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Performance of Urban Transit in Jordan

Amir Shtayat, Hashem Al-Masaied and Sara Moridpour

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ABSTRACT

Urban public transit has an essential and active role for sustainable and balanced socio-economic and environmental development. This study investigated the performance of urban public transit services in two major cities in Jordan, including Amman and Irbid cities. Accessibility, mobility, productivity, punctuality, and waiting time of public transit were investigated in the study. Data were obtained from the Land Transport Regulatory Commission of Jordan, Municipalities, and field surveys.

The accessibility was found to be relatively low in the selected cities. Also, the results indicated that the mobility and waiting time for public transit were found to be marginally comparable with that in developed countries. In contrast, the productivity of public transit was very high compared with the productivity of transit in developed countries.

Keywords: Performance evaluation, Transport means, Bus, Productivity, Speed

1. INTRODUTION

Jordan is located in the Middle East. According to the 2016 population and housing census, the country has a population of 9.5 million, of which approximately 3 million are Syrian and Iraqi refugees, among others. Due to its geographical location, Jordan is considered as a major transport hub in the region. The contribution of the transport sector in the gross national product is about 10%. Thus, an efficient and effective transport system, including both passenger and goods transport, is crucial for sustainable and balanced socio-economic and environmental developments.

Currently, Land Transport Regulatory Commission (LTRC), Ministry of Transport, is responsible for passengers and goods transport at the kingdom level. While the Directorate of Transport in Amman, the capital of Jordan, is only responsible for passenger transport within the city. The responsibility includes planning, development, implementation, and supervision of public transport strategies, policies and actions to improve the sector.

During the last few years, Jordanian cities experienced intolerable congestion levels. This congestion may cause by the lack of an acceptable passenger transit services, consequently, many private vehicle owners used their cars instead of public transit. This situation creates large pressure on the existing infrastructure, which required huge investment to ease this problem.

In Jordan, passenger transport modes include buses, mini-buses and shared service taxis, which are working on fixed routes. Definitely, the use of more efficient modes such as rapid bus transit and light rail systems is necessary especially for large cities such as Amman, which has a population of 4 million. In fact, the use of an efficient transit system will attract more users and encourage private vehicle users to convert to the new system, and ultimately reduce congestion levels on street network.

The objective of this study was to evaluate performance of the existing public transit services in large cities in Jordan, including Amman and Irbid. Residents of these cities comprised high percentage of Jordan's population. In fact, Irbid is considered as the second and largest city in Jordan. Performance indicators such as accessibility, mobility, productivity, punctuality, and passenger waiting time were investigated in the study.

2. Literature Review

The literature review will provide an overview of the performance measures which include; Accessibility, Mobility, Productivity, Punctuality, and Waiting time for passengers.

Transport is the back bone of urban life. It is one of the factors which determines the form and socio-economic development of a city (Zuidgeest 2005). In the developing countries, the primary importance of public transit is to move large numbers of people with considerable flexibility, in order to meet mobility demand particularly access for employment throughout the city (Armstrong-Wright et. al.1987).

Public transit in developing countries do not satisfy the demand for a number of reasons include; not access for all regions, increased rate of accidents and poor service operations (Transafety 1998). Performance measures give an indication about the situation of public transit. These measures used from many agencies include; accessibility, mobility, Productivity, punctuality, and Waiting time for passengers. In 2008, the Central of Urban Transportation Research, the Performance measures is a process of defining and monitoring objective indicators to assess and report organizational performance on a regular basis. More simply, indicators are defined as things that we measure in order to evaluate progress toward goals and objectives. An accurate picture of service performance can provide passengers beneficial information to help them become active contributors in the transit policy and decision-making process and give operators input to identify and investigate service problems (Nakanishi 2007).

2.1 Accessebility;

After discovery of oil and rapid growth in traffic and increasing numbers of vehicles and people, there became a need for the development of the transport system, particularly public transport , through a better planning of public transport to provide service for all and access to all areas.

The importance of publice transport have emerged in to early 1950, where appeared several studies for the development of public transport network. Also many studies use the spatial analysis for the public transport. In addition, the (Hammond and McCullagh 1974) book is the best referance in geographical and spatial analysis, where this book is play a significant role in development of the analysis of transport networks.

In Jordan, there are many geographical studies emerged concerning public transit, was created by Grater Amman Municipality, Municipalities of governates and Land Transport Regulatory Commission.

Whenever a successful planning process, the evaluation and performance of public transit results would be a good and successful (Murray 2003). Perhaps the most important planning tools for public transport system is the accessebility. It is a comprehansive performance measure of the interaction between the land use and the transportation (Assumpta 2009). Also it defined the distance that people are willing to walk to transit (Cervero 2011).

Accessibility means spatial analysis to classified the areas to served and unserved areas. Service areas are commonly used to visualize accessibility for pedestrian to transit system, the service areas for station is defined over the maximum network walking distance from a transit station (Zielstra and Hochmair 2010). Accessibility is an important concept for urban planners because it reflects the possibilities for activities, such as working or shopping, available to residents of a neighborhood, a city or metropolitan areas (Handy and Clifton 2001).

The most common standard measures of walking distance to transit station has been 400 m (El-Geneidy 2013, Kimpel et al 2007, Murray 2003). There are many researchs for the standard walking distance to classified the regions to served and unserved areas, where there are many authors were used the Geographic Information System GIS in spatial analysis for the transit networks (El-Geneidy 2013, Cerda 2009, Abley 2008). The GIS uses the buffers areas which include the served areas, the buffers based on the network distances and the time needs to walk to transit station (El- Geneidy 2013).

In developing countries there are a highly varied and complex in the spatial structure in cities resulte in different of distribution of population (Basorun 2012), where the distribution of population depend on the facilities and service provided withen cities and the movement of traffic.

2.2 Mobility;

The speed is an essential parameter to describing traffic conditions in transport network, also provide the information about the current situation in transport networks (Birr 2014). Mobility is the ability to move, it indicates the average speed of public transit modes along the routes.

Meyer and Miller 2000 discribed the mobility at average travel speed between the stations. Mobility refers to the movement of people or goods. It assumes that any increase in travel mileage (Litman 2011).

Mobility and accessibility are the two side of the same coin. Both performance measures depend on the land use and movement of passenger and public transit vehicles (Scheurer and Curtis 2007).

Some studies linked the mobility that manage the movement of passengers to and from public transit stations (Litman 2011, Sen and Majumder 2013). On the other hand, some studies linked the mobility as the averge speed and travel time of public transit between the stations along the routes (Litman 2011).

Public transit that works give passengers the ability to avoid road congustion and save time. Fast and frequent of public transit is very important to help publice transit users (Lewis and Williams 1999).

The speed of the public transit vehicles is affected by many external factors including traffic volume and infrastructure (Birr 2014). Studies have shown when traffice volumes in roads increase the speed of public transit will be slows down. If road traffic slows down any more than public transit, passengers switch to public transit and relieve of traffic to increase again (Lewis and Williams 1999). Fast and frequent of public transit allows passengers to be kept informed about the arrival time of vehicles, thus enabling them to plan possible alternative routes, therefore saving time (Birr 2014).

2.3 Productivity;

Productivity is measured by the total number of passengers per day (Demelash 2007). It is a ratio of total passengers transported divided by total revenue of service hours provided during a given period.

The productivity is a ratio of it's output and it's input. Where the output usually indicates the daily- passenger, and the input used in analyzing public transit production function include number of workers and vehicles (Demelash 2007). Productivity is one of the performance indicators, it is calculated as a ratio between two operating statistics for service inputs, service outputes and service consumption (Lem 1994).

According to Federal Transit Administration FTA , (Annual Report 2000) the incom of the public transit modes depends on the size of public transit modes, through classifed the buses to three types depending on numbers of seats. Service input include number of employees, number of vehiches and amount of fuel. On the other hand, the service output in terms of revenue vehicle mile or revenue vehicle hours (Lem 1994).

Vehicle revenue service when the vehicle is available to the public with expectation of carrying passengers. Vehicle revenue increased by nearly 28% between 1991-2000 in United State (FTA, Report 2000). Many agencies reported that 11 to 20 passengers per houre was the minimum acceptable standard for productivity (TCRP).

Operating expenses are incurred by transit agencies that are associated with operating mass transportation service. It increased by 30% over the last 10 years in United State. In addition, data is reported by mode and object class, where object class include; vehicle operation and vehicle maintenance (FTA, Report 2000).

2.4 Punctuality;

The punctuality is timely operation of public transit modes, according to their operation schedules. It is often considered as one of the important measure of bus users. It is included; travel time and departure time (Patel 2014). Public transit service plays an important role in the society, where the passengers movers and travels within and between cities.

The puctuality index is one of the performance measures in determining the service reiability (Yaakub and Napiah 2011). Punctuality is the comparison of actual departure time with scheduled departure time at station (Chen et al 2009). According to (Yaakub and Napiah 2011) the punctuality index based on routes (PIR), where the PIR is the probabitlity of a bus to arrive at the stations in a specific time period.

Kho et al (2005) found that the punctuality as an umbrella concept containing on-time performance and headway adherence. He suggested three punctuality index P1, P2, and P3, where P1 is an index indicating the magnitude of a time gap between actual arrival time and scheduled arrival time, also P2 is the time gap between actual headway and scheduled headway, and the last one P3 indicating the magnitude of a time gap between average headway of a day and each headway of successive buses.

There are many studies have been conducted on punctuality index and on-time performance analysis of public transit service. The punctuality during weekends when there was low traffic volume is higher than those of the other days (Kho 2005). On the other hand, punctuality index during weekends and weekdays are not significant defferent (Napiah, Kamaraddin, and Suwardo 2011). There are many factors affect on punctuality these some factors include; length of routes and numbers of stops along the routes.

2.5 Waiting time;

Public transit is an important sector to providing service to passengers and to help them to move from one place to another. The waiting time of passengers is very important to measures the level of service provided and passenger satisfaction and the service recipient of public transit. When the waiting time of passengers increase the delay will be increase then the service provided will be decrease. The waiting time of passengers is related with punctuality measure, through it depends on the arrival and departure times of public transit. Waiting time is the total delay of passengers by public transit modes along the routes depends mainly on the number of stopping model of the bus and size of the bus (Abojaradah 2013).

The average waiting time of passenger at stop or station is important criterion in evaluating the quality of public transit systems. The accurate measurement of the average waiting time at station leads to more appropriate and timely schedules (Amin-Naseri and Baradaran 2014). Naseri and Baradaran suggested that average waiting time measured based on the assumptions that the passengers arrive at stations uniformly and public transit modes arrive at station independently.In addition, (Demelash 2007) found that the longer waiting time indicates poor adequacy. Some reports have been indicated that average waiting time should be in the range of 5 – 10 minutes, with maximum waiting time of 10 – 20 minutes under the prevailing conditions.

3. METHODOLOGY AND DATA COLLECTION

In this study, the data were collected from related sources and through field surveys. For each city, data on transit routes, fleet size on each route, fare level, route length, and maps were obtained from LTRC and municipalities. For each region, data on resident population densities in Amman and Irbid cities were also obtained. Table 1 illustrates the number of public transit vehicles and number of routes in each city.

Table1. Number of transit vehicles and number of routes in the included cities.

Transit mode	Amman	Irbid
Buses	529	-
Mini-Buses	349	833
Shared Service Taxis	3264	268
Total	4142	1129
Total number of routes	83	40

Accessibility was measured using spatial analysis through Geographic Information System (GIS). Many studies used the GIS in transportation fields (Murray, Xiaolan 2003). Accessibility is defined as the percentage of population served by public transit. For each route, access was measured depending on time or distance to public transit route, terminals or stops (El-Geneidy et al. 2013). Several buffers; including 160, 240, 400, 600, and 1000 meters from the transit routes in each side; were identified, and these distances are correspondence to levels of service of A, B, C, D, and E, respectively (Jason 1982).

Using population density in each region, accessibility was computed based on the percentage of resident population within a given selected buffer area to the total city population.

Mobility was measured using the average travel speed of public transit for each route. In fact, average speeds of public transit may be affected by vehicle type, traffic level, type and length of

route, and the number of stops during the trip. As such, travel speed was measured during peak and off-peak hours.

The operating ratio of public transit and daily passengers carried by each transit vehicle were used for estimating productivity of public transit. In reality, the productivity is considered as a combined measure of the efficiency and effectiveness of transit performance. The operating ratio was computed for each route as the ratio of yearly revenue to the yearly operating cost. Fuel, oil, maintenance, salaries and overhead, licensing, tires, depreciation, taxes, and insurance costs were included in estimating the yearly operating costs. These cost elements were obtained from transit operators, drivers, among other sources. The LTRC regulations stipulated that operation life of buses, mini-buses and taxis are 20, 15, and 12 years, respectively. Thus, these values were considered in estimating depreciation rates. Furthermore, number of passengers carried by each transit vehicle and number of daily trips were also observed.

Field surveys were carried out to collect data on waiting time of passengers at terminals or stations. The average waiting time for public transit were used to measure the delay time of passengers in waiting for transit vehicle inside the terminals. In computing waiting time, it was assumed that arrival of passengers to the terminal is uniform (Govender 2014). The waiting time was measured during peak and off-peak hours.

The departure and arrival times of public transit were used to determine the punctuality. It is measured depending on the actual arrival time and the scheduled arrival time (Patel 2014). However, field observations indicated that both departure and arrival were not scheduled. Thus, to enhance transit operation in Jordan and attract more users, the transit operation should be scheduled.

The field surveys were conducted for each transit route on Saturday, as a holiday in Jordan, and two other working days. It is worth mentioning that data were obtained for 10 vehicles on each route served by more than 10 vehicles. In contrast, the data were collected on all vehicles for a route served by less than 10 vehicles (Shtayat 2015).

4. DATA ANALYSIS AND RESULTS

4.1 Accessibility

Figure 1 shows accessibility of public service to users' in Amman city. In this figure, the blue buffer represents the 160 meters or 2 minutes, with a percentage of about 20% of total coverage area. The green buffer represents 400 meters or 5 minutes, with a percentage of about 41% of total coverage area. The Highway Capacity Manual (HCM 2010) reported that the 400 meters distance was the limit of the served areas by public transit. Thus, only 41% of Amman area was served by public transit, which corresponding to the 400 meters limit or level of service C, as shown in the figure.

Using resident population density and service area for each region in the city, the percentage of population within the 400 m limit was found approximatly about 63%. Therefore, the aggregate or overall accessibility of public transit service in Amman was about 63%. Investigation of Figure 1 revealed that the outskirt of the city was not well served, thus extension of radial routes and addition of circumferential routs were required to improve accessibility.

Similarly, further accessibility analyses were made for Irbid city. The results indicated that the percentage of served area within the 400 meters limit is nearly 60% of the coverage area (see Figure 2). However, 91% of the coverage area in Irbid city was served within a walking distance of 1 km or less. Combining population density and service area in each region, the resulted overall accessibility of public transit network within a walking distance of 400 m, or 5 minutes, in the city was 73%.

Compared with some international values, the obtained accessibilities 63% and 73% in Amman and Irbid, respectively, were relatively low. For example, in Los Angeles, Berlin, and Ontario the corresponding values were 88%, 68%, and 77%, respectively (Brooking Institute 2010). Taking into account that a considerable fraction of transit users' in Jordan are captive, these accessibilities should be enhanced.

To improve this situation, three actions were recommended. First, routes should be extended to serve new developments in the periphery of cities. Second, public transit routes may be restructured to improve internal coverage. And third, circumferential routes are recommended to enhance passenger transfer and distribution

Figure 1. Coverage areas for public transit routes in Amman city.

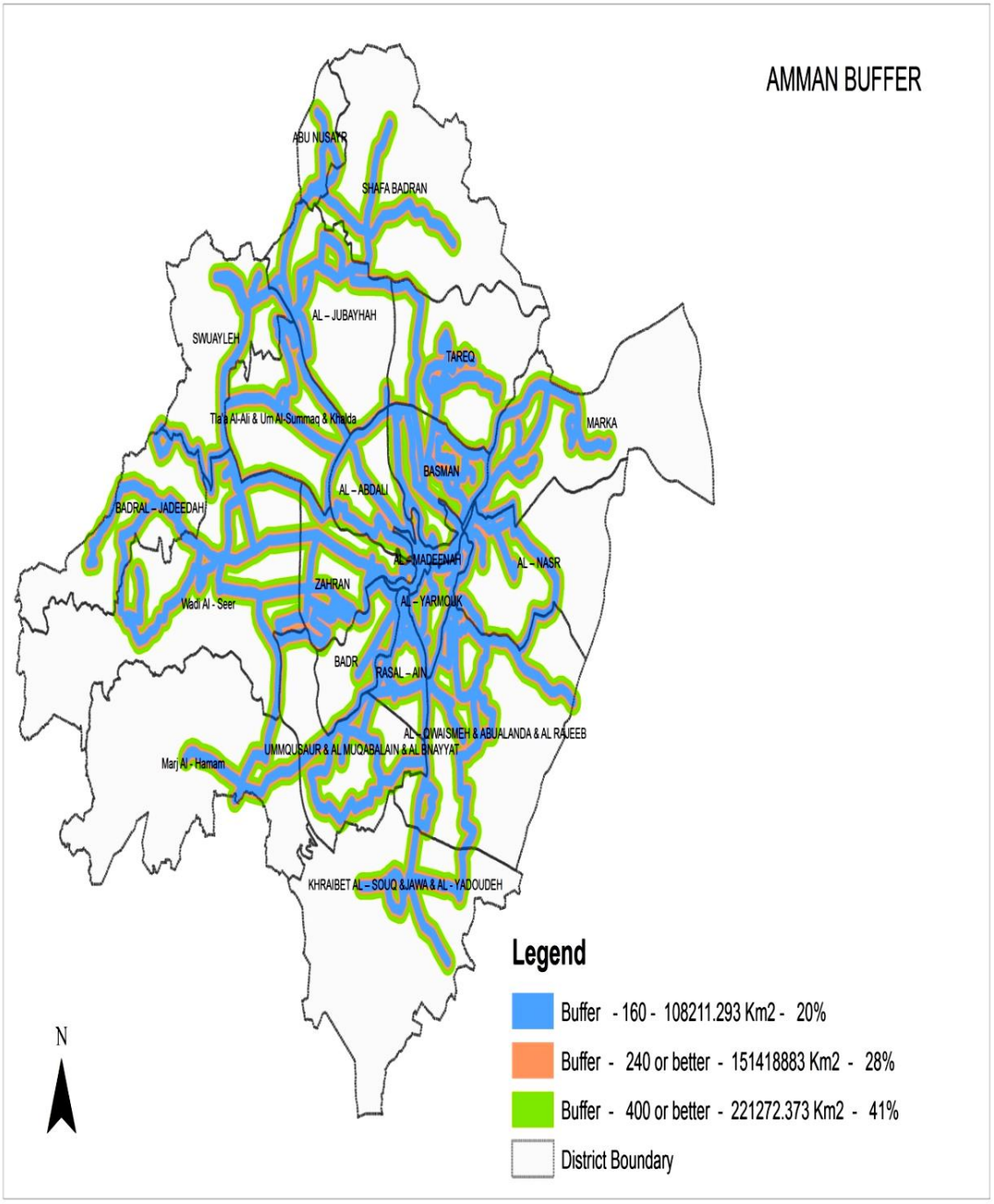
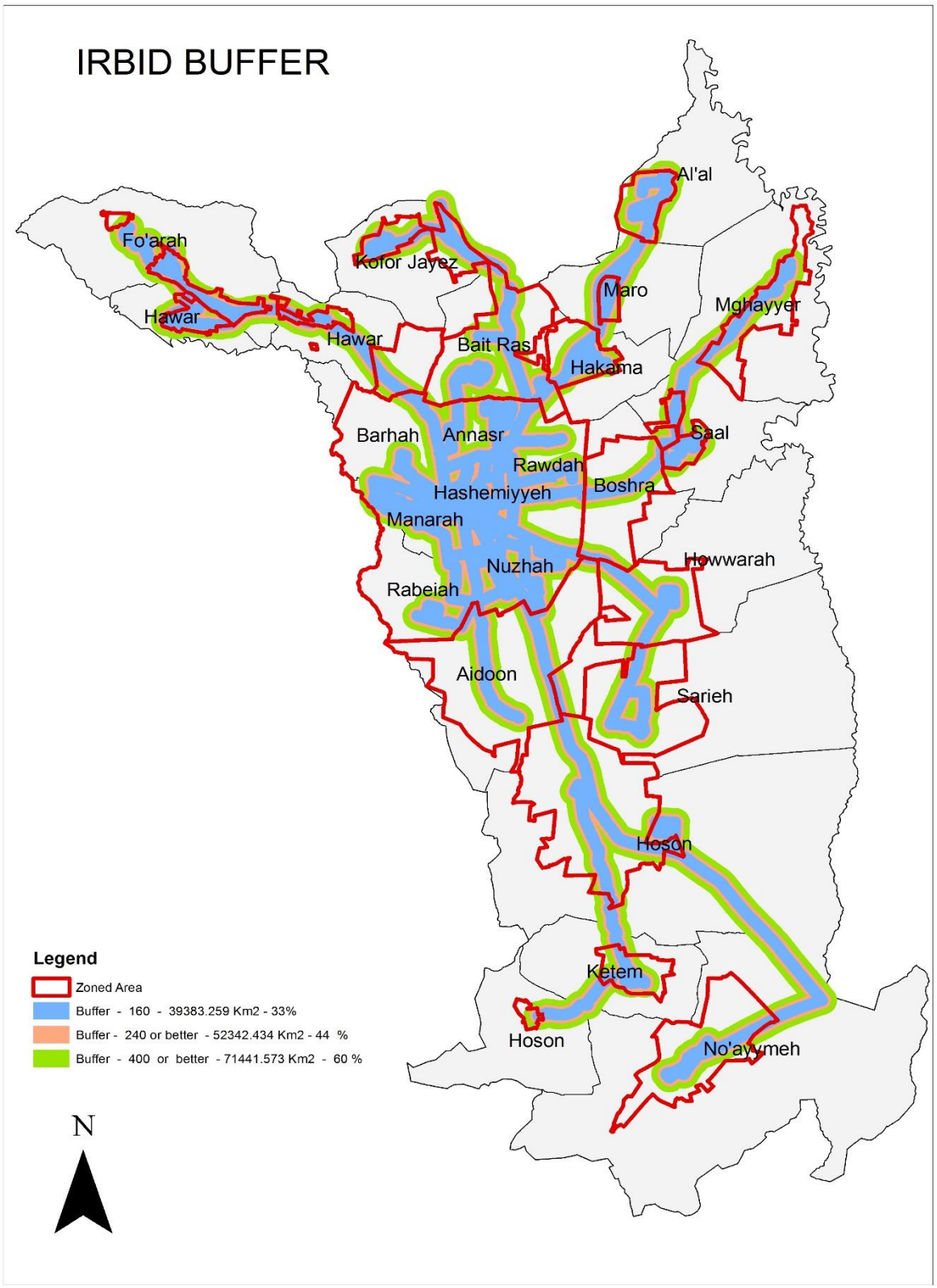


Figure 2. Coverage areas for public transit routes in Irbid city.



4.2 Mobility

Tables 2 shows the obtained results of average speed of public transit in Amman and Irbid. The results indicated that average speeds of buses in peak and off-peak periods were 20 and 26 km/hr, respectively. Thus, the average speed of buses was considered low compared with cited values in the United States or Canada (Nakanishi 1997). Also, the results revealed that average speeds of mini-buses and taxis were nearly comparable, with values ranged from 24 to 38 km/hr in peak and off-peak periods, respectively. Some of results indicated that longer routes showed higher speeds compared with the shorter ones, especially for mini-buses. In general, the number of stops during the trips was very high in the selected cities (see Table 2). In fact, traffic congestion, topographic, lack of traffic management may have a great influence on public transit speed. Clearly, introduction of bus rapid transit service is necessary to improve mobility, especially in Amman city.

Table 2. Route length, average speed, and number of stops in each city.

City	Transit vehicle type	Number of routes	Average route length, (Km)	Average speed (Km/hr) Peak/off-peak	Average number of stops	Waiting time (Min) peak/off-peak
Amman	Buses	37	12	20/26	7	23/16
	Mini-Buses	10	13	26/35	7	21/16
	Taxies	36	6	25/31	2	9/7
Irbid	Mini-Buses	39	10.3	25/30	6	23/16
	Taxies	5	3.7	26/30	2	9/6

4.3 Productivity

The Analyses indicated that the operating ratio of buses in Amman was (3.8), while operating ratio of mini-buses, for both included cities, was approximately (3.7). In contrast, taxis had low operating ratio was (2.3) Compared with world statistics, values obtained in this study are very high. For example, the operating ratio for buses in the United States and Japan was found in the range of 0.33 to 1.15 while in European countries the range was 0.5 to 1 (National Transit 2013). However, higher values in the range of 1.6 to 2 were recorded in Canada, Jakarta and Bangkok.

Large values of operating ratios in the included cities may be explained by the fact that most of public transit vehicles leave terminals only when they are full of passengers. The fare structure and method of calculation may be a crucial factor in this issue. Flat fare level is normally determined based on occupancy value of 60%. This assumption is made to reduce waiting time in terminals, and ultimately reduce waiting of passengers, especially during off-peak hours. Therefore, reduction of fair levels may encourage non-transit users to use the transit; and ultimately might reduce congestion problems.

Also, analyses revealed that the average daily number of passengers who carried by a bus was about 508. On the other hand, a mini-bus in Amman and Irbid, carried approximately 320 and 352 passengers per day, respectively. Furthermore, taxi vehicle carried about 107 and 124 passengers per day in Amman and Irbid, respectively. For each transit vehicle, differences may be due to route length and configuration, number of stops, and density of passengers in each city.

Based on the above utilization figures and fleet size in Table 1 the public transit in Amman carried nearly 730 thousands passenger trips per day in 2015. This figure is relatively low for a population of 4 million. Also, if the transit fleet in Amman is converted into an equivalent number of buses, based on the number of seats, then the result would be about 1000 buses. Hence, the ratio of buses to 1000 inhabitants in Amman would be 0.25. This ratio is also

very low compared with most statistics, which reported that the ratio was ranged from 0.5 to 1.2 buses per 1000 inhabitants of population (Brooking Institute 2010). Thus, an increase of the fleet size is recommended for all investigated cities.

4.4 Waiting Time

Table 2 shows that waiting time during peak hours is longer than that during off-peak hours. This result is logical because peak hours characterized by high passenger volumes and high traffic congestion which might impede public transit vehicles along routes. Compared to buses and mini-buses, taxi users' were experienced lower waiting times. Probably, schedule operation and increase fleet size during peak hours may reduce passenger waiting times.

The average waiting times of passengers for public buses in the investigated cities were found to vary from 12 to 23 min. The World Bank reported that the acceptable waiting time of passenger for public transit vehicles varied from about 10 to 20 min. (World Bank 2008). Therefore, the average waiting times of public transit users for the investigated cities were found to be marginally high.

5. Discussion of Result

This study presents the estimation of public transit performance in Jordan. This performance measures include; accessibility, mobility, productivity, punctuality, and waiting time. The measures of the performance are very important to evaluate the actual situation of public transit system and to give an indication about the level of services that provided in the selected cities.

Accessibility was evaluated using spatial analysis through Geographic Information System GIS. The high percentage of served areas mean that the public transit was served most of regions. The estimation was according to buffer areas through 160, 140, and 400 in all the routes of the selected cities (Shtayat 2015). In Amman and Irbid, the percentages of serviced areas were 41% and 60%, respectively. These results were correspondent with some results from developed countries. For example, in Tucson the percentage of the accessibility was about 73% (Brookings Institution 2010). The results of the selected cities showed that most of the cities were served by public transit systems. There are many solutions to increase the coverage areas and level of service of public transit by increasing number of routes in some regions and redesigning some routes to improve the accessibility level in the selected cities.

Mobility is an indication about the average speed of public transit modes. The results revealed that the average travel speed of buses, mini-buses and service taxis were about 22, 28, and 29 Km/hr, respectively. According to Jacksonuille 2006, the mobility of public transit vehicles depends on the number of stops during the trip. This study revealed that the average number of stops for all modes of public transit in Amman was 5 and 4 stops in Irbid The results of the average speed in the selected cities were compatible with some international studies around the world. For example, the average speed of public transit vehicles in London was about 21.3 km/hr (Tranter 2004). The average speed results in this study revealed that there were some traffic problems in term of management and routes design. Many solutions must be created to increase the mobility of public transit vehicles

such as increasing number of lanes in some routes and minimizing number of stops during the trip.

The productivity is measured by the total number of passengers per day (Demelash,2007). It is a ratio of total passengers transported divided by total revenue of service hours provided during a given period. The operating ratio is an indicator for efficiency of the public transit system .The average operating ratio were 5 for buses and mini-buses ,while for services taxes was about 3. These results revealed that the operating ratio for the public transit in the selected cities was very high compared with developed countries. International Association of Public Transport UITP (2006) reported that the operating ratio for public transit in Manchester was about 0.96. The incompatible results between Jordan and other countries due to the fare level may very high and the random loading and unloading passengers during the trip. Based on these results, it is recommended to replace taxis by buses or mini-buses as they have higher operating ratio and vehicle utilization.

The punctuality is timely operation of public transit modes according to their operation schedules. It is include; travel time and departure time (Patel 2014). The results revealed that there were random movements of public transit vehicles from terminals to their destinations. The operation system of public transit systems in Jordan were not scheduled compared with developed courtiers.

Waiting time is very important to measure the level of service provided and passenger's satisfaction and the service recipient of public transit. When the waiting time of passengers increase the delay time will increase then the service provided by public transit will decrease. The study revealed that the average waiting of passengers in Amman was about 16 minutes and about 14 minutes in Irbid. These results accepted by The World Bank report (2008) through reported that the acceptable range of waiting time of passengers varied from 10 to 20 minutes.

6. CONCLUSTION

This study investigated the performance of urban public transit in the two major cities in Jordan; including Amman and Irbid. Results of analyses indicated that accessibility of urban public transit, within walking distance of 400 m, was relatively low.

The mobility of buses was low, while the mobility of mini-buses and taxis was found to be acceptable in the selected cities. Compared with the operating ratio for developed countries, the operating ratio of buses or mini-buses, in both cities, was considerably very large. Also, the results indicated that the number of buses per one-thousand inhabitants was very low.

Field surveys showed that bus operation was not scheduled, and average waiting time of passengers for buses was marginally high, specifically during peak hours.

REFERENCES:

Abley, S., and Reuben W. (2008). Public Transport Accessibility Levels. New Plymouth: IPENZ Transportation Group Conference. New Zealand.

Armstrong-Wright, A., Thiriez, S. (1987). Bus services: reducing costs, raising standards. World Bank technical paper 68, 85-89. Washington, DC: The World Bank.

Birr, K., Kazimierz J., and Wojciech K. (2014). Travel Time of Public Transport Vehicles Estimation. Transportation Research Procedia 3, 359-365.

Brookings Institute (2010). The Suburbanization of Poverty: Trends in Metropolitan America, Analysis of Transit Agency, Nielsen Pop-Facts, 2010.

Cerdá, A. (2009). Accessibility: A Performance Measure for Land-Use and Transportation Planning In The Montréal Metropolitan Region. Supervised Research Project Report. School of Urban Planning, McGill University, Montreal.

Cervero. R. (2011). State Roles In Providing Affordable Mass Transport Services For Low-Income Residents. International Transport Forum Discussion Paper, No, 2011/17, OECD Publishing, Paris.

Demelash, A. (2007). Analysing public transport performance using efficiency measures and spatial analysis: the case of Addis Ababa Ethiopia. International Institute for Geo-Information Science and Earth Observation, Enschede, Netherlands.

Eboli, L. Mazzulla, G. (2011). A methodology for evaluating transit service quality based on subjective and objective measures from the passenger's point of view. Transport Policy, 18(1), 172-181.

El-Geneidy, A., Grimsrud M., Paul T., Wasfi R., and Legart J. S. (2013). "New Evidence On Walking Distances To Transit Stops: Identifying Redundancies And Gaps Using Variable Service Areas". Transportation, 41(1), 193-210.

Govender, K. (2014). Exploring Public Transport Service Quality – The Case Of Mini-Bus Taxi Service In South Africa. *Mediterranean Journal of Social Sciences,* 8(10), 317-326.

Hammond, R., and P a trick McCullagh. (1978). Quantitative Techniques in Geography: An Introduction. Second Edition. Clarendon Press: Oxford, England.

Handy, S. L., and Clifton K. J. (2001). Evaluating Neighborhood Accessibility: Possibilities and Practicalities. *Journal of Transportation and Statistics,* 4(2/3), 67–78.

International Association of public transport UITP. (2006). Brussels – Belgium.

Kho, S., Park, J., Kim, E. (2005). A Development of Punctuality Index for Bus Operation and Analysis of Its Characteristics. *Journal of Korea Society of Transportation,* 23(2), 131-141.

Land Transport Regulatory Commission (2007, 2011, 2012, 2013). Annual Reports. Amman, Jordan.

Lem, L. L., Jian-Ling L., and Martin W. (1994). Comprehensive Transit Performance Indicators. Berkeley: University of California Transportation Center.

Litman, T. (2008). Evaluating Public Transit Benefits and Costs - Best Practices. Guidebook.Victoria Transport Policy Institute. Canada.

Mohammad, A. (2013). Delay Study To Improve Public Transit Systems In Jordan'. *Journal of Environment and Earth Science,* 3(4), 2225-0948

Murray, A. T., and Xiaolan W. (2003).Accessibility Trade-offs In Public Transit Planning. *Journal of Geographical Systems,* 5(1), 93-107.

Nakanishi, Y.J. (1997). Bus performance indicators. On-Time Performance and Service Regularity. Transportation Research Record, 157, 3-13.

Nathanail, E. (2008). Measuring the quality of service for passengers on the hellenic railways., Transportation Research, 42 (A), 48-66.

Patel P., and Gor, R. (2014). Improving Punctuality By Adjusting Timetable Design. *IJSRD - International Journal for Scientific Research & Development,* 2(2), 274-278.

Scheurer, J., and Carey C. (2007). Accessibility Measures: Overview And Practical Applications. Working Paper, No. 4. Department of Urban and Regional Planning. Perth, Western Australia.

Sen, L., Sarmisha, R.M., Meredith, H., Linda, C., and Cinde, W. (2011). Performance Measures for Public Transit Mobility Management. Technical Report., Texas Department of Transportation and the Federal Highway Administration.

Shtayat A. ,"Evaluation of performance of public transit in Jordan", M.Sc. Thesis,Civil Engineering Department, Jordan University of Science and Technology, July, 2015.

TranSafety, I. (1998). Strategies for Solving Urban Transportation Problems in Developing Countries. *Road Management & Engineering Journal*.

World Bank (2008). Design for All: Implications for Bank operations. Harold Snider and Nazumi Takeda. Disability & Development, Social Protection & Labor, Human Development Network. Washington DC. October.

Yaakub, N., Nappiah, M. (2011). Public Transport: Punctuality Index for Bus Operation. World Academy of Science, Engineering and Technology, 5, 857-862.

Zielstra, D., and Hochmair H. H. Comparative Study of Pedestrian Accessibility to Transit Stations Using Free and Proprietary Network Data. Transportation Research Record: *Journal of the Transportation Research Board*, 2217-1, 145-152.

Zuidgeest, (2005). "Sustainable Urban Transport Development; A Dynamic Optimization Approach", Center for Transport Studies, University of Twente, The Netherland.