The Use of Geographic Information System to Analyze Stations Locating for Proposed Rapid Bus Route in AL KUT City.

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ABSTRACT. Bus Rapid Transit (BRT) It is one of the public vehicle systems in modern cities that provides fast, convenient, and cost-saving transport services. It operates on separate lines. The activation of the BRT system depends on the locations of the stations within its route. If the stations were located in suitable locations, it would attract a large number of passengers, this contributes to an increase in the use of public transport and thus reduces traffic congestion, road accidents and environmental pollution in the city. In this research, station locations for the proposed BRT route in Al Kut city will be studied and analyzed. 10 candidate sites were selected for BRT stations. Criteria that were used to analyze the sites of these stations are the locations of government institutions, health and educational services, stopping points for current means of transportation, and the population density of city areas. Geographical Information Systems (GIS) technology was used to represent these criteria spatially on the map to be processed and prepared for analysis using the Services Coverage Tool (Service Area) and allocation Tool (Allocation – Location) available in the network analysis toolbar and overlay tool (intersect) in the Toolbox menu. The results of the analysis showed that the sites of (10) BRT stations are within good and reasonable services coverage areas in relation to the services distribution sites in the city and the BRT route site, as the stations cover (76) government site, (69) educational institutions, (10) health sites, and (11) stops for the current transportation lines. The results of the statistical analysis also showed that the coverage of BRT stations is 88% of the total population density in the city.

KEY WORDS: BRT, Bus Station, GIS, Networks Analysis

1. General Introduction.

Public transportation is used to facilitate mobility and reduce the environmental effects of transportation in most cities. Transport stopping spacing is a necessary pointer for the spread of public transport services. A lot of cities often have a more complex land in terms of utilization and intensity of development. In most cases, they offer a multimodal transit service for example, BRT or railways. Economic growth generates increased demand for travel within cities and Thus, it requires providing more organized and efficient
means of transportation. Nevertheless, the inappropriate distribution of bus stations affects the decrease in
the quality of the public bus service for passengers [1] on the other hand, the lack of bus stops for the
outskirts of the city leads to poor accessibility on foot [2]. The selection of a BRT station is affected by
natural, economic, social, and traffic infrastructure factors. Socio-economic factors consist of residential
buildings, educational, cultural, and health institutions, as these locations have a lot of travel requirements.

As for the traffic infrastructure factors consisting of metro stations, current bus stations, intersections,
pedestrian bridges, and parking lots cars [3]. There are a number of previous studies that have dealt with
the topic of research, Including the following: Zhang [4], described the major merits of the BRT system
and the development of the BRT system in the state of Albany New York. Also review ArcGIS software
application to coordinate the locations of potential Western Avenue corridor BRT stations. In Albany New
York / Washington state, the study included other possible results of the development of the BRT system,
for example, improving access to jobs and housing by city residents, improving environmental quality,
and revitalizes society.

Pezeshknejad et al [5], considered bus rapid transit a strategy to develop high-quality transit networks in
line with a walking design suitable for the surrounding areas. In Tehran, a node location model for its
application on BRT stations was analyzed using three transit-oriented development (TOD) pointers,
including the design development indicator by measuring the walking density parameters, spatial
characteristics, and an indicator the place that represents the specifications of the land use and the demand
for the area and calculating the potential destination points close to the stations. The results show that
adequate access to BRT stations requires the provision of multi-lane corridors for the stations and that the
dense and developed pedestrian area requires short roads with a minimum number of turns to reach the
station. On the other hand, dealt Jiang [6] with the patterns of accessing express bus stops in China by
foot, studying the relationship between rapid transit bus stations and types of lanes and distances traveled
by pedestrians to reach the system. The analysis was based on (1233) user surveys in (19) BRT stations
and (3) bus corridors in Jinan City by estimating the relationship between the arrival distances and the
characteristics of the stations and the corridor area and the special features of each trip where the results
indicate that people walk a far distance from BRT stations when there are certain features of the walking
environment, for example, the location of the transit station, shaded and crowded lanes Interesting.

Phan et al [7] specified the location of bus rapid transit stations using geographic information systems
(GIS), and the application of (AHP) to a road Vo Van Kiet – Mai Chi Tho route at Ho Chi Minh City, Has
been relying on standards that define sites with high values that are suitable for building rapid transit
stations such as offices, buildings, hospitals, industrial complexes, and public transport as existing bus
stations, metro stations, in addition to crossroads, and car parks. The effect of each criterion was
determined by the method of hierarchy analysis, and treatment in the GIS environment, and (40) BRT
stations were selected. This result assists the city government in making appropriate decisions in urban
transport planning processes.

1.1 BRT Stations.
The stations are the point of contact between passengers, the BRT system, and other transit systems.
Passengers have a great influence on system image, which is why they need comfortable facilities to make
them feel comfortable. The stations need to accommodate more people than a conventional bus [8]
Because it is located on high-demand bus routes. Also, the stations should guard the users against climatic
conditions. Boarding platforms should be at the identical level of buses to make passenger access easier
and quicker [9]. The station width usually ranges from 2.5 meters to 5 meters, in partially narrow stations
the passenger space can be gained by increasing the overall length [10]. The stations must be at least forty
meters from the intersections to avoid delays, because when the stations are located directly behind the intersection, this may cause the delay of other buses to bypass the intersection due to the time it takes for passengers to get on and get off, especially when the frequency increases. Therefore, separating stations from intersections is extremely important to reduce this problem [11].

1.2 The Criteria of BRT Station Location.

Attractive stations are a distinct indicator of the BRT system which must be easily recognized by their image. Also, stations are essential in providing sufficient capacity along the BRT line. Safe pedestrian and car access to Stations, also a feeder bus service, are crucial to the investigation of Riding targets. The stations should be distinguished as much as possible by the presence of shelter with seats, Night lighting, Paint scheme that identifies the brand, Bus posted schedule, Phone, actual-time bus arrival information, Comfortable and safe Pedestrian or bicycle arrive. Correct selection of BRT station locations is critical to the success of the system. The locations of BRT stations should be in populated areas Capable of attracting the largest number of potential passengers. The principles guiding BRT stations location can be generalized as shown below [12].

- Stations spacing: The BRT stations must be separated by distances greater than Bus stops served by regular bus lines. The spacing of stations on highways for bus lines ranges from 2,000 feet (0.61 km) to 21,000 feet (6.4 km), allowing buses to operate at high speeds. Distances in Arterial streets range from 1,000 feet (0.3 km) to over 4,000 feet (1.22 km) depending upon local circumstances [13].
  - Demonstrated demand: The BRT stations must be situated in zones where current passenger’s numbers are higher at local service.
  - Good pedestrian accommodation: Passengers arriving at the station from side streets should have safe and easy access and able to cross the road safely through their location.
  - Park and ride: Determining which sites can accommodate parking and ride, particularly in suburban areas.
  - Feeder/Cross-town connections: It is preferable if BRT stations are located at locations where feeding roads or roads intersect across cities.
  - Station pairing: It is possible to build stations in locations where bi-directional stations are direct across the street.
  - Existing facilities: At some of the bus stops, a multiple significant infrastructure investments have been made. These locations should have primary priority as stations for the BRT system.
  - Supporting Future development: The land uses have to be improved and re-developed by the the BRT along the BRT corridor should be supported.

2. STUDY AREA.

The study area is the city of Kut, the center of Wasit Governorate, is located between two latitudes (32° 21’ and 32° 34’) north and longitudes (45° 54’ and 45° 45’) east, with an average height of about 20 meters. The area of the governorate is 17,153 square kilometers, as for the city of Kut, the built-up area it covers is about 40 square kilometers (4000 hectares), and it is located in an important location on the Tigris River that surrounds the city center on three sides and on close to the north of the city, two branches, branch out from the river (Al-Gharaf and Al-Dujailii). Public transport in the city of Kut depends on mini buses (Kia) in most public transport lines, with few lines still relying on medium-sized buses (28) passengers. As for
the large buses, they are not used on public transport in Al Kut. As for the main garage, it is located in the commercial center and on Hay Al Rabee'a Street, which is bounded by Wasit University. Most of the lines depart to the north of the city, where is the largest part of the city, it takes Al-Naseej Street as a corridor, after that it is distributed from Al-Mutanabbi Square towards Maysan Road and Baghdad Road, and a number of these lines cross the Karama Bridge. As for the second part that starts from the internal transport garage, it is towards the iron bridge to cross to the other side of the city, as shown in Figure (1).

3. The proposed BRT route.

The length of the proposed bus rapid route in the city of Kut is (31.85) kilometers (19.8) mil and connects this road from the northeast to the southwest of the city as Figure (2),

![Figure 1. The Study Area.](image1.png)

![Figure 2. Proposed BRT route.](image2.png)
starting from the Al-Jihad neighborhood, passing through the Sufla area, reaching the Kut-Hay road, passing through the Al-Anwar Bridge, then the two intersections of Al-Zuhur and Al-Mutanabi. Passing through Kut Baghdad Road, and Street 40 in the Al Khajia area, and ending at Kut Amara Road. It connects the suburbs and the city center to be an integrated network with the current transportation lines, thus contributing to improving the urban traffic system.

4. Data collection.

The city of Al-Kut is divided administratively into four sectors. Each sector is administered by a municipal section Subordinate to the Al-Kut Municipal Directorate. All sections of the municipality were reviewed, in addition to the Urban Planning Directorate, Wasit Statistic Directorate, and the Public Transport Authority. Trading was conducted with the concerned staff, and we were provided with the Sectoral maps and Cadastral maps available to them, and they were adopted in conducting field surveys to collect and determine the spatial data in addition to the descriptive data required in the study methodology.

4. 1 Preparing the Shape Files for required data in GIS Program.

To achieve the objective of the study, it was necessary to prepare shape files for the criteria that affect the locations of BRT stations depending on the characteristics of the study area.

The shapes files for the data collected were created by the satellite image of the city of Kut, which was obtained from the Al-Kut municipality directorate and for the year 2018, which is currently available. The satellite image specifications are:

File Formal: Geo TIFF.
Size: 10.7 GB.
Photography year: 2018.
Band number:3 Band.
Resolution: 0.5 meter.

Figure (3- a, b, c, d) shows the criteria maps that were prepared in ArcMap10.4 to be used as inputs in carrying out the processing and analysis steps in the next section.
Figure 3. Vital Places in Al Kut City (2020).
5. work methodology.

5.1 Network Analysis tools.

The networks analyst was employed in this study to select station locations by creating a database that included the road network metadata (name of the road, length of the road, the pedestrian walking speed on the road which is 4 km/hour[14], time in minute) as Figure (4 a&b), and the use of spatial maps for locations of previously mentioned parameters and referred to in Figure (3) to determine the service ranges and the passenger existence density to select the optimal riding points for a BRT bus through the spatial commands in the network analyzer tape tools as follows:-

![Figure (4-a). Road Network Analysis.](image-url)
Figure 4.b. Network Analysis Data

5.1.1 Service Areas Analysis Tool.

By using the service range analysis tool (service area), which enters in the analysis of accessibility, depending on the time cut off or the length of the path. It is one of the approved indicators in analyzing networks and finding the service range around any feature on the network. To determine the service coverage for each BRT station. The time was adopted for 15 minutes, which is the maximum time a passenger can take on foot to reach the station. Access is evaluated by the dielectric distance around the point as shown in Figure (5).

Figure 5. Service area.
5.1.2 (Allocation – Location) tool.

The assignment is intended to define the parts of the network that follow a specific point or a group of points in the study area, meaning that the network is divided into parts that each part follows a specific point, and this part is called the service circle for this point. It has been applied to the determinants of the study area (health, educational, government sites, and the stopping points for current transmission lines), and the services within the station's service circle were determined with a maximum impedance period of 15 minutes, which facilitates the decision-making process in fixing the sites of those stations, shown in Figure (6).

5.2 Overlay Analysis Tool (Intersect).

Intersect Tool: It is one of the overlay tools in the Analysis Tool group that works to find the common part of two or more layers. The resulting layer will have all the features in common between them, and the non-spatial database (Attribute table) for the new layer will include the properties of the first layer and the second layer of the common features.

The population density covered by the stations in the study area was determined in Figure (7) by applying the Overlay Tool (Intersect) to the total population density layer of Al Kut city Figure (8) and the service coverage layer obtained in Figure (5). After treating the coverage layer of the stations by dissolving all limits using the tool (Dissolve), this tool merges polygons or lines of neighbouring areas that have the same value for a specific element and creates a new, simplified coverage instead of complex coverage. The results were compared using the statistical analysis applications shown in Figures (7&8) below.
Figure 7. Population density of the service area.

Figure 8. Population density of Al Kut City.
6. Results.

(10) candidate sites were selected for BRT stations. Criteria that were used five Criteria. after completing the analysis procedures, the map was obtained in Figure (9) by:

1- integrating all the maps that were produced using the network analyser tools and the overlay tools in the GIS program referred to above.

2- The results showed that the stations sites are within the scope of service coverage in the city and cover (76) government site, (69) educational institutions, (10) health sites, and (11) stops for the current transportation lines. Which determines the actual accessibility of passengers within the specified impedance period.

3- The results of the statistical analysis also showed that the coverage of BRT stations in relation to the population density is 88% of the total population density in the city.

![Figure 9. BRT station location.](image)

7. Conclusion.

1. The study relied in analyzing the locations of BRT stations on the previously set criteria, which is the best representation of the possibilities in terms of daily trips and supports the express transportation service in identifying the stations that have the ability to attract a large number of passengers.
2. The study found that the sites of (10) BRT stations are located within services coverage areas good and reasonable services in relation to the services distribution sites in the city and the BRT route site, this facilitated the decision-making process in fixing the sites of these stations along the BRT path.

3. Efficiency of geographic information systems in the process of analyzing spatial data and obtaining a quick and easy assessment in locating BRT stations.

Acknowledgements.
The authors are grateful for the support and aid they have provided by the Mustansiriyah University, College of Engineering, Highway and Transportation Department.

This research was not funded in any way by the public, commercial, or not-for-profit sectors.

Conflict of interest
The authors assert that there is no conflict of interest resulting from this article.

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