THE REPUBLIC OF TURKEY

BAHCESEHIR UNIVERSITY

AN INTEGRATED GIS-FUZZY MCDM APPROACH FOR ROUTE SELECTION:CASE OF BAGHDAD METRO LINE

Master's Thesis

RUAA ADNAN ABDULRIDHA ALSHAREEFİ

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ABSTRACT

AN INTEGRATED GIS-FUZZY MCDM APPROACH FOR ROUTE SELECTION:CASE OF BAGHDAD METRO LINE

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Nowadays, Geographic Information System (GIS) is an important technique for data collecting and managing. GIS is a computer-based system and deals with geographic issues, and geospatial data is used to analyze in this system (data with its location information, such as longitude, latitude, altitude). A GIS system has a full process from gathering data, processing data and visualization. Lots of new methods are rapidly developed to satisfy the needs of scientific projects. Along with these new approaches, Fuzzy Multi-criteria Decision Making (FMCDM) is one of the best method for decision makers to make a systematic and scientific decision after considering multiple factors derived from sufficient geospatial data. FMCDM is ordinarily applied in large projects where the decision-makers have many options or criteria to consider, and the outcome may be very different depending on how the criteria are evaluated. The aim is to weight different criteria against each other and combine them so that the best possible solution can be found. Baghdad City suffers from intense traffic crowding due to the fast urban growing. Based on different studies, Experts and the related transit agencies suggest urban rail transit as an optimal solution to solve this problem. Route/site selection is a method of exploring locations that gathering requirement conditions which set by selection criteria. In this study, Route / site selection process of Baghdad Metro-rail network project is displayed, To prepare and analysis data we will use (GIS), Which was applied to investigate the diverse route alternatives, Data was examined using two-steps (MCDM) that involve Fuzzy Analytical Hierarchal Process (FAHP) And Fuzzy TOPSIS methods .In this manner, measurements and maps with a size of 1:10,000 were used. After overlaying, three locales were considered as choices. In the next stride, the determinant criteria were weighted in FAHP and then rank our alternatives using Fuzzy TOPSIS to find the best choice.

Keywords: Route/site selection, GIS, FMCDM, FAHP and Fuzzy TOPSIS.

ÖZET

GÜZERGÂH SEÇİMİ İÇİN CBS-BULANIK ÇKKV ENTEGRE YAKLAŞIMI: BAĞDAT METRO HATTI ÖRNEĞİ

Ruaa Adnan Abdulridha Alshareefı

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Günümüzde, Coğrafi Bilgi Sistemi (CBS), veri toplamak ve yönetmek için önemli bir tekniktir. CBS, bilgisayar tabanlı bir sistemdir ve coğrafi konularla ilgilenmektedir ve coğrafi veri, bu sistemde (boylam, enlem, yükseklik gibi yer bilgilerini içeren veriler) analiz etmek için kullanılmaktadır. Bir CBS sistemi, veri toplamak, veri işlemek ve görselleştirmeden tam bir sürece sahiptir. Bilimsel projelerin ihtiyaçlarını karşılamak için birçok yeni yöntem hızla geliştirilmektedir. Bu yeni yaklaşımlarla birlikte Bulanık Çok Kriterli Karar Verme (FMCDM), karar vericiler için yeterli coğrafi veriden türetilen çok faktörlerin incelenmesinden sonra sistemli ve bilimsel bir karar vermenin en iyi yöntemlerinden biridir. FMCDM, karar vericilerin üzerinde düşünülmesi gereken birçok seçenek veya kritere sahip olduğu büyük projelerde normal olarak uygulanır ve kriterlerin nasıl değerlendirildiğine bağlı olarak sonuç çok farklı olabilir. Farklı kriterleri birbirine karşı ağırlıklandırmak ve mümkün olan en iyi çözümü bulabilmek için onları birleştirmektir. Bağdat şehri hızlı kentsel büyüme nedeniyle yoğun trafik sıkıntısı çekiyor. Uzmanlar ve ilgili transit ajanslar, farklı çalışmalara dayanarak, kent içi demiryolu geçişini bu sorunu çözmek için en uygun çözüm olarak önermektedir. Güzergah / alan seçimi, seçim ölçütlerine göre belirlenen gereksinim koşullarını toplayan yerleri keşfetmek için kullanılan bir yöntemdir. Bu çalışmada, Bağdat Metro-demiryolu ağı projesinin Güzergâh / saha seçim süreci görüntülendi. Kullanılacak verileri hazırlamak ve analiz etmek için (CBS), çeşitli rota alternatiflerini araştırmak için uygulanmıştır. Veriler iki aşamalı olarak incelendi (MCDM) Ve Bulanık Analitik Hiyerarşik Süreç (FAHP) ve Bulanık TOPSIS yöntemlerini içeren ve bu şekilde 1:10,000 boyutlarında ölçümler ve haritalar kullanılmıştır. Üst üste bindikten sonra, üç yerel seçimler olarak değerlendirildi. Bir sonraki adımda, belirleyici ölçütler FAHP'de ağırlıklandırılmış ve daha sonra en iyi seçeneği bulmak için Fuzzy TOPSIS kullanarak alternatiflerimizi sıralayacaktır.

Anahtar Kelimeler: Güzergah / alan seçimi, CBS, FMCDM, FAHP ve Bulanık TOPSIS

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ABBREVIATIONS

AIA	:	American Institute Of Architects
CAD	:	Computer-Aided Design
DSS	:	Decision Support Systems
ES	:	Expert Systems
FAHP	:	Fuzzy Analytic Hierarchy Process
FUZZY TOPSIS	:	Technique For Order Preference By Similarity To Ideal Solution
GIS	:	Geographic Information Systems
IRBD	:	IRAQ Roads And Bridges Directorate
IFC	:	Industry Foundation Classes
MCDM	:	Multi-Criteria Decision Making Methods
MOT	:	Ministry Of Transportation
MOP	:	Ministry Of Planning
TQM	:	Total Quality Management

1. INTRODUCTION

Geographical Information System (GIS) was integrated with project management to present one of the most important tools for achieving the goal of Infrastructure projects; this integration will assist a planner in a better perception of the project. By GIS construction managers and different people with diverse backgrounds keep in touch with the project to get the information about the progress of the project and support Decision Making .Decisions related to the locations of the facilities (e.g. metro-rail routes, stations, depots, etc.) influence economies of the metropolitan area and strongly impact on the lifestyle of the whole residential community. Building a new infrastructure transportation facility is a major beneficial long-term for any country. Route/site selection is known as a critical decision that made by the agency which responsible to create it. Regarding the possibility of success or failure that significantly impact on the revenue and loss. The goal in a route selection of public transportation infrastructure project planning is to find the best optimal solution which begins with the recognition of an existing or projected need to meet the present and the growing demand in the future. Based on predefined selection criteria Route selection typically involves series of actions starting with searching out and define some candidate sites according to specific criteria then investigate each of candidate sites to reach the excellent selection.

Nowadays GIS application is applied to evaluate transportation network which is a computer-integrated tool. Moreover, GIS applications include transit service area analysis and network representation. Also, Network Analysis is a tool in Arc GIS software used to estimate, find the relationship, locations of network facilities in transportation, communication systems, and others. The selection method tries to optimize some objectives in deciding the proportionality of a particular route/site for a defined transit facility. This optimization often includes a plenty of factors, which is sometimes conflicting. In other time some of the factors increase the difficulty of the suitable choice which includes the existence of many possible options within a sought region .The alternatives were determined to depend on the closeness and accessibility of people and employees from the proposed and existing transit stations.

Experts are assist the decision makers in determining values for the screening criteria of the site selection phase, therefore building the decision model and assigning weights to the attributes used as evaluation criteria for the site assessment phase.

This study distinguishes the application of GIS and spatial analysis area of the transit station and decides which stations would serve a much more people. The best alternative route is selected based on the evaluation of the stated criteria as an application of Fuzzy Multi-Criteria Decision making.

1.1 STATEMENT OF THE PROBLEM

Notwithstanding, the determination of lines and stations in Baghdad had not obvious and characterized procedural choice, or it is not perceived in superior deliberate ways. Particularly it is not led by taking after main considerations which ought to be incorporated into metro station site determination forms. These are:

a- The determination criteria's are whether restricted in number or excluded (which implies the variables to be incorporated are less in number or absolutely excluded) furthermore the degree is constrained just to some designing criteria and monetary criteria however the other significant criteria are excluded or restricted to definite examination.

b- In order to Iraq is one of the nations which are new for Metro frameworks it needs to make sure of choice criteria and methodology. Such a nation will endure heaps of issues in outlining and arranging of metro lines. Surveying metro station area is a standout amongst the most troublesome assignment in its multi-criteria targets.

1.2 RESEARCH OBJECTIVES

1.2.1General Objective

The general objective is an attempt to find and coordinate a strategy to construct a Metro network by using GIS & Fuzzy Multi-criteria decision making (FMCDM) methods taking into consideration the effect on several criteria to attain the goals below.

a- The assessing of road network achievement and its effect on general transportation system of which is so critical to assessing and analyzing the present and future transportation frameworks.

b- Through researching in international metro networks, it is seen that is arrived at a judgment to construct, estimate requirements and business needs, and evaluate the provided features and the chance of establishing a metro network in Baghdad.

c- Route picking, end terminal, and the middle terminal is taking into careful thought in engineering, institutional and ecological criteria, which are related to metro network planning and designing.

d- Developing optimization models with the aid of a geographic information system (GIS).

1.2.2 Specific Objective

By these four particular goals which will be proficient in this study, so the general objective will be achieved:

a- Determine criteria and sub-criteria

b- Promote metro station site selection model

c- Determine the best suitable site, and employ the model evaluate.

d- The decision will done According to the model evaluation

1.3 SIGNIFICANT OF STUDY

Literature reviews shows that there are many research articles on site selection: like a study on An Integrated GIS/MCDM Approach by Farkas to select Route/Site of Urban Transportation Facilities A., a paper on "The analytic network process (ANP) approach to location selection: a shopping mall illustration" by Eddie W.L., and Akjol D. who has done his thesis on "Multi-criteria decision making and GIS for railroad planning in Kyrgyzstan" According to these research works this study has found there are no researches in the areas of Metro Route/ site selection by considering such a criteria and methods. And also, in order to Iraq is one of the nations which are new for Metro frameworks it needs to make sure of choice criteria and methodology. Such a nation will endure heaps of issues in outlining and arranging of metro lines. Surveying metro station area is a standout amongst the most troublesome assignment in its multi-criteria targets; we have not encountered a study on GIS-FMCDM in Route site selection in Iraq before. Therefore this thesis has a significant advantage to fill the gap and to contribute new practices to the areas of Metro Route/site selection.

1.4 THE SCOPE

The working of a metro line going through a metropolitan range includes a gigantic venture and outstandingly changes the transport framework .Subsequently, the comment that the analyses completed along this proposition are centered on openness and afterward the conclusions are incomplete. Different studies must be made with a specific end goal to get a general assessment of the various choices.

1.5 THESIS ORGANIZATION

There are six chapters of the thesis. First of all is an introduction, which introduced the background of the study, problem statement of this research, the objectives, the scope, and organization of the thesis. Secondly is the literature review, which shows introduction discussed and the previous studies in different fields. The third chapter explains methodology through site selection mechanism, the software and data acquirement, techniques, the approaches of the data process and also the determination of criteria and two ways of determining weights are essential parts of this chapter. The next chapter is result and discussion, building the GIS-based FMCDM model is the most important part of the whole study. In this chapter, the result is introduced, and the limitations are discussed. The fifth chapter is discussions what is the contribution of this study then in chapter six the conclusion of the entire study and lists few possible improvement of this kind of research in the future. Last but not least, the following presents all the references of this thesis.

2. LITERATURE REVIEW

Metro line having many facets framework that needs to accomplish various targets like: Sufficient capacity, economic feasibility, come up with the current and arranged improvements, availability, sustainable, and forth keeping in mind the end goal to satisfy these unlisted targets it is important to create and propose, for the arranging and acknowledgment of new or updating the current transportation system. Metro lines differ enormously with respect to their complexity, reasonableness and effectiveness of operations in any cases, in some way, will have an immediate contact with their last client. All transportation foundations, metro framework advancement ought to likewise start with the recognizable proof of a current or anticipated need to meet the present and the rising interest later on.

In a procedure of site selection, the analyst tries to decide the perfect area that would satisfy the selected criteria that were dictated by the proponents. The choice procedure endeavors to enhance various destinations in deciding the allure of a particular site for a metro line. Such advancement regularly includes a large number of choice components, which are oftentimes disagreeing. Expert Opinion (EO), Geographic Information Systems (GIS), and Fuzzy Multi-Criteria Decision-Making (FMCDM) methods consider as the tools that utilized to choice the best route for metro line.

Every tool has its own restrictions and couldn't be utilized alone to achieve an ideal determination, although these instruments have assumed an essential part in taking care of site choice issues (K. Eldrandaly).

2.1 ROLE OF GIS IN PROJECT MANAGEMENT

a- GIS is a private class of data framework, which can be classified into four Components including a PC framework, GIS programming, human master, and the information.

b- GIS is a PC framework for catching, putting away, quarrying, breaking down, and showing Geographic information.

c- The activity of GIS can be grouped into spatial information input, quality information administration, information show, Data investigation, information examination, and GIS demonstrating.

2.2 PREVIOUS STUDIES IN DIFFERENT FIELDS

Many studies have used GIS -based multi-criteria analysis for site selection. For site selection, based on various geographic features, GIS could do several works like integration, visualization, management and analysis, it could find useful information from a large amount of data; it is a valuable tool for optimal site selection and natural decision making (cheng, li & yu, 2007). In 1997, Gordon and his colleague were using GIS techniques to select the location of public health service (Gordon & Womersley, 1997). Hare and barcus were using the geographical distributions of heart-related hospitals along with travel times to figure out the accessibility of heart-related hospitals in Kentucky (hare & barcus, 2007). In 2008, a study of selecting the optimal site for the supermarket had been done. In this study, it discussed the main factors affecting the supermarket location and the methods for determining the location. In the study, geographic information system (GIS) as analysis platform for analysis and neural network analysis is also introduced in this study (Wei, qin, guo & lu, 2008).

A study introduced by chuvieco & congalton in 1989. In their study, GIS and remote sensing are used to develop a forest fire hazard map of a small area in Spain. In their study, they got high-resolution satellite images from Landsat to classify vegetation and some other objects. There are five influencing factors are considered in the survey, they are vegetation species, elevation, slope, aspect, and roads. The rank order according to the importance of the factors is vegetation, slope, aspect, proximity to roads and elevation (chuvieco & congalton, 1989). From this study, we can say that vegetation species is a very important influencing factor for optimal site selection.

Another case study performed by yildirim, nisanci and reis in 2006. It is about selecting the area in Trabzon situated at the black sea region of Turkey. The aim is to find the optimal path for a pipeline from macka county to bulak village (yildirim, nisanci & reis, 2006). To fit the optimal path analysis, it should be considered many different factors.

Especially the distance between two points, and other factors such as slope, land use, geology, landslide, streams, soil, administrative boundaries, roads and tourism. In the final analysis, another least-cost analysis was also added in the final result. After this study, it provides a new and different way to determine the optimal path between two locations.

GIS-based site selections have been widely used recently in China. In 2009, gao and qiu did a research of siting evaluation of resort areas in nan kun mountain. Seven factors were examined in the study, they are a national policy and regional planning, slope, climate, aspect, transportation and vegetation coverage, they are analyzed and weighted, the result shows perfect locations for resort areas (GAO & qiu, 2009). Chen and mao used three major factors, they are a distance to the major water body, identified slopes and land use types. Those three factors were modeled and reclassified; the areas with high possibility were marked in black, which represents the best locations for constructing a municipal solid waste landfill (Chen & Mao, 2013).

Church said in 2002, more and more site selection application will be performed in the future and the relationship with GIS will be closer (church, 2002). This conclusion based on the specialization of GIS technology, the spatial data collection, process. Moreover these functions, GIS software support spatial data analysis, which could be applied in many traditional location selection analyses. For instance, GIS visualization could simplify massive data and realize interactions between project target and decision makers' demands. In this way, the decision makers could quickly to make a reasonable and scientific decision (Hernandez, 2007). Another case depends on the great graphic representation of GIS technology, along with efficient data organization and mass spatial data analysis, GIS-based technology plays a crucial role in optimal commercial facility site selection. More cases are done by GIS-based technology make GIS become one of the most popular visualization platform site selection studies (Wei, Qin, Guo & Lu, 2008).

As mentioned above, both remote sensing and GIS techniques are perfect tools for site selection and land use by managing them in an accurate and efficient way. The advantage of using GIS -based MCDM is that it is an open and resettable analysis process. The weights can be changed by the time in different situations, and determine of weights is changeable during different situation as well. The more important reason for using MCDM to make the optimal site selection is the result can be directly used for making decisions in the next research or future cases.

2.3 GIS FOR DIFFERENT APPLICATION

Utilization of GIS in conjunction with consciousness strategies for resource administration in a transportation setting. Personnel, equipment, materials, and supplies are the allocation of resources it is a heuristic based on methodologies to optimize transportation asset management procedures.

2.3.1 GIS & Site Location

One of the key choices relating to any logistics network setup incorporates site choice. For instance, site determination is basic for arranging a land a real estate advancement project. Distinctive scientific and measurable models have been proposed in the writing to bolster land engineers in selecting appropriate destinations for advancement ventures. Li et al (2005) presents another approach those utilizations Data Envelopment Analysis (DEA) inside a GIS structure to decide ideal site areas for land ventures. A GIS helps clients to sort out and join the spatial, temporal and practical data.

2.3.2 GIS & Warehouse Management

A geographical information system (GIS)-based software system for managing and integrating multi-facility warehousing and production systems that are distributed within a relatively large geographical area that what described by Johnston, Taylor and Viswes Waramurthy (1999) Warehouse management is a key part of the general issue of coordination administration. The improvement of the product framework is inspired by an interesting warehousing environment at the Pine Bluff Arsenal in Pine Bluff, Arkansas. The software system has been designed to maximize technology transfer capability into diverse general warehouse settings, in spite of the fact that motivated by this unique problem.

Portrays highlights, and shows the adequacy of operations utilizing the product framework. The framework is checked and approved for a situation examines setting. It is exhibited that the GIS stage offers one of a kind capacities that improve issue arrangements. In determination, the paper offers a commitment to the writing by displaying the utilization of GIS as a combination system in an energizing new zone of use.

2.3.3 Network Analysis Using GIS

The representation and examination of both foundation (gas, electrical, water) and transport systems (street, rail, transport) in GIS requires particular information models and investigation strategies. This course will present the ideas that support arrange examination in cutting edge GIS, alongside their application to certifiable system issues. Members will figure out how to build full system models from standard spatial datasets and get comfortable with the devices required to check and guarantee their honesty. Organize analysis systems will be displayed and connected to genuine systems, e.g. finding the briefest ideal course between areas.

3. DATA AND METHOD

This study tries to build up the techniques which are proposed to be utilized and run across sub-subjects: -

A general review of study regions to make path between these zones shorter, there are many strategies demonstrates the certain techniques to be employed as a part of the investigation that was managed. The information was gathered and used characterize in the data collections section. Also, the information investigation area in this study gives a general structure to manage choices without making any presumptions about the strategies, criteria utilized to pick out from. There are two types of Integration with GIS to solve site selection problems

3.1 Integrated GIS With Multi Criteria Decision Making (MCDM)

3.1.1 Multi Criteria Decision Making

Given the multifaceted nature of life today, the majority of our critical choices require a various criteria primary leadership handle. A few choices might be made considering a single standard, the two terms "various criteria" and basic leadership" are indistinguishable, particularly when settling on multiple choices that require thought of all the diverse viewpoints that influence on the choice (A. Abdul-Aziz). As of late, multi-criteria decision-making (MCDM) strategies are noted to be useful in achieving critical decisions that can't be solved apparently. The hidden rule of MCDM is that choices ought to be produced by utilization of different criteria (W.L. Eddie, Cheng).Moreover; MCDM can encourage correspondence among Decision Makers (DMs) and partners with a specific end goal to achieve a reasonable choice through an orderly, straightforward and reported process (B. Marta, and F. Valentina). Spatial selection issues ordinarily include a substantial arrangement of doable options and numerous, conflicting and disproportionate assessment criteria .The alternatives are usually assessed by various people (chiefs, supervisors, partners, decision-makers). The individuals are defined by one of a kind inclinations concerning the relative significance of criteria on the premise of which the choices are assessed (J.Malczewski).

The decision-making issue is the way toward characterizing the choice objectives, gathering critical data, and selecting the ideal option (C. Gencer, D. Gurpinar,). There are different MCDM strategies have been created, for example,

a- The Elimination and Choice Translating Reality (ELECTRE).

b- The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

c- The Analytic Hierarchy Process (AHP), however, these strategies don't manage the relationship among components (S. Hemmati, F. Shapouri, and A. Keramati).

d- Diagnostic Network Process (ANP) is a relative new MCDM strategy as of late presented by Thomas Saaty (T. Saaty 1996) which can manage a broad range of conditions systematically.

It can be used as an analysis tool as a part of those issues where there are associations and conditions among the components of a framework (T. Saaty1999). Most decisions are broke down as far as what is critical to a man or a gathering and what is observed as favored in settling on a decision. However, when we permit input, what is probably going to turn out as an aftereffect of the considerable number of impacts is the thing that one truly might want to know. The following needs empower one to take the important activities and make the interests in assets.

3.1.2 GIS With Multi Criteria Decision Making (GIS-MCDM)

Numerous spatial selection issues offer ascent to the GIS-based multi-criteria decision making (GIS-MCDM). These two distinct zones of research, GIS, and MCDA, can profit by each other (A. Laaribi, J.J. Chevallier, and J.M. Martel),(J. Malczewski 1999), (J. Thill), (S. Chakhar, and J.M. Martel). From one viewpoint, GIS methods and techniques have a crucial part to play in breaking down choice issues. To be sure, GIS is frequently perceived “as a choice emotionally supportive network including the coordination of spatially referenced information in a critical thinking environment” (D. Cowen). Then again, MCDA gives a rich gathering of strategies and techniques for organizing selection issues, and planning, assessing and organizing elective choices. And no more simple level, GIS-MCDA can be considered as a procedure that changes and consolidates topographical information and esteem judgments (the decision makers preferences) to get data for decision-making (J. Malczewski 2006).

Decision making is a procedure that includes an arrangement of techniques, beginning with choice issue recognizable proof and completion with proposals. The nature of the choices relies on upon the succession of methods taken. These systems in the primary leadership process are centered on producing options that utilization the assessment criteria as the principal component.

Decision making is characterized to incorporate any decision or determination of option course of systems, which are significance in the many fields of both social and normal sciences, including geological data science. The general standard for organizing the basic decision-making process is that the assessment criteria indicated and the choice options are created to accomplish the best outcome. This indicates concentrating first on what is and after that on contrasting options to achieve it. In the central leadership prepare the first information are translated and investigated to create Data. The data utilized as a part of the basic leadership process is classified as "hard" and "delicate." Hard data is received from reports, evaluation information, remote detecting information, and so forth. Sensitive data depends on instinct, surveys, remarks and conclusion of leaders. Utilizing this sort of information is important because any necessary spatial leadership must concentrate on a blend of hard and delicate data (J. Malczewski 1999).

3.2 GIS –Fuzzy Multi-Criteria Decision Making FMCDM

3.2.1 Fuzzy Multi-Criteria Decision Making (FMCDM)

Fuzzy Multi-criteria decision making (FMCDM) consist of a finite set of alternatives, amidst which the decision-makers have to choose, assess or rank based on the weights of a finite set of criteria (attributes). (MEW)Multiplicative Exponential weighting, simple additive weighting (SAW), technique for ordering preference by similarity to ideal solution (TOPSIS), analytic hierarchy process (AHP) are some of the different methods for dealing with multi-criteria decision-making problems .when the information is vague or imprecise, It is unrealistic to allocate a crisp value for a subjective judgment. In this manner acquaints the fuzzy idea with utilizing an interim or a range exhibiting the instability and unclearness in this present reality. ‘‘fuzzy sets theory “originally proposed by Zadeh (Bellman, R.E., & Zadeh) to model personal decision-making processes. After Bellman and Zadeh augmented decision-making issues into fuzzy situations, various works adapted to dubious and obscure issues by using fuzzy sets hypothesis. Fuzzy MCDM investigation has been broadly used to handle issues including more than one property or option in questionable conditions. Fuzzy multiple attribute group decision-making model was proposed by Xu and Chen (Z.S. Xu, J. Chen) to set what type of air conditioning systems should be installed in a library to resolve the subjective judgment and objective information under an uncertainty environment, fuzzy multi attribute decision-making approach presented by Li (D.F. Li). To evaluate the financial performance of domestic airlines in Taiwan, fuzzy multi-criteria decision-making approach subjected by Wang (Y.J. Wang). Narukawa and Torra (Y. Narukawa, V. Torra) put strategies to evaluate measures and integrals in games. Chou et al. (T.Y. Chou, S.T. Chou, and G.H. Tzeng) applied fuzzy multi-criteria decision model to assess IT/IS development. Ding and Liang (J.F. Ding, G.S. Liang) used MCDM to choose partners of strategic alliances for liner shipping in a fuzzy environment. Lin et al.( ] F. Lin, H. Ying, R.D. MacArthur, J.A. Cohn, D. Barth-Jones, L.R. Crane) employed fuzzy discrete event systems to HIV/AIDS treatment planning. A procedure with fuzzy multi-granularity linguistic rating 356 T.-H. Chang, T.-C. Wang / Information Sciences information developed by Jiang et al. (Y.P. Jiang, Z.P. Fan, J. Ma) was made for group decision making. By utilizing fuzzy MCDM, Royes and Bastos (G.F. Royes, R.C. Bastos) weighted the suspicion in political voting activities. Chang et al. (S.L. Chang, R.C. Wang, and S.Y. Wang) used fuzzy linguistic quantifier to adopt supply chain partners at different phases of product life cycle. According to these literatures, FMCDM was essentially adopted in selection, estimate and ranking, rarely utilized to solve of prediction or to estimate. This is additionally an inspiration of this review to acquaint reasonable FMCDM approach with manage the information administration extend achievement forecast.

3.2.2 GIS-Fuzzy Multi Criteria Decision Making (GIS-FMCDM)

It utilizes a two-phase examination synergistically to shape a spatial choice emotionally supportive network (SDSS) for Route Selection in a quickly developing urban area. The principal organize investigation makes utilization of the topical maps in Geographical data framework (GIS) in conjunction with the foundation , private, natural, and institutional factors prompting to bolster the second-arrange examination utilizing the fuzzy multi-criteria decision-making(FMCDM) as an apparatus.

It contrasts from the customary strategies for incorporating GIS with FMCDM for site choice since this approach takes after two successive strides as opposed to a full coordinated plan. The contextual investigation was made for the city of Baghdad in central of Iraq, which is quickly developing into an expansive urban region because of its vantage position as a capital of Iraq. The motivation behind GIS was to play out an underlying screening procedure to dispose of unacceptable locales took after by use of FMCDM strategy to recognize the most reasonable site ,utilizing the data gave by the provincial specialists concerning five picked criteria. Look into discoveries demonstrate that the proposed SDSS may help in perceiving the advantages and disadvantages of potential regions for the restriction of Metro Route destinations in any review district. Given initial GIS screening and last FMCDM evaluation, a Best reasonable site was chosen as Metro Route site in Baghdad.

3.3 SITE SELECTION MECHANISM

Locate the best area with necessary conditions that fulfill right choice criteria consider the objective in a route/site choice scheme.

Route/site choice regularly includes two primary stages:

a- Site checking (consistency of a small number of nominee's sites from a wide geographic area and a group of selection criteria).

b- Site appraisal (trying to achieve the most effective use of targets in mark in the convenience of a specific route/site for a defined transit facility).

To solve site choice issues there is a technique combine three tools which are geographic information systems (GIS), Fuzzy Multi-criteria decision-making (FMCDM), Expert Opinion (EO).a brief image of the quality and lacking strength of each one relate to sitting issues is given below:

i. Geographic information systems: - the success of GIS in sitting problems is regarded to its capability to carry out deterministic covering and stop the process. In spite of GIS possess perfect ability for carry out spatial inspection according to map data; they are incapable of handling multiple criterion and inconsistent objectives. Geographic information systems defined as a computer-based application and a system of methods used for combination, managing, analyzing, designing, and gives a geographic data for a wide domain of applications. Besides they are restricted in emerging geographical information with individual values/preferences forced by the decision maker.

ii. Fuzzy Multi-Criteria decision-making methods: - these techniques were created to assess options in light of the managers subjective and goal qualities and needs. They have been utilized to explain different site determination. Be that as it may, they expect homogeneity inside the study region, which is farfetched for location choice issues. The FMCDM technique was expounded more in the taking after the segment.

iii. Expert Opinion: - to solve issues that require sufficiently high human experiences. Many expert systems make an effort to achieve solving different site chosen problems that are following with great degree human judgment and experience.

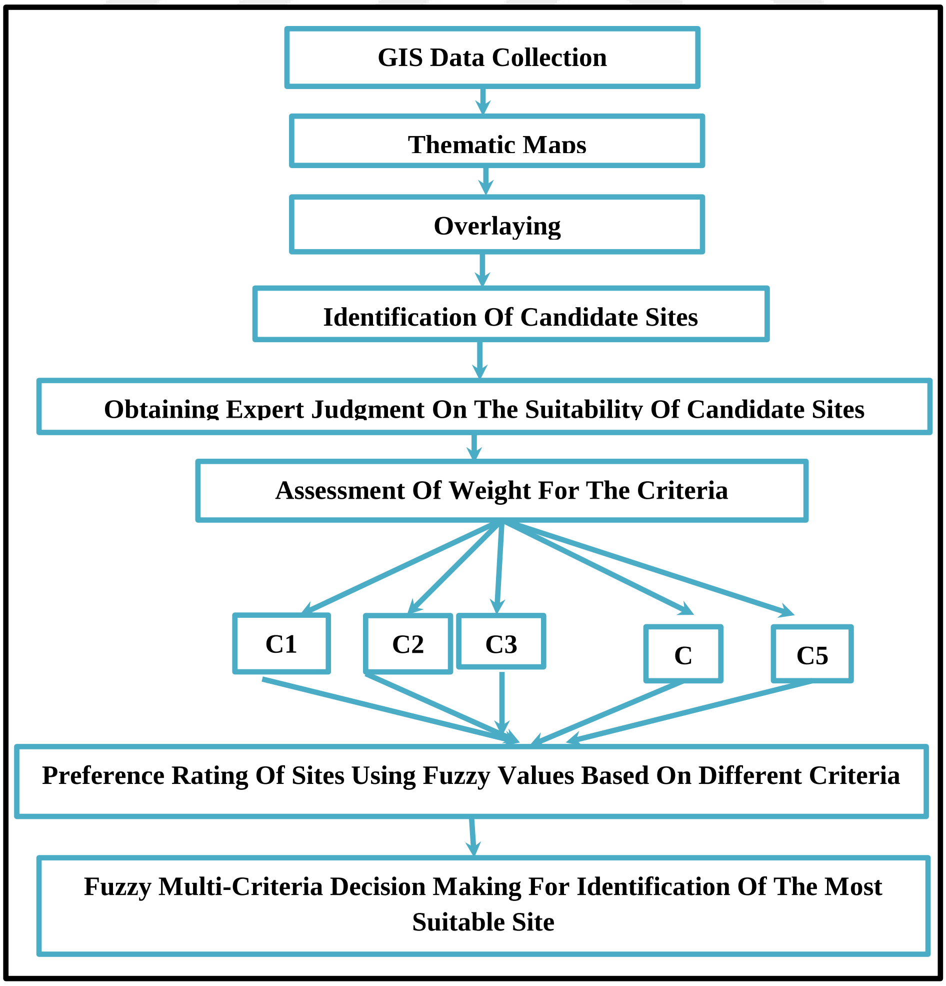
3.3.1 Advantages & Disadvantages Of The Approach

The technique followed in this study varies from the traditional processes of integrating GIS with FMCDM for site selection on the grounds that the approach put up with two successive moves instead of a full-integrated plan. In the main stage, GIS-based analysis of spatial information has been another particular procedure, equipped for analyzing the complex issue of assessing different geospatial features for focusing on potential areas for siting path site. Information accessibility can demonstrate to be a constraining element in its application for the choice of a Metro path; While GIS offers one of kind capacities with respect to mechanizing geospatial investigation for screening all potential sites. Path determination process can prompt to circumstances in which certain criteria, for example, general nuisance, financial components, and impacts on historical markers, may bring about expanded ambiguities in the decision-making prepare because of lacking adequate data. The select sites acquired in the main stage can be determined to utilize a recommended MCDM method. Multi-criteria assessment is fundamentally worried about how to join the data from a few criteria to frame a solitary file of evaluation. The arrangement ordinarily lies in the union (logical OR) or intersection (logical AND) of conditions, that, In the event of Boolean criteria. Be that as it may, for consistent calculates new MCDM handle, a weighted direct mix is a typical procedure

(Voogd, 1983). The criteria are standardized and converted that all factor maps are positively connected with suitability, as they are measured at vary scales. In the most commonly used mechanism is the pair-wise comparison matrix, achieving factor weights is the most difficult part. Area experts in the second stage got engaged, in response to the (fuzzy) status. Thorough the expert judgment and integrating them with the power of fuzzy and MCDM introduced a crystal structure a lot dependent on the inspection values of data sets. Aforementioned can be immensely worthwhile in explaining disputable political civil arguments later on. The benefit of this technique is accordingly put upon the capacity to join the learning of the area specialists in the questionable essential leadership prepare when there is an absence of fresh data identified with specific criteria, for example, opens aggravation and effect of course on recorded markers.

3.4 THE MAIN FRAMEWORK OF METHODOLOGY

Figure 3.1: Methodology framework



3.4.1 Data collection and analysis

GIS data sets of rivers, land-use, roads, wetlands, universities, airports, hospital, etc. were collected for this study from various sources, such as the Ministry of Planning (MOP), the ministry of Transportation (MOT), and IRAQI Geological Survey Department (IGSD).

Geographical features required fir the initial stage investigation could be separated by utilizing ArcGIS programming. For instance, to get GIS information sets of the buffer zone, the land was arranged by making cradle zones around geographic elements to be ensured utilizing writing values broadly employed as a part of the choice process.

3.4.2 Software And Data Acquirement

There are two main kinds of software were used in this project. They are Arc GIS 10.3 tools, Microsoft Excel for fuzzy analytic hierarchy process (FAHP) and Fuzzy TOPSIS as briefly introduced as follows. Arc GIS 10.3 tools, developed by the environmental system research institute of USA, is a set of tools that used for creating maps, linking attribute information with location, visualize and share geographic information and maintain a geographic information in a database. Arc map 10.3, the vital application of Arc GIS 10.3 tools, is mainly used for mapping, analyzing and visualization. In this case study, Arc map is used for digitization and classification of land use, and to generate maps. Arc catalog of Arc GIS 10.3 tools is used to organize and manage spatial data.

3.4.3 Thematic Maps

There are many ways to deal with geographic data in GIS, for example, layer-based approach and feature-based approach and so on. In the layer-based approach, the spatial information are represented to in an arrangement of thematic maps, named layer, which indicate some given subjects, for example, street, building, tram, shape, outskirt, etc. maps in layer-based approach are composed as following step:

a- Analyzing the specific property of target map, deciding the subject of layers which will be isolated.

b- Making the layers relying upon the topics, individually.

c- Making the ordering information for each layer.

3.4.3.1 School

The GIS layer for schools contains school sort data including the primary and secondary school. It includes a mix of school and instructive office addresses. The information contains chose fields signifying the physical address, school number, district, and contact data for schools situated in Baghdad.

3.4.3.2 Universities

The physical addresses and contact data for college and university depended on information. The layer contains a field that portrays the sort of type and was utilized to decide the quantitative.

3.4.3.3 Health Centers

The GIS layer for health centers contains data on medicinal services facility types such as clinics, hospitals, ophthalmology facilities, and Red Cross centers. This dataset contains fields denoting the physical address, type, and contact information for health care facilities situated in Baghdad.

3.4.3.4 Residential

The residential and destination locations of the population are the most important factor in determining which metro routes should implement. Obviously, those areas that have a greater percentage of population deserve to have higher quality transit services.

3.4.3.5 Agricultural

The GIS layer for agricultural contains land type information such as farm, forest, orchards, and so on. The data contains fields denoting the physical address and facility type information for agricultural land located in Baghdad.

3.4.3.6 Industrial

The GIS layer for industrial zones contains land type information such as factories, markets, storages; and so on .The data contains fields denoting the physical address and facility type information for industrial zones located in Baghdad.

3.4.3.7 Buffer Maps

Maps with buffer zones for hospital, schools, universities, residential, industrial zones and agricultural lands exhibit the permissible distance beyond which the metro routes can be sited for various criteria using the buffer option in ArcGIS 10.3.

3.4.4 Overlay Maps

Overlaying is to put at least one thematic layers on top of each other to see their spatial relationship. Moreover to visual examination, GIS offers potential computational outcomes to create new layers by given the info layers. Vector overlaying is a moderately complex computational errand. The function utilizes geometric changes like identity and intersects, union, which is considered as geoprocessing instruments. They are fundamentally accessible in point-in-polygon, line-in-polygon, polygon-on-polygon overlaying. It is vital that information is topologically right. The computational overlaying procedure will make new data layers however it is still possible to outwardly survey the spatial relationship between components. Vector is appropriate for this sort of undertakings. Furthermore, the topology can be used as a part of spatial questions to choose highlights from one layer in light of elements in another layer. In ArcView, Spatial issues' yield should be spared in the database keeping in mind the end goal to save new layers.

3.4.5 Identify Candidate Sites

3.4.5.1 Route Alternative 1

This line which shown in figure below has 11.75Km and start from ALlqiaa square and end by Bayaa passing through AL Mansour , Kindy Street ,Al nsoor square, Qahtan square, Al quadissiya ,Saydyaa.

Table 3.1: Advantages And Disadvantages for first alternative

Location Of The Station	Advantages	Disadvantages
Al-Liqaa	Availability of land	generally residential
Al-Mansour	Commercial area	Absence of space for new infrastructure
Al-Harthiyah	Commercial area	difficult to get land
Al-Yirmook	Large population Health center	inhabitance living near to the station
Al-Qadisiyah	Large population Medicine campus	inhabitance living near to the station
Al-Saydyah	Availability of land Engineering collage	many infrastructure in the same point: highways,
Al-Bayaa	Industrial area bus stations	Absence of space available

3.4.5.2 Route Alternative 2

This line length 8 Km which start from Ziyouna and end with Baghdad university passing through Alshaap international stadium street ,Al andulus square, Karada khramana square, karada dakhil, karada kharij , Alhurria square.

Table 3.2: Advantages And Disadvantages for second alternative

Location Of The Station	Advantages	Disadvantages
Ziyouna	Availability of land	residential function
Al-Shaab	government centers	Lack of possibility passengers

	sport centers	for nearer the station.
Al-Andulas	Health centers Collages	Absence of space for new infrastructure
Kahramana	government centers	Absence of space for new infrastructure
Karada Dakhil	Large population Commercial area	inhabitance living near to the station
Karada Kharij	Large population Commercial area	inhabitance living near to the station
Kamal square	Industrial area bus stations	Environment with high value .
Jadriyah	Baghdad University Connection with other side across river	many infrastructure in the same point: highways,

3.4.5.3 Route Alternative 3

This line length 16.37 km start from Alsadar city and end in Bab alsharqi passing through sector 51,sector 42 , sector 24, sector 17 , sector 60 , sector 59 , Jamila, Talbeeya, Almowal square, Palestine street , Beirut square , Al nhdha square , Shorjah ,Sinak

Table 3.3: Advantages & Disadvantages for third alternative

Location Of The Station	Advantages	Disadvantages
Sector 50-51	Large population Schools	generally residential
Sector 45	Large population Schools	generally residential
Sector 24	Large population Schools	Absence of space for new infrastructure
Jamila	Industrial area Commercial area	Absence of space for new infrastructure

Talbeeya	Industrial area Commercial area	inhabitance living near to the station
Qahira	Large population Commercial area government centers	inhabitance living near to the station
Mustansiriya	Mustansiriya University Parks	Environment with high value .
Palestine Street	Large population Commercial area Health centers	many infrastructure in the same point: highways
Nihdah	Public and privet bus stations Industrial area Religion area	Dense urban area Low residential
Shorja	Commercial area Large population Tourist destination	difficult in to get land
Bab Al Sharqi	Public and privet bus stations Commercial area government centers Health centers Connection with other side across river	Absence of space for new infrastructure

3.4.6 Identification Criteria & Sub –Criteria

Table 3.4: Name and short name for criteria and sub criteria

No.	Name Of Criteria And Sub – Criteria	Short Name
C1	Technology – Infrastructure	TI
C11	Design And Analysis Infrastructure	DI
C12	Technologies For Metro Site Characterization	TC
C13	Construction Logistics	CL

C2	Suitability With Baghdad Features And Growth Plants	SG
C21	The Proximity To Different Facilities	PF
C22	Employment Intensity	EI
C23	Land Availability	LA
C3	Occupant Service	OS
C31	Metro Station Locations	SL
C32	Time Accessibility	TA
C33	Services For Areas Of Destitute	SA
C4	Nature And Ecology	NE
C41	Nature Reserves	NR
C42	Encroachment To Critical Areas	EA
C43	Fitting With Environment	FE
C5	Institutional	IN
C51	Interconnectivity	IE
C52	Maximize Linkage To Vital Growth	ML
C53	Minimize Land	MA

i. Technology – Infrastructure (TI)

Society is more and more dependent on electronic, mechanized, remote, and arranged sensor frameworks to screen cooperation and educate robotized or human on the up and up choice structures; notwithstanding, such information accumulation frameworks are not guaranteed. New technologies that minimize the costs of the process of metro line and its facilities .More excellently design and organization options for the reuse of current characteristic of a city infrastructure and creating multi-utilize options at a later time such as new design connotations for facilities that are easier to repair or modify for further improve service life furthermore get the better potential for sustainability.

a- Design And Analysis Infrastructure (DI)

Project limitation such as authorities of way and apertures can influence picking of project alignment, and physical limitation like those related with water plumb gravity process , highest grade (for construction and operation), and-and shaft area additionally may influence plan decisions. Design and analysis of infrastructure are regularly vigorously centered on the quick opening and support of underground space; long haul issues identified with maintainable upkeep and utilize frequently ignored, as are lifecycle commitments of the foundation to society.

b- Technologies For Metro Site Characterization (TC)

More great decision making supported by excellent subsurface characterization. Reducing unanticipated land circumstances may permit make the best or most efficient design and more rational use of resources through construction.

c- Construction Logistics (CL)

Construction logistics is clearly identified to inspect the accessibility, signification. Which are documents, set by developers, and layout the arranged logistic activity linked with a specified construction project, and which are intended to act as the substance that for reducing the passive results of construction work on region occupants, and on the region circumference in light of crowding, contamination, and safety.

ii. Suitability With Baghdad Features And Growth Plans (SG)

This sub criteria point out to the physical relevance of insert a new metro path to the current transportation system already in place in Baghdad. So when a new way is being inserted into a system, it’s the relationship between the path and the system must be considered, and it must focus on the metro routes and its relation to Baghdad features and growth plans as a whole without influence to future plans or change in features.

a- The Proximity To Different Facilities (PF)

The proximity to different facilities of any zone can be delineated by how far the zone can cover within the specific time by the particular method of transportation. In addition, it can likewise consider what number of the populace can be served from a particular area inside a specific time by the particular method of transport.

b- Employment Intensity (EI)

Ordinarily, job travels represent an account equal to a half of the number of passengers using a particular form of public transportation, so employment intensity appears as the amount of works per square mile.

c- Land Availability (LA)

Construct metro line requires accessibility of available ground. This sub -criteria considers the capacity of an area to grow by on a level plane. Another coordination improvement will probably demand more land and framework. These sub-criteria can be covered by arranging the ground where there is a site then characterizes how much land can be utilized for the advancement of a coordination centers. Additionally, the land estimate likewise decides in a roundabout way the accessibility of land, if the land cost is low, the more probable it is to be unused and which is the key for the organization to build up another coordination center point.

iii. Occupant Service (OS)

This is based on the relationship among weekday ridership, temporal distribution of travel and peak service supply. The productive utilization of energy, encourage support and advance smooth and efficient operation of the metro lines. The person on foot route ought to be free from unexpected obstacles and limit bottlenecks should be evaded. Give powerful way discovering means, for example, signs, markings, and finished surfaces, and minimize clashing streams and travel distance.

a- Metro Station Locations (SL)

To perform main occupant destinations and to make proper integration with other kinds of transport it must locate adequate stations. Arranged and the average position at a distance from one another of stations is approaching to one km as able to be done. For that, the effort has also been made to put forward station positions and coordination of possibilities at metro stations cover approach ways to the stations, pervasion facilities, pedestrian paths and pervasion areas for various kinds of transportation apparently suitable to important stations, inclusive feeder buses , car-park for personal vehicles.

b- Time Accessibility (TA)

The metro accessibility means that the travelers' interest is request to get the availability of time and space in the meantime. Time availability is to request enhancing the running velocity of metro transport from the effectiveness of administration and shortening the period of transport trip, while space availability requests expanding the perfusion of metro routes and metro stations to get transport services helpfully.

c- Services For Areas Of Destitute (SA)

This systems would present service for densely populated areas and specially disadvantaged zones , which might growing tourism attraction areas.

iv. Nature & Ecology (NE)

It is necessary to separate ecologically reserved areas with possible decision areas. The metro system will be designed to minimize harm to the earth amid site development; preservation of ecology will score high, so it is important to isolate environmentally saved ranges with conceivable choice regions.

a- Nature Reserves (NR)

It is necessary to separate ecologically reserved areas with possible decision areas. The metro system will be designed to minimize harm to the earth amid site development; preservation of ecology will score high, so it is important to isolate environmentally saved ranges with conceivable choice regions.

b- Encroachment To Critical Areas (EA)

Very little encroachment into environmentally sensitive and reserved areas during structure further forward. The metro system will be designed to minimize encroachment to the environment; minimizing encroachment rate will score high.

c- Fittings With Environment (Noise/Air/Visual Pollutions) (FE)

The minimum amount of fuss effect to touchy land utilize, (for example, clinics, private structures, and schools) amid site development, low level of clamor will score high and in the same manner, a diminishment in vitality utilization, negligible emanation levels amid site development, minimization of discharges will rank high.

v- Institutional (IN)

This aim to find a simulation between the transit system and spatial policies of the government/urban city:-

a- (IE) Interconnectivity to existing public transportation systems.

b- (ML) Maximize linkages to vital growth centers (as designated/proposed in local plans), to provide proper linkages among cities and suburban railway networks, airports, long-distance bus stations, park.

c- (MA) Minimize land acquisition**.**

3.4.7 Find Weight Of Criteria Using Fuzzy Analytic Hierarchy (FAHP)

There are several methods of FAHP. These techniques have methodical approaches to the prioritization of criteria, alternative selection, and justify the problem. It can be shown with brief information about many of these technologies (Bozbura et al. 2007). In this study, Buckley’s FAHP is used to determine the fuzzy weights. The procedure can be reviewed as follows: The decision makers use a linguistic scale and corresponding triangular fuzzy numbers to express opinions about importance weights of criteria and sub-criteria are pulled using pair-wise comparisons which are given in Table 3.5.This combination of individual pair-wise comparisons is formed individual decision matrices as :--

$$C^{k}= \left| \begin{array}{cccccc} 1 & C^{k}_{12} & . & . & . & C^{k}_{1n} \\ C^{k}_{21} & 1 & . & . & . & C^{k}_{2n} \\ . & & . & & & . \\ C^{m1}_{m1} & C^{k}_{m2} & . & . & . & 1 \end{array} \right| \qquad (3.1)$$

Table 3.5: Linguistic scale of FAHP

Linguistic Scale	Triangular Fuzzy Number
Just Equal	(1,1,1)
Equally Important	(1,1,3)
Weakly Important	(1,3,5)
Essentially Important	(3,5,7)
Very Strong Important	(5,7,9)
Absolutely Important	(7,9,9)

In the matrix, c^k_{ij} corresponding to the comparison of criteria i and j by decision maker k. That represents the triangular fuzzy number, While forming the matrices, it should be noted that

$$\mathbf{C^k_{ij}} = \begin{cases} \mathbf{i>j} & \mathbf{(1,1,3),(1,3,5),(3,5,7),(5,7,9),(7,9,9)} \\ \mathbf{i=j} & \mathbf{(1,1,1)} \\ \mathbf{i<j} & \mathbf{(1/3,1.1),(1/5,1/3,1),(1/7,1/5,1/3),(1/9,1/7,1/5),(1/9,1/9,1/7)} \end{cases} \qquad \mathbf{(3.2)}$$

Where

i>j represent that criterion i is more important than criterion j,

i = j refers that these two criteria are exactly equal,

i<j denotes that criterion j is more important than criterion i.

If j>i, then the fuzzy reverse of the triangular fuzzy number in Table 1 is used as stated in Eq.3.2 .In Eqs. 3.2, 3.3, 3.4, 3.5 the extension principle is applied.

The extension principle extends the standard arithmetic operations to the fuzzy case. If there are an individual group of the decision, an aggregated decision matrix (~A) is constructed to satisfy each decision maker. Using geometric mean to get such an aggregation, this is taken for every pair-wise comparison as

$$\mathbf{a_{ij}} = \sqrt[k]{\boldsymbol{Cij^1} \times \boldsymbol{Cij^2} \times \dots . \times \boldsymbol{Cij^k}} \qquad \mathbf{(3.3)}$$

Where K is the number of decision makers and $\otimes$ is the fuzzy multiplication sign. In this study, we do not need to apply this equation because we have one group of expert that agreed to obtain a unify opinion so we will skip this step

Now, calculate the fuzzy weight matrix by Buckley's Method as adapted from Kahraman and Cebi (2009) as follows:-

$$\mathbf{r_{ij}} = \sqrt[n]{\boldsymbol{a_{i1}} \times \boldsymbol{a_{i2}} \times \dots . . \times \boldsymbol{a_{in}}} \qquad \mathbf{(3.4)}$$

$$\mathbf{w_i} = \mathbf{r_i} \times (\boldsymbol{r_1} + \boldsymbol{r_2} + \cdots \ldots + \boldsymbol{r_n})^{-1} \qquad \textbf{(3.5)}$$

Where a_{ij} is the fuzzy aggregate comparison value of criterion i to criterion j, r_i is the geometric mean of fuzzy comparison value of criterion i to each criterion, w_i is the weight of criterion i, and $\oplus$ is the fuzzy summation sign.

After all of the fuzzy weights are calculated, centroid the method is used to convert these fuzzy numbers to crisp values by the center of gravity procedure. In centroid method which is the most common method for defuzzification (Opricovic and Tzeng 2004). At first, we need to finish the defuzzification then, normalization follows. These two processes can be implemented simultaneously using Eq. 3.6:

$$\mathbf{W_r} = \frac{w_r}{\sum_{i=1}^{n} w_i} = \frac{w_{rl} + w_{rm} + w_{ru}}{\sum_{i=1}^{n} w_i} \qquad \textbf{(3.6)}$$

3.4.8 Rank Alternatives By Fuzzy TOPSIS

Fuzzy TOPSIS method is an MCDM technique that produced for the elimination of fuzziness stemming from a human judgment in the decision-making process, in solving problems it requiring group decisions and in environments with semantic fuzziness to deal with the deficiency in the traditional TOPSIS. It is based on the fact that the chosen alternative should have the shortest distance from the positive ideal solution and the longest distance from negative- ideal solution. Positive ideal solution is a solution that maximizes the benefit criteria and minimizes cost criteria, whereas the negative-ideal solution maximizes the cost criteria and minimizes the benefit criteria .Decision makers use relevant linguistic variables can be expressed as triangular fuzzy numbers as shown in Table 3.6 (Chen 2000) to evaluate alternatives with respect to criteria.

Table 3.6: Linguistic scale for fuzzy TOPSIS

Linguistic Scale	Triangular Fuzzy Number
Very Bad (VB)	(0,0,1)
Bad (B)	(0,1,3)
Medium Bad(MB)	(1,3,5)
Medium (M)	(3,5,7)
Medium Good (MG)	(5,7,9)
Good(G)	(7,9,10)
Very Good (VG)	(9,10,10)

In this study, the importance weights of the criteria (~wj) are calculated using fuzzy AHP and fed to Fuzzy TOPSIS. Then, the aggregate scores of alternatives against each criterion are calculated using Eq. (3.7).

$$X_j = \frac{1}{k}\left[x_{ij}^{1} + x_{ij}^{2} + \ldots + x_{ij}^{k}\right] \quad (3.7)$$

The result will expressed in the following decision matrix

$$D = \begin{array}{c|cccc|} & C_1 & C_2 & \ldots\ldots & C_n \\ A_1 & X_{11} & X_{12} & \ldots\ldots & X_{1n} \\ A_2 & X_{21} & X_{22} & \ldots\ldots & X_{2n} \\ . & . & . & \ldots\ldots & . \\ A_m & X_{m1} & X_{m1} & \ldots\ldots & X_{nm} \end{array} \quad i=1,2,..m, j=1,2,\ldots,n \quad (3.8)$$

$$W=[W_1, W_2, W_{3,\ldots,} W_n] \quad (3.9)$$

Where A_i and C_j denotes the i_{th} alternative and j_{th} criterion, respectively, x_{ij}, and w_j are linguistic variables described by triangular fuzzy numbers, x_{ij} = (l_{ij},m_{ij},u_{ij}) and w_j= (w_{jl},w_{jm},w_{ju})

Then, Normalized fuzzy decision matrix is indicated with ~R and expressed as in Eq. (3.10)

$$\mathbf{R=[r_{ij}]_{m*n}\ ,\ i=1,2,\ldots.,m\&\ j=1,2,\ldots,n} \tag{3.10}$$

Where

$$\mathbf{r_{ij}=\left(\frac{a_{ij}}{c*_j},\frac{b_{ij}}{c*_j},\frac{c_{ij}}{c*_j}\right)\quad ,\qquad C_j^{*}=\max c_{ij}} \tag{3.11}$$

Then construct matrix from weighted normalized fuzzy numbers take into account the different importance values of each criterion by this equations

$$\mathbf{V=[v_{ij}]_{m*n}\ ,\ i=1,2,\ldots,m\&\ j=1,2,\ldots,n} \tag{3.12}$$

Where

$$\mathbf{v_{ij}=r_{ij}*w_j} \tag{3.13}$$

In the next step, (FPIS and FNIS), the fuzzy positive ideal solution (FPIS, A*) and the fuzzy negative-ideal solution (FNIS, A-) are determined using the following equations (Ertugˇrul and Karakas¸ogˇlu 2008):

$$\mathbf{A^{+}=(v_1^{*},v_2^{*},\ldots\ldots\ldots,v_n^{*})} \tag{3.14}$$

$$\mathbf{A^{-}=(v_1^{-},v_2^{-},\ldots\ldots,v_n^{-})} \tag{3.15}$$

Where

$$\mathbf{v_j^{*}=\max\,[v_{iju}]\ \text{and}\ v_j^{-}=\min\,[v_{ijl}]} \tag{3.16}$$

Then use the formula below to calculate the distance between the alternatives from (A^*, A^-) via these equations:

$$d_i^* = \sum_{j=1}^{n} d(v_{ij}^-, v_{ij}^*) \quad i=1,2,\ldots,m \qquad (3.17)$$

$$d_i^- = \sum_{j=1}^{n} d(v_{ij}^-, v_{ij}^-) \quad i=1,2,\ldots,m \qquad (3.18)$$

d is the distance measurement between two fuzzy numbers. The distance between two triangular fuzzy numbers $A_1 = (a_1, b_1, c_1)$ and $A_2 = (a_2, b_2, c_2)$ is calculated by:-

$$d(A_1, A_2) = \sqrt{\frac{1}{3}\left[(a_1 - a_2)^2 + (b_1 - b_2)^2 + (c_1 - c_2)^2\right]} \qquad (3.19)$$

At the end, we need to find the closeness coefficient (CCi) of each alternative by using Eq. (3.20)

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-} \quad i=1,2,\ldots m \qquad (3.20)$$

And the alternatives are ranked according to their closeness coefficient (CCi) in descending order.

Therefore, the alternative with the highest CCi value will be the best choice which can be decided according to the priority order of options that found from closeness coefficient (Ozcakar and Demir 2011; Chen et al. 2006).

3.5 DESIGN OF THE QUESTIONNAIRE

The questionnaire form was designed and filled out via transportation experts (specialists in the field of transportation engineering) to gather their opinions. A group consist of 20 experts is selected to work together and fill out the designed questionnaire and reach to final opinion for evaluating the criteria by multiple and avoids the bias decision making and provides impartiality. The experts were asked to assess the importance of each criterion on according to Table (3.5) scale to give the relative rating of two criteria. They gave these final evaluation matrixes which contain the criteria main criteria technology – infrastructure, Suitability with Baghdad features and growth planes, occupant services, Natural and ecology, Institutional.

4. CALCULATION & RESULT

Baghdad is a standout amongst the most thickly populated places in the world, with an aggregate zone of (204,2 km²), a populace of more than(7,216,040) million. Numerous outer and inner political, monetary and social weights have been subjected on Baghdad that prompts poor financial conditions for its populace. Decision making is a standard action that is combined with people and associations. People produce on choices affected by area when they pick a store to shop, a way to drive, or an area for a place to live. Associations are very little unique in this regard. They consider the substances of the organization while selecting a site, picking a land advancement technique, allotting assets for general health, and overseeing frameworks for transportation or open utilities. Decision making is an exceedingly complex procedure of choosing among different options to achieve a goal or an arrangement of destinations under imperatives.

The quick incensement in Baghdad populace was the consequence of raising the request for transportation framing traffic blockages in numerous lanes of the city. Also, it can suspend activity development, particularly amid going to works, schools, colleges, and different spots. A standout between the most vital parts of the transportation frameworks is public transportation.

The new structure extends particularly road systems were developed to match the high request on basic transportation. In any case, the development was with somewhat logical base arranging.

Figure 4.1: Baghdad General Map

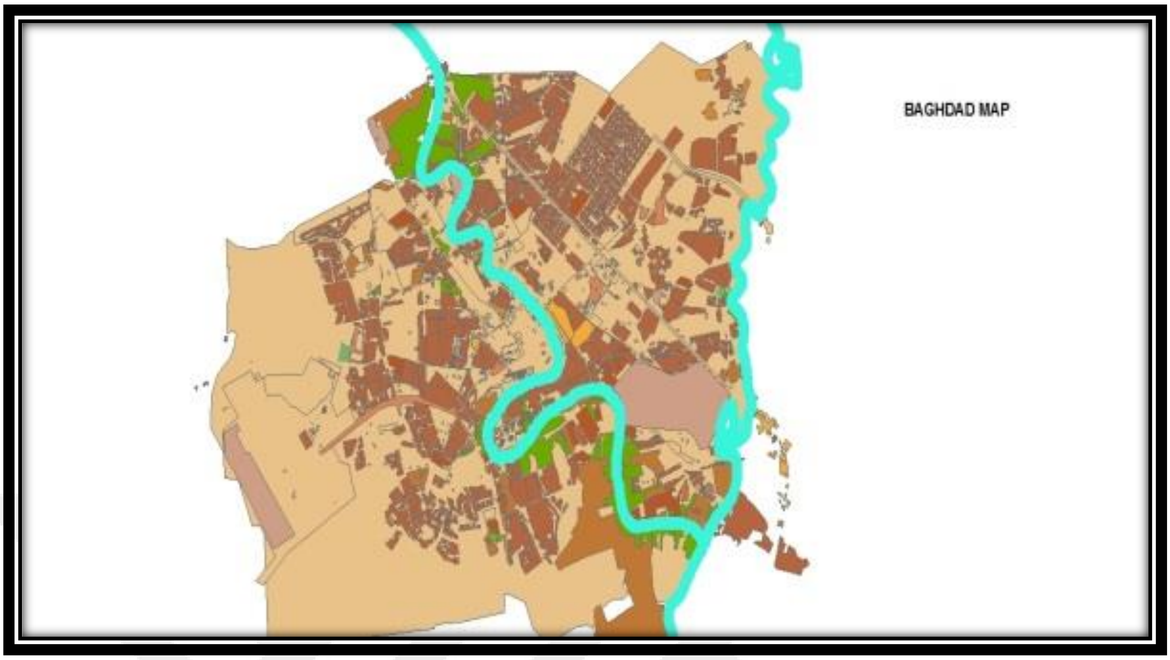
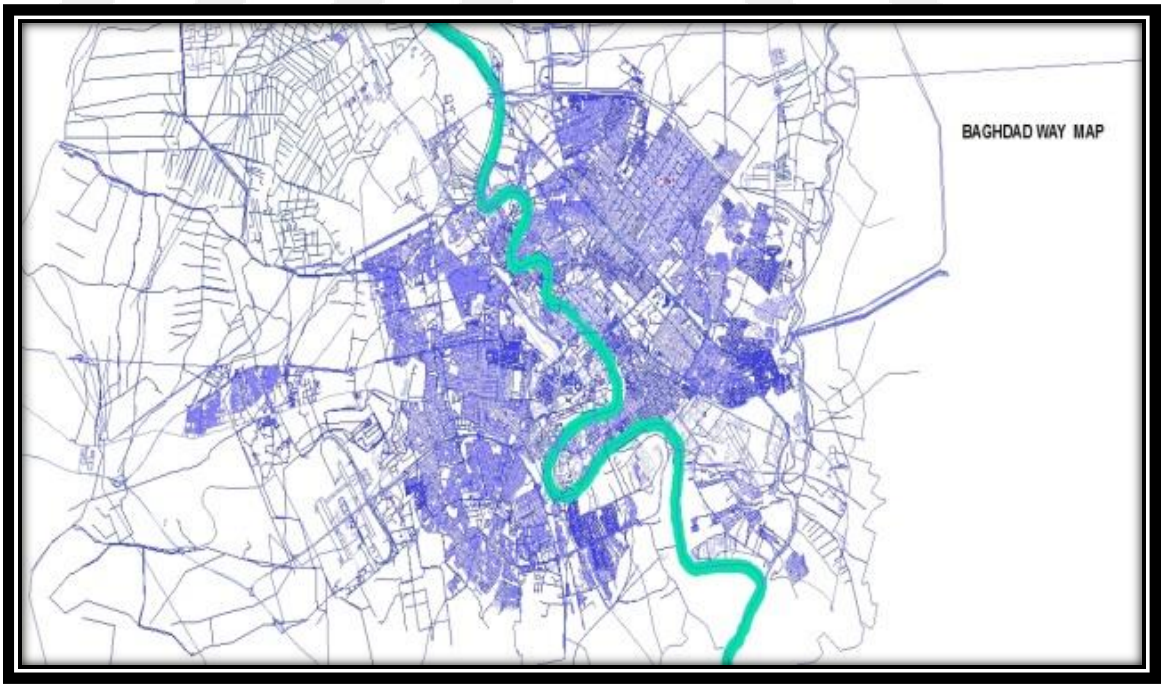


Figure 4.2: Baghdad Way Map



4.1 CASE STUDY

Route selection is a complicated procedure requiring a firm evaluation over an immense range to distinguish reasonable area for selecting metro lines subject to various criteria. GIS offers the spatial analysis capabilities to eliminate all unsuitable area for metro lines quickly. Identification of suitable candidate sites based on given criteria done by employed GIS to perform a screening process. The first-stage analysis examination utilizing GIS is essential for identification of appropriate metro lines sites previous of reasonable subway lines destinations preceding undertaking further examinations or field examinations. Despite the fact that, the underlying screening depends on criteria identified with natural and environmental components required in the site choice process, there are certain criteria, for example, the effect on general markers, public comfort, and monetary elements for which information are not promptly accessible. A second-stage examination in light of a modest bunch of reasonable destinations from the underlying GIS screening was implemented with the goal of including the assessments of space specialists in the area through an FMCDM approach. FMCDM was helpful in tending to the issue of the absence of accessibility of information for certain essential criteria and also to consolidate human judgment into the choice procedure that can demonstrate valuable in the fathoming political level headed discussions later on. The second-organize investigation utilizing FMCDM was connected to rank the proposed candidate sites and brief the last choice.

4.2 SELECTION MECHANISM

To solve site selection issues there is need to combine three tools which are:-

i. Geographic Information Systems (GIS).
ii. Expert Opinion (EO).
iii. Fuzzy Multi-criteria decision-making (FMCDM).

Information which required for this study comprised of local and non- local (illustrative). Urban maps with the size of 1:10,000 and in coordinate 33° 18`46.10``N and 44°21`41.36``.

The accompanying criteria were applied for Metro route site determination:

a- Proposed alternatives should be an averted tunnel, bridges.
b- Suggested alternatives should pass through major road.
c- Recommended alternatives should serve high residential density and pass through the area which serves a broad range of people (contain hospital, school, and university) .

Figure 4.3: Layer Maps

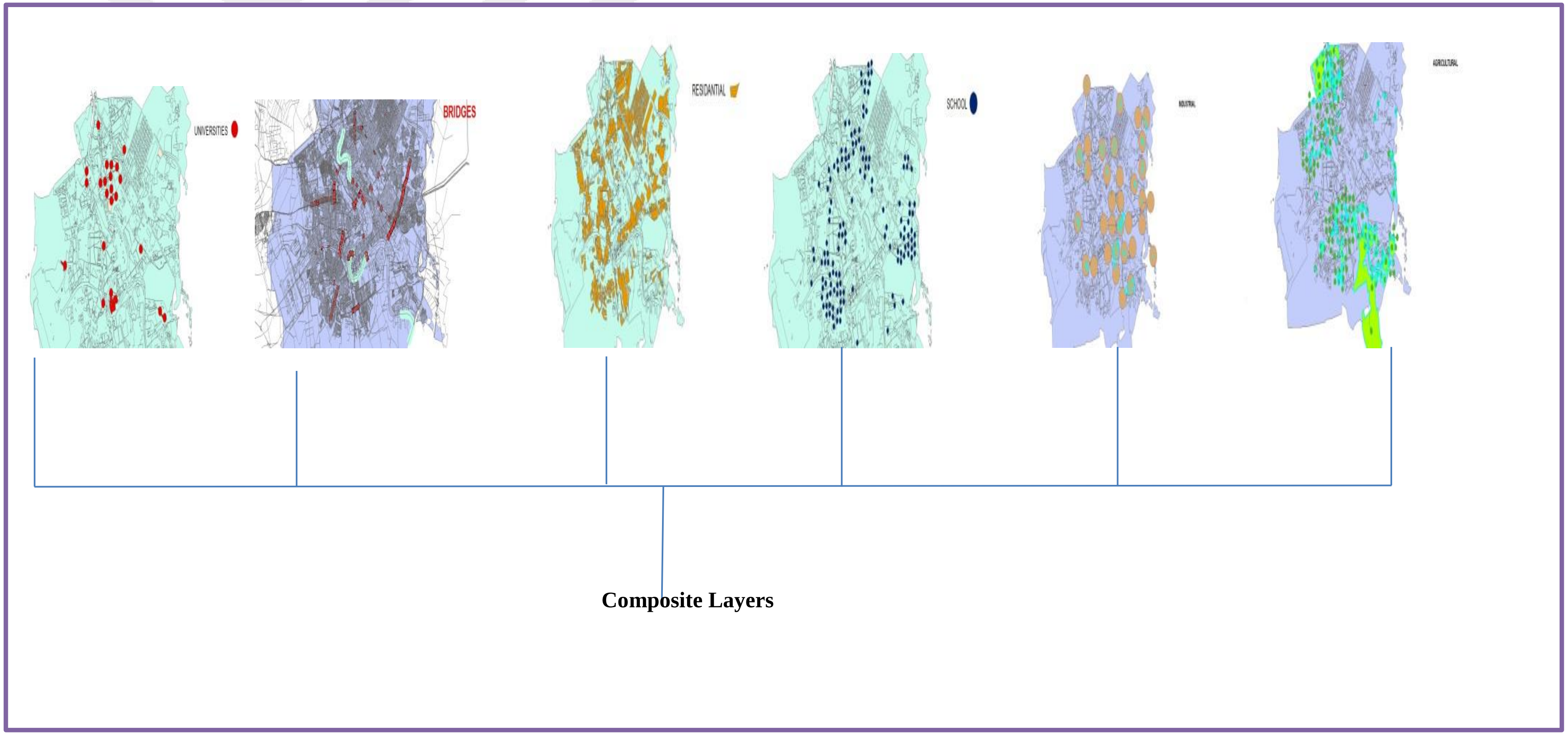
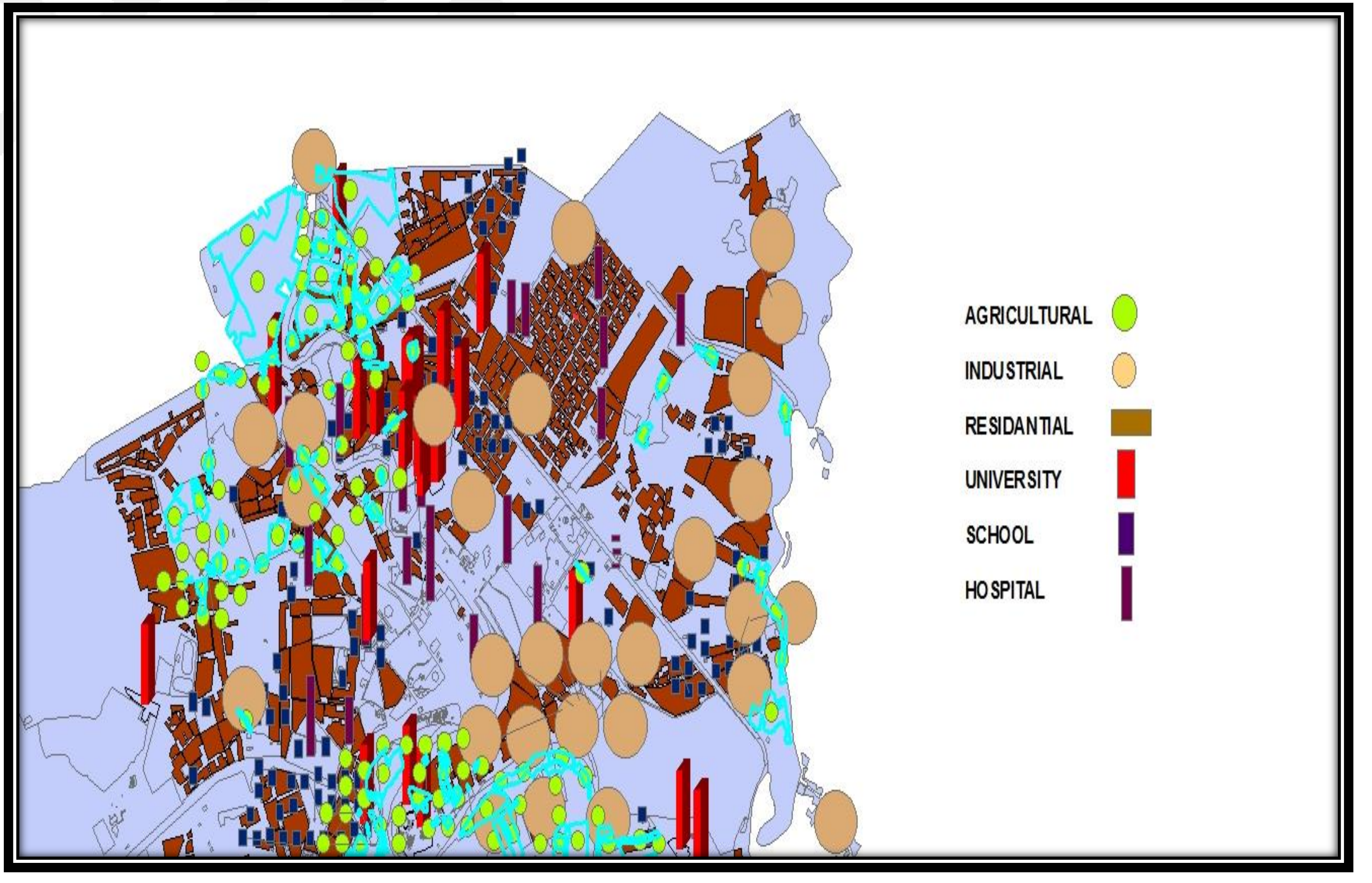
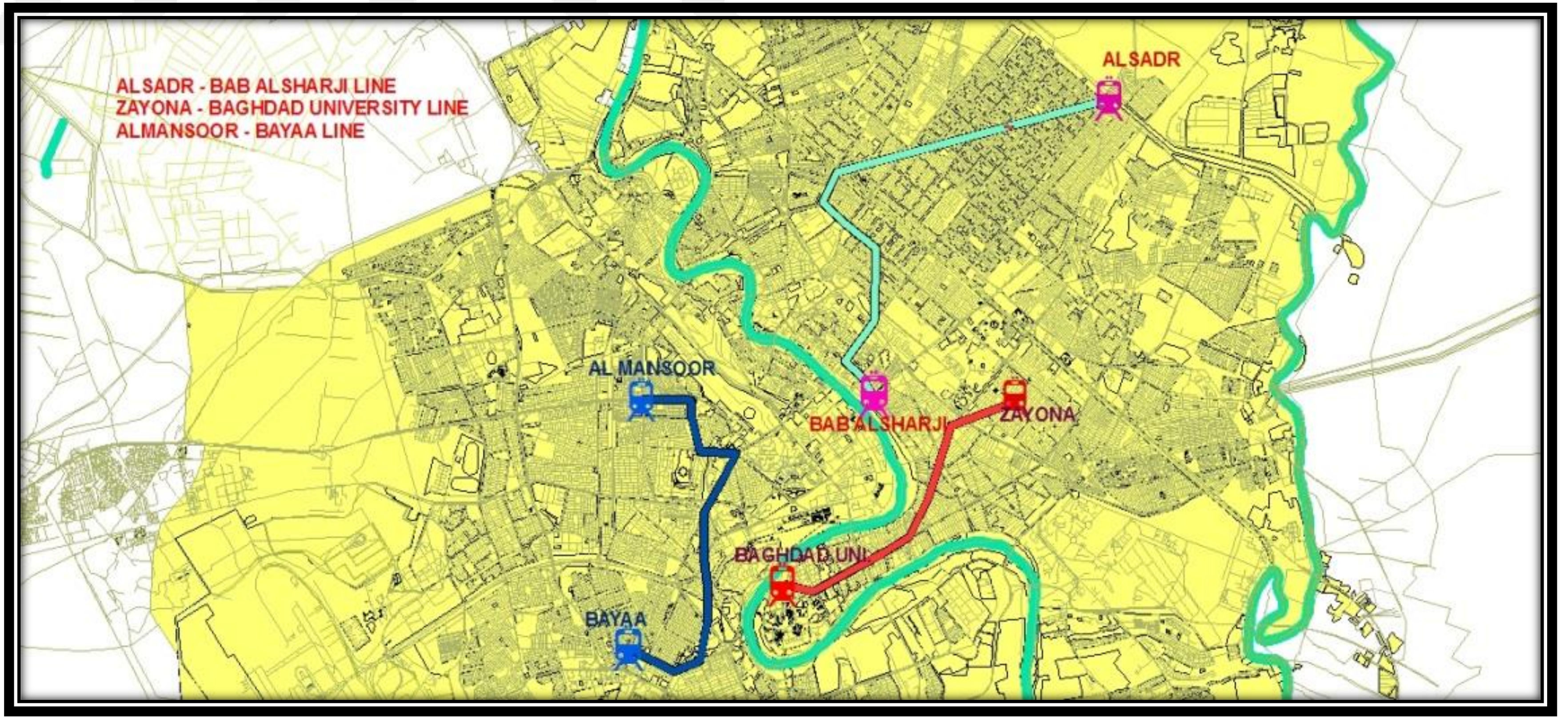


Figure 4.4: Combination Layers In Map



So we got these three alternatives

Figure 4.5: Alternatives Map



After that we made buffering via GIS to get 500m distance from each alternative to the facilities we get this maps

Figure 4.6: School Buffer Map

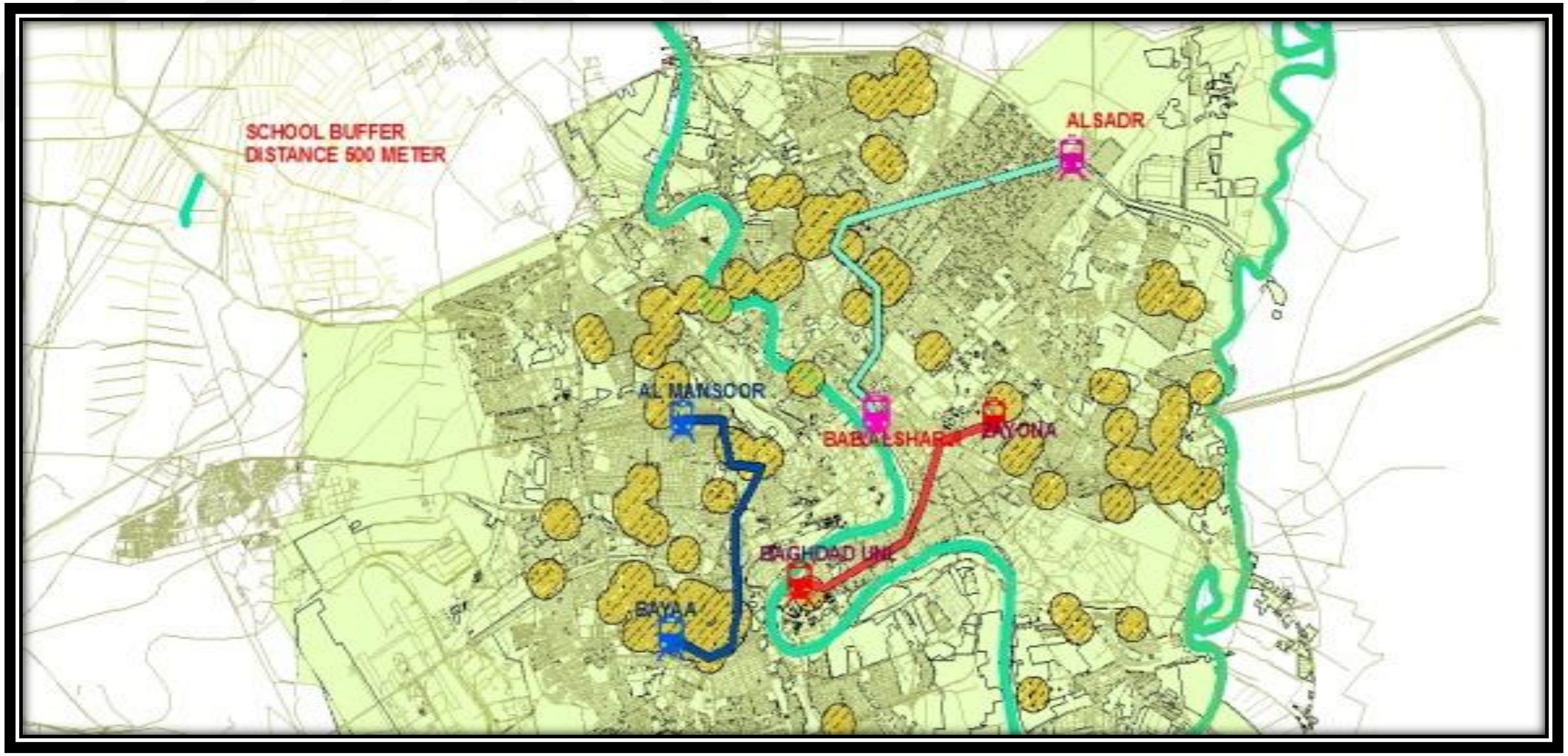


Figure 4.7: University Buffer Map

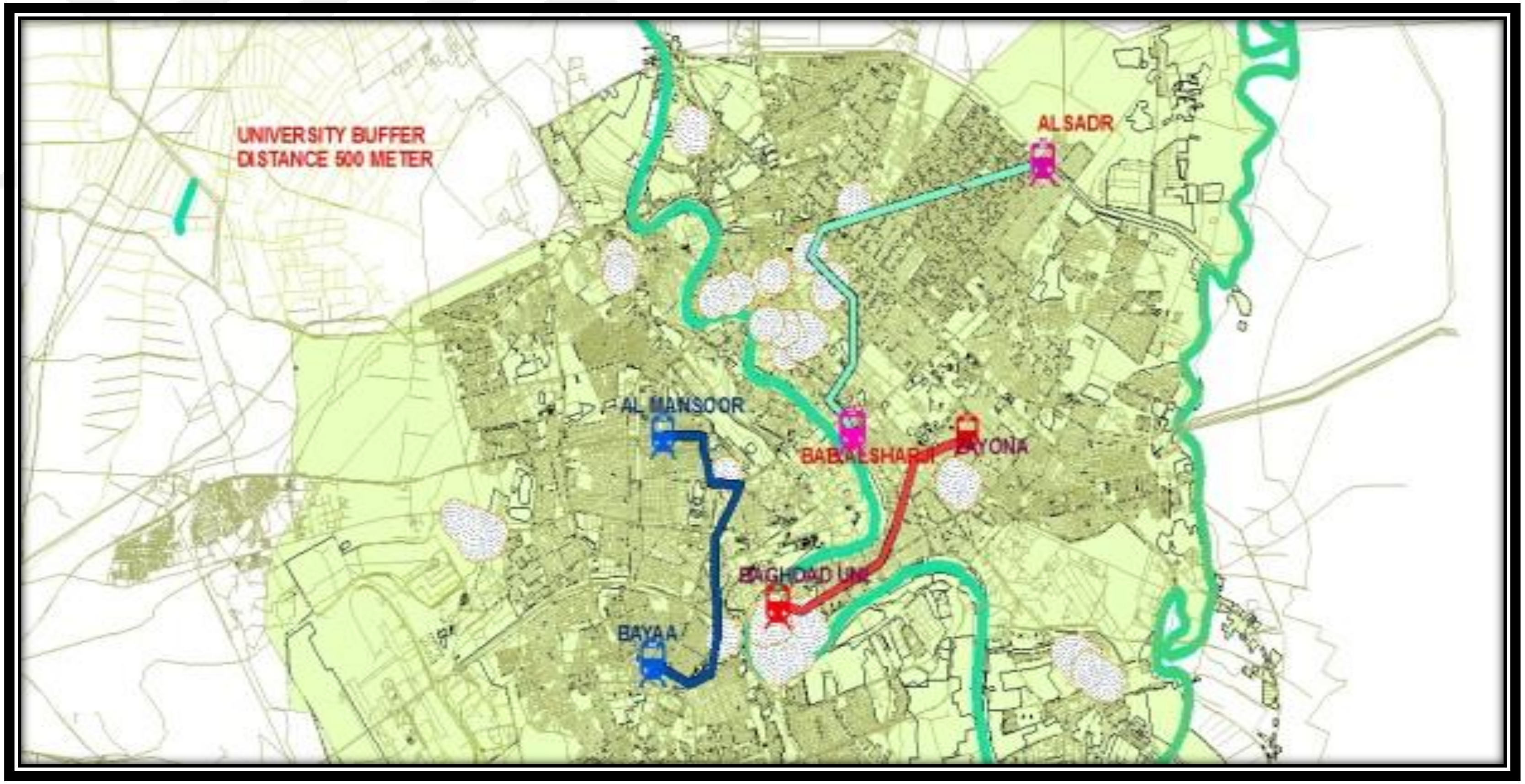


Figure 4.8: Residential Buffer Map

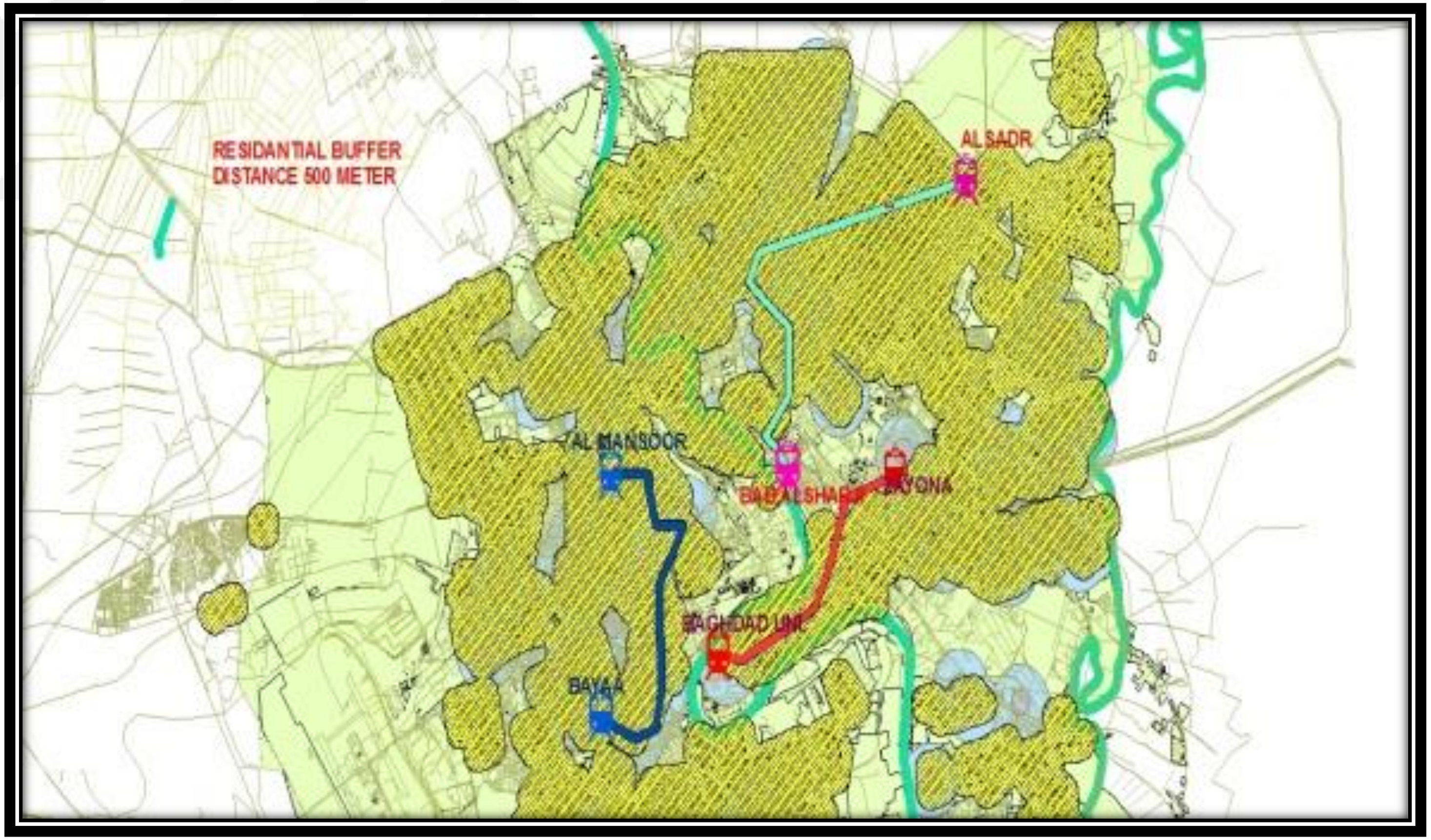
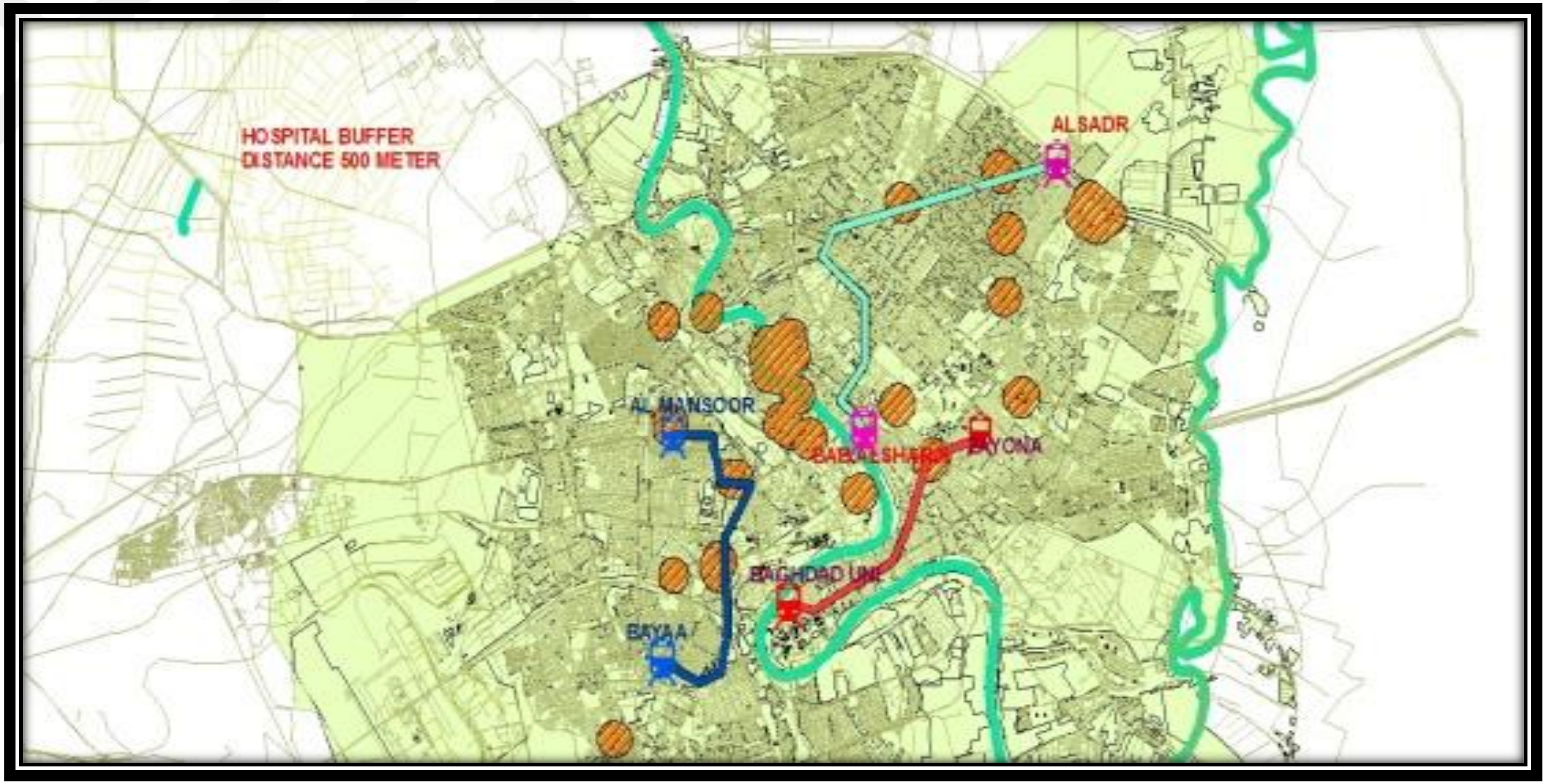
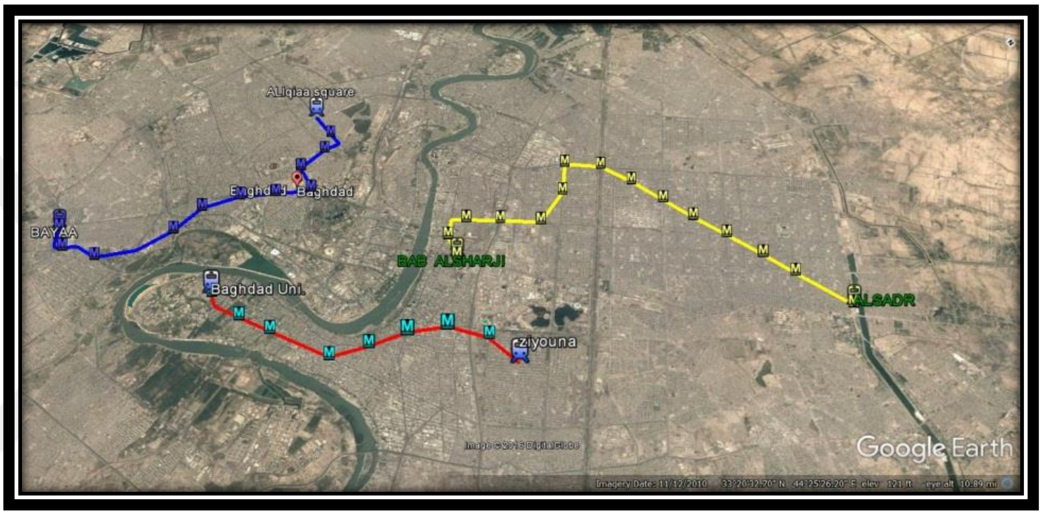


Figure 4.9: Hospital Buffer Map



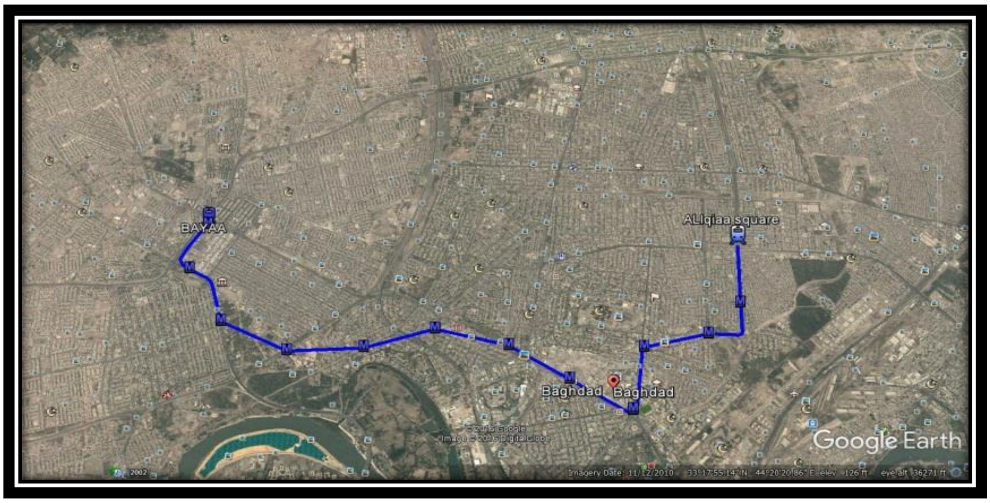
So as to decide the capability of each zone inside the study region, the main alternative included utilizing GIS along with Overlaying. Next, the best choice for the metro route was selected by weighting judging criteria in Fuzzy Analytic Hierarchy Process (FAHP) and Fuzzy TOPSIS. Which is an adaptable, straightforward, and successful technique utilized for necessary leadership while clashing basic leadership criteria entangle looking for the best option, Depend on these criteria; the following routes options are introduced as follows:-

Figure 4.10: Alternatives Map



Route Alternative 1:-

Figure 4.11: Alternative 1 Map



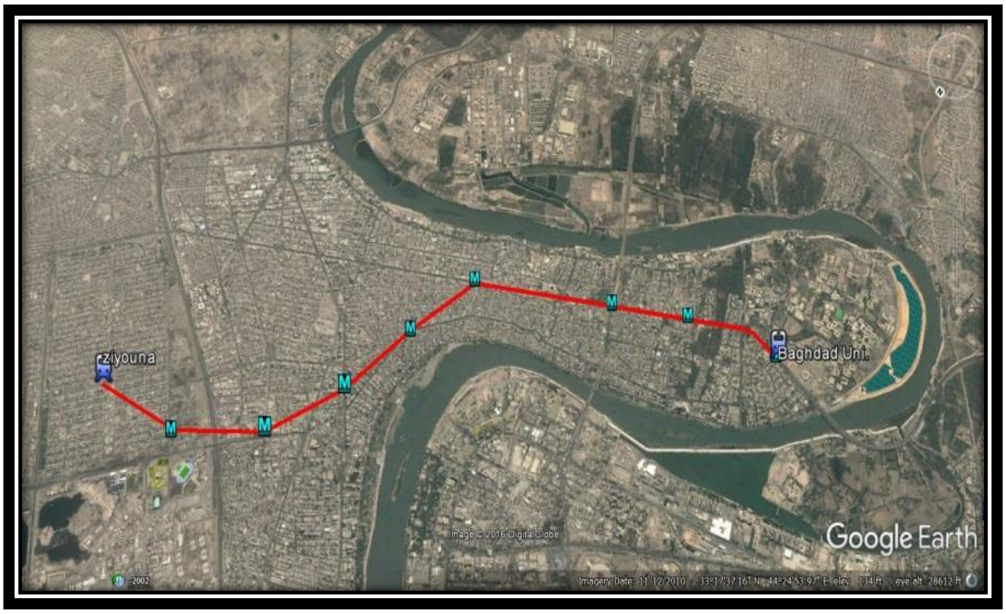
The distances for each station and the sketch for the line are shown in Table 4.1

Table 4.1: Alternative 1 Station

	Distance (km)
Al-Liqaa	0
Al-Mansour	1.4
Al-Harthiyah	2.41
Al-Yirmook	1.87
Al-Qadisiyah	3
Al-Saidiyah	1.2
Al-Bayaa	1.87

Route Alternative 2

Figure 4.12: Alternative 2 Map



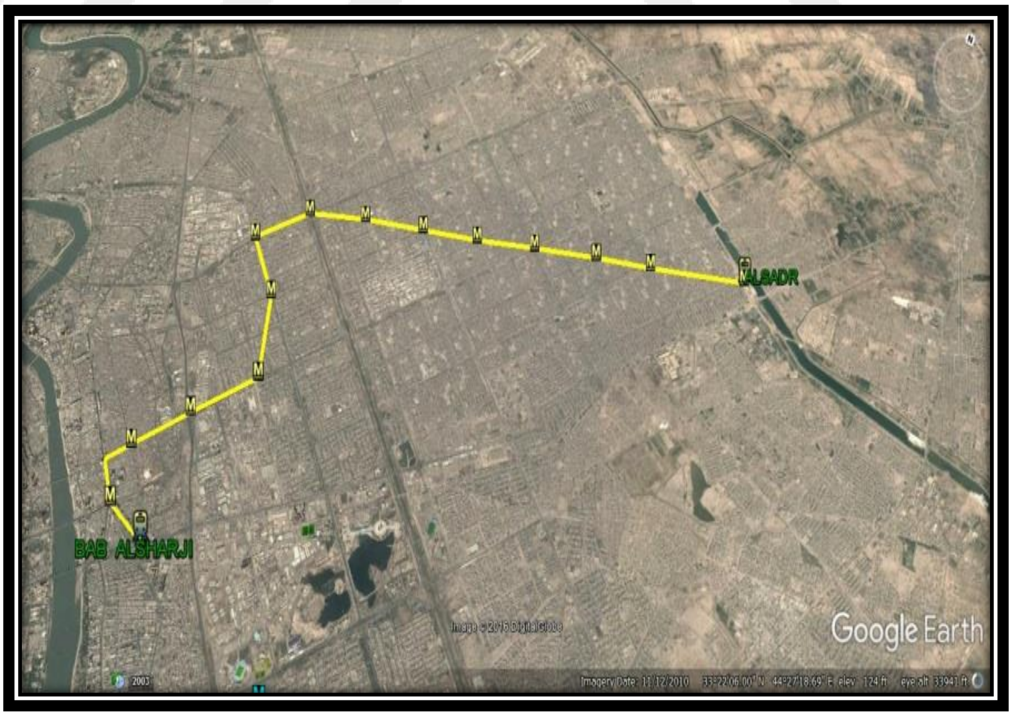
The distances for each station and the sketch for the line are shown in Table 4.2

Table 4.2 Alternative 2 Stations

	Distance (km)
Ziyouna	0
Al-Shaab	1
Al-Andulas	1
Kahramana	1
Karada Dakhil	1
Karada Kharij	1
Kamal square	1
Jadriyah	2

Route Alternative 3

Figure 4.13: Alternative 3 Map



The distances for each station and the sketch for the line are shown in Table 4.3

Table 4.3: Alternative 3 Stations

	Distance (km)
Sector 50-51	0
Sector 45	1.46
Sector 24	1.46
Jamila	2.36
Talbeeya	2.61
Qahira	1.84
Mustansiriya	1.14
Palestine Street	1.3
Nihdah	1.7
Shorja	1.3
Bab Al Sharqi	1.2

4.3 CONSISTENCY OF MAIN STANDARDS

In this study, the primary criteria's are applied as the groups/or components. More great value criteria and sub-criteria are specified containing all feature parts of metro line site selection. However, the managers can develop any criteria which are strictly correlated to the line under careful thought.

Criteria are very important in this project, and in this section, different criterion is going to be determined. The suggested framework is a straightforward structure where the criteria (5) have been considered as main and (3) sub-criteria for each main criteria. It has been chosen to examine all the factors. Consequently, the components of the issue have been sorted out as per five main/or significant criteria, factors. The vital thing is not to have numerous components to compare through the term of relative judgments since the choice guide apparatus ought not to be cleared as problem-solving operations that can give the suitable solution. However, it ought to rather bolster the DMs who have to make an orderly investigation of the option arrangements and who is exclusively in charge of the last decision. In this sense, for each of the significant criteria, the quantity of the components is restricted, and they are examined about as for their major criteria's.

The major criteria's and their symmetrical sub-criteria selection are based only on the group of experiences Iraqi Engineers. Consequently, the components (sub criteria's) may come up with opposite concepts.

4.3.1 Criteria Framework & Description

Figure 4.14: Decision Tree

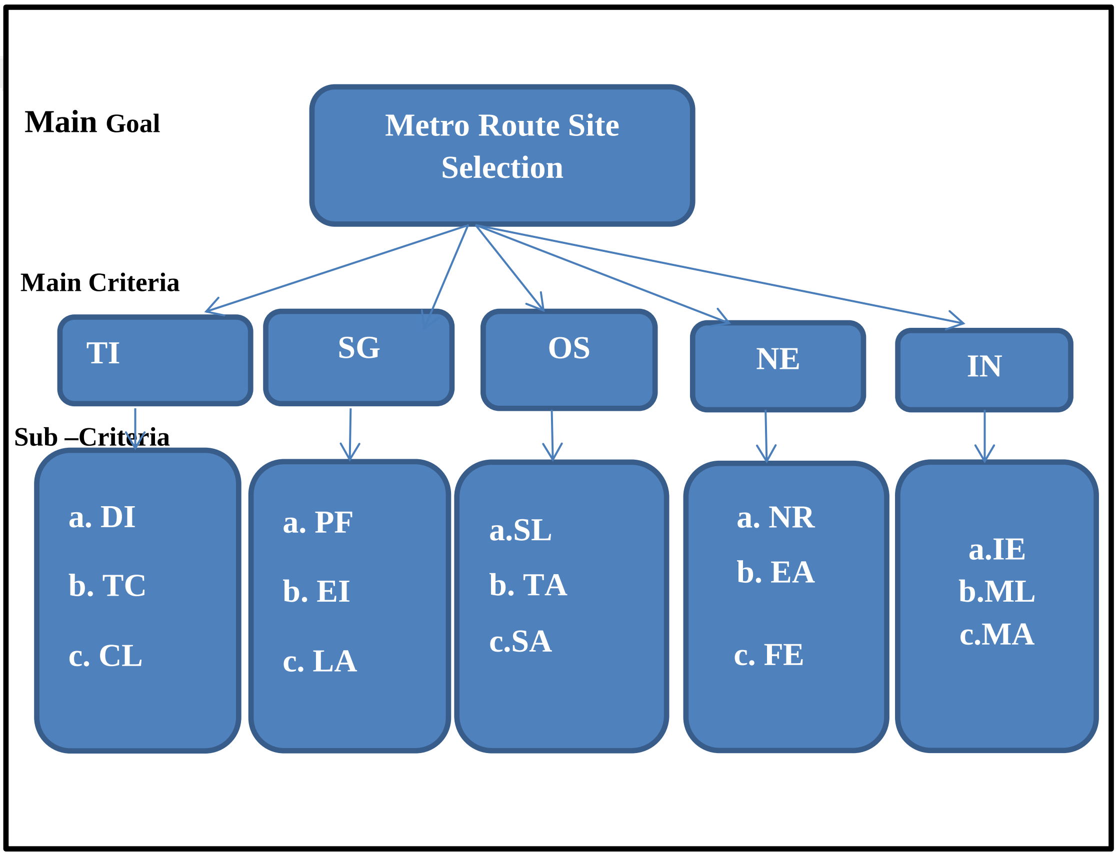


Table 4.4: Main Criteria Matrix

Criteria	TI			SG			OS			NE			IN		
TI	1.000	1.000	1.000	3.000	5.000	7.000	0.200	0.333	1.000	5.000	7.000	9.000	0.143	0.200	0.333
SG	0.143	0.200	0.333	1.000	1.000	1.000	5.000	7.000	9.000	1.000	1.000	3.000	3.000	5.000	7.000
OS	1.000	3.000	5.000	0.111	0.143	0.200	1.000	1.000	1.000	1.000	3.000	5.000	1.000	3.000	5.000
NE	0.111	0.143	0.200	0.333	1.000	1.000	0.200	0.333	1.000	1.000	1.000	1.000	1.000	1.000	3.000
IN	3.000	5.000	7.000	0.143	0.200	0.333	0.200	0.333	1.000	0.333	1.000	1.000	1.000	1.000	1.000

R Value

Table 4.5: r value for main criteria

	TI			SG			OS			NE			IN			Rl	Rm	Ru
TI	1.000	1.000	1.000	3.000	5.000	7.000	0.200	0.333	1.000	5.000	7.000	9.000	0.143	0.200	0.333	0.844	1.184	1.838
SG	0.143	0.200	0.333	1.000	1.000	1.000	5.000	7.000	9.000	1.000	1.000	3.000	3.000	5.000	7.000	1.165	1.476	2.290
OS	1.000	3.000	5.000	0.111	0.143	0.200	1.000	1.000	1.000	1.000	3.000	5.000	1.000	3.000	5.000	0.644	1.310	1.904
NE	0.111	0.143	0.200	0.333	1.000	1.000	0.200	0.333	1.000	1.000	1.000	1.000	1.000	1.000	3.000	0.375	0.544	0.903
IN	3.000	5.000	7.000	0.143	0.200	0.333	0.200	0.333	1.000	0.333	1.000	1.000	1.000	1.000	1.000	0.491	0.803	1.184

After defuzzification and normalization, the crisp values, this is the wright of main criteria which calculate r value

Table 4.6: r value

r	l	m	u
1	0.844	1.184	1.838
2	1.165	1.476	2.290
3	0.644	1.310	1.904
4	0.375	0.544	0.903
5	0.491	0.803	1.184
	3.519	5.317	8.119

weight value

Table 4.7: weight main criteria

w	L	m	U	sum of weight component	weight of each criteria
1	0.104	0.223	0.522	0.849	0.227
2	0.143	0.278	0.651	1.072	0.287
3	0.079	0.246	0.541	0.867	0.232
4	0.046	0.102	0.257	0.405	0.108
5	0.060	0.151	0.337	0.548	0.147
	0.433	1.000	2.307	3.740	

First Criteria Metro Technology – Infrastructure

Table 4.8:Mmatrix of sub criteria 1

Criteria	DI			TC			CL			Rl	Rm	Ru
DI	1.000	1.000	1.000	7.000	9.000	9.000	1.000	3.000	5.000	1.912	2.997	3.552
TC	0.111	0.111	0.143	1.000	1.000	1.000	3.000	5.000	7.000	0.693	0.822	1.000
CL	0.200	0.333	1.000	0.143	0.200	0.333	1.000	1.000	1.000	0.306	0.406	0.693

Table 4.9: r value of main criteria 1

r	l	m	u
1	1.912	2.997	3.552
2	0.693	0.822	1.000
3	0.306	0.406	0.693
	2.911	4.224	5.246

Weight of main criteria 1 = **0.227**

Table 4.10: Weight of sub criteria 1

W	l	m	u	sum of weight component	weight of each criteria	final weight
1	0.364	0.709	1.220	2.294	0.683	0.155
2	0.132	0.195	0.344	0.670	0.200	0.045
3	0.058	0.096	0.238	0.393	0.117	0.027
	0.555	1.000	1.802	3.357		

Second Criteria Suitability With Baghdad Features And Growth Plants

Table 4.11 : Evaluation Sub Criteria 2

Criteria	PF			EI			LA			Rl	Rm	Ru
PF	1.000	1.000	1.000	1.000	3.000	5.000	3.000	5.000	7.000	1.442	2.464	3.267
EI	0.200	0.333	1.000	1.000	1.000	1.000	7.000	9.000	9.000	1.119	1.441	2.079
LA	0.143	0.200	0.333	0.111	0.111	0.143	1.000	1.000	1.000	0.252	0.281	0.363

Table 4.12: r value of sub criteria 2

r	l	m	u
1	1.442	2.464	3.267
2	1.119	1.441	2.079
3	0.252	0.281	0.363
	2.812	4.187	5.709

Weight of main second criteria = 0.287

Table 4.13 weight of sub criteria 2

w	l	m	u	sum of weight component	weight of each criteria	final weight
1	0.253	0.589	1.162	2.003	0.569	0.163
2	0.196	0.344	0.739	1.279	0.363	0.104
3	0.044	0.067	0.129	0.240	0.068	0.020
	0.493	1.000	2.030	3.523		

Main criteria 3 Occupant Services

Table 4.14 : evaluation of sub criteria 3

Criteria	SL			TA			SA			Rl	Rm	Ru
SL	1.000	1.000	1.000	1.000	1.000	3.000	3.000	5.000	7.000	1.442	1.709	2.756
TA	0.333	1.000	1.000	1.000	1.000	1.000	5.000	7.000	9.000	1.185	1.912	2.079
SA	0.143	0.200	0.333	0.111	0.143	0.200	1.000	1.000	1.000	0.252	0.306	0.406

Table 4.15 : r value of sub – criteria 3

R	l	m	u
1	1.442	1.709	2.756
2	1.185	1.912	2.079
3	0.252	0.306	0.406
	2.878	3.927	5.240

Weight of main criteria 3 0.232

Table 4.16: weight of sub criteria 3

W	l	m	u	sum of weight component	weight of each criteria	final weight
1	0.275	0.435	0.958	1.668	0.495	0.115
2	0.226	0.487	0.722	1.435	0.426	0.099
3	0.048	0.078	0.141	0.267	0.079	0.018
	0.549	1.000	1.821	3.370		

Main criteria 4 Natural and Ecology

Table 4.17: evaluation sub criteria 4

Criteria	NR			EA			FE			Rl	Rm	Ru
NR	1.000	1.000	1.000	1.000	3.000	5.000	1.000	1.000	3.000	1.000	1.442	2.464
EA	0.200	0.333	1.000	1.000	1.000	1.000	0.200	0.333	1.000	0.342	0.481	1.000
FE	0.333	1.000	1.000	1.000	3.000	5.000	1.000	1.000	1.000	0.693	1.442	1.709

Table 4.18: r value of sub criteria 4

r	l	m	u
1	1.000	1.442	2.464
2	0.342	0.481	1.000
3	0.693	1.442	1.709
	2.036	3.364	5.173

Weight of main forth criteria = 0.108

Table 4.19 weight of sub criteria 4

w	l	m	u	sum of weight component	weight of each criteria	final weight
1	0.193	0.429	1.210	1.832	0.466	0.050
2	0.066	0.143	0.491	0.700	0.178	0.019
3	0.134	0.429	0.840	1.402	0.356	0.038
	0.394	1.000	2.541	**3.935**		

Main criteria 5 Institutional

Table 4.20 :Evaluation matrix of sub criteria 5

Criteria	IE			MI			MA			Rl	Rm	Ru
IE	1.000	1.000	1.000	7.000	9.000	9.000	1.000	3.000	5.000	1.912	2.997	3.552
MI	0.111	0.111	0.143	1.000	1.000	1.000	3.000	5.000	7.000	0.693	0.822	1.000
MA	0.200	0.333	1.000	0.143	0.200	0.333	1.000	1.000	1.000	0.306	0.406	0.693

Table 4.21: r value of sub criteria 5

r	l	m	u
1	1.912	2.997	3.552
2	0.693	0.822	1.000
3	0.306	0.406	0.693
	2.911	4.224	5.246

Weight of the fifth main criteria = 0.147

Table 4.22 : Weight of sub criteria 5

w	l	m	u	sum of weight component	weight of each criteria	final weight
1	0.364	0.709	1.220	2.294	0.683	0.100
2	0.132	0.195	0.344	0.670	0.200	0.029
3	0.058	0.096	0.238	0.393	0.117	0.017
	0.555	1.000	1.802	3.357		

After calculating the weights of the criteria, a new group of experts having perfect knowledge about the alternatives were referred to. They were asked to evaluate the route site alternatives against sub-criteria of the model using the linguistic scale in Table3.6. The next step in the calculations was normalizing the aggregate ratings matrix. To do so, the highest value within each 3* 3 matrix was found, and every value within this matrix was divided by this number as in Eq. 3.11. The values within this normalized decision matrix were multiplied with fuzzy weights of sub-criteria of the model, and a weighted normalized fuzzy decision matrix was derived Maximum and minimum values (corresponding to the positive and negative- ideal solutions, and were denoted by A* and A-, respectively) under each criterion were identified to construct fuzzy positive and negative-ideal solutions matrix.

final weight of sub criteria

c11	c12	c13	c21	c22	c23	c31	c32	c33	c41	c42	c43	c51	c52	c53
0.155	0.045	0.027	0.163	0.104	0.020	0.115	0.099	0.018	0.050	0.019	0.038	0.100	0.029	0.017

Table 4.23 : Evaluation matrix of main and sub criteria

	TI									SG								
	DI			TC			CL			PF			EI			LA		
Site 1	5.000	7.000	9.000	3.000	5.000	7.000	5.000	7.000	9.000	1.000	3.000	5.000	5.000	7.000	9.000	5.000	7.000	9.000
Site2	3.000	5.000	7.000	1.000	3.000	5.000	9.000	10.000	10.000	7.000	9.000	10.000	3.000	5.000	7.000	7.000	9.000	10.000
Site 3	7.000	9.000	10.000	3.000	5.000	7.000	7.000	9.000	10.000	5.000	7.000	9.000	9.000	10.000	10.000	3.000	5.000	7.000

	OS									NE								
	SL			TA			SA			NR			EA			FE		
Site 1	1.000	3.000	5.000	5.000	7.000	9.000	1.000	3.000	5.000	3.000	5.000	7.000	7.000	9.000	10.000	3.000	5.000	7.000
Site2	7.000	9.000	9.000	3.000	5.000	7.000	7.000	9.000	10.000	5.000	7.000	9.000	9.000	10.000	10.000	7.000	9.000	10.000
Site 3	5.000	7.000	9.000	7.000	9.000	10.000	5.000	7.000	9.000	9.000	10.000	10.000	5.000	7.000	9.000	5.000	7.000	9.000

	IN								
	IE			MI			MA		
Site 1	1.000	3.000	5.000	7.000	9.000	10.000	5.000	7.000	9.000
Site2	0.000	1.000	3.000	9.000	10.000	10.000	7.000	9.000	10.000
Site 3	5.000	7.000	9.000	3.000	5.000	7.000	9.000	10.000	10.000

Table 4.24: Normalize fuzzy weight matrix

Normalize Fuzzy Decision Matrix																		
	0.500	0.700	0.900	0.429	0.714	1.000	0.500	0.700	0.900	0.100	0.300	0.500	0.500	0.700	0.900	0.500	0.700	0.900
	0.300	0.500	0.700	0.143	0.429	0.714	0.900	1.000	1.000	0.700	0.900	1.000	0.300	0.500	0.700	0.700	0.900	1.000
	0.700	0.900	1.000	0.429	0.714	1.000	0.700	0.900	1.000	0.500	0.700	0.900	0.900	1.000	1.000	0.300	0.500	0.700
Fuzzy weight of sub criteria	0.155			0.045			0.027			0.163			0.104			0.020		
	0.111	0.333	0.556	0.500	0.700	0.900	0.100	0.300	0.500	0.300	0.500	0.700	0.700	0.900	1.000	0.300	0.500	0.700
	0.778	1.000	1.000	0.300	0.500	0.700	0.700	0.900	1.000	0.500	0.700	0.900	0.900	1.000	1.000	0.700	0.900	1.000
	0.556	0.778	1.000	0.700	0.900	1.000	0.500	0.700	0.900	0.900	1.000	1.000	0.500	0.700	0.900	0.500	0.700	0.900
Fuzzy weight of sub criteria	0.115			0.099			0.018			0.050			0.019			0.038		
	0.111	0.333	0.556	0.700	0.900	1.000	0.500	0.700	0.900									
	0.000	0.111	0.333	0.900	1.000	1.000	0.700	0.900	1.000									
	0.556	0.778	1.000	0.300	0.500	0.700	0.900	1.000	1.000									
Fuzzy weight of sub criteria	0.100			0.029			0.017											

Table 4.25: Weighted normalized fuzzy decision matrix

Weighted Normalized Fuzzy Decision Matrix	0.078	0.109	0.140	0.019	0.032	0.045	0.014	0.019	0.024	0.016	0.049	0.082	0.052	0.073	0.094	0.010	0.014	0.018
	0.047	0.078	0.109	0.006	0.019	0.032	0.024	0.027	0.027	0.114	0.147	0.163	0.031	0.052	0.073	0.014	0.018	0.020
	0.109	0.140	0.155	0.019	0.032	0.045	0.019	0.024	0.027	0.082	0.114	0.147	0.094	0.104	0.104	0.006	0.010	0.014
A*	0.109	0.140	0.155	0.019	0.032	0.045	0.024	0.027	0.027	0.114	0.147	0.163	0.094	0.104	0.104	0.014	0.018	0.020
A-	0.047	0.078	0.109	0.006	0.019	0.032	0.014	0.019	0.024	0.016	0.049	0.082	0.031	0.052	0.073	0.006	0.010	0.014

0.013	0.038	0.064	0.050	0.069	0.089	0.002	0.005	0.009	0.015	0.025	0.035	0.013	0.017	0.019	0.011	0.019	0.027
0.089	0.115	0.115	0.030	0.050	0.069	0.013	0.016	0.018	0.025	0.035	0.045	0.017	0.019	0.019	0.027	0.034	0.038
0.064	0.089	0.115	0.069	0.089	0.099	0.009	0.013	0.016	0.045	0.050	0.050	0.010	0.013	0.017	0.019	0.027	0.034
0.089	0.115	0.115	0.069	0.089	0.099	0.013	0.016	0.018	0.045	0.050	0.050	0.017	0.019	0.019	0.027	0.034	0.038
0.013	0.038	0.064	0.030	0.050	0.069	0.002	0.005	0.009	0.015	0.025	0.035	0.010	0.013	0.017	0.011	0.019	0.027

0.011	0.033	0.056	0.020	0.026	0.029	0.009	0.012	0.015
0.000	0.011	0.033	0.026	0.029	0.029	0.012	0.015	0.017
0.056	0.078	0.100	0.009	0.015	0.020	0.015	0.017	0.017
0.056	0.078	0.100	0.026	0.029	0.029	0.015	0.017	0.017
0.000	0.011	0.033	0.009	0.015	0.020	0.009	0.012	0.015

Table 4.26: Weighted normalized fuzzy decision matrix

A*	**Site 1**	0.0004	0.0000	0.0000	0.0043	0.0005	0.0000	0.0024	0.0001	0.0001	0.0003	0.0000	0.0001
	Site 2	0.0017	0.0001	0.0000	0.0000	0.0013	0.0000	0.0000	0.0007	0.0000	0.0001	0.0000	0.0000
	Site 3	0.0000	0.0000	0.0000	0.0004	0.0002	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
A-	**Site 1**	0.0005	0.0001	0.0000	0.0000	0.0002	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000
	Site 2	0.0000	0.0000	0.0000	0.0043	0.0000	0.0000	0.0024	0.0000	0.0001	0.0001	0.0000	0.0001
	Site 3	0.0016	0.0001	0.0000	0.0021	0.0013	0.0000	0.0013	0.0007	0.0000	0.0003	0.0000	0.0000

0.0010	0.0000	0.0000
0.0020	0.0000	0.0000
0.0000	0.0001	0.0000
0.0002	0.0001	0.0000
0.0000	0.0001	0.0000
0.0020	0.0000	0.0000

Table 4.27: Ranking alternatives

	sum A*	sum A-	CC
site 1	0.0092	0.0012	0.1197
sitte2	0.0058	0.0071	0.5490
site 3	0.0010	0.0094	0.9023

5. DISSCUSSION

Finding the best route/site selection with combine the environmental, social factors and the required situations that meet all criteria that were selected considered as the research problem. In the same cases data of multiple criteria is fundamental to the accomplishment of an aim of the decision making. The analytical methods include researching topologic relations like a merge between geographical features and proximity tools as well as utilization of the qualitative attributes. In case of need the distance task, the proportional concept is supposed between the metro line impact and spatial features. It implies that when the distance from the proposed Metro expands the possible effect decreases. Be that as it may, in actuality the interconnection of the anthropogenic and natural components forms more complex framework.

For instance, the effect of the metro line on an ensured region is not prone to be just related to the distance but additionally to the kind of site, underground water conditions, surface, and so forth. Effect on people would depend for instance on principle vocational of residents, their spatial moving, geology and other hindrances, and so on. In any case, any analysis needs constant updates of the database.

One of The evaluation criteria targets is the preservation of buildings, natural places and elected kinds of land, and contains some technical requirements for the metro line. The main idea is to explain which criteria ought to be taken and employment it but should not reduce the overall idea of sustainability.

As stated above, data availability consider as an important part in the analysis process, however, the quality of GIS-based method makes it simple to merge more data sources, for instance. Archaeological sites, cultural heritage places, underground water reservoirs or natural mineral supplies. The chosen technique for the metro line choice gives an only alternative thus. In any case, arranging process, as a rule, requires a couple of relevant recommendations with keeping in mind the final goal to settle on an educated decision. The final goal to create and test various options it is inescapable to automate the procedure of investigation by utilizing cartographic modeling and a programming language.

In this thesis, the alternatives are marked to say that:-

a- Alternatives 1 and 2 run through major areas where a lot of economic activities are situated.
b- Alternative 3 (Al Sader-Bab Al Sharji) connects several areas where the development potential is quite high.

Therefore, the third alternative has the highest growth potential, and it would generate important dynamic effects. Thus, this factor has to be taken into account in the final decision. However, these effects have to be actively estimated in further studies.

A major part of the third alternative route is running on long distance and crosses a lot of urban areas thus it is the unique feasible option in light of criteria evaluation and the services that will be present for people.

6. CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

This work has investigated the capacities of Fuzzy Multi-Criteria Decision Making strategies for finding a metro line in Baghdad. This study tries to put a solution for the current transportation system and characterize in detail the usage and abilities of Fuzzy Multi Criteria Decision Making technique for the decision of best metro route. In this thesis, Information preparation, investigation and directing were performed in GIS. Multi-criteria assessment methods were implemented in the spreadsheet and, in its basic layout, executed from GIS. In any case, it was experienced that the examination procedure requires many iterative GIS operations which are both unrealistic to perform manually and inclined to PC crashes. In order to gain an all-inclusive perspective, the process of decision-making consisted of a two-stage analysis, beginning with an initial site screening followed by a detailed assessment of the suitability of the candidate sites using a FMCDM approach guided by a panel of experts in the site selection process. The first-stage analysis was successful in preliminary Metro Route site screening leading to exclude the sensitive areas while retaining sufficient areas for further evaluation at the same time. Within the recovered fuzzy region in the second-stage analysis, MCDM method smoothly incorporated the information provided by experts leading to fulfilling the ranking of the three alternatives with respect to five different criteria. All the criteria were eventually aggregated to select the most suitable site regarding ratings given the fact that fuzzy set theory may aid in justification of the uncertainty in decision-making. In consequence, an SDSS may strengthen the generation and evaluation of alternatives by providing an insight of the problem among the various objectives and granting essential support to the process of decision-making under uncertainty (Malcezwki, 1999; Sharifi and Van Herwijnen, 2003). With such an effort, it is concluded that ‘‘site 3’’ located is the most suitable site for Metro Route based on an integrated GIS and FMCDM analysis. GIS thus offered the means to identify three potential Routes sites based on clear criteria, which were later ranked according to the preferences provided by a group of experts from the ministry of transportation that were based on their experiences. FMCDM offered the capacity to incorporate the opinions of the experts that can be useful in the future to settle political debate regarding the site selection. It is observed, that the metro line proposal needs to promote impressive keeping in mind the final goal to meet arranging requirements.

6.2 RECOMMENDATION

Any major projects are fulfilling according to their merits and demerits to the target aims. Here the Metro Route site selection is also one among major projects it has merits and demerits to the societies mainly metropolitan areas. These means that the design and implementation of Metro site selection was a multitude of characteristics and the procedures used must be good enough. Therefore this thesis has discussed the criteria and sub-criteria considered in this thesis try to identify the significant aspects/ factors which should influence. Also methods we propose were recent and influential in decision-making in general and it is a fantastic tool in site selection in particular. Therefore this study has such a right approach for Metro Route site selection in Iraq, and we recommend this research in the coming Metro construction programs to select an optimal Route location.

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