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RESEARCH ARTICLE OPEN ACCESS

A spatial analysis of public transit routes in Amman, Jordan

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ABSTRACT
Public transport is a basic service that must be provided to any society. An effective public transport system is the system that can provide adequate service coverage to all community groups, especially the low-income group, the elderly and the disabled. For performance evaluation, performance metrics are widely implemented; for this purpose transit accessibility is used in this study as it reflects the ease of reaching transit service and its convenience as a mode choice. This study aims to assess transit accessibility in Wadi Al-Seer, one of the main districts in Amman. Accessibility was measured on the basis of the percentage of service coverage area and served population. The analytical framework included the use of geographic information systems (GIS) software, through the creation of buffer areas representing the limits of pedestrians walking distance to public transit stations. The results shows that the overall accessibility is significant, but concentrated in the center of the district, while the outskirt is not properly served, in addition to a high percentage of overlapping routes. Thus improvements on the route distribution and increasing its numbers in low access areas are required.

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I. INTRODUCTION AND LITERATURE REVIEW

Developed cities are trying to build a new transport infrastructure capable of improving quality of life, Pattern of activities, health, and environmental conditions; as well as achieving greater levels of access and equity, believing that it's no longer feasible to reach destinations by improving the mobility of single occupant vehicles. Improving the access to the transit service will significantly improve the quality of service and the user experience, which will result in increasing the ridership. EPA (2011) has described transit accessibility as an important metric that reflects the ease of reaching public transit and reflecting its convenient as a mode choice. Several studies have investigated how transportation can enhance or detract from sustainability. Public transport has proven its role in increasing sustainability and resilience in today's cities (Miller et al., 2016).

Transit access is affected by many temporal and spatial factors, such as the distribution of transit routes, operational timetables, transport transfer, and passenger origins/destinations (Zhang et al., 2018). In order to consider the transit service to be accessible, it has to be within a certain threshold of travel time or distance. Boulangeet al.(2017) examined associations between urban design attributes and transport mode choice for walking, cycling, public transport and private motor vehicle trips, he also found that a neighbourhood environment with gross residential densities exceeding 20 dwellings per hectare, a well-connected street network, access to 9 or more local living destinations and short distances to public transport services encourage walking, cycling and public transport use, while discouraging driving. Most of the references have agreed on that is 400 m or 5 minutes are the distance and time that people are willing to walk to bus stops (O'Sullivan and Morrall, 1996:Ker and Ginn 2003).

For the purpose of estimating transit accessibility Geographic information system (GIS) software is widely utilized as it offers an easy way for interpreting and visualizing the results (Nicholls, 2001;Liu et al., 2004). Salvo and Sabatini, (2005) have calculated transit accessibility by creating buffers around the routes of interest, representing the threshold of the distance that people are willing to walk which is 400 meters for bus and 800 meters for a train or a metro station. Most of the time the area that is served by public transit is lower than the coverage area, due to the presence of roadside obstacles (TCQSM, 2013).Manout, et al. (2018) Have introduced a new approach based on the spatial distribution of potential passengers and their potential readiness to use the transport system; they rely on two automatic methods for the purpose of selection the transit facility; Based on proximity and length of transit route.

The objective of this study is to evaluate transit accessibility in Wadi Al-Seer district using spatial analysis for the public transit routes, in term of the percentage of service coverage area and the percentage served population, as well as addressing solutions for future implementation to improve the accessibility.

This study is divided into five sections: the first part includes introduction and review literature, the second is data collection. The third is the methodology. The fourth is the data analysis and results. And the fifth is the conclusion.

II. DATA COLLECTION

The study area is theWadi Al-Seer district, located in the west of Amman, the capital of Jordan, as shown in Figure 1.

In the 2016 census, its population was 248583 people (Department of Statistics, 2016) with an area of 80 km2. It has three public transit modes operating within its borders, including; Buses, Mini-Buses, and Public-Service-Taxis, with 9, 25 and 8 routes for each mode respectively, as obtained from Greater Amman Municipality (GAM) as shown in Figure 2.

Figure 1**:** Public transit routes map by mode for Wadi Al Seer. (Source: GAM).

III. METHODOLOGY

The adopted methodology for the purpose of evaluating transit accessibility is as shown in the following flow chart. Figure 3.

Arc Map 10 was used in this study to estimate the percentage of service coverage area and the percentage of served population within each buffer area. The procedure was implemented by creating three buffer areas around each route. Buffers were created on the basis of time and distance that people are willing to walk to access transit service.

According to (HCM, 2010), pedestrian walking speed ranges from 0.8 to 1.8 meters per second. The pedestrian walking speed was assumed to be 1.33 meters per second. As a result, three service thresholds were created; 160, 240, and 400 meters represented 2, 3 and 5 minutes respectively (Shtayat, 2015).

The percentage of served area was evaluated according to spatial analysis for public transit routes and the surrounded areas along them. The service thresholds along the routes were divided by distance or time. In this study, the distances to public transit stations were conducted by creating three types of distance buffers include 160, 240, and 400 meters to near public transit station or stop. These buffers also used to evaluate the accessibility level of service (LOS) A, B, and C respectively was calculated using equation (1). While the percentage of served population within each buffer was estimated using supervised classification to a Geo-Referenced Google earth imagery for Wadi Al-Seer, the procedure was carried out by dividing the image into some classes based on the land uses, which was distinguished through the pixels colours. Also, the percentage of served population represented by number of pixels that represent resident areas within the buffers to the total district resident area, using equation (2).

$$\text{Percantageofservedarea} = \left(\frac{\text{bufferarea}}{\text{districts area}}\right) * 100 \quad \text{..... (1)}$$

$$\text{percantageofservedpoulation} = \frac{\text{number of residential area pixels within the buffer}}{\text{number of residential area pixels within the district}} * 100 \quad \text{..... (2)}$$

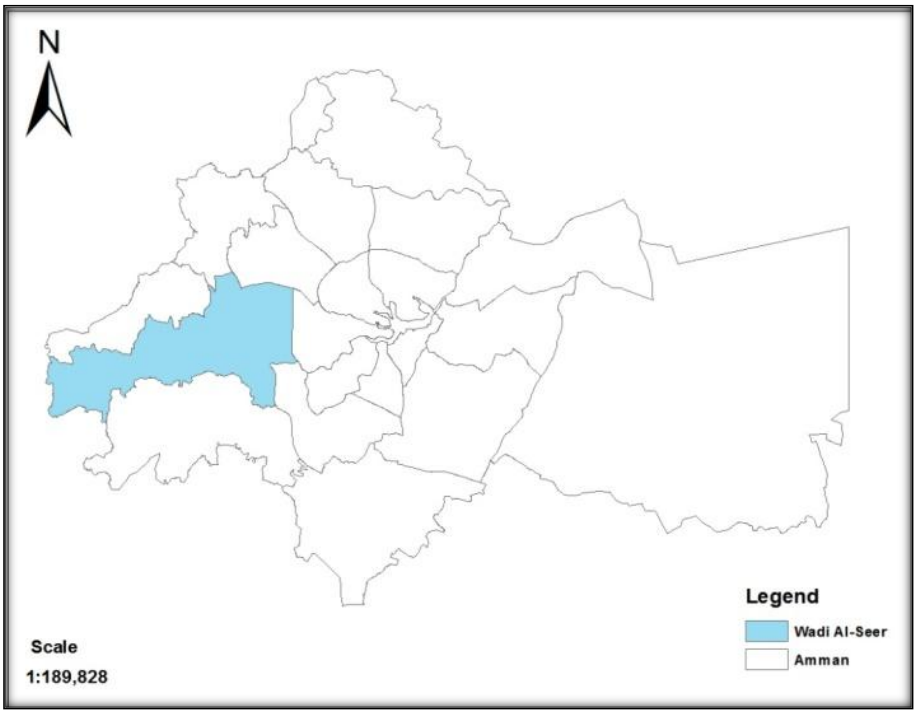

Figure 2. Wadi Al- Seer location within Amman.

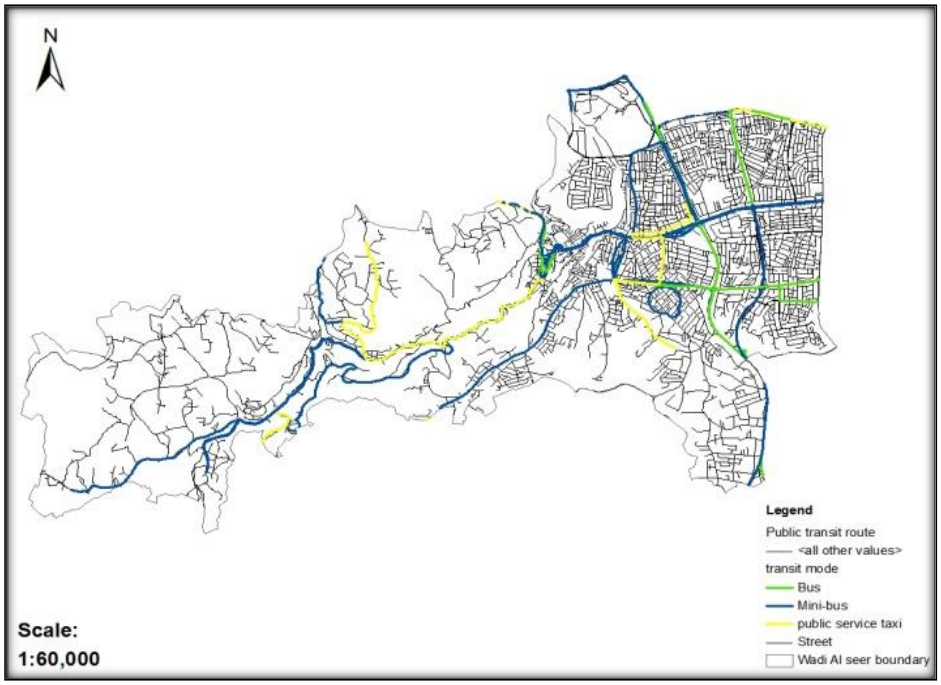

Figure 3: Public transit routes map by mode for Wadi Al Seer. (Source: GAM).

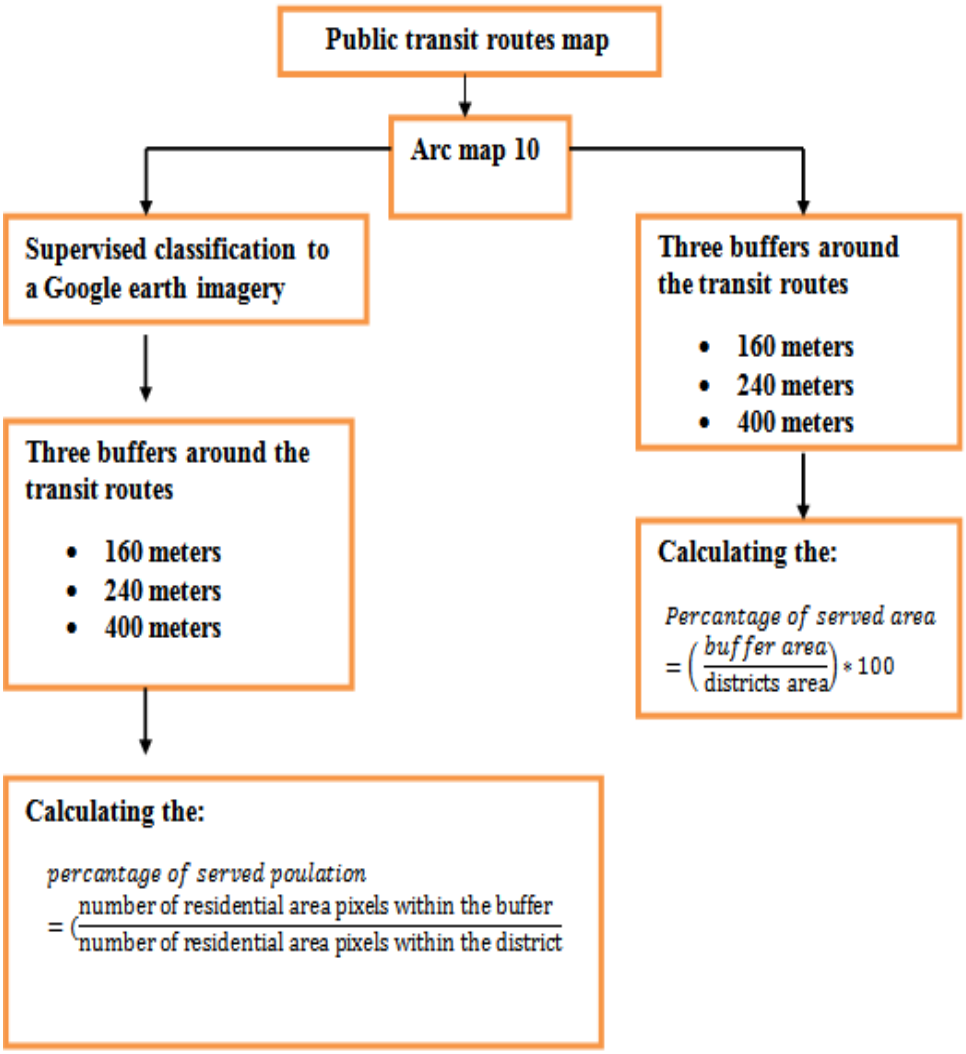

Figure 4. Flow chart of the adopted methodology.

IV. DATA ANALYSIS AND RESULTS

In Wadi Al-Seer, the percentageof the service coverage areas to the total district area were as shown in Figure (4), the first buffer of 160 meters(LOS A) was 17.17%, the second buffer of 240 meters(LOS B) was 24.28%,and the third buffer of 400 meters(LOS C) which represent the limit of the served area by public transit service was 36.38%.

Service coverage areas by mode for each of the three buffers were as shown in the Figure (5).Within a buffer of 400 meter, the service coverage area to the total coverage area is as follows: the highest coverage was 51.59% by mini-buses, then the second was 29.35% by public Service Taxis, and the lowest one was 28.22% by buses.

The percentage of served population to the total district's population based on the supervised classification of the Google Earth imagery was as the following, 25.2% within 160 meters, 35.41% within 240 meters, and 51.37% within 400 meters which represent the overall district accessibility.

The highest served area was served by mini-buses as the majority of routes Wadi Al Seer area is serving by mini compared with the other modes number of routes, where it is 25 routes of mini-buses, 9 routes of buses, and 8 routes of public shared taxis. The results of the transit accessibility for Wadi Al-Seer indicates that there are a high percentage of overlapping between routes, while at the same time the outskirt of the district is not properly served. Within buffer of 400 meters the routes overlapping for all public transit was 36.69% , Public service taxis showed the highest overlapping, within 400 meters it was 60.88%, that because public taxis sometimes they change their routes to find the shortest one or to

stay away of traffic congestions that happen frequently during peak-hours in these routes.

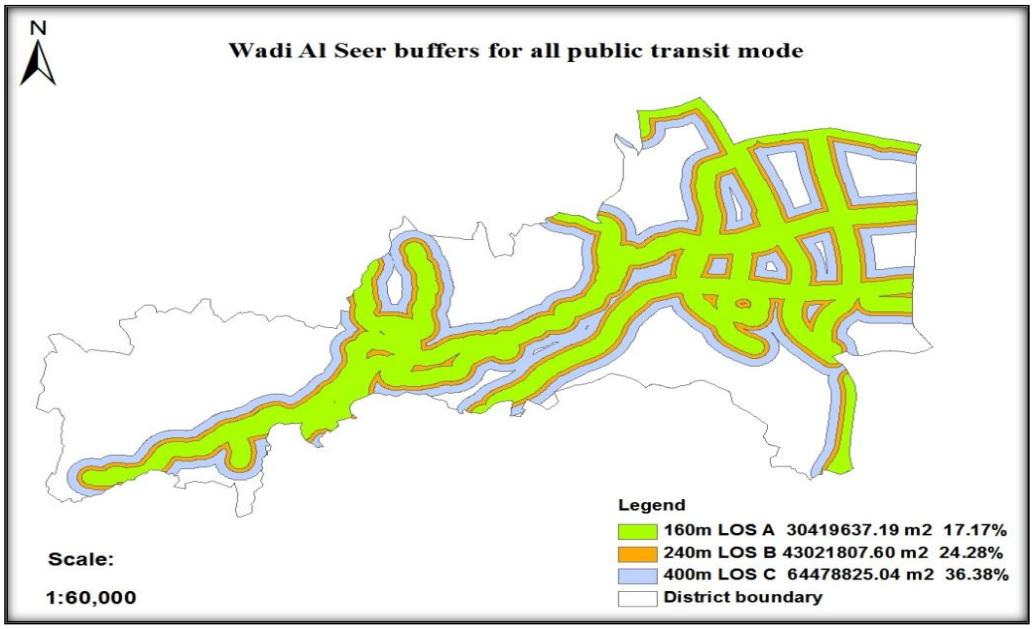

Figure 5. Buffer areas and the percentages of service coverage area in Wadi Al-Seer. (Al hurr, 2018).

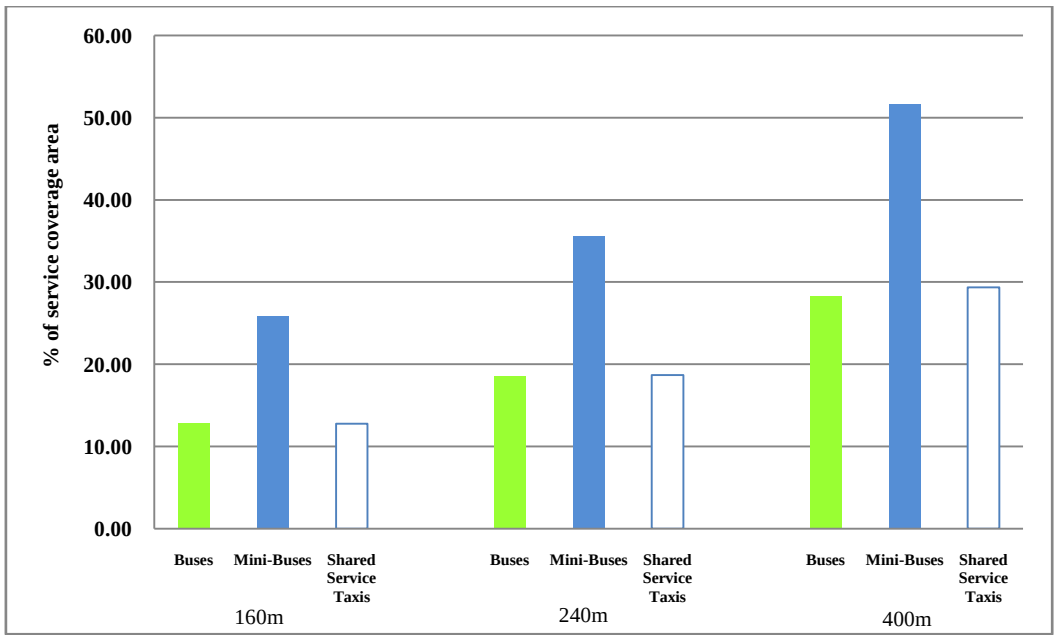

Figure 6. Percentages of Service coverage areas by mode for each of the three buffers. (Al hurr, 2018).

Table 3. Transit Level of Service Ratings (Leigh, Scott & Cleary 1999, p. VIII-3).

Transit Level -Of – Service	Portion of Demand Met
A	**90% or more**
B	**75 -89%**
C	**50 - 74%**
D	**25 – 49%**
E	**10 – 24%**
F	**less than 10%**

The percentage of served population within 400 meters was 51.37%, according to Table (3) the transit LOS will fall in LOS C. This level is acceptable especially the study area has a high congestion rate comparing with other area within Amman city.

V. CONCLUSION

This study has measured transit accessibility of Wadi Al Seer. The results showed that within 400 meters which represent the limit of transit service, the percentage of service coverage area was 36.38%, and the percentage of served population was 51.37%. As well as, the existence of a high relines on Mini-buses. The district suffers from lake of service coverage in the outskirt of the district and high percentage of routes overlapping, within 400 meters. The average was 36.96%, the highest was for public shared taxis with 60.88%. To improve the accessibility, several actions can be taken, like; increasing the numbers of the routes in the outskirt of the district, improving routes distribution by serving the unserved areas and reducing the overlapping. In addition, the possible and efficient solution that may use to increase the level of service and enhance the service provided for public transit users is replacing all buses and public taxis by mini-buses, as Mini-buses has a higher ability to maneuver within the congestion state in compared with buses, It also can carry around 23 passenger per trip compared with taxis with about 4 passengers. Government should go for an efficient scheduling for departing and arriving in the terminals, and changing the routes depending on the demand and the congestion levels, as this will help on increasing the coverage to meet the demand.

For future research, it's recommended that taking into account the dynamic changes into transit accessibility through taking into consideration the performance of each transit route and the variation of the attractiveness of the destinations along the day. In addition to taking into account, the accessibility profile variation for each area as each location has its attributes, in order to achieve that a reliable, detailed source of data should be adopted.

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