knowledge this is acting under certainty. Otherwise, it is performing under uncertainty. On the other hand, decision under risk conditions, decision maker has some possibility of events and for each result the probability distributions is known. In the conditions of probability is not known then the decision maker under uncertainty condition one speaks about decision under uncertainty.

2.3 Decision Making Process

In the process of decision making, there are lots of stage which requires consider in logical manner and wastes a lot of time.

This long process requires to be followed to take logical oriented decisions. In respect to Mintzberg, et al. (1976) study a decision procedure is as 'a set of activity and dynamic parameters that starts with the determination of a stimulus for activities and finishes with a special commitment to activity' Lawson, et al. (1998) described this process of selecting among various alternatives, applying a decision and taking the following result of data making a decisions in the future connected with the preceding one. Making a decision procedure gives several rules for instructions to tell decision maker, how should make a decision. It includes rationale steps. 'The Practice of Management' which is one of the most famous and known books written by Drucker (1954) give a scientific method of decision making. According to this pioneering book it is suggested that decision making process has six steps:

1. Explain the supervisory problem,
2. Analyze and search the cause of problem,
3. Generate different alternative for solutions,
4. Choose the most appropriate solution among the existing alternatives,
5. Implement giving decision into action, and

6. Provide constantly pursuit and take feedback

In general manner, decision making process initiate with the description of an occasion (anticipatory/ forward decision making) or problem (decision making in a reactive manner).The concept is already separated. Usually, Decision making groups are not focus on historical or forecast inputs they prefer to use the real time data to spot opportunities. Then, the groups of decision makers have to decide if the main situation is an important occasion/opportunity or it is a problem which requires attention. In following steps 3 and 4, according to decision maker's situation risk averse or not will complete quickly or slowly. If they have a high tolerance is for speedier decision making. By using several alternatives, decision makers focusing on figuring out the problems. So there is a linkage between process and result of elements. In the last two steps by thinking right to left the aim and foreseen outcome of the decision is now clearly gives an attention to make a plan of what will be done and working on form the first step which is goal ant to present. This thinking enlarges the expectation of obstacles and evolvement of strategies to cope with them. After decision is implemented, the following of the outcome measures must be control carefully because in the absence of feedback the overall efficiency could not be determined.

The process that mentioned above is not standard for decision making stages. In accordance with the size of the problems encountered in the structure of the decision, and decision-making environment one or more of these stages can be omitted.

In general sense, decision problem dealt with in a process of decision-making includes the following items.

2.4 Definitions Related With Decision Making Process

Decision maker: the person or persons who decide on a specific topic.

Goal: the target or situation that decision maker wants to achieve.

Decision criteria: the decision maker has taken into consideration when making a choice.

Decision alternatives (choices): different courses of action or strategies which decision maker must follow to achieve the goal.

States of nature: the factors which are beyond the control of the decision maker but influence the choice between alternatives. In other words, the future environmental conditions that influence the desirability of decision alternatives are referred to as states of nature.

Results (outcome): The result or a value as an outcome of the combination of each alternative and event.

There are several factors that influence decision-making process. Among these factors; the nature of state, the decision maker, goals to be achieved, alternatives (choices), results and the options among choices can be counted. Of primary importance have factors in decision making is characteristics of decision-maker. The person must have an active personality. So the decisions providing growth of businesses may be taken.

Although the decision maker is an effective factor in decision making process, other people in external environment is also affected from this process. Any decision problem solution requires the participation in decision-making process that persons specified below:

Decision makers: the person who has control over the decision to be taken.

Person who uses solution: the person who use the solution created by the decision maker and / or implement the decision, but not authorized any changes on the solution.

Person affected by decision: the person who benefitted or damaged from the results of the solution or decision.

Decision analyst / problem-solver: the person who analyzes the problem and develops solutions for decision makers or help the decision maker or analyst for decision-making process.

2.5 Decision Models

Decision-making action is significantly affected by possibilities of realization of the factors that influence the decision, the results of alternatives that are fully known or unknown and also sufficient information to determine which alternative is the best. Decision-making models will vary according to characteristics of the variables, emergence of options and the results. In short, the difference between the models used in deciding is caused decision makers' information degree. In this sense decision making models can be classified as follows:

- Decision under certainty
- Decision under uncertainty
- Decision under risk
- Decision under additional information
- Decision under competition

Actually most of the decisions are taken in a situation to at least a little uncertainty however; the degree will change from relative definiteness to big uncertainty. Probability is a tool used to evaluate occurrence possibility of an event. If the all situation of event are known then it is deterministic and has a probability of one or zero while the other side has a flat probability (Taghavifard, et al., 2009).

2.5.1 Decision making under certainty

According to stats of nature different information types are unite with utility matrices in decision making theory. In a stinted situation, knowledge of decision maker about which state of nature will occur is could be definite. In the case of just one state of nature needs to be consider, are called "decision-making under certainty". In this situation, the knowledge of decision maker is perfect which means that the whole information which is trustworthy and cause and effect relationship is obvious for making a decision is known and by decision maker.

All alternative related with problem have only one result and the number of alternatives is equivalent to number of result. The amount of income to be obtained as a result of an investment in government bonds is precisely known, the investment decision for the decision-making under certainty can be given as an example. Moreover, a good example is the decision to reorder inventory automatically when stock falls below a determined level.

2.5.2 Decision making under risk

Risk if each action direct one of a set of possible specific result, each result taking place with a situation that probability is known. In decision under risk, each alternative will have various possible outcomes, and the probability of existing for each outcome is known. As soon as the decision maker has some information considering the states of nature, he/she could identify subjective probability forecast for the existing of each state. The basis of these possibilities may be based on the decision maker's personal thinking about forthcoming situations, or on data got from market questionnaires, expert idea, and so on. In such situations, the problem is grouped as decision making under risk.

2.5.3 Decision making under uncertainty

In a circumstance of uncertainty, on the other hand, people have lack of information and an insufficient knowledge, they are not sure about reliability of their data, and also they don't have any knowledge about the situation may change or not. Multiple outcomes for each alternative can be identified but there is no knowledge of the probability to be attached to each (Luce & Raiffa, 1957).

2.5.4 Decision under additional information

Additional information is required for choosing best alternatives. In conventional decision making theorem to develop the solution, ones should have additional information which is taken from test market for determining a distributions weight of nature state. (Rommelfanger, 1994). What startup and expansion stage managers should take from this is that a certain degree of uncertainty is healthy in everyday decision-making. If they are not attempting to make decisions while uncertainties still exist in the information around the decision, then they are waiting too long to make the decision and are probably not maximizing the expected value of each opportunity. The way to think about identifying the appropriate point to make decisions is to recognize that the value of information diminishes over time, so at some point the cost of collecting additional information outweighs the cost of collecting it to minimize risk. It also leaves the door open longer for others to take advantage of an opportunity.

2.5.5 Decision under competition

The reason of why some decisions are not easy is the requirement to take into consideration of others respond to the decision that is taken in that situation. Competitive decisions are complicated by the presence of intelligent competitors whose own actions affect the result for the decision maker. Game Theory is a efficient tool for forecasting results of a number of firms which have relations with each other where an action of a single firm directly effects the payoff of other participants. Given the dynamic nature of many competitive decision situations, how well do decision makers guess and evaluate their opponents' next moves?

Every decision maker is also players in the business game. This yields the person while choosing the firms or making a decision looking at the potential choices and payoffs of others and be aware of while making a decision this is also valid for other decision maker (Osak, 2010).

2.6 Multi-Criteria Decision Making

Efficient and consistent decision making is a hard challenge. Multiple-criteria decision-making (MCDM) or multiple-criteria decision analysis (MCDA) is known as a most important sub-disciplines of operations research that obviously considers multiple criteria in decision-making environments. MCDM has been used as a decision making since 1960's following the development of operational research in World War II. Nowadays, MCDM is already an entrenched technique with lots of books, voluminous implementations, devoted scientific journals, software packages and university lectures (Figueira, Greco, & Ehrgott, 2005). MCDM's scope and objective is to help decision makers during the problem solving to overcome the decision problems that involve multiple criteria. The variation of MCDM techniques from other simple decision models, they are focused on the model development aspects that are relevant with the modeling and rendition of the decision makers' choices, values and judgment policy (Doumpos & Zopounidis, 2002). The MCDM method deals with complicated issues to take their control one should divide them into parts. Following, this method combine the parts to offer a coherent with all pictures to decision makers (Voogd, 1982). It should be known that MCDM includes an area of various techniques that are suitable for different targets. Generally, decision making approaches can be distinguished in two groups, i.e. decision making based on quantitative and decision making based on qualitative models. In quantitative models, the criteria values are numerical and continuous, whereas qualitative models consist of discrete criteria, whose values are presented by words rather than numbers (Bohanec, et al., 2000; Zimmermann, 1991) classified the MCDM into two groups: multi-objective decision making (MODM) and multi-attribute decision making (MADM). These groups include several classes.

According to Decision Makers (DM) number of the methods can be categorized considering the number of people single or group decision making techniques (Goicoechea, Hansen, & Duckstein, 1982) .These methods have similar qualities that share common characteristics of incommensurable units and complexities in the choosing of alternatives. The main difference between the MODM and MADM methods is based on the number of alternatives under assessment. MODM have a very large number of feasible alternative and the objectives and the constraints are affiliated with the decision variables. The problems in MODM models are generally continuous in which the number of variables is infinite and variables used to define the decision problem inclined to be continuous. Most of MODM methods are based on mathematical programming which is used to evaluate the optimization of selection issues in which some purposes are to be optimized and trying to obtain an appropriate compromise solution form a set of efficient solution (non-dominated or pareto optimal solutions). The first example to mathematical programming problems is predicated on (Kuhn & Tucker, 1951). Contrarily, MADM methods are concentrating on selecting discrete alternatives. In MADM, each alternative is described by using multiple attributes. MADM methods are designate as un-supervised choice and screening procedures as they do not need the functional relationship among the attributes of the given alternatives but employ several different mathematical models to compare and rank the alternatives with an ideal or foreordained solution that may be either user defined or data generated depending upon the type of algorithm used (Chauhan & Vaish, 2013). In MADM, each alternative is defined by using multiple attributes. For a given set of alternatives, MADM models try to select the best alternative of them, order the alternatives from the best to the worst or classify them into classes. Despite the MADM methods are usually using in solution of discrete problems they can also be used in continuous decision problems (Doumpos & Zopounidis, 2002). These methods have the benefits to evaluate a miscellaneous of alternatives in accordance with miscellaneous of elements which have various units. This is a very important benefit over classical making a decision method in which all elements require to transform to the same unit. The other important benefit of multi attribute decision making methods is that they possess the capability to examine evaluation of tangible and intangible elements simultaneously.

Despite the MADM methods being extensively different from each other, generally their certain idea is general (Chen & Hwang, 1992). The concepts of options, and elements as briefly defined fallows:

Alternatives: They make the various options of activity suitable for the decision maker. Generally, alternatives are supposed to be limited, ranging starting in few to hundreds. They are believed to be sifted, organized according to importance and ultimately ranked (Triantaphyllou, Shu, Nieto Sanchez, & Ray, 1998).

Multiple criterion: Every MADM problem is concerned with multiple criterion. Criteria are sometimes called as "goals" or "attributes". Criteria demonstrate varied numbers from which the alternatives possibly seen. If the number of criteria is exceeding approximately fifty, criteria may be ordered in a hierarchical mode. In other words, some criteria can be main criteria. Every main criterion may be connected to different sub-criteria. In a similar manner, each sub- criteria may be connected to various sub-subs- criteria and so forth. Despite some MADM techniques may clearly take in to account a arranged hierarchically, large number of criteria accept only one stage of criteria (Triantaphyllou, Shu, Nieto Sanchez, & Ray, 1998).

Contradiction between attributes: Because of various criteria represent various dimensions of the choices, this attributes might oppose with one to another. For example cost and profit oppose with each other, and so on (Triantaphyllou, Shu, Nieto Sanchez, & Ray, 1998).

Decision weights: Generally MADM techniques necessitate that the criteria be defined according to their weights of importance. Commonly, after normalization of weights they add for making their summation will be one (Triantaphyllou, Shu, Nieto Sanchez, & Ray, 1998).

Decision matrix: Multi attribute decision making problem is described as absolutely in matrix form. A is a $(M \times N)$ decision matrix where factor aij shows the performance degree of alternative A_i and this is appraised in the sense of decision making element C_j, (i =1,2,3,..., M, and j = 1,2,3,..., N). In other words, the decision matrix rows represent the alternatives of which some are in competition with each other, the columns refers to the criteria which used for assessing alternatives. In addition supposed that the expert has defined the priorities of notional performance of the criteria (symbolized as W_j, for j = 1, 2, 3,..., N) (Lai & Hwang, 1996). The summary of this explanation is showed in eq. (2.1)

$$\begin{array}{c|cccccc} & & & \text{CRITERIA} & & & \\ & C_1 & C_2 & C_3 & \cdots & C_N \\ \text{Alt} & W_1 & W_2 & W_3 & \cdots & W_N \\ \hline A_1 & a_{11} & a_{12} & a_{13} & \cdots & a_{1N} \\ A_2 & a_{21} & a_{22} & a_{23} & \cdots & a_{2N} \\ A_3 & a_{31} & a_{32} & a_{33} & \cdots & a_{3N} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ A_M & a_{M1} & a_{M2} & a_{M3} & \cdots & a_{MN} \end{array} \quad (2.1)$$

Different methods are used to solve MCDM problems in literature, none of these methods are based on values of others cannot provide a complete superiority. The most important advantage of these methods the possibility that they provide evaluation of a combination of both quantitative and qualitative criteria together (Dağdeviren, Eraslan, & Kurt, 2007).

In literature many of studies in different areas used MCDM techniques. MCDM has begun to penetrate many new areas of research and applications. DEA (Liu, Yuen

Ding, & Lall, 2000) in e-Commerce (Chiu & Tseng, 2004) in financial (Rafiei, Ghaffari, & Parsapur, 2012) in flexible manufacturing systems (Wabalickis, 1988), in plant layout design (Cambron & Evans, 1991), in manufacturing system integrations (Putrus, 1990), in the decisions of technology investment problems (Boucher & MsStravic, 1991), in engineering (Wang & Raz, 1991), in location planning (Awasthi, Chauhanb, & Goyal, 2011), supplier selection and transportation (Behzadian, Kazemzadeh, Albadvi, & Aghdasi, 2009) and in energy (Doukas, Andreas, & Psarras, 2007) can be given as an example.

There are different numbers of multiple criteria techniques to assist choosing in terms of a multiple criteria. MCDM has been rapidly growing problem fields in many disciplines. Although the criticism made for multi dimensional methods, there is considerable interest on them. With the rapid growth of decision methods and their diversification different practical methods have developed for solving discrete alternative problems to assist expert to select among a various set of options. Some of these methods are listed as follows:

- TOPSIS
- Weighted Sum Model (or WSM)
- PROMETHEE
- Weighted Product Model (or WPM)
- ELECTRE
- Analytic Hierarchy Process (or AHP)

In this study, a fuzzy AHP is utilized to compare alternative university campuses. Firstly, fundamentals of AHP are described below. Then, Fuzz Logic is introduced in detail. After all, Fuzzy AHP is considered as a method for comparing alternative campuses.

2.7 Analytic Hierarchy Process (AHP)

AHP, proposed by American professor Saaty (1976), is a versatile frame aforethought to deal with the indistinctive, the logical, and the senseless in the conditions of multi objective, multi-criterion and multi-factor decisions with or without certainty regarding large number of choices (Harker & Vargas, 1987). Since its inception, it is one of the most applicable and popular method between the researchers and decision makers. The reason of its popularity is the fact that it's considering both quantitative and qualitative criteria together.

The AHP is perhaps, the most famously used decision making method. Many noticeable works have been produced based on AHP: they include applications of AHP with more than 1300 papers and 100 doctoral dissertations in various field of science and technology in which the AHP results were accepted and used by the cognizant decision makers (Sipahi & Timor, 2010) for example; in planning (Kwak & Lee, 2002) in setting priorities (Schniederjans & Wilson, 1991), in location selection (Tzeng, Teng, Chen, & Opricovic, 2002), in finance (Arbel, et al., 1990; Meziani, et al., 1988; Ossadnik, 1996) in weapon selection (Dağdeviren, Yavuz, & Kılınç, 2009) in evaluation or assessment of technologies (Ramanujam & Saaty, 1981); (Chatzimouratidis & Pilavachi, 2009), in natural resource and environmental management (Weiss & D., 2002), in business decisions (Liberatore, Nydick, & J, 1992), in selection the Research and Development programs areas (Elkarmi, 1993), in site selection (Önüt, Efendigil, & Soner Kara, 2010) in selection of telecommunication technologies (Tam & Tummala, 2001) in software selection problems (Cebeci, 2009), in supplier selection (Kahraman, Cebeci, & Ulukan, 2003), in manufacturing systems (Yang, Chuang, & Huang, 2009), in selection of the best alternative between different outsourcing contracts in terms of maintenance services (Bertolini & Bevilacqua, 2006) and so on. Some studies use AHP in connected to mathematical applications. In these implementations weights from AHP are used as objective function coefficients for their programs (Hyung-Jin & Min, 1998).

2.7.1 The primary functions of AHP

AHP has been widely used to a great diversity of areas – one of them is multi objective decision making. A considering the three principal functions of AHP, organizing complexity, assessment on ratio scale, and synthesis of priorities helps in comprehending why it is so excessively common technique with such a numerous of implementations. To increase the participation of nonexpert people Saaty found easy method to cope with complexity which was hierarchical structuring. This method decomposed complex systems into smaller units which are subdivided into smaller units. In addition, Saaty suggested using assessments of the rates of each pair of factor in the hierarchically to make measuring scale. The weights of the factor at any stage of the system are defined by multiplying the priorities of the factor in that stage by the weights of the main factor. Because of multiplying two interval stage measures is have no meaning, the ratio scale are need in this stage.AHP uses this scale from the lowest stage to the upper stage of hierarchy, thus the resulting priorities for alternatives in an AHP model will be ratio scale measures. Synthesis includes connecting parts into a whole. Although AHP's hierarchical structure make easy analysis, an even more significant role is AHP's capability to assist decision maker measure and synthesizes the large quantity of criteria in a hierarchy.

2.7.2 Theoretical Structure of AHP

The set of assumption (Saaty, 1986) parallel to hierarchic plans are a specific case of assumptions for priority arrangement in systems with feedback which take into consideration an expansive class of dependencies. The assumptions are explained as follows:

Assumption 1 The Reciprocal Comparison : Using a pair-wise comparison matrix for n items the decision maker indicates how much more suitable item i is then item j. if $P_K(E_L,E_M)$ is a paired comparison of items L and M with regards to their parent, item K, representing how many times more the item L possesses a property than does item M, then $P_K(E_M,E_L) = 1/ P_K(E_L,E_M)$ .For example, if L is 5 times larger than M, then M is one of five as large as L.

Assumption 2 Homogeneity: The items being compared should not be different too much; otherwise there will be big mistakes in judgment. When making a hierarchy of objectives, one should try to organize items in a group in order that items will not differ by more than an order of magnitude in any cluster (The AHP verbal scale ranges from 1 to 9 or about an order of magnitude).

Assumption 3 Dependence: This assumption indicate that judgments about the preferences of the items in a hierarchy do not depend on lower level items which is necessitated for the fundamental rule of hierarchic construction to implement and obviously means that the significance of higher level objectives should not depend on the weights of any lower level factors.

Assumption 4 Expectations: Saaty's last assumption indicates those people who have reasons for their opinions should verify that their ideas are sufficiently represented for the result to match this expectance. This assumption means that output preferences should not be essentially distinctive to any previous expectance that a decision maker has.

The AHP neither assumptions the stronger situation of consistency nor does it comprise strong supposition of the common concepts of rationality. Several facts are based on these assumptions giving a functional foundation for the AHP.

2.7.3 AHP methodology

1. The overall goal (objective) is defined, and the issue is clearly defined.

2. After finding the objective, the criteria used to satisfy the overall goal are identified. Then the sub-criteria under each criterion must be identified so that an appropriate alternative may be determined. The hierarchical structure is constructed.

3. Pair-wise comparisons are constructed; elements (criteria) of the problem are paired (concerning their common relative impact on a property) and then compared.

4. Weights of the decision elements (criteria) are estimated by using the eigenvalue method. Consistency of judgments is checked.

5. Working downward through the hierarchy, hierarchical composition is used to combine the weight vectors and arrive at global and local relative contributions (priorities) of each element (criteria).

2.7.4 Hierarchical decomposition of the decision

Decision making implementations of AHP are formed in two stages: hierarchic design and evaluation.While constructing hierachy it needs the expertise and knowlege of the problem field. Two decision makers usually can make two different hierarchies of the same problem;thus a hierarchy is not unique.At the same time, even two people make the same hierarchy,their choices can create different cources of action. The AHP decision making process begins with dividing the problem into a hierarchy by breaking the problem down into its components according to their common characteristics. These hierarchical orders help to simplify the illustration of the problem and bring it to a condition which is more easily understood. With the AHP, the objectives, criteria and alternatives are arranged in a hierarchical structure similar to a family tree (Albayrak & Erensal, 2004). The topmost level is the 'goal' of the problem. The intermediate levels correspond to criteria and sub-criteria which provides an overall view of the complex relationships inherent in the situation and helps the decision maker assess whether the elements in each level are of the same order of magnitude (Saaty T. L., 1990). In addition, the lowest level contains the "decision alternatives". In Figure 2.1, where the construction of AHP tools is demonstrated, it is explain that the goal is agreed using several criteria. These criteria decide the degree of achieving the goal utilizing any of Alternatives (A_i , i=1... k). The A_i are different alternatives that could be used to achieve the final aim of the project.

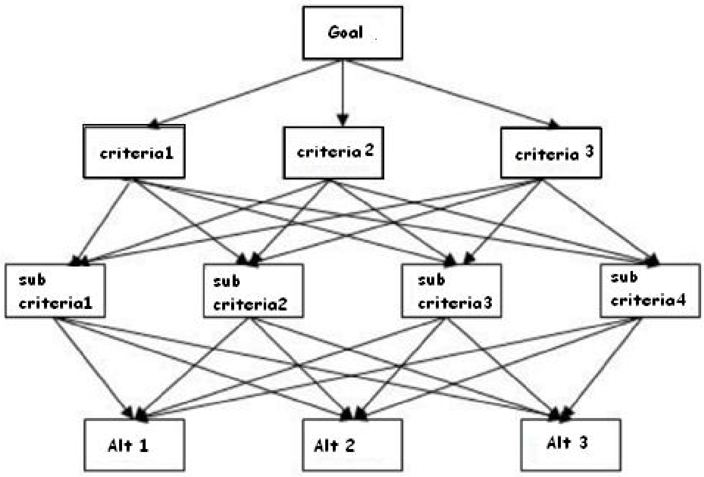

Figure 2. 1: Hierarchic Structure of AHP

2.7.5 Pair-wise comparisons

Before the deciding the weights of criteria, the hierarchical form of problem should have been construct. Elements (criteria) of a problem on each level are paired by taking account to their influence on the criteria afterwards comparison is made. While pair-wise comparisons of elements are making, their notional (relative) importance could possibly institute which do not have to be based on the standard measures like meter or kilogram etc. The only thing that need in this phase is connection of two elements being compared.

The pair-wise comparison begins from the second stage and finishes in the lowest stage, alternatives. In every stage, the criteria are compared in pairs considering their levels of affect and based on the pointed out criteria in the immediately upper level (Albayrak & Erensal, 2004). If two criteria are not connected to common criteria in the level immediately higher, they are not pair-wise compared. If two criteria are connected to more than one common criterion in the level immediately higher, these two criteria are pair-wise compared for each common criterion in the level immediately higher. A decision matrix is planned and used for calculating the preference of the corresponding criteria. Initially, criteria are compared in pairs regarding the aim of that study which is decided by asking questions of the type: "of the two criteria Ci and Cj, which is more important and how much more?" (Saaty T. L., 1980) proposes the use of a 9-point scale to convert the linguistic judgments into numerical quantities. According to the reciprocal assumption, if criteria A is absolutely more important than criteria B and is rated at 9, then B must be absolutely less important than A and is valued at 1/9. It also applies to the other linguistic judgments in the AHP. The scale is explained in Table 2.1 (Duan, Pang, & Wang, 2011).

Table 2. 1: The AHP Pair-wise Comparison Scale

Degree of Importance	Definition	Explanation
1	Equally important	Two criteria attend equally to the objective
3	Weakly /Moderately important	Experience and judgement slightly favour one criteria over another
5	Essentially or strongly important	Experience and judgement strongly favour one criteria over another
7	Very strongly or demonstrated important	A criteria is favored very strongly over another; its dominance demonstrated in practice
9	Extremely important	The evidence favouring one criteria over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent values	Used to represent compromise between the priorities listed above
Reciprocals of above	If criteria i has one of the above non-zero numbers assigned to it when compared with criteria j, then j has the reciprocal value when compared with I	A logical supposition

Let C = {Cj | j =1, 2, ..., n} be the set of criteria. We wish to find their weights of influence, $w_1, w_2, ..., w_n$ on some element in the next level.

$$A = \begin{vmatrix} & C_1 & C_j & C_n \\ C_1 & 1 & \frac{w_1}{w_j} & \frac{w_1}{w_n} \\ & \vdots & \vdots & \vdots \\ C_i & \frac{w_i}{w_1} & \frac{w_i}{w_j} & \frac{w_i}{w_n} \\ & \vdots & \vdots & \vdots \\ C_n & \frac{w_n}{w_1} & \frac{w_n}{w_j} & 1 \end{vmatrix} \quad (2.2)$$

where w_i is the relative weight of alternative i.

The matrix shows our personal judgments about the pair-wise comparisons of criteria (figure 2.3). The element a_{ij} indicates the relative importance of criterion C_i when compared to C_j. Therefore a_{ij} can be written as in eq. 2.3:

$$a_{ij} = \frac{w_i}{w_j} \text{ and } a_{ij} = 1/a_{ji}, \quad i,j=1....,n \quad a_{ji} \neq 0 \quad (2.3)$$

That is, the pair-wise comparison matrix is a reciprocal square matrix whose diagonal is equal to 1. The size of the matrix is equal to the number of criteria. Given the mutual caharacteristic, only n(n−1)/2 actual making comparison in pairs are required for an n×n matrix.

2.7.6 Eigenvector method

Computation of the exact eigenvector of a matrix is complex and costly process. However, there are four approximate methods presented to compute the eigenvector of a matrix by (Saaty T. , 1986).

1) After summation of each factor in each row then normalization phase start by dividing each sum by total of all the sums, so the results add up the unity.
2) After summation of each factor in each column then normalization phase start by dividing each reciprocal by the total sum of them.
3) Divide the elements of each column by the sum of that column, and then add the elements in each resulting row, then divide this sum by the number of elements in the row.
4) Take the geometric mean of each row after this take normalize this numbers.

Saaty recommended 3rd method which gives the best approximation.

2.7.7 Consistency of the matrix

In the situation of having completely consistent matrix, then $a_{ik}=a_{ij}*a_{jk}$ for all i, j, k and the matrix A has rank 1 and λ_{max} =n. Then, the weights of matrix can be calculated by normalizing any of rows/columns of A (Wang & Yang, 2007). For example, let there be three elements, x, y, z to be compared. If x is preferred to y and y is preferred to z, then by transitivity property x should be preferred to z. If this property holds for all the comparisons of the decision maker for some degree, then the pair-wise comparisons are said to be consistent (or consistent enough). Nevertheless, in actually it is not realistic to predict the decision-makers make the comparison matrices which are exactly consistent particularly while there are numerous alternatives. Explaining the actual emotions of experts mostly directed the matrices which are being inconsistent. Somehow, some matrices may damage consistency very slowly by only 2 or 3 criteria when others might have values which could not even be called near the consistency. If the inconsistency of the pair-wise comparison matrices is limited, slightly the highest eigenvalue (λmax) deviates from n. This deviation is utilized as the scale of inconsistency. This scale is divided by (n-1) to obtain the "consistency index" (CI) as follows (eq. 2.4) (Saaty, 1980):

$$CI = \frac{\lambda_{max}-n}{n-1} \tag{2.4}$$

For make an important comment of either the divergence or the consistency index, Saaty (1980) suggested random pair-wise comparisons for different size matrices, computing the consistency indices and reach an average consistency index for random numbers for each size matrix. The upper row is the order of the random matrix, and the lower is the parallel index of consistency for random judgments (Table 2.2).

Table 2. 2: Index of consistency for random evaluations

n	1	2	3	4	5	6	7	8
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41
n	9	10	11	12	13	14	15	
RI	1.45	1.49	1.51	1.48	1.56	1.57	1.59	

To the judgment matrix whose order is 3 or more than 3, choosing the ratio value CR of random consistency to decide (eq. 2.5) :

$$CR = \frac{CI}{RI} \tag{2.5}$$

If the judgment matrix is perfect then it has a consistency index of 0, and of course its consistency ratio will be zero. A consistency ratio of 1 represents consistency related to that would be obtained if judgments were not made in an intelligent manner, but rather at random. This ratio is called the inconsistency ratio since the bigger the rate, the more inconsistent the judgments. When the CR<0.10, we can consider the judgment matrix possess satisfying consistency.

2.8 Conclusion

In this chapter, some essentials belonging to area of “decision-making” has been presented to introduce some readers about the fundamentals of the relevant areas. The literature about the decision making was summarized in a concise manner through this chapter. Several decision making environments and the possible decision making approaches was also discussed. Subsequently, the chapter covered the AHP methodology its levels in a stepwise manner.

CHAPTER 3

FUZZY DECISION MAKING

3.1 Introduction

Since its beginning in 1965, the fuzzy set theory has developed in lots of various fields. The recent interest in fuzzy set theory belonged to acting indistinctness in human perceptive processes. Fuzzy set theory is now useable in the fields of operations research, computer science, medicine, control engineering, expert systems, logic, management science, decision theory, pattern recognition, artificial intelligence, and robotics (Zimmermann, 1992). Fuzzy sets are the expand version of conventional set theory which were suggested by Zadeh in 1965 which deals the uncertainty of life by using mathematic (Zadeh L. A., 1965). It includes factors that have changing degrees of membership in the set. This opinion is as opposite to traditional sets because members of a classical set would not be members unless their membership was full or, complete in that set (Ross, 1995). Zadeh (1965) proposed a adjusted set theory in which individual factors could have a degree of membership which fluctuated over a continuum values rather than 0 for non-membership or 1 one for full membership. Fuzzy set theory allows degree of membership so something maybe partly true and partly false simultaneously, that means the gray color between black and white.

3.2 The Definition of Fuzzy Sets

A conventional set A can be described the gathering of objects or components. Any objects or components x either related to or does not related to A. The membership $\mu_A(x)$ of X in A is a mapping (eq. 3.1):

$$\mu_A\colon x \rightarrow \{0, 1\} \quad (3.1)$$

that is, it may take the value 1 or 0,. to each element of the set X, they accept any value in the closed unit interval [0, 1] rather than crisp 0 and 1 as in the classical set theory which shows the truth value of x in A hence, if is the complement set of A and ∩ shows intersection of sets (eq. 3.2),

$$\boldsymbol{A} \cap \overline{\boldsymbol{A}} = \emptyset \tag{3.2}$$

The difference between classical sets and fuzzy sets is shown in Figure 3.1

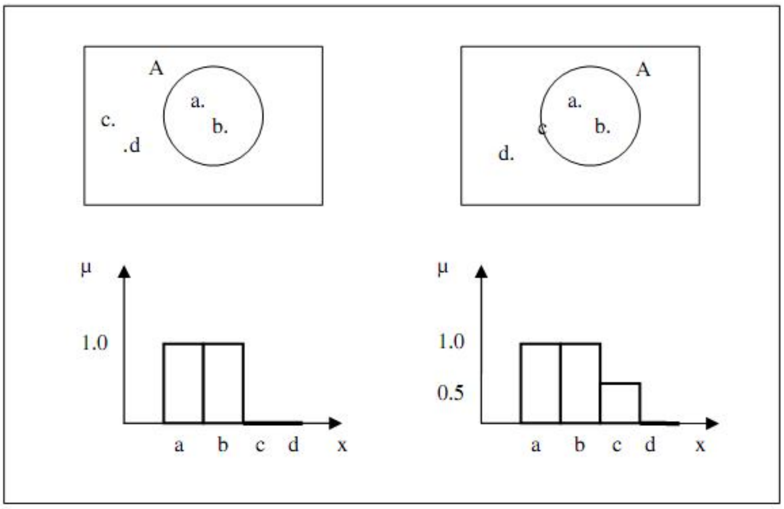

Figure 3. 1: Graphical representation of classical and fuzzy sets (Baykal & Beyan, 2004)

Classic set characteristic function and membership function of fuzzy sets are comparable with the help of an example as follows (figures 3.2-3.3; (Tanaka, 1997)

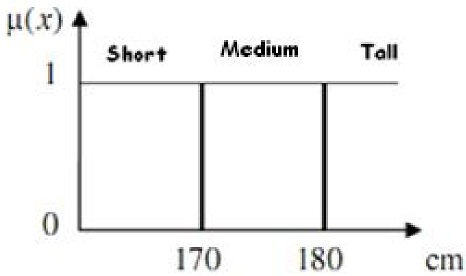

Figure 3. 2: The characteristic function of *Height* in classic set

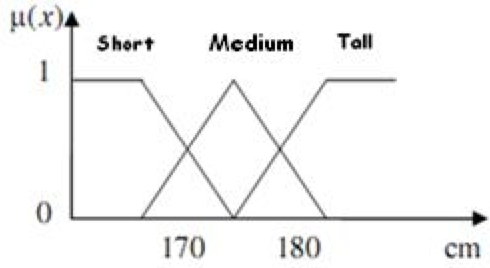

Figure 3. 3: The membership function of *Height* in fuzzy set

Heights of three people are given as follows:

A: 179 cm ; B: 171 cm; C: 168 cm

If Heights of these three people are defined as in classical set we reach the characteristic function as Table 3.1. According to a characteristic value of the function A and B belong to the set of medium and C belong to the set of short stature.

Table 3. 1: Characteristic function of Height in classical set

	Height	Short	Medium	Tall
A	179 cm	0	1	0
B	171 cm	0	1	0
C	168 cm	1	0	0

Despite the fact that, differences are 3 in height between B and C they are in different groups, A and B are in same group while difference is 8 cm. The reason of this position is the medium height cluster of differentiation 170 and 180 cm (Tanaka, 1997).

Fuzzy membership function of the set of cluster height is created. Membership values of A, B, C are as shown in Table 3.2.

Table 3. 2: Membership function of Height in fuzzy set

	Height	Short	Medium	Tall
A	179 cm	0	0.4	0.6
B	171 cm	0,4	0.6	0
C	168 cm	0.7	0.3	0

According to Table 2.4, A is belong to medium height cluster with the degree of membership of 0.4 and also with the degree of membership of 0.6 is belongs to tall height cluster. Similarly, B is belong to short height cluster with the degree of membership of 0.4 and also with the degree of membership of 0.6 is belongs to medium Height cluster. C is belong to short height cluster with the degree of membership of 0.7 and also with the degree of membership of 0.3 is belongs to medium height cluster.

3.3 Membership Functions

Every factor is an element of the fuzzy set to some degree, might even zero. The set of criteria which have a non-zero membership is named the support of the fuzzy set. The function that assigns a numeric value to all criteria *x* of the universe is said the *membership function* μ(x).

Consider fuzzy proposition A ("approximately two") on IR fuzzy logic offers means to construct such imprecise sentences (figure 3.4).

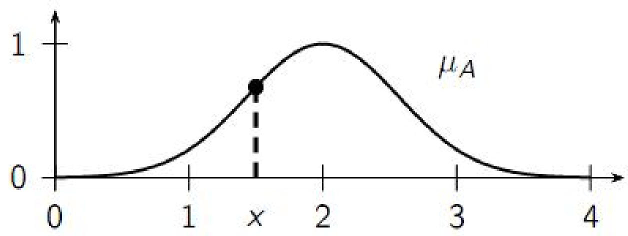

Figure 3. 4: Fuzzy membership function

A defined by membership function μA, i.e. truth values ∀x ∈ IR let x ∈ IR be a subject/observation and μA(x) is the degree of truth that x is A (eq. 3.3-3.4);

$$\mu_A : X \rightarrow [0,1] \quad (3.3)$$

and is expressed as a set of pairs:

$$A = \{(x, \mu_A(x))\} \quad (3.4)$$

3.4 Types of Membership Function

The famous and generally used membership functions are as follows (Dubois & Prade, 1980)

- triangular membership function
- linear membership function
- sigmoidal membership function
- trapezoid membership function
- gaussian membership function.
- Π-type membership function

In this study, the membership functions of the verbal terms are characterized by triangular fuzzy numbers. For this reason only triangular membership function is described.

3.4.1 Triangular membership function

A triangular membership function is defined by three parameters as a_1, a_2, a_3.Figure 3.5 shows the triangular membership function. The expression this function mathematically is as follows (eq. 3.5):

$$\mu_A(x;a_1,a_2,a_3) = \begin{cases} a_1 \leq x \leq a_2 & then, (x - a_1)/(a_2 - a_1) \\ a_2 \leq x \leq a_3 & then, (a_3 - x)/(a_3 - a_2) \\ x > a_3 \ or \ x < a_3 & then, 0 \end{cases} \quad (3.5)$$

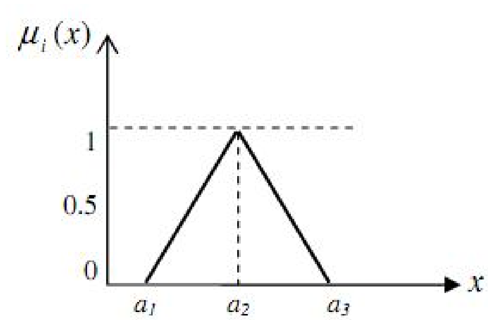

Figure 3. 5: Triangular membership function

3.4.2 Parts of membership function

The membership function of fuzzy set can be described by three parts (Ross, 1995);

- the core → $\mu A = 1$
- the support, → $\mu A > 1$
- the boundaries. → $0 < \mu A(x) < 1$
- support (A) = {x ∈ E|$\mu A(x) > 0$}

The **core** of membership function for a fuzzy set ***A*** is defined by the region that contains elements having complete membership function in the set ***A***. The **support** of a membership function for a fuzzy set ***A*** is defined by the region which contains factors having nonzero membership in the set ***A***. The **boundaries** of a membership function for a fuzzy set ***A*** are defined by the region that contains elements having nonzero membership but non-complete membership. The core, the support, the boundaries of a membership function can be seen in Figure 3.6

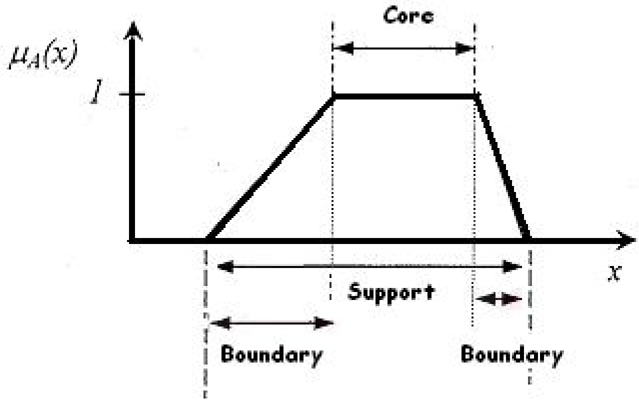

Figure 3. 6: The core, support and boundaries of a fuzzy set

3.5 Linguistic Variables

In everyday life natural language is used for communication. By its very nature, natural language is vague and imprecise; yet it is the most commonly used form of information exchange among people. Some misunderstandings can occur due to the vagueness of natural language during communication with people. For example, what is the meaning of a young person? To individual A a young person might be anybody over 15 years old. To individual B a young person is someone who is over 35 years old. Despite the potential for misunderstandings, the term 'young' carry adequately similar information to the two individual, even though they are different age themselves, understanding and communication is possible between them. Fuzzy set theory is a quantitative method to found a formal model of linguistics (Ross, 1995).

Linguistic variables uses the values described in its expression set: its set of linguistic expression. These are personal classes for the verbal value.

A linguistic variable is a variable in which the values are words or sentences instead of numbers. In this thesis, the calculative method is on the basis of the following fuzzy numbers described in Table 3.3 is used. In this place, each membership function is described by three parameters of the symmetric triangular fuzzy number. Similar to the importance scale explained in Saaty's well-known AHP (1980) it is suggested to use five main linguistic terms for making comparison of criteria: ‘‘just equal’’, ‘‘equally important, ‘‘weakly important, ‘‘moderately important’’ and ‘‘strongly important’’. For example, if criterion A is evaluated ‘‘strongly important’’ than criterion B, then this answer means that criterion B is ‘‘strongly unimportant’’ than criterion A.

Table 3. 3: The linguistic scale and corresponding triangular fuzzy numbers

Linguistic scale	**Corresponding triangular fuzzy numbers**	**The inverse of the corresponding triangular fuzzy numbers**
Just Equal	(1,1,1)	(1/1,1/1,1/1)
Equally Important	(1,3,5)	(1/5,1/3,1/1)
Weakly Important	(3,5,7)	(1/7,1/5,1/3)
Moderately Important	(5,7,9)	(1/9,1/7,1/5)
Strongly Important	(7,9,9)	(1/9,1/9,1/7)

According to Zadeh (1965) a linguistic variable is a variable whose values are words or sentences in a natural or synthetic language. These variables express the decision makers’ judgments about the alternatives Figure 3.7 illustrate the ages of human by linguistic variables (Bojadziev & Bojadziev, 1998) .

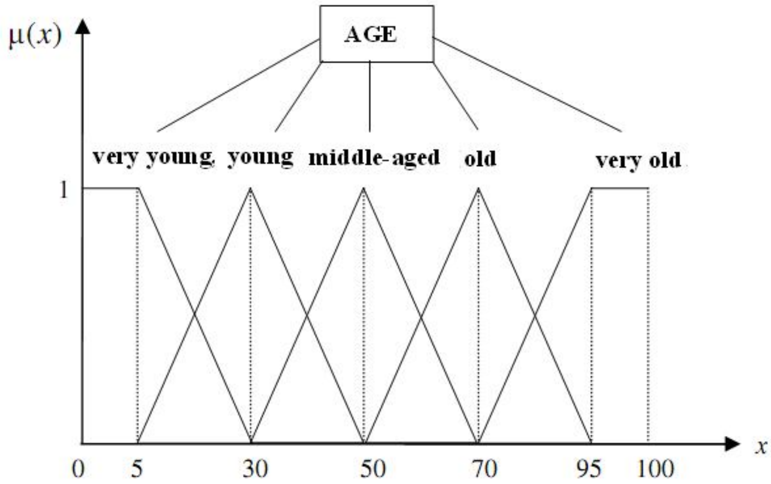

Figure 3. 7: Age linguistic variable

In figure 3.7, multiple subjective categories defining the same position are integrated. In case of old, not only young but also very young, middle old and very old exist. These are called 'linguistic terms' and show the possible values of linguistic variables (Altrock, 1995). If we define these terms by using triangular fuzzy number the membership function is as follows (Bojadziev ve Bojadziev, 1998):

$$\mu_{very\ young}(x) = \begin{cases} 1 & , \ 0 < x \leq 5 \\ \frac{30-x}{25} & , \ 5 \leq x \leq 30 \end{cases}$$

$$\mu_{young}(x) = \begin{cases} \frac{x-5}{25} & , \ 5 < x \leq 30 \\ \frac{50-x}{20} & , \ 30 \leq x \leq 50 \end{cases}$$

$$\mu_{middle-aged}(x) = \begin{cases} \frac{x-30}{20} & , \ 30 < x \leq 50 \\ \frac{70-x}{20} & , \ 50 \leq x \leq 70 \end{cases}$$

$$\mu_{old}(x) = \begin{cases} \frac{x-50}{20} & , \ 50 < x \leq 70 \\ \frac{95-x}{25} & , \ 70 \leq x \leq 95 \end{cases}$$

$$\mu_{very\ old}(x) = \begin{cases} \frac{x-70}{25} & , \ 70 \leq x \leq 95 \\ 1 & , \ 95 \leq x \leq 100 \end{cases}$$

In linguistics, principal terms are often defined with adjectives (nouns) or adverbs (verbs) like very, low, slight, more or less, fairly, slightly, almost, barely, mostly, roughly, approximately etc. Using fuzzy sets as the calculus of interpretation, these linguistic terms have the effect of modifying the membership function for a basic term (Zadeh L. , 1963)

3.6 Properties of Fuzzy Sets

It can be defined different properties for fuzzy sets. The height of a fuzzy set hgt(A) h(A) is the largest (supremum or maximum) membership grade obtain by any element in the set (eq. 3.6, Bojadziev and Bojadziev,1998). So,

$$hgt(A) \sup_{x \in X} \mu A(x). \quad (3.6)$$

A fuzzy set A is normal if hgt(A) = 1. This means that, there is an x for which μA(x) = 1. Some sets will be not normal such a set A can be normalized utilizing the normalization function norm (A). It is described such that, for all x ∈ X, we have eq. 3.7

$$B = norm(A) \Rightarrow \mu B(x) = \frac{\mu A(x)}{hgt(A)} \quad (3.7)$$

The α- cut of α- level set of fuzzy set $\widetilde{A}$ is a set comprise of those elements of the universe X whose membership values exceed the threshold level α. That is eq. 3.8,

$$A_\alpha = \alpha\text{-cut } (A) = \{x | \mu A(x) \geq \alpha\}. \quad (3.8)$$

Let's check a set A. Its membership function μA(x) is named unimodal if it only has one global maximum. The corresponding set A is then called convex. However, if μA(x) is multimodal (has several local maxima), then A is non-convex. Finally, the cardinality card (A) = |A| of a finite discrete set A is the sum of the membership grades. Thus (eq. 3.9),

$$card (A) = |A| = \sum_{i=1}^{n} \mu_A(x_i) \quad (3.9)$$

3.7 Convexity of a Fuzzy Set

The convexity of a fuzzy set is a significant; property from the viewpoint of the implementation aspect. A fuzzy set $\tilde{A}$ is convex (eq. 3.10) if

$$\mu_{\tilde{A}}(\lambda x_1 + (1-\lambda)x_2) \geq \min \ \mu_{\tilde{A}}(x_1), \mu_{\tilde{A}}(x_2)) \quad (3.10)$$

where $x_1, x_2 \in X$ and $\lambda \in [0,1]$. Alternatively, a fuzzy set is convex if all α-level sets are convex. Figure 3.8 gives a convex fuzzy set and a nonconvex fuzzy set. In general terms, unless otherwise stated, the term fuzzy set will denote a convex fuzzy set (Bojadziev and Bojadziev, 1998).

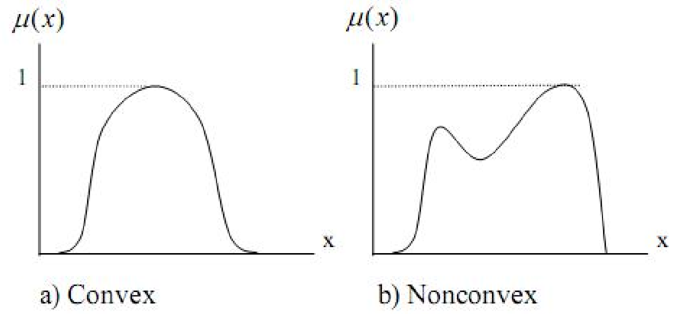

Figure 3. 8: Example of convex and nonconvex fuzzy set.

3.8 Fuzzy Numbers

A fuzzy variable is a fuzzy subset of the real line whose maximum membership values are classified around a given exact variable said the mean value; the membership function is monotonia on both sides of this mean value.

A fuzzy set $\tilde{A}$ on R (real number) must have at least the following three properties to qualify as a fuzzy number (Aytar, 2004).

- $\tilde{A}$ must be a normal and convex fuzzy set,
- The core consists of one value only,
- The support of $\tilde{A}$, must be bounded.

Fuzzy numbers is a special subset of fuzzy sets. They are quite useful in determining the uncertain or approximate numeric quantities such as “almost 9”, “about 15”,” less than 200”,”several”,”near” and so on.

A fuzzy number can be represented in discrete or continuous form. It is possible to utilize various fuzzy numbers depending on the subject matter. There is as much fuzzy number as membership function types as sampled in Figure 3.9 the most common shapes of membership functions are trapezoidal and triangular shapes. These types of fuzzy numbers are easy to construct and manage (Gülbay, 2006).

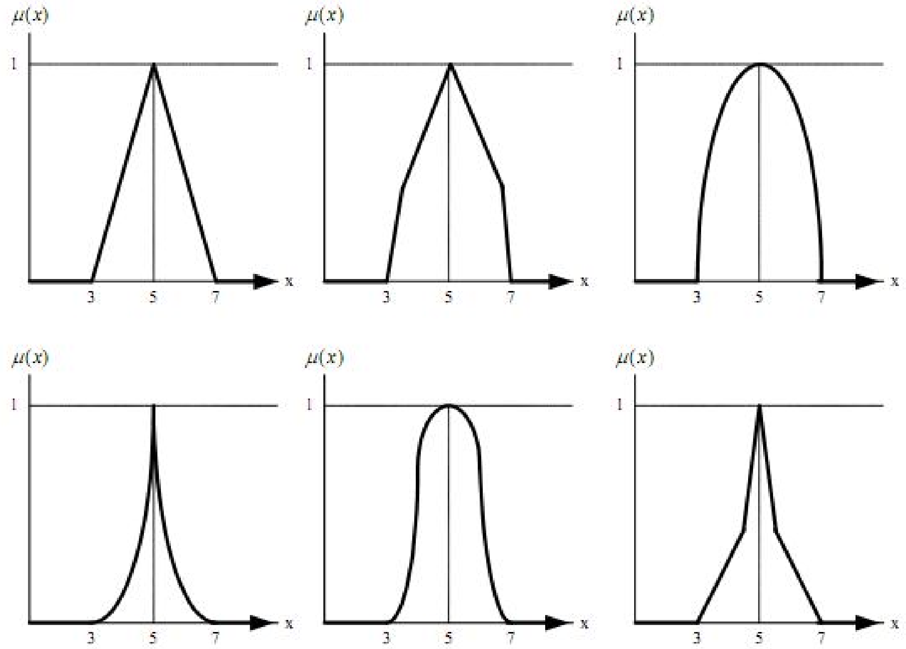

Figure 3. 9: Possible fuzzy numbers to capture the concept of "around 5".

3.9 Triangular Fuzzy Numbers

A triangular fuzzy number as illustrated in Figure 3.10 is actually a special case of the trapezoidal fuzzy number and will be represented as (a_1, a_2, a_3). In this situation, membership function of the triangular fuzzy number becomes as follows:

$$\mu_A(x;a_1,a_2,a_3) = \begin{cases} a_1 \leq x \leq a_2 & then, (x-a_1)/(a_2-a_1) \\ a_2 \leq x \leq a_3 & then, (a_3-x)/(a_3-a_2) \\ x > a_3 \ or \ x < a_3 & then, 0 \end{cases} \quad (3.11)$$

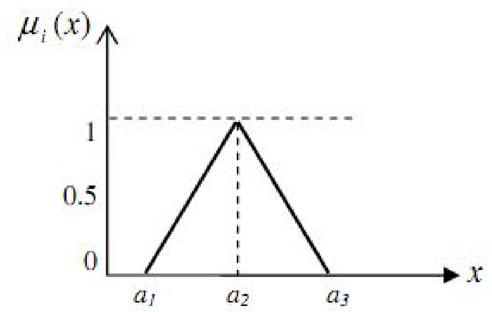

Figure 3. 10: A triangular fuzzy number

Triangular fuzzy numbers are generally used in different fields such as fuzzy controllers, managerial decision-making, social sciences, additionally, in the case of little information can be created easily (Kaufman and Gubta, 1988).

3.9.1 Operations on triangular fuzzy numbers

Some of the features that should be considered when dealing with triangular fuzzy numbers are as follows:

- Addition or subtraction operations of two triangular fuzzy numbers results again triangular fuzzy number.
- Result of multiplication, division or reverse operations of triangular fuzzy numbers is not always triangular fuzzy numbers.
- Result of maximum or minimum operations of triangular fuzzy numbers is not always triangular fuzzy numbers.

However, the results of these processes can be regarded as approximately triangular fuzzy number (Kaufmann & Gupta, 1988).

Basic operations for two triangular fuzzy numbers are given in equations from 3.12 to 3.23 for M= (l,m,u) , N = (a,b,c)

Image of N $-N=(-c,-b,-a)$ (3.12)

Inverse of N $N^{-1} = (\frac{1}{c}, \frac{1}{b}, \frac{1}{a})$ (3.13)

Addition $M+N=(l+a, m+b, u+c)$ (3.14)

Substraction M-N=(l-c, m-b, u-a) (3.15)

Scolar multiplications $\forall k > 0, k\epsilon R$ $kM = (kl, km, ku)$ (3.16)

$\forall k < 0, k\epsilon R$ $kM = (ku, km, kl)$ (3.17)

Multiplications M>0, N>0 MN=(la, mb, uc) (3.18)

M<0,N>0 MN=(lc,mb,ua) (3.19)

M<0,N<0 MN=(uc,mb,la) (3.20)

Divisions M>0,N>0 $\frac{M}{N} = \left(\frac{l}{c}, \frac{m}{b}, \frac{u}{a}\right)$ (3.21)

M<0,N>0 $\frac{M}{N} = (\frac{u}{c}, \frac{m}{b}, \frac{l}{a})$ (3.22)

M<0,N<0 $\frac{M}{N} = (\frac{u}{a}, \frac{m}{b}, \frac{l}{c})$ (3.23)

3.9.2 Advantages and disadvantages of fuzzy logic

Fuzzy logic approach has some advantages and disadvantages compared with classical approaches. The advantages of the concept of fuzzy logic are as follows:

- Enable the use of vague linguistic, not numerical, variables terms in the rules which make it similar to the way humans think.
- Simplicity gives chance the solution of previous unsolved problems.
- Provide for rapid prototyping because, it does not require all knowledge about system before starting.
- Cheaper because they are easier to design
- They have increased robustness.
- Make easier knowledge acquisition and representation.
- Can reach steady state in a shorter time interval (Rao & Valluru, 1995).

Besides its advantages fuzzy logic also has some disadvantages. Some of these disadvantages are as follows:

- It's hard to develop a model from a fuzzy system.
- Difficult to estimate membership function
- Have a stigma connect to the word fuzzy (at least in the Western world); engineers and most other people are used to crispness and shy away from fuzzy control and fuzzy decision making.

- Though they're easier to design and faster to prototype than conventional control systems, fuzzy systems require more simulation and fine tuning before they're operational (Rao & Valluru, 1995).

3.10 Fuzzy Decision Making

Generally data could not be determined easily and they are fuzzy because of incomplete or missing information in real life situations. Decision-making is a subjective process. Therefore, the decision makers sometimes have to decide by using non-numeric and incomplete information. In such cases, more effective decisions can be reached by including fuzzy set theory in decision-making process (Karakaşoğlu, 2008).

Prevalently, many decision-making and problem-solving tasks are not clearly explained as their purposes and characteristic are not exactly known. Many authors have dealt with these difficulties, which are because the lack of certainty. But, due to the fact that the environmental and the data need are very strict and that many real world problems are fuzzy by nature and not random, the probability implementations have not been suitable in so many cases. Conversely, the implementation of fuzzy set theory in real world decision making problems has given acceptable outcomes. (Gu & Zhu, 2006).

Fuzzy set theory look like human thinking in its use of approaching data and indistinctness to make decisions. The foundation of using a fuzzy method is to decide the relative importance of criterion using fuzzy numbers in place of crisp numbers (Yang & Hung, 2007).

3.11 Fuzzy Multi Criteria Decision Making

One of the most appropriate fields of the use of fuzzy set theory is decision analysis. Generally, the making a decision in the real life occurs in an surrounding in which the goals, the constraints and the results of probable actions are not known exactly (Bellman & Zadeh, 1970). Fuzzy set theory proposes a chance for dealing with the data and information including the subjective characteristics of human nature in the decision-making process (Hung, Jayagopi, Ba, Gatica-Perez, & Odobez, 2008). In recent years inclusion of fuzzy sets in multi-criteria decision-making process this field has been expanded impressively. Thus, fuzzy MCDM has emerged.

Making effective decisions necessitates sufficient recompense of the nature of the problem, the size of the problem, the amount of information available, the number of decision maker(s) involved, and the time available for making the decision in a fuzzy environment (Chen, et al., 2006; Yang, et al., 2007). Subjectiveness and imprecision is existent in multi-criteria decision making because of incomplete information, abundant information, conflicting evidence, ambiguous information, and subjective information (Samson, Renekea, & Wieceka, 2009). To suitably model the subjectiveness and imprecision in multi-criteria decision making, linguistic terms approximated by fuzzy numbers are often used to explain the decision maker's subjective evaluations. The use of fuzzy numbers is associated with their simpleness in both concept and computation (Kahraman, 2008).

3.12 Fuzzy Multi Criteria Decision Making Methods

Fuzzy multi criteria decision making finds a solution for decision problems by making a comparison of alternatives versus few contingently contradictory criteria and choosing the most suitable alternatives in spite of having ambiguity and inaccuracy. Decision making problem might grouped as selection problem, classifying problem or ranking problem Vanderpooten (1990). In fuzzy multi criteria decision making, the most suitable options are chosen and ordered in accord with their priority. Using priority models in Fuzzy MCDM offers forceful statements that chosen options have greater degree than the others; therefore a high point of priority shows a persuasive claim for convenience relative to degree of likeness to only one reference. Moreover, the weights of chosen options versus few elements also give a description of selecting reason of alternatives (Pedro & Burstein, 2003)

Most research is being done by improving the various fuzzy multi-criteria analysis approaches for solving different practical problems (Bellman and Zadeh, 1970; Dubois, et al., 1980; Hwang, et al., 1981). Numberless implementations of the approaches developed for addressing real world fuzzy MCDM problems have been reported in the literature. These applications contain portfolio management (Yeh & Chang, 2009), supplier selection (Araz & Ozkarahan, 2007), information systems allocation (Badri, 2001) and location planning (Kahraman, et al., 2003; Awasthi, et al., 2011) etc.

The most encountered fuzzy MCDM methods in literature are Fuzzy Analytic Hierarchy Process, Fuzzy TOPSIS method (Karakaşoğlu, 2008). However, in this chapter only Fuzzy AHP method was mentioned.

3.13 Fuzzy Analytic Hierarchy Process

The AHP method has been greatly used to apply the general multi-criteria problems in the literature. This method, however, is frequently censured for its inconsistent ordering results, unsuitableness of the crisp ratio representation, and tiresome comparison processes when lots of attributes are included (Yeh, et al., 2000, Deng, 1999). With the utilization of AHP method, the expert is inquired to choose opinions related with either the relative importance of the evaluation and selection criteria or also its preferences of one alternative on one criterion versus other. This gives an impression simple and reasoning in real decision making conditions. However, the pair-wise comparison process becomes burdensome, and the risk of producing inconsistent evaluations increases at the time of number of options and elements increases, therefore endangering the practical applicability of the AHP method (Chen, et al., 1992; Pohekar, et al., 2004).

Fuzzy AHP method is an improved version of classical AHP. Fuzzy AHP is able to reduce the indistinctness and unclarity being in most of problems related to decision making may cause the inaccurate assessments of decision makers in traditional AHP methods (Bouyssou, Marchant, Pirlot, Perny, Tsoukiàs, & Vincke, 2000).

Due to the limitation of the AHP technique in dealing with the subjectiveness and inexactness of the making a decision process, most analyst (Boender, et al., 1989;

Buckley, 1985; Chang, 1996; Lootsma, 1997) whose studies are on the basis of fuzzy AHP demonstrate that fuzzy AHP exhibits proportionately adequate explanations of these type of procedures relative to the classical AHP techniques.

The fuzzy AHP technique is a methodical approach takes advantage of the notions of fuzzy set theory to make a decision (Kwong & Bai, 2002) This approach enables the decision maker to describe his/her precedence with linguistic variables for deciding the significance of each weights of criterion (Cheng, 1996; Kahraman, et al., 2004). The importance of criteria is computed by using 1-9 scale which proposed by Saaty (1980). Although this method is simple contains a number of inconsistencies. Besides decision maker generally say that giving judgments by using crisp values is more difficult than using linguistic variables because of fuzzy theory is more appropriate to language.

Even if the objective of AHP is to deal with judgments of experts, the conventional AHP cannot represent the personal feeling. It is not easy for people to make always precise ratios when comparing two alternatives. Fuzzy numbers help to reduce this indistinctness. Hence, both of AHP and its fuzzy version are improved to find a solution of hierarchical issues (Kahraman et al., 2004).

3.13.1 A literature view on fuzzy AHP applications

Van Laarhoven and Pedrcyz (1983) suggested the earliest application of fuzzy logic principle to AHP. They proposed an approach which extent the Saaty's pair-wise comparison technique with fuzzy degrees using triangular fuzzy numbers. Fuzzy weights and fuzzy performance scores are calculated by using Lootsma's logarithmic least-squares method (Chen, Hwang, & and Hwang, 1992) the method has two steps. In first step, fuzzy weights of decision criteria determined later alternative fuzzy scores are obtained. They used this method on professor selection problem at a college.

Buckley (1985) proposed a method which is also extension of Saaty's AHP method the difference of this method from Van Laarhoven and Pedrycz's (1983) method is he preferred trapezoidal fuzzy numbers to define the opinions of expert on options for every criteria. According to Buckley (1985) their method has two problems. One of them is the linear equalities are not always have only one solutions. Secondly, acquiring triangular fuzzy numbers for their priorities will cause more than one solution and losing lots of data. Buckley (1985) derived a single fuzzy number for weights in his study. This also prevents the loss of data.

Boender, et al.(1989) modified the Van Laarhoven, et al.(1983) fuzzy MCDM technique. Initially the priorities of the decision elements are computed by reduction the function of logarithmic regression. Then, the priorities of the alternatives are computed for every criterion one by one. Finally, the fuzzy results of the options are defined by a suitable integration of the computed priorities.

Chang (1996) presented a new algorithm for fuzzy AHP process, by utilizing triangular fuzzy numbers for pair-wise comparison measure of fuzzy AHP, for determining the priorities the extent analyses technique is used. In the application part he took up Van Laarhoven and Pedrycz'in (1983) study as a professor choice problem at a college and solved it with the extended analysis method.

Cheng (1996) presented a new approach by using fuzzy AHP based on grade value of membership function. In the evaluation firstly all criteria membership functions are which is said fuzzy standard are determined then , these function by practical information to show their value of performance are computed and finally fuzzy AHP technique and entropy notions to compute added priorities are used.

Weck, et al. (1997) suggested an approach for ratings various production cycle options combining the fuzzy logic with conventional AHP. Whichever production cycle used thus gives a fuzzy set. The alternative cycles for production examined could possibly classified in order regarding the main objective set.

Cheng (1999) proposed a common technique for the assessment of weapon systems by multiplying the fuzzy judgment matrix on the basis of verbal variable priority.

Stam, et al. (1996) investigated how in recent times improved artificial intelligence methods could be utilized to decide or approach the predilection degrees in AHP. They finalized that the neural network formulation of feed-forward looked as if an effective method to examine distinct options of MCDM problems with inexact or fuzzy measure predilection opinions.

Kwong, et al. (2002) suggested a method for deciding the significance of priority of consumer requirements by using AHP in fuzzy environment.

Kahraman, et al. (2003)find a solution of plant location issues using four various solution methods of fuzzy multi-attribute group decision-making one of which is one is fuzzy AHP. Kahraman, et al.(2004) proposed an analytical method to choose the best catering firms obtaining the most customer contentedness. The fuzzy AHP was utilized for making comparisons of firms. Büyüközkan, et al. (2004) proposed a method to develop the deciding quality in the software improvement project with vague situations. A technique on the basis of the extent fuzzy AHP forming to evaluate the sufficient economical and quality balance is applied to manage the indistinctness, and ambiguity from personal intuition and knowledge of peoples in the deciding.

Tsaur, et al.,(2002) utilized fuzzy set theory, AHP and TOPSIS methods to measure airline service quality. Wang, et al.(2007) also used SERVQUAL scale to evaluate service quality of long-term care institutions. They applied simple additive weighting and fuzzy AHP as MCDM methods to decide the weight of significance of each criterion.

Enea, et al.(2004) proposed an approach by using a fuzzy extension of the AHP. This study concentrated upon the constraints which must be measured by using fuzzy

AHP for considering all the attainable data. Which shows that the specific and trustworthy outcomes can be obtain by taking into account whole data extracted from the constraints.

Pan, (2008) proposed fuzzy AHP approach to select a suitable bridge building technique. He integrates two types of fuzzy numbers to have fuzzy priorities from group assessments, the max–min aggregation and center-of-gravity (COG) defuzzification methods are used. Moreover, the α-cut notion is performed to define definite degrees of indistinctness connected to the decision environment. According to his outcome the approach is uncomplicated and its accomplishment is give the solution rapidly.

Huang, et al.(2008) presented a fuzzy AHP technique and used crisp judgment matrix to appreciate personal opinions of decision makers made by the technical committee of the Industrial Technology Development Program in Taiwan. According to their evaluation the scientific and technological deserve is the most significant evaluation criterion measured in overall technical committees. They also exhibit the notional significance of the evaluation criteria difference under assorted risk environments by simulating them.

Seçme, et al.(2009) proposed a fuzzy MCDM to appraise the banks performance. Fuzzy AHP and TOPSIS techniques are combined in their suggested model. The criteria priorities are computed by utilizing the choices of decision makers using the fuzzy AHP technique; these priorities are entries to the TOPSIS technique for ordering banks. Due to their results besides the financial performance of banks non-financial performance can be added.

Dağdeviren, et al.(2009) suggested weapon choosing by utilizing the fuzzy AHP and fuzzy TOPSIS techniques which produces an estimation model based on the (AHP) and the (TOPSIS).

Ertugrul, et al. (2009) improved a model for appraising companies performance with utilizing financial ratios in fuzzy conditions and simultaneously, taking personal opinions of experts into consideration.

Tiryaki, et al. (2009) used the fuzzy AHP technique to find a solution for selecting portfolio. They applied two fuzzy AHP methods among the current ones. By modifying one of them they find its revised version said revised constrained fuzzy AHP method (RCFAHP).

Naghadehi (2009) use the combination of conventional AHP and fuzzy AHP to choose optimum mining technique for this reason they proposed fuzzy model.

Önüt, et al. (2010) modeled shopping center site selection problem for a real world application in Istanbul which is the most populated city in Turkey. They suggested an integrated MCDM technique. Fuzzy AHP is used for determining priorities of the factors for site choice and moreover, fuzzy TOPSIS is utilized to decide the most appropriate alternative site by using the criteria weights. Finally the sensitivity analysis of the results is determined.

Javanbarg, et al. (2012) proposed method which is able to transform a problem of giving fuzzy priorities to optimize a constricted non-linear model. They used advanced particle swarm optimization to solve this model. Fuzzy AHP is used in the verification phase.

Shaw, et al. (2012) presented a linear programming model which has a multi objective in fuzzy environment and integrate this model with fuzzy AHP to select appropriate supplier for finding a solution of carbon emission problem. Understanding the priorities of factors effect they utilized from fuzzy AHP, afterwards these priorities are used in their proposed model.

In literature various fuzzy AHP techniques are suggested by different authors. These techniques are methodological and logical algorithms for prefer suitable alternative by applying the notions of fuzzy set theory (Büyüközkan, Kahraman, & Ruan, 2004)

Some of these methods are ;

- Van Laarhoven and Pedrycz (1983)
- Buckley (1985)
- Boender, et al., (1989)
- Chang (1996)
- Cheng (1996)

In this thesis, we apply Chang's (1996) extent analysis technique since the steps of this methods are comparatively have less computations than the other fuzzy AHP method and there is lots of similarity with traditional AHP.

3.13.2 Chang's Extent analysis method on fuzzy AHP

Let X ={x_1, x_2, ... ,x_n} be an object set, and U{u_1,u_2, ... ,u_n}be a goal set, In accord with the approach of Chang's (1996) extent analysis, each object is taken and extent analysis for every goal, g_i is executed, respectively. Hence, m extent analyses variables for each object can be acquired, by using the Eq. 3.24,

$$M_{gi}^{1}, M_{gi}^{2}, \dots, M_{gi}^{m} \quad , \quad i = 1, 2\dots,n, \tag{3.24}$$

where all the $M_{gi}^{j}(j = 1,2 \dots m)$ are TFNs.

The steps of Chang's extent analysis can be given as in the following (Chang, 1996):

Step 1: The value of fuzzy synthetic extent with respect to the ith object is defined as Eq. 3.25:

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} * \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} \tag{3.25}$$

To obtain$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}\right]^{-1}$, perform the fuzzy addition operation of m extent analysis values for a particular matrix such that Eq. 3.26 and 3.27:

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_i \sum_{j=1}^{m} m_i \sum_{j=1}^{m} u_i\right) \tag{3.26}$$

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{n} l_i \sum_{j=1}^{n} m_i \sum_{j=1}^{n} u_i\right) \tag{3.27}$$

and then compute the inverse of the vector in Eq. 3.27 such that Eq. 3.28:

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \tag{3.28}$$

Step 2: The degree of possibility of $M_2 = (l_2,m_2,u_2) \geq M_1 = (l_2,m_2,u_2)$ is defined as Eq. 3.29:

$$\mathrm{V}(\mathrm{M}_2 \geq \mathrm{M}_1) = \mathrm{y} \geq \sup\ x\left[\min\left(\mu_{M_1}(x), \mu_{M_2}(y)\right)\right] \tag{3.29}$$

Can be equivalently expressed as follows Eq. 3.30:

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M_2}(d)$$

$$= \begin{cases} 1, & if\ \ (m_2 \geq m_1) \\ 0, & if l_1 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & otherwise \end{cases} \tag{3.30}$$

where d is the ordinate of the highest intersection point D between μ_{M_1} and μ_{M_2} (see Fig. 3.11).For comparing this M_1 and M_2, we need both the values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$

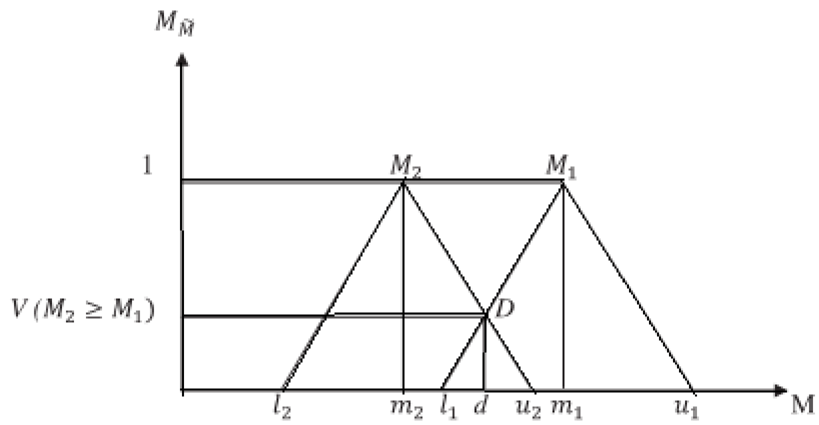

Figure 3. 11: The intersection between M_1 and M_2 (Chang, 1996).

Step 3: The degree possibility for a convex fuzzy number to be bigger than k convex fuzzy values M_i (i =1,2, ... ,k) can be expressed by Eq. 3.31:

$V(M \geq M_1, M_2, \ldots, M_K) = [(M \geq M_1)$ and $(M \geq M_2)$ and ….and $(M \geq M_K)]$ min $V(M \geq M_i)$, $i = 1,2,3,\ldots,k$ (3.32)

Suppose that Eq. 3.33:

$d'(A_i) = \min V(S_i \geq S_k)$ (3.33)

For k =1,2, ...n; $k \neq i$ then the weight vector is given by Eq. 3.34:

$W' = (d'(A_1), d'(A_2), \ldots, d'(A_n))^T$, (3.34)

where $A_i (i = 1,2, \ldots ,n)$ are n elements.

Step 4: via normalization, the normalized weight vectors are given by Eq. 3.35:

$W = (d(A_1), d(A_2), \ldots, d(A_n))^T$ (3.35)

where W is a nonfuzzy number.

3.13.3 Consistency in fuzzy AHP

The AHP method of Saaty (1980) suggests a consistency ratio to evaluate any inconsistency within the opinions of decision makers in every pair-wise matrix and likewise for the whole hierarchy. This ratio shows if the aim of problem could be arranged suitably. In addition it says that the matrix is consistent or not.

The pair-wise comparisons of fuzzy AHP must be consistent with each other like classical AHP. However, reviewing the literature, fuzzy numbers or linguistic variables used in many AHP analysis consistencies of applications has not been checked much. As a result of review of the literature only Kwong and Bai (2003) made consistency analysis in their study. Kwong and Bai used Chang's (1996) extended analysis method attempted to prioritize the needs of an enterprise customer. In this study similar technique is used for the consistency analysis them to control the consistency of pair-wise matrix. First, defuzzification of triangular fuzzy numbers was employed to transform fuzzy numbers to crisp ones. Fallowing the consistency index ,CI, and consistency ratio CR, for a comparison matrix was calculated with using the equations Eq. 3.36-3.37, respectively.

$CI = (\lambda_{max} - n) / (n - 1)$, (3.36)

$$CR = (CI/RI\ (n))100\%, \quad (3.37)$$

Table 3. 4: The mean consistency index of randomly generated matrices

n	1	2	3	4	5	6	7	8
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41
n	9	10	11	12	13	14	15	
RI	1.45	1.49	1.51	1.48	1.56	1.57	1.59	

where, λ_{max} is the largest eigen value of the comparison matrix, n is the dimension of the matrix, and RI(n) is a random index, that relies on n, as point out in Table 3.4 If the computed CR of a comparison matrix is not bigger than 10%, the consistency of the pair-wise judgment can be admissible. Else, the judgments explained by the decision makers are said to be inconsistent, and the decision maker has to reiterate the pair-wise comparison matrix. A triangular fuzzy number, symbolized as M = (l, m, u), can be defuzzified to a crisp number as follows (Eq. 3.38):

$$M\ crisp = (4m + l + u)/6. \quad (3.38)$$

According to Saaty's idea (1980), the consistency ratio (CR) of less than 0.1 is admissible. However, it is not easy to make the matrix with suitable CR due to the complex of the examined criteria and the bounded capacity of human thinking. There could be a way of handling the matrices with undesirable consistency ($CR \geq 0.1$), that is, giving those matrices to the decision makers again to rethink making new matrices in accordance with their new judgments and following this process until the matrices with suitable CR are acquired. This technique is trustworthy and exact however, not practical due to the numerous amounts and the needs lots of time for work. Therefore, for a given judgment matrix, if $CR \geq 0.1$, we can use various methods to settle the judgment matrix thoroughly which the revised matrix controls admissible consistency ($CR < 0.1$). Afterwards, from the revised matrix, we can make the rational weight vector of the primary one by the eigenvector priority method (Zeshui, 2004).

The approach improving consistency of judgment matrix in AHP (Zeshui, 2004) , which uses the eigenvector to edit a pair of entries of judgement matrix each time is utilized in this thesis after converting triangular fuzzy numbers to crisp number. By using this method, any judgement matrix with a large CR can be modified to a matrix which can both tally with the consistency necessity and reserve a large number of data that the main matrix involves. An algorithm to make a judgment matrix with allowable consistency (i.e., CR < 0.1) and two criteria of evaluating modificatory effectiveness are also given (Zeshui, 2004).

Let N = {1,2,...n}. Recall that a judgement matrix A = (aij) is an nx n matrix, all of whose entries are positive such that $a_{ji} = 1/a_{ij}$, for all i,j ∈ N, especially $a_{ii} = 1$,i ∈ N. It is well known to us that a judgement matrix is a positive reciprocal matrix. An nxn judgement matrix is called a consistent matrix if $a_{ij} = a_{ik} a_{kj}$, for all i, j, k ∈ N.

If an n x n judgement matrix A = (a_{ij}) is a consistent matrix, and w = $(w_1,w_2, ...,w_n)^T$ is its principal right eigenvector, then a_{ij} = wi/wj , for all i, j, k ∈ N.

Let A = (aij) be an nx n judgement matrix, and w = $(w_1,w_2, ...,w_n)^T$ be the principal right eigenvector of A. we know that if A is a consistent matrix, then a_{ij} = wi/wj for all i,j, k ∈ N., namely (Eq. 3.39),

$$a_{ij}\frac{w_j}{w_i} = 1 \quad i,j \in N \tag{3.39}$$

However, humans have judgments which have their personal opinions and depend on their spiritual situation, knowledge degrees; in the general case, Eq. (3.39) does not hold. Hence, we can take the comparison matrix A as a perturbed matrix of the consistent matrix W = (wi/wj), namely (Eq. 3.40), set

$$a_{ij}\frac{w_j}{w_i} = \varepsilon_{ij} \quad i,j \in N \tag{3.40}$$

where ε_{ij} is a perturbation variable, $\varepsilon_{ij} > 0$, and $\varepsilon_{ji} = 1/\varepsilon_{ij}$.

Eq. 3.40 can be expressed as ε_{ij} = $a_{ij}(w_j/w_i)$ i , j ∈ N; in this case, we set $\varepsilon_{rs} = max_{i,j}\left\{a_{ij}\frac{w_j}{w_i}\right\}$, thus, a_{rs} related to ε_{rs} is an entry which has the largest deviation in matrix A.

Therefore, as the judgement matrix A possesses unacceptable consistency (C.R. ≥ 0.1) and we attempt to improve it, it is natural and reasonable to modify the entry a_{rs} first. In order to ensure that the modified matrix is a positive reciprocal matrix, the corresponding entry a_{sr} should also be modified simultaneously.

On the basis of the analysis above, we give the following algorithm to modify the judgement matrices with unacceptable consistency.

Algorithm (Zeshui,2004).

For any nxn judgment matrix A=(a_{ij}) , let k represent the k times of iteration and λ∈(0,1).The approximation method is given by the following procedures:

Step 1 Let $A^{(0)}=(a_{ij}^{(0)}) = (a_{ij})$, C.R.*=0.10 and k=0.

Step 2 Calculate the maximum eigenvalue $\lambda_{max}(A^{(k)})$ of $A^{(k)}$ and the normalized principal right eigenvector $(w_1^{(k)}, w_2^{(k)}, ..., w_n^{(k)})^T$.

Step 3 Calculate the consistency index $C.I.^{(k)} = \lambda_{max}(A^{(k)}-n)/(n-1)$ and the consistency ratio $C.R^{(k)} = C.I.^{(k)}/R.I.$, where R.I. is given by Saaty(1980) or as listed in Table 2.2.

Step 4 If $C.R.^{(k)} < C.R.^*$,then go to Step 7; otherwise, continue the next step.

Step 5 Determine the numbers r and s, such that $\varepsilon_{rs} = max_{ij}\left\{a_{ij}^{(k)}(w_j^{(k)}/w_i^{(k)})\right\}$, and let $A_{(k+1)}=(a_{ij}^{(k+1)})$, where $a_{ij}^{(k+1)}$,can be obtained by one of the following formulas:

(i) (The weighted arithmetic mean form)

$$a_{ij}^{(k+)} = \begin{cases} \lambda a_{rs}^{(k)} + (1-\lambda)\left(\dfrac{w_r^{(k)}}{w_s^{(k)}}\right), & (i,j) = (r,s); \\ \dfrac{1}{\lambda a_{rs}^{(k)} + (1-\lambda)(w_r^{(k)}/w_s^{(k)})}, & (i,j) = (r,s); \\ a_{ij}^{(k)}, & (i,j) \neq (r,s),(s,r) \end{cases}$$

(ii) (The weighted geometric mean form)

$$a_{ij}^{(k+1)} = \begin{cases} \left(a_{rs}^{(k)}\right)^{\lambda} (w_r^{(k)}/w_s^{(k)})^{1-\lambda}, & (i,j) = (r,s); \\ \left(a_{rs}^{(k)}\right)^{\lambda} (w_s^{(k)}/w_r^{(k)})^{1-\lambda}, & (i,j) = (s,r); \\ a_{ij}^{(k)}, & (i,j) \neq (r,s),(s,r). \end{cases}$$

Step 6 Let k = k + 1, and return to Step 2.

Step 7 Output k, $A^{(k)}$, $\lambda_{max}(A^{(k)})$, $C.R.^{(k)}$ and $w^{(k)}$, then $A^{(k)}$ is the modified judgement matrix and $w^{(k)}$ is the priority vector.

Step 8 End.

3.14 Conclusion

As a conclusion, in the related literature, there are various methods related fuzzy AHP to analyze criteria. As it is mentioned before, Chang's Extent analysis method is used in this study. The main advantage of this method is the easiness of its calculation. Saaty's method is used to check the consistency of fuzzy AHP matrices. However, some of the ratios are not satisfied the maximum 0.10 consistency ratio. To overcome this problem, first, Zeshui's approach is employed. Then, synthesis values and weights of criteria and sub-criteria are calculated.

CHAPTER 4

PROBLEM DEFINITION

4.1 Introduction

Universities aims to provide professional skills with academic training and practice, generating information in conducting scientific, social and economic-based practice and research, preparing young people in community life by giving duties and responsibilities, contributing to the level of the awareness and culture of society. Areas of social and cultural activities in universities have great significance in terms of social interaction in different cultures, ethnic and social structures of students who have spent a large part of their time in off course spaces throughout the educational process. Each day, university campuses change dramatically. The appearance of university campuses is the consequence of all the insignificant and major, ordinary and official, logical and illogical decisions that are taken in the everyday coactions of a living organization answering to these variations. While making any change universities encountered numerous complications. Considering all this difficulties, planning of universities should be methodical, attentive, and reasonable.

University planning is a long-term process that plans is received, discussed and applications are managed. The developments related to the universities in Turkey; especially, the foundation of new universities has always been an attractive subject; therefore, local folk, politicians and academicians have focused on this subject.

In this thesis, campus planning of Turkish universities is searched from the view of industrial engineering. Because of the university campus planning has a lot of criteria and sub-criteria one of the most multi-criteria decision making methods AHP is preferred for this study. However, as a preliminary study which made to the people who are specialized in campus planning gives that consistency ratio was very low and the experts have waste a lot of time when interpretation. So we decided it would be more appropriate to use fuzzy AHP method.

4.2 Determining University Campus Planning Criteria

The university campus planning criteria were determined consultation with experts and looking for related literature (Dober, 1996; Zengel, 1998).While comparing universities according to their campus planning with each other, we used twelve criteria (figure 4.1) which are related with campus planning. These criteria fundamentally take into consideration the decisions determined by the coordination of the city planners and architects at the theoretical and planning scales of campus planning concept. These are briefly described as the following (For more detail about criteria see (Kortan, 1978; Dober, 1996; Zengel, 1998).

4.2.1 Campus location criteria

Location appearances of university campus principally describe the potentials of the place like seas, forests, lakes, and mountains which means the availability of the place for building and appropriate topography. It indicates the significance of convenient guidance in a campus settlement. In a way the buildings are there to form area. Decision of where campus location will be inside the city or outside the city is important. Each university campus has a place boundary to identify its outdoor and indoor space uses which is actually connected to the campus scale (Zengel, 1998). An education area in a suitable measure offers good guidance by describing a compact and a consistent layout. Guidance can only be composed in campuses when the spatial appearance underscores the sense of place in psychological and intuitive terms. Hence, a feeling of area in a campus model can be shaped and stimulated by meticulously to position key factor in the planning structure and by answering to the natural situations proposed by climate and regional impacts. Afterwards, it can describe the best properties of the existing surroundings.

4.2.2 Cultural structure of the city

In making a neo- physical places cultural structure of the city which can be described as the regional settlement models, architectural concepts and typologies are the impressive planning criteria. In addition these particular places can be planned taking into account; regional circumstances, life standards of the region, culture, and nature of the area. This is immediately having a connection with the closeness or the separation of departments in the university. The utilization of varied density of departments within the campus may be the reason of students' psychological problems that come from low-density settlements (Zengel, 1998).

4.2.3 Financial situation of the university

Financial conditions of the university are the efficient element on the planning of the university .It presents restrictions to the choosing of appropriate place. Investment is collaborated with the area of the site, phasing of buildings and infrastructure, quality standards such as sq mt/students, sq mt/academic staff and the other requirements of the campus (Zengel, 1998).

4.2.4 Campus population

Campus population is comprised of students, faculty academic and administrative staff and other personnel. In discovering the average student population of recommended university campus, mainly social and economic connections between the neighborhood units, site conditions and students demands of the university has to be explored. According to State of" State Planning Organization of Turkish government has depicted this threshold as a maximum of 15,000 people." (Tekeli, 1971). However, this number enlarged to 20,000-45,000 people which are too much from this threshold in universities with no large campus (Zengel, 1998).

4.2.5 Education system criteria

Education system is effective planning criteria in the campus planning. Generally, universities are in use of different student groups. The reason is taking the same lesson or using same building. New technologic improvements increased relationship of departments with each other. Some faculties need similar spaces for example; lecture rooms, auditoriums and academic staff rooms in relation to their similar programs. Due to this cause, they should be integrated under their common uses in the campus. Another system of education that affects the campus pattern can be said as Day and Night Education (Zengel, 1998). This system enables student the freedom to utilize all the campus facilities 24 hours a day.

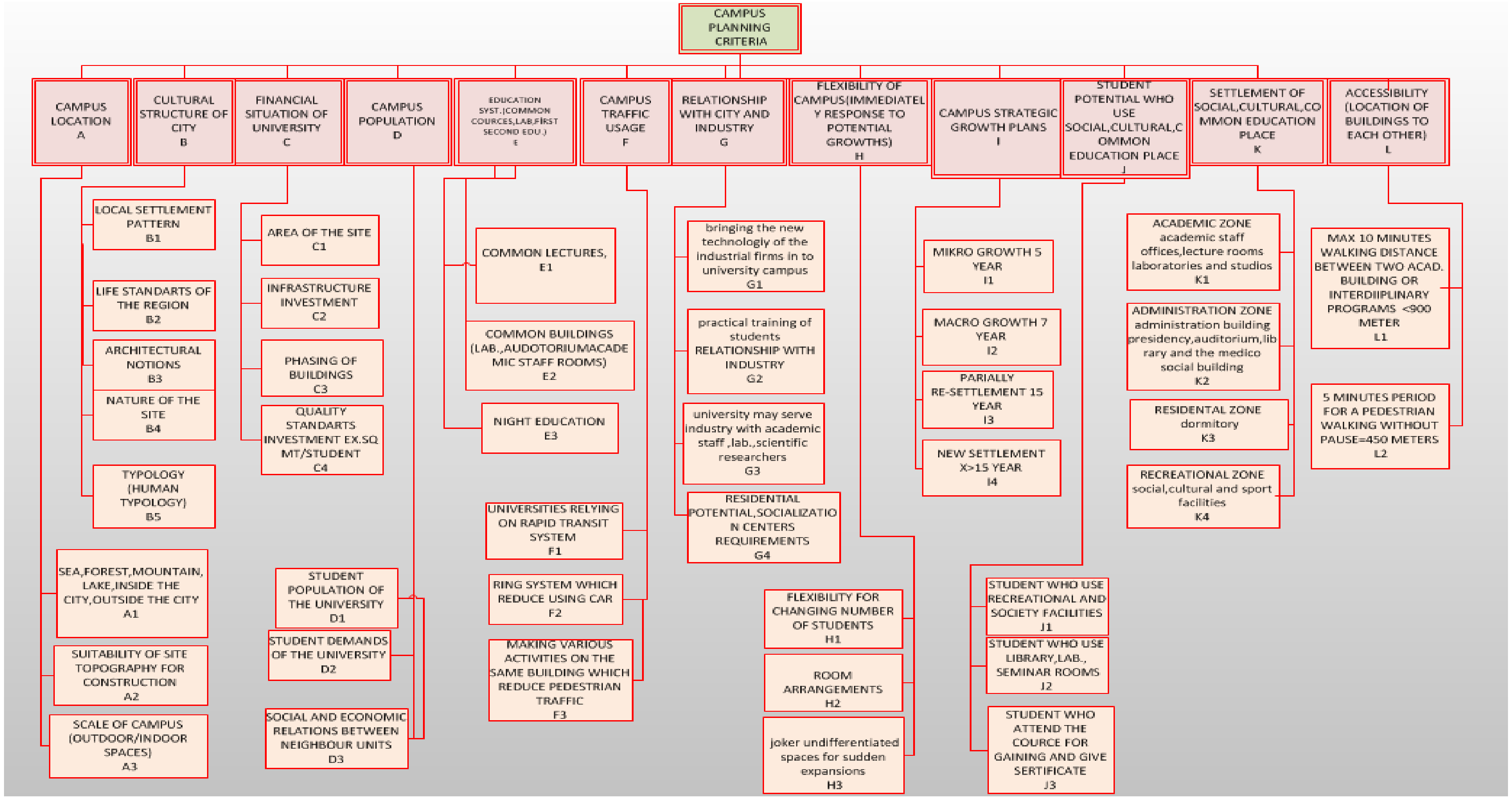

Figure 4. 1: Campus planning criteria

4.2.6 Campus traffic usage

A pedestrian's surroundings is planned by the components which describe his area as the ways on which he moves or relax and with these components filling of space is provided. Since traffic flow is the act of going from one location to another, planning arrangement can be set by using route of circulation to put limitations to surroundings to make them accessible and, to connect them together. These connections must direct pedestrians' clearly easy recognizable channels; some of the primary pedestrians' ways may possibly be encased. In spite of the fact that each university has its own special character, the problems happened by the vehicle are common to all. Students and faculty are recourse at making parking places instead of green areas. The problems because of the vehicle will force future university campuses in three classes according to their circulatory systems.

- Campuses based on a rapid transit system for transportation.
- Campuses based on an auto-oriented campus.
- Campuses based on traffic separation in perpendicular ways(Zengel, 1998).

Among the three options, planners do not take into account the evolvement of the auto-oriented campus locations as a several edifices swim in a sea of asphalt. They either protect a campus layout with a ring system for transportation which decreases walking space interval, so reducing student flow by car or they preferably want to separate traffic perpendicularly. That is to make different environmental areas for various activities.

4.2.7 Relationship between city and industries

A university campus placed near the city can give a chance to the residing of the city to the academic staff and students selecting to live outside the campus In addition, the socialization areas of the city can be the activity places for the students, academician etc. Moreover, introducing the new technological developments of the industrial firms with university campuses may enhance relations between them. Industries may be the pioneers of the universities for practical training of students and while overtaking the impressive, speed of advancement in modern technology. Additionally, universities may be render service to industry with the academician, laboratories and scientific researchers and developments (Zengel, 1998).

4.2.8 Flexibility criteria

Generally, the development and research activities change the both university life and society. Number of students becomes influencing parameter on the university life. Besides that, the teaching and research activities may necessitate new room settings and models of devices rooted different from those which are suitable today. Trend has frequently been based on favorably advanced systems, however this kind of devices are expensive. This situation is forcing universities to be flexible structure. This flexibility can be provided in the planning process of the campus. By using rule of joker undifferentiated place within areas can be allowed and they can be allocated for specialized activities for unexpected enlargement. In addition, the courtyard can be utilized to meet the need of space (Zengel, 1998).

4.2.9 Campus strategic growth models

There are several types of growth models in university campuses as in Table 4.1.

Table 4. 1: Types of Campus growth models (Erkman, 1990)

Types	Growth space	Growth year
Micro growth models	Min 2,000-3,000 sqmeters	In 5 years
Macro growth models	Min 20,000-30,000 sqmeters	In 7 years
Partially re-settlements	30,000-80,000 sqmeters	In 15 years
New settlements	80,000 sqmeters	15 years ≥X

4.2.10 Determination of user groups

Students, the academic staff and service staff comprise the user groups of a campus.

Academic staffs are employed on campus in 2 ways. First, being the teaching staff, the latter is to have administrative position. A predominant group of the population is formed by the students on campus. They have three types of students:

- Student who use recreational and society facilities
- Student who use library, lab., seminar rooms
- Student who attend the course for gaining and give certificate (Zengel, 1998).

4.2.11 Determination of major zones in campus settlements

Places utilizes in a university campus has been stated by the zoning criterion since modernism. There are four principal zones of the campus: The academic zone, residential zone, administration zone and recreational zone.

-Academic Zone: It includes; academic staff offices, lecture rooms, laborites, and studios.

-Administration Zone: The administrative places are localized of the administration building presidency, auditorium, library and the medico social building.

-Residential Zone: Place requirements for residential area should be organized under the needs of student dormitories and accommodation for the academic staff.

-Recreational Zone: It includes the great compactness of population in the campus. They are the attraction points that regards social, cultural and sport places. In lieu of, placing all of the recreational uses at one point spreading activitie around the campus in a coherent layout will be esteemed (Zengel, 1998).

4.2.12 Accessibility criteria on campus planning

The accessibility criteria on campus planning principally describe the procedure of exhibition maximum using the campus places within a narrow period of time. The ideal accessibility situations on a recommended campus settlement rely on the degree of decreasing the time spent while circulation between different groups of functions. There are two major accessibility criteria found by Kortan (1981)

- Maximum 10 minutes walking distance between two academic building or interdisciplinary programs < 900 meter

- 5 minutes period for a pedestrian walking without pause=450 meters (Kortan, 1981)

4.3 Conclusion

Campus planning problem has several aspects that should be considered carefully. However, it has not been an easy task to determine all criteria on such a critical problem that is requiring high expertise from the different academic disciplines. In this respect; some essentials of effective criteria determination was discussed through this chapter. The rationalities behind the decision factors were also linked with the previous studies.

CHAPTER 5

EXPERIMENTAL STUDY AND RESULTS

There are too many criteria and sub-criteria are considered related with campus planning in this study. Thus, we are compelled to limit university campus alternatives to six. These campuses are Gazi, METU, Hacettepe, Ankara, Bilkent, Başkent which are well-established university campuses built before 1994 located in Ankara, Turkey. Because of Gazi, Ankara and Hacettepe universities have more than one campus, in evaluation we used Gazi university Beşevler campus, Ankara university Tandoğan campus and Hacettepe University Beytepe campus. A questionnaire (Appendix A) was applied to 5 people who are expert in urban planning. The experts were especially selected from academician who lives in Ankara and knows all these campuses. The linguistic scale and corresponding triangular fuzzy numbers which used in the study is shown in Table 5.1.main criteria and sub-criteria are shown in Table 5.2 and Table 5.3 respectively.

Table 5. 1: The linguistic scale and corresponding triangular fuzzy numbers

Linguistic scale	Corresponding triangular fuzzy numbers	The inverse of the corresponding triangular fuzzy numbers
Just Equal	(1,1,1)	(1/1,1/1,1/1)
Equally Important	(1,3,5)	(1/5,1/3,1/1)
Weakly Important	(3,5,7)	(1/7,1/5,1/3)
Moderately Important	(5,7,9)	(1/9,1/7,1/5)
Strongly Important	(7,9,9)	(1/9,1/9,1/7)

After criteria and alternatives are evaluated by experts and generated fuzzy decision matrix values, the result of this evaluation is reduced to a single value with the help of equation 5.1.

$$\widetilde{M}_{ij} = \left(\frac{1}{N}\right) * (\widetilde{m}_{ij}{}^{1} * \widetilde{m}_{ij}{}^{2} * \dots * \widetilde{m}_{ij}{}^{N}) \quad (5.1)$$

Here $\widetilde{M}_{ij}$ is triangular fuzzy numbers indicating the value of an integrated decision-makers evaluation results $\widetilde{m}_{ij}{}^{1}$ shows the result of decision taken by k. experts i alternative j. criteria. N is a number of expert (Cheng, Chen, & Chen, 2008).

Table 5. 2: The main criteria of campus planning

Main Criteria	Symbol
Campus location	A
Cultural structure of city	B
Financial situation of university	C
Campus population	D
Education system	E
Campus traffic usage	F
Relationship with city and industry	G
Flexibility of campus	H
Campus strategic growth plans	I
Student potential who use social, cultural, common education place	J
Settlement of social, cultural, common education place	K
Accessibility	L

The consistency of results of experts survey are checked by using equations 3.36 and 3.37 however, some consistency ratios were bigger than 0.10 so we used Zeshui's (2004) proposed algorithm to improve the consistency of that judgment matrices. Inconsistent matrixes are modified and their consistency ratio is obtained less than 0.10 by this method. Results of pair-wise comparisons of experts are combined with the equation 3.38. The combination of five experts' pair-wise comparison matrix is shown in Table 5.5.

Table 5. 3: The sub criteria of university campus planning

Sea, Forest, Mountain, Lake, Inside The City, Outside The City (A1)
Suitability Of Site Topography For Construction (A2)
Scale Of Campus (Outdoor/Indoor Spaces) (A3)
Local Settlement Pattern (B1)
Life Standards Of The Region (B2)
Architectural Notions (B3)
Nature Of The Site(B4)
Typology (Human Typology)(B5)
Area Of The Site (C1)
Infrastructure Investment (C2)
Phasing Of Buildings (C3)
Quality Standards Investment Ex. Sq Mt/Student(C4)
Student Population Of The University(D1)
Student Demands Of The University (D2)
Social And Economic Relations Between Neighbor Units (D3)
Common Lectures (E1)
Common Buildings Lab., Auditorium, Academic Staff Rooms (E2)
Night Education (E3)
Universities Relying On Rapid Transit System (F1)
Ring System Which Reduce Using Car (F2)
Making Various Activities On The Same Building Which Reduce Pedestrian Traffic (F3)
Bringing The New Technology Of The Industrial Firms In To University Campus (G1)
Practical Training Students Relationship With Industry (G2)
University May Serve Industry With Academic Staff ,Lab., Scientific Researchers (G3)
Residential Potential Socialization Centers Requirements(G4)
Flexibility For Changing Number Of Students (H1)

Room Arrangements (H2)
Joker Undifferentiated Spaces For Sudden Expansions (H3)
Micro Growth (In 5 Years) (I1)
Macro Growth Models (In 7 Years) (I2)
Partially Re-Settlements(In 15 Years) (I3)
New Settlements (15 Years >X) (I4)
Student Who Use Recreational And Society Facilities (J1)
Student Who Use Library, Lab., Seminar Rooms(J2)
Student Who Attend The Course For Gaining And Give Certificate (J3)
Academic Zone Academic Staff Offices, Lecture Rooms Laboratories And Studios (K1)
Administration Zone Administration Building Presidency, Auditorium, Library And The Medico Social Building (K2)
Residential Zone Dormitory (K3)
Recreational Zone Social, Cultural And Sport Facilities (K4)
Max 10 Minutes Walking Distance Between Two Acad. Building Or Interdisciplinary Programs <900 Meter (L1)
5 Minutes Period For A Pedestrian Walking Without Pause=450 Meters (L2)

Table 5. 4: The combination of five experts' pair-wise comparison matrix

	A	B	C	D	E	F	G	H	I	J	K	L
A	(1,1,1)	(1,3,4)	(1,2,3)	(2,3,3)	(2,3,4)	(2,3,3)	(2,3,4)	(3/4,2,3)	(2,3,3)	(2,2,3)	(2,2,3)	(1/1,2,3)
B	(2/7,1/2,1)	(1,1,1)	(1/3,5/8,2)	(1/2,3/4,2)	(2/5,3/4,2)	(5/9,1,2)	(1/2,5/7,2)	(1/3,4/7,1)	(5/9,1,2)	(1/2,4/5,2)	(1/2,3/4,2)	(2/5,3/5,1/1)
C	(3/8,5/9,1)	(6/7,2,3)	(1,1,1)	(2,2,3)	(6/7,2,3)	(8/9,2,2)	(3/5,1/1,2)	(3/8,2/3,2)	(5/8,1,2)	(1/2,4/5,2)	(4/9,3/4,2)	(3/7,2/3,2)
D	(1/3,1/2,4/5)	(7/9,2,3)	(1/3,1/2,4/5)	(1,1,1)	(1/2,3/4,2)	(3/8,4/7,2)	(1/2,4/5,2)	(3/8,1/2,6/7)	(1/3,1/2,4/5)	(1/2,5/8,1/1)	(1/2,5/8,1/1)	(1/2,1/2,3/4)
E	(1/4,1/3,5/9)	(3/4,2,3)	(1/2,3/4,2)	(4/5,2,2)	(1,1,1)	(5/9,3/5,2/3)	(3/5,1/1,2)	(5/8,6/7,2)	(3/4,1/1,2)	(5/9,3/5,2/3)	(1/3,1/2,6/7)	(2/7,2/5,3/4)
F	(1/3,4/9,2/3)	(5/9,1,2)	(5/7,6/7,2)	(1/1,2,3)	(2,2,2)	(1,1,1)	(2/3,1/1,2)	(5/9,3/4,2)	(1/1,2,2)	(3/4,1/1,2)	(1,1,1)	(3/5,4/5,2)
G	(1/4,2/5,3/4)	(4/5,2,3)	(3/4,2,2)	(3/4,2,3)	(3/4,2,2)	(4/7,2,2)	(1,1,1)	(1/3,3/5,2)	(3/5,1/1,2)	(1/2,6/7,2)	(1/2,5/8,1/1)	(3/8,5/9,1)
H	(3/8,2/3,2)	(1,2,3)	(3/4,2,3)	(2,3,3)	(4/5,2,2)	(8/9,2,2)	(1/1,2,3)	(1,1,1)	(5/8,1,2)	(5/8,3/4,1)	(1/3,1/2,6/7)	(1/3,1/2,2)
I	(1/3,4/9,2/3)	(5/9,1,2)	(5/8,1,2)	(2,2,3)	(1/1,2,2)	(3/5,4/5,2)	(3/4,2,2)	(5/8,1,2)	(1,1,1)	(1/2,3/4,2)	(1/2,3/5,1)	(1/2,2/3,2)
J	(1/3,1/2,1/1)	(3/4,2,2)	(2/3,2,2)	(2,2,3)	(2,2,2)	(1/1,2,2)	(2/3,2,3)	(1,2,2)	(4/5,2,3)	(1,1,1)	(3/5,4/5,2)	(2/3,1/1,2)
K	(1/2,5/8,1/1)	(8/9,2,2)	(5/7,2,3)	(2,2,3)	(2,2,3)	(1,1,1)	(2,2,3)	(2,2,3)	(1,2,3)	(3/4,2,2)	(1,1,1)	(5/8,1,2)
L	(4/9,2/3,2)	(2,2,3)	(5/6,2,3)	(2,2,3)	(2,3,4)	(1/1,2,2)	(1,2,3)	(1/1,2,4)	(3/4,2,3)	(2/3,2,2)	(5/8,1,2)	(1,1,1)

Firstly synthesis values should be calculated according to Chang (1996) Extended Analysis method by using Table 5.4 data. According to equations 3.25 to 3.29 synthesis values of criteria is calculated as follows:

S_1=(14.27, 23.31, 33.27) ⊗ (1/234.21,1/159.121,1/106.75)=(0.0609, 0.1465, 0.3117)

S_2= (5.8679,9.0601, 14.9847) ⊗ (1/234.21,1/159.121,1/106.75)=(0.0251,0.0569,0.1404)

S_3= (8.2546,12.4585,19.6903)⊗(1/234.21,1/159.121,1/106.75)=(0.0352,0.0783,0.1844)

S_4=(8.2546,12.4585,19.6903) ⊗ (1/234.21,1/159.121,1/106.75)=(0.0352,0.0783,0.1844)

S_5=(5.9191,8.2185,12.6730) ⊗ (1/234.21,1/159.121,1/106.75)=(0.0253,0.0516,0.1187)

S_6=(7.0146,9.6244,13.8121) ⊗ (1/234.21,1/159.121,1/106.75)=(0.0299,0.0605,0.1294)

S_7=(7.0889,10.7968,16.6883) ⊗ (1/234.21,1/159.121,1/106.75)=(0.0303,0.0679,0.1563)

S_8=(8.8242,13.8832,21.3068) ⊗ (1/234.21,1/159.121,1/106.75)=(0.0377,0.0872,0.1996)

S_9=(8.0974,11.4171,17.1690)⊗(1/234.21,1/159.121,1/106.75)=(0.0346,0.0718,0.1608)

S_{10}=(9.9784,13.9255,19.7479) ⊗ (1/234.21,1/159.121,1/106.75)=(0.0426, 0.0875, 0.1850)

S_{11}=(10.9111,16.3083,22.6826)⊗(1/234.21,1/159.121,1/106.75)=(0.0466,0.1025,0.2125)

S_{12}=(10.9797,17.7410,25.4606) ⊗ (1/234.21,1/159.121,1/106.75)=(0.0469,0.1115,0.2385)

With the aid of these values fuzzy numbers are compared by using the equations 3.30 and 3.31, and the following values are obtained:

$V(S_1 \geq S_2)=1$	V(S2 ≥ S1)= 0,4701	V(S3 ≥S1)= 0,6443	$V(S_4 \geq S_1)$= 0,3787	$V(S_5 \geq S_1)$= 0,4433
$V(S_1 \geq S_3)=1$	V(S2 ≥ S3)=0,8311	V(S3 ≥ S2)=1	$V(S_4 \geq S_2)$= 0,9465	$V(S_5 \geq S_2)=1$
$V(S_1 \geq S_4)=1$	V(S2 ≥ S4)=1	V(S3 ≥ S4)=1	$V(S_4 \geq S_3)$= 0,7580	$V(S_5 \geq S_3)$= 0,8409
$V(S_1 \geq S_5)=1$	V(S2 ≥ S5)=0.9688	V(S3 ≥ S5)=1	$V(S_4 \geq S_5)$= 0,9095	$V(S_5 \geq S_4)=1$
$V(S_1 \geq S_6)=1$	V(S2 ≥ S6)=0.8267	V(S3 ≥ S6)=1	$V(S_4 \geq S_6)$= 0,7487	$V(S_5 \geq S_6)$= 0,8365
$V(S_1 \geq S_7)=1$	V(S2 ≥ S7)=0.9098	V(S3 ≥ S7)=1	$V(S_4 \geq S_7)$= 0,8452	$V(S_5 \geq S_7)$= 0,9308
$V(S_1 \geq S_8)=1$	V(S2 ≥ S8)=0.7721	V(S3≥S8)=0,9425	$V(S_4 \geq S_8)$= 0,6948	$V(S_5 \geq S_8)$= 0,7741
$V(S_1 \geq S_9)=1$	V(S2 ≥ S9)=0.8771	V(S3 ≥ S9)=1	$V(S_4 \geq S_9)$= 0,8072	$V(S_5 \geq S_9)$= 0,8938
$V(S_1 \geq S_{10})=1$	V(S2 ≥ S10)=0.7617	V(S3≥S10)=0,9389	$V(S_4 \geq S_{10})$= 0,6797	$V(S_5 \geq S_{10})$= 0,7625
$V(S_1 \geq S_{11})=1$	V(S2 ≥ S11)=0.6730	V(S3≥S11)=0,8507	$V(S_4 \geq S_{11})$= 0,5865	$V(S_5 \geq S_{11})$= 0,6634
$V(S_1 \geq S_{12})=1$	V(S2 ≥ S12)=0.6314	V(S3≥S12)=0,8055	$V(S_4 \geq S_{12})$= 0,5455	$V(S_5 \geq S_{12})$= 0,6179

$V(S_6 \geq S_1)$= 0,5823	$V(S_7 \geq S_1)$= 0,5482	$V(S_8 \geq S_1)$=0.701	$V(S_9 \geq S_1)$=0.572	$V(S_{10} \geq S_1)$= 0,678
$V(S_6 \geq S_2)=1$	$V(S_7 \geq S_2)=1$	$V(S_8 \geq S_2)=1$	$V(S_9 \geq S_2)=1$	$V(S_{10} \geq S_2)=1$
$V(S_6 \geq S_3)=0.996$	$V(S_7 \geq S_3)=0.9206$	$V(S_8 \geq S_3)=1$	$V(S_9 \geq S_3)=0.95$	$V(S_{10} \geq S_3)=1$
$V(S_6 \geq S_4)=1$	$V(S_7 \geq S_4)=1$	$V(S_8 \geq S_4)=1$	$V(S_9 \geq S_4)=1$	$V(S_{10} \geq S_4)=1$

$V(S_6 \geq S_5)=1$	$V(S_7 \geq S_5)=1$	$V(S_8 \geq S_5)=1$	$V(S_9 \geq S_5)=1$	$V(S_{10} \geq S_5)=1$
$V(S_6 \geq S_7)=1$	$V(S_7 \geq S_6)=0.9207$	$V(S_8 \geq S_6)=1$	$V(S_9 \geq S_6)=0.952$	$V(S_{10} \geq S_6)=1$
$V(S_6 \geq S_8)=0.9265$	$V(S_7 \geq S_8)=0.8595$	$V(S_8 \geq S_7)=1$	$V(S_9 \geq S_7)=1$	$V(S_{10} \geq S_7)=1$
$V(S_6 \geq S_9)=1$	$V(S_7 \geq S_9)=0.969$	$V(S_8 \geq S_9)=1$	$V(S_9 \geq S_8)=0.88$	$V(S_{10} \geq S_8)=1$
$V(S_6 \geq S_{10})= 0.9216$	$V(S_7 \geq S_{10})=0.8526$	$V(S_8 \geq S_{10})=0.998$	$V(S_9 \geq S_{10})=0.882$	$V(S_{10} \geq S_9)=1$
$V(S_6 \geq S_{11})= 0.8168$	$V(S_7 \geq S_{11})=0.7601$	$V(S_8 \geq S_{11})=0.909$	$V(S_9 \geq S_{11})=0.788$	$V(S_{10} \geq S_{11})= 0,902$
$V(S_6 \geq S_{12})=0.7652$	$V(S_7 \geq S_{12})=0.7149$	$V(S_8 \geq S_{12})=0.863$	$V(S_9 \geq S_{12})=0.741$	$V(S_{10} \geq S_{12})= 0,852$

$V(S_{11} \geq S_1)=0.775$	$V(S_{12} \geq S_1)=0.835$
$V(S_{11} \geq S_2)=1$	$V(S_{12} \geq S_2)=1$
$V(S_{11} \geq S_3)=1$	$V(S_{12} \geq S_3)=1$
$V(S_{11} \geq S_4)=1$	$V(S_{12} \geq S_4)=1$
$V(S_{11} \geq S_5)=1$	$V(S_{12} \geq S_5)=1$
$V(S_{11} \geq S_6)=1$	$V(S_{12} \geq S_6)=1$
$V(S_{11} \geq S_7)=1$	$V(S_{12} \geq S_7)=1$
$V(S_{11} \geq S_8)=1$	$V(S_{12} \geq S_8)=1$
$V(S_{11} \geq S_9)=1$	$V(S_{12} \geq S_9)=1$
$V(S_{11} \geq S_{10})=1$	$V(S_{12} \geq S_{10})= 1$
$V(S_{11} \geq S_{12})=0.948$	$V(S_{12} \geq S_{11})= 1$

With the help of these vector values using equation (3.32) the criteria priority values calculated as follows:

$d'(C_1)=\min(1,1,1,1,1,1,1,1,1,1,1)=1$

$d'(C_2)=\min(0.470,0.831,1,0.969,0,827,0.910,0.772, 0.877,0.762,0.673,0.631)= 0.4701$

$d'(C_3)=\min(0.644,1,1,1,1,1,0.943,1,0.939,0.851,0.806)= 0,644$

$d'(C_4)=\min(0.379,0.947,0.758,0.909,0.749,0.845,0.695,0.807,0.680,0.587,0.546)= 0.379$

$d'(C_5)=\min(0.443,1,0.841,1,0.836,0.931,0.774,0.894,0.762,0.663,0.618)= 0,443$

$d'(C_6)=\min(0.582,1,0.996,1,1,1,0.926,1,0.922,0.817,0.765)= 0.582$

$d'(C_7)=\min(0.548,1,0.921,1,1,0.921,0.859,0.969,0.853,0.760,0.715)= 0.548$

$d'(C_8)=\min(0.701,1,1,1,1,1,1,1,0.998,0.909,0.862)=0.701$

$d'(C_9)=\min(0.572,1,0.950,1,1,0.952,1,0.888,0.882,0.788,0.741)=0.572$

$d'(C_{10})=\min(0.678,1,1,1,1,1,1,1,1,0.902,0.852)=0.678$

$d'(C_{11})=\min(0.775,1,1,1,1,1,1,1,1,1,0.948)=0.775$

$d'(C_{12})=\min(0.835, 1,1,1,1,1,1,1,1,1,1)=0.835$

The following vector is obtained as a result of the calculation of the priority vector:

$W'=(1, 0.470,0.644,0.379,0.443,0.582,0.548,0.701,0.572,0.678,0.775,0.835)$

After the normalization, the priorities of criteria as;

W= (0.131, 0.062, 0.084, 0.050, 0.058, 0.076, 0.072, 0.092, 0.075, 0.089, 0.102, 0.110).

According to this values campus location and accessibility are the most important criterion for campus planning. This criterion is followed by, settlements of social, cultural common education place, flexibility, student potential, financial situation ,campus traffic usage, campus strategic growth plan, relationship with city and industry, cultural structure of city, education system and campus population, respectively. Table 5.5 summarized the criteria's weights.

Table 5. 5Weights of Criteria

Criteria No	Main Criteria	Weights
A	Campus location	0,131
B	Cultural structure of city	0,062
C	Financial situation of university	0,084
D	Campus population	0,050
E	Education system	0,058
F	Campus traffic usage	0,076
G	Relationship with city and industry	0,072
H	Flexibility of campus	0,092
I	Campus strategic growth plans	0,075
J	Student potential who use social, cultural, common education place	0,089
K	Settlement of social, cultural, common education place	0,102
L	Accessibility	0,110

After determining the criteria weights, decision-makers evaluations of each criterion under alternative six university campuses are discussed. Table 5.6 shows the combination of five experts 'pair-wise comparison results for Financial situation of university which is the third criterion. This is shown as an example the other criteria results can be found in Appendix B.

Table 5. 6: Combination of five experts 'pair-wise comparison results for Financial situation sub criteria

	C1	C2	C3	C4
C1	(1,1,1)	(3/4,5/6,1)	(2,2,3)	(2/3,7/8,2)
C2	(1,2,2)	(1,1,1)	(2,3,4)	(4/9,5/6,2)
C3	(1/3,1/2,2/3)	(1/3,2/5,2/3)	(1,1,1)	(3/8,1/2,5/7)
C4	(7/8,2,2)	(2/3,2,3)	(2,2,3)	(1,1,1)

The synthetic values are:

S_{C1} (3.862, 4.683, 5.894) ⊗ (1/23.59, 1/17.933, 1/ 13.71) = (0.164, 0.261, 0.429)

S_{C2} (3.88, 5.48, 7.08) ⊗ (1/23.59, 1/17.933, 1/ 13.71) = (0.165,0.306,0.517)

S_{C3} (2.036, 2.413, 3.109) ⊗ (1/23.59, 1/17.93, 1/ 13.71) = (0.0863,0.1346,0.2268)

S_{C4} (3.927, 5.348, 7.51) ⊗ (1/23.59, 1/17.93, 1/ 13.71) = (0.1664,0.2982,0.5478)

$V(S_1 \geq S_2)$=0.855   V(S2 ≥ S1)= 1   V(S3 ≥S1)= 0.333 $V(S_4 \geq S_1)$= 1

$V(S_1 \geq S_3)$=1   V(S2 ≥ S3)=1   V(S3 ≥ S2)=0.266 $V(S_4 \geq S_2)$= 0,98

$V(S_1 \geq S_4)$=0.876   V(S2 ≥ S4)=1   V(S3 ≥ S4)=0.269 $V(S_4 \geq S_3)$= 1

With the help of these vector values using equation (3.32) the criteria priority values calculated as follows:

d'(C_1)=min(0.85,1,0.87)=0.855

d'(C_2)=min(1,1,1)= 1

d'(C_3)=min(0.333,0266,0.269)= 0.2665

d'(C_4)=min(1,0.98,1)= 0.98

The following vector is obtained as a result of the calculation of the priority vector:

W'= (0.855, 1, 0.2665, 0.98)

After the normalization, the priorities of financial situation' sub-criteria as; W= (0.2757, 0.3224, 0.0859, 0.1019). According to this vector phasing of buildings is the most important criteria for financial situation. This criterion is followed area of the site, quality standards investment ex. sq mt/student and infrastructure investment, respectively as shown in Table 5.7 as below.

Table 5. 7: The weights of infrastructure investment criteria

Criteria No	Main Criteria	Weights
C1	Area of the site	0.2757
C2	Infrastructure investment	0.3224
C3	Phasing of buildings	0.0859
C4	Quality standards investment ex.sq mt/student	0.1019

From the comparison results the most effecting criteria is found campus location of university. The availability of places for building is key factor for planning .It is expected that campus layout has a great importance on habitable campus. Suitability of site topography for construction (W_{A2}=0.5348) allows for development of campus. Additionally, habitable campus depends on the location of campus which is in the city, out of the city, near the lake, or near the mountain. These are indispensable conditions for livable campus.

Accessibility is found the second important criteria (W_L=0.11) in our comparison results. The realization of campus functions requires reasonable, economical and effective optimization distribution of material flow, such as people flow and vehicle flow; and nonmaterial flow, such as information flow. To decrease the movements of pedestrians in the campus, planners should be careful while planning.

On the other hand, the least important criteria with the weight of 0.05 is population of campus. According to experts' opinion campus population is important factor in the campus livability but in the planning phase relation with neighbor units, student demands of campus or student population are less important than other criteria. The comparison of alternatives according to the area of the site which is financial situation sub-criteria is shown in Table 5.8.

Table 5. 8: Comparison of universities according to area of the site

area of the site(C1)	Gazi	Metu	Hacettepe	Ankara	Bilkent	Başkent
Gazi	(1,1,1)	(1/3,1/2,2)	(1/2,5/7,2)	(1/1,2,3)	(4/7,5/7,1/1)	(5/6,1,2)
Metu	(5/6,2,4)	(1,1,1)	(5/7,2,2)	(2,3,5)	(2/3,2,3)	(2,2,3)
Hacettepe	(2/3,2,3)	(1/2,4/5,2)	(1,1,1)	(2,2,3)	(2/7,1/2,2)	(3/5,1,2)
Ankara	(1/2,5/7,2)	(1/4,1/3,2/3)	(1/2,4/7,4/5)	(1,1,1)	(1/4,1/3,2/3)	(1/2,1/1,2)
Bilkent	(2,2,2)	(1/2,1/1,2)	(5/7,2,4)	(2,3,5)	(1,1,1)	(1/1,2,3)
Başkent	(5/6,1,2)	(2/5,4/7,1/1)	(3/5,1,2)	(2/3,2,3)	(1/2,5/7,2)	(1,1,1)

Table 5. 9: Synthesis values, Weights of Alternative

	Gazi	METU	Hacettepe	Ankara	Bilkent	Başkent	Min.	W
Gazi		0,6286	0,6906	1	0,6520	0,9914	0,6286	0,1421
Metu	1		1	1	1	1	1,0000	0,2261
Hacettepe	1	0,7470		1	0,7709	1	0,7470	0,1689
Ankara	0,8007	0,4340	0,6895		0,4550	0,7940	0,4340	0,0981
Bilkent	1	0,9768	1	1		1	0,9768	0,2209
Başkent	1	0,6362	0,8973	1	0,6597		0,6362	0,1438
							4,4225	

After the normalization, the priorities of financial situation' sub-criteria as; W= (0.1421, 0.2261, 0.1689, 0.0981, 0.2209, 0.1438) (Table 4.9). According to area of site METU is the most appropriate alternative which has 22.09% weight. Bilkent is the second important one with. This alternative is followed by, Hacettepe, Başkent, Gazi and Ankara respectively. For the other sub-criteria the same evaluation are made and by comparing sub-criteria of financial situation with alternative we get total weight vectors.

According to financial situation' total weight vectors for alternative campuses are shown in Table 5.10 the most important university regarding the financial situation is found METU with weight 26% which is followed by Bilkent with 24%. Gazi has the lowest weight with 7%.

Table 5. 10: Total weight vectors according to financial situation criteria

Weight vector of Sub-criteria	0.2757	0.3224	0.0859	0.3160	
Alternatives	Area of the site (c1)	Infrastructure investment (c2)	Phasing of buildings(c3)	Quality standards investment ex. sq mt/student (c4)	Total weight vector
GAZİ	0,1421	0,0595	0,0947	0,0207	0,07
METU	0,2261	0,2628	0,2414	0,2976	0,26
HACETTEPE	0,1689	0,2180	0,1866	0,1874	0,19
ANKARA	0,0981	0,0482	0,1418	0,1228	0,09
BİLKENT	0,2209	0,2452	0,1633	0,2575	0,24
BAŞKENT	0,1438	0,1663	0,1722	0,1141	0,14

Table 5. 11: The weight vector of main criteria

THE WEIGHT VECTOR OF MAIN CRITERIA

THE WEIGHT VECTOR OF MAIN CRITARIA	0,13	0,06	0,08	0,05	0,06	0,08	0,07	0,09	0,08	0,09	0,10	0,11	
ALTERNATIVES	CAMPUS LOCATION	CULTURAL STRUCTURE OF CITY	FINANCIAL SITUATION OF UNIVERSITY	CAMPUS POPULATION	EDUCATION SYST.	CAMPUS TRAFFIC USAGE	RELATIONSHIP WITH CITY AND INDUSTRY	FLEXIBILITY OF CAMPUS	CAMPUS STRATEGIC GROWTH PLANS	STUDENT POTENTIAL WHO USE SOCIAL,CULTURAL, COMMON EDUCATION PLACE	SETTLEMENT OF SOCIAL,CULTURAL ,COMMON EDUCATION PLACE	ACCESSIBILITY	TOTAL WEIGHT VECTOR
GAZİ	0,12	0,10	0,07	0,09	0,19	0,09	0,16	0,08	0,04	0,13	0,07	0,16	0,11
METU	0,22	0,07	0,26	0,21	0,19	0,22	0,12	0,28	0,04	0,29	0,21	0,26	0,21
HACETTEPE	0,24	0,05	0,19	0,15	0,17	0,18	0,09	0,22	0,01	0,23	0,29	0,21	0,18
ANKARA	0,07	0,05	0,09	0,11	0,12	0,17	0,07	0,05	0,00	0,21	0,07	0,10	0,09
BİLKENT	0,21	0,15	0,24	0,26	0,18	0,19	0,03	0,12	0,51	0,10	0,21	0,18	0,20
BAŞKENT	0,14	0,12	0,14	0,18	0,14	0,15	0,00	0,26	0,40	0,04	0,15	0,10	0,15

Our analyses show that (Table 5.11, Figure 5.1) the most appropriate university campus is METU with the weight of 0.23, because the METU campus has been established with a planned project. Its convenience of ideal campus planning criteria is the important factor of this result. In generally, nearly almost all criteria METU campus has the highest value or the second highest value by the experts according to other alternative campuses except "campus strategic growth plans" criteria. This means that, METU campus has nearly ideal campus location. Its relation with city and industry is better than other alternative university campuses. It has more flexible campus than others. Its social, cultural and common education places are more suitable to student than other campuses. On the other hand, its strategic growing situation is worse according to others because, it is well-established campus (For example, Başkent university is still a growing university and its campus strategic growth weights are bigger than METU).

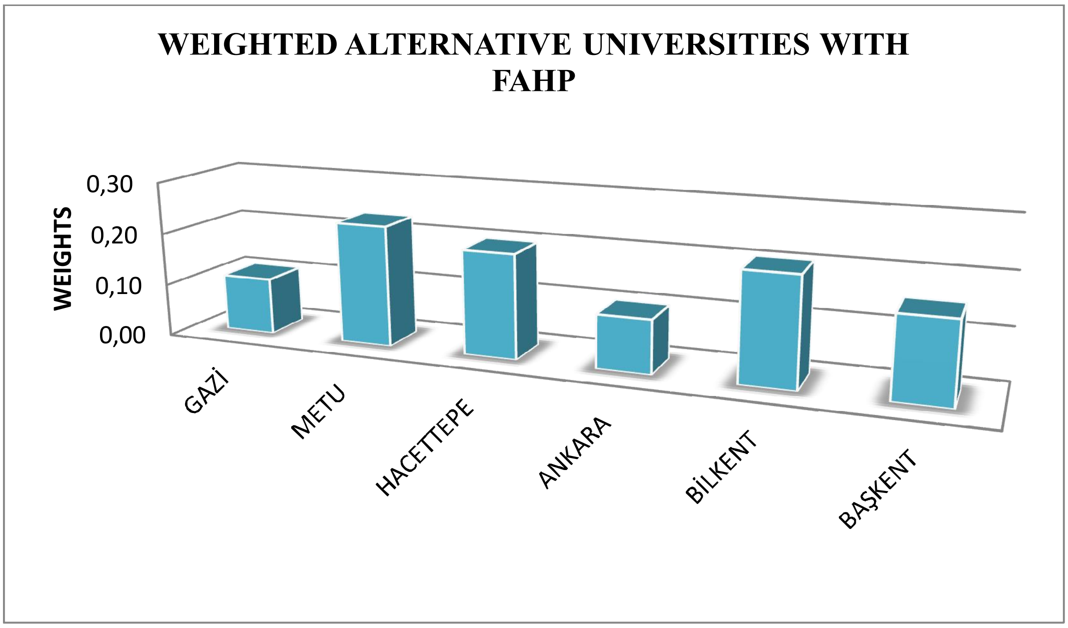

Figure 5. 1: Weighted alternative universities

According to the results the most appropriate university to ideal campus is found to be METU with the weight of 0.23 and the second one is Bilkent University (0.21). On the other hand, Ankara University and Gazi University have the minimum weights among the alternatives with the weights of 0.11 and 0.10, respectively.

METU founded in 1956, is one of the best universities in Turkey which has a history of 57 year. The most important feature of this university is great number of project including the campus planning obtained by architectural competitions. This explains why it took the highest weight from the experts. Bilkent University is the first private university established in Turkey its building has architectural language as METU.

If we interpret results in terms of the main criteria, sub-criteria and alternatives, the following conclusions can be drawn.

The campus location criterion (0.131) is the most important main criterion. The main reason of this is its sub criterion named as “sea, forest, mountain, lake and inside the city”. When the priorities of the alternatives on the basis of this criterion are considered, the alternative with the highest weight is METU by 29.9 %, which is followed by Bilkent University by 29.0 % and Hacettepe University by 27 %. In terms of this criterion, Gazi University and Ankara University couldn’t get any points from the experts and their weight has been defined as 0 %. The reason why the weights of METU, Bilkent and Hacettepe are high can be explained by the fact that these are the university towns founded outside the city. Moreover, these university towns self-sufficiently meet their needs such as sheltering, entertainment, shopping, sport, health and recreation. On the contrary, Gazi University and Ankara University need to use the facilities of the city, since they are located in the city center and consequently have limited possibilities of building their own structures. Among the compared universities, Gazi University was not located in a mountainous region, which makes this university closer to the ideal campus with respect to the sub criterion corresponding to appropriateness of the regional topography for the construction. However, as the terrain of Başkent, Bilkent and METU are mountainous and rough; their weights are close to each other and lower than Gazi University.

The “Campus Population” (0.05) is the criterion with the lowest weight when analyzed on the basis of the main criterion. The experts have regarded this criterion as not very important in terms of campus planning. However, when considered in terms of the long-term planning of the campus, the increase in the number of the students will increase the needs such as class, laboratory and a capacity problem. Thus, in the view of industrial engineering, the capacity constraint should be evaluated in the phase of long-term planning. In contrast to expert's opinions', we think that the weight of the campus population criterion should be higher.

One of the main criteria of campus planning is "Education System" (0.058) criterion which has the second lowest weight. This result came from its sub-criterion named as common lectures (1.00). One of the sub-criteria of "Education System" is night education (0.0) which is appeared unimportant in university campus planning, according to the experts. We think that the weight of the night education sub-criterion is not as insignificant as to be zero. Although there may not be a capacity problem due to the utilization of the academic places such as class and laboratory in the evening, a lack of capacity may emerge in terms of the capacity of residential places such as dormitories.

Making various activities in the same building reduces pedestrian traffic (0.5901). This is the most important sub-criterion of "Campus Traffic Usage" main criterion (0.076) by its weight. And the second most important sub-criterion is the ring system which reduces the rate of using car (0.4099). The weight of the universities relying on rapid transit system was found (0.0). The reason why this criterion has no weight is that the experts have thought there is no university meeting this criterion.

Although it is believed that "Relationship with City and Industry" (0.072) criterion an important factor in campus planning, experts gave one of the low weights to this criterion. The weights of the sub-criterion, University may serve industry with academic staff, lab., scientific researchers (0.3525) has the highest weight among all sub criteria of "Relationship with City and Industry". Practical training of students (0.3387) follows this sub-criterion. In the planning of the university campus, techno parks, small workshops and laboratories should be provided within the scope of the university, for the practical training of the students. It is thought that this sub-criterion should have a higher weight or at least same weight with other sub-criteria. When the alternatives are considered in terms of practical training of the student's relationship with the industry sub-criterion, Gazi University and METU are the best two universities. However, METU has the highest weight with respect to socialization centers requirement. Unfortunately, Başkent University couldn't get any weight in this criterion.

"Settlement of Social, Cultural, Common Education Place" is a very important main criterion by its weight of (0.102). In this main criterion, academic zone (0.4065) and residential zone (0.2674) are the most important sub-criteria. Administration and recreational zone follow these criteria by (0.2127 and 0.1135), respectively. METU, Hacettepe University and Bilkent University are the universities with the highest weights.

"Accessibility" is one of the main criteria with the highest weight by 10.11 %. One of the two sub-criteria of "Accessibility" is Max. 10 minutes walking distance between two academic buildings or interdisciplinary programs <900 meter (0.8299) has the highest importance because the ideal university campus should be a pedestrian campus. This means that relative faculties should be placed in less than every 900 meters distance. On the basis of this criterion, while METU has the highest weight, Gazi University has the lowest weight. The average walking time of the university students who walked without a pause or a break is calculated as 5,2 minutes. This period corresponds to 450 meters distance in horizontal direction for students between the ages of 17-25. This means that in less than every 450 meters distance a minor center, which may consider either a socialization area, a square, should be repeated on a pedestrian route that connects the campus facilities to each other. 5 Minutes Period for a Pedestrian Walking without Pause=450 Meters which is the second sub-criterion of "Accessibility" has 0.1701 weight. According to this sub-criterion again METU and Hacettepe University have the highest weight on the other hand Başkent University has the lowest weight (0.0963).

"Flexibility of Campus" is another important main criterion by (0.092). For new personnel arranging room has the highest importance (0.4953) followed by Joker undifferentiated spaces for sudden expansions (0.4082). While with respect to the first sub-criterion, the best university is METU, the worst is Bilkent University. In the second sub-criterion, while Gazi University and Ankara University have the lowest weight according to the experts, the other 4 universities share the points. The third sub-criterion of “Flexibility of Campus”, which is Flexibility for Changing Number of Students, has 0.0965 weights. When comparing this sub-criterion with other sub-criteria the weight of this criterion is less than others. According to this criterion Bilkent University and Başkent University have the highest and nearly same weights 0.2182, 0.2154, respectively.

While “Campus Growth Models” has (0.075) points, the growth was thought to be not very different in terms of planning by years. However, in our opinion, there will be growth and development in the campus within years and this will increase not only in the first years but in the years ahead. More weights could have been given to the last criterion.

According to “Student Potential that Use Social, Cultural, Common Education Place” (0.089) criterion; the most important factor in the campus is the Students that use the library as the group sub-criterion that has the highest value by (0.5293). The following one is paying attention to campus planning in place arrangement for the students attending certificate courses, by (0.3865) and the lowest rate belongs to recreational and society facilities (0.0841).

The weights of the first 4 sub-criteria of “Cultural Structure of City” criteria (0.062) are close to each other. These sub criteria are local settlement pattern (0.2160), life standard of region (0.2864), architectural notions (0.2315), and nature of site (0.2574). However; human typology sub-criterion is found to be insignificant (0.08). The main reason of this situation is that all these sub-criteria have a connection with each other. Consequently, among the alternatives, METU found to be superior for most of these sub-criteria. Among these sub-criteria, the highest weight is attained by architectural notions (0.3427) for METU. This can be attributed to being the first Campus University of Turkey together with its buildings being constructed by selected architectural project.

“Financial Situation” which is said to be one of the main criteria of university is found to be (0.084); Infrastructure Investment which is a sub-criterion of this criterion has been regarded as the most important element by (0.3224). Considering this sub-criterion, METU, Hacettepe University, Bilkent University and Başkent University are found to be the universities which have the most investment amount (see appendix B). For the same sub-criterion, Gazi University and Ankara University have the lowest weight by (0.0595 and 0.1663), respectively. According to the results, quality standards investment is found to be the second most important sub-criterion by 0.3160 weigh. According to the experts’s opinion, METU and Bilkent University have the most investment amount in quality standards and Gazi University, Ankara University and Başkent University are given low weight to this sub-criterion. According to the results, it is interesting to observe that “Financial Situation” main criterion has been given less weight than expected. Logically, the more money invested the best campus constructed. In this respect, the “Financial Situation” main criterion should at least follow the campus location criterion in the ranking.

CHAPTER 6

CONCLUSIONS

University campuses are dynamic and complex places. Planning such places should not be limited on the field of architecture and city planning because this issue requires interdisciplinary work of industrial engineers, designers, planners, architects, managers, students, teacher, infrastructure construction department etc. In Turkey, numbers of state and private nonprofit universities are increasing rapidly and large investments are being made in higher education. This increases the importance of planning a modern, available, accessible, campus. In this study, the importance of campus planning criteria is to be investigated through questionnaires to scholars who are known to be experts on urban planning. Six university campus planning are evaluated by using fuzzy AHP method. Expert opinions and related literature are considered while determining the criteria and sub-criteria of campus planning. After determining criteria of university campus planning, the alternative university campuses are chosen. These universities are founded before 1994 and located in Ankara, Turkey. The main reasons of choosing these universities are; firstly, it is important to select well-established university because in new campuses the considered criteria are believed to be not enough for our evaluation. Secondly, our experts are living in Ankara and have sufficient information about these campuses. While there are various methods related fuzzy AHP to analyze criteria, Chang's Extent analysis method is used in this study. The calculation of this method is easier than others. The consistency of fuzzy AHP matrices is checked by using Saaty's method but some of the ratios are not satisfied the maximum 0.10 consistency ratio. In order to satisfy this ratio, Zeshui's approach is used to improve inconsistent matrices. Afterwards, synthesis values and weights of criteria and sub-criteria are calculated.

The most important criterion is found "Campus Location" among the 12 main criteria. While making master plan of university campus, decision makers should be careful for choosing the campus area which should have suitable site topography for construction. In addition, the suitability of the climate (temperature, wind, humidity, rains, solar etc.), natural limits of region, and development capacity of the region should also be checked. Moreover, the land status of property, reconstruction status of area, legal status should be taken into considerations. Minimization of costs can be achieved with the right choice of a campus location. Besides, demolition of the existing buildings on the land, the protection of existing historic buildings, correction of rugged terrain, preparation of infrastructure should also be taken into account. By establishing the campus in the city, university will be benefited from possibilities (the city's infrastructure, housing, dining, shopping) of the city. The decision to build campus outside the city can result disjointed and isolated university from public. However, there are also positive aspects of universities founded outside of the city. The advantages of building a university campus outside the city can be counted as the possibility of development and growth of university, the ease of interdepartmental communication and accessibility in the campus. It is important to consider the accessibility criterion while planning campus. In the campus, transportation system has main two categories which are vehicle and pedestrian circulation. Since pedestrians are the main dominant elements that characterize the campus life, campus space organization should be made according to the pedestrians' ideal accessibility measures. Planners should left the pedestrian circulation as free as possible, teaching and research areas should be away from the noise of the vehicle. Beside, a student should be possible to reach on foot between two opposing units in 10-15 minute period on campus. At this time, the distance ranges between approximately 800-1000 m. that gives a rough idea about what should be the dimensions of the academic area. This measure affects the density of settlement of the units that compose the academic area. In order to decrease wasting time and increase efficiency of utilization of areas, academic units should be placed close to each other and also close to common areas like library, refectory and auditorium etc. In addition, it should be taken into consideration that health and social services and sports activities should be placed in close proximity to areas where there is dormitory and state lodgings. Due to its high cost of the building departments at the same time constructions should be made gradually in the campus. But this planning should not prevent the micro and macro growth of the campus. Because of the university is lively building, new units are being built constantly. Contemporary campus should be constructed a flexible manner to meet the growth needs. Moreover, it is important to take into consideration of student potential that use social, cultural, common education place to make modern campus. Campus financial situation is one of the important factors of planning a university campus which should be taken into account to construct of high quality, modern, robust infrastructure campus. Additionally, research and developments activities are the indispensible factor of competing with global world universities and industries should join their forces to look at the future with confidence. They should be liaising for meeting needs of each other. While, campus population and education system are not important factors of planning according to experts results, their importance are undeniable. The reason of this is the increase of university student population which will cause the new spaces for education. For this reason, planners should be considered this increment while planning.

Six university campus planning are evaluated by using fuzzy AHP method within the content of this thesis. As it is known, the fuzzy AHP is a synthetic extension of the traditional AHP method. The fuzzy AHP method is an advanced analytical method derived from the classical AHP in order to deal fuzzy nature of decision problems. There are many studies in the literature that uses fuzzy AHP methods for different multi criteria decision making problems. Although there are some studies on comparing university campuses, there is still a lack of research regarding to this topic. To fill this gap we evaluated the university campuses by using fuzzy AHP method. Our main focus is the university campus planning problem instead of method development. To our knowledge, there is not any study using fuzzy AHP method to deal with university campus planning problem. Consequently, the main contribution of this study is handling university campus planning problem. In order to focus on the problem, the simplest form of fuzzy method was employed. For the future studies, fuzzy AHP method can be improved.

Decision makers have difficulty and lost a lot of their time while planning university campus. In this study the importance of each campus planning criteria is determined to help decision maker while planning university campus. Facilities planning can be counted as the main subject of industrial engineers. In order to overcome difficulties and reach the targets efficiently and economically it is essential to optimize all physical, electronic and information flow with the carefully planned construction project. Hence implementation of advanced techniques of industrial engineering makes the planning of university campus people oriented. It is essential to merge facility planning techniques to campus planning. Accurate planning of universities is very important for long-term evolvement of campus. People's opinion should be taken while planning and the expert's experience should be integrated with the user's request. For instance, a new consciousness should emerge today, based on the campuses without barriers. In order to construct livable campus for each student, students with physical disabilities should be involved in planning a university campus project. Extensive analysis should be performed on this subject by considering user's opinions in the future.

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APPENDIX A: A SAMPLE EXPERT QUESTIONNAIRE FOR CAMPUS PLANNING

APPENDIX A.1 A Sample Expert Questionnaire of Comparison Matrix of Campus Decision Criteria

	CAMPUS DESICION CRITERIA MATRICE-									
CRITERIA	Strongly important	Moderately important	Weakly important	Equally important	Just equal	Equally important	Weakly important	Moderately important	Strongly important	CRITERIA
CAMPUS LOCATION				X						CULTURAL STRUCTURE OF CITY
CAMPUS LOCATION				X						FINANCIAL SITUATION OF UNI.
CAMPUS LOCATION				X						CAMPUS POPULATION
CAMPUS LOCATION			x							EDUCATION SYST.(COMMON COURCES,LAB,1. 2. EDU.)
CAMPUS LOCATION			x							CAMPUS TRAFFIC USAGE
CAMPUS LOCATION			x							RELATIONSHIP WITH CITY AND INDUSTRY
CAMPUS LOCATION				X						FLEXIBILITY OF CAMPUS(IMMEDIATELY RESPONSE TO POTENTIAL GROWTHS)
CAMPUS LOCATION				X						CAMPUS STRATEGIC GROWTH PLANS
CAMPUS LOCATION				X						STDNT POT.WHO USE SOCIAL,CULT.,COMMON EDUCATION PLACE
CAMPUS LOCATION				X						SETTLEMENT OF SOCIAL,CULTURAL,COMMON EDUCATION PLACE
CAMPUS LOCATION				X						ACCESSIBILITY (LOCATION OF BUILDINGS TO EACH OTHER)
CULTURAL STRUCTURE OF CITY					X					FINANCIAL SITUATION OF UNI.
CULTURAL STRUCTURE OF CITY			X							CAMPUS POPULATION
CULTURAL STRUCTURE OF CITY				x						EDUCATION SYST.(COMMON COURCES,LAB,1. 2. EDU.)
CULTURAL STRUCTURE OF CITY			x							CAMPUS TRAFFIC USAGE
CULTURAL STRUCTURE OF CITY					X					RELATIONSHIP WITH CITY AND INDUSTRY

CULTURAL STRUCTURE OF CITY					x					FLEXIBILITY OF CAMPUS(IMMEDIATELY RESPONSE TO POTENTIAL GROWTHS)
CULTURAL STRUCTURE OF CITY				x						CAMPUS STRATEGIC GROWTH PLANS
CULTURAL STRUCTURE OF CITY			X							STDNT POT.WHO USE SOCIAL,CULT.,COMMON EDUCATION PLACE
CULTURAL STRUCTURE OF CITY			X							SETTLEMENT OF SOCIAL,CULTURAL,COMMON EDUCATION PLACE
CULTURAL STRUCTURE OF CITY			x							ACCESSIBILITY (LOCATION OF BUILDINGS TO EACH OTHER)
FINANCIAL SITUATION OF UNI.				x						CAMPUS POPULATION
FINANCIAL SITUATION OF UNI.				x						EDUCATION SYST.(COMMON COURCES,LAB,1. 2. EDU.)
FINANCIAL SITUATION OF UNI.				x						CAMPUS TRAFFIC USAGE
FINANCIAL SITUATION OF UNI.				x						RELATIONSHIP WITH CITY AND INDUSTRY
FINANCIAL SITUATION OF UNI.				x						FLEXIBILITY OF CAMPUS(IMMEDIATELY RESPONSE TO POTENTIAL GROWTHS)
FINANCIAL SITUATION OF UNI.				x						CAMPUS STRATEGIC GROWTH PLANS
FINANCIAL SITUATION OF UNI.			x							STDNT POT.WHO USE SOCIAL,CULT.,COMMON EDUCATION PLACE
FINANCIAL SITUATION OF UNI.			x							SETTLEMENT OF SOCIAL,CULTURAL,COMMON EDUCATION PLACE
FINANCIAL SITUATION OF UNI.			x							ACCESSIBILITY (LOCATION OF BUILDINGS TO EACH OTHER)
CAMPUS POPULATION						x				EDUCATION SYST.(COMMON COURCES,LAB,1. 2. EDU.)
CAMPUS POPULATION					x					CAMPUS TRAFFIC USAGE
CAMPUS POPULATION					x					RELATIONSHIP WITH CITY AND INDUSTRY
CAMPUS POPULATION						x				FLEXIBILITY OF CAMPUS(IMMEDIATELY RESPONSE TO POTENTIAL GROWTHS)
CAMPUS POPULATION							x			CAMPUS STRATEGIC GROWTH PLANS
CAMPUS POPULATION						x				STDNT POT.WHO USE SOCIAL,CULT.,COMMON EDUCATION PLACE
CAMPUS POPULATION					X					SETTLEMENT OF SOCIAL,CULTURAL,COMMON EDUCATION PLACE
CAMPUS POPULATION					X					ACCESSIBILITY (LOCATION OF BUILDINGS TO EACH OTHER)
EDUCATION SYST.(COMMON COURCES,LAB,1. 2. EDU.)					X					CAMPUS TRAFFIC USAGE

EDUCATION SYST.(COMMON COURCES,LAB,1. 2. EDU.)						x				RELATIONSHIP WITH CITY AND INDUSTRY
EDUCATION SYST.(COMMON COURCES,LAB,1. 2. EDU.)					X					FLEXIBILITY OF CAMPUS(IMMEDIATELY RESPONSE TO POTENTIAL GROWTHS)
EDUCATION SYST.(COMMON COURCES,LAB,1. 2. EDU.)					X					CAMPUS STRATEGIC GROWTH PLANS
EDUCATION SYST.(COMMON COURCES,LAB,1. 2. EDU.)					X					STDNT POT.WHO USE SOCIAL,CULT.,COMMON EDUCATION PLACE
EDUCATION SYST.(COMMON COURCES,LAB,1. 2. EDU.)				x						SETTLEMENT OF SOCIAL,CULTURAL,COMMON EDUCATION PLACE
EDUCATION SYST.(COMMON COURCES,LAB,1. 2. EDU.)					X					ACCESSIBILITY (LOCATION OF BUILDINGS TO EACH OTHER)
CAMPUS TRAFFIC USAGE						X				RELATIONSHIP WITH CITY AND INDUSTRY
CAMPUS TRAFFIC USAGE						X				FLEXIBILITY OF CAMPUS(IMMEDIATELY RESPONSE TO POTENTIAL GROWTHS)
CAMPUS TRAFFIC USAGE					x					CAMPUS STRATEGIC GROWTH PLANS
CAMPUS TRAFFIC USAGE					X					STDNT POT.WHO USE SOCIAL,CULT.,COMMON EDUCATION PLACE
CAMPUS TRAFFIC USAGE					x					SETTLEMENT OF SOCIAL,CULTURAL,COMMON EDUCATION PLACE
CAMPUS TRAFFIC USAGE				X						ACCESSIBILITY (LOCATION OF BUILDINGS TO EACH OTHER)
RELATIONSHIP WITH CITY AND INDUSTRY					x					FLEXIBILITY OF CAMPUS(IMMEDIATELY RESPONSE TO POTENTIAL GROWTHS)
RELATIONSHIP WITH CITY AND INDUSTRY					X					CAMPUS STRATEGIC GROWTH PLANS
RELATIONSHIP WITH CITY AND INDUSTRY				X						STDNT POT.WHO USE SOCIAL,CULT.,COMMON EDUCATION PLACE
RELATIONSHIP WITH CITY AND INDUSTRY				X						SETTLEMENT OF SOCIAL,CULTURAL,COMMON EDUCATION PLACE
RELATIONSHIP WITH CITY AND INDUSTRY				X						ACCESSIBILITY (LOCATION OF BUILDINGS TO EACH OTHER)
FLEXIBILITY OF CAMPUS(IMMEDIATELY RESPONSE TO POTENTIAL GROWTHS)						x				CAMPUS STRATEGIC GROWTH PLANS

FLEXIBILITY OF CAMPUS(IMMEDIATELY RESPONSE TO POTENTIAL GROWTHS)					x					STDNT POT.WHO USE SOCIAL,CULT.,COMMON EDUCATION PLACE
FLEXIBILITY OF CAMPUS(IMMEDIATELY RESPONSE TO POTENTIAL GROWTHS)				x						SETTLEMENT OF SOCIAL,CULTURAL,COMMON EDUCATION PLACE
FLEXIBILITY OF CAMPUS(IMMEDIATELY RESPONSE TO POTENTIAL GROWTHS)			x							ACCESSIBILITY (LOCATION OF BUILDINGS TO EACH OTHER)
CAMPUS STRATEGIC GROWTH PLANS				X						STDNT POT.WHO USE SOCIAL,CULT.,COMMON EDUCATION PLACE
CAMPUS STRATEGIC GROWTH PLANS		x								SETTLEMENT OF SOCIAL,CULTURAL,COMMON EDUCATION PLACE
CAMPUS STRATEGIC GROWTH PLANS			x							ACCESSIBILITY (LOCATION OF BUILDINGS TO EACH OTHER)
STUDENT POT.WHO USE SOCIAL,CULT.,COMMON EDUCATION PLACE			x							SETTLEMENT OF SOCIAL,CULTURAL,COMMON EDUCATION PLACE
STUDENT POT.WHO USE SOCIAL,CULT.,COMMON EDUCATION PLACE			x							ACCESSIBILITY (LOCATION OF BUILDINGS TO EACH OTHER)
SETTLEMENT OF SOCIAL,CULTURAL,COMMON EDUCATION PLACE				X						ACCESSIBILITY (LOCATION OF BUILDINGS TO EACH OTHER)

APPENDIX A.2 A Sample Expert Questionnaire of Comparison of Alternatives According to Sub Criteria

	CAMPUS LOCATION - SEA,FOREST,MOUNTAIN ,LAKE,INSIDE THE CITY,OUTSIDE THE CITY (A1)									
ALTER NATIVE	**Strongly impor tant**	**Moderately impor tant**	**Weakly impo rtant**	**Equally imp ortant**	**Just equal**	**Equally impo rtant**	**Weakly impor tant**	**Moderately impo rtant**	**Strongly impor tant**	**ALTERN ATIVE**
GAZİ					X					**METU**
GAZİ					X					**HACETTEPE**
GAZİ					X					**ANKARA**
GAZİ					X					**BİLKENT**
GAZİ				X						**BAŞKENT**
METU					X					**HACETTEPE**
METU					X					**ANKARA**
METU					X					**BİLKENT**
METU				X						**BAŞKENT**
HACETTEPE					X					**ANKARA**
HACETTEPE						X				**BİLKENT**
HACETTEPE				X						**BAŞKENT**
ANKARA					X					**BİLKENT**
ANKARA				X						**BAŞKENT**
BİLKENT				X						**BAŞKENT**

	CAMPUS LOCATION - SUITABILITY OF SITE TOPOGRAPHY FOR CONSTRUCTION (A2)									
ALTER NATIVE	**Strongly impo rtant**	**Moderately impo rtant**	**Weakly impor tant**	**Equally impo rtant**	**Just equal**	**Equally impo rtant**	**Weakly impo rtant**	**Moderately impo rtant**	**Strongly impor tant**	**ALTER NATIVE**
GAZİ					X					**METU**
GAZİ					X					**HACETTEPE**
GAZİ					X					**ANKARA**
GAZİ				X						**BİLKENT**
GAZİ				X						**BAŞKENT**
METU					X					**HACETTEPE**
METU				X						**ANKARA**
METU					X					**BİLKENT**
METU				X						**BAŞKENT**
HACETTEPE					X					**ANKARA**
HACETTEPE					X					**BİLKENT**
HACETTEPE				X						**BAŞKENT**
ANKARA					X					**BİLKENT**
ANKARA				X						**BAŞKENT**
BİLKENT				X						**BAŞKENT**

	CAMPUS LOCATION - SCALE OF CAMPUS (OUTDOOR/INDOOR SPACES) (A3)									
ALTER NATIVE	Strongly impo	Moderately impo rtant	Weakly imp ortant	Equally impor tant	Just equal	Equally impo rtant	Weakly impor tant	Moderately impo rtant	Strongly impor tant	ALTERN ATIVE
GAZİ					X					METU
GAZİ					X					HACETTEPE
GAZİ					X					ANKARA
GAZİ					X					BİLKENT
GAZİ				X						BAŞKENT
METU					X					HACETTEPE
METU					X					ANKARA
METU					X					BİLKENT
METU				X						BAŞKENT
HACETTEPE					X					ANKARA
HACETTEPE					X					BİLKENT
HACETTEPE					X					BAŞKENT
ANKARA					X					BİLKENT
ANKARA				X						BAŞKENT
BİLKENT				X						BAŞKENT

	CULTURAL STRUCTURE OF CITY - LOCAL SETTLEMENT PATTERN (B1)									
ALTER NATIVE	Strongly impo rtant	Moderately impor tant	Weakly impor tant	Equally impo rtant	Just equal	Equally impo rtant	Weakly impo rtant	Moderately impor tant	Strongly impo rtant	ALTERN ATIVE
GAZİ				x						METU
GAZİ		X								HACETTEPE
GAZİ				X						ANKARA
GAZİ			X							BİLKENT
GAZİ		X								BAŞKENT
METU				X						HACETTEPE
METU				X						ANKARA
METU				X						BİLKENT
METU			X							BAŞKENT
HACETTEPE					X					ANKARA
HACETTEPE					X					BİLKENT
HACETTEPE					X					BAŞKENT
ANKARA				x						BİLKENT
ANKARA			X							BAŞKENT
BİLKENT			X							BAŞKENT

	CULTURAL STRUCTURE OF CITY - LIFE STANDARTS OF THE REGION (B2)									
ALTER NATIVE	Strongly impo rtant	Moderately impor tant	Weakly impo rtant	Equally impo tant	Just equal	Equally impor tant	Weakly impor tant	Moderately impo rtant	Strongly impo tant	ALTER NATIVE
GAZİ								X		METU
GAZİ					X					HACETTEPE
GAZİ					X					ANKARA
GAZİ						X				BİLKENT
GAZİ					x					BAŞKENT
METU					X					HACETTEPE
METU				X						ANKARA
METU				X						BİLKENT
METU			X							BAŞKENT
HACETTEPE					X					ANKARA
HACETTEPE					X					BİLKENT
HACETTEPE				X						BAŞKENT
ANKARA					X					BİLKENT
ANKARA				X						BAŞKENT
BİLKENT				X						BAŞKENT

	CULTURAL STRUCTURE OF CITY - ARCHITECTURAL NOTIONS (B3)									
ALTERN ATIVE	Strongly imp ortant	Moderately impo rtant	Weakly impo rtant	Equally imp ortant	Just equal	Equally imp ortant	Weakly imp ortant	Moderately impor tant	Strongly imp ortant	ALTER NATIVE
GAZİ					X					METU
GAZİ				X						HACETTEPE
GAZİ					X					ANKARA
GAZİ					X					BİLKENT
GAZİ					X					BAŞKENT
METU				X						HACETTEPE
METU				X						ANKARA
METU				X						BİLKENT
METU				X						BAŞKENT
HACETTEPE					X					ANKARA
HACETTEPE					X					BİLKENT
HACETTEPE				X						BAŞKENT
ANKARA					X					BİLKENT
ANKARA				X						BAŞKENT
BİLKENT				X						BAŞKENT

	CULTURAL STRUCTURE OF CITY - NATURE OF THE SITE(B4)									
ALTERN ATIVE	Strongly impor tant	Moderately impo rtant	Weakly impor tant	Equally impo rtant	Just equal	Equally impor tant	Weakly important	Moderately impor tant	Strongly impo rtant	ALTERN ATIVE
GAZİ								X		METU
GAZİ						X				HACETTEPE
GAZİ						X				ANKARA
GAZİ					X					BİLKENT
GAZİ					X					BAŞKENT
METU						X				HACETTEPE
METU					X					ANKARA
METU					X					BİLKENT
METU				X						BAŞKENT
HACETTEPE				X						ANKARA
HACETTEPE				X						BİLKENT
HACETTEPE				X						BAŞKENT
ANKARA				X						BİLKENT
ANKARA				X						BAŞKENT
BİLKENT				X						BAŞKENT

	CULTURAL STRUCTURE OF CITY - TYPOLOGY (HUMAN TYPOLOGY) (B5)									
ALTER NATIVE	**Strongly impor tant**	**Moderately impor tant**	**Weakly impor tant**	**Equally impor tant**	**Just equal**	**Equally impo rtant**	**Weakly important**	**Moderately impo rtant**	**Strongly impo rtant**	**ALTER NATIVE**
GAZİ			X							**METU**
GAZİ			X							**HACETTEPE**
GAZİ			X							**ANKARA**
GAZİ			X							**BİLKENT**
GAZİ					X					**BAŞKENT**
METU					X					**HACETTEPE**
METU					X					**ANKARA**
METU					X					**BİLKENT**
METU					X					**BAŞKENT**
HACETTEPE					X					**ANKARA**
HACETTEPE					X					**BİLKENT**
HACETTEPE					X					**BAŞKENT**
ANKARA						X				**BİLKENT**
ANKARA						X				**BAŞKENT**
BİLKENT						X				**BAŞKENT**

	EDUCATION SYST.(COMMON COURCES,LAB,FIRST SECOND EDU.)- COMMON LECTURES COMMON BUILDINGS LAB.,AUDOTORIUM, ACADEMIC STAFF ROOMS (E1)									
ALTER NATIVE	**Strongly impo rtant**	**Moderately impo rtant**	**Weakly impor tant**	**Equally impo rtant**	**Just equal**	**Equally impo rtant**	**Weakly important**	**Moderately impor tant**	**Strongly impo rtant**	**ALTERN ATIVE**
GAZİ					X					**METU**
GAZİ					X					**HACETTEPE**
GAZİ					X					**ANKARA**
GAZİ							X			**BİLKENT**
GAZİ						X				**BAŞKENT**
METU					X					**HACETTEPE**
METU					X					**ANKARA**
METU						X				**BİLKENT**
METU						X				**BAŞKENT**
HACETTEPE					X					**ANKARA**
HACETTEPE						X				**BİLKENT**
HACETTEPE						X				**BAŞKENT**
ANKARA						X				**BİLKENT**
ANKARA						X				**BAŞKENT**
BİLKENT					X					**BAŞKENT**

	EDUCATION SYST.(COMMON COURCES,LAB,FIRST SECOND EDU.)- NIGHT EDUCATION (E2)									
ALTER NATIVE	Strongly impor tant	Moderately impor tant	Weakly impo rtant	Equally impo rtant	Just equal	Equally impo rtant	Weakly impor tant	Moderately imp ortant	Strongly impo rtant	ALTERN ATIVE
GAZİ			X							METU
GAZİ			X							HACETTEPE
GAZİ			X							ANKARA
GAZİ			X							BİLKENT
GAZİ			X							BAŞKENT
METU					x					HACETTEPE
METU					x					ANKARA
METU				x						BİLKENT
METU				X						BAŞKENT
HACETTEPE					x					ANKARA
HACETTEPE				x						BİLKENT
HACETTEPE			X							BAŞKENT
ANKARA				x						BİLKENT
ANKARA			X							BAŞKENT
BİLKENT				X						BAŞKENT

	FINANCIAL SITUATION OF UNIVERSITY- AREA OF THE SITE (C1)									
ALTER NATIVE	Strongly impor tant	Moderately impor tant	Weakly impor tant	Equally impo rtant	Just equal	Equally importa nt	Weakly impo tant	Moderately importa nt	Strongly impor tant	ALTER NATIVE
GAZİ							X			METU
GAZİ					X					HACETTEPE
GAZİ				X						ANKARA
GAZİ					x					BİLKENT
GAZİ					X					BAŞKENT
METU				x						HACETTEPE
METU				X						ANKARA
METU				X						BİLKENT
METU				x						BAŞKENT
HACETTEPE					X					ANKARA
HACETTEPE						X				BİLKENT
HACETTEPE					X					BAŞKENT
ANKARA						X				BİLKENT
ANKARA				X						BAŞKENT
BİLKENT				X						BAŞKENT

	FINANCIAL SITUATION OF UNIVERSITY- INFRASTRUCTURE INVESTMENT (C2)									
ALTER NATIVE	Strongly impor tant	Moderately import ant	Weakly import ant	Equally impo rtant	Just equal	Equally impo rtant	Weakly imp ortant	Moderately import ant	Strongly impor tant	ALTERN ATIVE
GAZİ							X			METU
GAZİ							X			HACETTEPE
GAZİ						X				ANKARA
GAZİ						X				BİLKENT
GAZİ						X				BAŞKENT
METU				X						HACETTEPE
METU			X							ANKARA
METU			X							BİLKENT
METU			X							BAŞKENT
HACETTEPE			X							ANKARA
HACETTEPE				X						BİLKENT
HACETTEPE			X							BAŞKENT
ANKARA										BİLKENT
ANKARA										BAŞKENT
BİLKENT										BAŞKENT

	FINANCIAL SITUATION OF UNIVERSITY- PHASING OF BUILDINGS (C3)									
ALTER NATIVE	Strongly impor tant	Moderately imp ortant	Weakly impor tant	Equally impo rtant	Just equal	Equally impor tant	Weakly impo rtant	Moderately impor tant	Strongly impo rtant	ALTERN ATIVE
GAZİ							X			METU
GAZİ							X			HACETTEPE
GAZİ						X				ANKARA
GAZİ						X				BİLKENT
GAZİ						X				BAŞKENT
METU				X						HACETTEPE
METU			X							ANKARA
METU			X							BİLKENT
METU			X							BAŞKENT
HACETTEPE			X							ANKARA
HACETTEPE				X						BİLKENT
HACETTEPE			X							BAŞKENT
ANKARA					X					BİLKENT
ANKARA					X					BAŞKENT
BİLKENT					X					BAŞKENT

	FINANCIAL SITUATION OF UNIVERSITY- QUALITY STANDARTS INVESTMENT EX.SQ MT/STUDENT (C4)									
ALTER NATIVE	Strongly impor tant	Moderately impor tant	Weakly import ant	Equally impor tant	Just equal	Equally impo rtant	Weakly impo rtant	Moderately import ant	Strongly impor tant	ALTERN ATIVE
GAZİ								X		METU
GAZİ							X			HACETTEPE
GAZİ					X					ANKARA
GAZİ					X					BİLKENT
GAZİ				X						BAŞKENT
METU				X						HACETTEPE
METU				X						ANKARA
METU				X						BİLKENT
METU			X							BAŞKENT
HACETTEPE					X					ANKARA
HACETTEPE					X					BİLKENT
HACETTEPE				X						BAŞKENT
ANKARA						X				BİLKENT
ANKARA				X						BAŞKENT
BİLKENT				X						BAŞKENT

	CAMPUS POPULATION- STUDENT POPULATION OF THE UNIVERSITY(D1)									
ALTER NATIVE	Strongly imp ortant	Moderately impor tant	Weakly impor tant	Equally impo rtant	Just equal	Equally impo rtant	Weakly impo rtant	Moderately impor tant	Strongly impo rtant	ALTER NATIVE
GAZİ				X						METU
GAZİ				X						HACETTEPE
GAZİ			X							ANKARA
GAZİ			X							BİLKENT
GAZİ				X						BAŞKENT
METU					X					HACETTEPE
METU					X					ANKARA
METU					X					BİLKENT
METU					X					BAŞKENT
HACETTEPE					X					ANKARA
HACETTEPE						X				BİLKENT
HACETTEPE						X				BAŞKENT
ANKARA						X				BİLKENT
ANKARA						X				BAŞKENT
BİLKENT						X				BAŞKENT

	CAMPUS POPULATION- STUDENT DEMANDS OF THE UNIVERSITY (D2)									
ALTER NATIVE	Strongly imp ortant	Moderately impo rtant	Weakly impor tant	Equally impo rtant	Just equal	Equally impo rtant	Weakly impor tant	Moderately impor tant	Strongly impor tant	ALTER NATIVE
GAZİ									X	METU
GAZİ							X			HACETTEPE
GAZİ							X			ANKARA
GAZİ							X			BİLKENT
GAZİ				X						BAŞKENT
METU				X						HACETTEPE
METU				X						ANKARA
METU	X									BİLKENT
METU	X									BAŞKENT
HACETTEPE					X					ANKARA
HACETTEPE				X						BİLKENT
HACETTEPE			X							BAŞKENT
ANKARA					X					BİLKENT
ANKARA			X							BAŞKENT
BİLKENT				X						BAŞKENT

	CAMPUS POPULATION- SOCIAL AND ECONOMIC RELATIONS BETWEEN NEIGHBOUR UNITS (D3)									
ALTER NATIVE	Strongly impo rtant	Moderately impo rtant	Weakly imp ortant	Equally impor tant	Just equal	Equally imp ortant	Weakly impo tant	Moderately impo rtant	Strongly impo rtant	ALTER NATIVE
GAZİ					X					METU
GAZİ					X					HACETTEPE
GAZİ					X					ANKARA
GAZİ							X			BİLKENT
GAZİ						X				BAŞKENT
METU					X					HACETTEPE
METU					X					ANKARA
METU						X				BİLKENT
METU						X				BAŞKENT
HACETTEPE					X					ANKARA
HACETTEPE						X				BİLKENT
HACETTEPE						X				BAŞKENT
ANKARA						X				BİLKENT
ANKARA					X					BAŞKENT
BİLKENT						X				BAŞKENT

	CAMPUS TRAFFIC USAGE- UNIVERSITIES RELYING ON RAPID TRANSIT SYSTEM (F1)									
ALTER NATIVE	Strongly impor tant	Moderately impo rtant	Weakly impor tant	Equally impo rtant	Just equal	Equally impo rtant	Weakly impor tant	Moderately impo rtant	Strongly impor tant	ALTER NATIVE
GAZİ			X							METU
GAZİ			X							HACETTEPE
GAZİ					X					ANKARA
GAZİ			X							BİLKENT
GAZİ			X							BAŞKENT
METU				X						HACETTEPE
METU						X				ANKARA
METU					X					BİLKENT
METU				X						BAŞKENT
HACETTEPE							X			ANKARA
HACETTEPE						X				BİLKENT
HACETTEPE				X						BAŞKENT
ANKARA					X					BİLKENT
ANKARA				X						BAŞKENT
BİLKENT				X						BAŞKENT

	CAMPUS TRAFFIC USAGE- RING SYSTEM WHICH REDUCE USING CAR (F2)									
ALTER NATIVE	Strongly impo rtant	Moderately impor tant	Weakly impo rtant	Equally impor tant	Just equal	Equally impo rtant	Weakly impo rtant	Moderately impor tant	Strongly impor tant	ALTER NATIVE
GAZİ							x			METU
GAZİ							x			HACETTEPE
GAZİ					x					ANKARA
GAZİ							x			BİLKENT
GAZİ							x			BAŞKENT
METU					x					HACETTEPE
METU				x						ANKARA
METU					x					BİLKENT
METU					x					BAŞKENT
HACETTEPE				x						ANKARA
HACETTEPE					x					BİLKENT
HACETTEPE					x					BAŞKENT
ANKARA							x			BİLKENT
ANKARA					x					BAŞKENT
BİLKENT			x							BAŞKENT

	CAMPUS TRAFFIC USAGE- MAKING VARIOUS ACTIVITIES ON THE SAME BUILDING WHICH REDUCE PEDESTRIAN TRAFFIC (F3)									
ALTERN ATIVE	Strongly impo rtant	Moderately impo rtant	Weakly impor tant	Equally impo rtant	Just equal	Equally impo tant	Weakly impor tant	Moderately impor tant	Strongly impo rtant	ALTERN ATIVE
GAZİ						X				METU
GAZİ					X					HACETTEPE
GAZİ					X					ANKARA
GAZİ				X						BİLKENT
GAZİ				X						BAŞKENT
METU				X						HACETTEPE
METU				X						ANKARA
METU				X						BİLKENT
METU				X						BAŞKENT
HACETTEPE						X				ANKARA
HACETTEPE					X					BİLKENT
HACETTEPE					X					BAŞKENT
ANKARA				X						BİLKENT
ANKARA				X						BAŞKENT
BİLKENT				X						BAŞKENT

	RELATIONSHIP WITH CITY AND INDUSTRY- RESIDENTIAL POTENTIAL G1									
ALTERN ATIVE	Strongly important	Moderately import ant	Weakly impo rtant	Equally impor tant	Just equal	Equally impor tant	Weakly impo rtant	Moderately impor ant	Strongly imp ortant	ALTERN ATIVE
GAZİ							x			METU
GAZİ							x			HACETTEPE
GAZİ					x					ANKARA
GAZİ							x			BİLKENT
GAZİ					x					BAŞKENT
METU					x					HACETTEPE
METU					x					ANKARA
METU					x					BİLKENT
METU			x							BAŞKENT
HACETTEPE					x					ANKARA
HACETTEPE					x					BİLKENT
HACETTEPE			x							BAŞKENT
ANKARA					x					BİLKENT
ANKARA			x							BAŞKENT
BİLKENT			x							BAŞKENT

	RELATIONSHIP WITH CITY AND INDUSTRY- SOCIALIZATION CENTERS REQUIREMENTS G2									
ALTERN ATIVE	**Strongly impo rtant**	**Moderately impor tant**	**Weakly impo rtant**	**Equally impo rtant**	**Just equal**	**Equally impo rtant**	**Weakly impo rtant**	**Moderately impo rtant**	**Strongly impo rtant**	**ALTERNA TIVE**
GAZİ			x							**METU**
GAZİ			x							**HACETTEPE**
GAZİ				x						**ANKARA**
GAZİ		X								**BİLKENT**
GAZİ				x						**BAŞKENT**
METU						X				**HACETTEPE**
METU					X					**ANKARA**
METU					X					**BİLKENT**
METU				X						**BAŞKENT**
HACETTEPE					X					**ANKARA**
HACETTEPE					X					**BİLKENT**
HACETTEPE				X						**BAŞKENT**
ANKARA					X					**BİLKENT**
ANKARA					X					**BAŞKENT**
BİLKENT				X						**BAŞKENT**

	RELATIONSHIP WITH CITY AND INDUSTRY- BRINGING THE NEW TECHNOLOGIY OF THE INDUSTRIAL FIRMS IN TO UNIVERSITY CAMPUS (G3)									
ALTER NATIVE	**Strongly impo rtant**	**Moderately impo rtant**	**Weakly import ant**	**Equally impo rtant**	**Just equal**	**Equally impo rtant**	**Weakly impo tant**	**Moderately impor tant**	**Strongly impor tant**	**ALTERN ATIVE**
GAZİ									X	**METU**
GAZİ								X		**HACETTEPE**
GAZİ						X				**ANKARA**
GAZİ							X			**BİLKENT**
GAZİ					X					**BAŞKENT**
METU			X							**HACETTEPE**
METU			X							**ANKARA**
METU			X							**BİLKENT**
METU		X								**BAŞKENT**
HACETTEPE					X					**ANKARA**
HACETTEPE					X					**BİLKENT**
HACETTEPE				X						**BAŞKENT**
ANKARA						X				**BİLKENT**
ANKARA				X						**BAŞKENT**
BİLKENT				X						**BAŞKENT**

	RELATIONSHIP WITH CITY AND INDUSTRY- PRACTICAL TRAINING STUDENTS RELATIONSHIP WITH INDUSTRY (G4)									
ALTERN ATIVE	**Strongly impor tant**	**Moderately impor tant**	**Weakly impor tant**	**Equally import ant**	**Just equal**	**Equally impor tant**	**Weakly impo rtant**	**Moderately impo rtant**	**Strongly important**	**ALTERN ATIVE**
GAZİ					X					**METU**
GAZİ				X						**HACETTEPE**
GAZİ				X						**ANKARA**
GAZİ				X						**BİLKENT**
GAZİ				X						**BAŞKENT**
METU				X						**HACETTEPE**
METU				X						**ANKARA**
METU				X						**BİLKENT**
METU				X						**BAŞKENT**
HACETTEPE					X					**ANKARA**
HACETTEPE				X						**BİLKENT**
HACETTEPE				X						**BAŞKENT**
ANKARA				X						**BİLKENT**
ANKARA				X						**BAŞKENT**
BİLKENT					X					**BAŞKENT**

	RELATIONSHIP WITH CITY AND INDUSTRY- UNIVERSITY MAY SERVE INDUSTRY WITH ACADEMIC STAFF ,LAB.,SCIENTIFIC RESEARCHERS (G5)									
ALTERNATIVE	**Strongly important**	**Moderately important**	**Weakly important**	**Equally important**	**Just equal**	**Equally important**	**Weakly important**	**Moderately important**	**Strongly important**	**ALTERNATIVE**
GAZİ					X					**METU**
GAZİ				X						**HACETTEPE**
GAZİ				X						**ANKARA**
GAZİ			x							**BİLKENT**
GAZİ			x							**BAŞKENT**
METU				X						**HACETTEPE**
METU				X						**ANKARA**
METU				X						**BİLKENT**
METU				X						**BAŞKENT**
HACETTEPE					X					**ANKARA**
HACETTEPE				X						**BİLKENT**
HACETTEPE				X						**BAŞKENT**
ANKARA				X						**BİLKENT**
ANKARA				X						**BAŞKENT**
BİLKENT					X					**BAŞKENT**

	FLEXIBILITY OF CAMPUS(IMMEDIATELY RESPONSE TO POTENTIAL GROWTHS- FLEXIBILITY FOR CHANGING NUMBER OF STUDENTS (H1)									
ALTERNATIVE	**Strongly important**	**Moderately important**	**Weakly important**	**Equally important**	**Just equal**	**Equally important**	**Weakly important**	**Moderately important**	**Strongly important**	**ALTERNATIVE**
GAZİ							X			**METU**
GAZİ							X			**HACETTEPE**
GAZİ						X				**ANKARA**
GAZİ							X			**BİLKENT**
GAZİ							X			**BAŞKENT**
METU						X				**HACETTEPE**
METU					X					**ANKARA**
METU						X				**BİLKENT**
METU						X				**BAŞKENT**
HACETTEPE					X					**ANKARA**
HACETTEPE						X				**BİLKENT**
HACETTEPE						X				**BAŞKENT**
ANKARA							X			**BİLKENT**
ANKARA							X			**BAŞKENT**
BİLKENT					x					**BAŞKENT**

	FLEXIBILITY OF CAMPUS(IMMEDIATELY RESPONSE TO POTENTIAL GROWTHS- ROOM ARRANGEMENTS (H2)									
ALTERNATIVE	**Strongly important**	**Moderately important**	**Weakly important**	**Equally important**	**Just equal**	**Equally important**	**Weakly important**	**Moderately important**	**Strongly important**	**ALTERNATIVE**
GAZİ						X				**METU**
GAZİ						X				**HACETTEPE**
GAZİ					X					**ANKARA**
GAZİ						X				**BİLKENT**
GAZİ						X				**BAŞKENT**
METU					X					**HACETTEPE**
METU				X						**ANKARA**
METU					X					**BİLKENT**
METU					X					**BAŞKENT**
HACETTEPE				X						**ANKARA**
HACETTEPE						X				**BİLKENT**
HACETTEPE						X				**BAŞKENT**
ANKARA						X				**BİLKENT**
ANKARA						X				**BAŞKENT**
BİLKENT					X					**BAŞKENT**

	FLEXIBILITY OF CAMPUS(IMMEDIATELY RESPONSE TO POTENTIAL GROWTHS- JOKER UNDIFFERENTIATED SPACES FOR SUDDEN EXPANSIONS (H3)									
ALTERN ATIVE	Strongly impo rtant	Moderately impor tant	Weakly impor tant	Equally impo rtant	Just equal	Equally impor tant	Weakly impo tant	Moderately impo rtant	Strongly impo rtant	ALTERN ATIVE
GAZİ							X			METU
GAZİ							X			HACETTEPE
GAZİ					X					ANKARA
GAZİ							X			BİLKENT
GAZİ							X			BAŞKENT
METU				X						HACETTEPE
METU				X						ANKARA
METU				X						BİLKENT
METU				X						BAŞKENT
HACETTEPE				X						ANKARA
HACETTEPE						X				BİLKENT
HACETTEPE					X					BAŞKENT
ANKARA						X				BİLKENT
ANKARA						X				BAŞKENT
BİLKENT				X						BAŞKENT

	CAMPUS STRATEGIC GROWTH PLANS- MICRO GROWTH (IN 5 YEARS) (I1)									
ALTERN ATIVE	Strongly impor tant	Moderately impo rtant	Weakly impor tant	Equally impo rtant	Just equal	Equally impo rtant	Weakly impo rtant	Moderately impor tant	Strongly impo rtant	ALTERN ATIVE
GAZİ						X				METU
GAZİ						X				HACETTEPE
GAZİ					X					ANKARA
GAZİ						X				BİLKENT
GAZİ							X			BAŞKENT
METU					X					HACETTEPE
METU				X						ANKARA
METU							X			BİLKENT
METU							X			BAŞKENT
HACETTEPE				X						ANKARA
HACETTEPE					X					BİLKENT
HACETTEPE							X			BAŞKENT
ANKARA							X			BİLKENT
ANKARA							X			BAŞKENT
BİLKENT							X			BAŞKENT

	CAMPUS STRATEGIC GROWTH PLANS- MACRO GROWTH MODELS (IN 7 YEARS) (I2)									
ALTERN ATIVE	Strongly impo tant	Moderately impor tant	Weakly import ant	Equally impo rtant	Just eq ual	Equally impor tant	Weakly impo rtant	Moderately impo rtant	Strongly impor tant	ALTERN ATIVE
GAZİ						X				METU
GAZİ						X				HACETTEPE
GAZİ					X					ANKARA
GAZİ						X				BİLKENT
GAZİ							X			BAŞKENT
METU					X					HACETTEPE
METU				X						ANKARA
METU							X			BİLKENT
METU							X			BAŞKENT
HACETTEPE				X						ANKARA
HACETTEPE					X					BİLKENT
HACETTEPE							X			BAŞKENT
ANKARA							X			BİLKENT
ANKARA							X			BAŞKENT
BİLKENT							X			BAŞKENT

	CAMPUS STRATEGIC GROWTH PLANS- PARTIALLY RE-SETTLEMENTS(IN 15 YEARS) (I3)									
ALTER NATIVE	Strongly impo rtant	Moderately impo rtant	Weakly imp ortant	Equally impo rtant	Just equal	Equally impor tant	Weakly impor tant	Moderately impor tant	Strongly impo rtant	ALTER NATIVE
GAZİ						X				METU
GAZİ						X				HACETTEPE
GAZİ					X					ANKARA
GAZİ						X				BİLKENT
GAZİ							X			BAŞKENT
METU					X					HACETTEPE
METU				X						ANKARA
METU							X			BİLKENT
METU							X			BAŞKENT
HACETTEPE				X						ANKARA
HACETTEPE					X					BİLKENT
HACETTEPE							X			BAŞKENT
ANKARA							X			BİLKENT
ANKARA							X			BAŞKENT
BİLKENT							X			BAŞKENT

	CAMPUS STRATEGIC GROWTH PLANS- NEW SETTLEMENTS (15 YEARS >X) (I4)									
ALTER NATIVE	Strongly impor tant	Moderately impo rtant	Weakly impo rtant	Equally impo rtant	Just equal	Equally impo rtant	Weakly impo rtant	Moderately impo rtant	Strongly impo rtant	ALTER NATIVE
GAZİ						X				METU
GAZİ						X				HACETTEPE
GAZİ					X					ANKARA
GAZİ						X				BİLKENT
GAZİ							X			BAŞKENT
METU					X					HACETTEPE
METU				X						ANKARA
METU							X			BİLKENT
METU							X			BAŞKENT
HACETTEPE				X						ANKARA
HACETTEPE					X					BİLKENT
HACETTEPE							X			BAŞKENT
ANKARA							X			BİLKENT
ANKARA							X			BAŞKENT
BİLKENT							X			BAŞKENT

	STUDENT POTENTIAL WHO USE SOCIAL,CULTURAL,COMMON EDUCATION PLACE- STUDENT WHO USE RECREATIONAL AND SOCIETY FACILITIES (J1)									
ALTERN ATIVE	Strongly impo rtant	Moderately impo rtant	Weakly impo rtant	Equally impor tant	Just equal	Equally impor tant	Weakly impor tant	Moderately impo rtant	Strongly impor tant	ALTERN ATIVE
GAZİ						X				METU
GAZİ					X					HACETTEPE
GAZİ					X					ANKARA
GAZİ						X				BİLKENT
GAZİ						X				BAŞKENT
METU				X						HACETTEPE
METU				X						ANKARA
METU					X					BİLKENT
METU					X					BAŞKENT
HACETTEPE					X					ANKARA
HACETTEPE						X				BİLKENT
HACETTEPE						X				BAŞKENT
ANKARA						X				BİLKENT
ANKARA						X				BAŞKENT
BİLKENT					X					BAŞKENT

	STUDENT POTENTIAL WHO USE SOCIAL,CULTURAL,COMMON EDUCATION PLACE- STUDENT WHO USE LIBRARY,LAB., SEMINAR ROOMS(J2)									
ALTERN ATIVE	Strongly impor tant	Moderately import ant	Weakly impor tant	Equally impor tant	Just equal	Equally impo rtant	Weakly import ant	Moderately impo rtant	Strongly impo rtant	ALTERN ATIVE
GAZİ						X				METU
GAZİ					X					HACETTEPE
GAZİ					X					ANKARA
GAZİ				X						BİLKENT
GAZİ				X						BAŞKENT
METU				X						HACETTEPE
METU				X						ANKARA
METU				X						BİLKENT
METU				X						BAŞKENT
HACETTEPE					X					ANKARA
HACETTEPE				X						BİLKENT
HACETTEPE				X						BAŞKENT
ANKARA				X						BİLKENT
ANKARA				X						BAŞKENT
BİLKENT					X					BAŞKENT

	STUDENT POTENTIAL WHO USE SOCIAL,CULTURAL,COMMON EDUCATION PLACE- STUDENT WHO ATTEND THE COURCE FOR GAINING AND GIVE SERTIFICATE (J3)									
ALTER NATIVE	Strongly imp rtant	Moderately impor tant	Weakly impor tant	Equally impo rtant	Just equal	Equally impor tant	Weakly impo rtant	Moderately impo tant	Strongly impor tant	ALTERN ATIVE
GAZİ					X					METU
GAZİ				X						HACETTEPE
GAZİ				X						ANKARA
GAZİ				X						BİLKENT
GAZİ				X						BAŞKENT
METU				X						HACETTEPE
METU				X						ANKARA
METU				x						BİLKENT
METU					X					BAŞKENT
HACETTEPE					x					ANKARA
HACETTEPE				X						BİLKENT
HACETTEPE				X						BAŞKENT
ANKARA				X						BİLKENT
ANKARA				X						BAŞKENT
BİLKENT					X					BAŞKENT

	SETTLEMENT OF SOCIAL,CULTURAL, COMMON EDUCATION PLACE- ACADEMIC ZONE K1									
ALTER NATIVE	Strongly imp rtant	Moderately impor tant	Weakly impor tant	Equally impo rtant	Just equal	Equally impor tant	Weakly impo rtant	Moderately impo tant	Strongly impor tant	ALTERN ATIVE
GAZİ							X			METU
GAZİ							X			HACETTEPE
GAZİ					X					ANKARA
GAZİ						X				BİLKENT
GAZİ						X				BAŞKENT
METU					X					HACETTEPE
METU			X							ANKARA
METU				X						BİLKENT
METU				X						BAŞKENT
HACETTEPE			X							ANKARA
HACETTEPE			X							BİLKENT
HACETTEPE					X					BAŞKENT
ANKARA						X				BİLKENT
ANKARA						X				BAŞKENT
BİLKENT					X					BAŞKENT

	SETTLEMENT OF SOCIAL,CULTURAL,COMMON EDUCATION PLACE- ADMINISTRATION ZONE K2									
ALTER NATIVE	Strongly imp rtant	Moderately impor tant	Weakly impor tant	Equally impo rtant	Just equal	Equally impor tant	Weakly impo rtant	Moderately impo tant	Strongly impor tant	ALTERN ATIVE
GAZİ							X			METU
GAZİ							X			HACETTEPE
GAZİ					X					ANKARA
GAZİ						X				BİLKENT
GAZİ						X				BAŞKENT
METU					X					HACETTEPE
METU			X							ANKARA
METU				X						BİLKENT
METU				X						BAŞKENT
HACETTEPE			X							ANKARA
HACETTEPE			X							BİLKENT
HACETTEPE					X					BAŞKENT
ANKARA						X				BİLKENT
ANKARA						X				BAŞKENT
BİLKENT					X					BAŞKENT

	SETTLEMENT OF SOCIAL,CULTURAL,COMMON EDUCATION PLACE- RESIDENTIAL ZONE DORMITORY K3									
ALTER NATIVE	Strongly imp rtant	Moderately impor tant	Weakly impor tant	Equally impo rtant	Just equal	Equally impor tant	Weakly impo rtant	Moderately impo tant	Strongly impor tant	ALTERN ATIVE
GAZİ							X			METU
GAZİ							X			HACETTEPE
GAZİ					X					ANKARA
GAZİ						X				BİLKENT
GAZİ						X				BAŞKENT
METU					X					HACETTEPE
METU			X							ANKARA
METU				X						BİLKENT
METU				X						BAŞKENT
HACETTEPE			X							ANKARA
HACETTEPE			X							BİLKENT
HACETTEPE					X					BAŞKENT
ANKARA						X				BİLKENT
ANKARA						X				BAŞKENT
BİLKENT					X					BAŞKENT

	SETTLEMENT OF SOCIAL,CULTURAL,COMMON EDUCATION PLACE- RECREATIONAL ZONE K4									
ALTER NATIVE	Strongly imp rtant	Moderately impor tant	Weakly impor tant	Equally impo rtant	Just equal	Equally impor tant	Weakly impo rtant	Moderately impo tant	Strongly impor tant	ALTERN ATIVE
GAZİ						X				METU
GAZİ				X						HACETTEPE
GAZİ					X					ANKARA
GAZİ					X					BİLKENT
GAZİ					X					BAŞKENT
METU				X						HACETTEPE
METU				X						ANKARA
METU					X					BİLKENT
METU			X							BAŞKENT
HACETTEPE						X				ANKARA
HACETTEPE						X				BİLKENT
HACETTEPE						X				BAŞKENT
ANKARA						X				BİLKENT
ANKARA						X				BAŞKENT
BİLKENT				X						BAŞKENT

	ACCESSIBILITY (LOCATION OF BUILDINGS TO EACH OTHER)- MAX 10 MINUTES WALKING DISTANCE BETWEEN TWO ACAD. BUILDING OR INTERDIIPLINARY PROGRAMS <900 METER(L1)									
ALTER NATIVE	Strongly impor tant	Moderately impo rtant	Weakly impo rtant	Equally impo rtant	Just equal	Equally impo rtant	Weakly import ant	Moderately impor tant	Strongly impor tant	ALTER NATIVE
GAZİ							X			METU
GAZİ							X			HACETTEPE
GAZİ					X					ANKARA
GAZİ						X				BİLKENT
GAZİ						X				BAŞKENT
METU					X					HACETTEPE
METU				x						ANKARA
METU				X						BİLKENT
METU					x					BAŞKENT
HACETTEPE			X							ANKARA
HACETTEPE					X					BİLKENT
HACETTEPE					X					BAŞKENT
ANKARA						X				BİLKENT
ANKARA						X				BAŞKENT
BİLKENT				X						BAŞKENT

	ACCESSIBILITY (LOCATION OF BUILDINGS TO EACH OTHER)- 5 MINUTES PERIOD FOR A PEDESTRIAN WALKING WITHOUT PAUSE=450 METERS (L2)									
ALTER NATIVE	Strongly imp rtant	Mode rately import ant	Weakly impor tant	Equally impor tant	Just equal	Equally impo rtant	Weakly impor tant	Moder ately impor tant	Strongly impo rtant	ALTERN ATIVE
GAZİ							X			METU
GAZİ							X			HACETTEPE
GAZİ					X					ANKARA
GAZİ						X				BİLKENT
GAZİ						X				BAŞKENT
METU					X					HACETTEPE
METU			X							ANKARA
METU				X						BİLKENT
METU					x					BAŞKENT
HACETTEPE			X							ANKARA
HACETTEPE					X					BİLKENT
HACETTEPE					X					BAŞKENT
ANKARA						X				BİLKENT
ANKARA						X				BAŞKENT
BİLKENT				X						BAŞKENT

APPENDIX A.3 A Sample Expert Questionnaire of Comparing sub-criteria with each

UNIVERSITY CAMPUS PLANNING										
CAMPUS LOCATION	**Pair-wise Comparison Matrix Of Campus Location Sub-Factors**									
CRITERIA	Strongly important	Moderately important	Weakly important	Equally important	Just equal	Equally important	Weakly important	Moderately important	Strongly important	CRITERIA
SEA,FOREST, MOUNTAIN, LAKE,INSIDE THE CITY,OUTSIDE THE CITY (A1)					X					SUITABILITY OF SITE TOPOGRAPHY FOR CONSTRUCTION(A2)
SEA,FOREST, MOUNTAIN, LAKE,INSIDE THE CITY,OUTSIDE THE CITY (A1)			X							SCALE OF CAMPUS (OUTDOOR /INDOOR SPACES) (A3)
SUITABILITY OF SITE TOPOGRAPHY FOR CONSTRUCTION (A2)				X						SCALE OF CAMPUS (OUTDOOR /INDOOR SPACES) (A3)

UNIVERSITYCAMPUS PLANNING										
CULTURAL STRUCTURE OF CITY	Pair-wise Comparison Matrix Of Cultural Structure Of City Sub-Factors									
CRITERIA	Strongly important	Moderately important	Weakly important	Equally important	Just equal	Equally important	Weakly important	Moderately important	Strongly important	CRITERIA
LOCAL SETTLEMENT PATTERN (B1)				X						LIFE STANDARTS OF THE REGION (B2)
LOCAL SETTLEMENT PATTERN (B1)					x					ARCHITECTURAL NOTIONS (B3)
LOCAL SETTLEMENT PATTERN (B1)				X						NATURE OF THE SITE(B4)
LOCAL SETTLEMENT PATTERN (B1)			x							TYPOLOGY (HUMAN TYPOLOGY) (B5)
LIFE STANDARTS OF THE REGION (B2)							X			ARCHITECTURAL NOTIONS (B3)
LIFE STANDARTS OF THE REGION (B2)					X					NATURE OF THE SITE(B4)
LIFE STANDARTS OF THE REGION (B2)					X					TYPOLOGY (HUMAN TYPOLOGY) (B5)
ARCHITECTURAL NOTIONS (B3)				X						NATURE OF THE SITE(B4)
ARCHITECTURAL NOTIONS (B3)				X						TYPOLOGY (HUMAN TYPOLOGY) (B5)
NATURE OF THE SITE(B4)					X					TYPOLOGY (HUMAN TYPOLOGY) (B5)

UNIVERSITYCAMPUS PLANNING										
EDUCATION SYST.	**Pair-wise Comparison Matrix Of EDUCATION SYST. (COMMON COURCES,LAB,FIRST SECOND EDU.) Sub-Factors**									
CRITERIA	**Strongly important**	**Moderately important**	**Weakly important**	**Equally important**	**Just equal**	**Equally important**	**Weakly important**	**Moderately important**	**Strongly important**	**CRITERIA**
COMMON LECTURES, BUILDINGS LAB.,AUDOTORIUM, ACADEMIC STAFF ROOMS (E1)			X							**NIGHT EDUCATION (E2)**

UNIVERSITYCAMPUS PLANNING										
FINANCIAL SITUATION OF UNIVERSITY	**Pair-wise Comparison Matrix Of Financial Situation Of University Sub-Factors**									
CRITERIA	**Strongly important**	**Moderately important**	**Weakly important**	**Equally important**	**Just equal**	**Equally important**	**Weakly important**	**Moderately important**	**Strongly important**	**CRITERIA**
AREA OF THE SITE (C1)						x				**INFRASTRUCTURE INVESTMENT (C2)**
AREA OF THE SITE (C1)						X				**PHASING OF BUILDINGS (C3)**
AREA OF THE SITE (C1)					X					**QUALITY STANDARTS INVESTMENT EX.SQ MT/STUDENT (C4)**
INFRASTRUCTURE INVESTMENT (C2)					X					**PHASING OF BUILDINGS (C3)**
INFRASTRUCTURE INVESTMENT (C2)				X						**QUALITY STANDARTS INVESTMENT EX.SQ MT/ STUDENT(C4)**
PHASING OF BUILDINGS (C3)				X						**QUALITY STANDARTS INVESTMENT EX.SQ MT/ STUDENT(C4)**

UNIVERSITY CAMPUS PLANNING										
CAMPUS POPULATION	**Pair-wise Comparison Matrix Of Campus Population Sub-Factors**									
CRITERIA	Strongly important	Moderately important	Weakly important	Equally important	Just equal	Equally important	Weakly important	Moderately important	Strongly important	CRITERIA
STUDENT POPULATION OF THE UNIVERSITY (D1)		X								STUDENT DEMANDS OF THE UNIVERSITY (D2)
STUDENT POPULATION OF THE UNIVERSITY (D1)			X							SOCIAL AND ECONOMIC RELATIONS BETWEEN NEIGHBOUR UNITS (D3)
STUDENT DEMANDS OF THE UNIVERSITY (D2)					X					SOCIAL AND ECONOMIC RELATIONS BETWEEN NEIGHBOUR UNITS (D3)

UNIVERSITY CAMPUS PLANNING										
CAMPUS TRAFFIC USAGE	**Pair-wise Comparison Matrix Of Campus Traffic Usage Sub-Factors**									
CRITERIA	Strongly important	Moderately important	Weakly important	Equally important	Just equal	Equally important	Weakly important	Moderately important	Strongly important	CRITERIA
UNIVERSITIES RELYING ON RAPID TRANSIT SYSTEM (F1)								X		RING SYSTEM WHICH REDUCE USING CAR (F2)
UNIVERSITIES RELYING ON RAPID TRANSIT SYSTEM (F1)								X		MAKING VARIOUS ACTIVITIES ON THE SAME BUILDING WHICH REDUCE PEDESTRIAN TRAFFIC (F3)
RING SYSTEM WHICH REDUCE USING CAR (F2)					X					MAKING VARIOUS ACTIVITIES ON THE SAME BUILDING WHICH REDUCE PEDESTRIAN TRAFFIC (F3)

UNIVERSITY CAMPUS PLANNING										
RELATIONSHIP WITH CITY AND INDUSTRY	Pair-wise Comparison Matrix Of Relationship With City And Industry Sub-Factors									
CRITERIA	Strongly important	Moderately important	Weakly important	Equally important	Just equal	Equally important	Weakly important	Moderately important	Strongly important	CRITERIA
BRINGING THE NEW TECHNOLOGIY OF THE INDUSTRIAL FIRMS IN TO UNIVERSITY CAMPUS (G1)							X			PRACTICAL TRAINING STUDENTS RELATIONSHIP WITH INDUSTRY (G2)
BRINGING THE NEW TECHNOLOGIY OF THE INDUSTRIAL FIRMS IN TO UNIVERSITY CAMPUS (G1)							X			UNIVERSITY MAY SERVE INDUSTRY WITH ACADEMIC STAFF,LAB.,SCIENTIFIC RESEARCHERS (G3)
BRINGING THE NEW TECHNOLOGIY OF THE INDUSTRIAL FIRMS IN TO UNIVERSITY CAMPUS (G1)							X			RESIDENTIAL POTENTIAL,SOCIALIZATION CENTERS REQUIREMENTS (G4)
PRACTICAL TRAINING STUDENTS RELATIONSHIP WITH INDUSTRY (G2)								X		UNIVERSITY MAY SERVE INDUSTRY WITH ACADEMIC STAFF ,LAB.,SCIENTIFIC RESEARCHERS (G3)
PRACTICAL TRAINING STUDENTS RELATIONSHIP WITH INDUSTRY (G2)					X					RESIDENTIAL POTENTIAL,SOCIALIZATION CENTERS REQUIREMENTS (G4)
UNIVERSITY MAY SERVE INDUSTRY WITH ACADEMIC STAFF ,LAB.,SCIENTIFIC RESEARCHERS (G3)						X				RESIDENTIAL POTENTIAL,SOCIALIZATION CENTERS REQUIREMENTS (G4)

UNIVERSITYCAMPUS PLANNING										
FLEXIBILITY OF CAMPUS(IMMEDIATELY RESPONSE TO POTENTIAL GROWTHS	Pair-wise Comparison Matrix Of Flexibility Of Campus (Immediately Response To Potential Growths Sub-Factors									
CRITERIA	Strongly important	Moderately important	Weakly important	Equally important	Just equal	Equally important	Weakly important	Moderately important	Strongly important	CRITERIA
FLEXIBILITY FOR CHANGING NUMBER OF STUDENTS (H1)			X							ROOM ARRANGEMENTS (H2)
FLEXIBILITY FOR CHANGING NUMBER OF STUDENTS (H1)					x					JOKER UNDIFFERENTIATED SPACES FOR SUDDEN EXPANSIONS (H3)
ROOM ARRANGEMENTS (H2)							X			JOKER UNDIFFERENTIATED SPACES FOR SUDDEN EXPANSIONS (H3)

UNIVERSITY CAMPUS PLANNING										
CAMPUS STRATEGIC GROWTH PLANS	Pair-wise Comparison Matrix Of Campus Strategic Growth Plans Sub-Factors									
CRITERIA	Strongly important	Moderately important	Weakly important	Equally important	Just equal	Equally important	Weakly important	Moderately important	Strongly important	CRITERIA
MICRO GROWTH (IN 5 YEARS) (I1)						X				MACRO GROWTH MODELS (IN 7 YEARS) (I2)
MICRO GROWTH (IN 5 YEARS) (I1)							X			PARTIALLY RE-SETTLEMENTS(IN 15 YEARS) (I3)
MICRO GROWTH (IN 5 YEARS) (I1)						x				NEW SETTLEMENTS (15 YEARS >X) (I4)
MACRO GROWTH MODELS (IN 7 YEARS) (I2)						x				PARTIALLY RE-SETTLEMENTS(IN 15 YEARS) (I3)
MACRO GROWTH MODELS (IN 7 YEARS) (I2)					X					NEW SETTLEMENTS (15 YEARS >X) (I4)
PARTIALLY RE-SETTLEMENTS(IN 15 YEARS) (I3)					X					NEW SETTLEMENTS (15 YEARS >X) (I4)

UNIVERSITYCAMPUS PLANNING										
STUDENT POTENTIAL WHO USE SOCIAL, CULTURAL, COMMON EDUCATION PLACE	Pair-wise Comparison Matrix Of Student Potential Who Use Social,Cultural,Common Education Place Sub-Factors									
CRITERIA	Strongly important	Moderately important	Weakly important	Equally important	Just equal	Equally important	Weakly important	Moderately important	Strongly important	CRITERIA
STUDENT WHO USE RECREATIONAL AND SOCIETY FACILITIES (J1)						x				STUDENT WHO USE LIBRARY,LAB., SEMINAR ROOMS(J2)
STUDENT WHO USE RECREATIONAL AND SOCIETY FACILITIES (J1)						x				STUDENT WHO ATTEND THE COURCE FOR GAINING AND GIVE SERTIFICATE (J3)
STUDENT WHO USE LIBRARY,LAB., SEMINAR ROOMS(J2)					X					STUDENT WHO ATTEND THE COURCE FOR GAINING AND GIVE SERTIFICATE (J3)

UNIVERSITY CAMPUS PLANNING										
ACCESSIBILITY (LOCATION OF BUILDINGS TO EACH OTHER)	Pair-wise Comparison Matrix Of Accessibility (Location Of Buildings To Each Other) Sub-Factors									
CRITERIA	Strongly important	Moderately important	Weakly important	Equally important	Just equal	Equally important	Weakly important	Moderately important	Strongly important	CRITERIA
MAX 10 MINUTES WALKING DISTANCE BETWEEN TWO ACAD. BUILDING OR INTERDIIPLINARY PROGRAMS <900 METER(L1)								X		5 MINUTES PERIOD FOR A PEDESTRIAN WALKING WITHOUT PAUSE=450 METERS (L2)

UNIVERSITYCAMPUS PLANNING										
SETTLEMENT OF SOCIAL,CULTURAL, COMMON EDUCATION PLACE	Pair-wise Comparison Matrix Of Settlement Of Social ,Cultural,Common Education Place Sub-Factors									
CRITERIA	Strongly important	Moderately important	Weakly important	Equally important	Just equal	Equally important	Weakly important	Moderately important	Strongly important	CRITERIA
ACADEMIC ZONE ACADEMIC STAFF OFFICES,LECTURE ROOMS LABORATORIES AND STUDIOS (K1)				x						ADMINISTRATION ZONE ADMINISTRATION BUILDING PRESIDENCY,AUDITORIUM,LIBRARY AND THE MEDICO SOCIAL BUILDING (K2)
ACADEMIC ZONE ACADEMIC STAFF OFFICES,LECTURE ROOMS LABORATORIES AND STUDIOS (K1)				X						RESIDENTIAL ZONE DORMITORY (K3)
ACADEMIC ZONE ACADEMIC STAFF OFFICES,LECTURE ROOMS LABORATORIES AND STUDIOS (K1)					X					RECREATIONAL ZONE SOCIAL, CULTURAL AND SPORT FACILITIES (K4)
ADMINISTRATION ZONE ADMINISTRATION BUILDING PRESIDENCY,AUDITORIUM,LIBRARY AND THE MEDICO SOCIAL BUILDING (K2)					x					RESIDENTIAL ZONE DORMITORY (K3)
ADMINISTRATION ZONE ADMINISTRATION BUILDING PRESIDENCY,AUDITORIUM,LIBRARY AND THE MEDICO SOCIAL BUILDING (K2)							X			RECREATIONAL ZONE SOCIAL,CULTURAL AND SPORT FACILITIES (K4)
RESIDENTIAL ZONE DORMITORY (K3)							X			RECREATIONAL ZONE SOCIAL,CULTURAL AND SPORT FACILITIES (K4)

APPENDIX B: THE RESULTS OF FUZZY AHP ANALYSIS

THE MAIN CRITERIA	THE SUB CRITERIA	ALTERNATIVES	WEIGHT
CAMPUS LOCATION (A) 0,131	SEA,FOREST,MOUNTAIN,LAKE,INSIDE THE CITY,OUTSIDE THE CITY (A1) 0.4652	G	0,000
		M	0,299
		H	0,272
		A	0,000
		Bİ	0,290
		BA	0,139
	SUITABILITY OF SITE TOPOGRAPHY FOR CONSTRUCTION (A2) 0.5348	G	0,2302
		M	0,1570
		H	0,2176
		A	0,1233
		Bİ	0,1386
		BA	0,1334
	SCALE OF CAMPUS (OUTDOOR/INDOOR SPACES) (A3) 0,0	G	0,0000
		M	0,2858
		H	0,2490
		A	0,0281
		Bİ	0,2273
		BA	0,2098
CULTURAL STRUCTURE OF CITY (B) 0,062	LOCAL SETTLEMENT PATTERN (B1) 0.2160	G	0,0928
		M	0,3030
		H	0,0000
		A	0,0622
		Bİ	0,2853
		BA	0,2567
	LIFE STANDARTS OF THE REGION (B2) 0.2864	G	0,1385
		M	0,0000
		H	0,1841
		A	0,1413
		Bİ	0,2974
		BA	0,2386
	ARCHITECTURAL NOTIONS (B3) 0.2315	G	0,1177
		M	0,3427
		H	0,1905
		A	0,1871
		Bİ	0,1143
		BA	0,0476
	NATURE OF THE SITE(B4) 0.2574	G	0,0000
		M	0,2761
		H	0,2387
		A	0,0684
		Bİ	0,2039
		BA	0,2130
	TYPOLOGY (HUMAN TYPOLOGY) (B5) 0.0088	G	1,0000
		M	0,0000
		H	0,0000
		A	0,0000
		Bİ	0,0000
		BA	0,0000

THE MAIN CRITERIA	THE SUB CRITERIA	ALTERNATIVES	WEIGHT
FINANCIAL SITUATION OF UNIVERSITY (C) 0,084	AREA OF THE SITE (C1) 0.2757	G	0,1421
		M	0,2261
		H	0,1689
		A	0,0981
		Bİ	0,2209
		BA	0,1438
	INFRASTRUCTURE INVESTMENT (C2) 0.3224	G	0,0595
		M	0,2628
		H	0,2180
		A	0,0482
		Bİ	0,2452
		BA	0,1663
	PHASING OF BUILDINGS (C3) 0.0859	G	0,0947
		M	0,2414
		H	0,1866
		A	0,1418
		Bİ	0,1633
		BA	0,1722
	QUALITY STANDARTS INVESTMENT EX.SQ MT/STUDENT (C4) 0.3160	G	0,0207
		M	0,2976
		H	0,1874
		A	0,1228
		Bİ	0,2575
		BA	0,1141

THE MAIN CRITERIA	THE SUB CRITERIA	ALTERNATIVES	WEIGHT
CAMPUS POPULATION (D) 0.05	STUDENT POPULATION OF THE UNIVERSITY(D1) 0.5419	G	0,1440
		M	0,2140
		H	0,1709
		A	0,1360
		Bİ	0,2122
		BA	0,1229
	STUDENT DEMANDS OF THE UNIVERSITY (D2) 0.2344	G	0,0316
		M	0,4126
		H	0,2438
		A	0,1607
		Bİ	0,1513
		BA	0,0000
	SOCIAL AND ECONOMIC RELATIONS BETWEEN NEIGHBOUR UNITS (D3) 0.2236	G	0,0000
		M	0,0000
		H	0,0000
		A	0,0000
		Bİ	0,4850
		BA	0,5150
EDUCATION SYST.(COMMON COURCES,LAB,FIRST SECOND EDU.) (E) 0,058	COMMON LECTURES (E1) 1.0	G	0,1908
		M	0,1887
		H	0,1715
		A	0,1213
		Bİ	0,1830
		BA	0,1446
	NIGHT EDUCATION (E2) 0.0	G	0,4914
		M	0,1149
		H	0,2110
		A	0,1827
		Bİ	0,0000
		BA	0,0000
CAMPUS TRAFFIC USAGE (F) 0.076	UNIVERSITIES RELYING ON RAPID TRANSIT SYSTEM (F1) 0.0	G	0,3164
		M	0,2029
		H	0,1425
		A	0,1469
		Bİ	0,1224
		BA	0,0689
	RING SYSTEM WHICH REDUCE USING CAR (F2) 0.4099	G	0,0529
		M	0,2605
		H	0,2287
		A	0,1427
		Bİ	0,1701
		BA	0,1450
	MAKING VARIOUS ACTIVITIES ON THE SAME BUILDING WHICH REDUCE PEDESTRIAN TRAFFIC (F3) 0.5901	G	0,1094
		M	0,1952
		H	0,1476
		A	0,1931
		Bİ	0,2017
		BA	0,1531

THE MAIN CRITERIA	THE SUB CRITERIA	ALTERNATIVES	WEIGHT
RELATIONSHIP WITH CITY AND INDUSTRY (G) 0.072	RESIDENTIAL POTENTIAL,SOCIALIZATION CENTERS REQUIREMENTS (G1) 0.0218	G	0,1939
		M	0,1690
		H	0,1698
		A	0,2206
		Bİ	0,1646
		BA	0,0821
	SOCIALIZATION CENTERS REQUIREMENTS G2 0.0	G	0,4999
		M	0,2190
		H	0,0967
		A	0,1547
		Bİ	0,0297
		BA	0,0000
	BRINGING THE NEW TECHNOLOGIY OF THE INDUSTRIAL FIRMS IN TO UNIVERSITY CAMPUS (G3) 0.2869	G	0,0365
		M	0,4083
		H	0,2321
		A	0,1049
		Bİ	0,2182
		BA	0,0000
	PRACTICAL TRAINING STUDENTS RELATIONSHIP WITH INDUSTRY (G4) 0.3387	G	0,2763
		M	0,2606
		H	0,2123
		A	0,1831
		Bİ	0,0501
		BA	0,0176
	UNIVERSITY MAY SERVE INDUSTRY WITH ACADEMIC STAFF ,LAB.,SCIENTIFIC RESEARCHERS (G5) 0.3525	G	0,1600
		M	0,3324
		H	0,2408
		A	0,1804
		Bİ	0,0864
		BA	0,0000

THE MAIN CRITERIA	THE SUB CRITERIA	ALTERNATIVES	WEIGHT
ACCESSIBILITY (LOCATION OF BUILDINGS TO EACH OTHER) (L) 0.11	MAX 10 MINUTES WALKING DISTANCE BETWEEN TWO ACAD. BUILDING OR INTERDIIPLINARY PROGRAMS <900 METER(L1) 0.8299	G	0,0663
		M	0,3987
		H	0,2081
		A	0,0360
		Bİ	0,1922
		BA	0,0591
	5 MINUTES PERIOD FOR A PEDESTRIAN WALKING WITHOUT PAUSE=450 METERS (L2) 0.1701	G	0,1563
		M	0,2611
		H	0,2075
		A	0,1006
		Bİ	0,1782
		BA	0,0963

THE MAIN CRITERIA	THE SUB CRITERIA	ALTERNATIVES	WEIGHT
FLEXIBILITY OF CAMPUS(IMMEDIATELY RESPONSE TO POTENTIAL GROWTHS (H) 0.092	**FLEXIBILITY FOR CHANGING NUMBER OF STUDENTS (H1) 0.0965**	G	0,1284
		M	0,1609
		H	0,1750
		A	0,1021
		Bİ	0,2182
		BA	0,2154
	ROOM ARRANGEMENTS (H2) 0.4953	G	0,1371
		M	0,2970
		H	0,2392
		A	0,0563
		Bİ	0,0000
		BA	0,2704
	JOKER UNDIFFERENTIATED SPACES FOR SUDDEN EXPANSIONS (H3) 0.4082	G	0,0000
		M	0,2760
		H	0,2101
		A	0,0230
		Bİ	0,2444
		BA	0,2465
CAMPUS STRATEGIC GROWTH PLANS (I) 0.075	**MICRO GROWTH (IN 5 YEARS) (I1) 0.2437**	G	0,0000
		M	0,0000
		H	0,0000
		A	0,0000
		Bİ	0,4119
		BA	0,5881
	MACRO GROWTH MODELS (IN 7 YEARS) (I2) 0.2555	G	0,0588
		M	0,1471
		H	0,0460
		A	0,0000
		Bİ	0,7481
		BA	0,0000
	PARTIALLY RE-SETTLEMENTS(IN 15 YEARS) (I3) 0.25	G	0,0000
		M	0,0000
		H	0,0000
		A	0,0000
		Bİ	0,4691
		BA	0,5309
	NEW SETTLEMENTS (15 YEARS >X) (I4) 0.2508	G	0,1096
		M	0,0000
		H	0,0000
		A	0,0000
		Bİ	0,4145
		BA	0,4759

THE MAIN CRITERIA	THE SUB CRITERIA	ALTERNATIVES	WEIGHT
STUDENT POTENTIAL WHO USE SOCIAL,CULTURAL,COMMON EDUCATION PLACE(J) 0.089	STUDENT WHO USE RECREATIONAL AND SOCIETY FACILITIES (J1) 0.0841	G	0,0974
		M	0,2481
		H	0,1599
		A	0,0896
		Bİ	0,2244
		BA	0,1805
	STUDENT WHO USE LIBRARY,LAB., SEMINAR ROOMS(J2) 0.5293	G	0,1556
		M	0,2988
		H	0,2352
		A	0,2211
		Bİ	0,0778
		BA	0,0115
	STUDENT WHO ATTEND THE COURCE FOR GAINING AND GIVE SERTIFICATE (J3) 0.3865	G	0,1024
		M	0,2905
		H	0,2485
		A	0,2137
		Bİ	0,0910
		BA	0,0539
SETTLEMENT OF SOCIAL,CULTURAL,COMMON EDUCATION PLACE(K) 0.102	ACADEMIC ZONE ACADEMIC STAFF OFFICES,LECTURE ROOMS LABORATORIES AND STUDIOS (K1) 0.4065	G	0,0988
		M	0,2734
		H	0,2270
		A	0,1006
		Bİ	0,1733
		BA	0,1268
	ADMINISTRATION ZONE ADMINISTRATION BUILDING PRESIDENCY,AUDITORIUM,LIBRARY AND THE MEDICO SOCIAL BUILDING (K2) 0.2127	G	0,0946
		M	0,3049
		H	0,1940
		A	0,1013
		Bİ	0,1615
		BA	0,1437
	RESIDENTIAL ZONE DORMITORY (K3) 0.2674	G	0,0000
		M	0,0000
		H	0,4943
		A	0,0000
		Bİ	0,2796
		BA	0,2261
	RECREATIONAL ZONE SOCIAL,CULTURAL AND SPORT FACILITIES (K4) 0.1135	G	0,0000
		M	0,0736
		H	0,3424
		A	0,1785
		Bİ	0,1069
		BA	0,2324