Estimation of the impact of Planned Light Rail Transit On accessibility patterns

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Abstract. Baghdad elevated train is one of the projects that has been suggested to improve accessibility in the city. This paper is dedicated to state the impacts of the planned train line on the accessibility in the selected study area, where the train is meant to be built in to connect the major cities in the capital (Al-Karkh and Al-Risafa). The Geographical Information System (GIS) has been used to build the existing networks (highway, public transport, and the train), to analyze them by the Network analyst tool, and to create an O-D matrix between the selected districts and a direct connection between two locations. The accessibility changes have been measured by measuring the travel time difference, checking the connection between the zones, and the direct connection between six origins in Al-Risafa for different districts to one destination in Al-Karkh before and after adding the elevated train. The results showed that the train could make a remarkable change to the accessibility in the area by reducing the travel time and make a direct connection between the mentioned districts.

Keywords: Accessibility, Public Transport, Baghdad Elevated Train, GIS, Network analyst.

1. Introduction

Accessibility refers to the ability to reach any pole of activity such as shops, office, or any destinations either for work or recreational smoothly and with minimum struggles [1], i.e., refers to the easement of an activity to be reached from an origin to a certain destination by using one of the modes kinds [2]. One of the challenges that big cities are facing nowadays is providing good, easy, and secured access to the individuals’ destinations, developing or inventing the transportation modes is considered one of the trials used to meet the long distances travel demand [3,4].

Hansen was the first author who tried to develop a new procedure to measure the accessibility within metropolitan areas through an empirical examination based on the gravity model, he defined it as the opportunities predicted for interactions, many authors have followed his steps [5].

The world has been searching for sustainable modes for decades that enhance the importance of accessibility as an indicator to measure the urban shape, therefore, recognition of the public transport systems accessibility is very substantial to encourage mode shifts and to reduce the dependency on private cars [6], also to reduce the traffic crashes and pollution emissions resulting from increasing
motor vehicle travel and potential health benefits from shifts to alternative modes [7], many authors have paid more attention to assess the improvements that public transit modes and show how they contribute to the accessibility in many aspects. (Karou and Hull) used the Spatial Network Analysis of Public Transport Accessibility (SNAPTA) and applied it to an empirical study to show the role of the improvements of the infrastructure of two systems of public transport in improving the accessibility by the public transport to six types of activity poles [8]. Handy and Niemeier, developed the accessibility measurements by using a framework provided by connecting the academic and practical aspects and fill the gap between them [9].

The number of private vehicles has been dramatically increased as a result of the increasing of the population of Baghdad city because of many reasons such as the immigration of people in the countryside to the city, moreover, the public transport in the city is suffering from the lack of efficient planning, thus the city is suffering from a congested traffic condition which leads to decrease the accessibility between the districts, and no direct access from one main district to another. Therefore, the responsible authority has adopted the Elevated Train project to improve the traffic situation. This paper aims to measure the accessibility by using geographical information system (GIS), firstly for the current public transport and secondly for the future situation after the implementation of the elevated train line.

The paper is arranged into six sections, first one is the introduction which defined the accessibility and referred to the previous studies for the related subject, next one is the definition of the study area in Baghdad, then the building of the geodatabase; next is the methodology of the paper, then the results of the calculations and finally the conclusion.

2. Study area

The study area is in Baghdad city which is the capital of Iraq divided by the Tigris river into two sections, containing 43 zones, 26 zones are located in Al-Risafa city and 17 zones located in Al-Karkh city which are surrounding the central line elevated train of 16 km long with 12 stations (see Image 1). which considered as most populated areas in the city, for the calculations the followed zones were chosen (513, 533, 331, 323, 531, 343, and 432) which cover the main districts of this area (Al-Sadr City, Jamila, Hay Al-Tujar (where the elevated train ended up), Hay Ur, Mustansiriya, Adhamiyah, and Kadhimiya) respectively, the data needed are mentioned in the next section.

Image 1. The Study Area
3. **Data collection and Building Geodatabase**

3.1 **Data Collection**

The existing public transportation routes’ directions were determined according to a reconnaissance survey for the public transport vehicles passing through the same direction of the elevated train, and the data concerned each route were surveyed depending on Ride Check Technique, which provides detailed information on passenger volumes along the route and determines the dwell times at each stop and the running time per route segment [10]. Furthermore, information about the vehicle's speed, time, and direction was collected by using the mobile application (Tracks Pro).

3.2 **Building Geodatabase**

In the aim of meeting the objectives of this study, the data collected has been built-in ArcGIS software to accomplish the work which is as follows:

a- The collected information about the public transit network was used to draw the routes in GIS; since the current public transit in Baghdad doesn’t have a uniform distribution of the network stops (it depends on the passengers’ demand to stop at their destinations), a 700m interval has been chosen between each stop and a 40 km/hr is chosen as the speed of the Public Transport vehicles, a route model has been created in GIS to connect between these stops’ stations by using the main streets network to build the network database, which clearly shows the poor service of the public transport network in comparison with the streets network in the area (see Figure 1).

b- The sidewalks network layer is also drawn in ArcGIS Map software, a speed of 4 km/hr [11] was adopted as the walking speed of the pedestrians and by using the following equation the walking time has been found,

\[ T_w = \frac{L_{km}}{V_m} \times 60 \]

Where \( T_w \) is the time of walking in minutes, \( L_{km} \) is the length of the road in km, and \( V_m \) is the walking speed (4 km/hr).

c- Baghdad elevated train layout, speed (50 km/hr) and stations’ locations were provided by the General Company for Iraqi Railways (IRR), (see Figure 2), the methodology is as mentioned in the next section.

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**Figure 1.** The public transport network in the study area

**Figure 2.** Baghdad Elevated Train Layout according to the General Company for Iraqi Railways IRR
4. Methodology

The methodology of this study has been based on creating an O-D matrix between the seven zones has been chosen to state the time changing and a direct route to check the connectivity between six districts which are lies in Al-Risafa city and Al-Kadhimiya district in Al-Karkh city in the study area, for two scenarios, first one is about measuring the current situation of the accessibility of the study area as the only modes of public transit are bus (locally called Coasters), and minibus (locally called Kia).

The second one is measuring the same after applying the elevated train line, and showing the difference in the accessibility in this area between the two cases, following the detailed information about these scenarios:

- The first scenario network building:

The mentioned network has been built by using ArcGis 10.8, as a multi-modal network connecting between the pedestrian’s sidewalks network layer and the stations of the public transit routes through transfer lines and stations.

- The Second scenario network building:

This network was also created in the same manner but this time the elevated train line has been added and connected to the sidewalks network and the public transit route stations with the elevated train stations through transfer stations located on the two networks linking through transfer lines as a connection medium between the networks.

5. Results

Once the mentioned procedures have been accomplished, the following details have appeared:

- In the aim of stating the travel time changing, for the first scenario Table 1, shows the results of the first O-D matrix of the seven zones selected containing the travel time of walking and using the public transportation (PT) network (bus and minibus) which represents the current situation, in a comparison with the result of the second scenario (Table 2), which shows the outputs of the second O-D matrix which contains the travel time of the walking, PT network, and the elevated train line into account.

- Regarding illustrating the accessibility between the selected districts, a table has been created to show each situation using the numbers (0 and 1), (0) refers to the inaccessible situation, and (1) refers to the accessible situation, Table 3, shows the accessibility for the first case, and Table 4, shows the results of the accessibility after taking both the current PT network and the elevated train line int considerations.

- The direct connection between the origins Jamila, Al-Sadr City, Hay Al-Tujar, Hay Ur, Mustansiriya, Adhamiyah, and the destination Al-Kadhimiya district, the first scenario showed that no connection existed, Figures (3 to 8), show the results of the second scenario.
Table 1. The travel time between the selected zones for the first scenario (Minute).

| Districts       | Zones’ No. | 513   | 533   | 331   | 323   | 531   | 343   | 432   |
|-----------------|------------|-------|-------|-------|-------|-------|-------|-------|
| Al-Sadr City   | 513        | 0.00  | 54.61 | 78.90 | 66.95 | 92.47 | 159.68| 199.11|
| Jamila         | 533        | 54.61 | 0.00  | 79.50 | 68.28 | 70.54 | 137.75| 177.18|
| Hay Al-Tujar   | 331        | 78.90 | 79.50 | 0.00  | 31.35 | 104.46| 171.14| 211.11|
| Hay Ur         | 323        | 66.95 | 68.28 | 31.35 | 0.00  | 101.22| 167.90| 207.86|
| Mustansiriya   | 531        | 92.47 | 70.54 | 104.46| 101.22| 0.00  | 93.77 | 125.42|
| Adhamiyah      | 343        | 159.68| 137.75| 171.14| 167.90| 93.77 | 0.00  | 71.29 |
| Kadhimiya      | 432        | 199.11| 177.18| 211.11| 207.86| 125.42| 71.29 | 0.00  |

Table 2. The travel time between the selected zones for the second scenario (Minute).

| Districts       | Zones’ No. | 513   | 533   | 331   | 323   | 531   | 343   | 432   |
|-----------------|------------|-------|-------|-------|-------|-------|-------|-------|
| Al-Sadr City   | 513        | 0.00  | 54.61 | 78.90 | 66.95 | 48.17 | 59.82 | 131.12|
| Jamila         | 533        | 54.61 | 0.00  | 79.50 | 68.28 | 50.53 | 62.18 | 133.48|
| Hay Al-Tujar   | 331        | 78.90 | 79.50 | 0.00  | 31.35 | 104.46| 119.87| 191.16|
| Hay Ur         | 323        | 66.95 | 68.28 | 31.35 | 0.00  | 96.32 | 107.97| 179.27|
| Mustansiriya   | 531        | 48.17 | 50.53 | 104.46| 96.32 | 0.00  | 29.73 | 101.03|
| Adhamiyah      | 343        | 59.82 | 62.18 | 119.87| 107.97| 29.73 | 0.00  | 71.29 |
| Kadhimiya      | 432        | 131.12| 133.48| 191.16| 179.27| 101.03| 71.29 | 0.00  |

Table 3. The accessibility of each zone for the first scenario.

| Districts       | Zones’ No. | 513 | 533 | 331 | 323 | 531 | 343 | 432 |
|-----------------|------------|-----|-----|-----|-----|-----|-----|-----|
| Al-Sadr City   | 513        | 0   | 1   | 1   | 1   | 0   | 0   | 0   |
| Jamila         | 533        | 1   | 0   | 1   | 1   | 0   | 0   | 0   |
| Hay Al-Tujar   | 331        | 1   | 1   | 0   | 0   | 0   | 0   | 0   |
| Hay Ur         | 323        | 1   | 1   | 0   | 0   | 0   | 0   | 0   |
| Mustansiriya   | 531        | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| Adhamiyah      | 343        | 0   | 0   | 0   | 0   | 0   | 0   | 1   |
| Kadhimiya      | 432        | 0   | 0   | 0   | 0   | 0   | 1   | 0   |
Table 4. The accessibility of each zone for the second scenario.

| Districts       | Zones’ No. | 513 | 533 | 331 | 323 | 531 | 343 | 432 |
|-----------------|------------|-----|-----|-----|-----|-----|-----|-----|
| Al-Sadr City    | 513        | 0   | 1   | 1   | 1   | 1   | 1   | 1   |
| Jamila          | 533        | 1   | 0   | 1   | 1   | 1   | 1   | 1   |
| Hay Al-Tujar    | 331        | 1   | 1   | 0   | 1   | 1   | 1   | 1   |
| Hay Ur          | 323        | 1   | 1   | 1   | 0   | 1   | 1   | 1   |
| Mustansiriya    | 531        | 1   | 1   | 1   | 1   | 0   | 1   | 1   |
| Adhamiyah       | 343        | 1   | 1   | 1   | 1   | 1   | 1   | 1   |
| Kadhimiya       | 432        | 1   | 1   | 1   | 1   | 1   | 1   | 0   |

Figure 3. The direct route between Jamila and Al-Kadhimiya

Figure 4. The direct route between Al-Sadr city and Al-Kadhimiya

Figure 5. The direct route between AL-Tujar and Al-Kadhimiya

Figure 6. The direct route between Ur district and Al-Kadhimiya
6. Conclusion

Referring to the objectives of this study the results showed that

- Depending on the results of (Table 1) which shows the travel time between the selected districts in the area for the first case when the only network is serving the mobility between the zones of the study area is the current public transport network, it can be noted that moving from the districts (Jamila, Al-Sadr City, Hay Al-Tujar, Hay Ur, Mustansiriya) in Al-Risafa to Al-Kadhimiya in Al-Karkh needs to ride on more than one bus or minibus to reach the destination which in turn increase the travel time. However, after taking the PT network along with the elevated train line into consideration, (Table 2) reveals that the travel time that needs to be spent on the movement between (Jamila, Al-Sadr City, Hay Al-Tujar, Hay Ur) with (Mustansiriya, Adhamiyah, and Al-Kadhimiya) is reduced. Moreover, Adhamiyah district is considered the most district benefited from the additional service of the elevated train as it can be seen that the travel time need to be spent to connect it with other districts has been significantly decreased with the following percentages (63%, 55%, 30%, 36%, and 68%) with (Al-Sadr City, Jamila, Hay Al-Tujar, Hay Ur and Mustansiriya) respectively.

- To show the accessibility between the districts (Table 3) illustrates that the PT network service is very poor in connecting between the districts, especially (Adhamiyah, and Al-Kadhimiya districts) with the other districts, but adding the elevated train makes them efficiently accessible connected (see Table 4).

- Also, the checking of the direct connection between the selected zones with Al-Kadhimiya it’s revealed that the elevated train makes the connection possible as it can’t be reached directly depending on the current PT network, given the mentioned above, it can be noted that the implementation of the elevated train has positive impacts on the area it will serve.
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