

Optimal Route Alternative to Connect Two Districts in Baghdad City - Based on Optimization Technique

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Abstract: Baghdad city suffers from the operation of the existing transportation network. The performance of transportation system operation is mainly due to the rate of growth in traffic volume, the development of new growth areas, the increase of population and rapid increase of vehicles, while no improvement has been carried out to the current transit system.

The present paper provided a highlight on the analysis to select the best route to connect Al-Kadomiya and Al-Grea'at in Baghdad city. Three alternatives are selected to be studied, geographic information system (GIS) and field surveys are carried out to collect the related field data for the existing highways network, a database has been made for the main existing highways in the study area which are considered as an effective in transportation. The main conclusion based on traffic analysis and transportation planning presents that the existing bridges in study area can't accommodate the demand for transit transport between the mentioned two districts and the congestion will be increased gradually with time. Based on GIS application in transportation planning and AHP optimization technique which applied weight different effective factors in the proposed criteria, ArcGIS 9.2 Spatial Analyst module is also applied by the aid of Digital Elevated Model (DEM to select an optimal route.

Furthermore, the economic- feasibility study based TRCA program concluded that the second path is the best from the economic point of view.

Keywords: Transportation Planning, Route Selection, Optimization Technique, Geographic Information System, Feasibility Study

1. Introduction

Enhancing the mobility between urban areas is one of the main goals for the planning process; therefore, the current transportation goals are not only the solution of transportation network problems,

but also enhancing of urban environment by controlling the properties of the site accessibility.

As known by the transportation engineers and planners, there are many effects of transportation and accessibility to form the architectural view of urban area.

The process to establishing accessibility based on several components, some of them are trip generation and attraction and modal split which can be defined as the process of distributing the individual trips on the different modes of travel, and it can be expressed by a fraction, ratio or percentage of the whole number of trips, and there are several methods to find this value. In general, the land use trips can be classified into:

- 1-Residential, which represents one of the most important land uses that generates and attracts trips.
- 2-Industrial and commercial, which represent the second class according to their importance to trip generation.
- 3-Educational and recreational, educational buildings and institutions are of the highest number of trip generators which gives them a special importance.

2. Study Area Boundary Data

The study considered two districts in Baghdad city; Al-Kadomiya and Al-Grea'at. Al-Kadomiya lies approximately (44.389, 33.387) from east and (44.306, 33.388) to the west. Tigris River forms the boundary of the Al-Kadomiya from the west, while the east for Al-Grea'at. Study area is approximately 34.5km².

The western side is important to traffic operation due to traffic attraction due to the religions places, as well as it connect the main entrance of Baghdad to the north. Figure 1 shows the location of the region area.

Furthermore, the study area is bounded by Mohammad Al-Qasim expressway from the east, Al-Muthana bridge and Ibn Manthour street from the

north, 14th of July street and Al-A'immah bridge from the west and Al-Kournish street from the south. from the south.

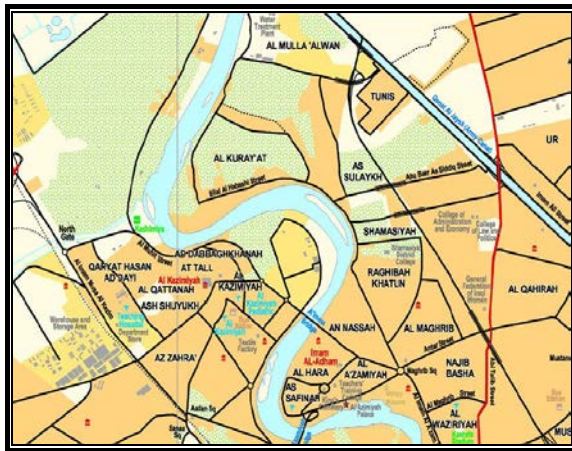


Figure 1: Location of the Study Area

3. Research's Goals and Objectives

The main goals and objectives of the study are: Evaluating transportation mobility between Al-Grea'at and Al-Kadomiya districts in Baghdad city. Furthermore, find out the optimized route to travel between these two districts in each time interval, which requires the minimum travel expense using ArcGIS program based on multi-criteria optimization approach.

4. Accessibility

In general, there are six main entrances which represent the access to the study area; are shown in Figure 2.

1. Muhammad Al-Qasim - Al-Qanat freeways then entering the study area at Mecca intersection from different origins like Al-Amin, Al-Sadir city, Hay Ur, Al-Sha'ab and from Al-Za'afarana were using those two highways.
2. Antar Bin Shadad street to Antar square and others from different origins like Al-Qahira and Palestine street.
3. Al-Imam Al-Am'atham, generally from Al-Waziria (beyond Al-Sarafia bridge) and Hay Al-Maghrib.
4. Al-Shu'ala, Al-Hurria, and Hay Al-Jamia'a, they use the entrances in the 14th of July street to enter the study area, i.e. Jeddah square, Adan and Sana'a intersections.
5. North of Baghdad (northern governorates or areas in the north of Baghdad city within the borders of Baghdad municipality or within the borders of Baghdad governorate).
6. Al-Karkh using Mosa Al-Kathim Street at Hammadi Shhab square to enter the study area, or use the entrances of the 14th of July Street.



Figure 2. Accesses of the Study Area

5. Transportation Network of the Study Area

The following articles described the details of the network of the study area

5.1 The existing highways network

Figure 3 shows the existing network within the study area.



Figure 3. Plan of the Existing Highways in the Study Area

Using the geographic information system (GIS) and field surveys done on the paved highways network, a database has been made for the main existing highways in the study area which are considered as effective in transportation mobility, and it is shown in Table 1.

Table 1. The Database of the Existing Highways in the Study Area

Road's name	Length (km)	classification within the study area
Antar Ibn Shaddad	1.375	TSE
Al-Imam Al-A'athm	1.380	TSO1
Al-Asma'i	2.200	TSO2
Omar Bin Abdil Aziz	2.700	TSO2
Al-Akhtal	1.170	TSO3
Al-Shamasiah	0.88	TSO3
Ibn Tufail	0.95	TSO2
Othman Bin Affan	2.800	TSO2
Ibn Fathlan	1.700	TSO2
Omro'o Al-Qais	6.680	TSO2
Muhammad Al-Qasim	4.900	TSF
The connector between Al-Qanat	2.800	TSO1
Road connecting Al-Qanat with the	1.350	TSO2
Ibn Manthour	4.900	TSF
14th of July	6.900	TSF
Muhammad Al-Jawad (Al-Muheet	4.300	TSO1
Hospital street	1.900	TSO1
Al-Hamza	1.200	TSO1
Al-Askariain	1.870	TSO2
Al-Hussein	1.360	TSO1
Al-Qasim	1.430	TSO1
Mousa Al-Kathim	1.000	TSO2
The street connecting	1.000	TSO2
Street connecting Muhammad Al-	2.500	TSO2

5.2 Classification of Streets in Planning Studies

Roads within the study area were classified according to planning studies that began with the comprehensive development plan of Baghdad at year of 1973. They were classified into five classes, the comprehensive transportation plan of Baghdad at 1982 agreed with this classification, as described below and shown in Figure 4:

- Class (TSF) represents freeways with right of way of (100-120) m.
- Class (TSE) represents freeways with right of way of (70-100) m.
- Class (TSO1) represents major arterials with right of way of (40-60) m.
- Class (TSO2) represents minor arterials with right of way of (30-40) m.
- Class (TSO3) represents local arterials with right of way of (20-30) m.



Figure 4. Classifications of Existing Highways within the Study Area

5.3 Suggested Highways in the Study Area

The comprehensive transportation study of Scott Wilson and the comprehensive development plan of Baghdad at 1973 suggested a transportation network that would serve future needs (at the time of the study), therefore and by using GIS technique, the suggested highways have been set out. By comparing the percentages of the existing highways shown in Figure 4 and suggested highways shown in Figure 5 it will be clear the delay of providing the highways needed to facilitate the transportation demand generated from land uses of the study area.



Figure 5. Classifications of Suggested Highways within the Study Area

Table 2 shows a comparison between the percentages of existing and suggested highways, knowing that class (TSO3) is considered as the same as class (TSO2) to simplify the comparison.

Table 2. Highways Percentages according to their Classification in the Study Area

Classification of Road	Existing Area		Proposed	
	Sq. Km	%	Sq. Km	%
Freeway	1.80	0.48	2.57	0.47
Principal	0.86	0.23	0.9	0.16
Secondary	1.072	0.29	1.96	0.36
Total	3.744	100%	5.43	100

5.4 Public Garages

There is a garage within the study area in Al-Askariain street, its area is about 20000 m² (the practically used area). This garage distributes transportation movement to different garages in Baghdad, which causes traffic congestion, especially the movement between the study area and garages in Al-Karkh and Al-Rusafa sides. It also serves passengers going outside of Baghdad.

5.5 Intersections

Intersections represent a very important parts of highways components. Intersections are of the most important nodes of traffic congestion because of the conflicts happening in the free traffic. Baghdad municipality presented that, in its future projects, will be a study to improve the efficiency of 14th July Street by grade separating its intersections like Adan and Sana'a intersections.

5.6 Public Transit in the Study Area

Services produced by each type of transportation modes are important factor in the distribution of trips on these modes, and time spent in trips and cost of private and public transit are important factors in the competition of systems.

The study area lacks to public transit systems as the case in Baghdad city where there is only private cars system, and public transit is represented by taxis, buses and minibuses. There is a main unique garage for the public transit in the study area which is the Said Muhammad garage in Al-Kadomiya city. Previous studies recommended that the Baghdad's metro line no. (1) (Al-A'adamiya – Al-Sadir city) could be extended in the second stage to Al-Kadomiya across Tigris River near Al-A'immah bridge according to a comprehensive planning study for the public transit (in the study of the fast transportation project committee in Iraq) that ended at 1979, and this suggestion has been agreed with the other transportation studies.

By using GIS technique, the path has been projected on the spatial image, and it has been shown that the length of the suggested extension is about 4.7 km from the end of the first line in the first stage including 4 stations. The construction of the project of Baghdad Metro and its extension into Al-Kadomiya city will connect the study area with the CBD of Baghdad and the sectors centers of Al-Sadir city.

6. The Division of the Study Area into Residential Sectors:

The study area consists of 20 residential sectors, according to maps of residential sectors existed at the municipality of Baghdad, after they were projected on the spatial image in the GIS. As presented in Figure 6.



Figure 6. Residential Sectors within the Study Area

7. Population and Transportation

As shown in the following map (Figure 7), which shows the population densities of Baghdad, it is clear that one of the highest population densities, between

351 to 525 people per hectare, is within the study area (within Al-Kadomiya city).

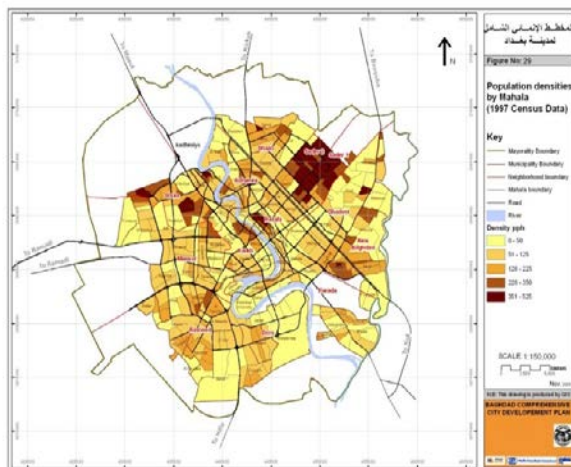


Figure 7. Population Densities Distributed on the Residential Sectors of Baghdad City

8. Land Use and Its Relationship with Transportation

The hierarchy of the city is related to land uses distribution, densities and connection with each other which have great effect on the size and generation of trips and the way of its distribution on the network. There are a lot of cases that the network cannot afford this traffic movement, and also there are adjacent land uses that are inappropriate, because one generates high traffic volumes that are out of the capacity of the network and the other suffers from its negative effects.

The general form of the city is related to the nature of the transportation network, in the recent design of cities the choice of form and hierarchy is done in a way related to movement lines which makes them compatible with each other.

Although of the variety of land uses in urban areas, what are used in the study of trip generation are only the main land uses, and the residential land uses are the most important ones, therefore they represent 80% to 90% of the total trip generation in the area.

Industrial and commercial land uses come in the second level of importance in trip generation, and in the same time they represent a good percent of trip attraction i.e. they are considered as attraction centers more than generation centers.

The current land use plan is the one done by Polservice Company within the comprehensive developing plan of Baghdad in 1973 till the goal year of 2000 and can be seen in Figure 8.

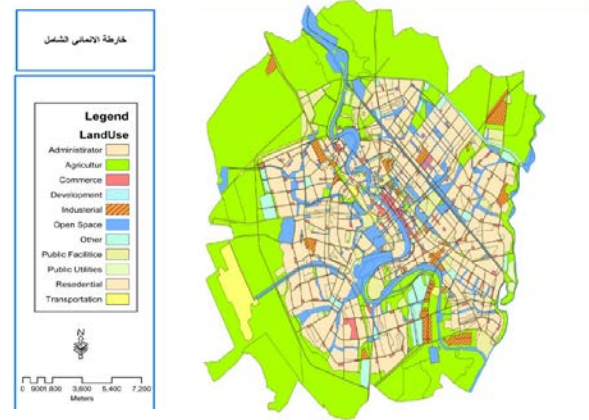


Figure 8. Land Uses Plan in Baghdad City

As per the opinions of a number of specialists in Baghdad municipality, it has been shown that there are not many changes happened in main land uses in the study area.

Using the GIS a database has been prepared for land uses depending on the comprehensive developing plan, by using this system we could compute final areas of land uses within the study area, results are shown in Table 3.

Table 3. Main Land Uses in the Study Area

Land Use	Sq. Km	Percentage
Residential	7.500	19.4 %
Industry	0.874	2.3%
Commercial	1.113	2.9%
Transport	5.578	14.5%
Open Space	6.183	16%
Agriculture	11.294	29%
Utility	0.932	2.4%
Facility	5.050	13%
Development	0.166	0.5%
Total	38.69	100

9. Tigris River Bridges and Traffic Volumes

Tigris River is one of the natural features in Baghdad city; it divides Baghdad into two divisions, Al-Rusafa and Al-Karkh. There are 13 bridges connecting the two sides of Baghdad. Planning studies which was carried out on the transportation in Baghdad focused mostly on the transportation operation between the two sides of Baghdad. Throughout the urban transportation study and traffic counts which were carried out on the Tigris bridges, it was found that the number of vehicles that used bridges at that time was 440000, and it was also found that the percent of vehicles going to Al-Kadomiya and the boundary area was about 21.1%

from the whole number of vehicles passing the Tigris river.

The study also showed that public transportation was 5.8% and private modes were 94.2% of the total volume of vehicles passing on the bridges of the Tigris River.

The comprehensive transportation study of Baghdad recommended that a number of bridges and/or tunnels passing across the river should be 17 at the year of 2000 which is the goal year of the study; this number was based on the estimations of number of vehicles passing Tigris River of 1125000.

By using the ratio of 21.1% which is the ratio of vehicles going to Al-Kadomiya and the boundary area, there are 237375 vehicles according to the estimations of Scott Wilson, and by using a growth rate of 3% the traffic volume expected to cross on the bridges towards Al-Kadomiya is about 319012 veh/day.

To find the design hourly volume (DHV):

$$DHV = ADT * K * D \text{ (vph)}$$

DHV two-way traffic volume ranges from 10 to 17 percent of two-way traffic volume ADT.

By assuming that the directional distribution is equal for both sides and $K=10\%$, the following can be estimated:

$$DHV \text{ (Towards Al-Karkh)} = 0.1 * 0.5 * 319012 = 15951 \text{ vph}$$

To find number of vehicles per lane in bridges in the study area, field surveys have been made for these bridges.

From what proceeded and by summing traffic lanes for each direction, it is clear that there are six traffic lanes transport vehicles across the river (from Al-Rusafa (Al-Grea'at and the boundary area) to Al-Karkh (Al-Kadomiya and the boundary area)), i.e. each lane transports 2659 vph, and this is of course more than the capacity of a lane in the ideal conditions. Assume that the full lane capacity 1900 vph (HCM,2000). Accordingly, for the target year (45 years) the required no. of lane to handle the estimated traffic volume will be as follows':

$$15951 / 1900 = 8.4 \text{ lane} \dots \text{ say } 9 \text{ lane}$$

As mentioned above the available no. of lane was six. Accordingly, 3 lanes will be needed to handle the rest of the traffic volume. The proposed bridge will be three lanes per direction.

10. Alternatives for Proposed Paths

Tigris River is the focus of expansion for the study and passing this river is the target to connect each sides. The preliminary vision of the development process is as follows: -

10.1 Alternative No.1

Connects AlGrea'at boundary approaches and Ocean Street in Al-Kadomiya area by a bridge, almost length of the path is found to be 3950 meters,

and the width of the river cross section for this path is 380 meters. To execute this path, it is necessary to acquisitive all residential land within the right of way in AlGrea'at Main Street and construct a new road through agricultural land in AlGrea'at side. This path is shown in Figure 9.



Figure (9), Alternative No.1.

10.2 Alternative No.2

This path will connect Nadhum Altakchali square in AlGrea'at and extends to the military area in Al-Kadomiya. To execute this path, its needs to acquisitive all residential land within the path right of way in AlGrea'at side, construct a new road in agricultural land in Al-Kadomiya side and acquisitive 1349 meter in Al-Kadomiya agricultural land. Total length of path is 2,06 km, crossing Tigers River through curved section of 480 m width. This path is shown in Figure 10.



Figure (10), Alternative No.2.

10.3 Alternative No.3

This alternative matches with Scott Wilson proposal in their previous study (Baghdad comprehensive transportation study). It represents the proposed ring road No.3 in northern end of the Baghdad city. They recommend that the orbital route should use a tunnel under Tigris River. The approximate path length is 5.94 km., crossing Tigers

River in a straight section of 286 m width. This path is shown in Figure 11.



Figure (11), Alternative No.3

11. Economic - Feasibility Study

A feasibility study is defined as an evaluation or analysis of the potential impact of a proposed project. It is conducted to assist decision-makers in determining whether or not to implement a particular project. It is based on extensive research on both the current practices and the proposed project. The feasibility study will contain extensive data related to financial and operational impact and will include advantages and disadvantages of both the current situation and the proposed plan. It is conducted to assist the decision-makers in making the decision that will be the best.

11.1 Economic Indicators

There are several economic indicators available in the economic evaluation of projects. The most common include benefit/cost ratio (B/C), net present value (NPV), equivalent uniform annual cost (EUAC), and internal rate of return (IRR). The transportation agency's choice of the appropriate indicator depends on several factors such as the level and context of analysis or the economic environment in which the analysis is conducted. For example, the IRR is the preferred economic indicator when projects are evaluated in developing countries where the discount rate is highly uncertain [1].

11.2 Cost-Benefit Analysis

A benefit cost analysis involves the calculation of the stream of benefits and costs over the lifetime of the project. In addition to the benefit-cost analysis, non-monetary but quantifiable considerations, and non-quantifiable considerations should be evaluated to determine if a project is economically justified.

The appraisal of benefit and loss appraisal in term of transportation engineering and planning is used to compare the performance of several planning alternative proposed due to the improvement of transportation system service quality in a study area. The alternative to sustain existing service performance (do-minimum) or allow the existing

condition (do-nothing) should be included as part of the evaluation, as the basic of the comparison among other alternatives. The alternative of performance improvement (do something) measured by comparing the benefit and loss of each proposed alternative [2].

Costs include the construction and maintenance of the road projects. There are also environmental costs associated with any project of this kind, and we quantify these where possible, without calculating the scale of potential environmental impacts. Benefits are composed of the savings in travel costs and time on the part of road users, as well as increased transportation activity spurred by the upgraded infrastructure. The aggregate of benefits is accruing to all sectors of the economy in our benefits calculation. In other words, the benefits to agriculture, tourism, commerce and all other sectors are added together to determine the road's total benefits. These benefits are compared to the road's construction and maintenance costs to determine whether the investment represents a net gain or loss for economy.

The principal alternative to the cost occasioned approach is the benefits approach, in which an attempt is made to identify and measure the benefits received by both users and nonusers of the system. The benefits approach begins with the recognition that the purpose of a highway system is to provide benefits, both directly to highway users and indirectly to the rest of society. Benefits are not directly measurable, and the benefits associated with traveling a mile on a given road. Arguments that support charging nonusers for highways are based on the societal benefits attributable to the highway system, including increased mobility, safety, and economic development. There are, however, some serious conceptual problems in quantifying benefits and deciding which accrue to users and which accrue to nonusers.

Full benefit-cost analysis would allow construction costs to be compared to benefits accrued from factors such as decreased traffic congestion and reduced accident rates. The benefit-cost analysis identifies projects which make effective use of resources.

11.3 Cost Estimation Process

Cost estimation is an essential component of infrastructure projects. Accurate estimation will assist project managers to choose adequate alternatives and to avoid misjudging of technical and economic solutions. The accuracy of cost estimation increases toward the end of the project due to detailed and precise information. The conceptual phase is the first phase of a project in which the need is examined, alternatives are assessed, the goals and

objectives of the project are established and a sponsor is identified [3].

Major difficulties which arise while conducting cost estimation during the conceptual phase are lack of preliminary information, lack of database of road works costs, and lack of up to date cost estimation methods. Additional difficulties arise due to larger uncertainties as result of engineering solutions, socio-economical, and environmental issues. Parametric cost estimation or estimation based on historic database during the conceptual estimate phase is widely used in developed countries. However, developing countries face difficulties related to the creation of a road work costs database, which may be used for cost estimation in either the conceptual stage or the feasibility study of a project cycle, [4].

The objective of the Cost Estimation Procedures for Highway Design Projects is to maintain consistency in cost estimation practices and to develop estimates that more accurately reflect the final construction costs [5]. Project cost deviations via Transportation Route Cost Analysis software (TRCA) which estimates the Project cost and ensure Construction cost to those sufficient funds are available for construction. It's worthwhile to mentioned that the mentioned program was developed by Abeer. J.Abd-Al-Razaq as a part of her MSC, Thesis, Al-Nahrain University, Baghdad – Iraq [6].

The cost component is the remuneration of cost that should be paid either by government, operator or users in providing, operating, maintaining, and/or using a transportation system.

In general, as basic of economic evaluation, the components of transportation cost consist of 2 major parts. First, the provision of transportation infrastructure investment which is generally provided by the government, this cost covers:

- Initial cost (development)
- Routine and periodic maintenance
- Other cost (subsidies, compensation, etc)

Second, cost that is expensed by the users of transportation system:

- Vehicle operating cost and value of time
- Other cost (taxes, toll, parking, etc)

12. Economic Benefits

Throughout the process of benefit-cost analyses, the most important benefits are the monetary equivalent value of time savings to transportation users and the monetary equivalent value of the reduction in accidents, injuries, and fatalities that would result from the use of a new facility.

Another important benefit to consider is the reduction in the vehicle operating costs.

12.1 Vehicle Operating Cost

Throughout the construction of the proposed project, there should be savings in the cost of operating a vehicle traveling within the vicinity of the proposed alignment. These savings would come due to the reduction in consumption of motor fuels and oil, as well as reduced wear and tear on the vehicle itself.

12.2 Travel Time Savings

The FHWA's Procedural Guidelines for Highway Feasibility Studies emphasizes the importance of the benefit of time-savings to transportation users.

This benefit is computed by determining how much time motorists might save as a result of constructing.

12.3 Accident Savings

In order to consider the safety benefits to society resulting from the construction of new road, costs must be assigned to the various types of accidents that may occur on the existing routes and the proposed routes.

All decisions related to highway projects are typically required to maintain road user safety; hence, alternative proposals must be scanned for their impact on road safety. For example, it is often argued that value engineering initiatives compromise safety.

A number of road safety prediction models have been developed to assess different geometric conditions on safety measures.

13. Formulation the Cost Function for a Transportation Route

Economic analysis of transportation schemes is an extremely useful tool, particularly in assessing priorities between route schemes, and between alternatives for the same. The major cost components of transportation route can be classified into several categories as follows:

1. Planning, Design and Administrative Costs.
2. Construction Cost.
3. Maintenance Cost.
4. User Costs (Fuel Cost, Tire Cost, Oil Cost, Travel time Cost, and Accident Cost).
5. Social and Environmental costs.

13.1 Modeling the cost function using TRCA program

The cost functions of transportation route are modeled using TRCA software. The total cost is a criterion reflecting the goodness of an alignment. All required cost computations can be computerized and then incorporated into the model.

13.2 Formulation the Cost Function of the Study area

The general input values in the TRCA software are:

1. No. of lanes in each direction
2. PHF (Peak Hour Factor)
3. Heavy Traffic
4. Construction cost per Km
5. Length of highway
6. Gross Domestic Product

Construction cost of bridge = 3000\$ per 1m²,
 Construction cost of highway = 650000\$ per Km

13.3 Cost Estimation

The cost functions of transportation route are modeled using Visual BASIC language as software named (TRCA); it means Transportation Route Cost Analysis. The total cost is a criterion reflecting the goodness of an alignment.

The following Table 4 shows the summary of the results for all cost elements for different alternatives project.

Table 4. Summary of Results Obtained Using TRCA Program

Element Cost	Alt.1 (ID)	Alt.2 (ID)	Alt.3 (ID)
Administrative Cost	2850953105	2870333215	8012129036
Construction Cost	74050730000	74554109500	2081072479 20
Maintenance Cost	651646424	656076163	1831343779
-Fuel Cost	1142156599	682342963	4454997050
-Tire cost	74824036	51296937	1213904809
-Oil Cost	221579173	145127057	1065864316
-Travel Time Cost	29730990	17699125	115685524
-Accident Cost	N/A	N/A	N/A
-Total User Costs	1468290798	896466082	6850451699
Social and Environmental	7481868	4994945	34760047

The third alternative proposed interchange type (FULL CLOVERLEAF) in the same location of the intersection portion of the road ring with the Al-Qanat in the Rusafa side, as well as at the site of 14th of July intersection in the Karkh side.

In addition, it proposed (3 PARTIAL CLOVERLEAF) in three locations (first in the intersection of Ibn Fathlan with the portion of the road (that proposed in path number three), (second,

in the intersection with Muhammad al-Qasim and the third, in the Karkh side (road intersects with a secondary distributor).

The establishment of a ring road (No. 3) will include in addition to the portion crossing of the river (2 FULL CLOVERLEAF (the total area approximately 80000 m²)) + (3 PARTIAL CLOVERLEAF (the total area approximately 60000 m²)).

The second proposal also includes a tunnel. The portion proposed that connects Nadhum Al-Tabaqchali square with Muhammad al-Jawad street needs to a tunnel in the Rusafa side at the site of its intersection with Omro'o Al-Qais Street. Besides that, the proposal one which connects the AlGria'at street with Muhammad al-Jawad street might need to overpass bridge to avoid the road coming from the Altojiat (the road connecting Muhammad al-Jawad street and passing to the north of Baghdad) in the case of opening the bridge after this signal.

Total cost for all interchange, tunnel and overpass are shown in Table 5 a and b.

Table 5. Summary of Results Obtained Using TRCA Program.

-a-

Cost Element	Full Interchange ID	Partial Interchange ID	Total Cost of (2Full Interchange + 3Partial Interchange)
Administrative Cost	1647773847	881026504	5938627206
Construction Cost	42799320720	22883805360	154250057520
Maintenance Cost	376634022	201377487	1357400505
-Fuel Cost	1039119960	393214588	3257883684
-Tire cost	320454990	178030550	1175001630
-Oil Cost	227732923	109962735	785354051
-Travel Time Cost	26953477	10199497	84505445
-Accident Cost	N/A	N/A	N/A
-Total User Costs	1614261350	691407370	5302744810
Social and Environment	7313618	3524010	25199266

- b -

Cost Element	Tunnel for Proposal 2 (ID)	Overpass for Proposal 1 (ID)
Administrative Cost	232432200	755404650
Construction Cost	6037200000	19620900000
Maintenance Cost	53127360	172663920
-Fuel Cost	86738512	130107768
-Tire cost	35606110	35606110
-Oil Cost	16192547	26192547
-Travel Time Cost	2249889	3374833
-Accident Cost	N/A	N/A
Total User Costs	140787058	195281258
Social and Environmental Cost	600402	822402
Total Cost ID	6464147020	20745072230

14.Land Acquisition & Right of Way Limitation

Each of the proposed alternatives requires obtaining additional rights-of-way. Land acquisition compensation costs including residential and agricultural area. The cost of this required acquisition may be decreased by abandonment of some of the existing right-of-way.

Land Acquisition will also affect agricultural activities. Farmers will have to change their activities on the plots impacted before construction commences. Land acquisition in a particular section of the Project road must have been completed before construction commences.

One of the most significant challenges in acquiring right of way is that dependent on factors over which may have little or no control. Delays may be encountered from property owners and their legal counsel, title companies and the court system, just to mention a few. All topography items that are within the area of ROW acquisition or within 100 feet of the centerline are to be shown on the plans.

Additional topography items outside of these areas should also be shown if they affect the value of the acquisition. Topography items to be shown include objects such as: homes, buildings, farm appliances, sidewalks, paved or unpaved driveways,

trees, waterlines/steams/lakes, fences, or above and below ground utilities.

Table 6, is shows area of each land acquisition and its cost for all alternatives of the study area.

Table 6. Area and Cost of Land Acquisition.

Land Acquisition	Path1	
	Area m ²	Cost (ID)
Residential	73920	14784000000
Agriculture	37000	4440000000
Total Cost	110920	15228000000
Land Acquisition	Path2	
	Area m ²	Cost (ID)
Residential	10560	6758400000
Agriculture	53600	8576000000
Total Cost	64160	15334400000
Land Acquisition	Path3	
	Area m ²	Cost (ID)
Residential	233750	46750000000
Agriculture	291250	46600000000
Total Cost	525000	51410000000

*1m²=2000000 ID for Residential Area.

*2500m²=400000000 ID for Agriculture Area in Kadomiya city

*2500m²=300000000 ID for Agriculture Area in AlGria'at city.

The pricing of lands for different uses were obtained from the Kadomiya Real State Registration and the advice of the local private real states agencies. The prices are for the year of study and is subject to increase or decrease with the change of the land market.

15.Cost-Benefit Analysis

A benefit cost analysis involves the calculation of the stream of benefits and costs over the lifetime of the project. In addition to the benefit-cost analysis, non-monetary but quantifiable considerations, and non-quantifiable considerations should be evaluated to determine if a project is economically justified. In benefit-cost analyses, the most important benefits are the monetary equivalent value of time savings to transportation users and the monetary equivalent value of the reduction in accidents, injuries, and fatalities that would result from the use of a new facility.

Another important benefit to consider is the reduction in the vehicle operating costs. Furthermore, connecting Al-Kadomiya with Al-Rusafa side of

Baghdad city is one of the most important and necessary projects because inability of current bridge to absorb the demand for transit transport between Karkh and Rusafa of the study area, so it is necessary to provide three additional lanes for each direction (i.e, six lanes for both directions), passing on Tigris River to solve transport problems.

The expected results of construction such projects are very importance for solve traffic problems, increase the accessibility of the areas by increasing the efficiency of traffic management, reduce the delays caused by traffic jams, reduce environmental pollution and provide easy access between Al-Karkh and Al-Rusafa sides.

Regarding the summary mentioned in Table 4, the following Table 7 presents the Economic-Feasibility evaluation. It clear that alternative 2 is more economic from the feasibility point of view.

Table 7. Economic-Feasibility Evaluation

Benefit/Cost (B/C)	Path 1	Path 2	Path 3
	2.4	6.3	1

16.Routes Alternatives

All the alternative proposals will be mainly "dependent" on many related factors. As will be described in the following articles.

16.1 Alternative No. 1 (Linking Al-Grea'at the main street with the road of Muhammad al-Jawad)

1 - This proposal does not need to take acquisition of more than 40 meters right of way where the bridge would become with the elevation of nature earth before meet roads (aerial photo can be seen on both sides of Al-Grea'at and Al-Al- Kadhimiya)
 2 – Width section of the river within the range of (340 to 380) meters depending on the limits of right of way from both directions.

3 The path remains high over this way and come down later to meet the road of Muhammad al-Jawad and benefit from the intersection of the hospital, which opens on it.

16.1.1 Engineering requirements

The provision of right of way from Al-Grea'at side:

The provision of right of way is 40 meters on both sides of Al-Grea'at and Al-Al- Kadhimiya). This acquisition requires (Acquisition of residential areas from Al-Grea'at area, starting from Ahud square until the end of residential areas. Area is estimated (2640 m * 28 m = 73920 square meters). Note :(Currently

available width of Al-Grea'at the main street is 12 meters). And acquisition of empty land (agricultural or otherwise) (including the sides of river, starting approach of the proposed bridge and up the side of the river - the area is estimated as (455 * 40) = 18200 square meters.

The provision of right of way from Al-Al-Kadhimiya side:

This acquisition requires the empty land area within Al- Kadhimiya area on side of the river until the merged of the alternative with proposed highway of Mohammed Jawad, and the area to be acquisitions in this section is (470 * 40 = 18800 square meters. This acquisition is necessary for the implementation of the proposed alternative, whether the acquisition is "agricultural, residential, river, etc. The total area of land acquisition is 110920 m².

16.1.2 Implementation of Engineering Modifications

1 - The new bridge would be preferable to work with three lanes of traffic in each direction with the providing of median of bridge at least a meter and side sidewalks of not less than (1.5) m for each direction.

2 - This proposal requires to change width of Al-Grea'at main street to be (the way that will be altered with two directions, separated by a median, each direction including at least three lanes of traffic separated by a median with width not less than 4 meters and side walk for each direction with width not less than 3 m for each direction).

3 – Construction new road by starting from the end of Al-Grea'at Main Street until the approach of the bridge on the other hand with the specification of the bridge Al- Kadhimiya.

4 – Implementation new engineering modification for Mohammed Jawad highway to suit the new traffic used for the new proposed alternative (modulations at the mergence's of Mohammed Jawad with new bridge

5- Implementation new engineering modification in Ahud square to fit the sizes of traffic used.

16.2 Alternative No. 2 (Linking Nadhum Al-Tabaqchali square with Muhammad al-Jawad's road)

1 - This proposal requires the provision of right of way with 40 meters for the entire path except the part that link between the Kornish Road (Kornish Al-Grea'at to the Nadhum Al-Tabaqchali square) require the provision of right of way with 60 m, to provide side streets linked between the square and the Kornish..Road.

2 - This proposal requires provision of a tunnel under the Kornish Road because the lack of net height at

the site of merges of the Kornish Road with the proposed path of the bridge.

3 Length section of the river in view of this proposal is 480 meters. Overall length of the road with included cross-section of the river will be up to 2060 meters.

16.2.1 Engineering requirements

1-The provision of right of way in the Al-Grea'at side requires the acquisition of residential land, agricultural (based on the provision of right of way with 60 meters from this side). Area to be acquisitions estimated as:

$$((180 * 48) + ((60 * 40) - (12 * 40))) = 10560 \text{ m}^2.$$

This area is the construction of the first line from the intersection of the river up to the side of the river + (15 * 40).

2-The provision of right of way from Al- Al-Kadhimiya side:

The provision of right of way in Al- Kadhimiya (required only provide 40 m): -

- Acquisition of agricultural land area of approximate estimates (1340 * 40) = 53600.

Note "that within the area above in the side of Al-Kadhimiya acquisition of one of the military buildings within the military zone. The total area of land acquisition is 64160 m².

16.2.2 Implementation of Engineering Modifications

1 - With the same specifications contained in the proposal (1).

2 -This proposal requires the construction of side roads on the side of Al-Grea'at (part of the link between Nadhum Al-Tabaqchali square and Kornish Al-Grea'at.

3-The construction of a tunnel under the Kornish Road Al-Grea'at at the site of intersection it with the path of the bridge.

4-Implementation new engineering modification for Mohammed Jawad highway to suit the new traffic used for the new proposed alternative (modulations at the mergence's of Mohammed Jawad with new bridge).

5-Implementation new engineering modification for Nadhum Al-Tabaqchali square to fit with the new sizes of traffic flow.

16.3 Alternative No. 3

There are two options for implementation in the case of approval of the implementation of the bridge at this site, either to be implemented the way the full specifications and the entire path, or use of Ibn Manthour road located on the side of Rusafa and associated with by Muhammad al-Qasim – Al-Qanat,

by raising the level of service of the street to the end of river and development bridge crossing at the same proposed location under the previous studies is linked to the 14th July road and in general, This alternative proposed strategic terms is an important part "of the local transport network" For this alternative the following is

- 1- Under planning studies and traffic operation, it will provide of right of way ranges (70 -100) m under the classification of the road in these studies.
- 2- Provision of a total length of 5.820 km for the highways specifications.
- 3- Create a huge interchange in both of the Karkh and Rasafa sides. The first interchange in Rusafa represents by Muhammad al-Qasim expressway through the AL-Qanat road with the new route the newly introduced (three highways in a single node).
The second interchange in the Karkh district represents the meeting of the newly road with the 14 July expressway and Salah al-Din expressway too.
- 4- The length of the transit along the river to this proposal is "almost 320 meters.

16.3.1 Engineering requirements

- 1- The provision of right of way from Al-Grea'at side on the regard the right of way is 100 meters, the acquisition of residential, governmental, agricultural in Rusafa side, and the area is estimated to be in Northern Al-Grea'at is (182 000) square meters, note "that is predominantly government - departments, institutions on the ground to be acquisitions on this side).
- 2- The provision of right of way from Al-Kadhimiya side Acquisition of government buildings, agricultural land in the Karkh area, and the area of acquisitions is estimated to be (368,000) square meters. The total area required acquisitions 550000 square meters of right of way= 100. The total area required acquisitions 385000 square meters of right of way 70 meters.

16.4 Advantage and Disadvantage of each Proposed Alternatives

Alternatives route characteristic is shown in Table 8.

Table 8. Alternatives Route Characteristics

Properties	Path1	Path2	Path3
Length m	3950	2060	5940
Right of Way, m	40	40-60	70-100

Land Acquisition, m ²	110920	64160	550000 for ROW =100 385000 for ROW=70
Width cross section of river	360 m	480 m	320 m
Cost ID	7902910219 5	7898197990 5	22483593248 1
Passing Tigers River Cross Section	Curved section	Curved section	Straight section

16.5 Selection of the Best Alternative

The following articles described the selection of best alternatives.

16.5.1 Route Planning Analysis

Route planning analysis in (GIS) within this study supports the proposals within the first phase of the study (planning and traffic). Route planning analysis in Geographical Information System (GIS) provides strong decision support for users in searching for optimal route, finding the optimal path is an important advanced analysis function in GIS.

This study presents the problem of selecting route to connect two locations in Baghdad city; Al-Kadomiya and Al-Grea'at. Three alternatives were investigated using a multi criteria approach and spatial decision support system, (SDSS) that will assist the decision-maker, to select the optimal route for a new road path. In ARCGIS 9.2, spatial analysis has been used to carry out the search strategy.

In general, the goal of this study is to develop a (GIS) - based model to determine suitable route. Therefore, the required data for the proposed model building were identified by using, land use, transportation maps, aerial photographs and demographic features then reviewed for model development requirements. Six factors were considered; Geotechnical, Geometrical, Social, Benefit\Cost ratio, Environmental and economic factors for multi-criteria evaluation to select the best route alternative. ARC GIS 9.2 software was used for the analysis and model building requirements.

In actualizing the aim, satellite images of the study area were provided while the land-use map was obtained from Design Office-Amanat Baghdad. The land-use over the study area was classified into eight different classes.

A Digital Elevated Model (DEM) over the study area was downloaded from the Global Mapper

Software, used to derive the slope map over the area of study and the Analytic Hierarchy Process (AHP) was used in weighting the criteria.

Finally, the case study demonstrated that GIS based on multi-criteria approach is recognized to be used as a tool for the optimum route selection by considering the factors affecting the decision-maker route selection, as well as for, saving in money, time and effort.

16.5.2 Spatial Analysis Methodology for Route Planning

ArcGIS Spatial Analyst provides a broad range of powerful spatial modeling and analysis features. Using ArcGIS Spatial Analyst, GIS users can create, query, map and analyze cell based raster data, perform integrated raster/vector analysis, derive new information and can derive information about geospatial data such as terrain analysis, spatial relationships, suitable locations, and the accumulated cost of traveling from one point to another.

The study's main goal is to identify the most suitable areas where new route can be established. This will be achieved through the ESRI's Model Builder environment. The framework for the model includes the problem definition, the criteria selection, the parameters' weighting, the spatial analysis implementation, the illustration and inspection of the selected areas, and finally the recommendation of the most suitable areas. In this case study, analyses were carried out on one growing center in the religion city of Baghdad.

In addition, the land use meets the criteria for a new route. Since the location of the case studies, Al-Kadomiya and Al-Grea'at, are adjacent, it will be practical to integrate the allocation of route alignment in these two areas. There are four main stages involved in the implementation of this research, which are:

- Stage1: Identifying the objectives and evaluation criteria
- Stage2: Implementing the multi-criteria analysis,
- Stage3: The generation of alternative route
- Stage4: Evaluation and selection of route

A new raster-based GIS model that combines multi-criteria evaluation and least-cost path analysis was developed to determine the optimal routes.

The analyst might take the following steps:

- 1-Identify the relevant map layers
- 2-Reclassify maps to indicate good or bad area
- 3-Perform a weighted analysis on the map layers

In this implementation, the best route is found. The steps to produce such a path are outlined below and shown in Figure

- 2- Generate A Thematic Cost Map (Classify and Weighting)
- 3- Perform Cost Weighted Distance
- 4- Create Direction Datasets and Perform Shortest Path

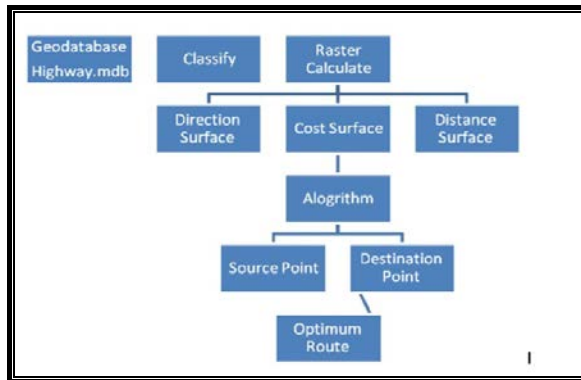


Figure 12. A conceptual model for optimal route

The model logic can consider multiple criteria simultaneously (i.e. land use, elevation, distance and soil effect). Digital Elevated Model (DEM), land use and soil layer data are overlaid in GIS using weight output from AHP to generate cost dataset, so all processes are made on raster format. The start and destination points for the road path were created using ArcMap9.2.

The re-classed map helps to differentiate a bad area from a good one to build a road path. In the classified map, number 1 was used to represent good areas with low cost value to build a road while 10 represents bad, on which it a high cost to build a road.

The benefits of a conventional decision support system are combined with the flexibility and the scalability which are offered in a spatial analysis model, developed on ESRI's Model Builder environment to select the optimum alternative.

16.5.3 Application of the Analytic Hierarchy Process (AHP)

AHP is a multi-criteria decision method used for representing a problem by using hierarchical structures and then for developing precedence for alternatives according to the decision maker. It has been shown that hierarchical structuring and pairwise comparisons are used for weighting activities by Saaty in 1980 [7]. There are AHP scales for pair comparisons.

These scales are used in calculating weight for each layer. Pairwise Comparison Method (PCM) has been used to determine the comparative weight of each parameter. The number of route selection criteria is set in AHP to derive weight for each criterion. To prepare the preference matrix, the nature of the study area should be considered.

Accordingly, the soil properties and the slope represent minor effects while, route length and land use represent major effects on the preference matrix. The final stage is to calculate a Consistency Ratio (CR) to measure how consistent the judgments have been relative to large samples of purely random judgments. If the CR is much in excess of 0.1 the judgments are untrustworthy because they are too close for comfort to randomness and the application is valueless or must be repeated.

16.5.4 Selection of the Optimal Alternative

After identifying the alternative sites, selection of the most appropriate site can be made by consideration of multi-criteria imposed by the user.

Multi-criteria decision aids in supporting the choice from among a set of alternatives described by values for criteria. This study has selected three types of routes in generating alternatives. Using spatial analysis model, all three types of routes will be evaluated against the set criteria in order to select optimum route.

It is important to note however, that the analysis needs to provide the capability to maximize the output to connect strategic locations and maximize network. The three proposed route alternatives are evaluated on the basis of the four criteria discussed above. Decision rules provide the basis for sorting and ranking the decision alternatives under consideration of route attributes and user preferences. The application of final step for Multi-criteria procedure can be presented below by the cross-table of criteria and alternatives.

The decision maker selects the suitable score between (1-10) for each cell given in Table 9. In this table, a higher value was used to represent low cost value to build a road while low value represents high cost to build a road.

The six selection criteria are set in AHP to derive weight for each criterion as shown in Figure 15. The normalized sum computes the sum of all factors for each alternative, which the higher values are more preferable than smaller values in selecting the preferred alternative.

Table 9. Brief Table of Alternatives Route Characteristics

Criteria Type	Path1	Path2	Path3	Weight (from AHP)
Geometrical				0.0678
Length	7	9	6	
Crossing	8	6	9	
Curvature	N.E	N.E	N.E	
Maximizing	8	10	10	

Grade	N.E	N.E	N.E	
Geotechnical				N.E
Bearing	N.E	N.E	N.E	
Social				0.0678
Population	7	8	6	
Economic				0.1687
Land Use	7	9	5	
Benefit\Cost ratio				0.6277
Benefit\Cost	7	10	5	
Environmental				0.0678
Passing	6	5	10	
Sum	8.01	10.3	6.7	
Normalized	32.04	41.2	26.8	

- N.E. (Not-Effective), this is regarding the nature of study area.

It is worthwhile to mention that the scoring weight which is presented in Table 9 was prepared by considering the transportation experts' opinion. Moreover, Selection of the preferred alternative is based upon a reviewing the impacts identified as shown in Table 9.

Accordingly, alternative (Path 2) is proposed to represent the optimal path based on multi criteria evaluation.

17. Conclusions and Recommendations

The present paper provided a highlight on the analysis to select the best alternative (path) to connect two districts in Baghdad city; Al-Kadomiya and Al-Grea'at. The main conclusion, that the existing bridges in their current state can't accommodate the demand for transit transport between the main sides of Baghdad city; Karkh and Rusafa.

Furthermore, the congestion will be increased gradually with time. It's appeared from the conclusion of stage one, that the study area needs to provide three additional lanes for each direction to provide suitable traffic operation within the design life of the project, which considered to be 45 years. Based on GIS application and AHP as an optimization method which used in weighting of different effective factors in the proposed criteria, ArcGIS 9.2 Spatial Analyst module is applied to provide an optimal route selection. The present paper investigates how non-spatial and spatial data can be integrated within a multi criteria decision framework to formulate and select the best and optimal route.

Accordingly, and regarding the present case study, path (2) is proposed to be selected as the optimal route to connect Al-Kadomiya and Al-Grea'at in Baghdad city. The selected roadway starts in the origin of a coordinate of (44.21 56 88E, 33.24

35 35N) and the destination of a coordinate of (44.18 22 90E, 33.23 41 76N), with 2.06 km length. The GIS based analysis as applied to the present case study demonstrates that; multi-criteria approach is recognized to be used as a tool for the optimum route selection by considering different factors affecting decision-maker selection. Moreover, it saves in money, time and effort.

Finally, the economic- feasibility study concluded that the second path also is an optimal alternative from the economic point of view

18. References

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