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A GIS-ASSISTED OPTIMAL BAGHDAD METRO ROUTE SELECTION BASED ON MULTI CRITERIA DECISION MAKING

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Abstract: Baghdad City suffers from severe traffic congestion due to the rapid urban expansion and travel demand growth. Based on many studies, urban rail transit was proposed by experts and the related transit agencies as an optimal solution to solve this problem. Accordingly, Baghdad metro route selection based on multi-criteria was proposed to be studied, evaluated and searched in the present research. The methodology utilizes a GIS to prepare and analysis data. Data was analyzed using a two-stage multiple-criteria decision making (MCDM) model which includes Analytical Hierarchal Process (AHP) and TOPSIS methods. Moreover, Geographic Information System (GIS) was used to explore the various route alternatives. To select the best alternative, all alternatives were evaluated against the selected criteria. The weighting system is not only based on expert's opinions but also includes a set of measures based on real data. Based to the outcomes of the present study, alternative route number 1 can be recognized to be the optimal route in the year 2014, and alternative route 2 is recommended to be adopted to meet the high travel demand requirement in the year 2035.

Keywords: *Optimal Route Selection, MCDM, AHP, TOPSIS, GIS.*

اختيار افضل مسار لمترو بغداد مسندا بنظم المعلومات الجغرافية أعتمادا على صنع القرار متعدد المعايير

الخلاصة : تعاني مدينة بغداد من الاختناق المروري الحاد نتيجة التوسع الحضري السريع وزيادة مستويات الطلب على الرحلة. أعتمادا على عدد من الدراسات التي أجريت في الماضي فانه تم اقتراح ستراتجية النقل الجماعي السريع (المترو) من قبل عدد من الشركات المتخصصه بالنقل كحل امثل لحل هذه المشكلة. ونتيجة لذلك فلقد تم اقتراح دراسة وتقييم اختيار خط المترو الامثل لمدينة بغداد اعتمادا على صنع القرار المتعدد المعايير. ان منهجية البحث تستند على أستخدام نظم المعلومات الجغرافية لبناء وتحليل البيانات وكذلك تحليل البيانات باستخدام طرق متعددة المعايير باستخدام طريقة مبدأ التحليل الهرميAHP و طريقة TOPSIS . تم تحليل مختلف انواع المسارات بنظم المعلومات الجغرافية ومن اجل اختيار افضل مسار فان جميع المسارات تم تقييمها اعتمادا على متغييرات محدده مختارة. ان هذه الطريقة لاتسنتد على رأي الخبراء فقط بل تأخذ بنظر الاعتبار البيانات الحقيقة المتعلقة بكل مسار. وأستنادا على نتائج هذه الدراسة فانه تم أعتبار المسار رقم واحد هو الأمثل في سنة ٢٠١٤ وأما بالنسبة للمسار الثاني فأنه يوصى بأعتمادة لتلبية متطلبات الطلب العالي في المستقبل لسنة ٢٠٣٥.

1. Introduction

The selection process attempts to optimize a number of objectives in determining the suitability of a particular route for a defined transit facility. Such optimization often involves a multitude of factors, sometime contradicting. Some of the important factor that add to the

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difficulty of the proper choice include the existence of numerous possible options, multiple objectives and intangible objectives [1].
The goal in a route selection project in transportation planning is to find the best optimal location based on predefined selection criteria. Route selection typically involves two main phases: (i) site investigated (i.e., define a number of candidate sites and number of selection criteria) and (ii) site evaluation (i.e., investigate each of candidate sites to find the optimum selection) [2].

GIS application is a computer-integrated tool proposed to be used in the present study to evaluate transportation network. Moreover, GIS applications include transit service area analysis, and network representation. In addition, 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.

GIS and spatial analysis is used to analyze the station access and closeness of people and employees to the proposed and existing transit stations. The optimum route alternative is selected based on the evaluation of the related indicators and adopted criteria as an application of Multi-Criteria Decision making approach. It deals with a number of criteria, rather than on a one criterion and leads the decision maker with a recommendation on the best decision alternatives. This study identifies the application of GIS and spatial analysis to delineate catchment area of transit station, and determine which stations would serve a much more people by using socioeconomic data of transportation analysis zones around area surrounding each station. AHP (Analytic Hierarchy Process) and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) methods, as a multiple attribute decision making (MADM) methodologies are used to select an optimal route of Baghdad metro. In this regard, weight of the criteria is derived using AHP, while TOPSIS method is adopted to evaluate the alternatives.

2. Identification Metro Route Alternatives

Developing Metro routes alternatives are proposed and presented based on dual metro lines as the base case. Identification of route corridors and the destinations that will serve is based on several criteria as follows .

- Proposed alternatives should avoided tunnel, bridges .
- Proposed alternatives should pass through main road .
- Proposed alternatives should serve high residential density and pass through commercial area.

Based on these criteria, the following routes alternatives are proposed as follows:

1- Route Alternative 1

Route Alternative 1 represents metro 2 Line as the base case as shown in Fig. 1.

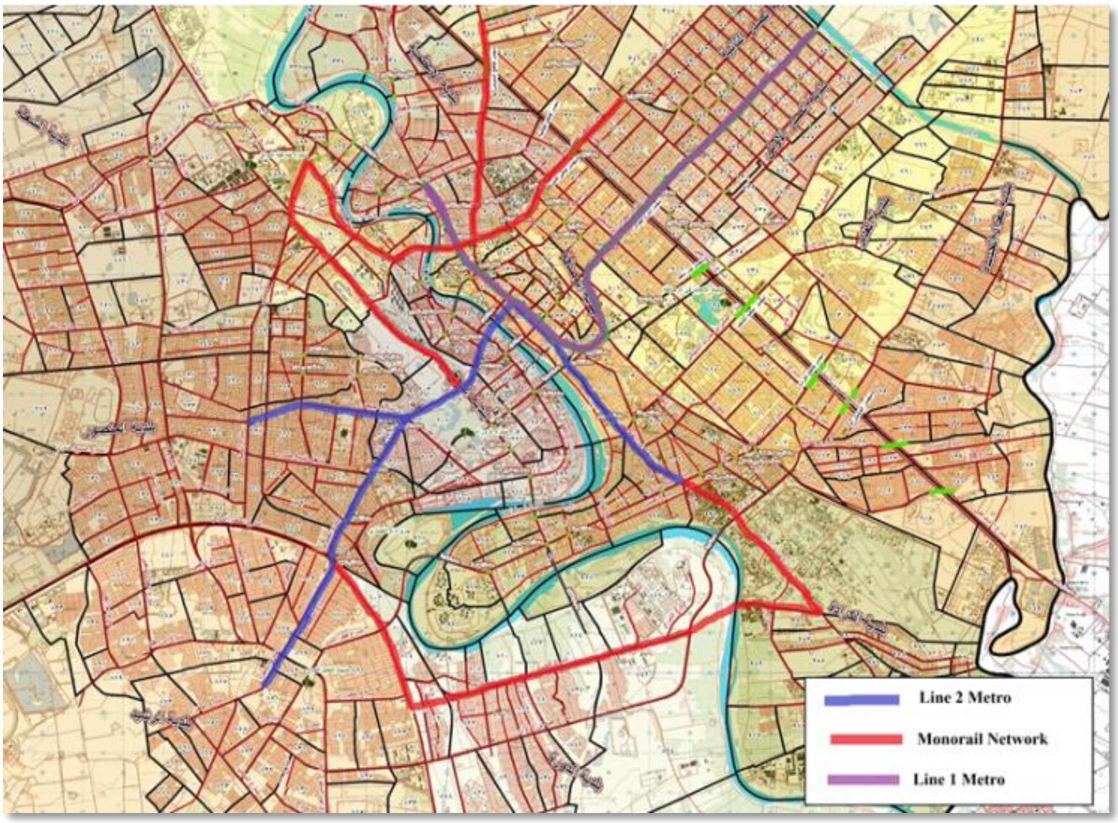

Figure (1) Route Alternative 1

Route Alternative 1 has a length of about 21.5 km with 21 stations crosses Baghdad City from South East to West and South West also through the CBD area. This line starts from Aqba Bin Nafi Square in Al Masbah and continues in Al Saadoon street to reach Al Fath Square. Then it reaches the Al Firdaws Square and continues on Al Saadoon street to Al Tahrir Square and reaches Al Kalani Square before continuing on Al Khulafa street passing in front of Amanat Baghdad Administration Building where the interchange station with Line 1 is located. Then in Wathba Square the alignment turns left to reach Al Rashed street and crosses the Tigris River between Al Ahrar Bridge and Shuhada Bridge. It continues on Qahira street and passes in front of the National Museum before reaching Damascus street and Al Faris Al Arabi Square. The two branches start from this place.

2- Route Alternative *2*

This route alternative include Route Alternative 1 and extension to new Baghdad area has a length of about 28.5 km which starts at al-Hurah square continues straight to Aqba Bin Nafi Square until reach garage al Amina square then it turning and passing reaching to new Baghdad through Cinema al badhaa square and continues straight to al mushtal area. The extension ends close to al mushtal Bridge. Route Alternative 2 represents as shown in Fig. 2.

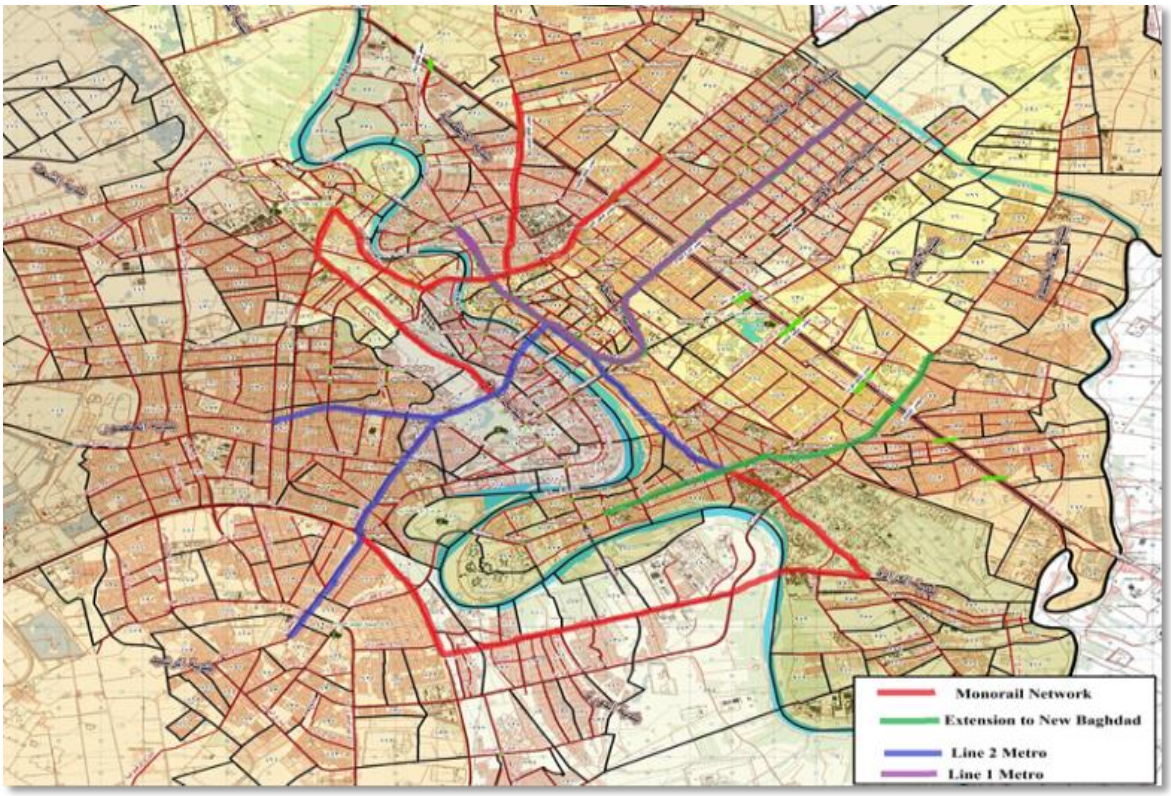

Figure (2) Route Alternative 2

3-Route Alternative 3

This route alternative includes Route Alternative 1 and extension to Shulah area has a length of about 29 km. It start at the end of Al Mansour Branch of Route Alternative 1 and turning to reach al Gazila main street, continues in straight line and ends in Al-Hamazia mosque intersection. It proposed to serve Shulah area, which is represents a high demand area. Fig. 3 shows route alternative 3.

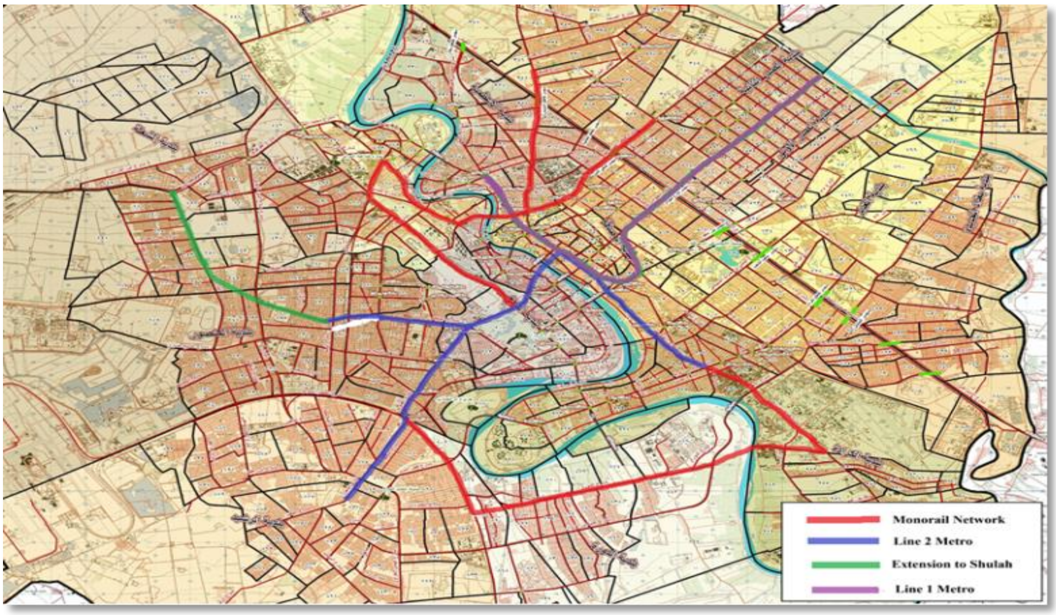

Figure (3) Route Alternative 3

3. Potential Metro Rail Ridership by Walking

Walking accessibility is one of the factors that will affect people's willingness to travel by transit system. It is one of the most important factors that influence the transit system use. Therefore, pedestrian's accessibility is playing an important factor in the design transit route alignment and the location of transit stops [3].

Highway network representation in ArcGIS version 10.0 cannot represent the actual walking distance because it neglects the highway's width. Creation walkway network represents the topology of the network used by pedestrians. This network is different from the street centerline network in having a separate line segment for each side of the street and line segments representing crosswalks [4].

As shown in the Fig. 4, the existing highway network mapping in ArcGIS is represented as centerline in the left side of the above mentioned Figure. This technique is proposed and used as the base to build and represents the pedestrian network. In this regards, Freeways are removed from pedestrian walkway network because it is an inaccessible to pedestrians. The right side of Fig. 4 represents pedestrian network as coded in in ArcGIS.

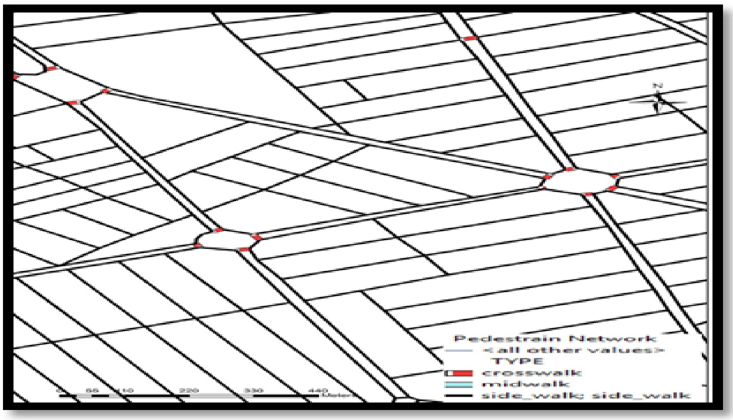

Figure (4) Representation of Pedestrian Network

ArcGIS network analysis tools is used to estimate access coverage of a transit station, measuring service areas or catchment areas help to find which station has the largest demand for walking. As per the local traffic study [5], the average walk speed is estimated to be 2.585 km/hr (43.092 m/min) which is used in this study which is found to be slower than national average speed equal to 4 km/hr. Fig. 5 illustrates the service area within a 5, 10 and 15 minute from proposed and existing transit station.

Population and employment data is gathered from central organization for statistics and technology information and entered in ArcGIS using Transportation Analysis Zones (TAZ). Higher population and employment near transit station increase public transit by minimizing the time and cost of accessing transit. Service areas within five minutes walking time will be well served and areas within ten minutes walking time will be served. Increasing the access to the transit station more than 15 minute walking time will tend people to take several modes like bus, car, and bicycle. Network service area method results are more realistic than a circular buffer method for estimating the catchment area of a transit station.

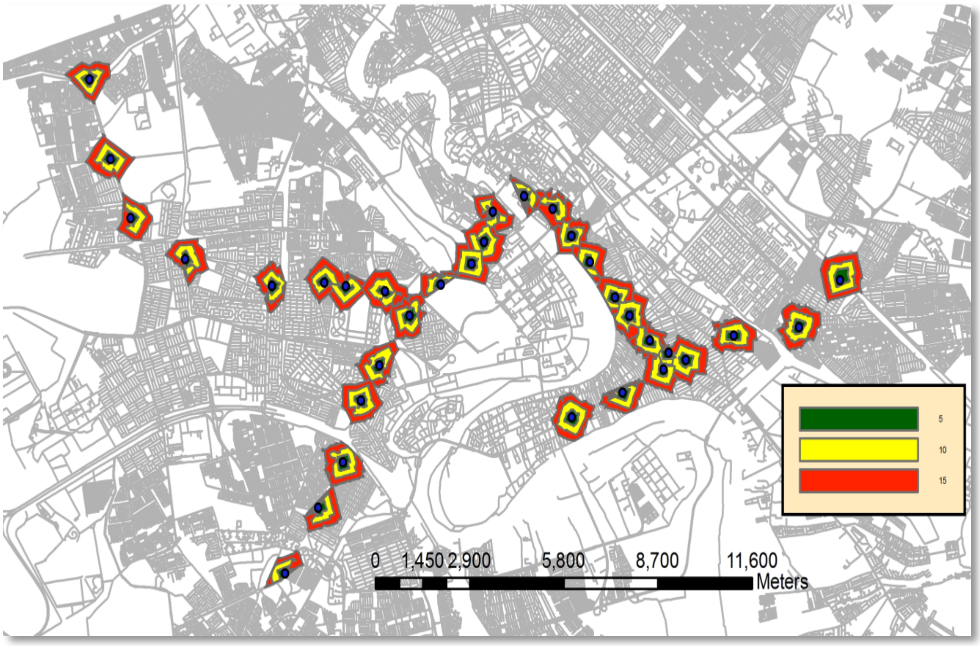

Figure (5) Catchment Areas around Stations

People are generally willing to walk farther to a rail stop than a bus stop [6]. The population and employment within the 5, 10 and 15 minute can be estimated from a query between socio-economic data and catchment area. The following equation used interpolation method to estimate catchment area properties.

$$P = \sum_{i=1}^{n} Pi * aPi \qquad (1)$$

Where P is the population in the surrounding catchment area of the metro station,

i=1 . . . n represents the transport zones totally or partially covered by the catchment area,

Pi is the Population in transport zone i, and api is the area proportion of the transport zone i that is contained within the catchment area. Population and employment around the metro station for the year; 1997, and 2014 is provided on Table (1). Prediction population of 2014 is based on medium growth scenario of Baghdad Comprehensive City Development Plan project (CCDP) study and prediction employment data for 2014 dependent on the following equation:

Employment 2014 = (Population 2014)/ (Population 1997) * Employment 1997 (2)

Table (1) Catchment Area Properties

Name	*Catchment area 1997*		*Catchment area 2014*	
	Population	Employment	Population	Employment
ST 1	١٩٦٥	٥٠٠٤	3186	8113
Al Masrah Al Watany	5977	7160	9691	11610
Mordjane Square	٧٦٣٨	23826	17316	38631
Firdaws Square	١٠٢٦	11704	4888	18976
Nasser Square	٥٣٣٧	12350	5811	20025
Tahrir Square	٧٥٩٣	23476	10591	38063
Baghdad Municipality	٧٠٣٠	25782	11397	41802
L2 Station 8	٤٥٤٧	13361	7373	21664
Sharih Haifa	١٦٣٢٠	12924	26461	20955
Medhaf Al Watan	١٩٤٢٠	12552	31486	20351

Al Alamiya	٥١٩٠	4253	8415	6896
Al Faris Al Arabi	٥٥٣	700	896	1136
L2 Station 13	٤١٨١	2760	6779	4476
L2 Station 14	٣٤٣٩	2989	5576	4847
L2 Station 15	٢٥٦٧	3304	4161	5356
L2 Station 16	٤٤٠٩	2356	7149	3820
Nisur Square	٢٦٤٣	2267	4285	3676
Qahtan Square	٣٢٧٧	2459	5313	3988
Oum Toboul	١٠٥٣٨	3330	17087	5399
L2 Station 20	٧٣٧٤	6107	11957	9901
Tamim	٣١٨١	٩٣	5157	151

Name	Catchment area 1997		Catchment area 2014	
	Population	Employment	Population	Employment
Al –Hurah	5855	6855	9493	11114
Al-Karada	3317	5505	5378	8927
Al Musbah	4238	4412	6872	7154
Aqba	1965	5004	3186	8113
Garage Al-Amina	6350	6480	10297	10507
Cinema Al-Badhaa	14970	8496	24273	13776
Almushtal	11841	795	18861	11278
Al- shulah	14308	795	23106	1290
Al Gazila	4861	334	7578	543
Inter Gazila	3150	902	5056	1463

4. Optimization Techniques based on Multi Criteria System

Optimization techniques solution the optimum location based on multi criteria using different optimization methods. To solve a decision problem, there are several methods used to select the best decision alternatives. The selection of an appropriate method depends on the decision problem and the preference of decision makers. Some of these techniques of optimization used in this study are as following:

4.1 Analytic Hierarchy Processes Method (AHP)

AHP was presented by Saaty [7] to solve decision-making problems depended on multiple attributes. Over the time, it has been widely used. It is an optimization method based on the Multi criteria decision principle. AHP is a multi-criteria decision making technique that can help express the general decision operation by decomposing a complicated problem into a multilevel hierarchical structure of objective, criteria and alternatives [8]. AHP is used to determine relative priorities on absolute scales from pair comparisons in multilevel hierarchic structures [9]. A comparison scale developed by Saaty (1980) is used to represent the relative importance of the criteria.

At the first the Problem is structured and decomposed into a series of level. Each level shows a definite attributes. The second phase includes collecting the data. The third phase includes a decision maker was asked to assigns weight for each pairs of attributes; the most common nine-point Saaty scale is used. The problem structuring graphics of optimum metro route selection is presented in Fig.6.

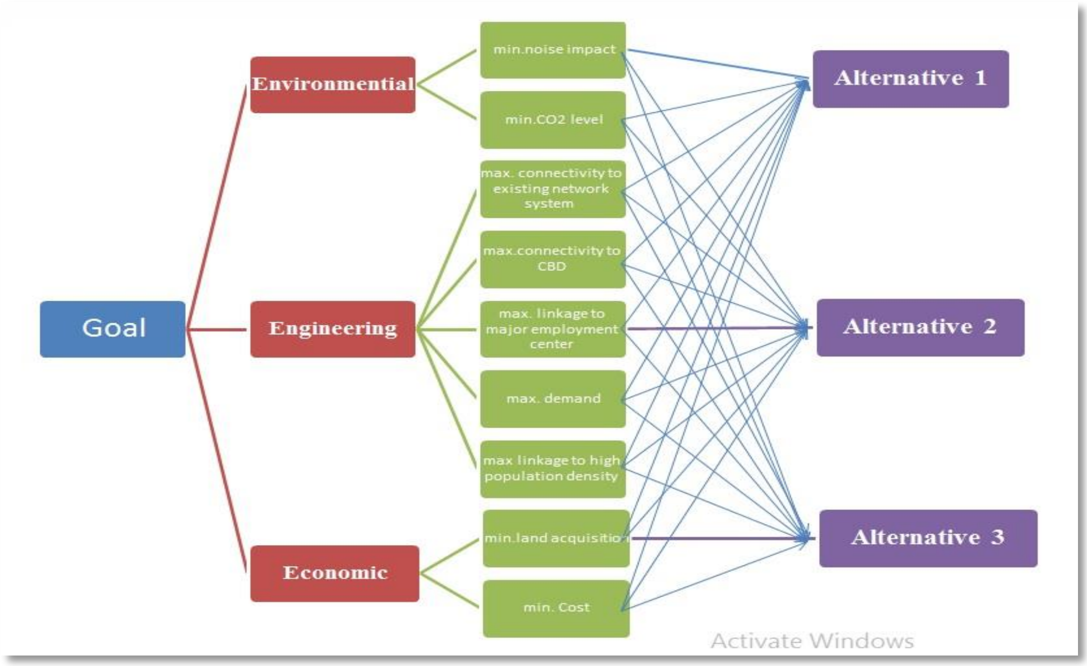

Figure (6) Hierarchies of the Problem

In Fig.6, the first level represents the goal of the decision problem which is the selection of the optimum route alternative. In the second level, the problem is consisted of main criteria and the lower level is divided into other sub-criteria. Based on the available literatures, the selected criteria can be shown in the above mentioned figure.

4.1.1 Design of the Questionnaire

Weighting the criteria by multiple experts avoids the bias decision making and provides impartiality [10]. Questionnaire form was designed and filled out via experts (specialists in the field of transportation engineering) to gather their opinions. Special academic staff and specialists in the related agencies are selected. The experts were asked to assess the importance of each criterion on a nine point Saaty's scale to give the relative rating of two criteria. Moreover, personal interviews with the experts are conducted to assist this process. The sample size of 20 is selected for the experts to fill out the designed questionnaire. The scale of scoring assumes that the row criteria are equal or more importance than the column criteria. The reverse values such as (1/3, 1/5, 1/7, or 1/9) where used when the column criteria is more important than the row criterion [11]. After receiving the results of the respondents, the criteria were arranged and averaged using AHP Excel Template. Geometric means of experts' choice values are calculated to form the final pairwise comparison matrix. The judgment should be consistent; all judgment matrices are checked for consistency test using the consistency ratio C.R. The consistency ratio (C.R.) is the last step of the AHP method. Priority weighting acceptance is inspected by consistency ratio, where the CR value equal or lower than 0.1, the weight values are valid. Fig. (7) and (8) show the analysis of AHP results.

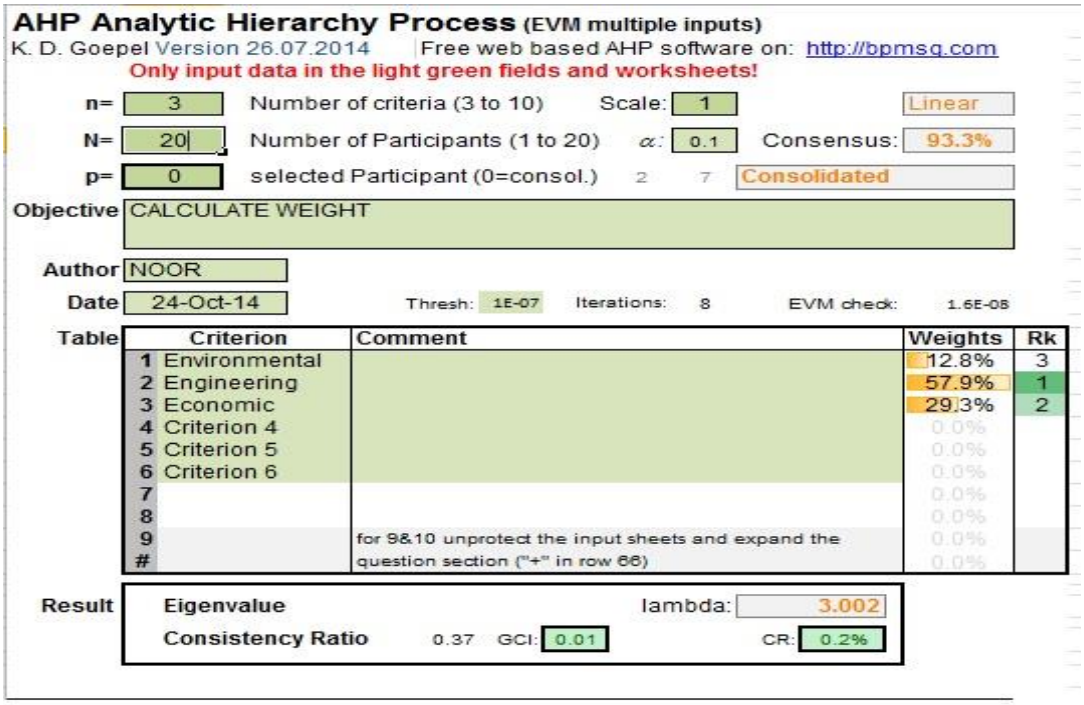

Figure (7) AHP of Main Criteria

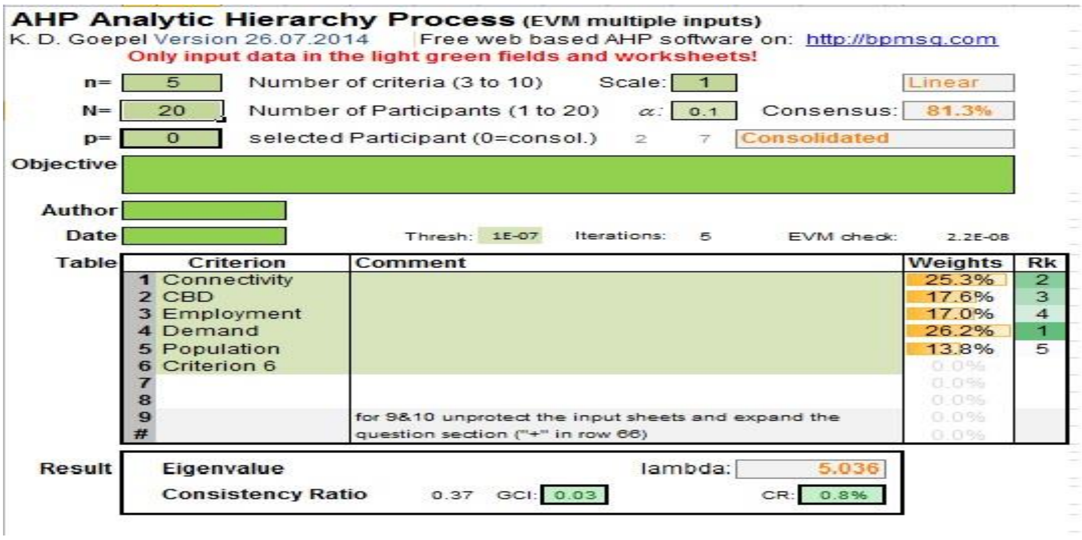

Figure (8) AHP of Engineering Criteria.

4.2 TOPSIS Method

TOPSIS, a method was used by Yoon in (1980) [12]. A MCDM (multiple criteria decision making) problem was solved by "TOPSIS" method, taking into account the concept that stat the selection alternative should has:

- The smallest distance from the positive ideal solution (PIS)
- The farthest distance from the negative ideal solution (NIS).

Positive ideal solution tries to maximize the "benefit" and minimizes the cost, whereas in contrary the negative ideal solution maximizes the "cost" and minimizes the "benefit".

The method proposes, each criterion must be maximized or minimized. TOPSIS method is a useful and simple method for ranking alternatives priority, depending on the closeness of selected alternative from the ideal solution. Advantages of TOPSIS method is the pair-wise comparisons are avoided [13]. The steps of TOPSIS method are as follows:

- Formulation of the Decision Matrix

A matrix is formed with the existing real data in which the rows are the alternatives and the columns show the selected criteria. In this matrix, Xij represent the value of alternative i based on the criterion j.

- Normalize the Decision Matrix

Normalization removes units from all data sets and values are between 0 and 1. Making the data from different scales converted to a one scale.

- Estimating the (PIS) and (NIS)

$$A^{+} = \{V_1^{+},\ldots,V_n^{+}\} = \{(\max j \ V_{ij} \mid i \in I), (\min j \ V_{ij} \mid i \in J)\} \quad (3)$$

$$A^{-} = \{V_1^{-},\ldots,V_n^{-}\} = \{(\min j \ Vij \mid i \in I), (\max j \ Vij \mid i \in J)\} \quad (4)$$

Where i is the benefit criteria, j is the cost criteria.

- Separation Measure Calculation

To find the Euclidian distance of each alternative from the PIS, the equation below is used to find this distance:

$$D_i^{+} = \sqrt{\sum_{j=1}^{n}(Vij - Vj^{+})^2}, \quad i = 1, \ldots, m \quad (5)$$

The equation below is used to find the Euclidian distance of each alternative from the NIS:

$$d_i^{-} = \sqrt{\sum_{j=1}^{n}(Vij - Vj^{-})^2}, \quad i = 1, \ldots, m, \quad (6)$$

- Find the Ranking of the alternatives Based on Closeness to the (PIS) and (NIS).

The final weight of the alternatives is calculated based on the following equation:

$$Ci = \frac{d_i^{-}}{(d_i^{+} + d_i^{-})} \quad (7)$$

Where i=1,…,m

The final score of the routes is calculated and the optimum route is selected. TOPSIS method requires the weight for each criterion to calculate the normalized weighted matrix. The obtained weights from the AHP stage were applied.

5. Perdition of Optimal Baghdad‘s Metro Route

In order to predict the optimal Baghdad metro route, AHP and TOPSIS methods are used in this selection process. For alternatives route evaluation, first the weight of criteria is derived from the AHP. Second, TOPSIS method is adopted to evaluate the alternatives.

5.1 Factors Affecting Route Selection

Route selection is the process to find locations that meet the desired conditions set by the selection criteria. In such a process, manipulation of spatial data and satisfaction of multiple criteria are essential to the success of decision-making [14]. Measuring criteria affecting the optimum route is conducted with aid of GIS spatial analysis can be presented as follows:

- *Population Density and Major Employment Center*

Population and employment density around metro station is a major factor for trip generation and attraction of current and future demand. The higher population and employment density around metro station increase the potential volume of ridership. To determine these values, network service method by the aid of ArcGIS software is used. A travel time equal 15 minute can be considered as the proper time for access to the metro station on foot. Catchment area properties were calculated previously in Table (١).

- *Connectivity to Existing Network and CBD*

Connectivity maximizing the highway network, increasing highway capacity and improves the traffic operation by reducing congestion. Metro route stations connected with a series of major network intersection will result in reducing the amount of congestion on existing intersections thus making the overall transportation service faster and more reliable. Connectivity to existing major network is measured by street density within the station catchment area which is the ratio between street length and service catchment area [15]. This is done by considering the sum of highway network length inside catchment area of each station of the network divided by the coverage served area. The results are shown in the Fig. 9.

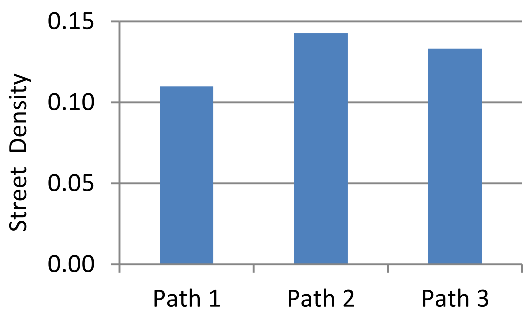

Figure (9) Street Density of the Proposed Routes

Distance from CBD is measured using Near Distance tool in ArcGIS to determine the distance from each station feature to nearby CBD feature, the results are recorded in the output Table (2).

Table (2) Distance of Metro Stations from CBD

Name	Near Distance m	Name	Near Distance m
Aquba	1794		
Al Masrah Al Watany	802	L2 Station 13	2081
Mordjane Square	6	L2 Station 14	2797

Firdaws Square	0	L2 Station 15	3242
Nasser Square	0	L2 Station 16	4528
Tahrir Square	0	Al Faris Al Arabi	889
Baghdad Municipality	0	Nisur Square	3367
L2 Station 8	4528	Qahtan Square	4283
Sharih Haifa	0	Oum Toboul	5569
Medhaf Al Watan	0	L2 Station 20	6746
Al Alamiya	0	Tamim	8396
Al –Hurah	1615	Al Gazila	8598
Al-Karada	1738	Inter Gazila	7931
Al Masbah	1576	Hay jamaa	6579
Aqba	1794		
Garage Al-Amina	2165		
Cinema Al-Badhaa	3495		
mushtal Al	4315		
Al- shulah	9656		

Fig. 10 represents the sum of distance from CBD of all station for each alternative.

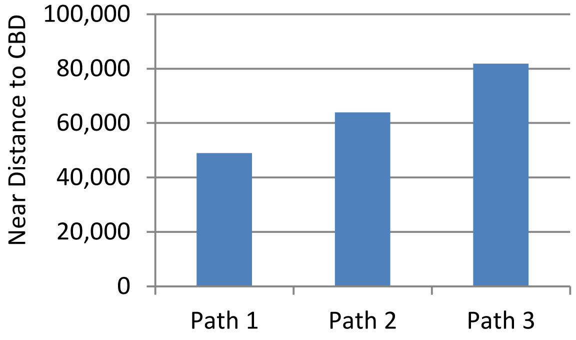

Figure (10) Near Distance to CBD for each Alternative.

- *Cost and Land Acquisition*

Cost should be minimizing for construction, operation and maintenance. Cost of the underground with an estimated one hundred twenty (120) million dollars per Km (Baghdad Comprehensive City Development Plan project (CCDP), 2014) [16]. Land price is conducted based on the existing average price gathered from the real estate offices surrounding the proposed metro routes areas. The cost and land acquisition of each alternative can be seen in Table (3)

Table (3) Cost and Land Acquisition of each Alternative

Name	*Cost Million $*	*Land Acquisition Million $*
Alternative 1	2580	60
Alternative 2	3420	100
Alternative 3	3480	200

- *Environmental Effects*

Field measurements of the intersections along the proposed routes were done for one hour to obtain various values of noise level, CO and CO_2. Try to minimize intersection-related air pollution and noise to protect the natural resources. Fig. 11 shows the pollution for each alternative.

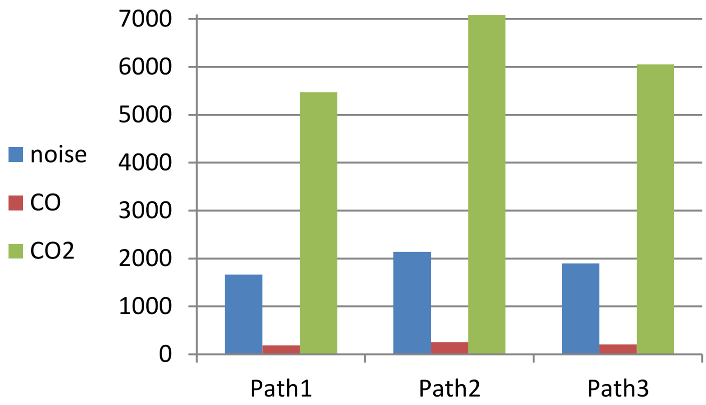

Figure (11) Pollution for each Alternative.

5.2 Selection of Optimal Alternative

Field measurement, data collection and analysis results are used as an input data for the implementation of TOPSIS method to select the best alternative. The results can be shown in Table (3) and Table (4). The analysis results appeared that alternative 1 can be considered to be the optimum Metro route for the case study in 2014. This alternative operated on high demand corridors which will maximize revenues to the operator.

Table (3) TOPSIS Analysis Results.

MIN.	MAX.	MAX.	MAX.	Max.	MAX.	MIN.	
Cost	**Population**	**Demand**	**Employment**	**CBD**	**Connectivity**	**Environment**	
2640	204975	310000	289863	49028	0.10992	7326	**1.Alternative**
3520	283335	360000	360705	63932	0.14256	9472	**2.Alternative**
3680	240715	340000	293132	81792	0.13312	8161	**3.Alternative**
0.293	0.08	0.152	0.098	0.102	0.146	0.128	**weight**
Cost	**Population**	**Demand**	**Employment**	**CBD**	**Connectivity**	**Environment**	
2640	204975	310000	289863	49028	0.10992	7326	**1.Alternative**
3520	283335	360000	360705	63932	0.14256	9472	**2.Alternative**
3680	240715	340000	293132	81792	0.13312	8161	**3.Alternative**
Cost	**Population**	**Demand**	**Employment**	**CBD**	**Connectivity**	**Environment**	
6969600	42014750625	9.61E+10	84020558769	2403744784	0.012082406	53670276	**1.Alternative**
12390400	80278722225	1.296E+11	1.30108E+11	4087300624	0.020323354	89718784	**2.Alternative**
13542400	57943711225	1.156E+11	85926369424	6689931264	0.017720934	66601921	**3.Alternative**
32902400	1.80237E+11	3.413E+11	3.00055E+11	1.3181E+10	0.050126694	209990981	**SUM**
5736.061366	424543.5008	584208.867	547772.7861	114808.435	0.223889916	14491.06556	**SQRT**
Cost	**Population**	**Demand**	**Employment**	**CBD**	**Connectivity**	**Environment**	**rij**
0.460251046	0.482813284	0.53063293	0.529167245	0.42704341	0.490955599	0.505555172	**1.Alternative**
0.613668061	0.667388227	0.61621888	0.658494775	0.55686015	0.636741541	0.653647091	**2.Alternative**
0.641562064	0.566997925	0.5819845	0.535135056	0.71242422	0.59457796	0.563177144	**3.Alternative**
0.293	0.08	0.152	0.098	0.102	0.146	0.128	**Weight**
Cost	**Population**	**Demand**	**Employment**	**CBD**	**Connectivity**	**Environment**	**vij**
0.134853556	0.038625063	0.0806562	0.05185839	0.04355843	0.071679517	0.064711062	**1.Alternative**
0.179804742	0.053391058	0.09366527	0.064532488	0.05679974	0.092964265	0.083666828	**2.Alternative**
0.187977685	0.045359834	0.08846164	0.052443236	0.07266727	0.086808382	0.072086674	**3.Alternative**
0.13485	0.05339	0.09366	0.064532	0.04356	0.092964	0.08366	**Positive Ideal Solution**
0.187978	0.038625	0.0806562	0.051858	0.07267	0.07167	0.064711	**Negative Ideal Solution**
Cost	**Population**	**Demand**	**Employment**	**CBD**	**Connectivity**	**Environment**	**Sep. from Ideal Solution**
0	0.000218035	0.00016924	0.000160633	0	0.00045304	0.000359321	**1.Alternative**
0.002020609	0	0	0	0.00017533	0	0	**2.Alternative**
0.002822173	6.45006E-05	2.7078E-05	0.00014615	0.00084732	3.78949E-05	0.0001341	**3.Alternative**
Cost	**Population**	**Demand**	**Employment**	**CBD**	**connectivity**	**Environment**	**Sep.from Negative Solutior**
0.002822173	0	0	0	0.00084732	0	0	**1.Alternative**
6.6797E-05	0.000218035	0.00016924	0.000160643	0.00025178	0.00045304	0.000359321	**2.Alternative**
0	4.53571E-05	6.0925E-05	3.42044E-07	0	0.000228883	5.43997E-05	**3.Alternative**

- Weight in this Table from AHP

Table (4) Optimum Alternatives

Alternative	***S+***	***S-***	***Closeness***	***Rank***
Alternative 1	0.036882	0.060576379	0.62156302	**1**
Alternative 2	0.046861	0.040973775	0.466487618	2
Alternative 3	0.059634	0.019746045	0.248753465	3

6. Conclusions

Analytical Hierarchal Process (AHP) and TOPSIS methods are very effective tools can be used to select and evaluate optimal alternative. The evaluation system is not only based on expert opinions, but also tack into account a set of measures based on real data. Based to the results of this study, alternative route number 1 can be recognized to be the optimal in the year 2014, and alternative route 2 is recommended to be adopted to meet the expected high travel demand requirement in 2035.

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